# FINAL REPORT

## Coupling Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage

## ESTCP Project EW-201135

MARCH 2017

Charles W. Hammock, Jr.
Stephen Sullens
**Andrews, Hammock & Powell, Inc.**

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AGWT | American Ground Water Trust |
| AHU | Air Handling Unit |
| ATES | Aquifer Thermal Energy Storage |
| ASHRAE | American Society of Heating, Refrigeration and Air-Conditioning Engineers |
| AVG | Average |
| | |
| BTES | Borehole Thermal Energy Storage |
| BTU(H) | British Thermal Unit (per Hour) |
| | |
| CGD | Certified Geothermal Designer |
| CHP | Combined Heat and Power |
| CIBL | Capital Improvements Business Line |
| COP | Coefficient of Performance |
| COC | Cycles of Concentration |
| $C_p$ | Specific Heat |
| CW | Chilled Water |
| CxA | Commissioning Agent |
| | |
| DC | District of Columbia |
| DDC | Direct Digital Control |
| DIA | Diameter |
| DOD | Department of Defense |
| DOE | U.S. Department of Energy |
| | |
| ECIP | Energy Conservation Investment Program |
| ESTCP | Environmental Security Technology Certification Program |
| etc. | Etcetera |
| | |
| FEMP | Facility Energy Management Program |
| FICA | Federal Insurance Contributions Act |
| Ft | Foot |
| ft2/person | Square Feet Per Person |
| FY | Fiscal Year |
| | |
| GA | Georgia |
| GHP | Geothermal Heat Pump (also known as GSHP or GSHC System) |
| GHX | Ground Heat Exchanger |
| GPM | Gallons Per Minute |
| GSHP(C) | Ground Source Heat Pump (or sometime Cooling (system) is substituted for the word Pump. Alternately called a GHP |
| | |
| Hr | Hour |
| HDPE | High-Density Polyethylene |
| HVAC | Heating, Ventilating and Air-Conditioning |

| | |
|---|---|
| HW | Hot Water |
| IGSHPA | International Ground Source Heat Pump Association |
| kBtu(h) | Kilo British Thermal Unit (per Hour) |
| kW | Kilo-Watt |
| kWh | Kilo-Watt Hour |
| $lb/ft^3$ | Pound per Cubic Foot |
| LCC | Life Cycle Cost |
| m | Mass |
| m | Meter |
| $m^2/sec$ | Square Meters Per Second |
| $m^3/hr$ | Cubic Meters Per Hour |
| MAX | Maximum |
| MCLB | Marine Corps Logistics Base (Albany GA location in this report) |
| MCLBA | Marine Corps Logistics Base Albany |
| MILCON | Military Construction |
| MIN | Minimum |
| NAVFAC SE | Naval Facilities Engineering Command Southeast |
| NEBB | National Environmental Balancing Bureau |
| NIST | National Institute of Standards and Technology |
| PE | Professional Engineer |
| PV | Photo-Voltaic |
| PWD | Public Works Department |
| SIR | Savings-to-Investment Ratio |
| SW | Source Water |
| TAB | Test and Balance |
| TC | Thermal Conductivity |
| TCT | Thermal Conductivity Testing |
| TRNSYS | Transient System Simulation Tool |
| UESC | Utility Energy Service Contract |
| US | United States |
| USA | United States of America |
| UDTES | Underground Diurnal Thermal Energy Storage |
| USTES | Underground Seasonal Thermal Energy Storage |
| UTES | Underground Thermal Energy Storage |
| UV | Ultraviolet |
| VA | Veterans Administration |

| | |
|---|---|
| VDI | Verein Deutscher Ingenieure (Largest Engineering Association in Western Europe) |
| VAV | Variable Air Volume |
| Wh | Watt-hour |
| YR | Year |
| ΔT | Temperature Differential |

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# ACKNOWLEDGEMENTS

This project attempted, and succeeded, in implementing the first known Borehole Thermal Energy Storage (BTES) in the United States (US). It also created the US's only known active "full" (warm and cold) Aquifer Thermal Energy Storage (ATES) system. This Demonstration was a team effort with many contributors and "champions", without who's support and enthusiasm the project would have stalled or even failed. Though too many people and organizations were involved to mention everyone by name, the Principal Investigator (PI) and Co-PI would like to identify the following contributors:

**ESTCP:** The entire leadership and staff of ESTCP including the head of the Energy and Water (EW) Program Tim Tetreault, and former employees and support personnel Dr. Jim Galvin, Glen DeWille and Scott Clark. Without ESTCP, the US would still not have a BTES or full ATES system.

**The Marine Corps Logistics Base (MCLB), Albany, GA:** BG Terry Williams, Fred Broome, "Ski" Smigelski, Mike Henderson, Eddie Hunt, David Anderson, DJ Riordan, Jeanne Geisel, Chuck Phelps, Patty Morgans LCDR Jason Boatright, personnel with NAVFAC LANT/NAVFAC Mid-LANT/NAVFAC SE. Also, the General Contractor Artesian Contracting and their sub-contractors.

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**Industry Partners:** Several Industry Partners made significant partial or full in-kind contributions to the ATES project at Ft. Benning. Their role, and the high-quality equipment, systems and support they contributed is detailed in Appendix H. Key contributors included: Goulds (submersible pumps), ABB/Borie-Davis (Variable Frequency Drives-VFD & Filters), Climate Master (Geothermal Heat Pumps), and ISCO (High Density Polyethylene (HDPE) Pipe.

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# EXECUTIVE SUMMARY

EW-201135, *Coupling Geothermal Heat Pumps (GHPs) with Underground Thermal Energy Storage (USTES)* was proposed because, in the US, the fundamental design of GHP systems, with their underground Groundloop Heat Exchanger (GHX) or water supply wells, has been largely unchanged for decades, while the international design community has progressed to more innovative and efficient architectures. Energy consumption associated with Heating, Ventilation and Air-Conditioning (HVAC) systems are generally a significant contributor to a building's entire energy consumption. In pursuit of reducing energy consumption, the HVAC industry is typically progressing to develop various types of HVAC technology to help reduce the energy consumption of an associated HVAC system. Historically, conventional GHP HVAC systems are considered one of the most, if not the most efficient active HVAC systems. Most DoD (and non-DoD commercial) facilities in many geographic regions are cooling dominated due to the consistent presence of cooling loads associated with people, lights and equipment (computers, copiers, monitors, etc.). Furthermore, most HVAC systems used in the Southeastern (SE) US (the region where both ESTCP projects were accomplished), are *significantly* cooling dominated. Typically, DoD facilities have imbalanced cooling versus heating loads, which in some applications, can have annual cooling loads that are as much as 5-10 times more than the annual heating loads. For a conventional GHP system, this load imbalance, over time, can lead to higher supply water temperatures and cause the operating efficiencies (EER or COP) of the water-cooled equipment to decrease. In extreme cases, the supply water temperatures can increase up to the point where the water-cooled equipment can fail/fault due to high refrigerant pressure safeties. Most designers either design the geothermal field large enough to account for the load imbalance or they design a "hybrid" geothermal system, which utilizes a cooling tower or dry fluid cooler as a type of peak shaving heat rejection device during the hottest of conditions. HVAC systems with Underground Thermal Energy Storage (UTES) capability, whether seasonal (USTES), or Diurnal (UDTES), do not necessarily have to reject (or extract when heating dominated) heat during peak conditions. In retrospect, since both the Borehole Thermal Energy Storage System (BTES) installed at the Marine Corps Logistic Base in Albany Georgia (MCLB) and the Aquifer Thermal Energy Storage (ATES) installed at Ft. Benning Georgia (GA) both are capable of diurnal and seasonal storage, this project would more aptly be named simply *Coupling GHPs with **UTES***. The only known BTES in Canada, over the course if its execution found that its diurnal component was as, or more important than its seasonal component.

The objective of this demonstration was to fully maximize the inherent advantages of the geology and hydrogeology accessed by means of Ground-loop Heat Exchangers (GHX) with closed loop systems or via direct ground water use with open-loop systems, which conventional GHP systems in the U.S. are not designed to achieve. Deliberately engineered UTES systems not only allow for the waste heat of cooling systems and the waste cool of heating systems to be captured, but also allow for the out-of-season capture of the winter's "cold" or summer's "heat" (from the air or via solar thermal collectors), if needed, in cooling-dominated or heating-dominated buildings, respectively.

This demonstration project involved the implementation of high-efficiency GHP systems, coupled with an UTES system, at two locations in the SE U.S. to provide a sustainable infrastructure with higher energy savings than conventional geothermal systems, but with lower installation cost. The demonstration project at MCLBA coupled GHPs with a particular form of UTES commonly known within the international community as BTES. The demonstration project at Fort Benning, GA coupled GHPs with a particular form of UTES known internationally as ATES. Both systems, at proper scale, demonstrate significant capital cost benefits, while concurrently demonstrating significant reduced annual energy consumption when compared to conventional HVAC systems and even conventional GHP systems when compared at proper scale.

As part of the demonstration project, several quantitative performance objectives were proposed and evaluated as part of the overall performance. Table 0.1 lists a brief summary of the quantitative performance objectives and the results from the demonstration project. All but one of the performance objective were achieved as part of this demonstration project. Each of those successful non-binary (100%) reductions exceeded their target reductions (when examined as a ratio) by a range of 1.38 to 1.76. The only performance objective not satisfied was the proposed Greenhouse Gas (GHG) Emissions associated with fossil fuel source energy production of air-source heat pumps vs. GHPs. Even so, those reductions were significant (26.5% to 32.5% reductions for ATES/BTES respectively and probably due to modeling difficulties that, if resolved, might show a greater reduction. Overall, the demonstration project illustrated a successful performance evaluation for the implemented technology and it is hoped opens up two new architectures of HVAC system that can create significant energy and water savings for DoD and others.

**Table 0.1. Brief Summary of Performance Objectives**

| PERFORMANCE OBJECTIVES | | | |
|---|---|---|---|
| **Performance Objective** | **Metric** | **Success Criteria** | **Results** |
| **Quantitative Performance Objectives** | | | |
| Facility GHP-USTES HVAC Energy Usage vs. Conventional HVAC | Energy Intensity (MMBtu/ft$^2$ or kWh/ft$^2$) | 30% Reduction | BTES: 47.5% Reduction<br>ATES: 52.7% Reduction |
| Facility GHP-USTES HVAC Energy Usage vs. Conventional GHP HVAC | Energy Intensity (MMBtu/ft$^2$ or kWh/ft$^2$) | 10% Reduction | BTES: 15.1% Reduction<br>ATES: 13.8% Reduction |
| Water Usage by On-Site Conventional Cooling Tower | Water (Gallons) | 80-100% Reduction | BTES: 100% Reduction<br>ATES: 100% Reduction |
| Direct On-Site Greenhouse Gas (GHG) Emissions for HVAC Space Heating | Direct on-site fossil fuel GHG emissions (metric tons) | 100% Reduction | BTES: 100% Reduction<br>ATES: 100% Reduction |
| Installed Cost Of GHP-BTES vs. Conventional GHP Systems | HVAC Construction Cost | 20% Reduction | 33.6% Reduction |
| Greenhouse Gas Emissions at Source (Power Plant) to power Air-to-Air Heat Pumps vs. GHP-USTES System | Source fossil fuel GHG emissions (metric tons) | 40% reduction | BTES: 32.5% Reduction<br>ATES: 26.5% Reduction |

# 1.0 INTRODUCTION

This project was proposed because the “conventional architectures” of Geothermal Heat Pumps (GHP) in the United States do not fully maximize the inherent advantages of the geology they access by means of Ground-loop Heat Exchangers (GHX) with closed loop systems or via direct ground water use with open-loop systems. Deliberately engineered Underground Seasonal Thermal Energy Storage (USTES) systems allow not only the waste heat of cooling systems and the waste cool of heating system to be captured, but also allow for the out-of-season capture of the winter’s “cold” or summer’s “heat” if needed in cooling dominated or heating dominated buildings respectively. Installing a USTES system within the boundaries of a military installation (“inside the fence”) is a perfect way to increase energy security and provide an alternate means of utilizing renewable energy at Department of Defense (DoD) installations worldwide.

## 1.1 BACKGROUND

With the billions of dollars DoD spends on procurement of energy and water, this USTES project neatly intersects the energy-water nexus by significantly reducing *both* energy and water consumption at DoD facilities. Combining Geothermal Heat Pumps with a USTES in this demonstration allowed DoD to utilize the "inside the fence" (secure) native geology/ground water to store both waste heat and "waste cooling" to reduce electrical and water consumption and eliminate on-site fossil fuel consumption and the associated greenhouse gas emissions.

To heat their buildings, DoD currently primarily burns fossil fuels, utilizes electric resistant heat or extracts heat from the cold winter air via heat pumps and then the "waste cooling" of the heat pump is discarded into the ambient air where it is carried away by convection and wind. Cooling is typically accomplished by either air-cooled condensing units or water cooled chillers that are assisted by cooling towers that evaporate millions of gallons of water for heat rejection.

DoD rarely takes advantage of the local geology by utilizing Geothermal Heat Pumps which allow access to the superior heat sink/heat source/energy storage capability of the underground. The demonstration team is unaware of any previous DoD attempts to couple GHPs with USTES and seasonally store waste heating/cooling as this project accomplished.

### 1.1.1 Brief Technology Description:

There are two variations of USTES featured in this demonstration: Borehole Thermal Energy Storage System (BTES) and Aquifer Thermal Energy Storage System (ATES). The BTES technology demonstrated in this project at Marine Corps Logistics Base, Albany Georgia is a closed loop Ground Heat Exchanger (GHX) system that utilizes a bore field configured in a bullseye pattern, an adiabatic dry cooler, and reversing valves to redirect flow into the perimeter or the core of the bore field depending upon the season. The principle of operation for this technology is to utilize the adiabatic dry cooler in the dry mode during periods of cold outside air temperatures to efficiently dump heat from the building and bore field to the outside air and therefore “charge” the core of the bore field with “cold”. In the opposite season, the reversing valves change position to use the stored energy from the core of the bore field to cool the building. Given the geographic location of the BTES, it is not designed to store heat for heating in the building during the heating season. The BTES contains sufficient heat to accomplish this if needed, but the main source of heat for the building comes from the modular heat recovery chillers.

These chillers use the waste heat from the chilled water loop and the heat of compression to produce heating hot water. If this particular building were located in a colder climate, the BTES could be designed as a "hot" BTES to store heat during the cooling season.

The ATES technology featured at a different location (Ft. Benning, GA) is similar to the BTES mentioned above, but is an open loop system instead of a closed loop. With the ATES technology, energy is stored in the aquifer in either the cold well or the warm well. These wells are located approximately 500'- 600' apart. During the cooling season, cold water is pumped from the cold well and used to cool the building. The heat extracted from the building is then injected into the warm well. During the heating season, warm water is extracted from the warm well and used to heat the building. An adiabatic dry cooler is then used to efficiently dump additional heat to the air during times of cold outside air conditions. This helps to balance the load between heating and cooling, and allows for additional cooling to be stored in the cold well. After the water leaves the building or dry cooler, the cold water is injected back into the cold well where it is stored for use again in the cooling season.

### 1.1.2 Benefit:

The major benefit of this technology over conventional HVAC systems and even conventional geothermal systems is that ATES and BTES both allow the geo system to become more efficient over time by removing more heat from the geology than is injected. This can be done efficiently using an adiabatic dry cooler in the dry mode during the time of cold outside air temperatures.

An additional benefit of this technology is its potential reduction of water. Initial cooling tower water consumption for the BTES project measured prior to BTES installation was approximately 3 million gallons. However, the cooling tower had excessive scale build-up, and per the chemical provider company, the cooling tower should have been using approximately 4.3 million gallons/year to satisfy the Cycles of Concentration (CoC) requirements. At Ft Benning, the annual cooling tower water consumption prior to installing ATES is estimated to be approximately 166,000 gallons/year. Installing the new BTES and ATES systems has completely eliminated the need for potable water by the HVAC system.

## 1.2 OBJECTIVE OF THE DEMONSTRATION

The objective of this project was to successfully demonstrate that a high-efficiency GHP System, coupled with an USTES system could provide truly sustainable infrastructure with higher energy savings than conventional geothermal systems, but with lower installation cost and thereby address DoD's substantial building energy consumption issues in a widely deployable and more affordable manner. One project coupled GHPs with a particular form of USTES commonly known within the Industry as Borehole Thermal Energy Storage (BTES). Another similar project coupled GHPs with a particular form of USTES commonly known within the Industry as Aquifer Thermal Energy Storage (ATES). The BTES systems demonstrated significant Capital Cost reductions from conventional GHP systems while both technologies concurrently demonstrated significant reduced annual energy consumption when compared to conventional Heating, Ventilation and Air Conditioning (HVAC) systems and even conventional geothermal (GHP) systems. DoD can have no greater energy security component than an on-site system that places a large portion of the thermal energy needed to heat and cool its buildings safely underground and provides a means to harvest and store its already pre-existing waste heat and waste cooling.

USTES systems do not need the wind to blow, the sun to shine, nor the clouds to stay away to work effectively.

### 1.2.1 Issues Validated:

The project validated the performance, costs, and benefits of the technology by monitoring and comparing the existing energy and water consumption of the buildings before and after the GHP/USTES technology was deployed and by carefully tracking the costs associated with its installation and presenting this data in report form.

Overall the BTES system compared to the conventional HVAC system consisting of a water cooled chiller, cooling tower, and natural gas boilers has shown approximately a 48% reduction in energy consumption. Before the demonstration project was installed, the existing 400-ton cooling tower water use (evaporative plus blowdown) was monitored and metered at 3.2 million gallons per year. However, after observing the condition of the cooling tower, its operation was discussed with the chemical treatment company servicing the cooling tower. Through that discussion, it was calculated that the cooling tower was operating at a higher cycle of concentration than required. For each gallon of water evaporated, a lower cycle of concentration requires additional blowdown water use than a higher cycle of concentration. Through that calculation, it was determined that the existing cooling tower operating at a proper cycle of concentration would use approximately 4.3 million gallons per year due to its operation at lower cycle of concentration. Therefore, due to the elimination of the existing 400-ton cooling tower and no operation of the dry cooler's adiabatic evaporative cooling function, the water use reduction associated with the demonstration project is 4.3 million gallons per year. The BTES system has a calculated payback of approximately 11 years.

The ATES system compared to the conventional HVAC System (Chilled water multi-zone air handler connected to a central chilled water plant and a local natural gas boiler.) has shown approximately a 52.7% reduction in energy consumption.

Since the AHU chilled water coil was connected to a central chiller plant, accurate metering of the cooler tower water use associated with the building's operation was improbable. Therefore, the annual chilled water demand was metered and used to calculate the building's water use associated with the central plant's cooling tower operation. The metered chilled water demand was adjusted by 1.25 to account for the heat added by the compressor's operating in the central plant chillers to determine the building's share of heat rejection by the central plant cooling towers. Since approximately 1,050 BTUs are required to evaporate one pound of water, the heat rejection calculation can be converted to gallons of water evaporated by the cooling tower by dividing the heat rejection number by 1,050 BTUs per pound and 8.33 pounds per gallon. A reasonable cycle of concentration was also used for the Fort Benning area to determine the approximate water use associated with blowdown. After calculating both evaporative water use and blowdown water use, it was determined that the water usage had been reduced by approximately 166,000 gallons per year. The ATES system has a calculated payback of approximately 10 years.

## 1.3 DRIVERS

Many Executive Orders, Policies, Industry Standards, Mandates and Regulations are pushing all DoD entities to lower energy and/or water consumption. Some examples of these drivers and their relationship to this project are as follows:

### 1.3.1 Executive Orders:

EO 13514, "Federal Leadership in Environmental, Energy and Economic Performance" stresses Sustainable Buildings, greenhouse gas reduction, water efficiency and most of the aspects of EO 13423. EO 13423, "Strengthening Federal Environmental, Energy and Transportation Management" mandates reducing energy intensity and water intensity and increasing renewable energy consumption. USTES in both its forms proposed for this project (BTES and ATES) provide a means for accessing not only the renewable energy of the earth itself, but also allows the renewable (annually recurring) waste heat and waste cooling of the building to be captured and seasonally stored for use in the opposite season. Due to their inherently efficient nature (due to lower/higher heat sink/source temperatures) energy intensity reduction is always achieved with these systems. Evaporative cooling needs are greatly reduced by the USTES system's capability of releasing its heat in winter when the heat can easily flow from the loop into the ambient air. This means the massive (approximately 4.3 million gallons annually at our BTES site at MCLB, and approximately 166 thousand gallons annually at our ATES site at Ft Benning) water consumption associated with a standard cooling tower can be drastically reduced or eliminated. The Veterans Administration (VA) has recognized the benefits of ATES and sought sources (March 2013) of engineering/technical support to help them with an upcoming feasibility assessment for an ATES system at two Medical Centers in Ohio. The solicitation quoted both of the above standards and the Energy Policy Act of 2005 (EPAct 2005) mandate below as the requirements that led to this project.

### 1.3.2 Legislative Mandates:

EPAct 2005 mandates an increase in the use of renewables and the procurement of energy efficient products and this project meets both of these objectives. The decision to utilize a modular chiller with heat recovery capabilities (BTES system at MCLB) means that when operating in the heat recovery mode, the effective COP of the unit increases dramatically as a single compressor does the work of two, creating chilled and hot water simultaneously. The Energy Independence and Security Act of 2007 proposes energy reduction goals for all Federal buildings and the USTES system will make a substantial difference in both buildings where it is installed.

### 1.3.3 Federal Policy:

The Federal Leadership in High Performance and Sustainable Buildings MOU 2006 brought together 16 Federal Agencies to commit to design, construct and operate their facilities in an efficient and sustainable manner. The replacement of the existing HVAC systems at both the BTES site at MCLB and the ATES site at Fort Benning have achieved the goals of this memorandum by: Reducing the total ownership cost of facilities; Improving energy efficiency and water conservation; Providing safe, healthy, and productive built environments; and Promoting sustainable environmental stewardship.

### 1.3.4 DoD Policy:

Strategic Sustainability Performance Plan, Energy Security MOU with DOE, the Army Energy Security Implementation Strategy, the Navy's Task Force Energy and the Air Force Energy Plan all seek the energy efficiency and renewable energy benefits that can be provided by a system such as those provided by coupling GHPs with USTES.

### 1.3.5 Guide:

The Whole Building Design Guide (http://www.wbdg.org/) describes the use of geothermal and groundwater cooling specifically as one of the ways to employ renewable energy resources in buildings. More information is at (http://www.wbdg.org/design-objectives/sustainable/optimize-energy-use) and (http://www.wbdg.org/resources/high-performance-hvac?r=minimize_consumption)

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# 2.0 TECHNOLOGY DESCRIPTION

## 2.1 TECHNOLOGY OVERVIEW

### 2.1.1 Description and Schematics:

This project proposed taking the existing technology of GHPs, which is somewhat known/implemented within the DoD community and coupling it with another technology, USTES, which is virtually unknown in the U.S., and to our knowledge, not previously installed at DoD installations. This project sought to demonstrate that this marriage of GHPs and USTES can truly define "Sustainable Infrastructure" and is innovative in the realm of HVAC systems. We believe it is uniquely aligned with the energy and water goals and policies of DoD.

- **Overall System Configuration:** This project included the installation of two system types of GHP-USTES HVAC systems, with each of these system types being installed in their own unique (separate) building. The buildings that received these GHP-USTES type HVAC systems were existing DoD facilities that were in need of replacement HVAC systems due to the age/condition. These two buildings/systems are located at two geographically separate DoD installations as described in Section 4.0.

  - **BTES**

    Building 3700 at MCLB received 6 heat recovery modular chillers capable of simultaneous heating and cooling. The building's existing ductwork and air distribution system was re-used where possible. The air handling units (AHUs) are approximately eight years old and were re-used. The system architecture is a four-pipe chilled water (CW)/hot water (HW) system that is distributed to variable air volume (VAV) AHUs (six each) with CW coils and VAV terminal boxes (105 total) with HW coils. The AHUs were reused whereas the VAV boxes were replaced with new VAV boxes equipped with deeper (four-row) HW coils to accommodate the lower temperature water produced by the six-new modular heat recovery water-to-water Geothermal Heat Pumps. The building's GHP was connected to closed loop system comprised of 306 conventional underground grouted vertical boreholes with HDPE u-bends, but has an active outdoor adiabatic dry cooler. The dry cooler is optimized, from a construction and control/operational perspective, to capture the cooling energy of winter and store this energy in the underground formation for use in the peak summer months. This style of USTES is commonly referred to as a Seasonal Borehole Thermal Energy Storage system or simply "BTES". This particular form of GHP systems with USTES can be more specifically described as a GHP-BTES system.

  - **ATES**

    Building 3215 at Ft Benning received conventional, off-the-shelf water source heat pumps suitable for GHP duty, along with the necessary ancillary associated HVAC sub-systems like ductwork, piping, pumps, etc. The building's existing ductwork and air distribution system was re-used where possible. Fort Benning's AHU was at the end of its life span, and of an antiquated design (multi-zone), which was replaced by seven small GHPs that are of the water-to-air design that also function as the air handling units.

The ATES system at Fort Benning includes an outdoor adiabatic dry-cooler, but utilizes an open loop system of four wells to directly extract/inject the native ground water from/to the local aquifer. This configuration is NOT the same as conventional open loop GHP systems that have dedicated extraction wells that are never used as the injection wells and vice-versa. The Fort Benning open loop is properly known as a seasonal Aquifer Thermal Energy Storage system or simply "ATES". It is fundamentally/ thermodynamically/physically different compared to conventional open loop systems in that each well can function as an extraction or injection well. Together, this system can be described as a GHP-ATES system.

- **<u>Specific HVAC System Configuration Description (BTES):</u>**

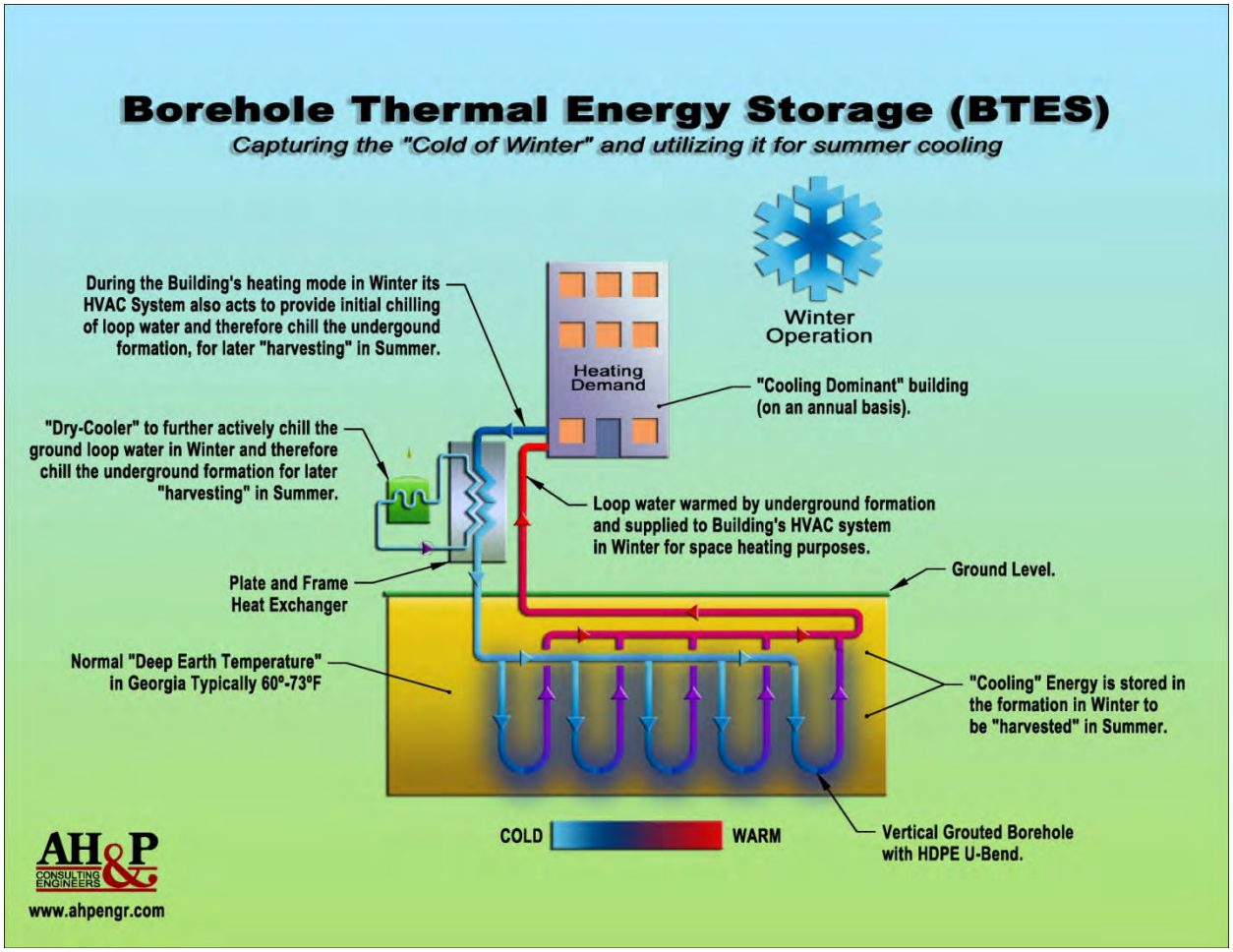


**Figure 2.1. Borehole Thermal Energy Storage (BTES) Overview**

1. General

This section describes the technology in sufficient detail to provide an understanding of its theory, functionality, and operation. For a more detailed description of the BTES technology, see Appendix B. The BTES GHP HVAC system operates similar to other typical GHP HVAC systems. Heat is removed from the building and delivered to the earth though vertical boreholes. Note: Heat is also removed from the earth and added to the building during dedicated heating mode, but this will rarely happen since the building is typically heated using heat recovery. There are two fundamental differences in the BTES system from a traditional Geothermal System.

a. The BTES system utilizes two adiabatic dry coolers, *see Figure 2.4.* The dry cooler has two functions:
   i. To reject heat from the building anytime it can be rejected efficiently using just the ambient air. This allows the cooling-dominated system to be balanced so as to not overheat the bore field over time.
   ii. To seasonally reject additional heat from the bore field any time it can be rejected efficiently (i.e. – winter) and therefore store cooling capacity in the earth.

b. The BTES bore field consists of 306 vertical boreholes configured in concentric circles as a "bullseye" shape, *see Figure 2.2*. This bullseye pattern allows storage of the cooling capacity created by the dry cooler in the center (core) of the bore field. Storing the cooling capacity in the core allows the outer layers of the bullseye to act as an insulating layer to preserve the cooling capacity.

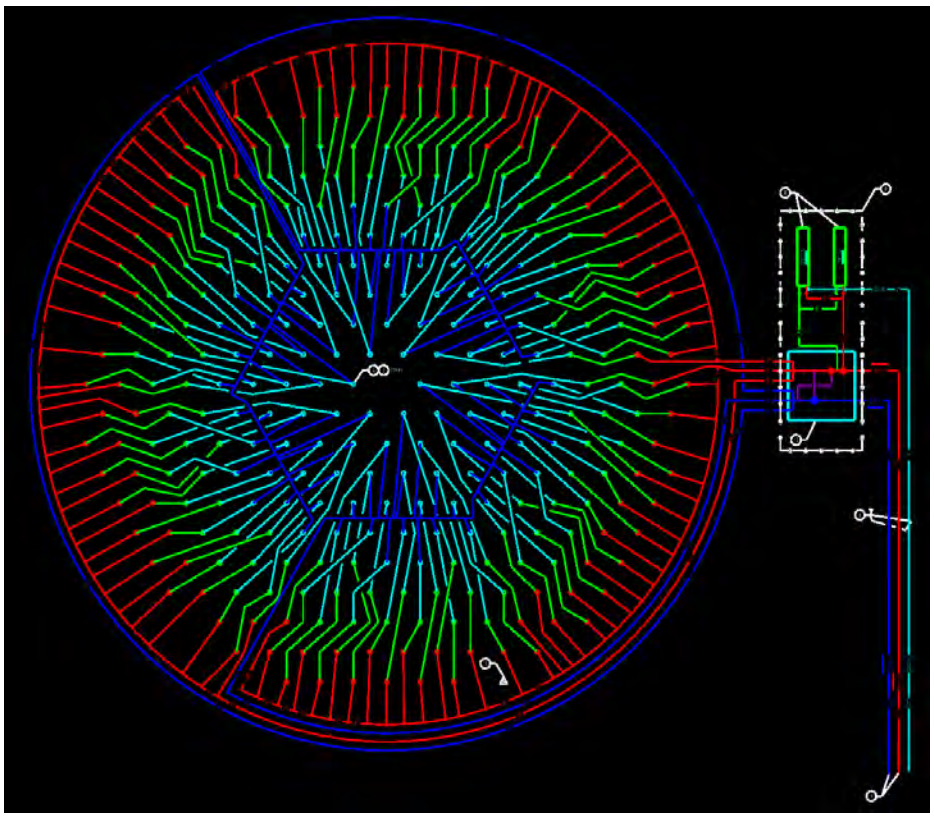

**Figure 2.2. BTES Bore field/Vault/Adiabatic Dry-Cooler Layout**

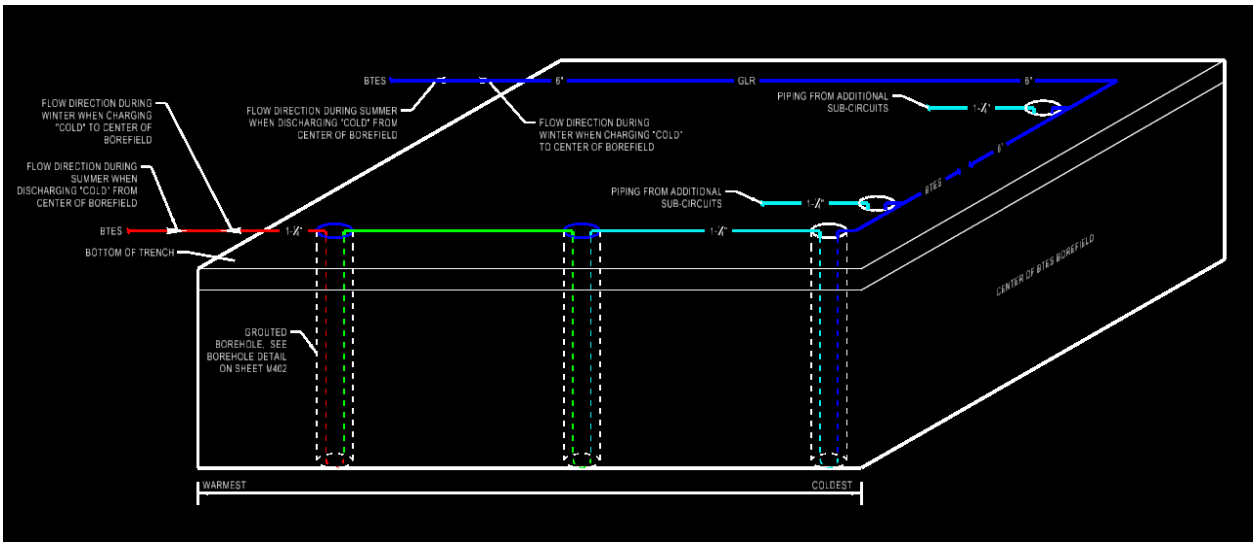


**Figure 2.3. Typical Sub-Circuit/Three-Series Borehole Schematic for the BTES**



**Figure 2.4. Adiabatic Dry Coolers**

2. Heat Recovery Modular Scroll Chiller

The cooling and heating medium for the building is chilled and hot water. The chilled and hot water is produced by a heat recovery chiller manufactured by Clima-Cool. The heat recovery chiller operates differently compared to a traditional chiller. The heat recovery chiller has 6 different water connection points:

a. Chilled Water Supply
b. Chilled Water Return
c. Hot Water Supply
d. Hot Water Return

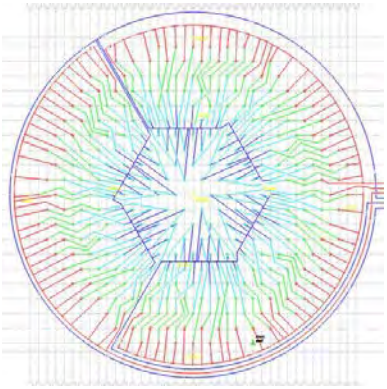

**Figure 2.5. BTES Bore field**

e. Source (bore field) Water Supply
f. Source (bore field) Water Return

The heat recovery chiller has five separate modules, with two compressors per module. Each module can perform three different tasks.

a. Create chilled water by injecting heat into the source water
b. Create hot water by extracting heat from the source water and rejecting waste compressor heat.
c. Create chilled and hot water simultaneously by moving heat from the chilled water directly to the hot water.

The five different modules stage their compressors and switching valves to satisfy the chilled water and hot water supply set points. The modules also stage between each other to equalize runtime between the modules. *See Figure 2.3.*

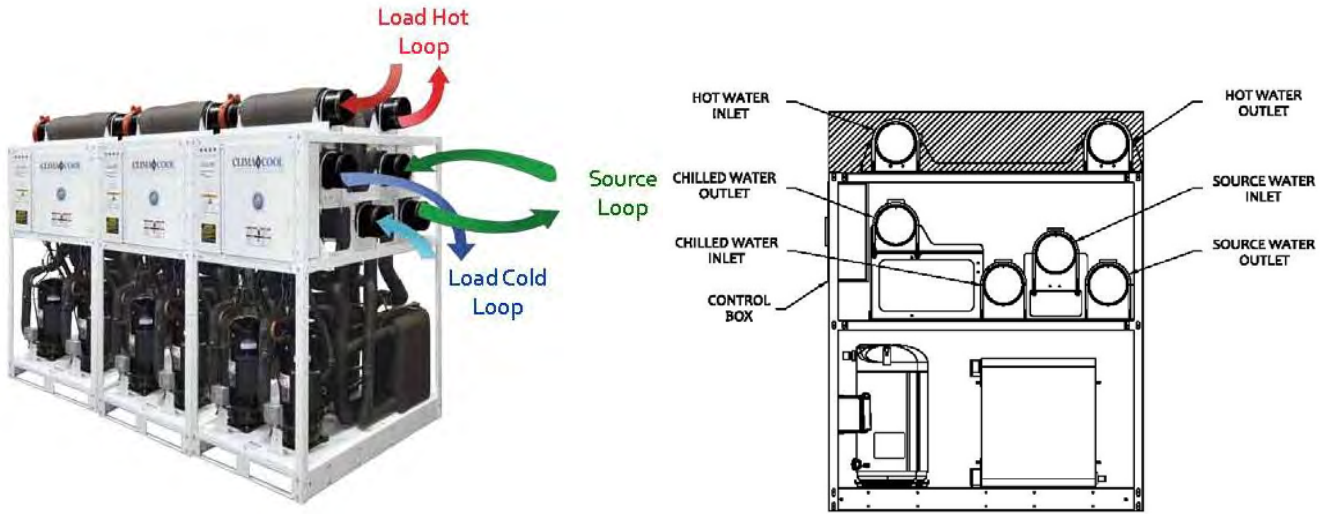


**Figure 2.6. Heat Recovery Six-Pipe Modular Chillers**

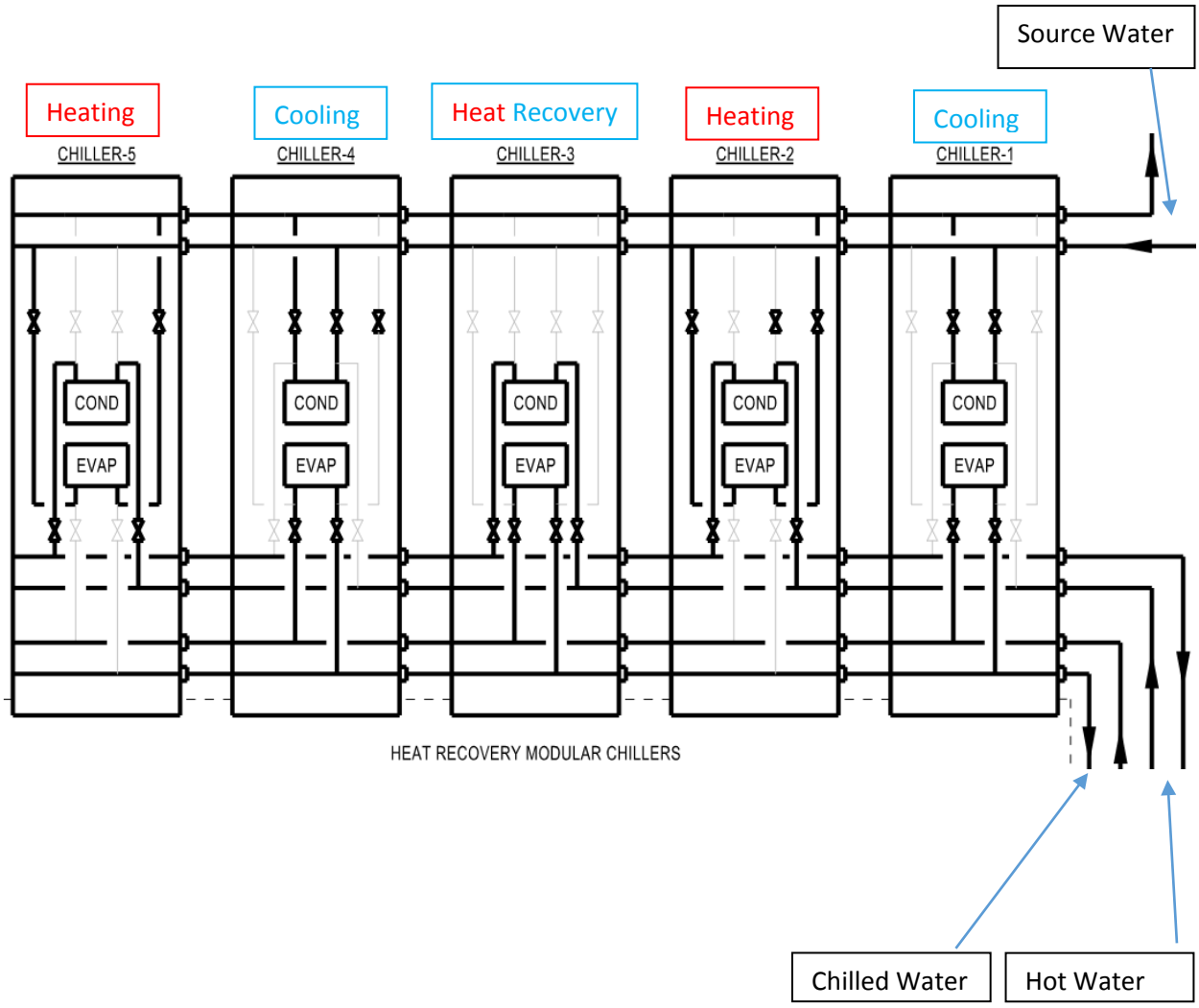


**Figure 2.7. Heat Recovery Chiller Piping Schematic Diagram**

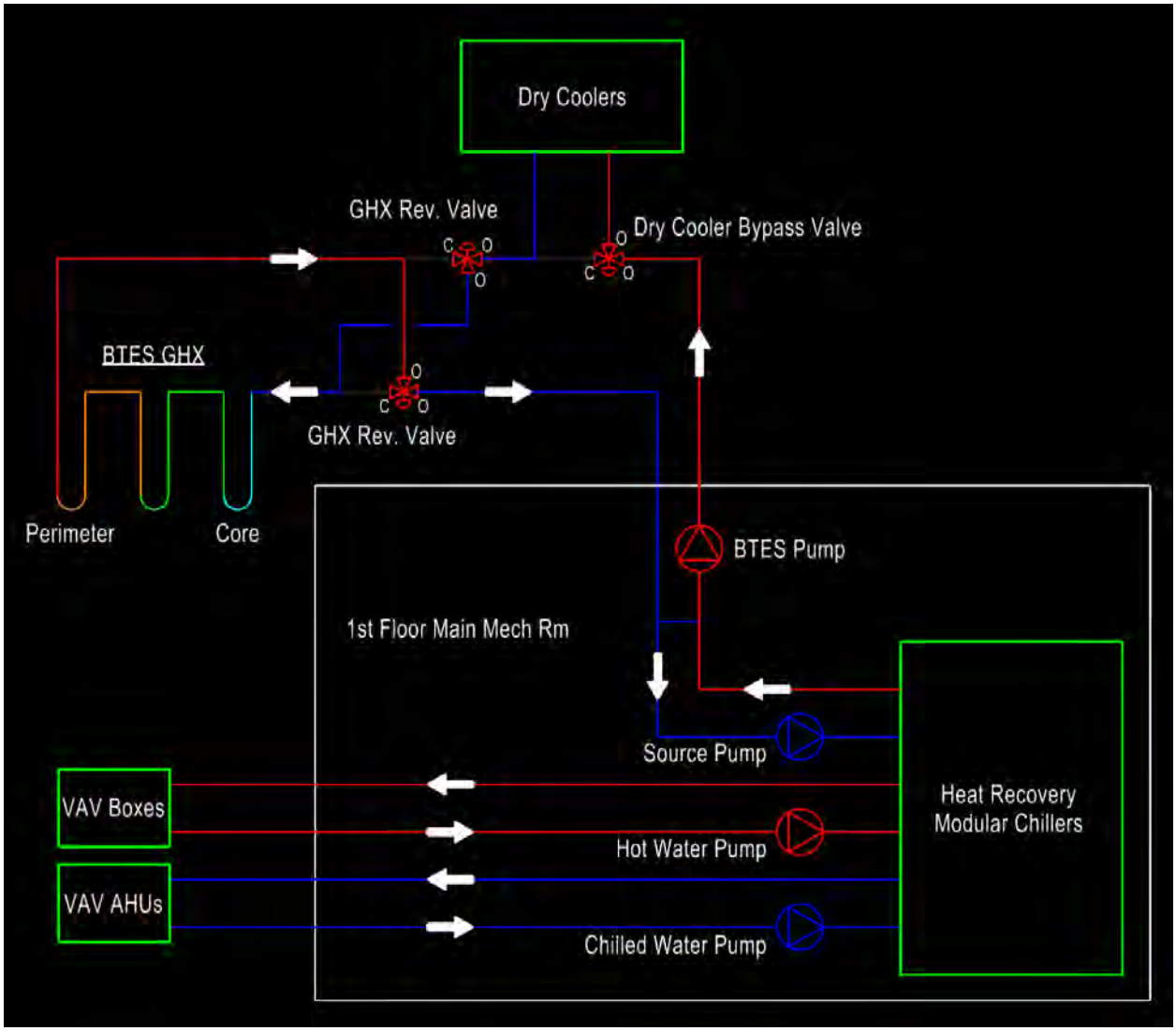


**Figure 2.8. BTES Diagram**

- **Specific HVAC System Configuration Description (ATES):**

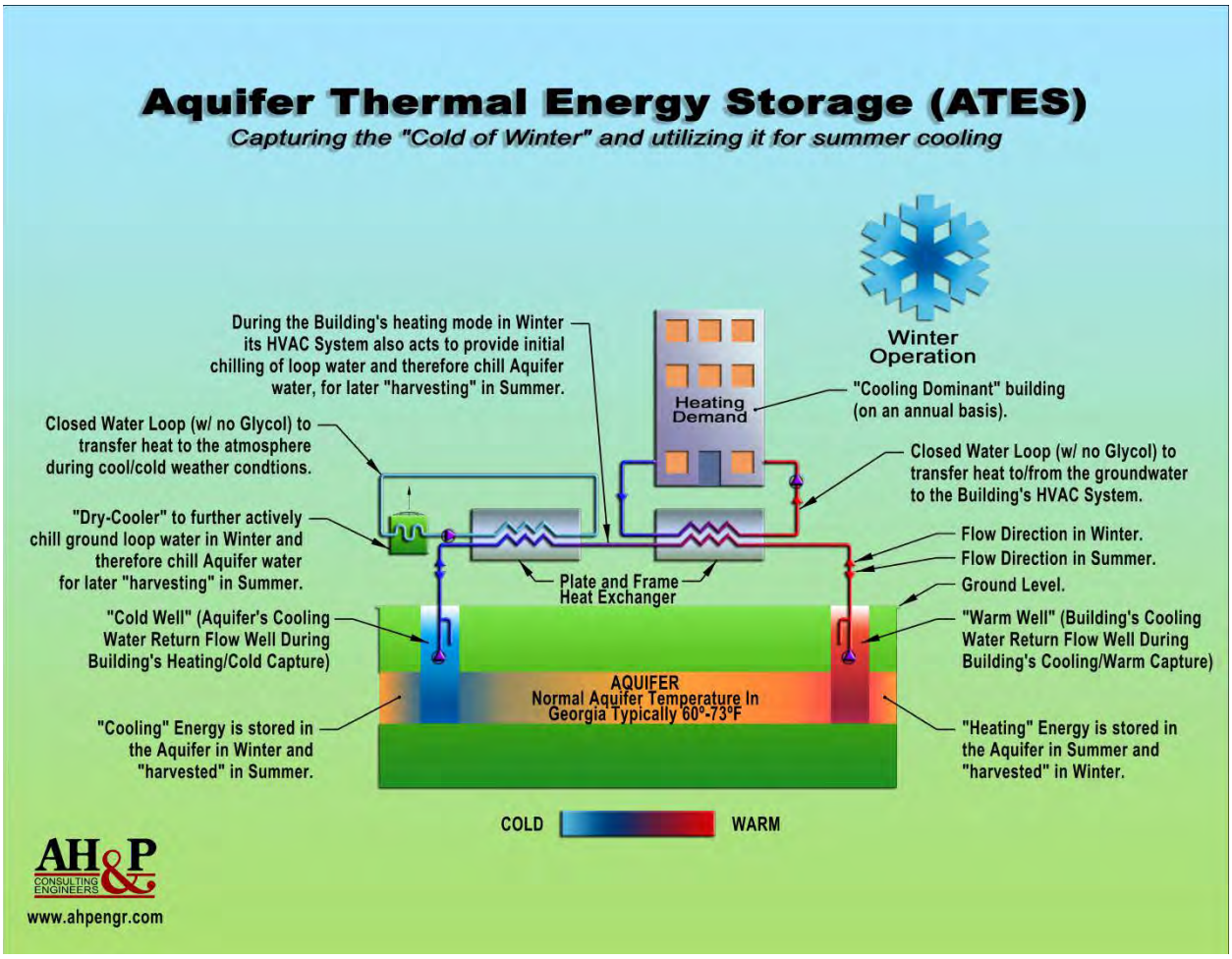


**Figure 2.9. Aquifer Thermal Energy Storage (ATES) Overview**

1. General

   The ATES GHP HVAC system is different than at BTES in that ATES is an open loop system. Ground water is pumped from one well and injected back into the opposite well. Cooling capacity is extracted from the cold well and used to remove heat from the building. The heat that is removed from the building during cooling mode is injected into the aquifer at the “warm well”. During heating mode, heat is removed from the warm well and added back to the building. Before being injected back into the cold well, the ATES water can be diverted through the dry cooler heat exchanger during times of cold outdoor air temperatures to reject additional heat. There are two fundamental difference in the ATES demonstration system from a traditional Ground Source Heat Pump Geothermal System.

a. The ATES system utilizes one dry cooler, *see Figure 2.12.* The dry cooler basically has two functions:
    i. To reject heat from the building anytime it can be rejected efficiently using just the ambient air. This allows the cooling dominated system to be balanced to keep the cold well cold over time.
    ii. To seasonally reject additional heat from the warm well any time it can be rejected efficiently (i.e. – winter) and therefore store additional cooling capacity in the cold well. \
b. The ATES bore field consists of 4 vertical wells. Two wells are dedicated as cold wells, and two wells are dedicated as warm wells. Each well is equipped with an intake screen, a submersible pump, and an injection valve. This allows bi-directional flow into and out of each well.

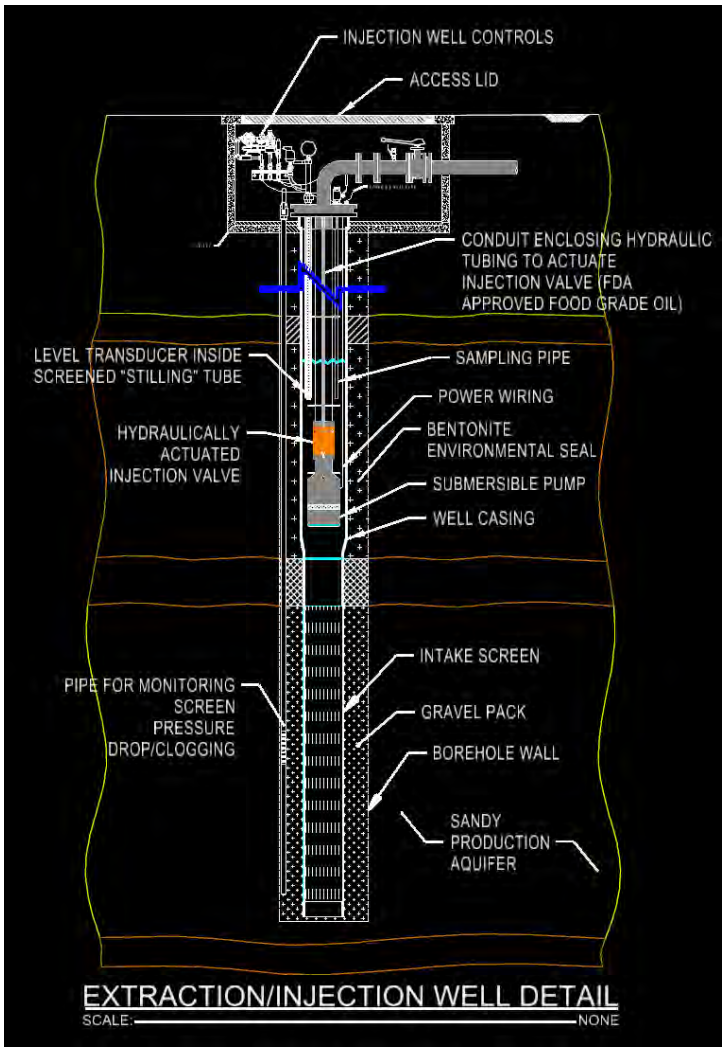


**Figure 2.10. ATES Well**

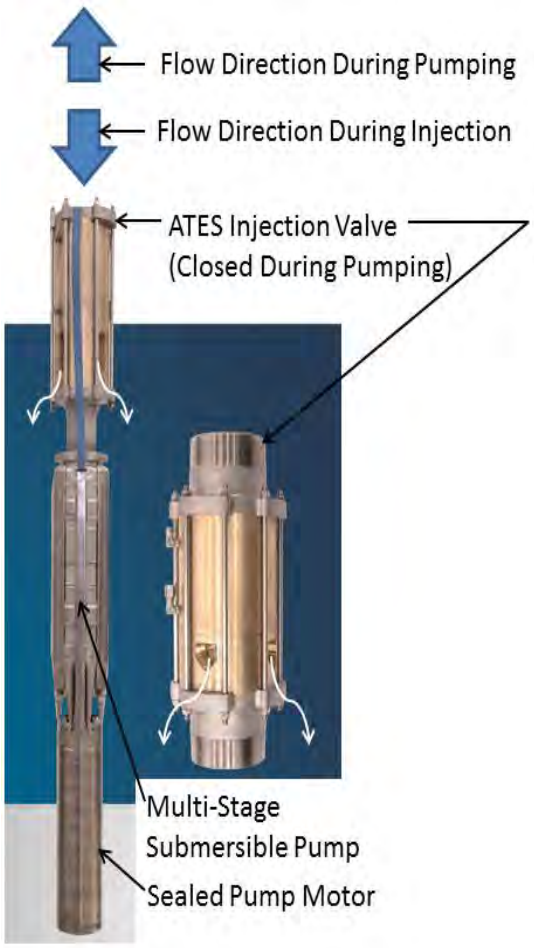


**Figure 2.11. ATES Injection Valve**



**Figure 2.12. Dry Cooler**

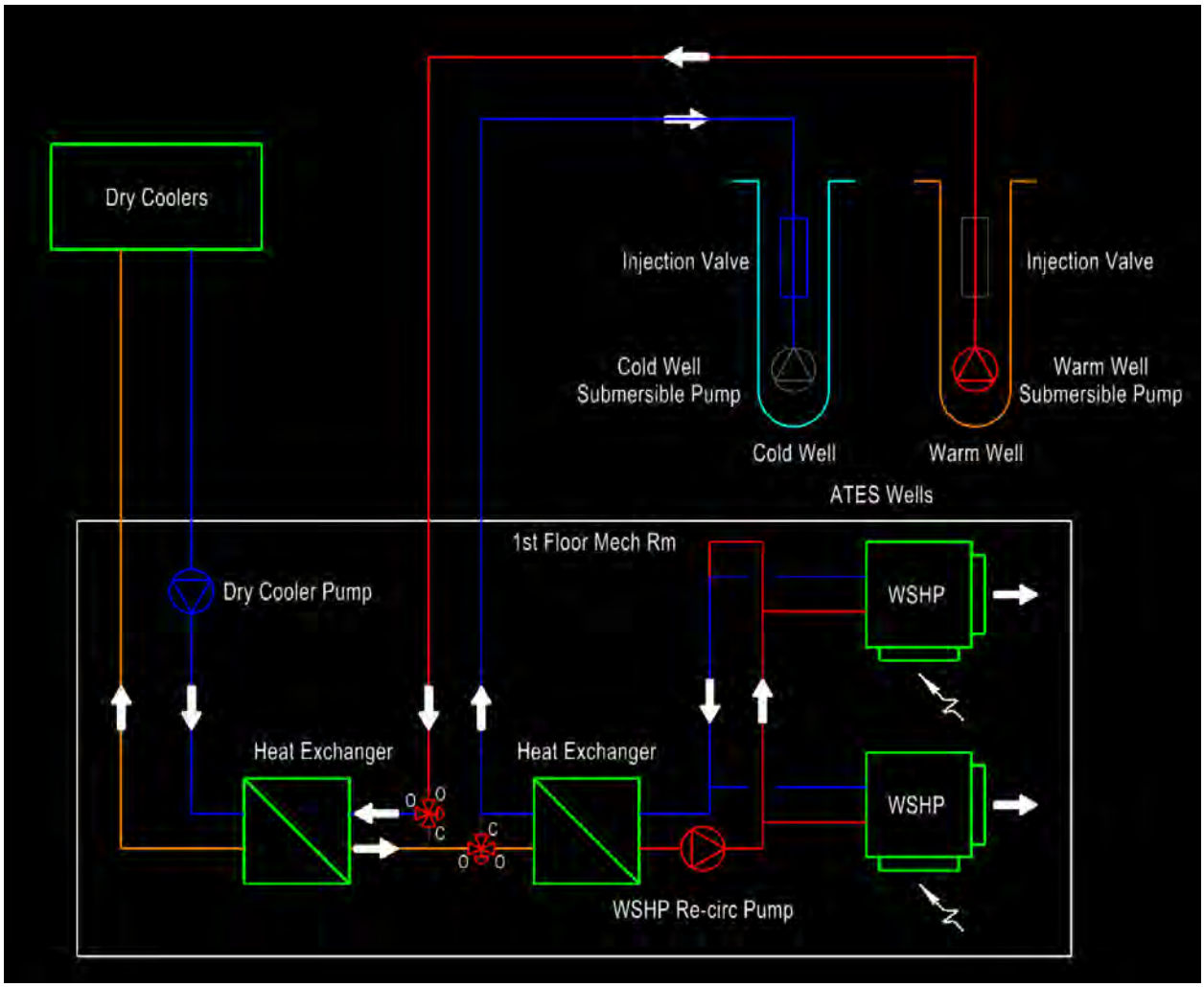


**Figure 2.13. ATES System Schematic**

2. Water Source Heat Pumps

   Heating and cooling of the space is achieved by utilizing seven water source heat pumps located in a central mechanical room. The sizes of the heat pumps range from approximately 3 tons to 6 tons for a total of approximately 30 tons.

3. ATES, Dry Cooler, and Loop Water Distribution System

   a. ATES System

      As stated above, the ATES system consists of a warm well and a cold well. In cooling mode, cool water is pumped via a submersible well pump from the cold well and is directed to the loop water plate and frame heat exchanger (HX-1). The cool water extracts heat from the loop water as it passes through the heat exchanger, and is then routed to the warm well. The water is then injected into the warm well aquifer via an injection valve located above the submersible pump in the warm well. In heating mode, warm water is pumped from the warm well and is then directed to HX-1. The ATES loop rejects heat to the building loop as it passes through the heat exchanger.

After leaving the heat exchanger, the ATES water then has the option of either flowing through the dry cooler or flowing directly into the cold well. If the difference between outside air temperature and ATES water temperature is great enough, then additional heat can efficiently be dumped to the air, in this case the ATES water would be directed to the dry cooler. After leaving the dry cooler, the cold water is then injected directly into the aquifer via an injection valve located directly above the submersible pump.

b. Dry Cooler

The dry cooler installed for the ATES project is similar to the two dry coolers installed for the BTES project, except that the ATES system dry cooler does not have an adiabatic cooling option. The dry cooler however does have the ability to utilize the Low Capacity Motor Management (LCMM) to reduce fan speed and stage fans to maintain tight control of the discharge water temperature set point. Water is pumped from the dry cooler plate and frame heat exchanger (HX-2) by two inline centrifugal pumps (lead/standby) located in the mechanical room into the inlet of the dry cooler. The ECM fan motors modulate their speed and stage their fans to cool the water to the desired set point. After the water leaves the cooling tower it is directed back to HX-2 where it removes heat from the ATES water and the cycle restarts.

c. Loop Water System

The loop water is cooled and heated by flowing through HX-1. HX-1 is adding or removing heat depending on whether water from the warm well or cold well is flowing through the opposite side of HX-2. Each individual water source heat pump contains an internal variable speed water pump that pumps the required amount of water from the loop through the heat pumps internal coaxial heat exchanger. The speed of the pump is controlled to maintain a pre-set $\Delta T$ between entering and leaving loop water. Each pump contains an internal check valve to eliminate the possibility of one pump pumping water through the inactive heat pumps.

### 2.1.2 Chronological Summary:

The basic heat pump (reverse Carnot cycle) at the heart of each GHP is approximately 100 years old. GHPs themselves have been in use in this country for over 50 years. Yet, due to obscurity and other issues, GHPs have only achieved 1.5-2.5% market penetration in the U.S., while in portions of other countries have achieved a 10-fold or more market penetration of this remarkable technology. USTES has been very successful in the Netherlands, having been implemented in over 1000 projects. Ironically, though we consider America to be the most advanced country in the World, USTES is virtually nonexistent with perhaps two or three partial systems in place in the entire U.S. To supplement the in-house knowledge of conventional and hybrid GHP systems, a team was assembled to accomplish this project. It included the Dutch firm “IF Technology”, the world’s leading Engineering and Consultancy firm on USTES systems due to their successes in their home country. While GHPs coupled with USTES is new to DoD, globally speaking, it is not new from an equipment or engineering perspective. We found virtually all the components needed to deploy this technology on both of these projects were already manufactured in North America. With the exception of the proper control algorithms AH&P developed, all aspects of the systems were available.

The major hardware that was needed to implement the BTES and ATES system was pre-existing in the marketplace and was readily available for commercial deployment.

### 2.1.3 Expected Applications:

GHPs with USTES are a broad description of an HVAC system that comes in many arrangements making it very flexible for wide deployment within DoD. Specifically, and as illustrated by these projects use of "small" (30 ton), "large" (325+ tons), open loop (ATES), closed loop (BTES), water-to-air, water-to-water, DX, constant air volume, VAV, and chilled/hot water system sub-types, it is obvious that GHPs with USTES can be deployed in a wide variety of configurations. There are few buildings and/or sites within the DoD domain that cannot utilize GHPs with USTES as one of its various HVAC architectures. From conventional deployments of heating/cooling buildings or domestic water/process loads to unique deployments like runway snow-melt or even heat-pump-less systems that only embrace the USTES portion of this project to store other waste heat sources, solar-thermal, etc., the application of these core technologies is significant within DoD.

- **A unique and truly RENEWABLE HVAC system:** GHPs coupled with USTES can harvest either the cold of winter's air or the heat of summer's air and store it in the underground formation. Depending upon the building's dominant HVAC need, the stored energy can be used by the HVAC system when the facility's dominant HVAC load occurs to increase energy efficiency and reduce energy consumption. When a building has an annual HVAC load profile that indicates it needs much more HVAC cooling energy than heating energy, it is considered to be "cooling dominant". When a building has an annual HVAC load profile that indicates it needs much more heating energy than cooling energy, it is considered to be "heating dominant". On rare occasions, (typically residential buildings in mild climates), the building's annual HVAC load profile is considered balanced and conventional GHP systems work at their best, not generally needing the added benefits of USTES. Unfortunately, commercial/industrial/institutional buildings, like those that dominate the DoD inventory rarely have balanced annual HVAC load profiles. Commercial buildings, with their higher-than-residential occupant density ($ft^2$/person), computers, higher lighting/equipment levels, etc., tend to be cooling dominant on an annual basis in all but the coldest climates. In cooling dominant buildings, it is desirable to harvest the available (and annually renewable) cold of the winter air and store this cooling energy in the underground formation and/or aquifer for later use during the cooling season. The inherent cooling of the GHP water loop as the GHP's extract heat from the loop during winter operations for building heating purposes is also harvested. Buildings whose HVAC system's load profile indicate that they are cooling dominant now have an underground summer time source of that cooling energy to utilize to maximize the efficiency of the GHPs and transfer the stored cooling energy into the building where it is needed. Similarly, harvesting the heat of the summer air to supplement the heat of rejection the GHPs during the cooling mode, and storing this annually renewable heat in the underground formation/aquifer allows this heat to be used in the heating season in buildings whose annual HVAC load profile indicates they are heating dominant.

- **A Highly Energy Efficient System:** GHP systems, when properly engineered, have been known for decades in this country and around the world as being one of the most energy efficient HVAC technologies that exist. Coupling GHPs with USTES concepts, equipment, controls & sequence-of-operation, allows this already efficient technology to be even more efficient. In cooling dominant buildings, this is achieved by lowering the overall annual temperature of the "heat sink" that is necessary for the operation of all Reverse Carnot Cycle systems (air conditioners/heat pumps). In heating dominant buildings, this is achieved by raising the overall annual temperature of the "heat source" that is necessary for the operation of all Reverse Carnot Cycle systems. The bottom line is that USTES significantly improves the Coefficient of Performance (COP) of GHP systems. While not the focus of this project, in certain climates/load profiles/geological conditions, it is possible to chill the loop water to a sufficiently lower temperature in winter to a point where this chilled water can be stored in the subterranean aquifer and utilized to directly cool the building without the use of compressors. This results in equivalent COPs of 20-40, versus COPs or 3-5 for conventional (reverse Carnot cycle) chillers/heat pumps.

## 2.2 TECHNOLOGY DEVELOPMENT

USTES systems are intended to maximize the energy savings of GHP systems Not only does an USTES system allow the waste heat of cooling systems and waste "cool" of heating systems to be captured, but it also allows for the out-of-season energy capture of the winter's "cold" or summer's "heat" in a cooling dominated or heating dominated buildings, respectively.

### 2.2.1 BTES

While there are operational BTES systems around the world, the BTES system demonstrated for this project is the first one of this configuration type and operation in the U.S. As known very well in the geothermal community, the size (i.e. total length of underground vertical piping) of a geothermal system heavily influences the installation cost. Greater energy savings can be achieved by installing a larger GHX, but the capital cost will also increase. . Two of the demonstration goals for this project were to increase energy savings over a conventional closed-loop system, and to achieve those energy savings at a lower cost than a conventional closed-loop geothermal system.

The size of any engineered GHX is a function of many parameters, such as a building's heating/cooling coil loads, the formation thermal conductivity (TC), thermal diffusivity and deep-earth temperature. Once these parameters are known, the grout TC and maximum/ minimum loop water temperatures are then selected. The optimum borehole spacing and overall bore field geometry is then determined. These variables, utilized in conjunction with the cooling/heating peak loads (kW or BTU/hr) and cooling/heating annual cumulative loads (kWh/yr. or BTUs), are used by most GHX modeling software programs to calculate the primary parameter of total length of vertical borehole piping needed.

The initial step in the design of the BTES GHX was to complete an energy model of B3700 at MCLB-Albany, GA to determine peak cooling/heating coil loads and annual cumulative cooling/heating coil loads. The energy model was also utilized to simulate B3700's existing energy consumption. The eQuest software program (www.doe2.com/equest/, 2016) was utilized for calculating the heating/cooling loads, which was exported into TRNSYS (www.trnsys.com).

**Table 2.1. MCLB-B3700 Heating & Cooling Loads**

| | Cooling | | Heating | |
|---|---|---|---|---|
| **Annual Cumulative** | **8,623,471,227** | | **789,593,520** | ***Btus*** |
| **Cooling-to-Heating** | **10.92** | **to** | **1.0** | ***Ratio*** |
| **Peak** | **3,734,820** | | **1,971,740** | ***Btu/hr*** |
| **Peak** | **311** | | **164** | ***Tons*** |

This total borehole length can be a wide combination of quantity and depth to achieve this total length. In a standard GHX design, a designer would normally maximize the depth they believed the driller could achieve without encountering drilling or u-bend installation issues. Typical depths range from 200' to 400', although depths might be as shallow as 150' or as deep as 600'. This would minimize the number of boreholes needed and therefore minimize the land area and rig mobilization/set-ups needed. Within reason and certain parameters, it is often desirable to maximize the number of boreholes with BTES system as it increases the quantity of interior boreholes, which are more useful for storage than perimeter boreholes. The aspect ratio (width-to-height) of the GHX is also important. If practical, with conventional GHX design you would want to maximize the ratio of the overall GHX surface area to the overall volume, whereas with heat storage in a BTES you would want to minimize this ratio. For cylindrical GHX designs, German designers generally recommend a GHX diameter slightly less than its depth below grade (VDI-4640, 2006).

Several factors affected the design of the BTES GHX. To effectively design thermal zones and radial stratification into the GHX, it was determined at least three boreholes piped in series would be required. Initial performance simulations began with five thermal zones (i.e. five boreholes in series) with a depth of 200 feet. The boreholes were also arranged in what has alternately been described as a hexagonal, equilateral triangle or diamond shaped pattern. This is unlike normal U.S. GHX configurations of an orthogonal grid of boreholes laid out in a square or rectangular configuration. This configuration is used to provide optimum equal spacing between each borehole and its adjacent neighbor. It is also done to provide a more compact GHX with its overlying surface area 25% smaller than a rectangular patterned GHX (VDI-4640, 2006).

The depth of 200 feet was chosen to minimize the BTES GHX pressure drop as the piping would be in series in lieu of parallel, as conventional GHX designs typically are. Given the series borehole design, careful consideration was given to pumping energy consumption to ensure the BTES GHX design would not maximize HVAC equipment compressor energy savings at the cost of increasing pumping power and energy consumption.

Borehole spacing was also considered in the BTES GHX design. Tighter/closer spacing was preferred, which was initially modeled in the performance simulations. However, after discussing the drilling conditions of the installation process with credible drillers, it was determined a spacing of no less than 20 feet would be utilized. The 20-foot spacing would allow sufficient spacing for the driller during the installation process, while minimizing the impact of using a less compact design.

It is not atypical to incorporate a heat rejection (or heat injection) device with a GHX system. Generally, a GHX coupled with an auxiliary heat rejection/injection device is referred to as a hybrid geothermal system, which are not uncommon. A GHX coupled to a building with a higher cooling load than heating load will typically utilize an evaporative cooling tower as a peak load "shaving" device. In other words, the cooling tower will be used to reject some, if not all, of the cooling load from a building when GHX supply water (i.e. leaving water) temperatures are elevated. The reverse of this would be the use of a boiler when a building has a higher heating load than cooling load. While evaporative cooling towers can be a cost-effective option for a geothermal system, they can be very maintenance intensive if not properly taken care of. It is also not unusual for a GHX to be slightly undersized when used in a hybrid geothermal application since the thought process is the auxiliary device will be available to handle the remaining load not designed into the GHX. If the cooling tower is not maintained, the GHX will be exposed to additional load it was not designed to handle, which can lead to a heat saturated GHX.

Due to the load imbalance of B3700, a heat rejection device was always going to be incorporated to reject enough heat to balance the load on the BTES GHX. However, to provide the cold storage aspect, the heat rejection device must reject enough heat to balance the load on the GHX *and* reject enough heat to provide cold storage BTUs to the GHX. Since water consumption reduction was a performance objective for this demonstration, an adiabatic dry cooler was chosen as the heat rejection device. An adiabatic dry cooler rejects heat without having to evaporate water. However, the dry coolers were equipped with an adiabatic function to increase heat rejection capacity, if needed, but not to exceed the water use performance objective stated for this demonstration. When operating in dry mode, the heat rejection capacity is a function of the coil design, entering air dry-bulb temperature, entering water temperature, GPM and airflow. Entering water temperature minus entering air dry-bulb temperature is defined as "spread". For heat rejection purposes, spread must be a positive number. For this demonstration, various performance selections were completed to better understand how a dry cooler would perform under different operating conditions.

**Table 2.2. Dry Cooler Performance at 100% fan and pump speed**

| Heat Rejection (MBH) | EWT (°F) | LWT (°F) | EAT (°F) | Spread (°F) | % of Spread Achieved | Pump Speed (%) | Fan Speed (%) |
|---|---|---|---|---|---|---|---|
| 503.5 | 90.0 | 61.4 | 50.0 | 40.0 | 71.5 | 100 | 100 |
| 376.7 | 90.0 | 68.6 | 60.0 | 30.0 | 71.3 | 100 | 100 |
| 251.7 | 60.0 | 45.7 | 40.0 | 20.0 | 72.0 | 100 | 100 |
| 126.8 | 60.0 | 52.8 | 50.0 | 10.0 | 71.5 | 100 | 100 |

The performance selections illustrate the % of spread stays approximately the same for a given pump and fan speed. Since the spread changes, the water-side ΔT changes, but the ability of the dry cooler to achieve the same % of spread does not. Percent of spread in this case is defined as the spread divided by the achieved water-side ΔT (i.e. entering water minus leaving water temperature).

Another aspect of the dry cooler design is the fan energy consumption. Similar to pumping energy and how the BTES GHX is designed with minimizing pumping energy in mind, the use of a dry cooler to provide cold storage capabilities cannot be provided at a cost of high fan energy consumption. Therefore, over-sized dry coolers are utilized so the fan speeds can operate at 50% or less and the design can take advantage of the fan law where brake horsepower follows the cube of the quotient between two airflows.

$$hp_2 = \left(\frac{CFM_2}{CFM_1}\right)^3 x\ hp_1$$

**Figure 2.14. Fan Affinity Law #3**

This allows for the dry cooler to have enough heat rejection capacity while achieving a higher coefficient of performance (COP).

$$COP = \frac{Output}{Input} = \frac{Capacity\ (kW)}{Consumption\ (kW)}$$

**Figure 2.15. Coefficient of Performance**

Analysis of the dry cooler performance against various fan and pump speeds were completed so the required performance could be estimated based on the design heat rejection required.

**Table 2.3. Tower Capacity versus Fan Speed and Pump Speed**

**Dry Cooler Capacity (%)**

| | | Pump Speed (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Fan Speed (%) | 10 | 13.2 | 14.1 | 14.3 | 14.5 | 14.5 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 |
| | 20 | 20.9 | 24.9 | 26.2 | 26.8 | 27.1 | 27.4 | 27.5 | 27.7 | 27.7 | 27.8 |
| | 30 | 25.5 | 32.8 | 35.7 | 37.1 | 38.0 | 38.6 | 39.0 | 39.3 | 39.5 | 39.7 |
| | 40 | 28.5 | 38.8 | 43.4 | 45.9 | 47.4 | 48.4 | 49.2 | 49.7 | 50.1 | 50.5 |
| | 50 | 30.4 | 43.5 | 49.8 | 53.4 | 55.7 | 57.2 | 58.3 | 59.2 | 59.8 | 60.4 |
| | 60 | 31.6 | 47.5 | 55.1 | 59.9 | 63.0 | 65.1 | 66.6 | 67.8 | 68.7 | 69.5 |
| | 70 | 32.5 | 50.7 | 59.6 | 65.6 | 69.5 | 72.2 | 74.2 | 75.7 | 76.9 | 77.9 |
| | 80 | 33.1 | 53.3 | 63.9 | 70.5 | 75.3 | 78.6 | 81.1 | 83.0 | 84.5 | 85.8 |
| | 90 | 33.6 | 55.5 | 67.7 | 74.9 | 80.5 | 84.5 | 87.5 | 89.8 | 91.6 | 93.1 |
| | 100 | 33.9 | 57.3 | 70.9 | 79.1 | 85.2 | 89.8 | 93.3 | 96.0 | 98.2 | 100.0 |

**Table 2.4. Tower COP versus Fan Speed and Pump Speed**

**Dry Cooler COP**

| | | Pump Speed (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Fan Speed (%) | 10 | 354.4 | 191.7 | 107.0 | 66.1 | 44.3 | 31.6 | 23.6 | 18.3 | 14.6 | 11.9 |
| | 20 | 185.9 | 166.9 | 124.9 | 91.1 | 67.3 | 51.1 | 39.7 | 31.6 | 25.7 | 21.2 |
| | 30 | 107.3 | 119.5 | 106.5 | 88.5 | 71.9 | 58.3 | 47.6 | 39.3 | 32.8 | 27.6 |
| | 40 | 68.8 | 86.1 | 85.0 | 77.1 | 67.3 | 57.9 | 49.4 | 42.3 | 36.3 | 31.3 |
| | 50 | 47.4 | 64.3 | 67.6 | 65.0 | 59.9 | 53.8 | 47.8 | 42.2 | 37.2 | 32.8 |
| | 60 | 34.5 | 49.8 | 54.4 | 54.6 | 52.2 | 48.6 | 44.5 | 40.4 | 36.5 | 32.9 |
| | 70 | 26.1 | 39.6 | 44.5 | 46.0 | 45.3 | 43.3 | 40.7 | 37.8 | 34.8 | 31.9 |
| | 80 | 20.4 | 32.2 | 37.2 | 39.1 | 39.4 | 38.5 | 36.9 | 34.9 | 32.7 | 30.4 |
| | 90 | 16.4 | 26.7 | 31.6 | 33.6 | 34.4 | 34.2 | 33.3 | 32.0 | 30.4 | 28.7 |
| | 100 | 13.4 | 22.4 | 27.1 | 29.2 | 30.3 | 30.5 | 30.1 | 29.2 | 28.1 | 26.9 |

The final aspect of the dry cooler design was engineering the design heat rejection capacity. The final dry cooler design was chosen following several iterations of the BTES GHX with the dry cooler performance incorporated into the performance simulations. It was determined the dry cooler would be sized such that the heat of rejection of the modular chillers operating at peak cooling conditions could be rejected when the dry cooler was operating in adiabatic mode. This design criteria led to the implementation of two dry coolers, which allowed for enough heat rejection for cold storage purposes and lets the building's HVAC system to operate should something occur at the BTES GHX (i.e. accidental cutting of buried header or sub-header piping). This also gave MCLB a level of comfort that the building could operate sufficiently if the BTES GHX performance was less than anticipated.

Finally, the BTES GHX design would also need to incorporate a way to allow for flow reversal. Since the demonstration project at this site utilized a cooling dominated building, space cooling energy storage would need to occur at the core. Flow reversibility thru the BTES GHX allows for cooling energy to be stored in the core when operating conditions are ideal and allows that energy to be extracted from the core when needed. Therefore two 3-way, 2-position control valves were installed in the BTES header piping after the dry coolers but before entering the GHX. Based on sequence of control parameters, the valves will position accordingly when operating conditions allow the dry cooler (via heat rejection when OA temperatures allow) or the building load (heating load > cooling load) to store cooling energy in the BTES GHX core. When cold storage cannot be performed, the control valves will position accordingly to allow the cold storage energy to be extracted. There are also times when the dry cooler can efficiently operate for heat rejection purposes but conditions do not allow for cold storage to occur. This is also acceptable as the dry cooler operation allows for efficient heat rejection and reduces the cooling energy extracted from the BTES GHX core. If conditions to not allow for the dry cooler to efficiently operate, the BTES water loop bypasses the dry cooler, via another 3-way, 2-position control valve to reduce un-desired pressure drop or heat transfer that may occur.

### 2.2.2 ATES

While there are numerous operational ATES systems around the world, the ATES system demonstrated for this project, is also the first system of this configuration type and operation in the U.S. Open loop geothermal systems are not uncommon for a geothermal heat pump application. However, open loop systems generally allow for one-way water flow. Water is extracted from a dedicated extraction well for both cooling and heating purposes, while injecting water into a dedicated injection well. An ATES system design allows for flow reversibility such that a cold well(s) and hot well(s) is/are intentionally created. Operating the building's HVAC system to utilize the appropriate ATES well increases the HVAC system's COP by supplying the equipment with closet to ideal water temperatures, which decrease the equipment's energy consumption.

The initial step in the design of the ATES system design was to complete an energy model of B3215 at Fort Benning, GA to determine peak cooling/heating coil loads and annual cumulative cooling/heating coil loads. The energy model was also utilized to simulate B3215's existing energy consumption. The eQuest software program (www.doe2.com/equest/, 2016) was utilized for calculating the heating/cooling loads, which was exported into TRNSYS (www.trnsys.com).

**Table 2.5. Fort Benning-B3215 Heating & Cooling Loads**

| | Cooling | | Heating | |
|---|---|---|---|---|
| **Annual Cumulative** | **618,864,023** | | **52,276,225** | ***Btus*** |
| **Cooling-to-Heating** | **11.84** | **to** | **1.0** | ***Ratio*** |
| **Peak** | **351,815** | | **152,752** | ***Btu/hr*** |
| **Peak** | **29.3** | | **12.73** | ***Tons*** |

With an open loop GHX the maximum water flow of the system is determined and the yield from the wells determined the number of wells that are needed to achieve the desired maximum flow. In particular, with open loop ATES systems not only is there a concern with the water yield from the extraction well, but there is also a concern with the rate at which water can be injected into the injection well without the water mounding to the surface.

To determine if the hydrogeology at Ft Benning could be utilized to an ATES system the company IF Technology was hired as a consultant. IF Tech is a leading geothermal energy consultancy and engineering firm based in Arnhem in the Netherlands. Their firm contains experienced geologists, hydro-geologists, civil and mechanical engineers. IF Technology has special expertise in ATES, BTES, Deep Geothermal Energy Systems, High Temperature Storage, and Well Engineering. IF Tech developed the initial Hydrogeological evaluation for Ft. Benning. The main conclusion from the evaluation was that the ATES system could be applied for the heating and cooling of building 3215 at Ft Benning. See the Appendix to view the Hydrogeological Assessment Report.

After the Hydrogeological Assessment Report was issued IF Tech prepared a Test Well Drilling Program for the ATES site. This program described how to perform the investigation to determine the characteristics of the aquifer at Ft. Benning. The Test Well Drilling Program explained general drilling techniques, it recommended clean pumping the observation wells, and it explained how to perform measurements and analysis of the clean water from the wells. Organization and planning for the well drilling procedures was also included in the drilling program. See the Appendix to view the Test Well Drilling Program for the ATES site.

After drilling of the ATES test wells, development of the ATES test wells was performed per instructions from IF Tech. The methods for developing the wells was to first air surge the wells using compressed air to push a thinning fluid through a well screen. This method breaks apart the filter cake around the well screen and gravel pack. The next step was to extract water from the wells using a technique called airlifting. Airlifting allows pumping of water from a well after drilling without damaging a submersible pump due to sand or clay entrained in the water. Airlifting was performed on the test wells first by pumping through specific sections of the well screen. This was accomplished by using rubber "packers" on the airlifting pipe to seal the pipe to the screen section. After sectional pumping, the wells were air lifted without using the packers until they ran clear water. After the airlifting was performed, the wells were over pumped using a submersible pump connected to a timer to over pump the wells for a period of time and then allow it to recover for a set period of time. See Appendix F for a complete well development log. After these procedures were performed, the wells ran clear and were ready to perform the sand test specified by IF Tech.

After fully developing the wells, a pumping test was performed on the test boreholes to fully investigate the opportunities for an ATES system at the site. During the pumping test, ground water was extracted for a period of three days. The hydraulic head was monitored inside the well and in surrounding monitoring wells. All this data was sent to IF Tech to be analyzed. IF Tech then issued a pump test report, and the results of the report was that the site contained relatively low hydraulic conductivity. This resulted in the decision to drill a total of four production wells (two warm and two cold) with extended screens for this demonstration project.

As known very well in the geothermal community, the quantity and the depth of water wells for geothermal systems heavily influences the installation cost. The need to drill four wells instead of two well for the ATES project did increase capital cost, but also allows for higher flow rates and therefore the ability to store more energy seasonally using the dry cooler if needed. Storing more energy can increase energy efficiency since it gives the ability to make the ground water cooler and cooler each year for this cooling dominated system.

To seasonally store energy in the cold well and to remove additional heat from the warm well, it was decided to utilize a dry cooler for the ATES project very similar to the dry cooler described for the BTES system previously in this report. Since the native ground water temperature at Ft Benning is approximately 68-70° it was decided that there was no need for the dry coolers to include the adiabatic option. Design calculations and performance considerations for the ATES dry cooler was the same for two dry coolers located on the BTES project.

To heat and cool the building, typical ground source heat pumps were utilized in place of the existing chilled/hot water multizone AHU. The original multizone AHU had a total of seven zones.

Each zone was replaced with a dedicated water source heat pump. The WSHP's are energy efficient and relatively easy to maintain.

## 2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

GHPs with USTES offer a variety of cost and performance advantages and feature very few performance limitations due to their inherently efficient nature. Advantages and limitations of the technology are discussed in the following sections.

### 2.3.1 Performance and Cost Advantages:

The benefits of this technology are numerous and includes the ability to enhance already highly efficient GHP technology to achieve a lower first cost. Additional benefits of the technology are: higher efficiencies, renewable HVAC, smaller carbon footprint, lower energy consumption, and elimination of on-site fossil fuel consumption. All this is done while still achieving the important goals of maintainability, system longevity and minimized Life Cycle Cost (LCC). Furthermore, with GHP's inherent environmentally benign-nature and our team's partnering with the non-profit American Ground Water Trust for regulatory/environmental support and the Technical & Environmental Guidelines, which will be issued at the project's conclusion, will insure the highest level of environmental success. Unlike other green technologies like wind or PV, we fully expect some type of GHP-USTES to be deployable at over 80% of DoD facilities in the U.S. and abroad. We expect GHP-USTES to be LCC effective at most DoD facilities with a payback of less than 15 years. The recently constructed BTES system has a payback of approximately 10.6 years, and the ATES system is projected to have a very similar payback. The underground GHX utilized in BTES has no moving parts, an indefinite life and when properly viewed as the sustainable infrastructure (and therefore amortized over its life cycle like other infrastructure investments such as power-lines, pipelines, etc.), its true impact on actual building first cost is minimal. In terms of expected aggregate benefit to DoD, it is expected that GHPs with USTES will provide a benefit of an average of at least 30% less energy consumption than conventional HVAC systems. This value multiplied by at least 60% of the heated and cooled DoD facility inventory could result in significant national energy and cost savings if fully deployed.

### 2.3.2 Performance and Cost Limitations:

GHPs, even without the enhancement of USTES are generally viewed as one of the most, if not the most, efficient architectures to use for a HVAC system. Therefore, their limitations are not really performance related but rather first cost related and lack-of-knowledge related. Of the two USTES architectures that are being demonstrated, BTES, with its closed loop design (no groundwater is physically removed from the ground) has the least environmental impacts. The conventional closed loop GHP system already enjoys implementation in all 50 states. As long as the borehole is fully grouted from top to bottom, it is environmentally acceptable everywhere and does not depend on the presence of a large aquifer. Generally, as long as the horizontal movement of the groundwater stays below 3 to 11 centimeters per day (1.2 to 4.3 inches per day or 36.5 to 130 feet per year), BTES can be installed. Economic considerations are primarily related to the local drilling cost and type of formation (rock, sand, etc.), thermal conductivity, economics of scale (tonnage), land availability and thermal balance (heating vs. cooling loads) of the building.

Facilities and personnel that are pre-existing users of conventional GHP systems, and those who are motivated to meet renewable and other green goals/mandates, will obviously be more likely to transition into the enhanced form of a GHP system. ATES systems, with their open loop design are more complicated (at least from an evaluation and engineering perspective) but have the benefit of potentially lower first cost and lower operating cost. Figure 2.16, a color coded "ATES Feasibility Map" that our Dutch consultant, IF Tech, has generated for the entire U.S., is shown to provide just a rough initial guideline as to where ATES might successfully be deployed. However, a local hydrological investigation is needed before any ATES site is ruled "in" or "out".. Please note that with both of the current demonstration sites located south of the Fall Line (generally the dark green/light green NE-SW border/line through the middle of Georgia), they both have a high probability of ATES feasibility based on this high-level overview. The feasibility map is an excellent tool to give a broad overview of the U.S.'s geographical potential for ATES. All the "brownish" areas on the map are generally still suitable for BTES, as BTES is not dependent on a presence of a substantial aquifer for its operation.

- Having an un-desirable aquifer for the project is viewed as a performance limitation. Aquifers can generally be classified as either containing oxygen (oxic or aerobic) or without oxygen (anoxic or anaerobic). Oxygenated aquifers tend to be near the surface of the earth (so-called surficial aquifer) and due to issues like fertilizer run-off, may also contain nitrogen and other undesirable contaminates. While either type of aquifer can potentially be utilized, anoxic aquifers are preferred, as the water remains anoxic and potential biological or mineral precipitate issues are minimized. Intra-aquifer transfers of water are also not preferred due to environmental considerations and other issues. The ATES demonstration project remained in the same aquifer with our extraction and injection wells. Overall, an aquifer that has an upper and lower confining layer (typically made of clay on top and sometimes rock on the bottom), is generally considered the optimum aquifer for an ATES project. This project utilized an aquifer free from surface contaminants with an upper confining layer, generally insuring it will be anoxic.
- ATES injection permits are required for some states by the EPD to inject water into the aquifer, regardless if the injected water was recently removed from the same aquifer. Obtaining the required injection permits can prove to be very time consuming.
- To insure a high level of performance in deploying both types of USTES at any facility, beyond some of the geologic and aquifer considerations previously mentioned, we believe the key to successful deployments will have in common: on-site test boreholes drilled with detailed drilling logs of the geology analyzed/recorded, (in-situ) thermal conductivity (BTES) test or water flow pumping test (ATES) being accomplished, adequate GHP-USTES design guidelines being developed, an accurate hour-by-hour energy analysis of the building's thermal loads being completed, proper computer modeling of the GHX/BTES or the ATES being accomplished, and thorough, high-quality designs, plans and specifications being provided to the installing contractor and their drillers. In terms of economic considerations, while BTES systems will generally be appropriate almost anywhere conventional closed loop GHP systems are installed, ATES systems will not be economical unless there is an adequate aquifer on site. Figure 2.16 is a good starting point to understand where adequate aquifers exist, but previous or new test wells will generally be necessary to determine the actual adequacy of each specific site when ATES systems are being contemplated.

Overall, DoD clients that are seeking the absolute lowest first cost will not deploy GHP systems with USTES, but those seeking to comply with all the energy mandates and those seeking true energy security for their installation will carefully consider these system types.

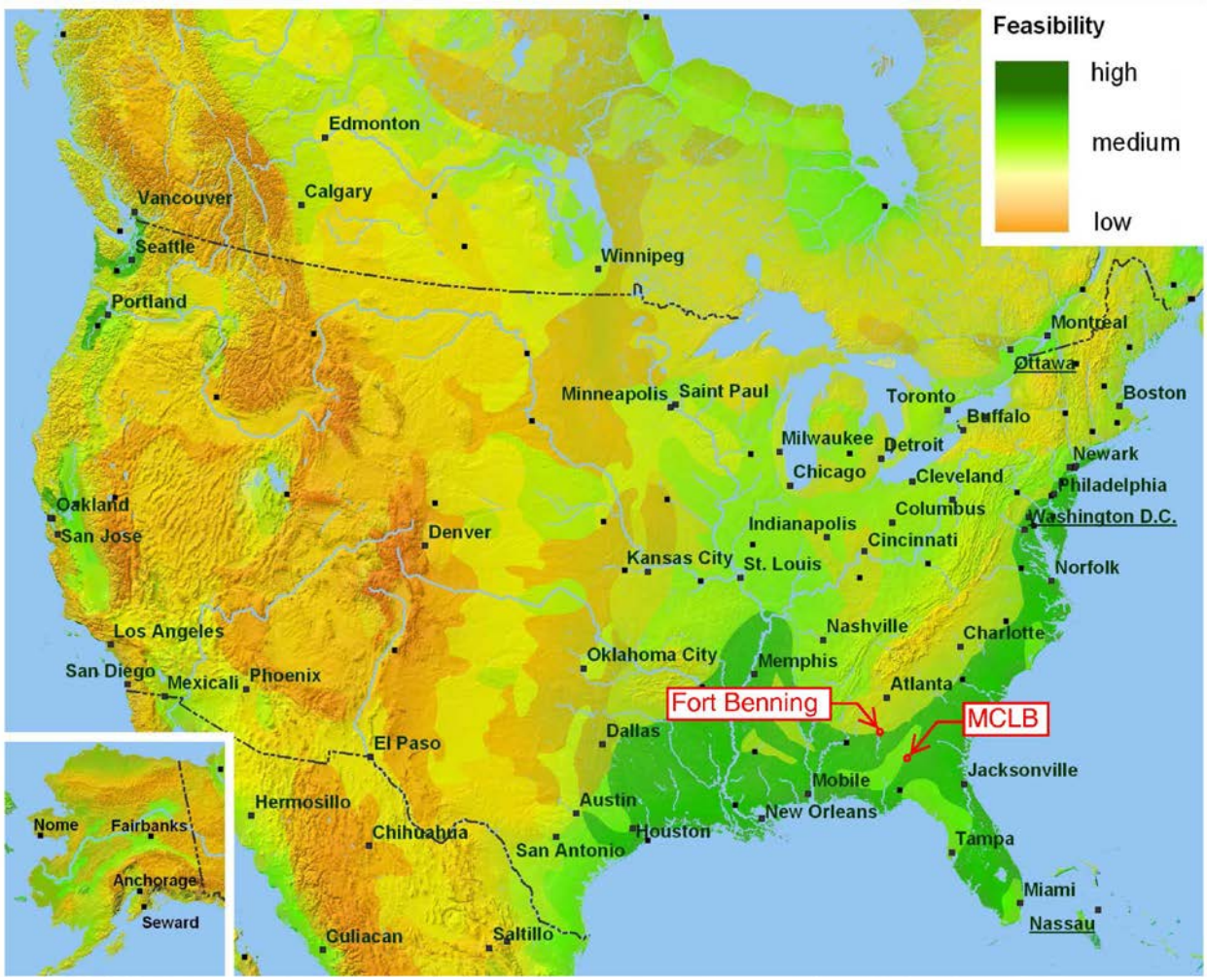


**Figure 2.16. North America ATES Feasibility Map (Courtesy of IF Technology)**

### 2.3.3 Social Acceptance:

The primary barrier to acceptance will be fear of the unknown as these systems are not yet broadly utilized across DoD. Nevertheless, it seems that the successful, though limited, deployments of conventional GHPs at both installations involved with this project has resulted in their acceptance, and even championing of this technology. Once all parties involved understand that a BTES system is primarily a simple, all-welded HDPE, underground heat exchanger, their concerns tend to go away. The BTES GXP also has a nearly infinite life with no moving parts. ATES with its submersible pumps sometime creates questions, but if there are already domestic water wells on the installation, this tends to be less of a concern. Fort Benning personnel have observed the hydrological investigations being performed, and this tends to increase their confidence that the deployment is being accomplished in a thoughtful and studied manner that enhances its chance for long-term success.

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# 3.0 PERFORMANCE OBJECTIVES

The technology and economic Performance Objectives (PO) are summarized Table 3.1. Descriptions of how each PO was measured and how each was determined to be successful is also included.

Table 3.1 summarizes actual results for the BTES project. Due to construction scheduling and permitting issues for the recently constructed ATES system, there is currently insufficient demonstration data to compare to the baseline data for the ATES system. The results of the ATES system are based on computer modeling of the demonstration.

**Table 3.1. Summary of Performance Objectives**

| Performance Objective | Metric | Data Requirements | Success Criteria | Results |
|---|---|---|---|---|
| **Quantitative Performance Objectives** | | | | |
| Facility GHP-USTES HVAC Energy Usage vs. Conventional HVAC | Energy Intensity (MMBtu/ft$^2$ or kWh/ft$^2$) | Actual metered readings of HVAC energy used by installation (baseline and demonstration); square footage of the buildings using energy | 30% Reduction compared to baseline | BTES: 47.5% Reduction<br><br>ATES: 52.7% Reduction (Modeled) |
| Facility GHP-USTES HVAC Energy Usage vs. Conventional GHP HVAC | Energy Intensity (MMBtu/ft$^2$ or kWh/ft$^2$) | Actual metered readings of demonstrated HVAC energy used by installation versus modeled conventional GHP HVAC; square footage of the buildings using energy | 10% Reduction compared to Conventional GHP HVAC | BTES: 15.1% Reduction<br><br>ATES: 13.8% Reduction (Modeled) |
| Water Usage by On-Site Conventional Cooling Tower | Water (Gallons) | Actual metered readings of water used by installation (baseline and demonstration) | 80-100% Reduction compared to baseline | 100% Reduction compared to baseline |
| Direct On-Site Greenhouse Gas (GHG) Emissions for HVAC Space Heating | Direct on-site fossil fuel GHG emissions (metric tons) | Measured/calculated release of GHG based on source of energy (baseline and demonstration) | 100% Reduction compared to baseline | 100% Reduction compared to baseline |
| Installed Cost Of GHP-BTES vs. Conventional GHP Systems | HVAC Construction Cost | Construction cost data from construction contractor for both GHP-BTES and alternate conventional GHP design | 20% Construction Cost Reduction from conventional GHP systems vs. GHP-BTES systems | 33.6% Reduction |
| Greenhouse Gas Emissions at Source (Power Plant) to power Air-to-Air Heat Pumps vs. GHP-USTES System | Source fossil fuel GHG emissions (metric tons) | Measured/calculated release of GHG at Source (demonstration) versus an Hour-By-Hour model of project building with air-to-air heat pumps (baseline) | 40% reduction compared to air-to-air baseline model | BTES: 32.5% Reduction<br><br>ATES: 26.5% Reduction (Modeled) |
| **Qualitative Performance Objectives** | | | | |
| Elimination of maintenance of HVAC water treatment system | Hours/Cost spent maintaining HVAC water treatment system | Observe presence/removal of HVAC Cooling Tower Water treatment system | Interview/record maint. personnel positive experience with removal of HVAC water treatment system | Maintenance personnel extremely satisfied. Pending formal results. |
| Energy Security | Survey of Base personnel regarding the perceived Energy Security Aspect of the GHP-USTES system | Conduct formal Surveys of Base personnel to determine if USTES system provides Energy Security | Survey results show the inside-the-fence (underground) USTES system is highly robust and provides additional Energy Security | Pending formal results. MCLB is in the process of implementing BTES for 3 other buildings. |

## 3.1 PERFORMANCE OBJECTIVES DESCRIPTIONS

### 3.1.1 Reduce Facility HVAC Energy Usage Compared to a Conventional HVAC System:

- **Definition & Relevance**: The project's new HVAC system was projected to have lower energy consumption than the building's existing baseline HVAC system. The purpose of the objective was to demonstrate reduced energy consumption of DoD facilities to help accomplish their stated goals of building energy reduction, improved energy security, and increased sustainable infrastructure.
- **Metric:** The energy intensity (Btu/ft$^2$ or kWh/ft$^2$) of building 3700 at MCLB (BTES) existing and new HVAC systems was determined by direct measurement to assess the intensity. Currently the baseline energy intensity of building 3215 at Ft. Benning has been measured, but the newly constructed ATES system energy intensity has not been measured. (See Executive Summary) Office buildings in the U.S. have been measured by DOE to have HVAC energy intensities around 92,800 BTU/ft$^2$ in one survey performed as part of their Commercial Building Energy Consumption Survey or CBECS (DOE, 2003). It was expected that the buildings retrofitted with GHPs and USTES would have significantly less energy consumption than this value.
- **Data:** The area (square footage) of the conditioned space used in the denominator of the above metric is taken from area take-offs of the vector based computer-aided design (CAD) drawings provided by the military installations to the investigators. The numerator in terms of BTU or kWh for the new and existing systems is taken from a combination of: direct measurements of HVAC equipment. kWh consumption was measured by watt-meters and data-loggers; natural gas consumption in BTUs from dividing the output of the equipment by the equipment efficiency; temperature sensors and mass/volumetric flow meters to determine energy delivery. All this information is divided by published or estimated equipment efficiency values or even hour-by-hour computer simulation modeling programs, such as eQuest or TRNSYS.
- **Analytical Methodology:** Instrumentation and data-loggers were placed on the various existing HVAC system components (e.g. pumps, AHUs, chillers, etc.) during the many months leading up to the demonstration project. This data was used to determine the baseline estimated HVAC energy consumption of the buildings. However, typical problems were encountered with maintenance personnel disabling data-logging instrumentation; instrumentation failures; changing weather/occupancy levels; etc. Therefore, computer modeling or extrapolation techniques were also be utilized to help inform the baseline energy consumption calculations when appropriate.
- **Success Criteria:** The initial criteria for the demonstration program to be considered a success was if the ATES or BTES systems installed in the facilities at Fort Benning (ATES) and MCLB (BTES) exhibited a 30% reduction in annual HVAC energy consumption when compared to baseline HVAC system energy consumption.

  The BTES system for bldg. 3700 at MCLB greatly surpassed the success criteria by achieving a 47.5% energy savings over a 12-month period. The ATES system (scheduled for completion in March of 2017) is expected to perform similarly. The modeled ATES system is projected to have a 52.7% energy savings over a 12-month period when compared to the conventional HVAC system.

### 3.1.2 Reduce Facility HVAC Energy Usage Compared to a modeled Conventional GHP System:

- **Definition & Relevance:** The project's new HVAC system will have lower energy consumption when compared to an hour-by-hour simulation model (eQuest or TRNSYS) of a conventional GHP system as the baseline HVAC system. The purpose of the objective was to demonstrate reduced energy consumption of DoD facilities to help accomplish their stated goals of energy consumption reduction, improved energy security, and increase sustainable infrastructure.
- **Metric:** The energy intensity of each building's new HVAC systems (Btu/$ft^2$ or kWh/$ft^2$) was measured by direct measurement to determine its intensity. Since neither of the buildings are currently utilizing a conventional GHP system, the existing computer models that were built to inform the design of the new GHP w/USTES system were modified to represent a conventional GHP system. Each building's energy consumption was estimated based on these models to determine the performance of each building had they been installed with a conventional GHP system.
- **Data:** The area (square footage) of the conditioned space used in the denominator of the above metric is taken from area take-offs of the vector based computer-aided design (CAD) drawings provided by the military installations to the investigators. The numerator in terms of BTU or kWh for the new and existing systems is taken from a combination of: direct measurements of HVAC equipment kWh consumption measured by watt-meters and data-loggers; gas consumption in BTUs from dividing the output of the equipment by the equipment efficiency; temperature sensors and mass/volumetric flow meters to determine energy delivery. All this information is divided by published or estimated equipment efficiency values or via hour-by-hour computer simulation modeling programs, such as eQuest or TRNSYS. For this PO, the baseline energy consumption is determined solely by computer simulation. For additional information on the computer simulation see Section 6.0.
- **Analytical Methodology:** The instrumentation and data-loggers placed on the various existing HVAC system components (e.g. pumps, AHUs, chillers, etc.) during several months leading up to the demonstration project is not useful for this PO's baseline comparison as it must be a conventional GHP system, which does not physically exist now, or in the future. Accordingly, the baseline data was exclusively obtained by computer simulation. For additional information on the computer simulation see Section 6.0. Recorded data for the new systems were used to determine the HVAC energy consumption of the ATES and BTES systems. However, problems were encountered such as maintenance personnel disabling data-loggers; instrumentation failures; changing weather/ occupancy levels; etc. Extrapolation and computer modeling techniques were utilized to help inform the demonstration energy consumption calculations when appropriate.
- **Success Criteria:** The initial criteria for the demonstration program to be considered a success was if the ATES or BTES systems installed in the facilities at Fort Benning (ATES) and MCLB (BTES) exhibited a 10% reduction in annual HVAC energy consumption when compared to a modeled baseline Conventional GHP HVAC system energy consumption. The BTES system had a 15.1 % reduction, and the modeled ATES system had a 13.8% reduction.

### 3.1.3 Reduce Water Consumption by 80-100%:

- **Definition & Relevance:** The project's new HVAC system was projected to have 80% to 100% lower water consumption (for heat rejection purposes) than the building's baseline HVAC system. The purpose of the objective was to reduce water consumption of DoD facilities to help accomplish their stated goals of reduced water consumption, and increased sustainable infrastructure.
- **Metric:** The water consumption of each building's existing and new HVAC systems (gallons/year) at each site was measured by direct measurement to determine the amount of water consumed by the heat rejection device. Conventional cooling towers, such as those servicing the buildings at MCLB and Fort Benning, utilize evaporative cooling which requires approximately one pound of evaporated water per 1,050 BTUs of heat rejection plus any liquid water carry-over and "bleed water" needed to prevent over-concentration of solids in the cooling water. The ATES and BTES systems utilized in EW-201135 accomplished most their heat rejection in the shoulder (fall/spring) or winter months when evaporative cooling needs are low. This is accomplished by utilizing the dry cooler to reject heat to the outside air any time it can be rejected efficiently. Accordingly, the metered water consumption of the adiabatic dry-cooler is non-existent as they have been able to operate in the dry-mode most, if not all, of the year.
- **Data:** The water consumption of the existing cooling tower and new adiabatic dry-coolers was metered to determine its water consumption. This was easily accomplished at MCLB with its dedicated cooling tower, which has been metered for months now. Fort Benning, on the other hand, uses a 6,000 ton+ central plant to serve our building and many others. To determine our building's pro-rata share of energy consumption at Ft Benning, the building load was monitored, and the load to the cooling tower was calculated based on 15,000 BTU's rejected to the cooling tower per ton of building load rejected to the chilled water loop. Water usage was calculated using 1,050 BTU's of cooling tower load/ pound of water evaporated.
- **Analytical Methodology:** Water meters, existing data-loggers and permanent instrumentation installed with the new system was used to determine/estimate annual water consumption of the heat rejection devices. Since the water treatment systems for the conventional systems were not operating properly to maintain the level of solids (via conductivity meters) in the basin water, a spreadsheet analysis accounts for this deficit, and it is reflected in the total water usage savings.
- **Success Criteria:** The initial criteria for the demonstration program to be considered a success was if the ATES and BTES system installed in the facilities at Fort Benning (ATES) and MCLB (BTES) exhibits a 100% reduction in the annual water consumption of the heat rejection system (cooling tower for the baseline and dry-cooler for the demonstration project). Since the dry coolers are currently operating without the use of water, the project has successfully achieved 100% water reduction.

### 3.1.4 Reduce Direct On-site Greenhouse Gas (GHG) Emissions by 100%:

- **Definition & Relevance:** The project's new HVAC system was projected to have a 100% reduction in the amount of GHGs emitted at the project site. The purpose of the objective was to reduce GHG emissions at DoD facilities to help accomplish their stated goals of GHG reductions.
- **Metric:** The GHG emissions of each building's existing natural gas boilers at each site was determined by metering their heating load over the period leading up to the installation of the new GHP w/USTES system. The heating load was divided by the efficiency of the boilers to determine the heating input. This value was be mathematically converted to its equivalent metric tons of GHG emissions. During demolition and construction of each new system, the boilers were removed. The new HVAC system does not utilize any fossil fuel boilers. Therefore, the on-site GHG emissions are zero.
- **Data:** The GHG emissions of the existing boilers was determined by the method stated above and its total annual level in metric tons/year was recorded. The fact that the new GHP/USTES systems do not emit GHGs was also recorded.
- **Analytical Methodology:** Initially, AH&P attempted to monitor the natural gas usage by utilizing the existing gas meters. During the data collection period, it was determined that the existing gas meters were not operating properly. The natural gas usage for this project was determined by monitoring the BTU output of the heating system. The output of the heating system was divided by the boiler efficiency to determine the natural gas input to the boilers. The existing natural gas consumption was converted mathematically to metric tons of GHGs per year.
- **Success Criteria:** This PO was successful since there was a 100% reduction in direct on-site GHG emissions.

### 3.1.5 Reduce Installed Cost of GHP-BTES by 20% when compared to Conventional GHP Installation Cost:

- **Definition & Relevance:** The project's new BTES HVAC system was projected to have a 20% lower installed cost than if a conventional closed loop GHP system were installed in its place. The purpose of the objective was to increase the deployment of closed loop GHP systems by giving the DoD program's project managers and engineers a lower cost (primarily via fewer boreholes needed while yet being more efficient) system architecture for closed loop GHP systems. While this PO was achieved with a BTES system, this PO was not possible with ATES systems vs. conventional open loop GHP systems. While ATES is always significantly more efficient due to its ability to capture waste heat and waste cool, the virtually identical system architecture does not allow for construction cost savings. This is evident when you consider that ATES systems have ATES valves and pumps in both the extraction and injection wells vs. pumps-only in extraction wells with conventional open loop GHP systems.

- **Metric:** Bidding on the construction of the BTES project established the true installed cost of the GHP-BTES system. AH&P then performed sufficient modeling such that the number of boreholes needed for a conventional GHP system could be estimated and rule of thumb (cost/linear foot of borehole) pricing could be applied to establish the cost of the baseline system.
- **Data:** Hard construction cost of the GHP-BTES system was established by the successful low bidder via the process described above. AH&P then estimated the pricing a conventional GHP system based on additional boreholes needed for conventional closed loop geo-thermal. The two prices between a GHP-BTES system and a conventional GHP system were compared.
- **Analytical Methodology:** The actual bidding data from the General Contractor selected by NAVFAC SE to install this project shall be used to determine the real cost of the GHP-BTES system installed at MCLB. Conventional GHP pricing shall be established via the methodology previously described herein. Subtracting the GHP-BTES bids from the conventional GHP estimate and dividing the difference by the cost of the conventional GHP system and multiplying by 100 will determine the construction cost savings on a percent (%) basis.
- **Success Criteria:** This PO of the demonstration program was considered a success since the BTES system installed in the facility at MCLB exhibited a 33.6% reduction in construction cost.

### 3.1.6 Reduce GHG Emissions at the Power Plant by 40% when comparing the emissions resulting from the installation of a GHP-USTES system vs. what it would have been had air-to-air heat pumps been installed:

- **Definition & Relevance:** The project's new HVAC system was projected to have a 40% reduction in the amount of GHGs emitted at the Source (Power Plant) than if a conventional air-to-air heat pump system were installed in its place. The purpose of the objective was help DoD facilities accomplish their stated goals of GHG reductions.
- **Metric:** As the baseline system, an hour-by-hour computer model of each building, installed with air-to-air heat pumps as their HVAC system, was completed to estimate GHG emissions at the power plant based on estimated annual kWh consumption. This information was compared to the actual energy consumption of these buildings after being equipped with their GHP-USTES system. This value was mathematically converted to its equivalent metric tons of GHG emissions after considering transmission and generation inefficiencies.
- **Data:** The GHG emissions of the power plant was determined by the method stated above and the total annual level in metric ton/year was recorded for both the modeled air-to-air HVAC system and the actual GHP-USTES system that is installed.
- **Analytical Methodology:** Electrical energy consumption of the new GHP-USTES system was determined by direct measurement of power consumption after the systems are made operational. For the air-to-air system, it shall be done via hour-by-hour computer simulation. These kWh figures were then converted mathematically to metric tons of GHGs per year.

- **Success Criteria:** This PO was not met since the calculated 40% reduction in power plant GHG emissions is calculated to be 32.5% for the BTES and 26.5% for the ATES system.

### 3.1.7 Elimination of HVAC Water Treatment System Maintenance:

- **Definition & Relevance:** The projects new HVAC system does not have a conventional cooling tower water treatment system involving conductivity meters, biocide/algaecide/etc. chemicals and their associated maintenance. The purpose of the objective is to reduce the burden and expense of maintaining a water treatment system that is normally associated with a conventional cooling tower that can evaporate millions of gallons of water per year in its task of rejecting maximum heat to the atmosphere during periods of extreme heat, but also on a year-round basis.
- **Metric:** The chemical treatment cost associated with the water consumption of the buildings existing and new HVAC systems (gallons/year) was measured by direct measurement and/or computer simulation. Its associated cost was determined by meeting with DoD maintenance personnel to determine the cost associated with this water consumption and treatment. Conventional Cooling towers, such as those originally servicing the buildings at MCLB or Fort Benning, utilize evaporative cooling which require approximately one pound of evaporated water per 1,050 BTUs of heat rejection plus any liquid water carry-over and bleed water needed to prevent over-concentration of solids in the cooling water. The ATES and BTES system accomplished their heat rejection in the shoulder (fall/spring) or winter months when evaporative cooling needs are low. Accordingly, the metered water consumption of the adiabatic dry-cooler when operating is zero.
- **Data:** The chemical/maintenance cost/hassles/experience/time/etc. associated with the existing cooling towers vs. new adiabatic dry-cooler was measured, compared and documented numerically.
- **Analytical Methodology:** Water meters, existing data-loggers, and permanent instrumentation installed with the new systems along with interviews with personnel was used to determine/estimate annual water consumption and associated chemical treatment cost/experience of the heat rejection devices treatment.
- **Success Criteria:** The demonstration program was considered a success since the simplified water treatment system associated with the ATES or BTES system are considered significantly easier to maintain that the previous treatment system. A formal survey has been sent, but results are pending.

### 3.1.8 Increase Energy Security:

- **Definition & Relevance:** The project's new HVAC system was expected to increase the Energy Security of Fort Benning and MCLB. The purpose of the objective was to increase the energy security of DoD facilities and military installations to help accomplish DoD's stated goals of increased energy security.

- **Metric:** Written surveys and /or interviews find that the vast majority (80% or more) of interviewed DoD personnel and/or their contractors feel the new GHP-BTES system increases the energy security of the installation.
- **Data:** Yes-No-Comment questionnaires delivered to personnel via email, U.S. Mail, phone solicitation, direct contact, etc. with the above question and the cumulative results were calculated.
- **Analytical Methodology:** The yes votes were be divided by the total number of votes returned and the percent answering "yes" will be calculated.
- **Success Criteria:** Formal questionnaires have been sent to satisfy this PO, and formal results are pending. Currently MCLB has already made plans to implement BTES for three additional buildings.

# 4.0 FACILITY/SITE DESCRIPTION

The ATES system was demonstrated at the Army Base at Fort Benning, GA and the BTES system was demonstrated at the Marine Corps Logistics Base-Albany, GA (MCLB). The Fort Benning ATES project was conducted at Building 3215 (B3215), which is located on the Sand Hill side of Fort Benning and is home to the 192nd Infantry Brigade. The MCLB BTES project was conducted at Building 3700 (B3700), which is an administrative building. It is located close to the central point of the MCLB installation.

## 4.1 FACILITY/SITE LOCATION AND OPERATIONS

B3700 at MCLB is located just north of the main gate. Below is a Google Earth image of B3700's location illustrating the location of the BTES bore-field.




**Figure 4.1. MCLB Albany, Building 3700 Google Earth Image**

The Google Earth image above shows the BTES bore-field located North of B3700. The field originally contained standing timber that was cleared for the installation of the BTES field.

The building itself is a three-floor, 168,000 $ft^2$ administration building. Its construction is mostly brick with a flat roof and single-pane windows. The original building was constructed in 1974 with several renovation projects thereafter.

B3215 at Fort Benning is located northeast of the main gate on the Sand Hill side. Below is a Google Earth image of the location of B3215 and well locations.




**Figure 4.2. Fort Benning, Building 3215 Google Earth Image**

The building itself is a two-floor, 10,000 $ft^2$ administration building acting as the headquarters for the 192nd Infantry Brigade. Its construction is mostly brick with a flat roof and single-pane windows. The original building was constructed in 1975 with several small renovation projects thereafter.

This construction of both buildings is typical of buildings installed on other military installations. Administration type buildings are also commonplace within military installations. Most buildings of this type are cooling dominated year-round, independent of climate zone, as these buildings are occupied most of the time during business hours. A cooling load will be present most the time, due to the people, lights, computers, printers, etc., which is a driving factor of why energy models of this facility illustrate a 10-to-1 cooling-to-heating yearly energy consumption ratio.

The locations of both facilities are not located near any non-administrative military operations (physical training, maneuvering, etc.). Therefore, there were little interactions or disruptions to either of the military operations. However, there were some minor interactions and disruptions to the administrative operations that occurred. The change-over from the existing system to the demonstration project's systems required the use of temporary equipment to keep the building conditioned during the construction process. The existing-to-temporary system change-over and temporary-to-demonstration system change-over occurred over weekend time periods, and had little effect on the building occupant's comfort. The temporary equipment installation did cause some disruption in regards to trailer mounted temporary equipment being installed in the parking lot area and the use of fire hoses to supply chilled and hot water to the existing HVAC equipment.

MCLB's and Fort Benning's secure network system did not allow for remote access for this demonstration project. Since network access was not available during the baseline monitoring and recording period, on-site visits were used to download the information manually as needed. AH&P was able to gain a government issued CAC (Common Access Card) and received a government owned laptop computer from MCLB to have the ability to monitor the BTES system live for fine tuning. Additional data collection devices were still required to capture the required data for analysis of the new BTES system. Efforts are still being made to gain future access to the network communication system at Ft Benning to allow for data retrieval/monitoring after completion of the demonstration project installation. If so, the planned approach is to have this technology and its various data-points graphically displayed "live" via a password protected website.

## 4.2 FACILITY SITE CONDITIONS

The site for each system (ATES & BTES) was chosen based on several criteria. With this demonstration project focusing on seasonal underground thermal energy storage more consideration had to be given concerning the underground geology of the site versus the real-estate above ground. Also, understanding that harvesting cooling energy from the outside air during the winter is very important to balancing the cooling/=heating load in most commercial buildings in the Unites States helped to determine that adequate "above ground" real-estate was needed for the installation dry coolers. The site conditions for each system are listed below.

### 4.2.1 BTES Site Conditions

Bldg. 3700 at the Marine Corps Logistics Base (MCLB) located in Albany, GA was selected as the location for the BTES system. Located in south west Georgia, this military base is below the "Fall Line" and the underground formation consists of karst limestone. This "swiss cheese like" limestone holds a vast amount of ground water, and the movement of the ground water was determined to be minimal.

Since BTES construction is closed loop in nature, and requires the drilling of multiple boreholes it was very important that a site be chosen that contained an adequate amount of property to configure these boreholes to allow for storing of energy in the core of the bore field. Bldg. 3700 had a large wooded area directly to the north of the parking lot that was prime real-estate for installing the BTES bore field. Bldg. 3700 has approximately 180,000 square feet and has a maximum cooling load of approximately 400 tons. The existing timber was harvested in this location to allow for installation of the 306 vertical boreholes needed for this cooling load.

Locating a building that could be easily converted to BTES was important to the success of this project. The existing HVAC system for Bldg. 3700 was found to be compatible since it utilized a system of chilled water air handlers and hot water re-heat variable air volume terminal units. This system was able to be converted very easily to BTES by removing the existing water cooled chillers and cooling tower and installing the heat recovery modular chillers connected to the BTES system.




**Figure 4.3. MCLB Bldg 3700 Site Conditions (BTES)**

### 4.2.2 ATES Site Conditions

Bldg 3215 at Ft. Benning located in Columbus, GA was selected for the location of the ATES system. Located in West Georgia, Ft Benning is approximately 90 miles North West of MCLB. The underground formation at Ft Benning contains an aquifer located below a confining clay layer.

Bldg. 3215 has approximately 10,000 sq. ft. of floor area, and has a cooling load of approximately 31 tons. With an ATES system, adequate water flow for this cooling load can be provided by utilizing two wells each (cold and warm). Therefore, the amount of real estate needed for this project was very small compared to the BTES project. Bldg. 3215 has enough property located North, North East, and West of the parking lot to accommodate these wells. As stated above for the BTES system, it was desirable to choose a building that could be easily converted to ATES. Building 3215's HVAC consisted of a chilled water/hot water multi zone air handler. This air handler had 7 different zones, and each zone was re-connected to a new water source heat pump that is connected to the ATES System




**Figure 4.4. Ft Benning Bldg. 3215 Site Conditions (ATES)**

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# 5.0 TEST DESIGN

A detailed description of each respective system (BTES and ATES) is illustrated in Section 5.3 of this Final Report. In either case, each USTES system type has demonstrated a different method of creating a more efficient way of applying GHX systems with seasonal energy storage. The existing systems at each site were considered conventional HVAC systems, whose performance was compared against the performance of the demonstration project installed at the same site. For MCLB, the VAV AHUs and VAV boxes were coupled with a BTES system consisting of heat recovery modular chillers, GHX bore-field and adiabatic dry coolers in lieu of the centrifugal chillers, cooling tower and hot water boiler previously installed. For Fort Benning, the HVAC system received a complete overhaul as new WSHPs, adiabatic dry coolers and ATES warm/cold wells were installed to replace the existing multi-zone AHU and hot water boiler. Existing HVAC system performance data at each site was monitored and recorded for a minimum of 12 months, which was compared against performance data of the new USTES systems to determine several of the energy consumption comparison-based performance objective's success or failure. Note that as stated in previous sections the ATES baseline data was metered, but the demonstration data was modeled due to ongoing construction schedule.

## 5.1 CONCEPTUAL TEST DESIGN

To evaluate the performance objectives, AH&P implemented an extensive data monitoring plan to determine the energy usage, heating and cooling output, and COP of the original and the demonstration projects. The following strategies used for each system is listed below.

### 5.1.1 MCLB Bldg. 3700 (Conventional HVAC System):

The monitoring for the original conventional HVAC system focused primarily on electrical usage monitoring, and cooling and heating output monitoring. In addition to this, historical weather data was monitored to compare weather data from the pre-demonstration period to the demonstration period.

Watt hour meters were installed to monitor the electrical consumption of all HVAC related equipment including air handlers, pumps, energy recovery unit, chillers, and the cooling tower. Ultra-sonic flow meters were utilized to monitor the chilled, hot, and condenser water flow of the system. Strap on and immersion temperature sensors were used to monitor the supply and return temperatures of the hot, chilled, and condenser water. For the air side equipment, temperature and relative humidity sensors were used to determine the entering and leaving air temperatures of the chilled water coils. Also, the temperature and relative humidity of the supply, return, and outside air was monitored.

### 5.1.2 MCLB Bldg. 3700 (BTES HVAC System):

To compare the energy usage of the BTES with the energy usage of the conventional system all of the meters and sensors for the air handlers remained in place. In addition to the air handler sensors, the ultra-sonic flow meters and strap on temperature sensors remained in place to determine the BTU output of the new system. Additional instrumentation was installed for the new pumps, the modular chiller, and the cooling tower. This new instrumentation included new immersion water temperature sensors, and watt hour meters for select pieces of HVAC equipment.

An additional watt hour meter was placed at the new electrical panel to capture the energy usage of all the newly installed HVAC equipment.

In addition to this instrumentation used to compare energy usage and COP, AH&P monitored the water temperatures in and out of the BTES bore-field, the water temperatures in and out of the dry cooler, the dry cooler valve position, and the two reversing valve positions. This data was analyzed and used to determine how much energy was being stored in the BTES bore-field by the dry cooler.

### 5.1.3 Ft Benning Bldg. 3215 (Conventional HVAC System):

The monitoring for the original conventional HVAC system focused primarily on electrical usage monitoring, and cooling and heating output monitoring. In addition to this, historical weather data was monitored to compare weather data from the pre-demonstration period to the demonstration period.

Watt hour meters were installed to monitor the electrical consumption of all HVAC related equipment including the supply and return fans, and the pumps. To determine the pro rata share of energy consumed by the building at the central plant, the central plant equipment was evaluated and an equivalent central plant KW/ton was calculated based on equipment literature and capacities. Ultrasonic flow meters were utilized to monitor the chilled, and hot water flow of the systems at building 3215. Strap-on and immersion temperature sensors were used to monitor the supply and return temperatures of the hot, and chilled water. For the air side equipment, temperature and relative humidity sensors were used to determine the entering and leaving air temperatures of the chilled and hot water coil. Also, the temperature and relative humidity of the supply, return, and outside air was monitored.

### 5.1.4 Ft Benning Bldg. 3215 (ATES HVAC System):

The monitoring instrumentation for the new ATES system has not been installed yet since the project is still under construction. The ATES system energy consumption was modeled to compare against the metered baseline data, see section 6.0. A watt hour meter can be installed to monitor the complete ATES system to compare energy usage with the baseline data. A combination of air and water temperature sensors, pump statuses, and injection valve positions connected to the building automation system will aid in analyzing the performance of the newly installed ATES system.

## 5.2 BASELINE CHARACTERIZATION

The following information is used to describe the baseline characterization used to support the demonstration.

### 5.2.1 Reference Conditions:

There were many baseline reference conditions that were data-logged for both project sites. To accurately compare the baseline existing performance against the demonstration project's performance, a minimum of one year's worth of data was collected for the existing system.

After the demonstration project construction was completed, performance data was collected and compared against the baseline's performance data. The list of baseline conditions collected for each site can be seen in below:

**Table 5.1. MCLB Albany: List of Baseline Reference Conditions**

| MCLB ALBANY - MCLB BUILDING 3700 | | |
|---|---|---|
| # | Reference Condition | Units |
| 1 | Chilled Water Supply Temperature | °F |
| 2 | Chilled Water Return Temperature | °F |
| 3 | Hot Water Supply Temperature | °F |
| 4 | Hot Water Return Temperature | °F |
| 5 | Supply Air Temperature | °F |
| 6 | Return Air Temperature | °F |
| 7 | Mixed Air Temperature | °F |
| 8 | Outside Air Temperature | °F |
| 9 | Supply Air Humidity | % RH |
| 10 | Return Air Humidity | % RH |
| 11 | Mixed Air Humidity | % RH |
| 12 | Outside Air Humidity | % RH |
| 13 | Energy Consumption | KWh |
| 14 | Chilled Water Flow | GPM |
| 15 | Hot Water Flow | GPM |

**Table 5.2. Fort TaTable 5.2 - Ft. Benning: List of Baseline Reference Conditions**

| FT. BENNING - BUILDING 3215 | | |
|---|---|---|
| # | Reference Condition | Units |
| 1 | Chilled Water Supply Temperature | °F |
| 2 | Chilled Water Return Temperature | °F |
| 3 | Hot Water Supply Temperature | °F |
| 4 | Hot Water Return Temperature | °F |
| 5 | Supply Air Temperature (downstream of hot and cold deck) | °F |
| 6 | Return Air Temperature | °F |
| 7 | Mixed Air Temperature | °F |
| 8 | Outside Air Temperature | °F |
| 9 | Supply Air Humidity | % RH |
| 10 | Return Air Humidity | % RH |
| 11 | Mixed Air Humidity | % RH |
| 12 | Outside Air Humidity | % RH |
| 13 | Energy Consumption | KWh |
| 14 | Chilled Water Flow | GPM |
| 15 | Hot Water Flow | GPM |

### 5.2.2 Baseline Collection Period:

For MCLB, baseline data collection started on Wednesday, April 18, 2012 and continued until the demolition process for the demonstration project installation began, which was in August of 2014. The time period that was used as the official baseline data time period was August 1st 2013 thru July 31st 2014.

For Fort Benning, baseline data collection started on Tuesday, May 1, 2012 and continued until the demolition process for the demonstration project installation began, which was February of 2017. The time period that was used as the official baseline data time period was August 1st 2013 thru July 31st 2014.

### 5.2.3 Existing Baseline Data:

The cooling tower make-up water consumption (MCLB only) was not being data-logged continuously due to an existing water meter already in place. Logging cooling tower makeup water consumption for the central plant at Ft Benning was infeasible. Therefore, it was determined to base the makeup water usage from the cooling output of the building plus blowdown to satisfy Cycles of Concentration requirements. Make-up water usage for cooling tower operation at MCLB had an existing meter, which we recorded at every site visit to keep track of water consumption. This allowed us to know the annual water consumption due to the operation of the existing cooling tower and how much water was saved due to the installation of this demonstration project.

For MCLB, the natural gas meter was not operating properly, and at Ft Benning, the gas meter readings were incomplete. Natural gas metering was calculated based on the heating output of the HVAC system divided by the efficiency.

### 5.2.4 Baseline Estimation:

Initially, differential pressure (ΔP) transducers were installed at each site to measure the pressure differential across each pump (chilled water, hot water and condenser water). For each pump, a performance chart of pump flow versus ΔP was developed using an ultrasonic flow meter to measure flow at definitive ΔPs. After this chart was completed, ΔP measurements were used to approximate water flow at every data-logged ΔP recording. This information proved to be very difficult to work with due to the flat pump curves that were obtained. (The flow could change drastically with very little ΔP change.) AH&P decided that installing permanent ultrasonic flow meters connected to our data loggers would be a better approach. The flow of the chilled and hot water systems as measured by the ultrasonic flow meters was used to calculate baseline building heating and cooling loads at each data-point. Also, the instantaneous flow of the condenser water system was measured and recorded. Since the condenser water system was a fixed system with no variable speed pumps of modulating valves, the condenser water flow was determined to be constant.

### 5.2.5 Data Collection Equipment (Baseline):

New and existing data-logging equipment was used at each site for obtaining baseline reference data. Various types of equipment and methodologies were used to obtain the information critical for comparison purposes. Due to the inability to achieve a network connection to remotely download the recorded periodically, on-site visits were used to manually download the information before the hardware's hard drive space was full.

A detailed list of the baseline data collection equipment used for the demonstration project at MCLB is as follows in Table 5.3, while the equipment used for the demonstration project at Fort Benning is shown in Table 5.4. A detailed list of the demonstration data collection equipment can be found in Table 5.9.

**Table 5.3. MCLB Albany: Detailed List of Baseline Data Collection Equipment**

| MCLB ALBANY - BUILDING 3700 | | | | | | |
|---|---|---|---|---|---|---|
| # | Tag | Description | Location | Logging Interval | Serial No. | Manufacturer |
| 1 | A | U-30 Datalogger (2) | Mech 154 | 3 Minutes | 10137871 | Onset |
| 2 | B | U-30 Datalogger (3) | Mech 154 | 3 Minutes | 10197733 | Onset |
| 3 | C | Watt Node (Watt Hour Meter) | 400 Ton Chiller | 3 Minutes | 10101866 (1) | Continental Controls |
| 4 | D | Watt Node (Watt Hour Meter) | 200 Ton Chiller | 3 Minutes | 9804494 (1) | Continental Controls |
| 5 | E | Watt Node (Watt Hour Meter) | 200 Ton Chiller Pump | 3 Minutes | 9819490 (1) | Continental Controls |
| 6 | F | Watt Node (Watt Hour Meter) | Condenser Water Pump | 3 Minutes | 10101876 (1) | Continental Controls |
| 7 | G | Watt Node (Watt Hour Meter) | 400 Ton Chiller Pump | 3 Minutes | 9812618 (1) | Continental Controls |
| 8 | H | Watt Node (Watt Hour Meter) | Hot Water Pump-1 | 3 Minutes | 10101874 (1) | Continental Controls |
| 9 | I | Watt Node (Watt Hour Meter) | Hot Water Pump-2 | 3 Minutes | 9804493 (1) | Continental Controls |
| 10 | J | Watt Node (Watt Hour Meter) | Hot Water Pump-3 | 3 Minutes | 9812580 (1) | Continental Controls |
| 11 | K | Differential Pressure Transducer | 200 Ton Chiller Pump | 3 Minutes | 10125753 (3) | Omega |
| 12 | L | Differential Pressure Transducer | 400 Ton Chiller Pump | 3 Minutes | 10125753 (3) | Omega |
| 13 | M | Differential Pressure Transducer | Cooling Tower Pump | 3 Minutes | 10141564 | Omega |
| 14 | N | Pressure Transducer | Hot Water Pump-1 Suct. | 3 Minutes | 10164447 | Ashcroft |
| 15 | O | Pressure Transducer | Hot Water Pump-1 Disch. | 3 Minutes | 10141575 | Ashcroft |
| 16 | P | Pressure Transducer | Hot Water Pump-2 Suct. | 3 Minutes | 10187576 (3) | Ashcroft |
| 17 | Q | Pressure Transducer | Hot Water Pump-2 Disch. | 3 Minutes | 10187576 (3) | Ashcroft |
| 18 | R | Pressure Transducer | Hot Water Pump-3 Suct. | 3 Minutes | 10141577 | Ashcroft |
| 19 | S | Pressure Transducer | Hot Water Pump-3 Disch. | 3 Minutes | 10164445 | Ashcroft |
| 20 | T | Stainless Temp Sensor (Inserted in thermo well) | 400 Ton Chiller Supply | 3 Minutes | 10177405 | Onset |
| 21 | U | Stainless Temp Sensor (Inserted in thermo well) | 400 Ton Chiller Return | 3 Minutes | 10172403 | Onset |
| 22 | V | Stainless Temp Sensor (Inserted in thermo well) | 200 Ton Chiller Return | 3 Minutes | 10172406 | Onset |
| 23 | W | Stainless Temp Sensor (Inserted in thermo well) | 200 Ton Chiller Supply | 3 Minutes | 10172407 | Onset |
| 24 | X | Stainless Temp Sensor (Strap On) | 400T Chill. Supp. upstream of 200T Chill. | 3 Minutes | 10177403 | Onset |
| 25 | Y | Stainless Temp Sensor (Strap On) | CHW Supply Main | 3 Minutes | 10177404 | Onset |
| 26 | Z | Stainless Temp Sensor (Strap On) | CHW Return Main | 3 Minutes | 9900673 | Onset |
| 27 | AA | Stainless Temp Sensor (Strap On) | Hot Water Return Main | 3 Minutes | 10177432 | Onset |
| 28 | BB | Stainless Temp Sensor (Strap On) | Hot Water Supply Main | 3 Minutes | 10172404 | Onset |
| 29 | CC | U-30 Datalogger (5) | Mech. 114 | 3 Minutes | 9824639 | Onset |
| 30 | DD | Temperature/Relative Humidity Sensor | AHU-1A Return Air | 3 Minutes | 9824689 | Onset |
| 31 | EE | Temperature/Relative Humidity Sensor | AHU-1A Mixed Air | 3 Minutes | 9824694 | Onset |
| 32 | FF | Temperature/Relative Humidity Sensor | AHU-1A Supply Air | 3 Minutes | 9824701 | Onset |
| 33 | GG | Temperature/Relative Humidity Sensor | AHU-1B Return Air | 3 Minutes | 9824696 | Onset |
| 34 | HH | Temperature/Relative Humidity Sensor | AHU-1B Mixed Air | 3 Minutes | 9807672 | Onset |
| 35 | II | Temperature/Relative Humidity Sensor | AHU-1B Supply Air | 3 Minutes | 9824693 | Onset |
| 36 | JJ | Watt Node (Watt Hour Meter) | AHU-1A Disconnect | 3 Minutes | 10101877 (1) | Continental Controls |
| 37 | KK | Watt Node (Watt Hour Meter) | AHU-1B Disconnect | 3 Minutes | 9835267 (1) | Continental Controls |
| 38 | LL | Stainless Temp Sensor (Strap On) | CHW Supply Temp at AHU-1A &1B | 3 Minutes | 10146207 | Onset |
| 39 | MM | Temperature/Relative Humidity Sensor | AHU-2A Return Air | 3 Minutes | 9824700 | Onset |
| 40 | NN | Temperature/Relative Humidity Sensor | AHU-2A Mixed Air | 3 Minutes | 9807665 | Onset |
| 41 | OO | Temperature/Relative Humidity Sensor | AHU-2A Supply Air | 3 Minutes | 9807660 | Onset |
| 42 | PP | Temperature/Relative Humidity Sensor | AHU-2B Return Air | 3 Minutes | 9807658 | Onset |
| 43 | QQ | Temperature/Relative Humidity Sensor | AHU-2B Mixed Air | 3 Minutes | 9824695 | Onset |
| 44 | RR | Temperature/Relative Humidity Sensor | AHU-2B Supply Air | 3 Minutes | 9824703 | Onset |
| 45 | SS | Watt Node (Watt Hour Meter) | AHU-2A Disconnect | 3 Minutes | 9835268 (1) | Continental Controls |
| 46 | TT | Watt Node (Watt Hour Meter) | AHU-2B Disconnect | 3 Minutes | 9819487 (1) | Continental Controls |
| 47 | UU | U-30 Datalogger (6) | Mech. 209 | 3 Minutes | 9836842 | Onset |
| 48 | VV | Temperature/Relative Humidity Sensor | AHU-3A Return Air | 3 Minutes | 9824691 | Onset |
| 49 | WW | Temperature/Relative Humidity Sensor | AHU-3A Mixed Air | 3 Minutes | 9824690 | Onset |
| 50 | XX | Temperature/Relative Humidity Sensor | AHU-3A Supply Air | 3 Minutes | 9807669 | Onset |
| 51 | YY | Temperature/Relative Humidity Sensor | AHU-3B Return Air | 3 Minutes | 9824692 | Onset |
| 52 | ZZ | Temperature/Relative Humidity Sensor | AHU-3B Mixed Air | 3 Minutes | 9807659 | Onset |
| 53 | AAA | Temperature/Relative Humidity Sensor | AHU-3B Supply Air | 3 Minutes | 9807662 | Onset |
| 54 | BBB | Watt Node (Watt Hour Meter) | AHU-3A Disconnect | 3 Minutes | 9835270 (1) | Continental Controls |
| 55 | CCC | Watt Node (Watt Hour Meter) | AHU-3B Disconnect | 3 Minutes | 9819448 (1) | Continental Controls |
| 56 | DDD | U-30 Datalogger (7) | Mech. 310 | 3 Minutes | 9836841 | Onset |
| 57 | EEE | Temperature/Relative Humidity Sensor | ERU Exhaust Air Entering | 3 Minutes | 9807668 | Onset |
| 58 | FFF | Temperature/Relative Humidity Sensor | ERU Exhaust Air Leaving | 3 Minutes | 9824698 | Onset |
| 59 | GGG | Temperature/Relative Humidity Sensor | ERU Outside Air Entering | 3 Minutes | 9824707 | Onset |
| 60 | HHH | Temperature/Relative Humidity Sensor | ERU Outside Air Leaving | 3 Minutes | 9824706 (11) | Onset |
| 61 | III | Watt Node (Watt Hour Meter) | ERU Disconnect | 3 Minutes | 10101872 (1) | Continental Controls |

**Table 5.3. MCLB Albany: Detailed List of Baseline Data Collection Equipment (cont'd)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 62 | JJJ | U-30 Datalogger (8) | Roof @ ERU | 3 Minutes | 9836844 | Onset |
| 63 | KKK | Watt Node (Watt Hour Meter) | Mechanical Yard | 3 Minutes | 10101875 | Continental Controls |
| 64 | LLL | U-30 Datalogger (9) | Mechanical Yard | 3 Minutes | 9824637 | Onset |
| 65 | MMM | U-20 Water Level Logger | BH #1 Depth 200' from TOC (10) | 5 Minutes | 10137380 | Onset |
| 66 | NNN | U-20 Water Level Logger | BH #2 Depth 150' from TOC (10) | 5 Minutes | 10121324 | Onset |
| 67 | OOO | U-20 Water Level Logger | Existing Well Depth 150' from TOC (10) | 5 Minutes | NA | Onset |
| 68 | PPP | TFX Ultrasonic Flow Meter | Main Chilled Water Piping (Mech Room) | 3 Minutes | NA | Dynasonic |
| 69 | QQQ | TFX Ultrasonic Flow Meter | Main Hot Water Piping (Mech Room) | 3 Minutes | NA | Dynasonic |
| | | | | | | |
| | Notes: | (1) Serial # references the pulse adapter from the watt hour meter to the logger. | | | | |
| | | (2) Tags associated with logger: A, C, D, E, F, G, H, I, J, K, L, M, V, W, Y, Z | | | | |
| | | (3) Tags associated with logger: B, N, O, P, Q, R, S, T, U, X, AA, BB | | | | |
| | | (4) Transducers use a common smart sensor or U-30 analog bus. | | | | |
| | | (5) Tags Associated with Logger: DD, EE, FF, GG, HH, II, JJ, KK, LL | | | | |
| | | (6) Tags Associated with Logger: MM, NN, OO, PP, QQ, RR, SS, TT | | | | |
| | | (7) Tags Associated with Logger: VV, WW, XX, YY, ZZ, AAA, BBB, CCC, | | | | |
| | | (8) Tags Associated with Logger: EEE, FFF, GGG, HHH, III | | | | |
| | | (9) Tags Associated with Logger: KKK | | | | |
| | | (10) Depths as of 2/7/13. Before 2/7/13 depths were: BH #1-200', BH #2-190', Existing Well-140'. | | | | |
| | | (11) Temp/RH sensor became defective approximatley on 12/17/12 @ 5:49 PM. | | | | |

**Table 5.4. Fort Benning: Detailed List of Baseline Data Collection Equipment**

| FORT BENNING - BUILDING 3215 | | | | | | |
|---|---|---|---|---|---|---|
| **#** | **Tag** | **Description** | **Location** | **Logging Interval** | **Serial No.** | **Manufacturer** |
| 1 | A | U-30 Datalogger (2) | Equipment 107 | 3 Minutes | 9824638 | Hobo |
| 2 | B | U-30 Datalogger (3) | Equipment 107 | 3 Minutes | 9836843 | Hobo |
| 3 | C | Watt Node (Watt Hour Meter) | Chilled Water Pump | 3 Minutes | 9812581 (1) | Continental Controls |
| 4 | D | Watt Node (Watt Hour Meter) | Hot Water Heating Pump | 3 Minutes | 10101871 (1) | Continental Controls |
| 5 | E | Watt Node (Watt Hour Meter) | AHU Fan Motor | 3 Minutes | 10101873 (1) | Continental Controls |
| 6 | F | Watt Node (Watt Hour Meter) | Domestic Water Heater Recirc. Pump | 3 Minutes | 10101870 (1) | Continental Controls |
| 7 | G | Watt Node (Watt Hour Meter) | Return Air Fan | 3 Minutes | 10101869 (1) | Continental Controls |
| 8 | H | Stainless Temp Sensor (Strap On) | AHU CHW Supply | 3 Minutes | 10160460 | Hobo |
| 9 | I | Stainless Temp Sensor (Strap On) | AHU CHW Return | 3 Minutes | 10160463 | Hobo |
| 10 | J | Stainless Temp Sensor (Strap On) | AHU Hot Water Supply | 3 Minutes | 10160462 | Hobo |
| 11 | K | Stainless Temp Sensor (Strap On) | AHU Hot Water Return | 3 Minutes | 10160461 | Hobo |
| 12 | L | Pressure Transducer | Hot Water Pump Suction | 3 Minutes | 10141566 | Ashcroft |
| 13 | M | Pressure Transducer | Hot Water Pump Discharge | 3 Minutes | 10141565 | Ashcroft |
| 14 | N | Differential Pressure Transducer | Chilled Water Pump Suction/Discharge | 3 Minutes | 10141576 | Omega |
| 15 | O | Temperature/Relative Humidity Sensor | AHU Return Air | 3 Minutes | 9807666 | Hobo |
| 16 | P | Temperature/Relative Humidity Sensor | AHU Outside Air | 3 Minutes | 9824704 | Hobo |
| 17 | Q | Temperature/Relative Humidity Sensor | AHU Mixed Air | 3 Minutes | 9807667 | Hobo |
| 18 | R | Temperature/Relative Humidity Sensor | AHU Supply Air | 3 Minutes | 9807661 | Hobo |
| 19 | S | TFX Ultrasonic Flow Meter | Hot Water Main Piping | 3 Minutes | NA | Dynasonic |
| 20 | T | TFX Ultrasonic Flow Meter | Chilled Water Main Piping | 3 Minutes | NA | Dynasonic |
| 21 | | | | | | |
| | Notes: | (1) Serial # references the pulse adapter from the watt hour meter to the logger. | | | | |
| | | (2) Tags associated with logger: C, D, E, F, G, O, P, Q, R | | | | |
| | | (3) Tags associated with logger: A, B, H, I, J, K, L, M, N | | | | |

## 5.3 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

The following information is used to describe the components of each demonstration project system.

### 5.3.1 MCLB Albany (BTES):

- **System Design:** The building's existing HVAC system consisted of six variable airflow (VAV) air-handling units (AHUs) and 105 VAV air terminal units serving B3700.

Each AHU is equipped with a chilled water coil designed for 44°F entering water temperature and a modulating three-way valve designed to maintain 55°F air to the inlet of each VAV box. The existing VAV boxes were heating-only devices equipped with a single-row hot water coil designed for 180°F entering water temperatures. In the first floor main mechanical room there was a 200-ton chiller and a 400-ton chiller. The operation of each chiller depended upon the time of year as both chillers did not operate simultaneously. Each chiller operated to maintain a 44°F chilled water supply temperature to the AHU chilled water coils. The chiller's source water loop consisted of an approximately 500 ton (1,200 GPM) cooling tower designed to supply 85°F during peak summer conditions. The mechanical room also contained two non-condensing boilers designed to deliver 180°F hot water to the VAV boxes.

The demonstration project for this location was "wrapped around" a pre-existing ECIP MilCon project originally conceived to be a conventional GHP project. In this project, the building's existing six (6) VAV AHUs, which were recently replaced during a renovation project, remained for reuse while the associated VAV terminal units were replaced. The new VAV boxes were equipped with deep-row heating coils to achieve the necessary heating load capacity with 115°F heating hot water temperature in lieu of the original 180°F. The existing chillers, boilers, cooling tower and pumps were also replaced with a new central plant capable of providing the necessary chilled and hot water supply temperatures. The boilers and chillers were replaced with water-cooled heat recovery modular chillers, which can generate chilled water (CW), heating hot water (HW) or both as needed for space heating and space cooling purposes.

The BTES design has four separate water loops; CW, HW, source water (SW) and BTES water. The BTES water loop is responsible for pumping water thru the closed loop piping system that is coupled to two (2) dry coolers and 306 vertical boreholes (GHX) that serve as the heat source (in winter) and heat sink (in summer). The SW, which is responsible for pumping water thru the modular chillers, is connected to the BTES loop by a de-coupler pipe (sometimes referred to as a bridge). This piping architecture is typical of Primary/Secondary pumping and requires two separate pumps but allows each loop to operate independently.

Initially, the existing natural gas hot water heaters were going to be replaced with a dedicated geothermal domestic hot water (DHW) system. However, observations concluded that B3700 does not utilize enough DHW to justify the use of a dedicated geothermal DHW heater. Therefore, the final plan was to keep the existing DHW system in place.

The preliminary (non-modeled) GHX was designed at 510 boreholes, 210 feet deep, 8-foot spacing, 1-½" Ø u-bends with five u-bends in series. After dozens of TRNSYS optimization simulations, it was determined that the GHX could be revised to 306 boreholes, 200 feet deep, 20-foot spacing, 1-¼" Ø u-bends with three u-bends in series. This design decreased the pressure drop thru the GHX, which allowed for smaller pumps and better energy performance.

- **System Depiction:** The following diagrams and schematics will help depict the BTES system and how it is applied to this demonstration project.

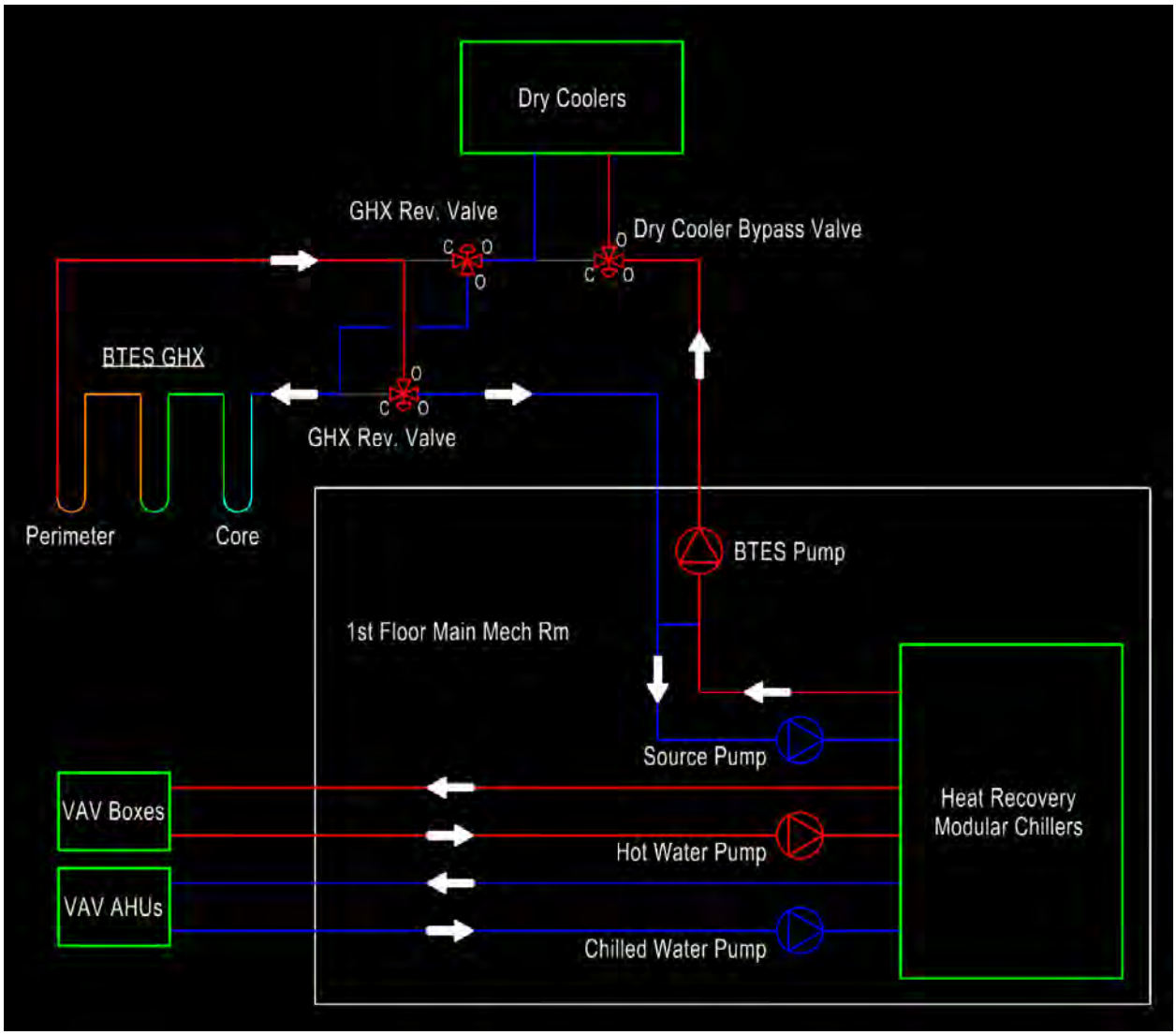


**Figure 5.1. BTES Charging Mode Flow Schematic Diagram**

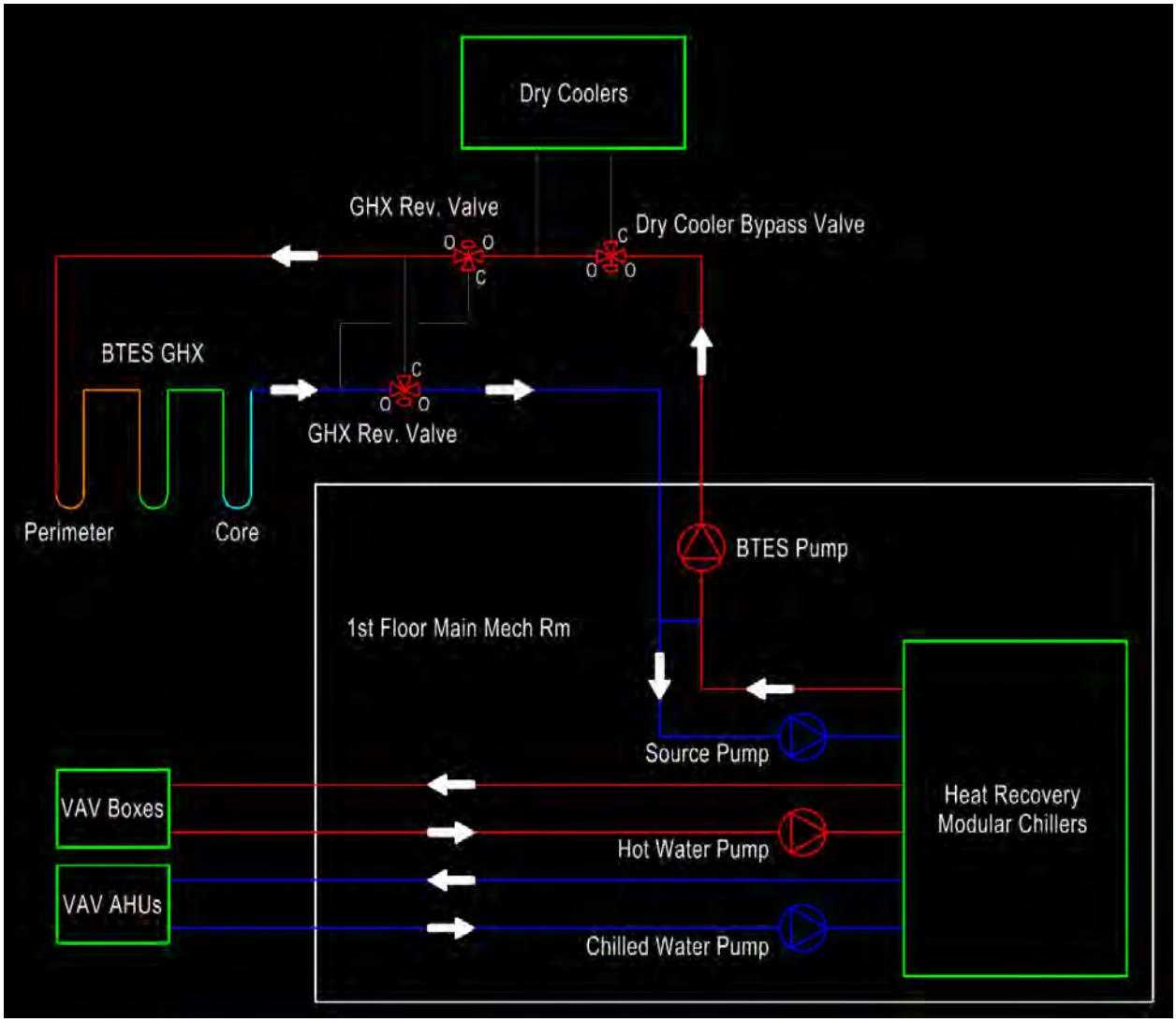


**Figure 5.2. BTES Discharging Mode Flow Schematic Diagram**

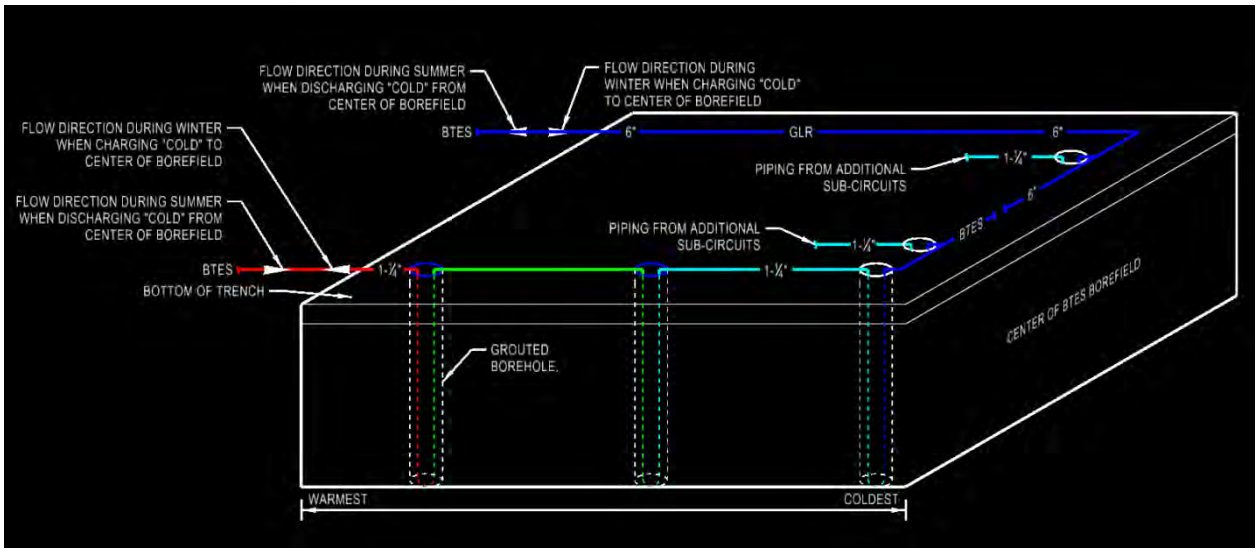


**Figure 5.3. BTES Typical Sub-Circuit Piping Schematic**

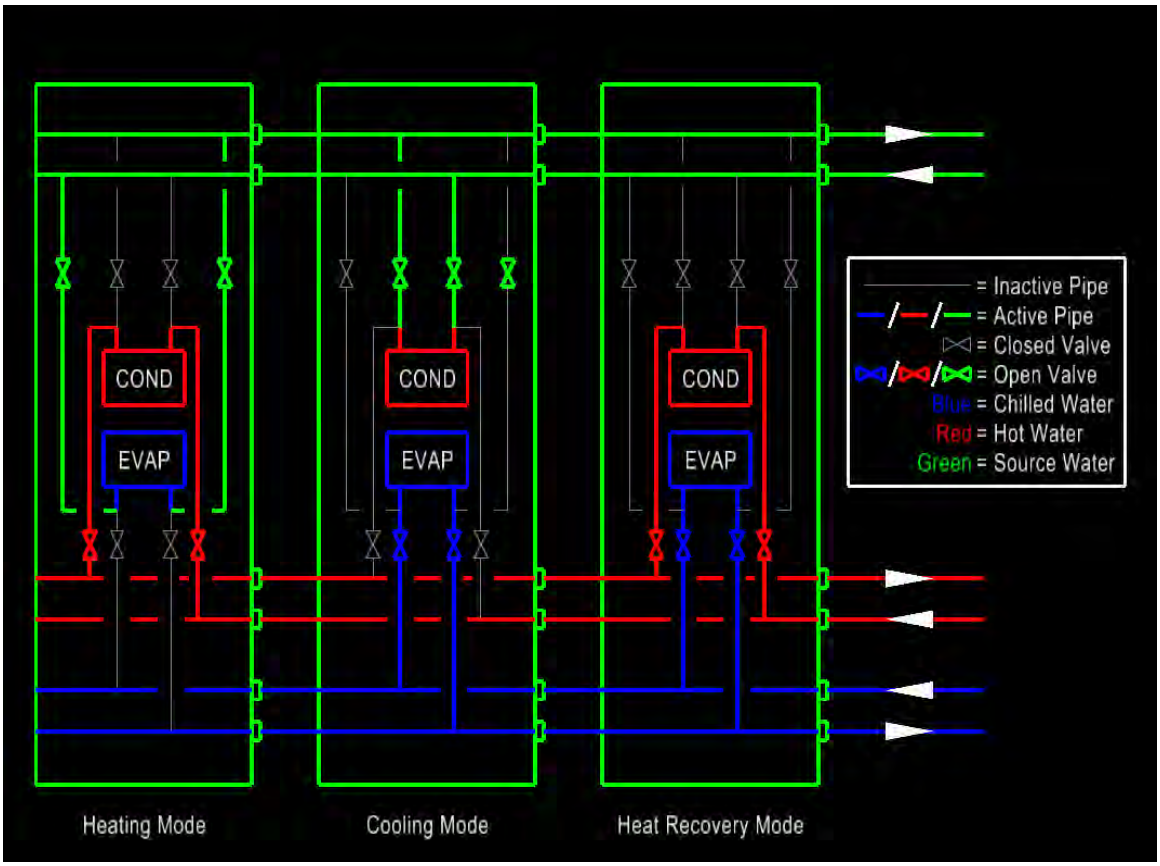


**Figure 5.4. Heat Recovery Modular Chiller Flow Diagram**

- **Components of the System:** The heat recovery modular chiller that was utilized has six (6) pipe connections; CW inlet/outlet, HW inlet/outlet and SW inlet/outlet. When a chiller is operating in cooling mode, the CW connections are active as well as the SW connections. When a chiller is in heating mode, the HW and SW connections are active. We also achieve even higher energy efficiency by utilizing heat recovery. In the heat recovery mode, the SW connection is inactive while both the CW and HW connection are active. The modular chiller will take the waste cooling from the HW loop and use it to produce 44°F CW supply water. The modular chiller will also take the waste heat from the CW loop and use it to produce 115°F HW supply water.

  The adiabatic dry-cooler functions as the cold-capture (i.e. heat rejection) device during milder (lower) outside ambient conditions. This active device combines with the borehole based GHX to form the BTES system. While the intent is to operate the dry-cooler predominantly in the dry mode, we are using a "hybrid" type dry-cooler which can also operate in the wet mode a few hours per year, if needed, during extreme or unexpected peak conditions. To date, the BTES system has not utilized the dry cooler in the wet mode. The adiabatic dry cooler is equipped with high pressure spray nozzles that adiabatically cool the outside air stream before entering the V-Bank coils, which allows for an increase in heat rejection capacity due to the colder air stream. The use of an adiabatic dry cooler with adiabatic spray nozzles eliminates the need for a chemical treatment system for the BTES loop (other than a one-shot chemical feeder) and keeps the V-Bank coils dry. After multiple TRNSYS optimization simulations, we designed around two (2) dry coolers to achieve greater energy savings and performance. TRNSYS simulations determined that operating over-sized dry coolers with fans at half or quarter speed, will reduce annual energy consumption significantly with only a minimal reduction in heat rejection performance.

  The new VAV boxes will be equipped with deep-row heating coils to achieve the necessary heating load capacity with 115°F heating hot water temperature in lieu of the current 180°F. The modular chillers can produce up to 165°F HW using R-134a refrigerant. However, the energy efficiency improves when the modular chillers are allowed to produce 135°F or lower hot water with R-410a refrigerant.

- **System Integration:** The existing six (6) AHUs were recently replaced in a renovation project and did not have to be replaced for this project. The AHUs are adequate for providing enough cooling capacity for the given design conditions. With the modular chiller's ability to produce 44°F chilled water supply temperature, the integration between it and the AHUs was straightforward. The controls were also renovated at the time the new AHUs were installed, which also integrated well with the new controls that were installed for the central plant upgrade/replacement. The existing chilled water and heating hot water piping outside of the first-floor main mechanical room was also kept. Since the GPM for both systems (chilled and hot) was kept identical to existing conditions, this allowed the interior piping remain in place. The selection of the new VAV boxes was carefully and strategically engineered to incorporate deeper-row coils with lower hot water supply temperatures at the same water flow, while still supplying the necessary sensible heating capacity to each zone.

- **System Controls:** The BTES pumping design is variable flow on the CW, HW, SW and BTES loops. The CW loop pump is controlled by two different differential pressure (ΔP) sensors in the CW piping. One sensor is located across the modular chiller headers to maintain a set-point pressure differential. The other sensor is located in the chilled water piping headers located on the third floor. The controls will maintain the set-point of the sensor located in the modular chiller headers by modulating the chilled water pumps speed in response to pressure drop change caused by multiple chiller modules being activated/de-activated. As control valves in the chilled water system (at the AHUs and at the modular chillers) begin to close (ΔP increases) or open (ΔP decreases), the CW bypass valve will modulate open to keep minimum flow through the pump.

  The HW loop pump will also be controlled in a similar manner to the CW loop pump.

  The SW loop pump is variable speed and is also controlled based on the ΔP across the bank of modular chillers. As the CW and HW loop temperatures begin to indicate that cooling and/or heating demand is being satisfied, the chillers will begin to de-energize and their motorized valves will close, which will increase the ΔP. The SW pump then throttles back to maintain the ΔP set-point. As the chillers begin to energize again, their motorized valves will begin to open and the ΔP will decrease causing the SW pump to speed up to maintain the set-point.

  The BTES loop pump is also be variable speed. However, its speed is controlled by the operation and flow rate of the SW loop pump. The BTES loop pump is controlled to operate at a flow rate slightly higher than the SW loop pump. Otherwise, this would cause operational issues at the modular chillers.

  There are also several controls valves in the BTES system that serve various purposes. One set of control valves allow flow reversal thru the GHX. In times of the year when return water to the GHX is colder than the GHX core temperature, flow direction is routed core-to-perimeter (charging). In times of the year when the return water to the GHX is hotter than the GHX core temperature, flow direction is routed perimeter-to-core (discharging). Another set of valves is designed for bypassing the dry coolers. If the return water from the building is hotter than the outside air dry-bulb temperature by a set-point temperature differential, then the dry coolers will energize. However, if this set-point temperature differential is inadequate, the dry coolers do not energize and water flow is bypassed around the dry coolers and routed to the GHX.

  While the BTES system will operate most of the time with the DDC system, provision was made in the design to have the system capable of operating manually in case of a DDC failure. Manual mode allows maintenance personnel to operate the system while the DDC system is being repaired. While manual operation does not encompass the controls necessary to optimize the BTES system operation, it allows maintenance personnel to keep the HVAC system operational and building conditioned.

  A more detailed Control Diagram of the BTES system can be seen in Appendix C.

### 5.3.2 Fort Benning – Building 3215 (ATES):

- **System Design:** The building's existing HVAC system consisted of a multi-zone AHU with seven (7) zone dampers. The AHU was equipped with a chilled water coil designed for 44°F entering water temperature and a modulating two-way valve that was designed to maintain 59°F air to each zone. The AHU was also equipped with a hot water coil designed for 180°F entering water temperature. The chilled water was produced at nearby central plant facility, which supplies chilled water to multiple facilities. The hot water was produced by a natural gas boiler installed in the mechanical room.

  For this demonstration project, the existing AHU, boiler, pumps, hot water piping, chilled water piping and ductwork in the mechanical room was removed and replaced with a new HVAC system. The HVAC system now consists of individual water source heat pumps (WSHPs) serving each of the seven (7) zones. In lieu of chilled water and hot water, the WSHPs utilize source water supplied by the ATES system. The ATES system has warm and cold wells that operate as injection or extraction wells depending upon building heating/cooling loads and outside air conditions. The water extracted from the aquifer is hydraulically separated from the WSHP source water by a stainless-steel plate-and-frame heat exchanger (HX). This will insure that the water injected back into the underground formation will be free any refrigerant that could possibly leak from the WSHPs.

  An adiabatic dry cooler is also being utilized for this project to provide an active means of storing seasonal energy into the underground aquifer. Depending on the time of year and outside air conditions, the dry cooler operates to capture the cold of winter and store its energy for use during the cooling dominant months of the year. Due to the location of the facility in the South East and results from preliminary modeling, building loads are cooling dominated and the operation of the dry cooler is needed to achieve a balanced load condition on the underground aquifer.

- **System Depiction:** The following diagrams and schematics will help depict the ATES system and how it is applied to this demonstration project.

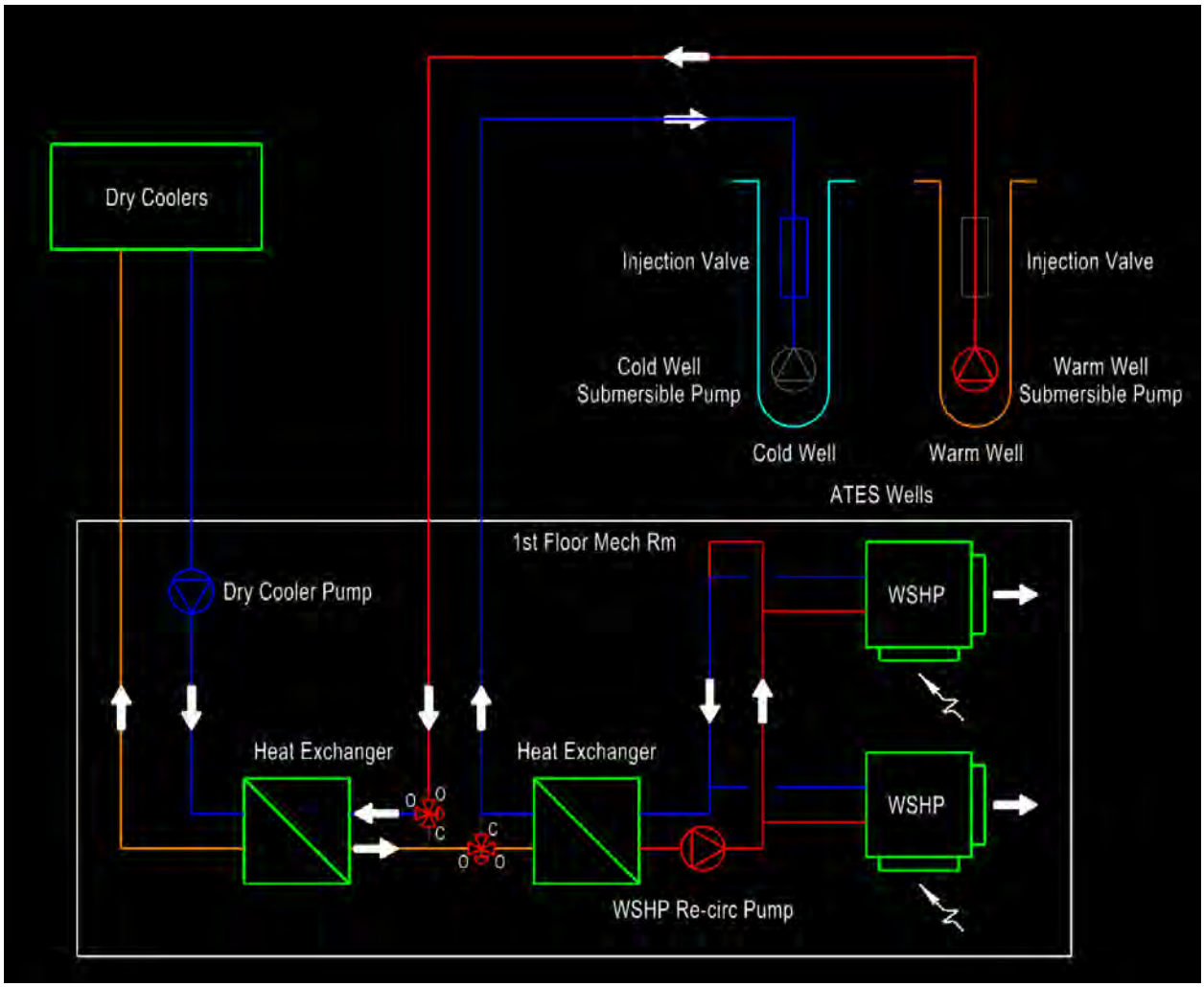


**Figure 5.5. ATES Cold Charging Mode Flow Schematic Diagram**

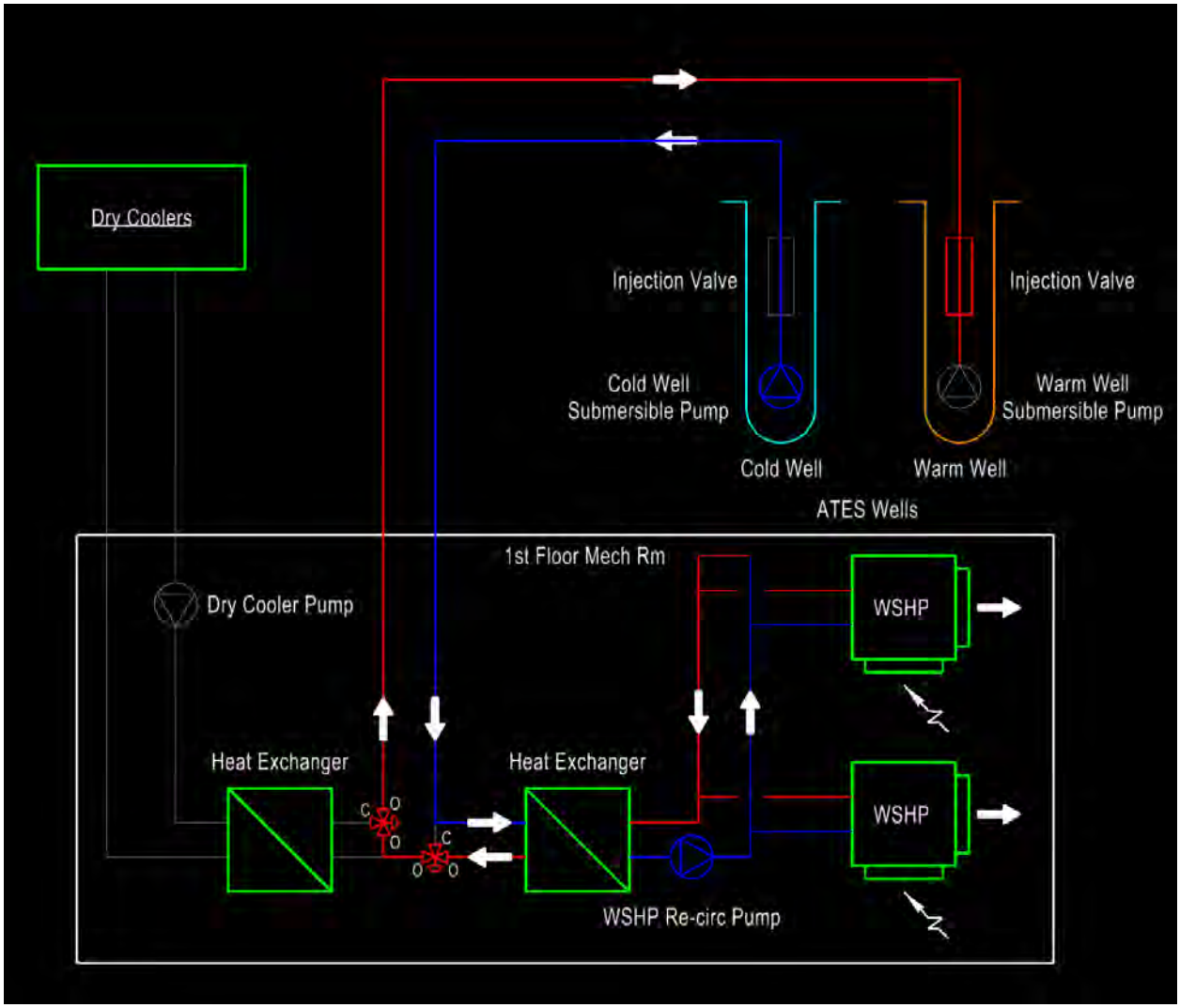


**Figure 5.6. ATES Cold Discharging Mode Flow Schematic Diagram**

- **<u>Components of the System:</u>** There are several key components to the ATES system. Each component is critical to achieving a successful system capable of providing enough heating and cooling source energy for B3215. Each well has a submersible pump and control valve capable of allowing each well to operate as either an injection or extraction well. During cooling dominant times of the year, water is extracted from the cold well, passed thru the plate HX, and injected into the warm well. During heating dominant times of the year, water is extracted from the warm well, passed thru the plate HX, and injected into the cold well. The motive behind this design is to raise the COP of the HVAC equipment during applicable times of the year to increase energy efficiency and reduce energy usage.

  The dry-cooler functions as the cold-capture (i.e. heat rejection) device during milder (lower) outside ambient conditions. The intent is to operate the dry-cooler only in the dry mode, therefore a dry type (non-adiabatic hybrid) dry cooler was installed.

The installation and operation of the dry cooler allows the design to actively store seasonal energy in the underground aquifer at optimal times of the year until the stored energy is needed. Given the load imbalance of this facility, the dry cooler is critical to achieving a balanced thermal load on the aquifer.

The use of WSHPs for the project is also important. WSHPs can operate against a wide range of source water temperatures to provide heating or cooling, depending on the load of the particular zone. WSHPs allow for maximum operating flexibility for this demonstration project. Down to certain entering source water temperatures, WSHPs EERs increase when operating in the cooling mode. Alternately, up to certain entering source water temperatures, WSHPs COPs increase when operating in the heating mode.

- **System Integration:** The integration of the seven (7) new WSHPs to the existing ductwork system was straightforward. To reduce cost and installation inconvenience to the personnel working in this facility, the existing ductwork and grilles were kept in place. With engineering and selection of the new WSHPs to maintain approximately the same airflow as the existing system, the existing ductwork was only removed at strategic locations in the mechanical room with the new ductwork connected back to those locations from the new WSHPs.

  Unfortunately, with the existing system consisting of a chilled water coil from a central plant and a hot water coil from a natural gas boiler, neither of these systems could be re-used.

- **System Controls:** The current pumping design is variable flow on the source water (SW), dry cooler (DC), and ATES loops. The SW loop pumps are variable speed and are integral to the water source heat pumps. The pumps are controlled to maintain a $\Delta T$ set point between the WSHP loop supply and return water. As the room thermostats begin to indicate that cooling or heating demand is being satisfied, the WSHPs will begin to de-energize. As the WSHPs de-energize, their control valve closes and the internal pump de-energizes. As the WSHPs begin to energize again, their motorized valves open and they each control to maintain their respective $\Delta T$ set point.

  The dry cooler loop pump is also variable speed. When the cold well is being discharged, the dry cooler loop pump operates when the supply water from the cold well is hotter than the outside air dry-bulb temperature by a set-point temperature differential. However, if this set-point temperature differential is inadequate, the dry cooler does not energize and water flow is bypassed around the dry cooler HX and routed to the WSHP HX and then the warm well. Alternately, when the warm well is being discharged, the dry cooler loop pump will operate when the return water from the WSHP HX is hotter than the outside air dry-bulb temperature by a set-point temperature differential. However, if this set-point temperature differential is inadequate, the dry cooler does not energize and water flow is bypassed around the dry cooler HX and routed to the cold well.

  The ATES loop pump and flow direction is controlled by the operation of the building. If the DDC system monitors the building and determines that it is operating in the cooling mode, the ATES loop will initially start-up with the cold well pump operating. If the OA conditions are ideal and its operation can net cool the warm well water temperature to the same temperature of the cold well, the flow will reverse and the water from the warm well will pass thru the dry cooler HX and then to the WSHP HX.

Otherwise, the cold well bypasses the dry cooler HX and supply water to the WSHP HX and then to the warm well. If the DDC system monitors the building and determines that it is in the heating mode, the ATES loop will start-up with the warm well pump operating. The warm well supply water then passes thru the WSHP HX. The water leaving the WSHP HX then passes through the dry cooler HX, and if the OA conditions are ideal and its operation can cool the water temperature efficiently, the dry cooler and dry cooler pump will operate. This water leaving the dry cooler HX then is routed to the cold well. A sample description of a sequence of control would be as follows:

- If (Building = cooling mode)
  - AndIf (Dry cooler can net cool warm well (plus heat added from building) water temperature to ≤ cold well temperature)
    - Then (Flow = warm well to WSHP HX to dry cooler HX to cold well)
  - Else (flow = cold well to dry cooler HX to WSHP HX to warm well)
- ElseIf (Building = heating mode)
  - Then (Flow = warm well to WSHP HX to Dry Cooler HX to cold well)
    - If (warm well temperature – OA temperature ≥ set-point)
      - Then (dry cooler = "ON")
    - Else (dry cooler = "OFF")
- Else (Building = "OFF")
  - AndIf (warm well temperature – OA temperature ≥ set-point)
    - Then (dry cooler = "ON")
  - Else (dry cooler = "OFF")

There are also several controls valves in the ATES system that serves various purposes. One control valve will allow flow to bypass the dry cooler HX when OA conditions are not ideal for seasonal storage. Another control valve allows flow to bypass the WSHP HX when the WSHP loop is inactive and when OA conditions exist to efficiently charge the cold well. This would allow the ATES loop to over pump and bypass water around the WSHP HX when less than peak conditions exist. This is important since there will be a need to mass balance (gallons) between the warm and cold wells, on an annual basis. Due to the cooling dominated loads of the building, water from the warm well needs to bypass the WSHP HX when ideal to achieve this mass balance. The two other control valves are injection valves, each located in the warm wells and cold wells. These valves are essential to allow the flow to reverse between the warm well and cold well.

While the ATES system will operate most of the time with the DDC system, provision was made in the design to have the system capable of operating manually in case of a DDC failure. Manual mode will allow maintenance personnel to operate the system while the DDC system is being repaired. While manual operation does not encompass the controls necessary to optimize the ATES system operation, it allows maintenance personnel to keep the HVAC system operational and building conditioned.

A representative control diagram of the ATES system can be seen in Appendix C.

## 5.4 OPERATIONAL TESTING

The following information is used to provide a description of significant operational testing phases of the technology.

Baseline reference information was collected up to the point where installation of the new system began. After the installation of the new equipment was complete, a full Commissioning (Cx) and Test, Adjust and Balance (TAB) process was performed. Data-loggers were re-installed in applicable areas to achieve the information necessary to compare the demonstration project against the baseline reference. Along with the installed data-loggers, the new controls had the necessary sensors installed to operate the new system effectively and efficiently. A list of conditions that recorded by the demonstration project at MCLB and Fort Benning is as follows in Table 5.7.

### 5.4.1 System Start Up:

All systems involved with the BTES and ATES systems were fully commissioned. During the Commissioning (Cx) process, the new equipment was installed and started up per the manufacturers recommendations. In addition to this, AH&P performed flushing and purging of the BTES system to ensure that the boreholes were free from all air and debris. AH&P also assisted with well development of the ATES wells.

### 5.4.2 Operational Testing Under Different Operating Parameters:

All systems involved with the BTES and ATES systems were fully commissioned. During the Commissioning (Cx) and Test, Adjust and Balance (TAB) process, the new equipment operated at various conditions to simulate peak cooling and heating loads as best as possible. Once all the equipment passed the Pre-Functional Performance Test Checklist, Functional Performance Testing (FPT) was performed during the Cx phase at various types of operating modes (Cooling/ Heating/Heat Recovery/etc.). Identical pieces of equipment such as VAV boxes were sampled at 20% for pre-functional and functional testing. See Appendix I for the Cx and TAB report.

### 5.4.3 Operational Testing During Warranty Phase

AH&P continued to test and fine tune the BTES system after construction by monitoring and optimizing the operation of the system.

### 5.4.4 Timeline:

The below charts indicate the time period for the operational testing of the BTES and ATES systems. Note that since the ATES system is under construction, the time periods are not yet available for operational testing.

**Table 5.5. MCLB: BTES Operational Testing Timeline**

| BTES Operational Testing Timeline | | | |
|---|---|---|---|
| # | **Task** | **Start Date** | **End Date** |
| 1 | Equipment Start Up | 03/27/15 | 5/1/2015 |
| 2 | BTES Borefield Flushing and Purging | 4/21/2015 | 4/27/2015 |
| 3 | Testing, Adjusting, and Balancing of Systems | 5/12/2015 | 8/31/2015 |
| 4 | Commissioning of Systems | 5/4/2015 | 8/24/2015 |
| 5 | Warranty Phase Operational Testing | 8/1/2015 | 7/31/2015 |

**Table 5.6. Ft Benning: ATES Operational Testing Timeline**

| ATES Operational Testing Timeline | | | |
|---|---|---|---|
| # | **Task** | **Start Date** | **End Date** |
| 1 | Equipment Start Up | TBD | TBD |
| 2 | BTES Borefield Flushing and Purging | TBD | TBD |
| 3 | Testing, Adjusting, and Balancing of Systems | TBD | TBD |
| 4 | Commissioning of Systems | TBD | TBD |
| 5 | Warranty Phase Operational Testing | TBD | TBD |
| | | | |

## 5.5 SAMPLING PROTOCOL

The following information will illustrate the sampling protocol used in the collection of relevant and sufficient data to validate the technology cost and performance under real-world conditions. Table 5.7 below illustrates the sensors and devices used to sample and monitor the BTES and ATES systems performance. For a chart Illustrating the sensors and devices used for sampling/monitoring the baseline system see Table 5.3 & 5.4. The sampling devices have not been installed yet for the newly constructed ATES project.

The method used for sampling was to utilize a combination of standalone data loggers, remote access data loggers sending live stream data over a secure cellular network, and the Building Automation System storing trend data. This data was analyzed monthly to determine the performance and energy savings of the systems.

## Table 5.7. MCLB BTES Demonstration System Monitoring Devices

| MCLB ALBANY - BUILDING 3700 BTES System Monitoring Devices | | | | | | |
|---|---|---|---|---|---|---|
| # | Tag | Description | Location | Logging Interval | Serial No. | Manufacturer |
| 1 | A | U-30 Datalogger (2) | Mech 154 | 5 Minutes | 10137871 | Onset |
| 2 | B | U-30 Datalogger (3) | Mech 154 | 5 Minutes | 10197733 | Onset |
| 3 | C | U-30 Datalogger (5) | Mech. 114 | 5 Minutes | 9824639 | Onset |
| 4 | D | Temperature/Relative Humidity Sensor | AHU-1A Return Air | 5 Minutes | 9824689 | Onset |
| 5 | E | Temperature/Relative Humidity Sensor | AHU-1A Mixed Air | 5 Minutes | 9824694 | Onset |
| 6 | F | Temperature/Relative Humidity Sensor | AHU-1A Supply Air | 5 Minutes | 9824701 | Onset |
| 7 | G | Temperature/Relative Humidity Sensor | AHU-1B Return Air | 5 Minutes | 9824696 | Onset |
| 8 | H | Temperature/Relative Humidity Sensor | AHU-1B Mixed Air | 5 Minutes | 9807672 | Onset |
| 9 | I | Temperature/Relative Humidity Sensor | AHU-1B Supply Air | 5 Minutes | 9824693 | Onset |
| 10 | J | Watt Node (Watt Hour Meter) | AHU-1A Disconnect | 5 Minutes | 10101877 (1) | Continental Controls |
| 11 | K | Watt Node (Watt Hour Meter) | AHU-1B Disconnect | 5 Minutes | 9835267 (1) | Continental Controls |
| 12 | L | Stainless Temp Sensor (Strap On) | CHW Supply Temp at AHU-1A &1B | 5 Minutes | 10146207 | Onset |
| 13 | M | Temperature/Relative Humidity Sensor | AHU-2A Return Air | 5 Minutes | 9824700 | Onset |
| 14 | N | Temperature/Relative Humidity Sensor | AHU-2A Mixed Air | 5 Minutes | 9807665 | Onset |
| 15 | O | Temperature/Relative Humidity Sensor | AHU-2A Supply Air | 5 Minutes | 9807660 | Onset |
| 16 | P | Temperature/Relative Humidity Sensor | AHU-2B Return Air | 5 Minutes | 9807658 | Onset |
| 17 | Q | Temperature/Relative Humidity Sensor | AHU-2B Mixed Air | 5 Minutes | 9824695 | Onset |
| 18 | R | Temperature/Relative Humidity Sensor | AHU-2B Supply Air | 5 Minutes | 9824703 | Onset |
| 19 | S | Watt Node (Watt Hour Meter) | AHU-2A Disconnect | 5 Minutes | 9835268 (1) | Continental Controls |
| 20 | T | Watt Node (Watt Hour Meter) | AHU-2B Disconnect | 5 Minutes | 9819487 (1) | Continental Controls |
| 21 | U | U-30 Datalogger (6) | Mech. 209 | 5 Minutes | 9836842 | Onset |
| 22 | V | Temperature/Relative Humidity Sensor | AHU-3A Return Air | 5 Minutes | 9824691 | Onset |
| 23 | W | Temperature/Relative Humidity Sensor | AHU-3A Mixed Air | 5 Minutes | 9824690 | Onset |
| 24 | X | Temperature/Relative Humidity Sensor | AHU-3A Supply Air | 5 Minutes | 9807669 | Onset |
| 25 | Y | Temperature/Relative Humidity Sensor | AHU-3B Return Air | 5 Minutes | 9824692 | Onset |
| 26 | Z | Temperature/Relative Humidity Sensor | AHU-3B Mixed Air | 5 Minutes | 9807659 | Onset |
| 27 | AA | Temperature/Relative Humidity Sensor | AHU-3B Supply Air | 5 Minutes | 9807662 | Onset |
| 28 | BB | Watt Node (Watt Hour Meter) | AHU-3A Disconnect | 5 Minutes | 9835270 (1) | Continental Controls |
| 29 | CC | Watt Node (Watt Hour Meter) | AHU-3B Disconnect | 5 Minutes | 9819448 (1) | Continental Controls |
| 30 | DD | U-30 Datalogger (7) | Mech. 310 | 5 Minutes | 9836841 | Onset |
| 31 | EE | Temperature/Relative Humidity Sensor | ERU Exhaust Air Entering | 5 Minutes | 9807668 | Onset |
| 32 | FF | Temperature/Relative Humidity Sensor | ERU Exhaust Air Leaving | 5 Minutes | 9824698 | Onset |
| 33 | GG | Temperature/Relative Humidity Sensor | ERU Outside Air Entering | 5 Minutes | 9824707 | Onset |
| 34 | HH | Temperature/Relative Humidity Sensor | ERU Outside Air Leaving | 5 Minutes | 9824706 (11) | Onset |
| 35 | II | Watt Node (Watt Hour Meter) | ERU Disconnect | 5 Minutes | 10101872 (1) | Continental Controls |
| 36 | JJ | U-30 Datalogger (8) | Roof @ ERU | 5 Minutes | 9836844 | Onset |
| 37 | KK | Watt Node (Watt Hour Meter) | Mechanical Yard | 5 Minutes | 10101875 | Continental Controls |
| 38 | LL | U-30 Datalogger (9) | Mechanical Yard | 5 Minutes | 9824637 | Onset |
| 39 | MM | U-20 Water Level Logger | BH #1 Depth 200' from TOC (10) | 5 Minutes | 10137380 | Onset |
| 40 | NN | U-20 Water Level Logger | BH #2 Depth 150' from TOC (10) | 5 Minutes | 10121324 | Onset |
| 41 | OO | U-20 Water Level Logger | Existing Well Depth 150' from TOC (10) | 5 Minutes | NA | Onset |
| 42 | PP | TFX Ultrasonic Flow Meter | Main Chilled Water Piping (Breakroom) | 3 Minutes | NA | Dynasonic |
| 43 | QQ | TFX Ultrasonic Flow Meter | Main Hot Water Piping (Breakroom) | 3 Minutes | NA | Dynasonic |
| 44 | RR | Water Temperature Insertion Probe | Main Source Water Supply | 5 Minutes | NA | Omega |
| 45 | SS | Water Temperature Insertion Probe | Main Source Water Return | 5 Minutes | NA | Omega |
| 46 | TT | Watt Node (Watt Hour Meter) | Chiller modules #1-2-&3 | 5 Minutes | 10101874 (1) | Onset |
| 47 | UU | Watt Node (Watt Hour Meter) | Chiller modules #4 & 5 | 5 Minutes | 9812580 (1) | Onset |
| 48 | VV | Water Temperature Insertion Probe | Main Chilled Water Supply | 5 Minutes | NA | Omega |
| 49 | WW | Water Temperature Insertion Probe | Main Chilled Water Return | 5 Minutes | NA | Omega |
| 50 | XX | Water Temperature Insertion Probe | Main Hot Water Supply | 5 Minutes | NA | Omega |
| 51 | YY | Water Temperature Insertion Probe | Main Hot Water Return | 5 Minutes | NA | Omega |
| 52 | ZZ | Stainless Temp Sensor (Strapped onto Piping) | Main Chilled Water Supply (Breakroom) | 5 Minutes | 9900673 | Onset |
| 53 | AAA | Stainless Temp Sensor (Strapped onto Piping) | Main Chilled Water Return (Breakroom) | 5 Minutes | 10177404 | Onset |
| 54 | BBB | Stainless Temp Sensor (Strapped onto Piping) | Main Hot Water Supply (Breakroom) | 5 Minutes | 10177405 | Onset |
| 55 | CCC | Stainless Temp Sensor (Strapped onto Piping) | Main Hot Water Return (Breakroom) | 5 Minutes | 10177432 | Onset |
| 56 | DDD | Watt Node (Watt Hour Meter) | Main HVAC Breaker | 5 Minutes | 9819490 (1) | Onset |
| 57 | EEE | Watt Node (Watt Hour Meter) | Dry Coolers | 5 Minutes | NA | Onset |
| 58 | FFF | Water Temperature Insertion Probe | BTES bore field circuit well #1 East | 5 Minutes | NA | Omega |
| 59 | GGG | Water Temperature Insertion Probe | BTES bore field circuit well #1 West | 5 Minutes | NA | Omega |
| 60 | HHH | Water Temperature Insertion Probe | BTES bore field circuit well #2 East | 5 Minutes | NA | Omega |
| 61 | III | Water Temperature Insertion Probe | BTES bore field circuit well #2 West | 5 Minutes | NA | Omega |

**Table 5.9. MCLB BTES Demonstration System Monitoring Devices (Continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 62 | JJJ | Water Temperature Insertion Probe | BTES bore field circuit well #3 East | 5 Minutes | NA | Omega |
| 63 | KKK | Water Temperature Insertion Probe | BTES bore field circuit well #3 West | 5 Minutes | NA | Omega |
| 64 | LLL | Water Temperature Insertion Probe | Dry Cooler Common EWT | 5 Minutes | NA | Omega |
| 65 | MMM | Pressure Transducer | North BTES Header Pressure | 5 Minutes | NA | Omega |
| 66 | NNN | Pressure Transducer | South BTES Header Pressure | 5 Minutes | NA | Omega |
| 67 | OOO | Micro Lan Temperature Sensor | Outside Air Temperature | 5 Minutes | NA | Eze System |
| 68 | PPP | E-Mag Flow Meters | BTES Flow | 5 Minutes | NA | Onicon |
| 69 | QQQ | E-Mag Flow Meters | Source Flow | 5 Minutes | NA | Onicon |
| 70 | RRR | Temperature Well Water Temp Sensor | Dry Cooler Common Outlet Temperature | 5 Minutes | NA | BAPI |
| 71 | SSS | Temperature Well Water Temp Sensor | BTES Supply | 5 Minutes | NA | BAPI |
| 72 | TTT | Temperature Well Water Temp Sensor | BTES Return | 5 Minutes | NA | BAPI |
| 73 | UUU | Temperature Well Water Temp Sensor | Dry Cooler Common Inlet Temperature | 5 Minutes | NA | BAPI |
| 74 | VVV | Charging Discharging Status | BTES Reversing Valves & DC Valve | COV | NA | NA |
| 75 | WWW | Watt Node (Watt Hour Meter) | Source Water Pumps | 5 Minutes | 10101875 (1) | Onset |
| 76 | XXX | Watt Node (Watt Hour Meter) | BTES Pumps | 5 Minutes | 10101876 (1) | Onset |
| | | | | | | |
| | Notes: | (1) Serial # references the pulse adapter from the watt hour meter to the logger. | | | | |

### 5.5.1 Calibration of Equipment:

The instrumentation used to collect the data samples were off the shelf sensors and data loggers. AH&P verified the calibration of the off the shelf devices using handheld NIST calibrated instruments. AH&P is certified by NEBB for Testing, Adjusting, and Balancing (TAB), Retro Commissioning (RCx), and Commissioning (Cx) of HVAC systems, and therefore keeps a complete set of calibrated instruments on the shelf as required by NEBB for field verification of sensors. AH&P maintains calibration of the set of shelf instruments annually per NEBB's procedural standards for the disciplines we are certified in.

### 5.5.2 Quality Assurance Samples:

As stated above AH&P verified the accuracy of the sensors and data loggers using handheld NIST traceable calibrated instruments in accordance with the NEBB Procedural Standards. In addition to this, multiple points were sampled in several different locations and with different logging equipment. For example, the BTES supply and return temperature was recorded using immersion sensors connected to a standalone datalogger. In addition to this the BTES supply and return temperature was also recorded using the building automation system. Another example of quality assurance sampling is that the chilled and hot water supply and return temperatures were monitored by sensors connected to data loggers in the mechanical room, and was also monitored by sensors connected to a data logger located in the break room. The chilled and hot water flows were recorded by flow meters connected to stand alone data loggers located in the break room, and was also recorded by flow meters connected to the Building Automation System.

## 5.6 SAMPLING RESULTS

The data recorded in the pre-demonstration and the demonstration period resulted in literally millions of data points that were analyzed using standard computer programs such as Onset Hoboware, Microsoft Excel, and Microsoft Access. The data files were required to be split up monthly to keep the file size down, and the results were compiled into a summary spreadsheet. In addition to the logged data, historical weather data was compared for each site location for both the pre-demonstration and the demonstration period. The below graphs are used to show the results of each point that was monitored in terms of both spatial and temporal dependence.

### 5.6.1 MCLB Bldg. 3700 BTES Baseline Period Data Graphs

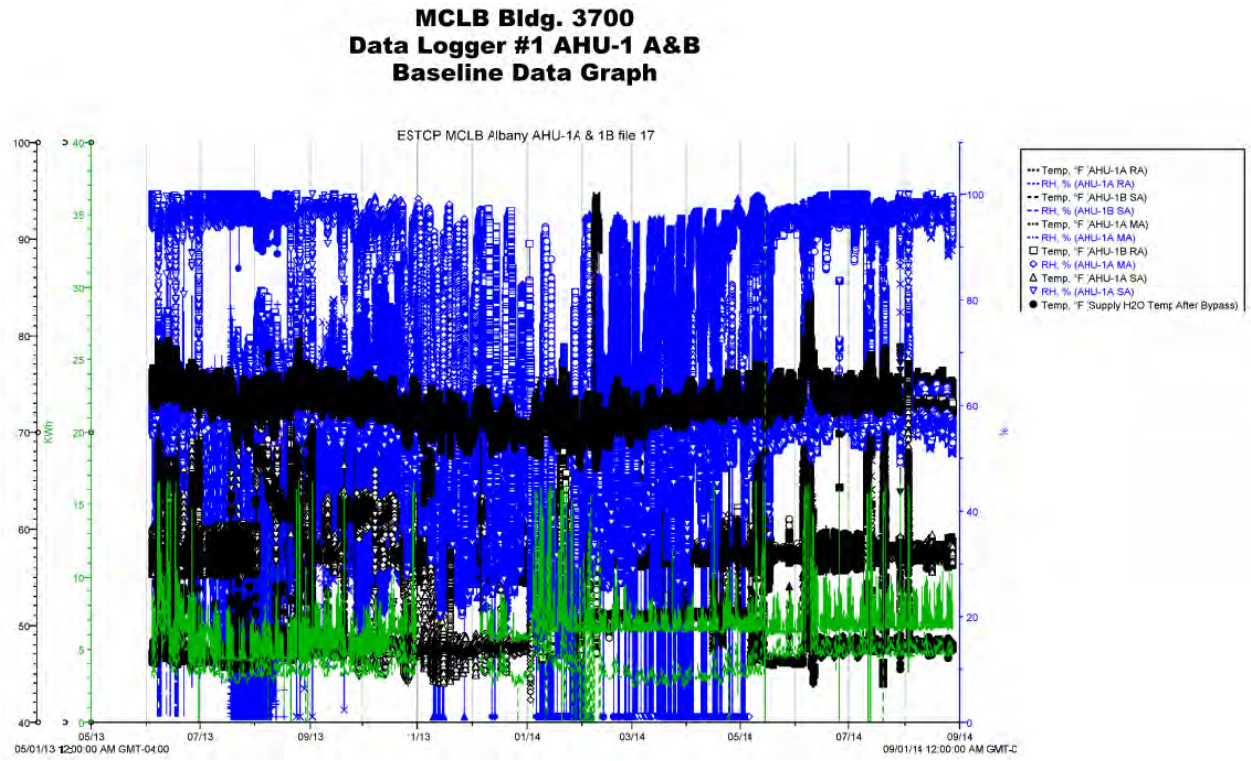


**Figure 5.7. MCLB BTES AHU-1 A&B Baseline Data Graph**

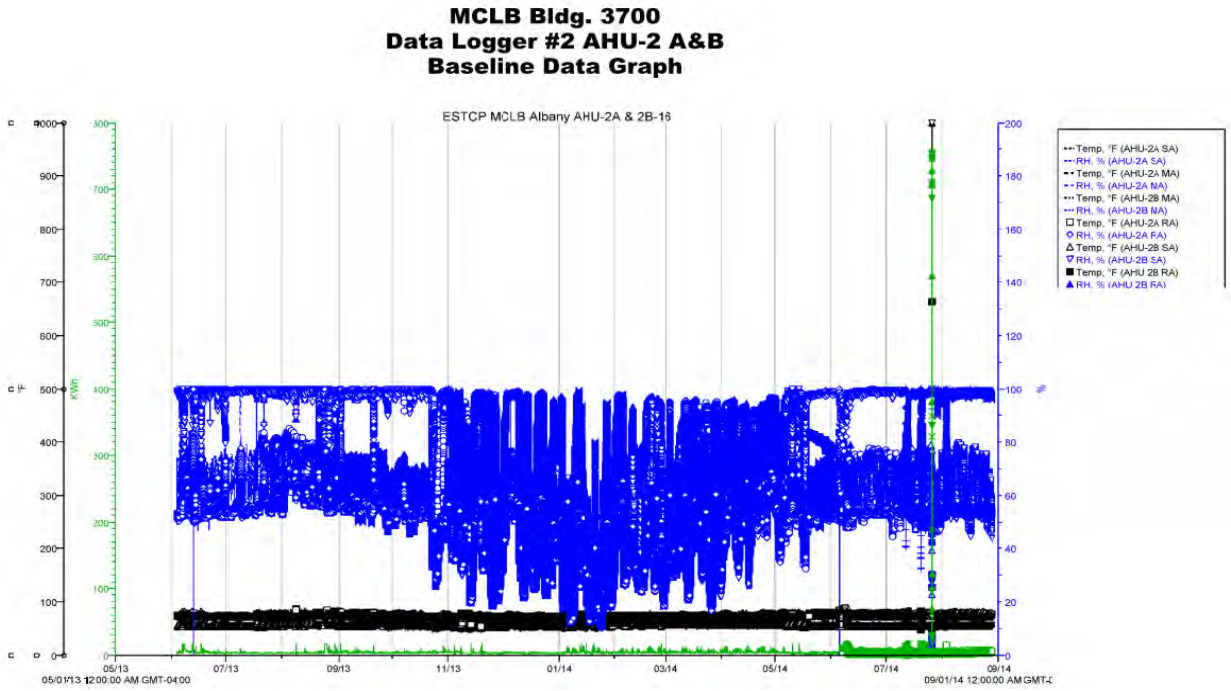


**Figure 5.8. MCLB BTES AHU-2 A&B Baseline Data Graph**

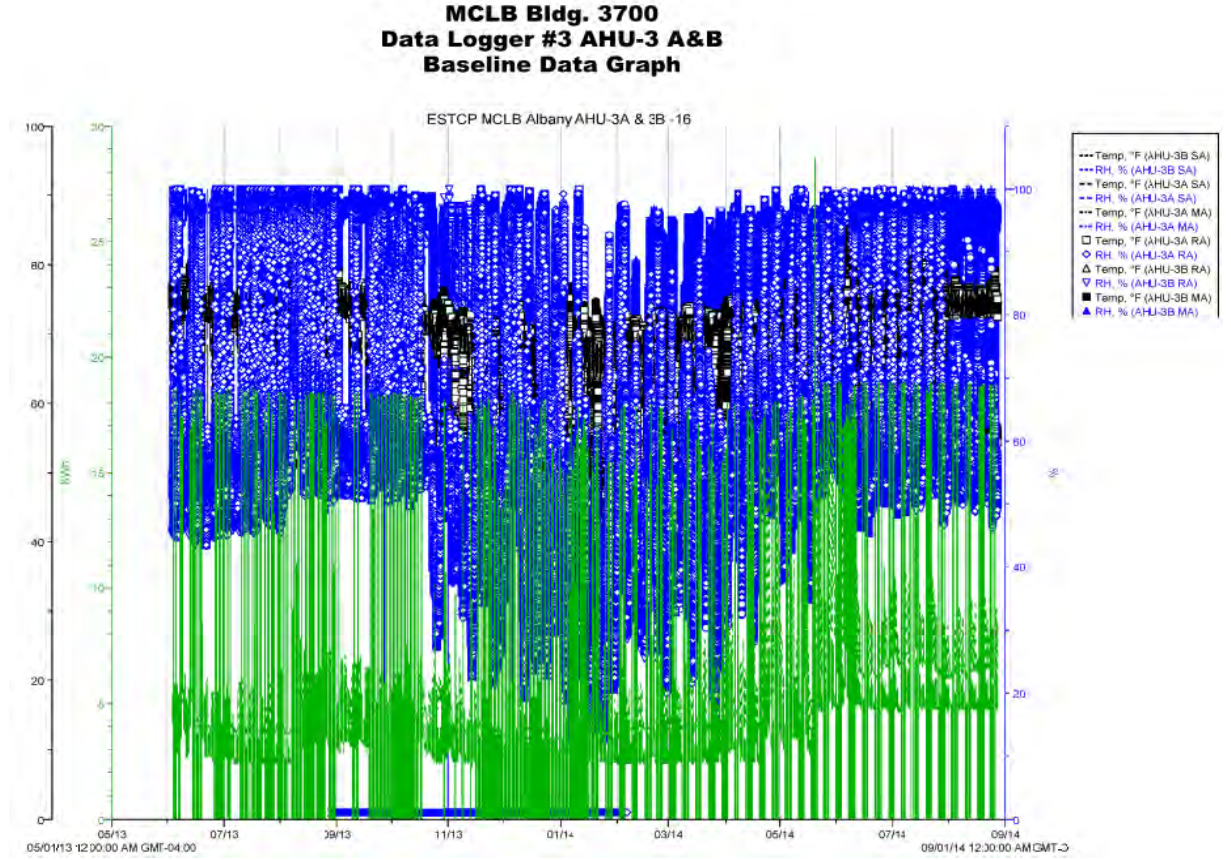


**Figure 5.9. MCLB BTES AHU-3 A&B Baseline Data Graph**

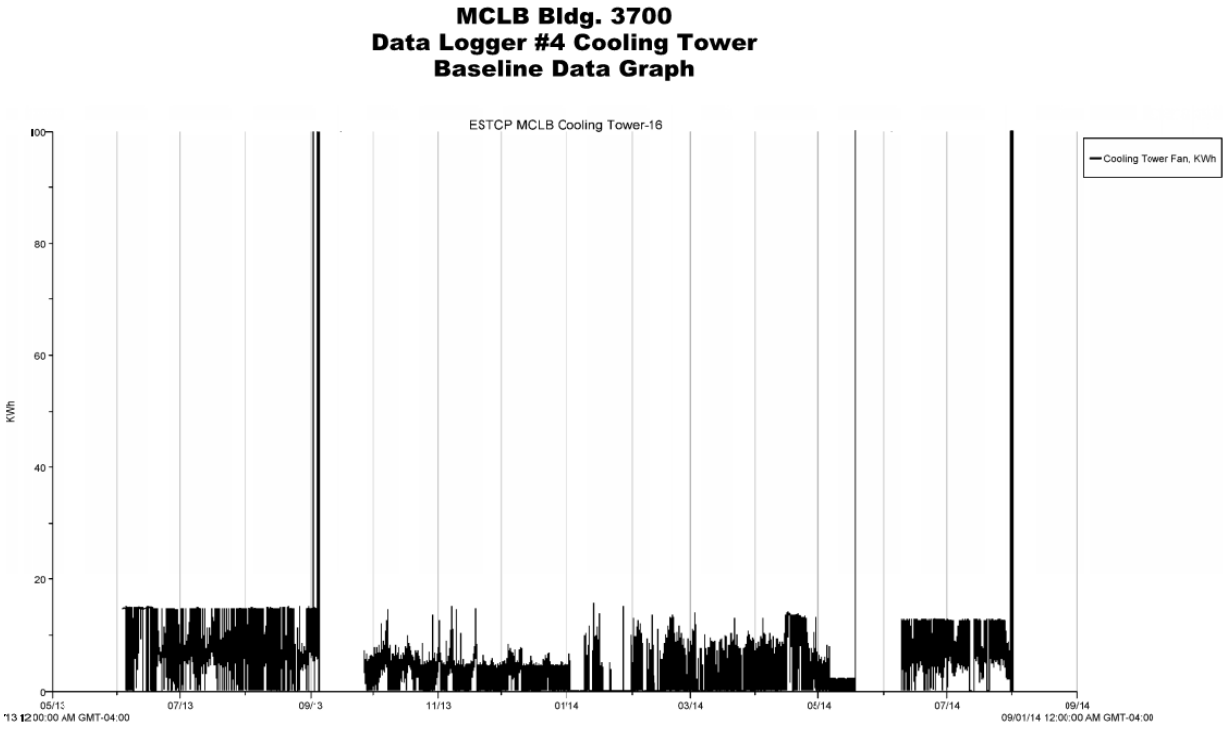


**Figure 5.10. MCLB BTES Cooling Tower Baseline Data Graph**

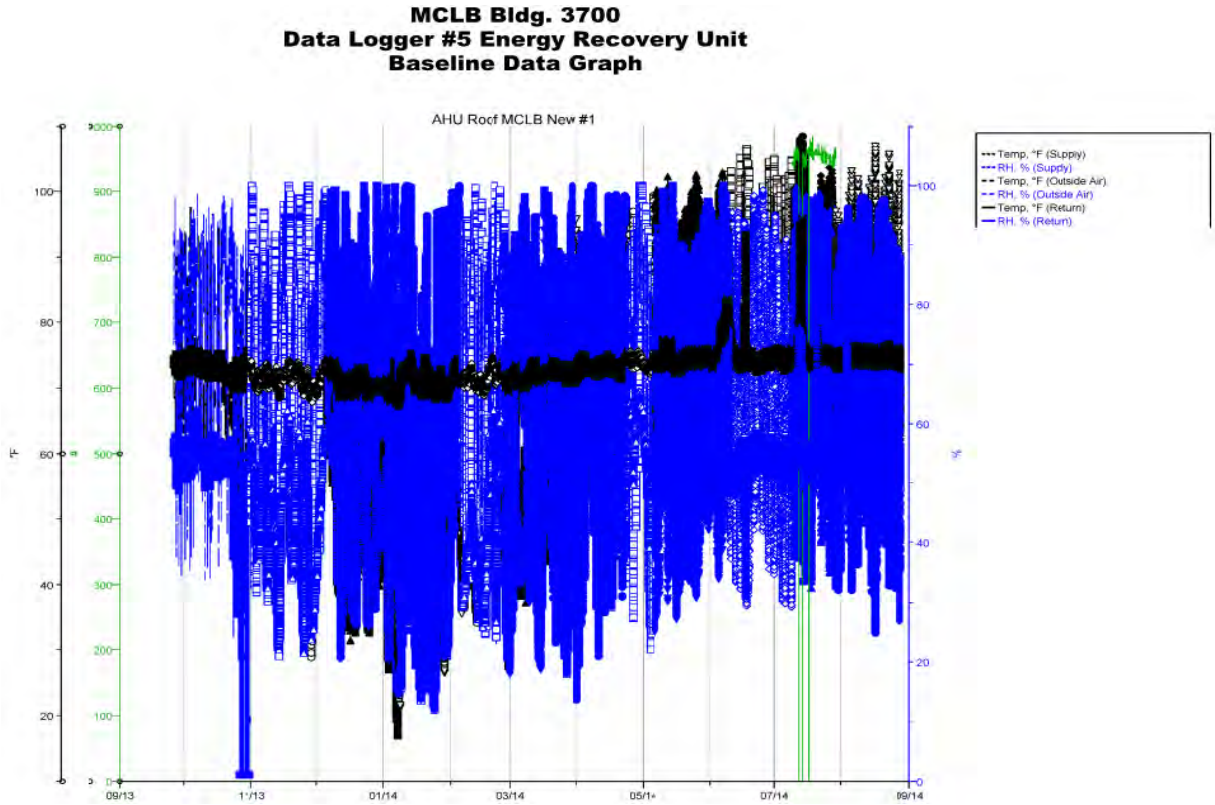


**Figure 5.11. MCLB BTES Energy Recovery Unit Baseline Data Graph**

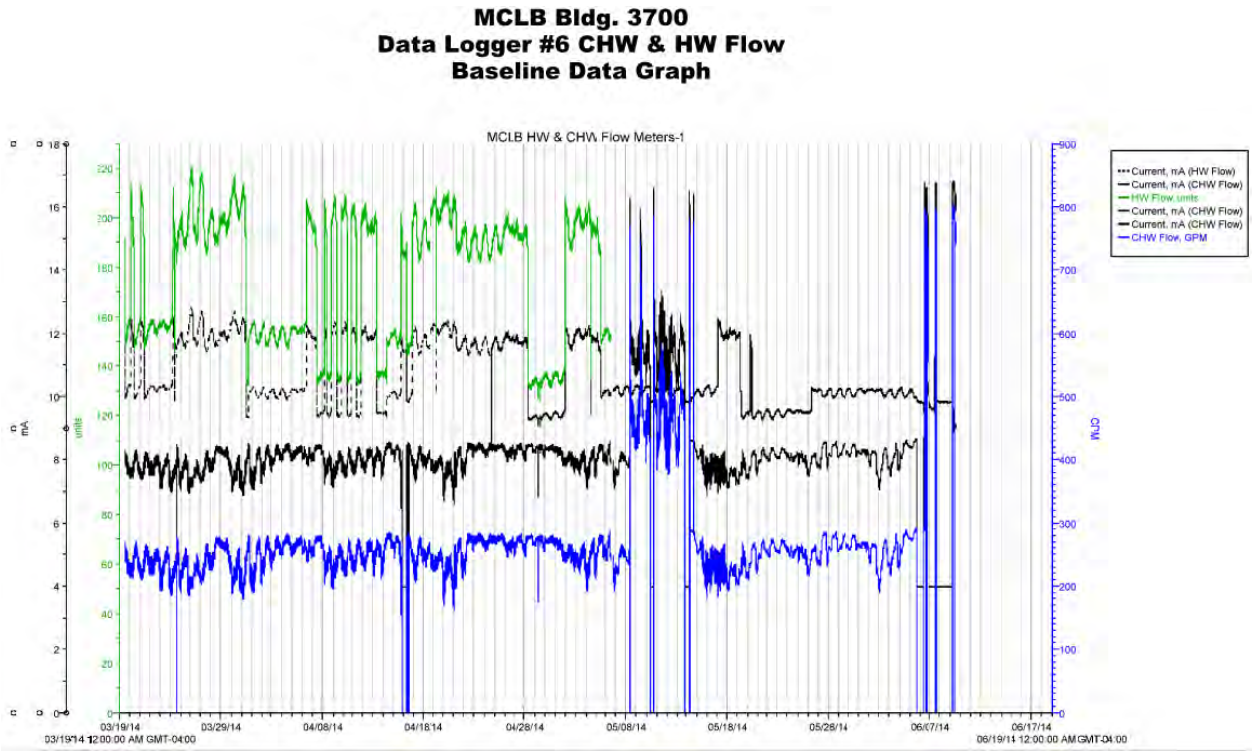


**Figure 5.12. MCLB BTES CHW & HW Flow Baseline Data Graph**

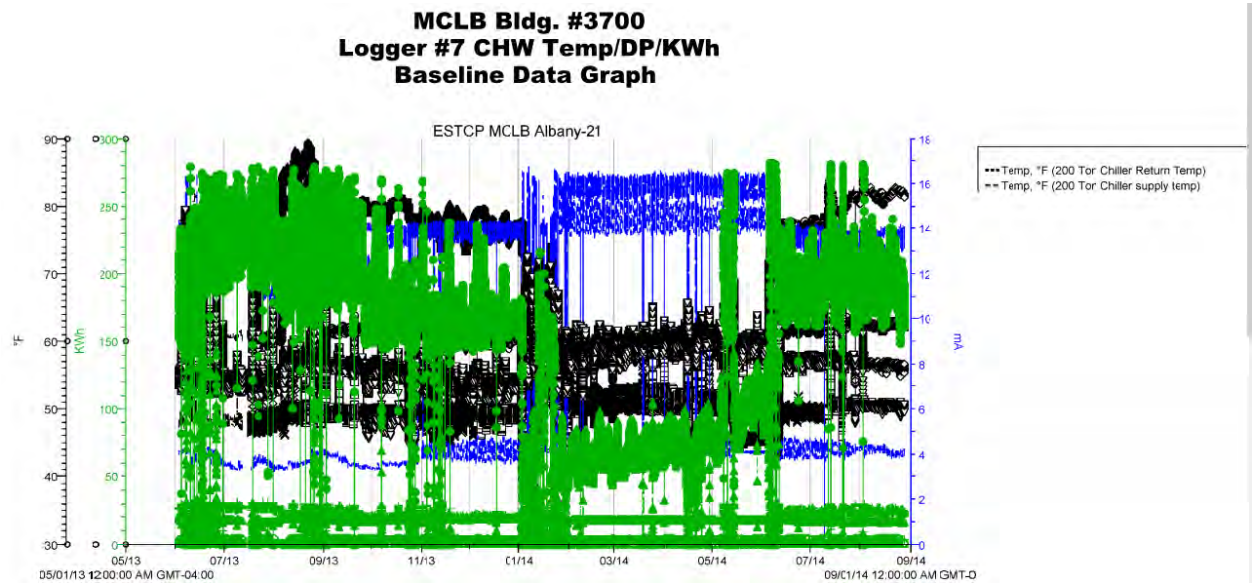


**Figure 5.13. MCLB BTES CHW Temp/Pump DP/Pump KW Baseline Data Graph**

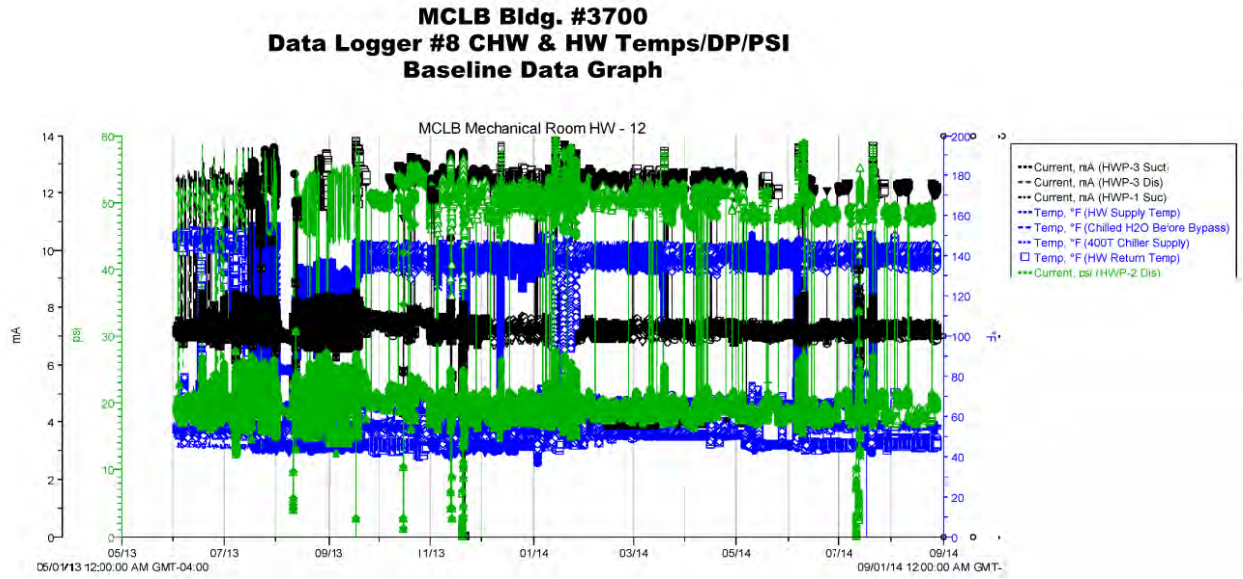


**Figure 5.14. MCLB BTES CHW & HW Temps/Pump DP Baseline Data Graph**

## 5.6.2 MCLB Bldg. 3700 BTES Demonstration Period Data Graphs

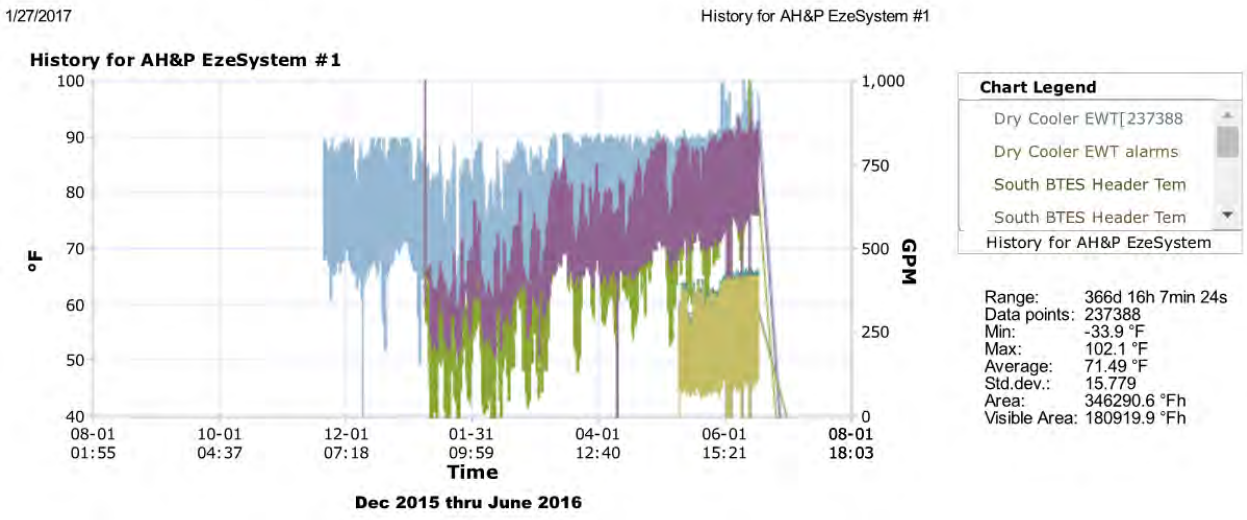


**Figure 5.15. MCLB BTES North & South Header Temps/BTES & Source Flow Demonstration Data Graph**

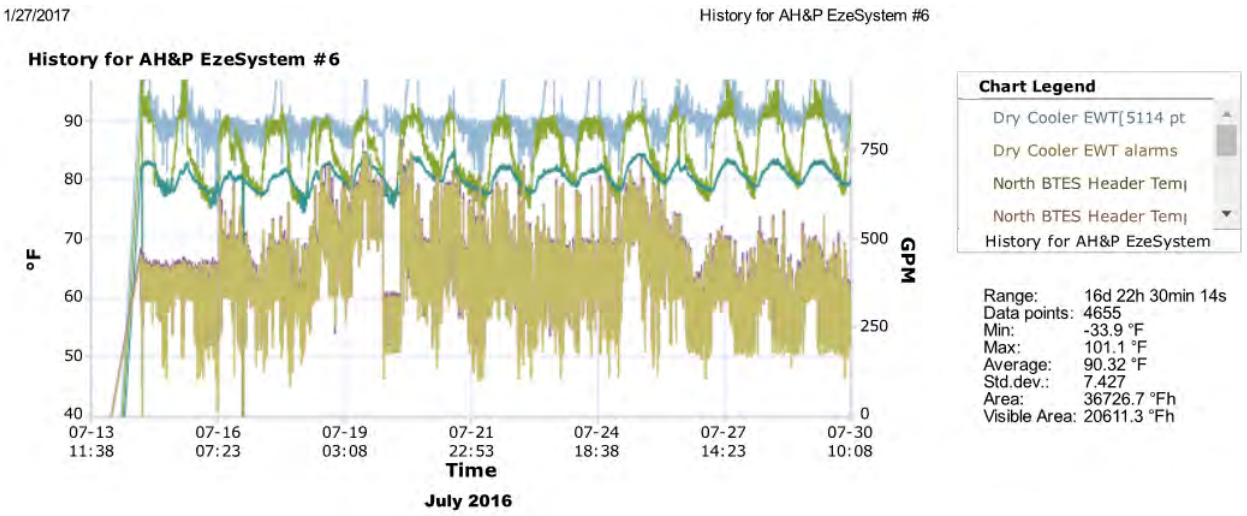


**Figure 5.16. MCLB BTES North & South Header Temps/BTES & Source Flow Demonstration Data Graph (July 2016)**

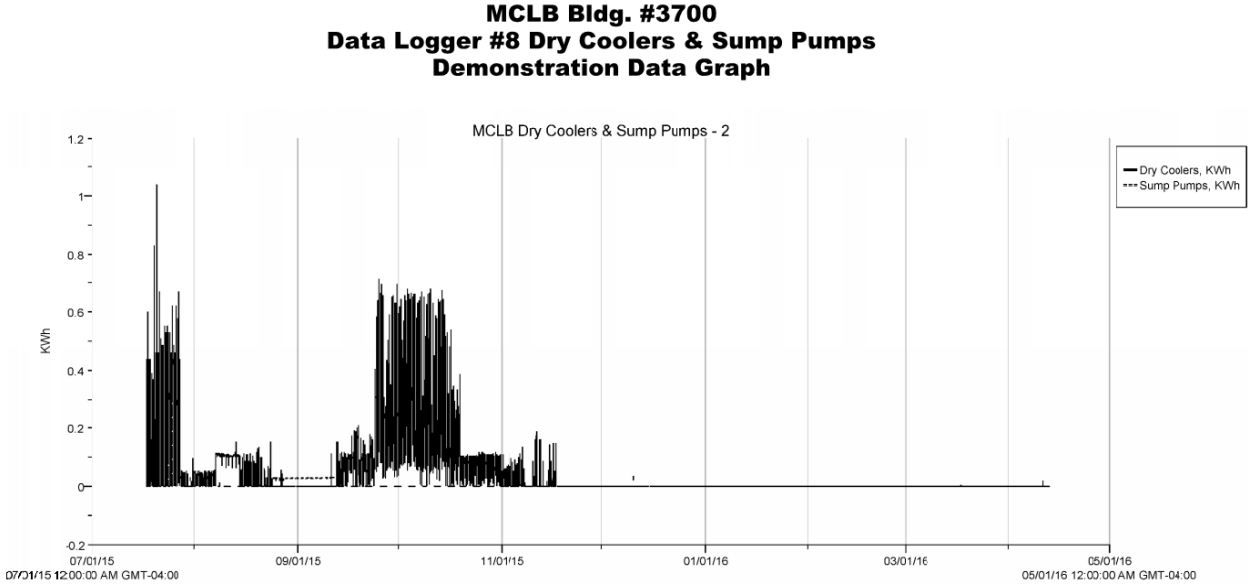


**Figure 5.17. MCLB BTES Dry Coolers and Sump Pumps Demonstration Data Graph**

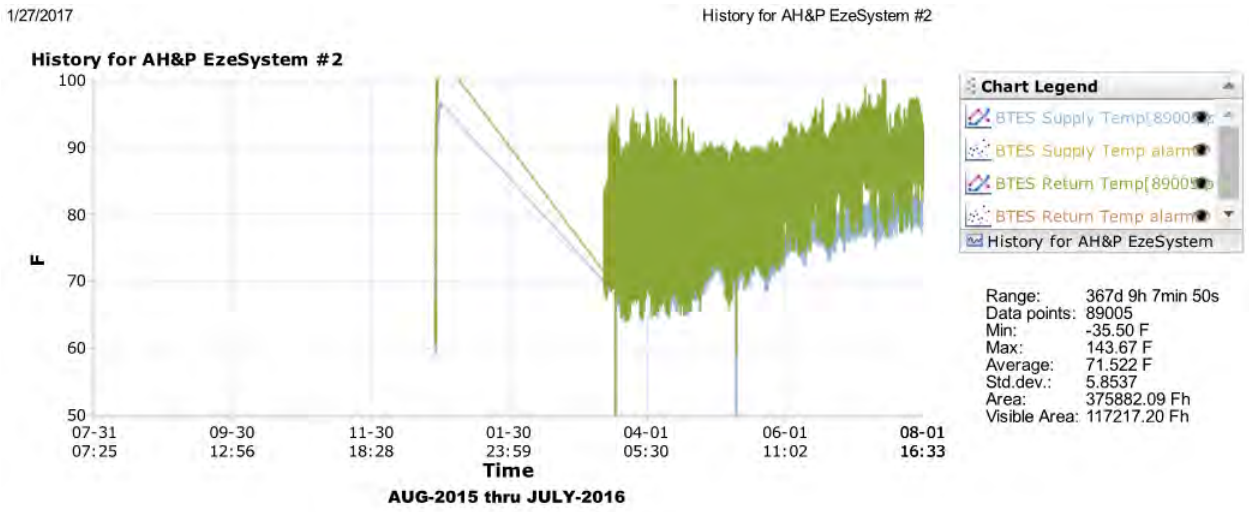


**Figure 5.18. MCLB BTES Supply and Return Temps Demonstration Data Graph**

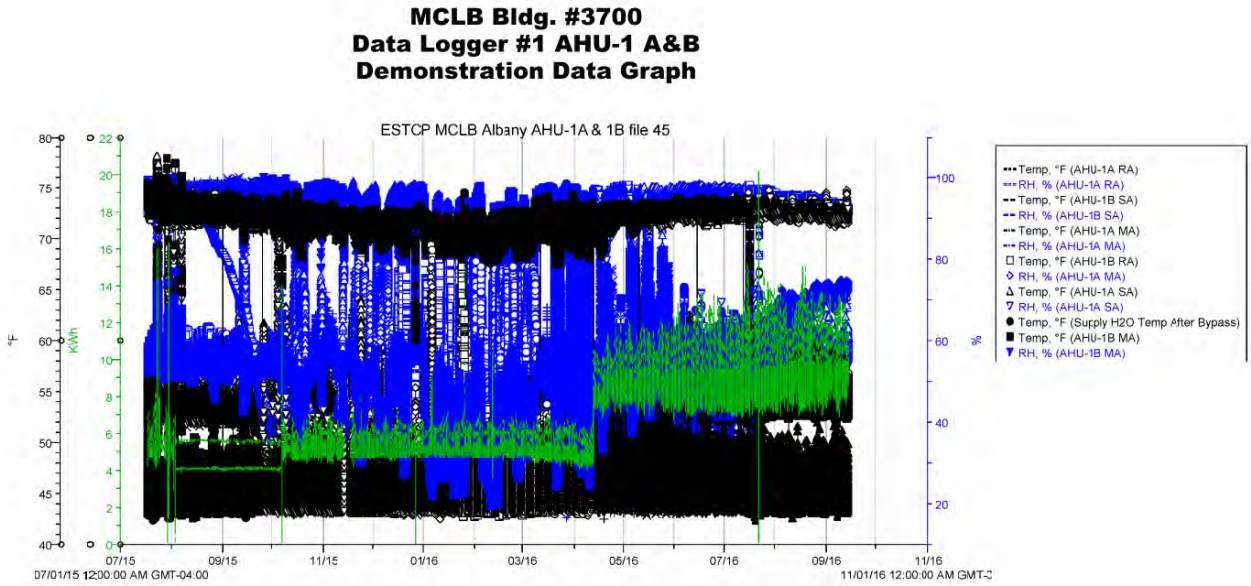


**Figure 5.19. MCLB BTES AHU-1 A&B Demonstration Data Graph**

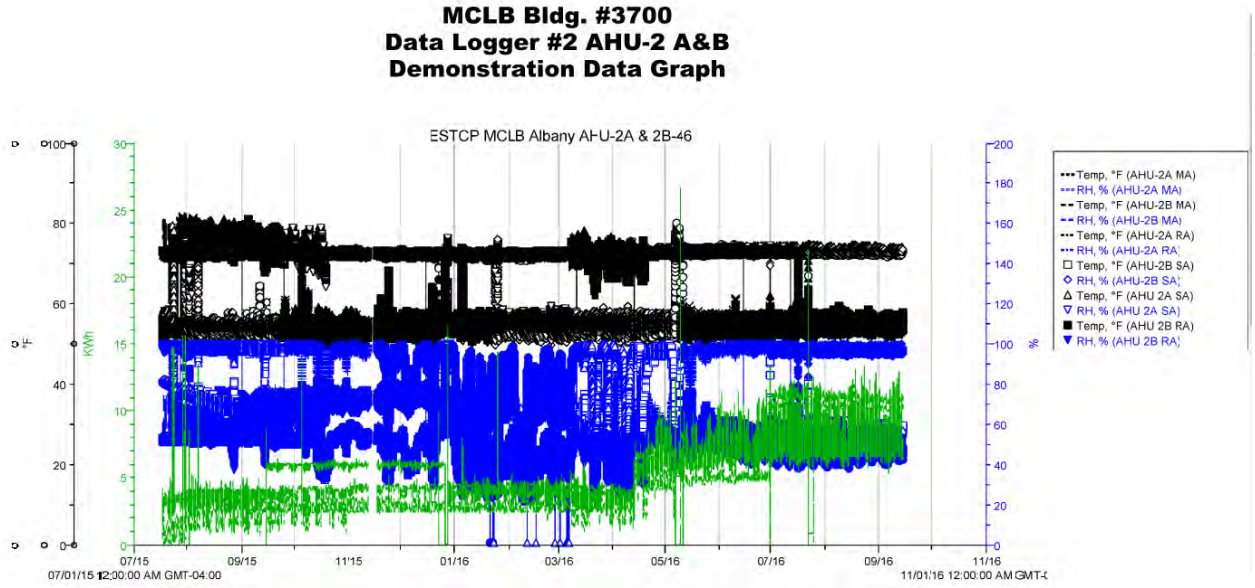


**Figure 5.20. MCLB BTES AHU-2 A&B Demonstration Data Graph**

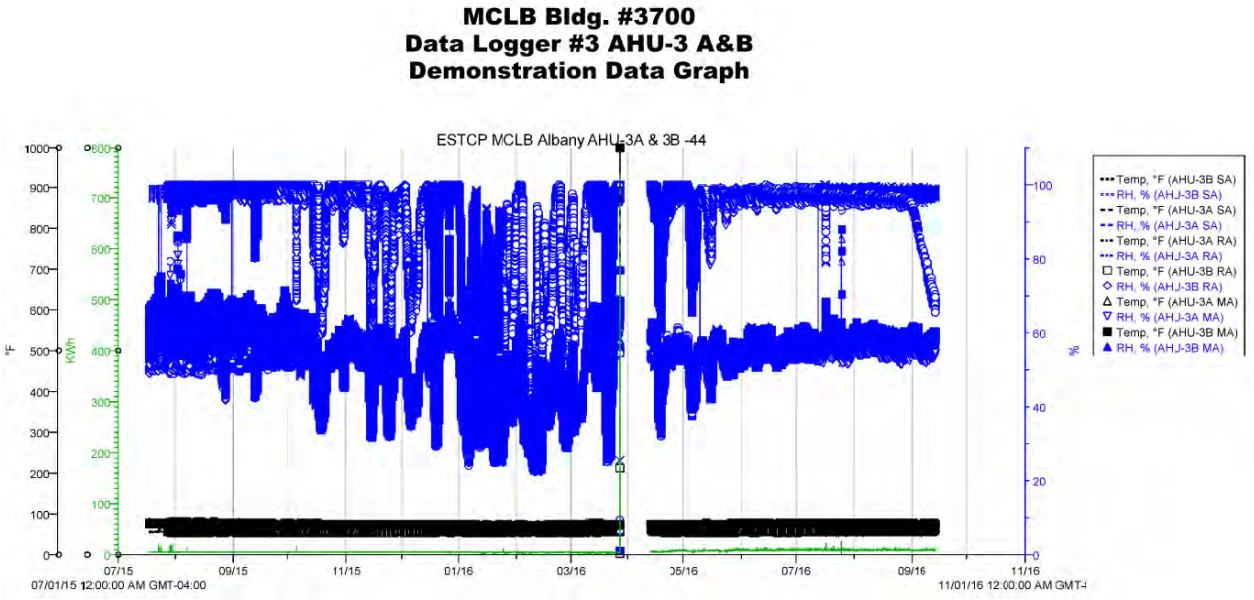


**Figure 5.21. MCLB BTES AHU-3 A&B Demonstration Data Graph**

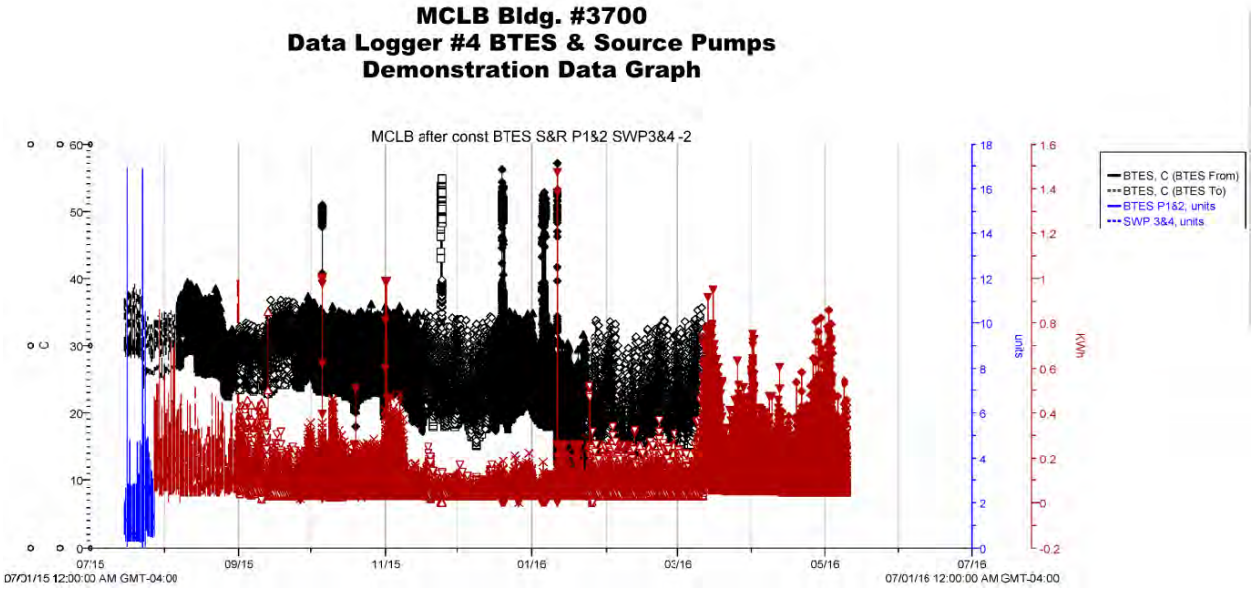


**Figure 5.22. MCLB BTES and Source Pumps Demonstration Data Graph**

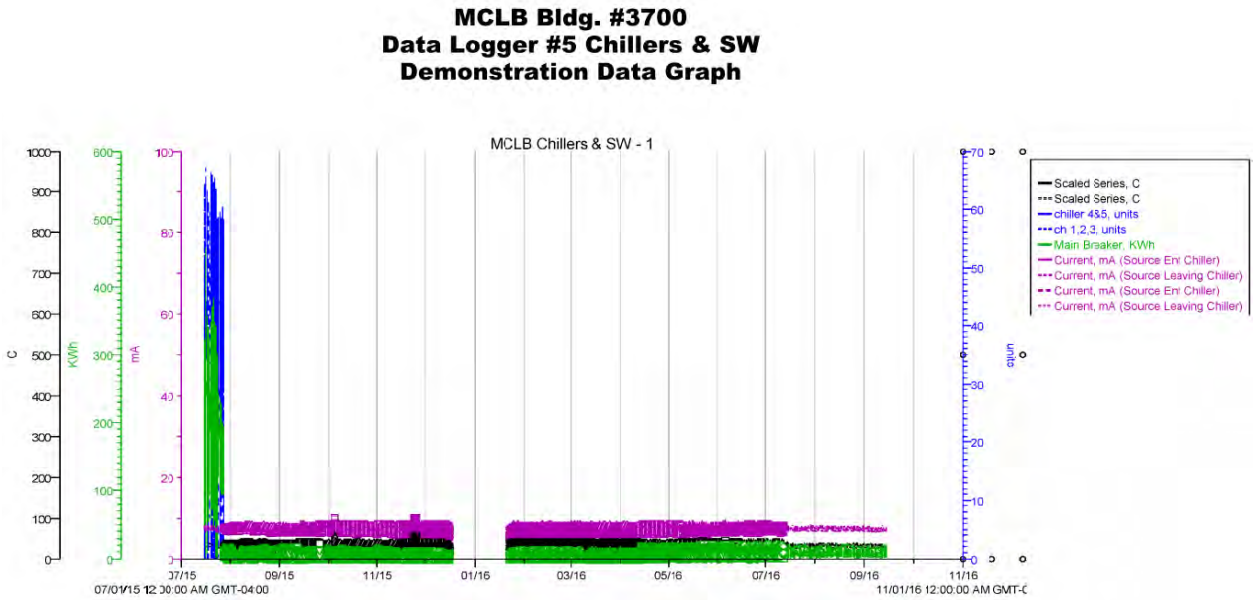


**Figure 5.23. MCLB BTES Chillers/Main Breaker/Source Temps Demonstration Data Graph**

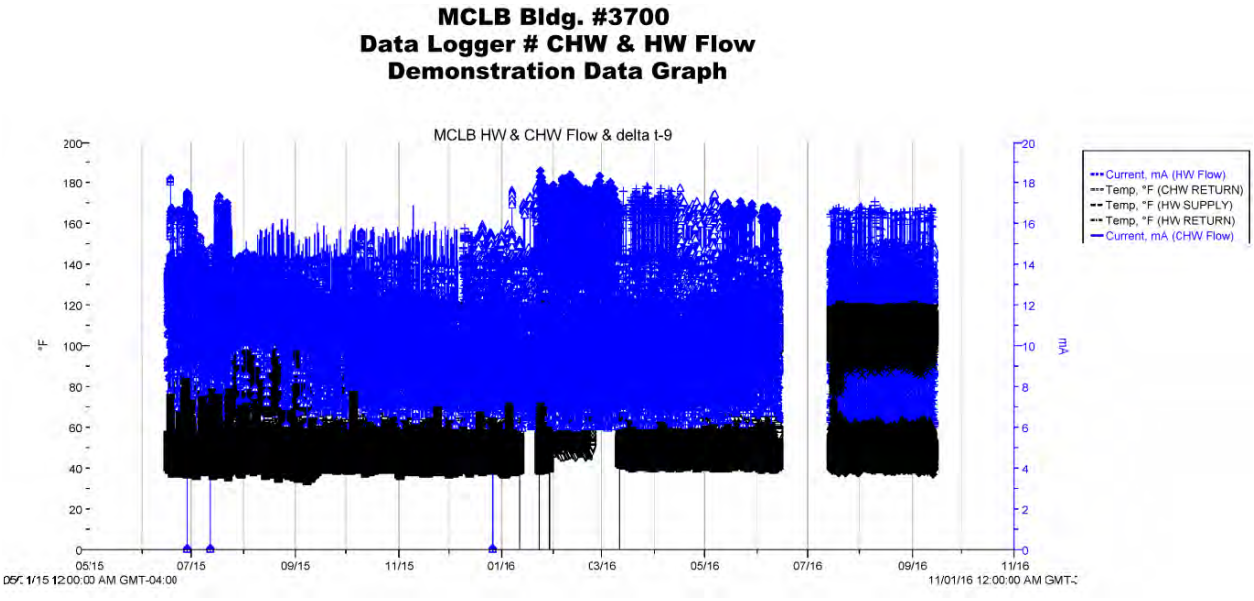


**Figure 5.24. MCLB BTES Chilled and Hot Water Flow Demonstration Data Graph**

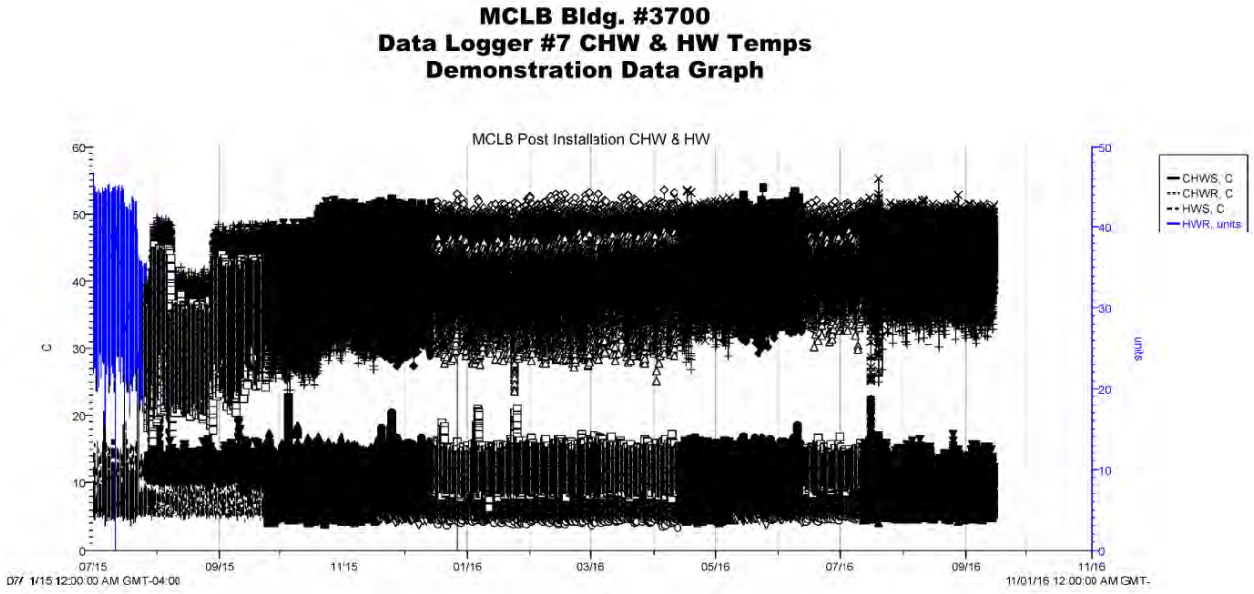


**Figure 5.25. MCLB BTES Chilled and Hot Water Temps Demonstration Data Graph**

### 5.6.3 Ft Benning Bldg. 3215 ATES Pre-Demonstration Period Data Graphs

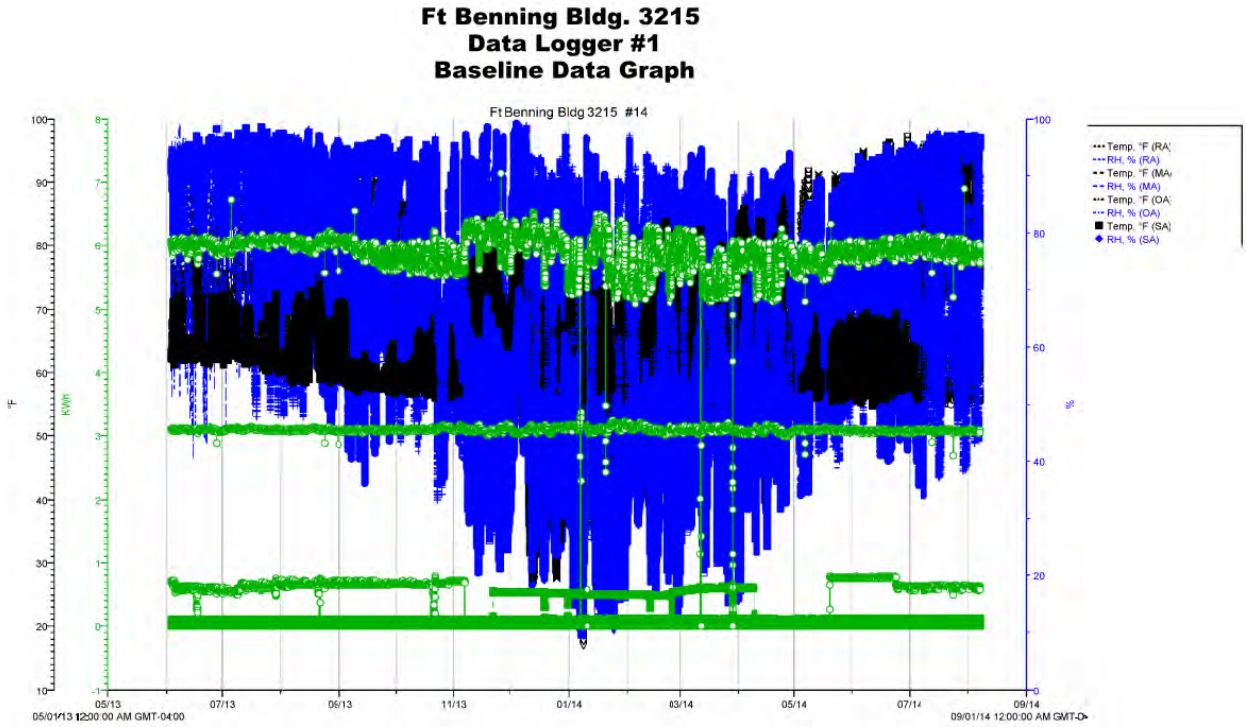


**Figure 5.26. Fort Benning Datalogger #1 Baseline Data Graph**

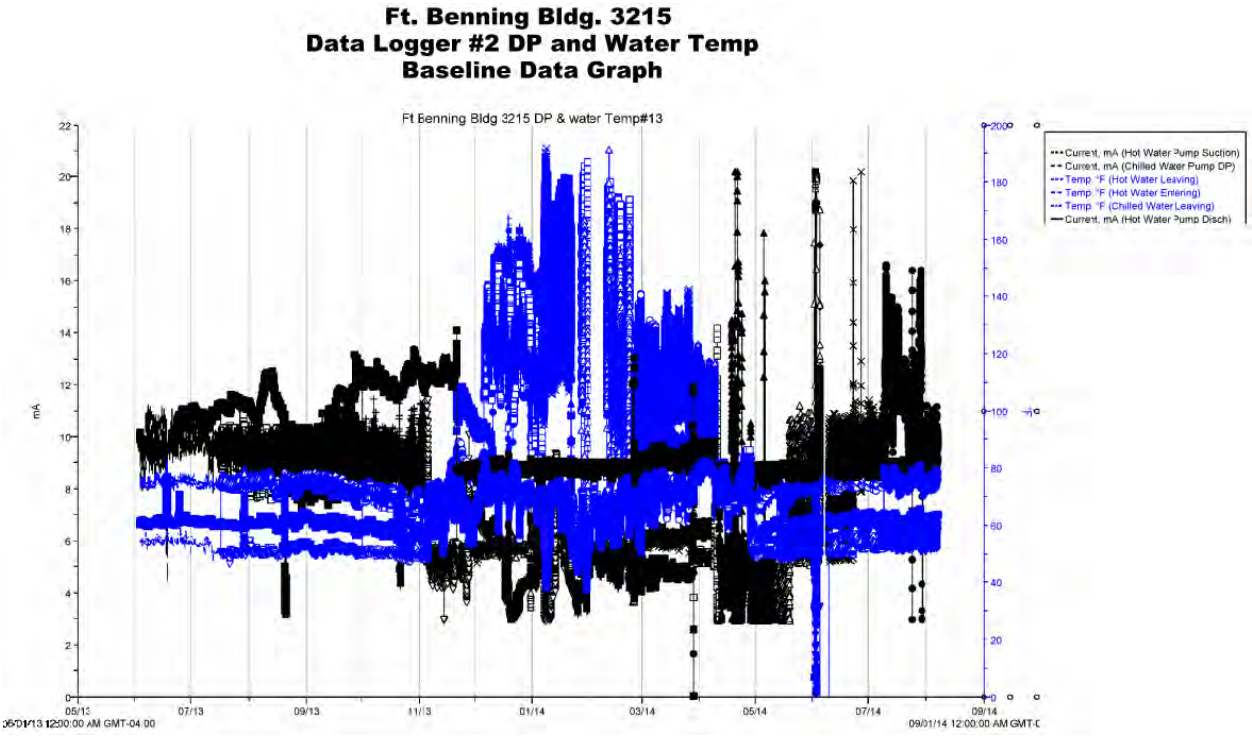


**Figure 5.27. Fort Benning Datalogger #2 Baseline Data Graph**

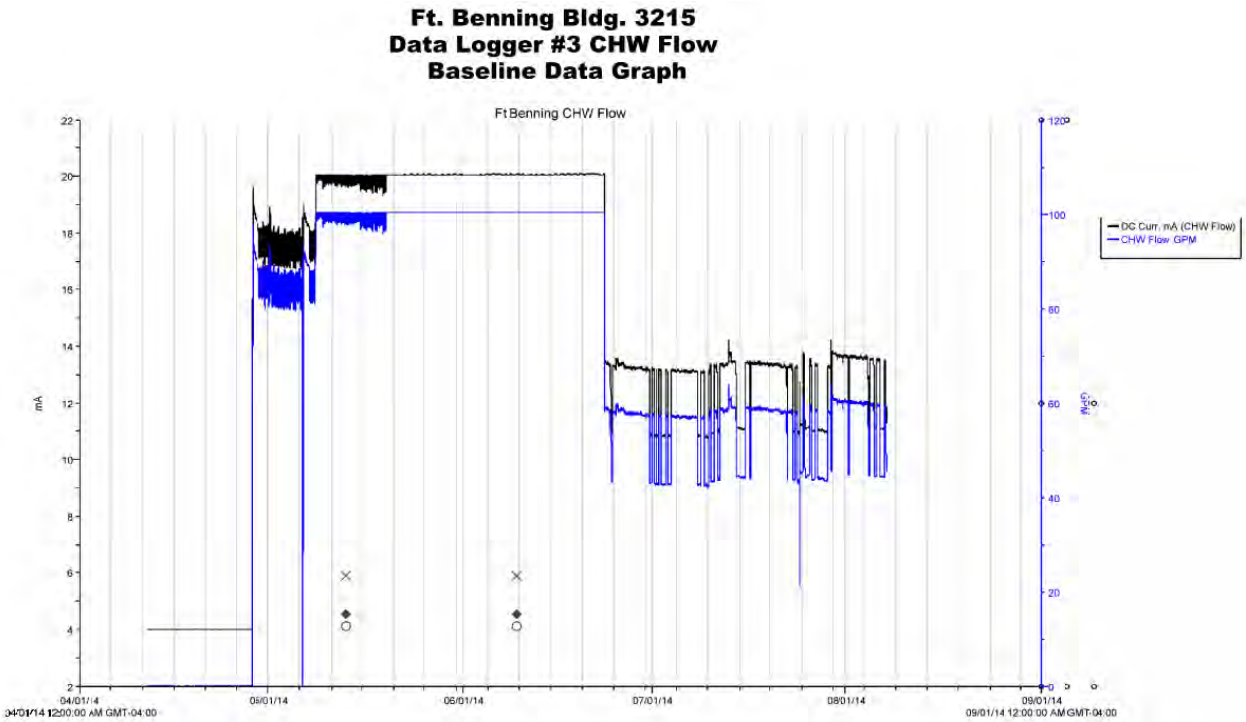


**Figure 5.28. Fort Benning Datalogger #3 Baseline Data Graph**

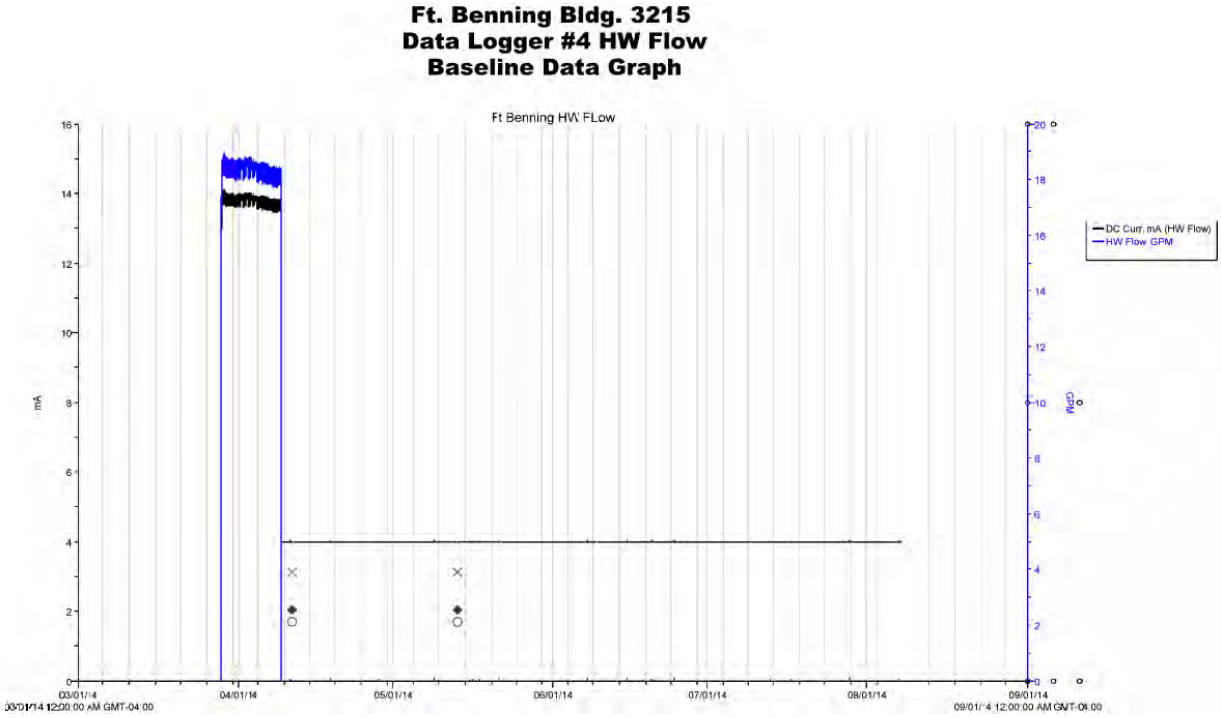


**Figure 5.29. Fort Benning Datalogger #4 Baseline Data Graph**

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# 6.0 PERFORMANCE ASSESSMENT

Data analysis was conducted in support of each performance objective listed in Section 3.0. The analysis process varied amongst each performance objective as some objectives involved recorded data comparison while some objectives involved both recorded and modeled data. Applicable energy modeling energy consumption output reports are included as part of Appendix J.

The following information provides a summary of the analysis completed for each performance objective.

### 6.1.1 Quantitative Performance Objectives:

1. **Performance Objective: Reduction in Energy Consumption vs. Conventional HVAC**

   The first quantitative performance objective is to evaluate the energy consumption of each GHP-USTES system when compared to a conventional HVAC system. The existing HVAC system operating at MCLB prior to the demonstration installation was considered a conventional HVAC system consisting of chillers, cooling towers, boilers, Central AHUs (equipped with chilled water coils) and VAV boxes (equipped with hot water coils), which is a typical application for large commercial buildings.

   The existing HVAC system at Fort Benning is an outdated HVAC system, which was used more often in the past, but is still considered a conventional HVAC system. The existing system utilized a multi-zone AHU equipped with both a chilled water coil (cold deck) and hot water coil (hot deck), which provides air to various thermal zones in B3215 using zone dampers. The chilled water for this building was produced using large centrifugal chillers and cooling towers at a central plant location, while the heating hot water was generated by a natural gas hot water boiler located in the building's mechanical room.

   As described in Section 5.5, many performance conditions were monitored and recorded at each demonstration site. The existing HVAC system at both sites are used as the baseline system utilized for each of their respective performance objective analysis. For the BTES system, over a year's worth of data was recorded for both the baseline and demonstration systems. The data recorded for each system was used for the comparison required of this performance objective. For the ATES system, over a year's worth of data was recorded for the baseline system. However, due to implementation issues described in Section 8.0, the ATES demonstration system is currently being constructed at the submission of this report. To complete the analysis required of this performance objective, the recorded data from the baseline system will be compared against estimated energy consumption expected from the ATES system.

   Analysis of the energy consumption comparison between the baseline system and BTES system consisted of totalizing a year's worth of recorded data at each of the locations illustrated in Section 5.5. From this analysis, annual energy consumption for each system was calculated. Electrical consumption of the baseline system was recorded at all HVAC equipment affected by the installation of the BTES system even if it was not replaced during the demonstration system installation.

For instance, while the central VAV AHUs were not replaced, fan energy of each AHU was recorded for the baseline system and the BTES system to determine if their operation was affected. For the natural gas consumption of the baseline system's condensing boiler, there was no convenient way to record gas consumption directly for the building. Therefore, the output of the heating hot water system was recorded and used in conjunction with boiler efficiency to calculate natural gas input.

Table 6.1 and 6.2 summarizes the energy consumption for the baseline and BTES demonstration system. From this analysis, it was determined that the BTES demonstration exceeded the requirement of this performance objective.

**Table 6.1. Baseline vs. BTES HVAC Monthly Energy Consumption**

| MCLB – B3700 – Baseline vs. BTES Monthly HVAC Energy Consumption Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Baseline HVAC Energy Consumption** | | | | **BTES HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** | **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug-2013 | 231,275 | 1,565 | 945,595 | Aug-2015 | 200,053 | 0.00 | 682,579 |
| Sep-2013 | 227,158 | 2,895 | 1,064,568 | Sep-2015 | 163,092 | 0.00 | 556,472 |
| Oct-2013 | 269,354 | 3,339 | 1,252,967 | Oct-2015 | 135,746 | 0.00 | 463,164 |
| Nov-2013 | 188,771 | 4,412 | 1,085,237 | Nov-2015 | 136,036 | 0.00 | 464,153 |
| Dec-2013 | 196,832 | 4,671 | 1,138,661 | Dec-2015 | 131,037 | 0.00 | 447,098 |
| Jan-2014 | 94,510 | 3,492 | 671,716 | Jan-2016 | 128,920 | 0.00 | 439,875 |
| Feb-2014 | 97,758 | 3,669 | 700,487 | Feb-2016 | 117,327 | 0.00 | 400,318 |
| Mar-2014 | 109,705 | 4,152 | 789,550 | Mar-2016 | 121,041 | 0.00 | 412,993 |
| Apr-2014 | 112,219 | 3,121 | 695,005 | Apr-2016 | 115,022 | 0.00 | 392,455 |
| May-2014 | 146,426 | 3,178 | 817,442 | May-2016 | 126,186 | 0.00 | 430,546 |
| Jun-2014 | 191,154 | 2,390 | 891,233 | Jun-2016 | 154,984 | 0.00 | 528,806 |
| Jul-2014 | 200,423 | 2,558 | 939,643 | Jul-2016 | 161,064 | 0.00 | 549,550 |
| | | | | | | | |
| Total: | 2,065,586 | 39,443 | 10,992,103 | Total: | 1,690,506 | 0.00 | 5,768,008 |

**Table 6.2. Baseline vs. BTES HVAC Energy Consumption Summary**

| MCLB – Albany, GA – B3700<br>Baseline vs. BTES HVAC Energy Consumption Summary | | | |
|---|---|---|---|
| **08/01/2013 thru 07/31/2014** | | **08/01/2015 thru 07/31/2016** | |
| **Centrifugal Chiller/Boiler** | | **BTES** | |
| Electrical Consumption (kWh) | 2,065,586 | Electrical Consumption (kWh) | 1,690,506 |
| Gas Usage (Therms) | 39,443 | Gas Usage (Therms) | 0.00 |
| | | | |
| Total Consumption (kBTU) | 10,992,103 | Total Consumption (kBTU) | 5,768,008 |
| | | | |
| Building Area (sq. ft.) | 168,138 | Building Area (sq. ft.) | 168,138 |
| HVAC kBTU/sq. ft. | 65.38 | HVAC kBTU/sq. ft. | 34.30 |
| | | | |
| | | **Energy Consumption Savings (kBtu)** | **5,224,095** |
| | | **Energy Consumption Savings (%)** | **47.5%** |

Analysis between the baseline system's energy consumption and the estimated ATES system's energy consumption consisted of totalizing a year's worth of recorded data at each of the locations illustrated in Section 5.5 and comparing that analysis against estimated energy consumption of the ATES system.

From this analysis, annual energy consumption for each system was calculated. Baseline electrical consumption in B3215's mechanical room was recorded at all HVAC equipment affected by the installation of the ATES system. Since the existing HVAC system at Benning-B3215 depends upon a central plant chilled water system to provide 44°F chilled water, there was no direct method of recording electrical energy consumption at the central plant location for the purposes of determining the electrical energy consumption dedicated to B3215's operation. As an alternate, the chilled water central plant equipment was evaluated and an equivalent central plant kW per chilled water ton (building cooling coil load) was calculated based on equipment literature and capacities. For the natural gas consumption of the baseline system's boiler, there was no convenient way to record gas consumption directly for the building. Therefore, the output of the heating hot water system was recorded and used in conjunction with boiler efficiency to calculate natural gas input.

From this analysis, annual energy consumption for each system was calculated/ estimated. Table 6.3, 6.4 and 6.5 summarizes the energy consumption for the baseline and ATES demonstration system. From this analysis, it was determined that the ATES demonstration is expected to exceed this performance objective.

**Table 6.3. Baseline Monthly HVAC Energy Consumption**

| Fort Benning – B3215 –Baseline HVAC Monthly Energy Consumption Summary | | | |
|---|---|---|---|
| **Baseline HVAC Actual Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug-2013 | 12,252 | 0.00 | 41,804 |
| Sep-2013 | 12,941 | 0.00 | 44,155 |
| Oct-2013 | 15,130 | 0.00 | 51,624 |
| Nov-2013 | 8,836 | 124 | 42,548 |
| Dec-2013 | 7,262 | 407 | 65,478 |
| Jan-2014 | 6,277 | 518 | 73,217 |
| Feb-2014 | 6,257 | 305 | 51,850 |
| Mar-2014 | 6,790 | 41 | 27,267 |
| Apr-2014 | 7,056 | 18 | 25,875 |
| May-2014 | 17,040 | 0.00 | 58,140 |
| Jun-2014 | 13,540 | 0.00 | 46,200 |
| Jul-2014 | 14,011 | 0.00 | 47,806 |
| Total: | 127,392 | 1,413 | 575,964 |

**Table 6.4. Estimated ATES Annual HVAC Energy Consumption**

| ESTIMATED ELECTRIC CONSUMPTION FOR ATES | | | | | | |
|---|---|---|---|---|---|---|
| **HVAC EQUIPMENT** | **QTY** | **SIZE** | **Unit** | **KW/Unit** | **EFLH/YR** | **KW/YR** |
| Dry Cooler Loop Pump | 1 | 2.26 | KW | 1.000 | 763 | 1,722 |
| Cold Well Pump | 1 | 3.23 | KW | 1.000 | 1,143 | 3,694 |
| Cold Well Pump | 1 | 3.23 | KW | 1.000 | 1,143 | 3,694 |
| Warm Well Pump | 1 | 3.23 | KW | 1.000 | 382 | 1,234 |
| Warm Well Pump | 1 | 3.23 | KW | 1.000 | 382 | 1,234 |
| Dry Cooler | 1 | 5.40 | KW | 0.25 | 763 | 1,030 |
| WSHP's (Cooling) | | | | | | |
| WSHP-1 | 1 | 4.74 | KW | 1.000 | 2,285 | 10,831 |
| WSHP-2 | 1 | 2.78 | KW | 1.000 | 2,285 | 6,352 |
| WSHP-3 | 1 | 1.97 | KW | 1.000 | 2,285 | 4,501 |
| WSHP-4 | 1 | 2.26 | KW | 1.000 | 2,285 | 5,164 |
| WSHP-5 | 1 | 2.01 | KW | 1.000 | 2,285 | 4,593 |
| WSHP-6 | 1 | 3.57 | KW | 1.000 | 2,285 | 8,157 |
| WSHP-7 | 1 | 4.08 | KW | 1.000 | 2,285 | 9,323 |
| WSHP's (Heating) | | | | | | |
| WSHP-1 | 1 | 5.04 | KW | 1.000 | 763 | 3,846 |
| WSHP-2 | 1 | 3.27 | KW | 1.000 | 763 | 2,495 |
| WSHP-3 | 1 | 2.46 | KW | 1.000 | 763 | 1,877 |
| WSHP-4 | 1 | 2.32 | KW | 1.000 | 763 | 1,770 |
| WSHP-5 | 1 | 2.44 | KW | 1.000 | 763 | 1,862 |
| WSHP-6 | 1 | 4.32 | KW | 1.000 | 763 | 3,296 |
| WSHP-7 | 1 | 4.14 | KW | 1.000 | 763 | 3,159 |
| | | | | | | **79,834** |

**Table 6.5. Baseline vs. ATES HVAC Energy Consumption Summary**

| **Fort Benning – B3215**<br>**Baseline vs. ATES HVAC Energy Consumption Summary** | | | |
|---|---|---|---|
| **08/01 thru 07/31** | | **08/01 thru 07/31** | |
| **Multi-Zone AHU w/ CHW & HHW** | | **ATES** | |
| Electrical Consumption (kWh) | 127,392 | Electrical Consumption (kWh) | 79,834 |
| Gas Usage (Therms) | 1,413 | Gas Usage (Therms) | 0.00 |
| | | | |
| Total Consumption (kBTU) | 575,964 | Total Consumption (kBTU) | 272,394 |
| | | | |
| Building Area (sq. ft.) | 9,638 | Building Area (sq. ft.) | 9,638 |
| HVAC kBTU/sq. ft. | 59.8 | HVAC kBTU/sq. ft. | 28.3 |
| | | **Energy Consumption Savings (kBtu)** | **303,570** |
| | | **Energy Consumption Savings (%)** | **52.7%** |

**2. Performance Objective: Reduction in Energy Consumption vs. Conventional GHP HVAC**

This quantitative performance objective evaluates the energy consumption of a GHP-USTES system compared to a conventional GHP system. As described in Section 5.5, many performance conditions of the existing systems and demonstration systems (BTES Only) were monitored and recorded for the demonstration project. The first performance objective addresses the energy consumption (recorded for BTES, estimated for ATES) of the demonstration systems, which will be used as part of the analysis required for this performance objective.

Since the existing HVAC system at each demonstration site were not conventional GHP systems, an hour-by-hour energy simulation of both buildings was utilized to establish a baseline energy consumption of a conventional GHP HVAC System. The energy consumption from each simulation will be compared against the energy consumption calculated in the first performance objective for each demonstration system.

For the BTES system, an eQuest (www.doe2.com) energy model of the existing HVAC system was completed for calculating heating/cooling loads, which was utilized for the BTES GHX performance simulations. For this performance objective, the energy model created for the existing system was modified to a conventional closed-loop GHP system consisting of WSHPs with no dry cooler or cooling tower. Prior to the modification of the energy model created for the existing system, the energy model's energy consumption and loads were compared to the existing HVAC system's recorded information prior to the demonstration installation. The energy model was then calibrated, as best as possible, based on the information gathered during this time period.

The existing system had aspects which were not ideal for energy consumption purposes. The existing control system did not have night set-up or night set-back programming and the energy recovery components in the dedicated outside air unit was not operating efficiently. Since improvements to these aspects were not part of the demonstration project, the energy consumption of the BTES system was also saddled with those less-than-ideal operating conditions. Therefore, since the existing system's energy model simulated those operating conditions, the GHP model created as the baseline system for this performance objective was simulated the same way. Tables 6.6 and 6.7 illustrate the HVAC energy consumption comparison between BTES recorded data and the modeled conventional GHP data.

**Table 6.6. Conventional GHP vs. BTES HVAC Monthly Energy Consumption**

| MCLB – B3700 – Conventional GHP vs. BTES Monthly HVAC Energy Consumption Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Conventional GHP Energy Consumption** | | | | **BTES HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (kWh)** | **Gas (Therms)** | **Total (kBTU)** | **Month-Year** | **Electrical (kWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 198,530 | 0.00 | 677,384 | Aug-2015 | 200,053 | 0.00 | 682,579 |
| Sep | 179,260 | 0.00 | 611,635 | Sep-2015 | 163,092 | 0.00 | 556,472 |
| Oct | 163,140 | 0.00 | 556,634 | Oct-2015 | 135,746 | 0.00 | 463,164 |
| Nov | 141,834 | 0.00 | 483,938 | Nov-2015 | 136,036 | 0.00 | 464,153 |
| Dec | 164,262 | 0.00 | 560,462 | Dec-2015 | 131,037 | 0.00 | 447,098 |
| Jan | 149,489 | 0.00 | 510,056 | Jan-2016 | 128,920 | 0.00 | 439,875 |
| Feb | 138,207 | 0.00 | 471,562 | Feb-2016 | 117,327 | 0.00 | 400,318 |
| Mar | 152,889 | 0.00 | 521,657 | Mar-2016 | 121,041 | 0.00 | 412,993 |
| Apr | 140,782 | 0.00 | 480,348 | Apr-2016 | 115,022 | 0.00 | 392,455 |
| May | 166,729 | 0.00 | 568,879 | May-2016 | 126,186 | 0.00 | 430,546 |
| June | 189,159 | 0.00 | 645,411 | Jun-2016 | 154,984 | 0.00 | 528,806 |
| July | 206,396 | 0.00 | 704,223 | Jul-2016 | 161,064 | 0.00 | 549,550 |
| | | | | | | | |
| Total: | 1,990,677 | 0.00 | 6,792,190 | Total: | 1,690,506 | 0.00 | 5,768,008 |

**Table 6.7. Conventional GHP vs. BTES HVAC Energy Consumption Summary**

| MCLB – Albany, GA – B3700 Conventional GHP vs. BTES HVAC Energy Consumption Summary | | | |
|---|---|---|---|
| **08/01 to 07/31** | | **08/01/2015 thru 07/31/2016** | |
| **Conventional GHP** | | **BTES** | |
| Electrical Consumption (kWh) | 1,990,677 | Electrical Consumption (kWh) | 1,690,506 |
| Gas Usage (Therms) | 0.00 | Gas Usage (Therms) | 0.00 |
| | | | |
| Total Consumption (kBTU) | 6,792,190 | Total Consumption (kBTU) | 5,768,008 |
| | | | |
| Building Area (sq. ft.) | 168,138 | Building Area (sq. ft.) | 168,138 |
| HVAC kBTU/sq. ft. | 40.40 | HVAC kBTU/sq. ft. | 34.30 |
| | | | |
| | | **Energy Consumption Savings (kBtu)** | **1,024,182** |
| | | **Energy Consumption Savings (%)** | **15.1%** |

For the ATES system, an eQuest energy model of the Baseline system was also completed for calculating heating/cooling loads. The energy model created for the existing HVAC system was modified to a conventional closed-loop GHP system consisting of WSHPs with no dry cooler or cooling tower.

The existing system had less-than-ideal aspects, which had to be accounted for appropriately. The existing HVAC system operated similar to a 2-pipe system. The Department of Public Works (DPW) would perform a manual seasonal changeover on the Chilled Water and Heating Hot Water systems. While this does lead to a decrease in energy consumption, there are time periods where there may be a demand for heating or cooling but the applicable system would not be available for operation. This type of operation is not typical of a GHP WSHP system. To account for this type of operation in the GHP model, the energy model created for the first performance objective was modified to operate with both Chilled Water and Heating Hot Water available for the entire year, which was then used to create a conventional GHP energy model. Prior to the modification of the original energy model created for the existing system, the energy model's energy consumption and loads were compared to the existing HVAC system's recorded information prior to the demonstration installation. The existing systems modified energy model was then calibrated, as best as possible, based on the information gathered during this time period. This energy model was then used and modified to a conventional closed-loop GHP system.

The GHP energy model's energy consumption was then compared against the estimate energy consumption of the ATES system. Tables 6.8, 6.9, 6.10 and 6.11 illustrate the HVAC energy consumption comparison between existing system HVAC recorded, modified existing HVAC modeled, GHP modeled and estimated ATES energy consumption.

**Table 6.8. Existing vs. Modeled Existing HVAC Monthly Energy Consumption**

| Fort Benning – B3215 – Existing vs. Modeled Existing Monthly HVAC Energy Consumption Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| Existing System's HVAC Energy Consumption | | | | Modeled Existing System's HVAC Energy Consumption | | | |
| Month-Year | Electrical (KWh) | Gas (Therms) | Total (kBTU) | Month-Year | Electrical (KWh) | Gas (Therms) | Total (kBTU) |
| Aug-2013 | 12,252 | 0.00 | 41,804 | Aug | 17,467 | 0.00 | 59,597 |
| Sep-2013 | 12,941 | 0.00 | 44,155 | Sep | 15,524 | 0.00 | 52,968 |
| Oct-2013 | 15,130 | 0.00 | 51,624 | Oct | 11,378 | 1 | 38,922 |
| Nov-2013 | 8,836 | 124 | 42,548 | Nov | 6,228 | 176 | 38,850 |
| Dec-2013 | 7,262 | 407 | 65,478 | Dec | 6,461 | 292 | 51,245 |
| Jan-2014 | 6,277 | 518 | 73,217 | Jan | 6,489 | 414 | 63,540 |
| Feb-2014 | 6,257 | 305 | 51,850 | Feb | 5,853 | 306 | 50,570 |
| Mar-2014 | 6,790 | 41 | 27,267 | Mar | 6,428 | 155 | 37,432 |
| Apr-2014 | 7,056 | 18 | 25,875 | Apr | 6,208 | 73 | 28,482 |
| May-2014 | 17,040 | 0.00 | 58,140 | May | 13,317 | 0.00 | 45,438 |
| Jun-2014 | 13,540 | 0.00 | 46,200 | June | 15,484 | 0.00 | 52,831 |
| Jul-2014 | 14,011 | 0.00 | 47,806 | July | 17,543 | 0.00 | 59,857 |
| | | | | | | | |
| Total: | 127,392 | 1,413 | 575,964 | Total: | 128,380 | 1,417 | 579,733 |

**Table 6.9. Modified Modeled Existing HVAC Monthly Energy Consumption**

| Fort Benning – B3215 – Modified Modeled Existing HVAC Energy Consumption Summary | | | |
|---|---|---|---|
| **Modified Baseline HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 17,576 | 0.0 | 59,969 |
| Sep | 15,631 | 0.0 | 53,333 |
| Oct | 11,518 | 67 | 45,999 |
| Nov | 8,731 | 194 | 49,190 |
| Dec | 7,766 | 302 | 56,698 |
| Jan | 7,055 | 421 | 66,172 |
| Feb | 6,607 | 315 | 54,043 |
| Mar | 9,119 | 174 | 48,514 |
| Apr | 11,136 | 63 | 44,296 |
| May | 13,381 | 17 | 47,356 |
| Jun | 15,596 | 0.0 | 53,214 |
| Jul | 17,659 | 0.0 | 60,253 |
| | | | |
| Total: | 141,775 | 1,553 | 639,036 |

**Table 6.10. Conventional GHP HVAC Monthly Energy Consumption**

| Fort Benning – B3215 –Conventional GHP HVAC Monthly Energy Consumption Summary | | | |
|---|---|---|---|
| **Baseline HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 12,272 | 0.00 | 41,872 |
| Sep | 10,741 | 0.00 | 36,648 |
| Oct | 7,041 | 0.00 | 24,024 |
| Nov | 4,999 | 0.00 | 17,057 |
| Dec | 4,780 | 0.00 | 16,309 |
| Jan | 5,424 | 0.00 | 18,507 |
| Feb | 4,391 | 0.00 | 14,982 |
| Mar | 5,087 | 0.00 | 17,357 |
| Apr | 6,626 | 0.00 | 22,608 |
| May | 8,414 | 0.00 | 28,709 |
| Jun | 10,494 | 0.00 | 35,806 |
| Jul | 12,395 | 0.00 | 42,292 |
| | | | |
| Total: | 92,664 | 0.00 | 316,170 |

**Table 6.11. Conventional GHP vs. BTES HVAC Energy Consumption Summary**

| Fort Benning – B3215<br>Conventional GHP vs. ATES HVAC Energy Consumption Summary | | | |
|---|---|---|---|
| **08/01 to 07/31** | | **08/01 thru 07/31** | |
| **Conventional GHP** | | **ATES** | |
| Electrical Consumption (kWh) | 92,664 | Electrical Consumption (kWh) | 79,834 |
| Gas Usage (Therms) | 0.00 | Gas Usage (Therms) | 0.00 |
| | | | |
| Total Consumption (kBTU) | 316,170 | Total Consumption (kBTU) | 272,394 |
| | | | |
| Building Area (sq. ft.) | 9,638 | Building Area (sq. ft.) | 9,638 |
| HVAC kBTU/sq. ft. | 32.8 | HVAC kBTU/sq. ft. | 28.3 |
| | | | |
| | | **Energy Consumption Savings (kBtu)** | **43,776** |
| | | **Energy Consumption Savings (%)** | **13.8%** |

**3. Performance Objective: Reduction in water consumption**

This quantitative performance objective evaluates the water consumption of a GHP-USTES system compared to a conventional cooling tower. As described in Section 5.5, dry cooler water consumption for the BTES system was monitored and recorded. This information is used to determine the water consumption reduction of the BTES system. For the ATES system, the dry cooler is equipped with the adiabatic evaporative supply piping system but is not equipped with the evaporative pads required for adiabatic operation. The installed dry cooler will only operate in "dry" mode but will be capable of future "wet" mode operation with the addition of the adiabatic pads, a water supply connection and a drainage system.

During the baseline data-logging period at MCLB-B3700, an existing water meter was used to periodically record water consumption of the cooling tower. This information is used to compare the water consumption of the baseline system to the BTES system. Table 6.12 illustrates the water consumption between the two systems.

**Table 6.12. MCLB-B3700-Baseline vs BTES Evaporative Water Consumption**

| MCLB – B3700 – Evaporative Water Consumption Comparison | | | |
|---|---|---|---|
| **Baseline vs BTES Water Consumption** | | | |
| **Baseline** | | **BTES** | |
| **Month-Year** | **Water Usage (Gallons)** | **Month-Year** | **Water Usage (Gallons)** |
| Sept-2013 | Start | Aug-2015 | Start |
| Oct-2013 | 186,400 | Thru | ↓ |
| Jan-2014 | 440,100 | | |
| Feb-2014 | 237,800 | | |
| Jun-2014 | 1,121,800 | | |
| Jul-2014 | 254,500 | | |
| Sept-2014 | 450,800 | Jul-2016 | 0.00 |
| | | | |
| Total: | 2,691,400 | 100% Reduction | |

Based on the water meter recordings, the BTES system achieved a 100% reduction in evaporative water use and succeed in satisfying this performance objective.

Since the existing HVAC system at Benning-B3215 depends upon a central plant chilled water system to provide 44°F chilled water, there was no direct method of recording water consumption at the central plant location for the purposes of determining the water consumption dedicated to B3215's operation. As an alternate, an annual cumulative chilled water load was calculated via chilled water GPM and supply/return temperature differentials. An annual evaporative consumption was then calculated using the annual cumulative chilled water load the generally accepted rules of thumbs of 15,000 btu/hr (condenser load with compressor heat) and 1,050 Btu/lb. This information is used to compare the calculated water consumption of the baseline system to the ATES system. Table 6.13 illustrates the estimated water consumption of the Baseline system. Table 6.14 illustrates the comparison between the estimated water consumptions between the Baseline system and the ATES system.

**Table 6.13. Benning-B3215-Estimated Baseline Evaporative Water Consumption**

| **Benning – B3215 – Estimated Evaporative Water Consumption** | |
|---|---|
| **Baseline Water Consumption** | |
| **Month-Year** | **Cumulative Cooling Load (Ton*hrs)** |
| Aug-2013 | 72,418 |
| Thru | |
| Jul-2014 | |
| | |
| Building Load to Central Plant (MBTUs) | 1,086 |
| Evaporative Water Consumption (lb/yr.) | 1,034,543 |
| Evaporative Water Consumption (gal/yr.) | 124,195 |
| Cycles of Concentration | 4.0 |
| Estimated Blowdown (gal/yr.) | 41,398 |
| Estimated Make-up due to Evaporative Cooling (gal/yr.) | 165,593 |

**Table 6.14. Benning-B3215-Baseline vs. ATES Evaporative Water Consumption**

| **Benning – B3215 – Estimated Baseline vs. Estimated ATES Evaporative Water Consumption** | | | |
|---|---|---|---|
| **Baseline vs. ATES Water Consumption** | | | |
| **Baseline** | | **ATES** | |
| **Month-Year** | **Water Usage (Gallons)** | **Month-Year** | **Water Usage (Gallons)** |
| Aug-2013 | 165,593 | Aug | 0.00 |
| Thru | | Thru | |
| Jul-2014 | | Jul | |
| | | | |
| Total: | 165,593 | 100% Reduction | |

Based on the comparisons between the estimated water consumption of each system, the ATES system will achieve a 100% reduction in evaporative water use.

4. **Performance Objective: Reduction in direct on-site Greenhouse Gas Emissions for HVAC Space Heating**

This quantitative performance objective evaluates the Greenhouse Gas Emission (GHG) associated with Space Heating of each GHP-USTES system compared to the existing HVAC system.

Natural gas consumption data from the first performance objective is utilized for calculating the results of this performance objective. The estimated gas consumption from each demonstration site is used in conjunction with GHG conversions referenced from EPA's website (https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references). Table 6.15 and 6.16 illustrates the results of this performance objective.

**Table 6.15. MCLB-B3700-Baseline vs. BTES GHG Comparison**

| MCLB – B3700 – Greenhouse Gas (GHG) Emission Comparison | | |
|---|---|---|
| **Baseline vs. BTES GHG Emission** | | |
| | **Baseline** | **BTES** |
| Annual HHW Gas Consumption (therms) | 39,443 | 0.00 |
| GHG Equivalency (0.005302 metric tons CO2 per therm) | 209.1 | 0.00 |
| | | |
| | 100% Reduction | |

**Table 6.16. Benning-B3215-Baseline vs. ATES GHG Comparison**

| Benning – B3215 – Greenhouse Gas (GHG) Emission Comparison | | |
|---|---|---|
| **Baseline vs. ATES GHG Emission** | | |
| | **Baseline** | **ATES** |
| Annual HHW Gas Consumption (therms) | 1,413 | 0.00 |
| GHG Equivalency (0.005302 metric tons CO2 per therm) | 7.5 | 0.00 |
| | | |
| | 100% Reduction | |

Each demonstration achieved the ability to reduce on-site GHG emissions by 100%. This is mostly attributed to the fact that on-site gas fueled equipment was replaced with electrical equipment capable of satisfying heating demand more efficiently.

5. **Performance Objective: Reduction in BTES Construction Cost vs. Conventional GHP HVAC**

This quantitative performance objective evaluates the construction cost of the BTES GHX compared to a conventional GHP HVAC GHX. Competitive bids were received for the BTES system from construction documents designed under this demonstration project.

The construction costs associated with the BTES GHX will be compared against conventional GHP GHX pricing information obtained from past recent projects completed by AH&P on other military installations. This performance objective does not apply to the ATES demonstration project.

**Table 6.17. MCLB-B3700-BTES GHX Construction Cost**

| MCLB – B3700 – BTES GHX Construction Cost Summary | |
|---|---|
| **BTES GHX Construction Costs (before GC mark-up)** | |
| | **Cost ($)** |
| Site Preparation/Demolition/Utility Modifications | $24,630 |
| Grading | $212,570 |
| Base & Asphalt Paving | $44,775 |
| Storm Drainage Connection | $6,750 |
| Erosion Control | $14,785 |
| Dry Cooler Fencing | $6,449 |
| Construction Temporary Fencing | $15,500 |
| Above Ground Concrete | $4,028 |
| Geothermal Drilling, Materials and Testing | $1,332,514 |
| Dry Coolers | $300,000 |
| | |
| Total Cost Associated with ONLY BTES GHX | $1,962,001 |

A cost for most conventional geothermal systems can be estimated based on the linear footage of borehole length installed and the area where the project is to be installed. For Georgia, most conventional geothermal systems average at approximately $16 per linear foot of borehole. The estimated cost generally accounts for the material and labor associated with the vertical boreholes and the horizontal piping installation into the building. The BTES GHX has 64,260 linear foot of borehole (306 boreholes x 210-foot depth per borehole). The cost of the geothermal drilling/materials/testing illustrated in Table 6.17 can be calculated at $18.79 per linear foot. This cost is slightly higher than the average cost due to grouting issues and a change order associated with those issues. Prior to the change order, the cost per linear foot was $15.56.

In the energy model created for second performance objective, an equivalent conventional GHX was utilized based on a maximum supply water (inlet water to HVAC equipment) parameter of 100°F, which is typical of most conventional GHX designs. For the conventional GHX energy model, 140,760 linear footage of borehole was required. Table 6.18 illustrates an estimated construction cost for a conventional GHP GHX.

**Table 6.18. MCLB-B3700-Conventional GHP GHX Construction Cost**

| MCLB – B3700 – Conventional GHP GHX Construction Cost Summary<br>Conventional GHP GHX Construction Costs (before GC mark-up) | |
|---|---|
| | **Cost ($)** |
| Site Preparation/Demolition/Utility Modifications | $24,630 |
| Grading | $212,570 |
| Base & Asphalt Paving | $44,775 |
| Erosion Control | $14,785 |
| Construction Temporary Fencing | $15,500 |
| Geothermal Drilling, Materials and Testing | $2,645,031 |
| | |
| Total Cost Associated with BTES GHX | $2,957,291 |

For a conventional GHP GHX, costs associated with a dry cooler(s) do not apply. A conventional GHX GHX for this site does require approximately the same cost associated with grading as the excavation/compaction effort of trenching would be approximately the same given the bore field size. A conventional GHP GHX at this site would also still require site preparation, paving, temporary fencing and erosion control, which is reflected in Table 6.18.

Based on the costs illustrated in both Tables 6.17 and 6.18, the construction cost reduction associated with a BTES GHX is 33.6%, which exceeds the performance objective requirement.

**6. Performance Objective: Reduction in Greenhouse Gas Emissions at Source (Power Plant) vs. Conventional air-to-air heat pump HVAC**

This quantitative performance objective evaluates the Source Site Greenhouse Gas Emission (GHG) of the GHP-USTES systems compared to conventional air-to-air heat pump systems. Performance conditions were monitored and recorded for each demonstration project and converted from source GHG emissions to site GHG emissions (Carbon Dioxide-$CO_2$, Methane-$CH_4$ and Nitrous Oxide-$H_2O$) based on information obtained from Energy Star's website (https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf) and EPA's eGRID2014 GHG Annual Output Emission Rate document (https://www.epa.gove/energy/egrid).

Since the existing HVAC system at each demonstration site were not conventional GHP systems, an hour-by-hour energy simulation of both buildings was utilized to establish a baseline energy consumption of an air-to-air heat pump system. The energy consumption from each simulation is compared against the energy consumption calculated in the first performance objective for each demonstration system. The simulated site electrical energy consumption will be converted to source GHG emissions (lbs. of $CO_2$, $CH_4$ and $H_2O$).

For each system, the eQuest (www.doe2.com) energy model created for a conventional GHP system required by the second performance objective was modified to an air-to-air heat pump system.

Table 6.19 and 6.20 illustrates the energy consumption from each air-to-air heat pump energy model.

**Table 6.19. MCLB-B3700-Air-to-Air Heat Pump HVAC Monthly Energy Consumption**

| MCLB – B3700 –Air-to-Air Heat Pump HVAC Monthly Energy Consumption Summary | | | |
|---|---|---|---|
| **Baseline HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 257,290 | 0.00 | 877,873 |
| Sep | 227,786 | 0.00 | 777,206 |
| Oct | 199,264 | 0.00 | 679,889 |
| Nov | 167,008 | 0.00 | 569,831 |
| Dec | 207,854 | 0.00 | 709,198 |
| Jan | 189,558 | 0.00 | 646,772 |
| Feb | 172,235 | 0.00 | 587,666 |
| Mar | 187,259 | 0.00 | 638,928 |
| Apr | 167,451 | 0.00 | 571,343 |
| May | 204,018 | 0.00 | 696,109 |
| Jun | 247,170 | 0.00 | 843,344 |
| Jul | 277,353 | 0.00 | 946,328 |
| | | | |
| Total: | 2,504,246 | 0.00 | 8,544,487 |

**Table 6.20. Benning-B3215-Air-to-Air Heat Pump HVAC Monthly Energy Consumption**

| Fort Benning – B3215 –Air-to-Air Heat Pump HVAC Monthly Energy Consumption Summary | | | |
|---|---|---|---|
| **Baseline HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 14,908 | 0.00 | 50,866 |
| Sep | 12,433 | 0.00 | 42,421 |
| Oct | 7,598 | 0.00 | 25,924 |
| Nov | 5,626 | 0.00 | 19,196 |
| Dec | 6,062 | 0.00 | 20,684 |
| Jan | 7,671 | 0.00 | 26,173 |
| Feb | 5,828 | 0.00 | 19,885 |
| Mar | 5,611 | 0.00 | 19,145 |
| Apr | 7,356 | 0.00 | 25,099 |
| May | 9,583 | 0.00 | 32,697 |
| Jun | 12,468 | 0.00 | 42,541 |
| Jul | 15,245 | 0.00 | 52,016 |
| | | | |
| Total: | 110,389 | 0.00 | 376,647 |

The information from Tables 6.19 and 6.20 were then used in Tables 6.21 and 6.22 to illustrate the site-to-source electrical consumption and the associated GHG emission comparison with each site.

**Table 6.21. MCLB-B3700-Baseline vs. BTES Source GHG Comparison**

| MCLB – B700 – Source GHG Emission Comparison | | |
|---|---|---|
| **Baseline vs. BTES Source GHG Emission** | | |
| | **Baseline** | **BTES** |
| Annual HVAC Site Electrical Consumption (kWh) | 2,504,246 | 1,690,506 |
| Electrical Site-to-Source Ratio (Energy Star) | 3.14 | |
| Annual HVAC Source Electrical Consumption (kWh) | 7,863,332 | 5,308,189 |
| eGRID SRSO sub-region $CO_2$ Emission Rate (lb/MWh) | 1,144.5 | |
| eGRID SRSO sub-region $CH_4$ Emission Rate (lb/GWh) | 105.4 | |
| eGRID SRSO sub-region $N_2O$ Emission Rate (lb/GWh) | 15.6 | |
| Source GHG Equivalent: $CO_2$ (lbs) | 8,999,584 | 6,075,222 |
| Source GHG Equivalent: $CH_4$ (lbs) | 828.8 | 559.5 |
| Source GHG Equivalent: $N_2O$ (lbs) | 122.7 | 82.8 |
| | | |
| | 32.5% Reduction | |

**Table 6.22. Benning-B3215-Baseline vs. ATES Source GHG Comparison**

| Benning – B3215 – Source GHG Emission Comparison | | |
|---|---|---|
| **Baseline vs. ATES Source GHG Emission** | | |
| | **Baseline** | **ATES** |
| Annual HVAC Site Electrical Consumption (kWh) | 110,389 | 81,126 |
| Electrical Site-to-Source Ratio (Energy Star) | 3.14 | |
| Annual HVAC Source Electrical Consumption (kWh) | 346,621 | 254,736 |
| eGRID SRSO sub-region $CO_2$ Emission Rate (lb/MWh) | 1,144.5 | |
| eGRID SRSO sub-region $CH_4$ Emission Rate (lb/GWh) | 105.4 | |
| eGRID SRSO sub-region $N_2O$ Emission Rate (lb/GWh) | 15.6 | |
| Source GHG Equivalent: $CO_2$ (lbs) | 396,708 | 291,544 |
| Source GHG Equivalent: $CH_4$ (lbs) | 36.5 | 26.8 |
| Source GHG Equivalent: $N_2O$ (lbs) | 5.4 | 4.0 |
| | | |
| | 26.5% Reduction | |

From this analysis, each demonstration project did not achieve the performance objective of 40% reduction.

7. **Performance Objective: Eliminate maintenance of HVAC water treatment system**

   This qualitative performance objective evaluates the benefit of eliminating maintenance of the current HVAC water treatment system associated with the cooling tower open loop system.

   A brief survey was sent to maintenance personnel at MCLB observe what the benefits were to the maintenance department, such as time savings spent maintaining, repairing and monitoring the water treatment system. Maintenance costs were discussed to understand the cost savings of eliminating the water treatment system. This can be completed since B3700 at MCLB has a dedicated cooling tower for its operation with its own water treatment system. At this time, survey results from the maintenance department have not be received.

   At Fort Benning, the current water treatment system serves the central plant system. The elimination of one building off that system will not make a significant impact or improvement on maintenance. However, Fort Benning is in the process of eliminating the central plant by taking buildings off the central plant during renovation projects. The installation of this demonstration project helps in that regards as it is one less facility to remove from the central plant chilled water system. However, a brief survey was sent to the maintenance personnel to understand what they believe will the benefits of eliminating the water treatment system in the future, such as time savings spent maintaining, repairing and monitoring the water treatment system.

8. **Performance Objective: Energy Security**

   The other qualitative performance objective is to evaluate the energy security benefit of a GHP-USTES system. Energy security and the ability to reduce energy consumption by utilizing an on-site renewable energy resource (seasonal energy) are very important to the DoD infrastructure.

   A brief survey was sent to MCLB personnel interested in reducing energy consumption to observe what the benefit of the BTES system are to energy security. At this time, survey results from the maintenance department have not be received.

   Although the final construction of the ATES system is beginning at the time of submitting this report, a brief survey will also be sent to Fort Benning personnel interested in reducing energy consumption to observe what the benefit of the ATES system are to energy security

# 7.0 COST ASSESSMENT

For both demonstration projects, a Life Cycle Cost Analysis (LCCA) was completed. Costs of various critical components were either tracked or obtained from contractors so the analysis could be applied to other military installations. Since each demonstration site involved construction funding from the military installation, all costs that could not be tracked directly were obtained from installing contractors.

The critical components relevant to the GHP-USTES technology tracked during the implementation of the demonstration project are listed in Table 7.1. Once all associated costs are known, an LCCA will be completed by the use of the NIST Building LCCA program and NIST Handbook 135, which are both available on the DOE website:
http://www1.eere.energy.gov/femp/information/download_blcc.html#handbook

## 7.1 COST MODEL

**Table 7.1. Cost Model for a GHP-USTES System**

| System | Cost Element | Data Tracked During the Demonstration | Estimated Costs | |
|---|---|---|---|---|
| BTES | Geothermal Heat Exchanger Vertical Borehole (GHX) System | • Capital Cost: $ per foot of Vertical Borehole<br>• Installation Cost: $ per foot of Vertical Borehole | Total | $1,207,514 |
| | | | $/ft. Total | $18.79 |
| ATES | ATES Cold & Warm Wells | • Capital Cost: $ per foot of Vertical Well<br>• Installation Cost: $ per foot of Vertical Borehole | Total | $53,742 |
| | | | $/ft Total | $33.59 |
| | Horizontal Piping for ATES Wells | • Capital Cost: $ per foot of Vertical Well<br>• Installation Cost: $ per foot of Vertical Borehole | Total | $25,980 |
| | | | $/ft Total | $16.24 |
| BTES & ATES | Dry Coolers | • Capital Cost: $ per Dry Cooler<br>• Install/Shipping Costs:<br>• Maintenance Cost: | BTES Total | $306,449 |
| | | | $ per Dry Cooler | $153,225 |
| | | | ATES Total | $16,173 |
| | | | $ per Dry Cooler | $16,173 |
| BTES | Heat Recovery Modular Chillers | • Capital Cost: $ per Modular Chiller<br>• Install/Shipping Costs:<br>• Maintenance Cost: | Total | $325,000 |
| | | | $ per Chiller | $65,000 |
| ATES | WSHPs | • Capital Cost: $ per WSHP<br>• Install/Shipping Costs:<br>• Maintenance Cost: | Total | $25,900 |
| | | | $ per WSHP | $3,700 |
| BTES & ATES | Pumps & Injection Valves | • Capital Cost:<br>• Install/Shipping Costs:<br>• Maintenance Cost: | BTES Total | $53,000 |
| | | | ATES Total | $31,661 |

**Table 7.1. Cost Model for a GHP-USTES System (Continued)**

| System | Cost Element | Data Tracked During the Demonstration | Estimated Costs | |
|---|---|---|---|---|
| BTES & ATES | Pumping Accessories (Air separators, expansion tanks, suction diffusers, etc.) | • Capital Cost:<br>• Install/Shipping Costs: | BTES Total | Included in Pumps |
| | | | ATES Total | Included in Pumps |
| BTES & ATES | Controls and Control Components | • Capital Cost:<br>• Installation Cost:<br>• Maintenance Cost: | BTES Total | $517,000 |
| | | | ATES Total | $86,400 |
| BTES & ATES | Maintenance | • Maintenance Cost/Yr.: | BTES Total | $10,000 |
| | | | ATES Total | |
| BTES & ATES | Training | • Cost of Training | BTES Total | $5,000 |
| | | | ATES Total | $5,000 |
| BTES & ATES | Operational | • Utility Bills: | BTES HVAC Total kWh | 1,690,506 |
| | | | BTES HVAC Estimated $ | $160,598 |
| | | | ATES Estimated HVAC kWh | 79,834 |
| | | | ATES Estimated HVAC $ | $4,950 |
| BTES & ATES | Commissioning & TAB | • Cost of Commissioning<br>• Cost of TAB | BTES Cx Total | $74,000 |
| | | | BTES TAB Total | $56,700 |
| | | | ATES Total | $30,000 |

The LCCA and Cost Model information will be used to help estimate the costs associated with implementation and installation of a GHP-USTES system at other military installation locations.

### 7.1.1 Cost Elements Description:

For the BTES demonstration project, each life-cycle cost element was obtained as best as possible to acquire the information necessary to perform a LCCA. All applicable HVAC equipment was monitored for energy consumption, while the BTES GHX was monitored for performance as well. All recorded information was used in conjunction with the costing information to determine the life-cycle costs for the BTES technology. A typical timeframe of 20 years was used for the LCCA.

1. **Cost Element: Geothermal Heat Exchanger Vertical Borehole (GHX) System**

   A BTES system utilizes closed-loop vertical boreholes as the device for storing seasonal or even diurnal thermal energy, which can be used to operate an HVAC system more energy efficiently throughout the year.

   The cost listed in Table 7.1 represents the actual pricing of the BTES GHX. Since the BTES GHX was bid upon by multiple contractors, it is a representation of a "market value" for the BTES GHX. The pricing of the BTES GHX can be scaled, within reason, for other sites and HVAC systems. However, this BTES GHX would be considered a large-scale GHX and therefore, economies-of-scale would need to accounted for and applied appropriately.

2. **Cost Element: ATES Cold & Warm Wells**

   An ATES system utilizes cold and warm open-loop wells as the device for storing seasonal thermal energy, which can be used to operate an HVAC system more energy efficiently throughout the year. The ATES design is used for storing cooling or heating energy, depending on the building's HVAC loads. For this demonstration, the ATES system was designed primarily for storing cooling energy due to the HVAC loads of the building being cooling dominated.

   The cost listed in Table 7.1 represents the actual pricing of the ATES GHX, including drilling, screen, casing, gravel pack, grout and well development. The pricing associated with the ATES wells were obtained by the driller, vendors and suppliers, which is representative of market pricing. The pricing of the ATES wells can be scaled, within reason, for other sites and HVAC systems, but must be completed appropriately. ATES wells can be scaled along a curve less steep than a closed-loop geothermal system but have a higher starting price point. For example, upfront costs, such as site investigation/testing, are higher costs associated with ATES wells, which are costlier than closed-loop geothermal systems. Closed-loop geothermal systems, with enough land real estate, can be designed to incorporate whatever results come from the on-site testing phase. With ATES wells, on-site testing and analysis may lead to an outcome of an ATES system not being feasible. Therefore, sufficient analysis must be done prior to on-site testing to preliminarily determine the feasibility of an ATES system. However, if an ATES system is feasible, the installation cost of ATES wells, when analyzed from a $/ton basis, will likely be less expensive than a closed-loop system as increase in tonnage may not lead to the installation of additional ATES wells.

3. **Cost Element: Dry Coolers**

   ATES & BTES systems utilize dry coolers as the device for harvesting the cooling energy that is stored by the ATES and BTES bore fields.

   The cost listed in Table 7.1 represents the actual pricing of the dry coolers. Since the dry coolers were bid upon by multiple contractors, it is a representation of a "market value" for the dry coolers. The pricing of the dry coolers can be scaled, within reason, for other sites and HVAC systems. However, the dry coolers are considered large-scale GHX and therefore, economies-of-scale would need to accounted for and applied appropriately.

4. **Cost Element: Heat Recovery Modular Chillers**

   The BTES system utilizes heat recovery modular chillers to produce the chilled, and hot water for the building. The hot water is created using the waste heat from the chilled water loop and the heat of compression. Additional waste heat from the chilled water is delivered to the source water and sent to the dry cooler and BTES.

   The cost listed in Table 7.1 represents the total pricing of the five heat recovery modules. Since the heat recovery modular chillers were bid upon by multiple contractors, it is a representation of a "market value" for the chillers. The pricing of the chillers can be scaled on a $/ton basis, within reason, for other sites and HVAC systems. Since the chillers are modular and can be stacked together the scale should be fairly linear.

**5. Cost Element: WSHPs**

The ATES system utilizes WSHP's connected to the GHX to heat and cool the building. The WSHP's either extract heat from the ATES loop for heating, or reject heat to the ATES loop for cooling, depending on the building's HVAC loads. For this demonstration, the WSHP's connected to the ATES system was designed primarily for cooling due to the HVAC loads of the building being cooling dominated.

The cost listed in Table 7.1 represents the actual pricing of the WSHP's. Since the WSHP's were bid upon by multiple contractors, it is a representation of a "market value" for the ATES GHX. The pricing of the WSHP's can be scaled relatively easily for other sites and HVAC systems since WSHP's can be purchased as a stock item from a distributor.

**6. Cost Element: Pumps and Variable Frequency Drives**

Both the ATES and the BTES system utilize pumps in the architecture to recirculate water through the ATES and BTES water loops. To increase energy efficiency and to match the load, VFD's were utilized for all pumps.

The cost listed in Table 7.1 represents the actual pricing of the system pumps and drives including shipping and installation costs. Pumping accessories are not included in this cost element. The pumps were bid upon by multiple contractors, and therefore is a representation of a "market value" for the pumps. The pricing of the pumps can be scaled, within reason, for other sites and HVAC systems. The scaling for the pumps should be fairly linear.

**7. Cost Element: Hydronic Accessories**

The pumps for the ATES and BTES systems as described above require hydronic accessories to support the pump's functions. These accessories include air separators, expansion tanks, suction diffusers, etc. These components allow for proper hydraulic flow in the systems and optimizes efficiency.

The cost listed in Table 7.1 represents the actual pricing of the pumping accessories, including shipping and installation costs. The pricing associated with the accessories were obtained by bids from multiple contractors, and therefore is a representation of a "market value" for the accessories. The pricing of the hydronic accessories can be scaled similar to the scaling of the pump costs, within reason, for other sites and HVAC systems.

**8. Cost Element: Controls**

The ATES and BTES systems utilize Direct Digital HVAC Controls to optimize the systems' performance and to increase energy savings. Properly programmed control algorithms are critical to ensuring that energy is not wasted. The controls operate all parts of the system from the thermostats, to air side equipment, water side equipment, dry coolers, injection valves, submersible pumps, charging and discharging logic, etc. The system controls can be one of the most expensive parts of a BTES and ATES system.

The cost listed in Table 7.1 represents the actual pricing of the controls. Since the BTES and ATES system controls were bid upon by multiple controls contractors, it is a representation of a "market value" for the ATES & BTES controls. Control pricing can usually be expressed in $/control point, and scaling is fairly linear for other projects within reason.

**9. Cost Element: Maintenance**

Maintenance of the ATES and BTES systems is imperative to maintain maximum efficiency throughout the years. Maintenance will include regular HVAC servicing such as filter changes and strainer cleaning, but will also include routine maintenance of specialized equipment such as the adiabatic/non adiabatic dry coolers, heat recovery modular chillers, injection valve controllers, and specialized direct digital controls. Overall maintenance costs for the ATES and BTES will be lower than the maintenance of a conventional HVAC system since there is very little maintenance associated with the bore fields/wells. Also, elimination of the cooling towers eliminates chemical treatment for open loop systems.

The cost listed in Table 7.1 represents the estimated annual cost of the maintenance for each system. The maintenance cost for the BTES and ATES systems were determined by talking to base personnel to determine what the annual cost of the maintaining the baseline system was. Since only routine maintenance will be needed for the new systems and no water treatment will be needed for the cooling tower, maintenance for the existing system could be estimated.

**10. Cost Element: Training**

Since maintenance personnel in the US are generally not familiar with ATES and BTES systems, additional training will be required beyond the normal scope of training for conventional HVAC systems. Additional training costs are outweighed by additional energy savings of the BTES and ATES systems vs. conventional systems.

The cost listed in Table 7.1 represents the actual pricing of the training for the BTES and ATES systems. Since the projects were bid upon by multiple contractors, it is a representation of a "market value" for the training. The pricing for training of the ATES and BTES systems can be expected to be relatively consistent and should not be scaled. A small ATES and BTES project will require close to the same amount of training that a large system will require.

**11. Cost Element: Operational**

The operational cost for BTES and ATES systems are much less than the operational cost for a conventional HVAC systems and conventional GHP systems. The difference in operational cost comes from the ability to deliver cooler water to the heat pumps and chillers.

The cost listed in Table 7.1 represents the actual energy cost of the BTES system as monitored for a 12-month period. The energy cost of the ATES system is by computer simulation and is also for a 12-month period. The operational cost of the BTES & ATES can be scaled, to a degree, for other BTES & ATES systems. However, the geographical location and climate of the BTES and ATES plays a big factor in energy usage.

**12. Cost Element: Commissioning and TAB**

Typical conventional HVAC systems benefit greatly from proper Commissioning and TAB. Even more so, a BTES and ATES system benefits from proper TAB of the systems to maximum performance. Without Commissioning and TAB, complex ATES and BTES systems will suffer greatly from poor control setup, poor tuning, and overall imbalance of loads through the building. A Continuous Commissioning program to keep the systems tuned up through the years is also recommended. The BTES and ATES systems both received rigorous TAB and commissioning by NEBB certified TAB and commissioning Firms.

The cost listed in Table 7.1 represents the actual pricing of commissioning and TAB for the BTES and ATES systems. Since the projects were bid upon by multiple contractors, it is a representation of a "market value" for the commissioning and TAB. The pricing of the commissioning and TAB can be scaled, within reason, for other sites and HVAC systems. Prices can normally be converted to $/square foot of building area.

## 7.3 COST DRIVERS

As in any project where a reduction in energy consumption is a key point, energy rates must be considered when selecting any technology for future implementation. The locations for these two demonstration sites have some of the lowest electrical energy cost in the United States and were still able to achieve a favorable cost analysis. Other regions, where electrical energy costs are higher, will experience a greater annual electrical cost savings. This also applies to natural gas consumption and its associated energy cost. Water consumption is also a key factor that often gets overlooked in a cost analysis. Water consumption costs can help in most regions, especially those with high water usage costs, when water consumption can be substantially decreased, or even eliminated, as established at both sites for this demonstration.

Another cost driver is installation costs associated with drilling wells or boreholes. Some regions of the United States have lower drilling costs than others. This is generally attributed to the law of supply and demand. Areas, such as Texas, have more drillers than Georgia due to the oil and gas industry. As the oil and gas industry ebbs and flows, there are an abundance of drillers available, which has an impact and helps decrease the cost of drilling.

The underground geology and hydrogeology are also important cost drivers. For BTES, some sites will have better underground geology than others, which will lead to less boreholes and a decrease in capital investment costs. Hydrogeology is also important to BTES as high ground water movement impacts the ability to store thermal energy effectively. For ATES, hydrogeology is important as its operation is directly dependent upon the ability of the system to extract and inject groundwater. Geology is almost just as important as it is highly unlikely, for example, for a crystalline aquifer (i.e. rock) to achieve the ability for sufficient groundwater extraction or injection. Some site will have ideal conditions, which will lead to a decrease in capital investments cost. Sites who can achieve lower installation costs with ideal site conditions, along with lower energy/water costs, will benefit the most from the USTES technology.

## 7.1 COST ANALYSIS AND COMPARISON

**BTES:**

The cost analysis and comparison for the BTES demonstration was performed against a conventional HVAC system. In this particular case, the costs associated with the BTES system was compared against a replacement system for the mechanical room HVAC system similar to HVAC system in place before the demonstration project was installed. The BTES demonstration involved MILCON funding for the construction aspect of the ESTCP project. Contractor construction prices were obtained and utilized for the cost analysis and comparison. The cost analysis for the BTES demonstration assumes a construction project to replace the existing HVAC system was due occur in the near future. This is a reasonable assumption as the existing centrifugal chillers (Qty 1 – 200 ton; Qty 1 – 400 ton) and cooling tower were beyond their usable life. Up to the demonstration project installation, MCLB's Public Work Department had to incur major maintenance costs to keep the chillers operational. The HVAC system interior to the building not inside the main mechanical room (i.e. central plant AHUs, piping, ERU, etc.) were not incorporated into the cost analysis. These items were existing prior to the demonstration and were not part of the demonstration project installation. This approach allows for a closer comparison for cost analysis purposes.

Construction costs obtained from the BTES project were used and adjusted to represent the conventional HVAC replacement project cost. Items such as the BTES GHX, under-ground horizontal piping and above-ground piping were deducted from the BTES construction prices and applied to the construction cost of a conventional HVAC replacement with the assumption that two over-sized dry coolers, five modular chillers and corresponding related items would closely offset the cost of a new cooling tower, new chiller and new boiler. The investments costs associated with the BTES project and the alternate conventional HVAC system were input into the BLCC5 program (https://energy.gov/eere/femp/building-life-cycle-cost-programs) accordingly with the energy consumption data illustrated in Section 6.0 for Performance Objective No. 1 used in the life-cycle cost analysis (LCCA) comparison. Energy rates for electricity ($0.095/kWh), natural gas ($0.65/therm) and water consumption ($0.00997/gal) were also obtained from MCLB personnel. The LCCA utilized a 20-year length of study period (October 1, 2016 through September 30, 2036) with a Constant Dollar Analysis and a Real Discount Rate of 3.0%. Performing a cost comparison analysis computes the following results:

- Savings-to-Investment Ratio (SIR): 1.42
- Adjusted Internal Rate of Return: 4.84%
- Simply Payback: 11 years
- Discounted Payback: 13 years

The full comparative analysis report is included in Appendix K with the Table 7.2 below summarizing the inputs used:

**Table 7.2. Conventional HVAC vs. BTES Cost Comparison Summary**

| MCLB – B3700 – Cost Comparison Input Summary | | |
|---|---|---|
| **Input** | **Conventional HVAC Project** | **Demonstration HVAC Project** |
| Initial Investment | $3,196,912 | $5,100,000 |
| Annual Electrical Consumption (kWh) | 2,065,586 | 1,690,506 |
| Annual Natural Gas Consumption (therms) | 39,443 | 0.0 |
| Annual Evaporative Water Consumption (gallons) | 4,300,000 | 0.0 |
| Initial Annual Electrical Cost ($) | $196,231 | $160,598 |
| Initial Annual Natural Gas Cost ($) | $25,638 | $0 |
| Initial Annual Evaporative Water Cost ($) | $42,871 | $0 |
| General Maintenance ***Savings*** ($) | $50,000 | $0 |
| Chemical Treatment ***Savings*** ($) | $15,000 | $0 |

**ATES:**

The cost analysis and comparison for the ATES demonstration was performed against a conventional HVAC system. In this particular case, the costs associated with the ATES system was compared to a replacement system for the mechanical room HVAC system similar to HVAC system in place before the demonstration project was installed. The current system was a multi-zone AHU installed with chilled water and heating hot water coils, which utilized zone dampers to condition the seven thermal zones in the building. The chilled water is currently supplied by a central plant, which is scheduled to be off-line in the next few years. The heating hot water coil is supplied by a local boiler installed in the mechanical room.

The ATES demonstration project was coupled with a maintenance project for the interior mechanical construction aspect. Contractor construction prices were obtained for the interior mechanical room work and utilized for the cost analysis and comparison. The cost analysis for the ATES demonstration assumes a construction project to replace the existing HVAC system was due occur in the near future. This is a reasonable assumption as the existing multi-zone AHU was over 20 years old. The cost analysis also assumes the boiler would be replaced and the existing interior piping would be replaced in support of the replacement system.

Since the existing HVAC system was dependent upon the operation of a chilled water central plant, it is assumed a local air-cooled chiller would be installed for supplying the building's chilled water system. This is also reasonable as other buildings of this demonstration project's size utilized local air-cooled chillers when a renovation project took place to eliminate the need for the chilled water central plant. To complete the life-cycle cost analysis, the energy model created for the existing HVAC system in the second performance objective was utilized to calculate HVAC electrical and natural gas consumption. The original energy model was modified to reflect the use of a local air-cooled chiller in lieu of a chilled water central plant. The HVAC monthly energy consumption is illustrated in Table 7.3.

**Table 7.3. Modeled Conventional HVAC Monthly Energy Consumption**

| Fort Benning – B3215 – Modeled Conventional HVAC Monthly Energy Consumption Summary | | | |
|---|---|---|---|
| **Baseline HVAC Energy Consumption** | | | |
| **Month-Year** | **Electrical (KWh)** | **Gas (Therms)** | **Total (kBTU)** |
| Aug | 17,871 | 0 | 60,976 |
| Sep | 15,671 | 0 | 53,469 |
| Oct | 11,271 | 1 | 38,557 |
| Nov | 6,228 | 176 | 38,850 |
| Dec | 6,461 | 292 | 51,245 |
| Jan | 6,489 | 414 | 63,540 |
| Feb | 5,853 | 306 | 50,570 |
| Mar | 6,428 | 155 | 37,432 |
| Apr | 6,207 | 73 | 28,478 |
| May | 13,365 | 0 | 45,601 |
| Jun | 15,721 | 0 | 53,640 |
| Jul | 18,133 | 0 | 61,870 |
| | | | |
| Total: | 129,698 | 1,417 | 584,230 |

Construction costs associated with the ATES wells and corresponding piping outside the mechanical room were obtained from quotes and invoices. To establish the cost of the interior mechanical room work coupled to the ATES wells, the Contractor's bid price was used. To establish the conventional HVAC system cost, the Contractor(s) responsible for the maintenance project work estimated a construction cost if the new system would have been a comparable multi-zone AHU replacement system. The costs associated with both the ATES system and conventional HVAC system were utilized for the cost analysis.

The investment costs associated with the ATES project and the alternate conventional HVAC system were input into the BLCC5 program (https://energy.gov/eere/femp/building-life-cycle-cost-programs) accordingly with the energy consumption data illustrated in Section 6.0 for Performance Objective No. 1 used in the life-cycle cost analysis (LCCA) comparison. Energy rates for electricity ($0.062/kWh) and natural gas ($0.51/therm) were also obtained from Fort Benning personnel. The LCCA utilized a 20-year length of study period (October 1, 2016 through September 30, 2036) with a Constant Dollar Analysis and a Real Discount Rate of 3.0%. Performing a cost comparison analysis computes the following results:

- Savings-to-Investment Ratio (SIR): 1.61
- Adjusted Internal Rate of Return: 5.49%
- Simply Payback occurs in year: 10
- Discounted Payback occurs in year: 12

The full comparative analysis report is included in Appendix K with the Table 7.4 below summarizing the inputs used:

**Table 7.4. Conventional vs. ATES Cost Comparison Summary**

| Benning – B3215 – Cost Comparison Input Summary | | |
|---|---|---|
| **Input** | **Conventional HVAC Project** | **Demonstration HVAC Project** |
| Initial Investment ($) | $608,375 | $648,304 |
| Annual HVAC Electrical Consumption (kWh) | 129,698 | 79,834 |
| Annual HVAC Natural Gas Consumption (therms) | 1,417 | 0 |
| Annual Evaporative Water Consumption (gallons) | 0 | 0 |
| Initial Annual HVAC Electrical Cost ($) | $8,041 | $4,950 |
| Initial Annual HVAC Natural Gas Cost ($) | $723 | $0 |
| Initial Annual HVAC Evaporative Water Cost ($) | $0 | $0 |
| General Maintenance ***Savings*** ($) | $0 | $0 |
| Chemical Treatment ***Savings*** ($) | $0 | $0 |

# 8.0 IMPLEMENTATION ISSUES

## 8.1 OVERVIEW

Despite the various architectures of Underground Seasonal Thermal Energy Storage (USTES) being rare in the United States, its implementation as part of this project, though time consuming, was relatively straight-forward. This was especially true for the BTES architecture. The ATES architecture did present several regulatory challenges and one procurement challenge as described herein. The aggressive use of outside funding on both projects tended to prolong the time needed to complete them, but had the significant benefit of expanding the scope by an order of magnitude on the BTES and significantly on the ATES. Specifically, the BTES project, which was originally slated to be on the order of 30-40 tons, expanded to 425 tons through a unique arrangement where the ESTCP engineering effort was applied to a conventional GHP Mil-Con project that was funded outside of ESTCP. It took over a year to clear legal and administrative hurdles to do this, but this effort was highly beneficial as the external source of almost $5M in construction money facilitated a demonstration at a scale that greatly increases the probability of technology transfer and gave end users the confidence to know that BTES truly can work at scale. The success at a 425-ton scale, gave MCLB the confidence to redesign three more conventional GHP systems as BTES systems. Though Ft. Benning's site proved difficult for ATES (the international firm performing the hydro-geological consulting ultimately found its hydraulic conductivity to be only 10% of what their preliminary grain-size analysis led them to believe), Ft. Benning's keen interest in potential energy savings of ATES, kept the project moving forward. Over the course of almost a year, Ft. Benning decided to make a substantial ($450k) HVAC investment in the interior of the candidate building, to insure it could receive the ESTCP funded ATES system at the project site and operate at optimum efficiency. Though this challenge, and the regulatory/permitting challenges described herein, resulted in the ATES system's energy savings having to be modeled in this final report, rather than measured as was done on the 10X larger BTES project, it is anticipated that metering of the new system will continue into 2018 so that measured performance can be compared to the baseline.

## 8.2 REGULATORY/PERMITTING CHALLENGES:

Though the challenges described herein are specifically related to the implementation of ATES (Ft. Benning) and BTES (MCLBA) in Georgia (GA), the issues encountered will be generally applicable for most ATES/BTES projects throughout the US. With both projects involving either boreholes (BTES) or water wells/injection wells (ATES) they fall under the jurisdiction of the GA Department of Natural Resources' (DNR) Environmental Protection Division (EPD), hereinafter referred to as GAEPD. In the arena of so called Underground Injection Control (UIC), the GAEPD acts on behalf of the Federal Government's Environmental Protection Agency (EPA). They have been given the authority to rule on groundwater injection though a legal mechanism called "Primacy". For more details on Primacy, see https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program. Although ATES projects simply withdraw local groundwater, change it a few degrees and transfer it back to the aquifer from whence it came, legally this is considered a "Class V Injection Well" and therefore it falls under EPA's jurisdiction and in this case, a UIC permit is required from GAEPD. In some states, this is not a complex affair. In GA it proved to be difficult.

### 8.2.1 BTES regulations/permitting:

Overall, in the US, BTES system are not generally difficult to permit as they do not physically remove or inject groundwater and therefore no UIC permit is required. In essence, a BTES system is a close cousin to the traditional closed loop geothermal heat pump (CLGHP) systems that have been used in the US for decades. Basically, to the traditional CLGHP, reversing valves in the water loop, concentric thermal zones in the underground Ground Loop Heat Exchanger (GHX), a heat rejection device like a cooling tower/dry-cooler and more sophisticated controls are added. None of these items create any additional environmental concerns. In GA, the regulations are deceptively simple, the driller of the boreholes must be a licensed well driller in the state of GA and the boreholes must be fully grouted. Both are good practices, independent of the regulatory necessity. Generally, most states allow simple close loop boreholes to be installed in virtually every geological formation. Many regulations require the borehole to be grouted from top to bottom and some only require the upper (surface) region to be grouted (to prevent surface contamination) or if multiple aquifers are penetrated, grouting between aquifers is required to prevent inter-aquifer transfer of water. Overall, independent of regulatory requirements, the industry is moving quickly towards fully grouted boreholes for thermal and environmental reasons. A few State regulators have concerns about the industry standard grouting material (sodium bentonite grout with its extremely low hydraulic conductivity and ability to stay flexible when hydrated) in certain formations and therefore may require special grouting in some situations, like a high salt content aquifer. Overall, BTES projects can be permitted easily in most states and in some locations (like GA), no State permit is required. Closed loop boreholes do not require an injection permit under the UIC program as no liquid "injection" is occurring. With most DoD projects occurring on Federal land, the State may not be even involved, though some states may require a standard "well permit" for the closed loop boreholes. At the BTES project at MCLB, no Federal, State or Local permits were required for the 302 boreholes that were drilled.

### 8.2.2 ATES Regulations/Permitting:

As described previously, the fact that ATES systems inject water into the ground invoke the need for a Class V, UIC permit to inject the water. "Class V" is basically a group of widely diversified type wells that EPA groups together when they don't fall into any other category. It includes everything from "Cesspools" (no longer used), drainage wells for storm water, recharge wells for aquifers, salt water intrusion barrier wells and more. To determine if the EPA itself or a State Authority issue the Class V UIC permit, see the hyperlink in paragraph 8.2 which is also included with the following figure.

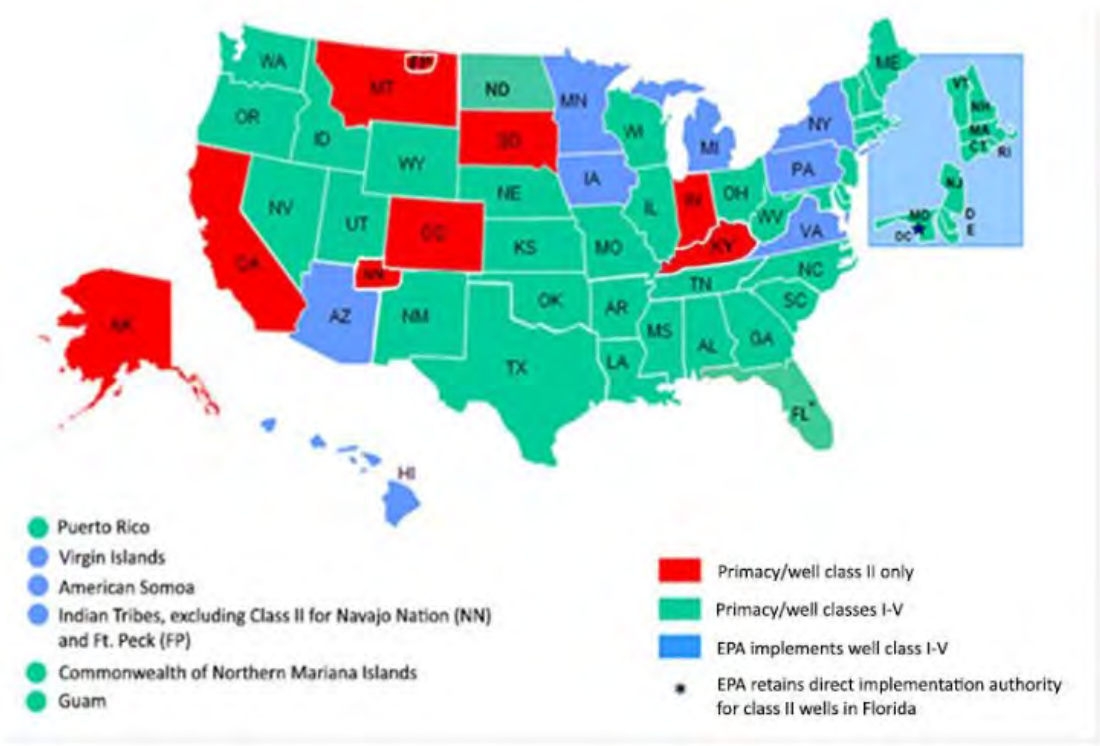


**Figure 8.1. Map of States with/without Primacy to Issue Class V UIC permits**

*per https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program as of January 2017.*

Perhaps more than any state in the US, this process was complicated in Georgia by the fact that traditional "open loop heat pump systems where return water is discharged into a well" are prohibited wells in GA whereas "non-contact groundwater cooling wells" are not. In essence, the former typically routes the groundwater through a refrigerant-to-water heat exchanger creating a slight risk of refrigerant getting in the groundwater) whereas the proposed ATES system utilizes potable water on the other side of the groundwater heat exchanger. According to regulations, it is permissible within Georgia for the "used" groundwater to be released to the surface, whereas elsewhere in the country, even within the same EPA Region (Region 4/Southeast in this case), other regulatory authorities virtually insist it be returned to the aquifer if its only change is a slight (6-20F) variation in temperature and returning it to the aquifer results in *no net withdrawal of water*. ATES wells, unlike irrigation or drinking water wells, produce no net withdrawal of water from the aquifer and hence are exceptional environmentally friendly and sustainable. Procuring the UIC permit for this project took many years due to this quirk in the GA regulations, the retirement of the Environmental lead person originally procuring the UIC permit at Ft. Benning and other issues. For the ESTCP ATES project in GA, in the end, the GAEPD required:

- A comprehensive subsurface investigation of the hydro-geology including geophysical logging and computer modeling of the aquifer to determine the amount of drawdown and "mounding" of the water table during ATES operation

- Water quality lab analysis of the groundwater for dozens of the potential contaminates listed in the Underground Source of Drinking Water (USDW) Standards (40 CFR 144.3) A comprehensive (65 page), UIC Permit Application, supervised and stamped by a licensed Professional Engineer (PE) or Professional Geologist (PG), that included all of the above, engineered drawings, schematics and maps. This is contrasted against a two-page permit application used in some states
- After construction of the ATES wells are complete, a Mechanical Integrity Test (MIT) must be performed on the well casings and quarterly water quality testing of the injected groundwater performed for dozens of potential USDW contaminants.

These complications for this Demonstration project do not mean procuring the UIC permit in other states will be as complicated or time intensive. This report is intended to guide potential users of this technology in all 50 states. As an illustration of the regulatory situation in other states, Florida (FL) serves as a good example. There are in excess of 5000 "air conditioning (injection) wells" (a cousin to an ATES wells) active in Florida. The statewide UIC program manager in FL, Joe Haberfield, PG, advises that permitting these wells typically only takes a few weeks and is in fact handled under the same "General Permit #0001" for all projects. When considering an ATES system for a specific Base, the UIC permit, while critical, is not necessarily a complicated or protracted exercise. The key take-away is to talk to the applicable state's UIC Coordinator, discuss the project in depth, understand their position for what is required to obtain a UIC permit and determine where the decision authority resides. If it is not the UIC Coordinator, attempt to meet with the ultimate decision makers and understand their position. Sometimes, decision authority is as high-up as the head of the entire State's EPA (equivalent) program, and sometimes, a "local" water management district's manager can sign off. In certain states, UIC permits can be done under "permit by rule" protocols or via a "general permit", and the process is relatively painless.

## 8.3 END-USER CONCERNS/RESERVATIONS/DECISION MAKING FACTORS:

In general, GHPs of any form (conventional, ATES or BTES) are fairly rare in the US market. Many experts put the market penetration of GHPs at around 1% of the US HVAC market, so there may be some hesitation to try something "new". Generally, though, in the DoD realm, due to the emphasis for energy efficiency, energy security and renewables, there has been some exposure to some form of GHPs on most installations. Terminology is also an issue as GHPs go by many other names such as Ground Source Heating and Cooling, Geo-Exchange, etc., but, in the end, they all are about using the geology/groundwater to heat and cool buildings. Properly engineered and installed GHP systems will always outperform their air-cooled counterparts and, in all but the coldest climates/load profiles, GHPs eliminate the need for on-site fossil fuel consumption, so they are generally preferred by most end users. The only time concerns arise is when the end-user has experienced an improperly engineered and/or installed system and therefore they have inappropriately "written off" the technology itself. This can normally be addressed by a proper educational presentations/discussions and references to other DoD personnel that have had good success with GHPs. Other concerns are GHPs higher first cost due to the HVAC project having to bear the cost of what is truly a nearly indefinite lasting, "inside the fence", underground utility. Users that understand that aspect of the project, and are focused on LCC, are typically willing to embrace the technology.

ATES and BTES are simply higher performing conventional open-loop and closed-loop GEO and typically have lower capital cost and use less energy than conventional GHPs. Emphasis on the basics is key: the geology/groundwater is a superior heat source as it's warmer than the air in winter, it is a superior heat sink as its colder than the air in summer and it offers you the ability to store a building's waste heat and "waste cool".

### 8.3.1 ATES Concerns

Overall, if the military base has management, engineering, geologist, managerial or administrative personnel are involved with traditional HVAC systems, they can fairly quickly gain an understanding of the fundamentals of an inject well type system. If they have water wells on base for irrigation or domestic water usage, they will generally have a basic understanding of a water supply well. Their past history (at work or even in their personal home) of maintaining submersible pumps will generally eliminate concerns about maintenance. Generally, with a properly designed well, these water-cooled devices are reasonably low maintenance and the remainder of the HVAC system is similar to the HVAC architecture they are already utilizing, and the elimination of a combustion boiler is a big plus.

### 8.3.2 BTES Concerns:

If a Base has had good experiences with conventional GHP systems, then the next step of utilizing a BTES is often a small one. Generally, most users can fairly quickly see the superiority of the BTES architecture over normal closed loop geothermal systems.

## 8.4 PROCUREMENT ISSUES:

The clear majority of the entire ATES and BTES systems are considered standard Commercial Off The Shelf (COTS) products. The major equipment and all the basic components have been available for decades. The heat recovery chillers at the BTES project are readily available from multiple US manufacturers as are the GHPs at the ATES projects. All pumps on both projects are standard products and at the BTES project, the AHUs and all the ductwork and piping outside the mechanical room were reused. The VAV boxes at the BTES site, due to the original design for 180F hot water only utilized 1 row HW coils, but it was a simple change-out to change them to COTS 4-row VAV boxes. The horizontal HDPE piping as well as when it is routed in a borehole as the GHX is a robust well established piping system utilized throughout the US for much more demanding applications like natural gas and to protect the nation's fiber optic cables. Two equipment exceptions, while COTS internationally, are rare in the US and are highlighted below.

### 8.4.1 Adiabatic Dry Cooler Issues:

Generally speaking, the most economical form of heat rejection is the ubiquitous cooling tower with its attendant high consumption of water due to its design as an evaporative cooling device. On the other end of the water consumption spectrum is a less prevalent, but COTS dry-cooler consisting of outdoor coils and fans for sensible heat transfer only with no water consumption. Due to the Demonstration plan goal of a 80-100% water reduction for the ESTCP project, a rare (in the US) adiabatic dry-cooler (sometimes referred to as a hybrid dry-cooler) was chosen.

Though now that the demonstration period has ended and MCLB may start using the adiabatic function (evaporative cooling the incoming outside air to the dry-cooler coil), during the demonstration period it was always run in the dry mode (mostly at night and in the winter) resulting in a 100% reduction in 4+ million gallons of water the baseline building consumed. While common in Europe and elsewhere, these are rare in the US. Nevertheless, there are multiple manufactures of this product and the selected units were made in North America. They worked very well, resulting in the recommendation that they be used for future BTES or ATES systems due to their unique ability to provide a "water-energy" nexus slider bar of sorts where a Base can choose to trade KWH reduction or water reductions based on how often they operate the adiabatic mode. On future ATES or BTES projects, if water reduction is not a high priority, less expensive cooling towers should be considered.

### 8.4.2 Injection Control Valves-imported from Europe

In the US, open loop GHP system do not typically have high level injection valve designs or controls. One reason for this is that they do not ever reverse the flow of the groundwater in order to store and reuse a building's waste heat or "waste cold". Another reason is typical HVAC engineers are not schooled or experienced in the nuances of groundwater chemistry. Regrettably, many US engineers, not understanding that groundwater may harbor water chemistry issues that can be prevented if maintained in a pressurized state or sometimes an anoxic state, simply release the injected water in the well near the surface. To avoid those issues on the ATES project, it was decided to provide world-class injection valves that from a manufacturer that had extensive experience in ATES systems. After US manufacturers were investigated, the search turned to Europe and elsewhere. After extensive investigation, ultimately a firm in Switzerland was selected. Ironically, this company was the European branch of a US firm, but with no demand yet for ATES valves in the US, this product is only manufactured in Europe and in metric dimensions and European electrical characteristics (230 VAC/50 Hz). These seemingly minor inconvenience created several delays, but though the use of US and Swiss piping adapters/fittings, and the ability of the hydraulic unit to be furnished at 120 VAC/60 Hz, the issues were ultimately resolved.

## 8.5 ENGINEERING/SPATIAL ISSUES:

### 8.5.1 Hydraulic Conductivity:

With many of the world's ATES projects having been constructed in The Netherlands, a Dutch firm was retained to provide technical assistance to the team. Though their experience was international, it was concentrated in The Netherlands where somewhat uniform geology allows them to perform a reasonable estimation of a formation's hydraulic conductivity from just a sieve (grain size) analysis of the formation. This technique led to an initial overestimation of the hydraulic conductivity of the proposed ATES site by approximately one order of magnitude. During a subsequent internal technical review, it was decided that a traditional aquifer pumping test be performed on one the monitoring wells that was installed in the early years of the project with drawdown monitored in adjacent monitoring wells. This resulted in the ability to calculate the actual hydraulic conductivity of the formation. This new data produced the need to redesign and increase the capability of the proposed ATES wells. In retrospect, ideally, hydrogeological studies would be performed at select locations around a base to determine which locations are best suited for ATES with the balance being limited to BTES.

Generally, if the aquifer is prolific enough to support the volumetric flow rate (GPM) needed for a building's heating/cooling loads, ATES, will often be less costly than BTES due to the former typically needing just pairs of wells vs. the dozens or even hundreds of boreholes required by a BTES. Still, simplicity, 50-state applicability, elimination of UIC permitting, familiarity and the closed loop nature of BTES will lead many end users towards BTES, even though ATES can have lower first cost and better LCC if there is an adequate aquifer. In an ideal situation, a base would perform some level of base-wide hydrogeological studies and determine what locations and buildings/loads would be most suitable for ATES (if any) and what locations would be better suited for BTES. As a minimum, an industry standard Thermal Conductivity Test (TCT), sometimes also referred to as a Thermal Response Test (TRT) should be performed at all candidate BTES sites. At all ATES candidate sites, water quality should be testing in a manner similar to that described in "Test Drilling Program" of Appendix E.

### 8.5.2 Water Quality Issues:

An aquifer is generally considered to be optimal for ATES use if the groundwater movement is low (typically in the magnitude of a few feet per year, it has good "yield" (GPM per foot of drawdown), and it has proper water quality. Typically, desired water quality characteristics include water low in iron (especially the species $FE^{2+}$, $FE^{3+}$), free of surface contaminates like nitrates ($NO_3^-$) or other pollutants. Especially important is to determine where the so-called Re-Dox interface is located and insure the oxygenated water and the nearly oxygen free water (anoxic water) do not mix during the operation of the system. Rainwater and near surface water will always contain some oxygen due to the presence of atmospheric oxygen. Deep (100+ ft. deep) groundwater will generally not contain much oxygen. The Ft. Benning site was fortunate in that it contained a 10-15' thick layer of clay, at about 250' below grade (located by conducting natural gamma ray radiation logging) that created a "confining layer" that form the top of the ATES "tank" and separated its water from the surficial layer above. Bedrock at about 400' below grade form the bottom of the ATES tank. This naturally anoxic water also proved to be free of typical surface water contaminated like nitrates and did not have significant or sometimes even measurable levels of iron. Accordingly it had proper water chemistry for a successful ATES deployment. Highly detailed water chemistry analysis information is beyond the scope of this Final Report, but more information can be found in Appendix C, about 2/3 of the way through the UIC permit application. As an illustration of water chemistry and ATES design that would be highly risky would be to take deep anoxic water that was laden with iron and expose it to air by cascading (aerating it) down the injection well (or injecting it into an oxygenated aquifer) so that the iron would oxidize and precipitate out. Next opportunistic iron-eating bacteria could now utilize the iron-oxide as a food source causing biological fouling. Couple this approach with improper well and gravel pack design that extracts sand or clay from the formation and then an injection well that might have operated for decades might clog in a matter of months. It is important that water quality be analyzed and good well design executed to experience the trouble free ATES injection wells that can be found throughout the world when the aquifer is fully investigated and the ATES wells properly engineered.

### 8.5.3 Mechanical Room and Real Estate Limitations:

Retrofitting ATES/BTES systems into existing mechanical spaces and available land can range from simple to problematic. Military base's land usage ranges from low density development to very high density (e.g. around naval docks, urban areas) situations. According, installing the outside ATES or BTES system often require careful planning. In general, it is sometime impossible to retrofit the hundreds or boreholes required by large (100+tons) HVAC system in high density situations. In those instances, either only smaller BTES systems could be considered; however, if the aquifer beneath the base is prolific, sometimes 100s or even 1000's of tons of capacity can be installed with just several pairs of ATES wells. In the case of the ATES and BTES project, land was not an issue and both bases were suitable for both architectures with the selection of system type being driven more by circumstances and funding availability. Certain building types also lend themselves to their adaptability to ATES or BTES. In the case of the BTES project at MCLB, the need to reuse recently replaced chilled water VAV AHUs and their hot water induction boxes architecture, were a natural fit to be replaced with a BTES supported 6-pipe, heat-recovery modular chiller. The tight foot print of the modular chillers and the removal of two large centrifugal chillers and the *elimination* of the gas boilers provided sufficient room for the GHP-BTES installation. A huge, partially cleared land area behind the building also was well suited for a the large (300+ ft. diameter) BTES though its footprint could have been reduced if needed by deepening the boreholes beyond their 210' depth. At the ATES project at Ft. Benning, a soon-to-be-shutdown central chilled water plant and an aged local boiler and obsolete 4-pipe multi-zone AHU we appropriately replaced with 7 GHPs, one per zone of the original AHU. Elimination of the boiler provided the needed real estate for the new GHP ATES system. In other situations, (e.g. packaged DX equipment), the mechanical system may not lend themselves to be easily retrofitted to indoor mechanical system that are compatible with ATES/BTES, though those instances are probably rare.

### 8.5.4 Accessibility for ESTCP monitoring and tuning of the ATES and BTES (Cyber Security):

Due to security concerns, direct connection to the base -wide energy monitoring system was not allowed at either site. All initial energy monitoring was done by on-site data-logging equipment that was downloaded by hand (during-site visits). Later, expensive independent cell modem based monitoring equipment was added that was kept separate from all DoD systems so that at least some monitoring could be done more frequently and without a site visit. Ultimately, at the BTES site only, after the system was put online, MCLB approved the PI and Co-PI to go through the CAC card process and a government laptop was issued to the Co-PI that had to be returned monthly for security updates and scanning. This Marine CAC-card equipped laptop was then allowed access to just the IP address of the JACE at the BTES project, via the Marines military secured VPN portal for monitoring purposes only. Though slow, and so securely laden it would often have to be returned for updates, it was an invaluable to observe the characteristic of the BTES operation and response to various climatic situations and building loads. This type access was never secured at the ATES project. It is hoped that in the near future, properly vetted and credentialed DoD researchers and PIs can obtain real-time access to their projects, for at least monitoring purposes. When leading edge energy and water projects can be observed and tuned in real time, solutions to meet DoD's energy security needs can be accomplished in a timely manner and technology transfer accelerated.

### 8.5.5 Borehole Grouting:

In the context of this project, grouting refers primarily to the addition of material to fill the annulus of a borehole to insure efficient heat transfer can occur between the underground vertical HDPE piping (U-bends) of the BTES and the surrounding geology and the groundwater. Grout also serves as a seal of very low hydraulic conductivity to prevent surface contaminates from reaching the aquifer and/or undesired inter-aquifer transfer of groundwater. To improve heat transfer, a thermal enhancement material like specialized high silica (99.9%) sand or graphite is often added. In sections of the geology where there a "holes" in the geology (e.g. gravel seams, karst limestone, etc.), many State regulations permit gravel to be placed in the annulus until the fill material has progressed up the borehole back to a "grout-able" section of the borehole. Unfortunately, that is not the case in GA where the BTES was constructed in karst limestone. Despite several test or production boreholes being drilled at MCLB over the years (including one at the beginning of the ESTCP BTES project) that were easily grouted, a few boreholes into the production drilling, all activities were temporarily stopped due to grouting problems. For many of the 306 boreholes at the BTES, the formation had so many voids, cracks and cavities that it could takes on (in essence) an unlimited amount of grout (at least 5 X the annulus volume) and never reach the surface. In some states, you would simply switch to gravel at that zone, and then presume grouting once you were past that location. In GA, that is not yet an option as the regulations "simply" require the borehole is grouted from top to bottom. Accordingly, work was stopped and the technique of simultaneously grouting from the bottom up via tremie tube at a vertical rise rate equal to the rate of surface placement of pea gravel poured down into the borehole. Expressed differently, as the pea gravel fell to the bottom and subsequently rose upward in the annulus as a fairly high porosity "matrix", pumped grout filled in the matrix and rose with the pea gravel to the surface as the tremie tube was extracted at the same rate. After the NAVFAC Contractor was fully trained with this technique, the engineers left the site, a change-order was processed and construction was restarted. Accordingly, special grouting techniques may be needed in highly porous formations. Similarly, if ATES or BTES projects are attempted in formations with high sodium content (brackish or salt waters), the groundwater should be tested and grout manufacturers should be consulted to determine if a suitable cementious grout is available.

### 8.5.6 Implementation Request from ESTCP's SEM systems "Action Items":

- *Discuss permitting of USTES systems at military installations*: See Section 8 in general and Paragraph 8.3 in particular.
- *Discuss what aquifer types are best suited for USTES*: See Sections 2.3.2, 8.5.1 and 8.5.2.
- *Discuss what tonnages are appropriate for USTES:* See section 2.1.3. In general, it is believed that if a project can be funded as a conventional closed loop or open loop GHP system, it is a candidate for BTES or ATES respectively. That being said, BTES system do need to have a minimum number of two concentric thermal storage zones, so probably a minimum of 20 boreholes would be needed. Also, the cost of the reversing valves probably has a minimum threshold for implementation. The scientific answer is to construct a computer model using (typically) a program like TRNSYS, run a LCC and see if BTES will pay back over traditional GHX designs.

As a practical matter, perhaps 50 tons is a minimum size. MCLBA was so pleased with the performance of "BTES-1" that they ordered three more BTES systems be designed. Those systems (BTES-2,3, & 4) range from around 56 tons to 183 tons. A larger BTES system (BTES-5) has also been designed for the Veterans Administration. Similarly, ATES system must bear the brunt of some additional first cost over traditional open-loop GEO systems, primarily in the form of additional pumps and injectional valves. While there are ways to mitigate some of these cost, 50 tons is also probably a good rule of thumb for the minimum tonnage of an ATES. In both cases, but especially ATES, economies of scale can radically reduce the cost per ton of these systems.

- *Discuss thermal storage capacity*. See Appendix L. UTES systems, because they are primary composed of the geology itself and the ground water, and are typically large, have an immense capacity to store energy. Presented in the Appendix L are some rudimentary calculations that show the storage capacity of the BTES itself, and the net capacity of the groundwater that is injected into the hydrogeology by the ATES, in terms of each degree F the building and its associated systems change the hydrogeology within the ATES/BTES. As can be seen in the Appendix, the larger scale BTES can store the equivalent of more than 1.4 billion BTUs of thermal energy (equivalent to 432,000 kWh) and the significantly smaller ATES can store 93 million BTUs (equiv. to over 27,000 kWh) *per degree F change in the BTES itself or the injected groundwater.* It should be noted that the BTES indirectly "accesses" the BTES via 306 each "fingers" (grouted HDPE U-bends inserted down 210 ft into the geology), while the ATES achieves "access" by direct injection of groundwater via two injection wells.
- *State GHG Reductions*: See the Executive Summary and Section 3.0
- *Can existing fire protection wells and drinking water wells be repurposed for ATES?* Absolutely! A proper engineering study that included a detailed environmental, water quality, hydro-geological properties (including proper characterization of the aquifer), along with a review of the appropriate State and Federal UIC regulations would be needed, but there are no fundamental overarching issues that would inherently eliminate repurposing before a careful investigation is conducted.
- *Provide LCC and Payback analysis*: See Section 7.3
- *Provide recommendations for additional narrative in the Whole Building Design Guide (WBDG) to support technology transfer to DoD*: Ideally, additional narrative in the WBDG would help support technology transfer of both ATES and BTES systems to DoD by requiring all sites/systems to be evaluated for USTES eligibilities/ capabilities. This would allow each site/system to be evaluated as the Baseline system and used as the baseline comparison to other system types from a capital cost and annual operating cost stand-point.
- Typical cooling dominated HVAC systems are designed more towards optimal heat rejection/dissipation while typical heating dominated HVAC systems are designed more towards for optimal heat extraction. Conventional geothermal systems are designed the same way. A cooling dominated GHX is typically designed such that ground loop temperatures do not become too hot over the course of a 20-to-30-year duration, while a heating dominated GHX is typically designed such that ground loop temperatures do not become too cold over the course of a 20-to-30-year duration.

For increased efficiency and lower operating costs, designing systems for underground seasonal thermal energy storage allows not only for the waste heat of cooling systems and the waste cool of heating system to be captured, but also allows for the out-of-season capture of the winter's "cold" or summer's "heat", if needed, in cooling dominated or heating dominated buildings, respectively.

- WBDG narratives would also promote active control of the ATES or BTES system via auxiliary heat rejection device (i.e. dry cooler) for cooling dominated systems or auxiliary heat injection device (i.e. dry cooler is still an option as well as solar heating) for heating dominated systems. Additional requirements of no evaporative water use would also assist in this aspect. WBDG narrative could also incorporate sequence of control requirements, which would support a USTES system to be utilized.

- *Include MCLB geothermal specifications sections that would benefit the committee responsible for updating United Facilities Guide Specifications (UFGS)*: Specifications utilized for the MCLB-B3700 project were revised specifically for the BTES system designed for this Demonstration and have been sent to ESTCP as a standalone document. Additional revisions to the specifications are recommended as over a year's worth of operation has provided additional information, which would benefit future BTES projects. These revisions would need to be incorporated and reviewed before the specifications could be integrated/added to the UFGS.

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**EQuest** (www.doe2.com)

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# APPENDIX A POINTS OF CONTACT

| Point of Contact Name | Organization Name Address | Phone Fax Email | Role in Project |
|---|---|---|---|
| Charles (Chuck) W. Hammock, Jr. | Andrews, Hammock & Powell, Inc., 250 Charter Lane, Macon, GA 31210 | (w) (478)405-8301, Ext 102 (fax) (478-405-8210 chammock@ahpengr.com | Principal Investigator |
| Stephen E. Sullens | Andrews, Hammock & Powell, Inc., 250 Charter Lane, Macon, GA 31210 | (w) (478)405-8301, Ext 126 (fax) (478-405-8210 ssullens@ahpengr.com | Co-Investigator |
| Kim Hopkins | Andrews, Hammock & Powell, Inc., 250 Charter Lane, Macon, GA 31210 | (w) (478)405-8301, Ext 100 (fax) (478-405-8210 khopkins@ahpengr.com | AH&P Administrative Contact |
| Bas Godschalk | IF Technology Velperweg 37 6800 AP Arnhem The Netherlands | (w)+31 26 3535 523 (fax) +31 26 3535 599 B.Godschalk@iftechnology.nl | ATES Consultant |
| Jeff Thornton | TESS, LLC 22 N. Carroll St. Madison, WI 53703 | (w)(608) 274-2577 (fax) (608) 278-1475 thornton@tess-inc.com | TRNSYS Software Consultant/Modeler |
| Garret Graaskamp | American Ground Water Association 50 Pleasant St. Concord, New Hampshire 03301 | (603) 228-5444 Fax (603) 228-6557 garret@agwt.org | Environmental Guideline Consulting Organization |
| Mark Fincher | Ft Benning Building 6, Meloy Hall Office 320U Fort Benning, GA | (w) (706) 545-0922 mark.j.fincher.civ@mail.mil | Installation Energy Manager |
| Fred Broome | MCLB Walker Avenue, Bldg 5500 Marine Corps Logistics Base Albany, Georgia 31704 | (w) (229) 639-5601 frederick.broome@usmc.mil | Director, Installation & Environment Division |

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# APPENDIX B ATES & BTES SYSTEM DETAILED CONFIGURATIONS AND DIAGRAMS

## 1. BTES System Detailed Configurations & Diagrams

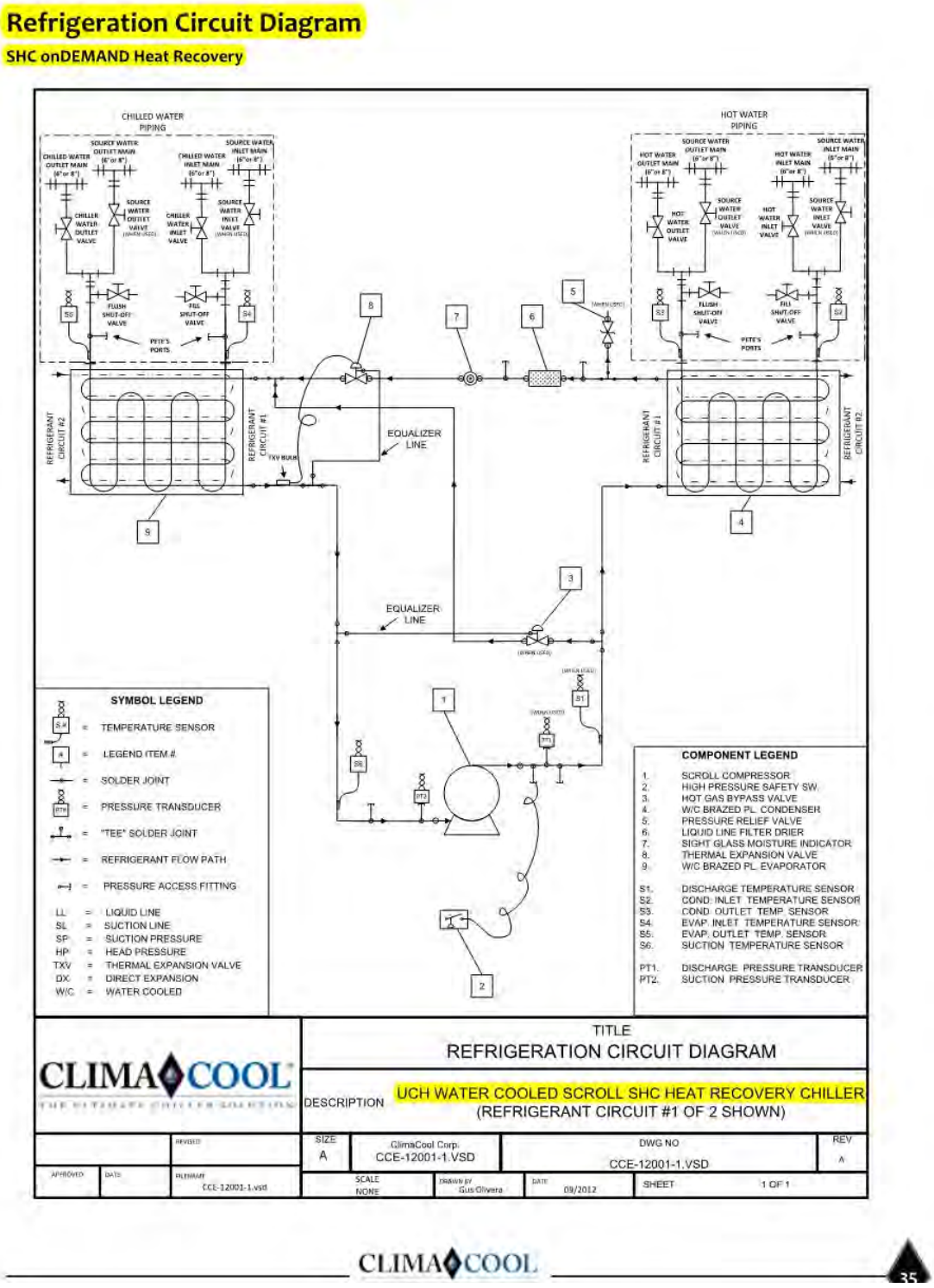


**Figure 2.4 Heat Recovery Chiller Refrigerant to Water Diagram**

Chilled, Hot, Source, & BTES Water Distribution System

a. Chilled Water System

The heat recovery chiller has a design chilled water supply water set point of 44°F. The chilled water supply leaves the modular chiller at approximately 44°F and is pumped into each of the three mechanical rooms inside the building. Each mechanical room contains two modular air handling units with chilled water cooling coils. (Note that the air handlers and corresponding controls were existing at the time of the BTES system installation.) The cooling capacity of the chilled water coil is controlled by a modulating three-way valve acting as a two-way valve. The bypass side of the existing three way valves was manually closed to force the valve to operate as a two-way valve. The chilled water enters the cooling coil where it extracts heat from the mixed air stream and then returns back to the mechanical room where it is piped to the suction of the chilled water pumps (P-5 & P-6). The chilled water pumps then recirculate it back to the heat recovery chiller.

The chilled water pumps operate as lead/standby, alternating every seven days to equalize wear. The chilled water pump speed is controlled by a variable frequency drive (VFD) that receives a signal from a differential pressure (ΔP) transmitter installed at the heat recovery chiller between the chilled water supply and return piping. The VFD modulates the pump speed to maintain a preset ΔP that was determined during Test and Balance operations.

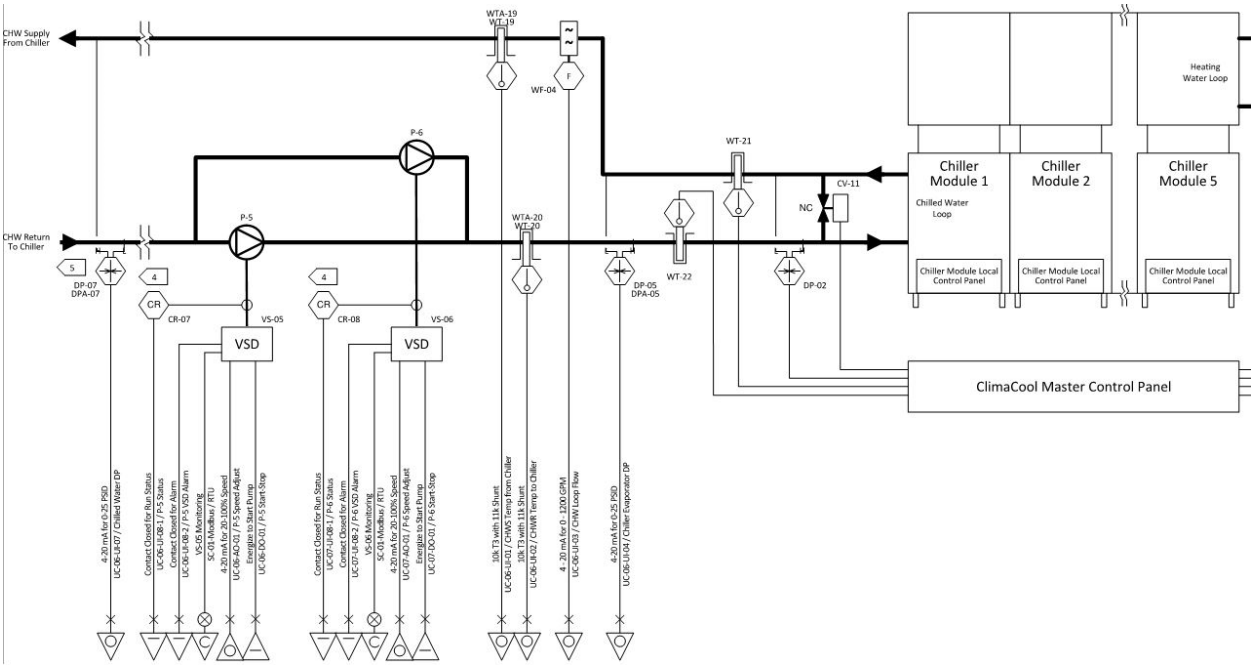


**Figure 2.1 Chilled Water System Diagram**

b. Hot Water System

The heat recovery chiller has a design hot water supply temperature of 115° F. The hot water supply leaves the heat recovery chiller and is pumped throughout the building where it serves re-heat coils installed in the VAV boxes. The existing VAV boxes were replaced with VAV boxes equipped with 4 row hot water coils to be able to produce approximately 90°F discharge air temperature using the 115°F hot water supply temperature. The hot water is then returned back to the mechanical room where it is piped to the suction side of the hot water pumps. The hot water pumps (P-7 & P-8) then recirculate the hot water return back to the heat recovery chiller.

The hot water pumps operate as lead/standby alternating every seven days to equalize wear. The hot water pumps speed is controlled by a VFD. The VFD receives a signal from a ΔP transmitter installed at the heat recovery chiller across the hot water supply and return piping. The VFD modulates the pump speed to maintain a preset ΔP that was determined during Test and Balance operations.

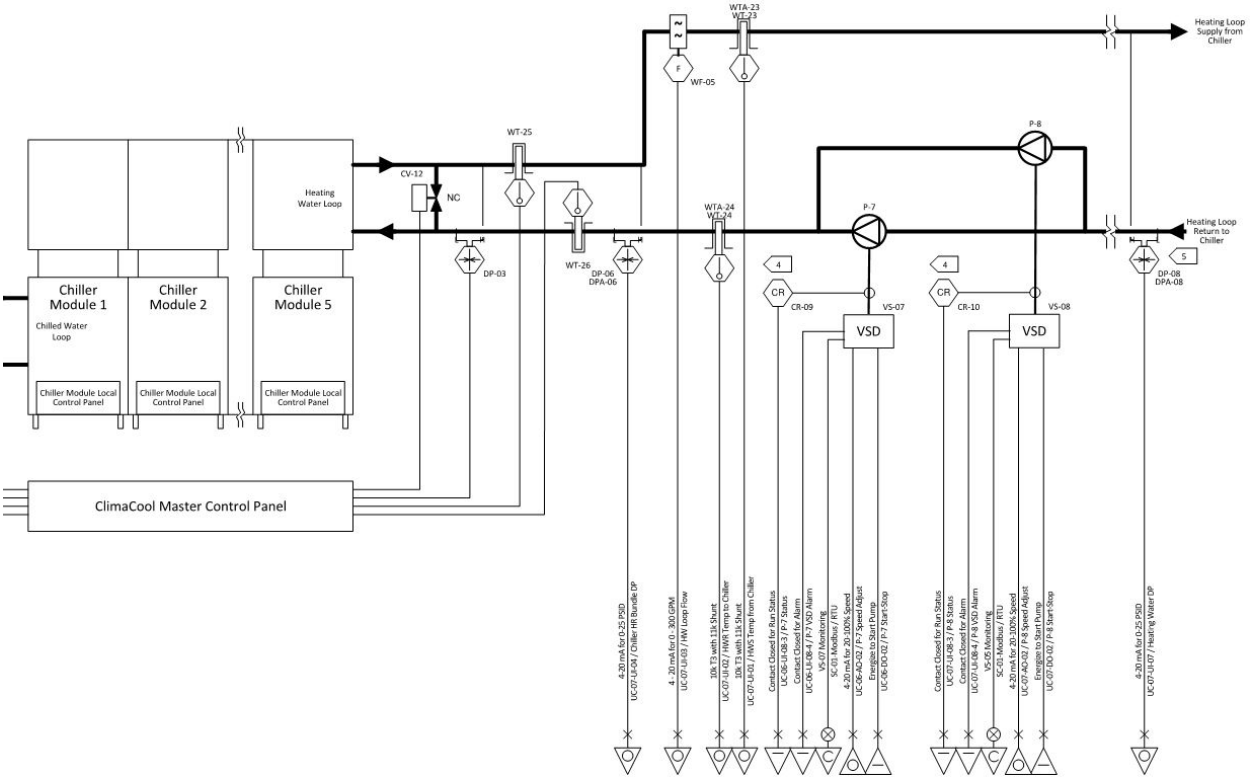


**Figure 2.2 Hot Water System Diagram**

c. Source Water System

The source water pumps (P-3 & P-4) pull water from the BTES piping and deliver it to the source side of the heat recovery chiller. The temperature range for the source water entering and leaving the heat recovery chiller is 60°F entering water temperature (EWT) minimum, and 135°F leaving water temperature (LWT) maximum. The source water flows through the water to refrigerant condenser

during cooling mode, and it flows through the water to refrigerant evaporator during heating mode. During heat recovery mode, the source water is completely isolated from the condenser and the evaporator for that particular module. *(Note that each module can operate independent of the other modules.)* After the source water leaves the condenser/evaporator it is pumped back to the BTES piping where it travels to the bore field.

Additional note: Since B3700 is a cooling dominated building, and the building needs very little heat even during the winter months, it is expected that the heat recovery chiller will never switch into the heating mode. Instead, the heat recovery chiller should typically have enough heat recovery capacity to meet the heating demand even in the winter months.

The source water pumps operate as lead/standby alternating every seven days to equalize wear. The source water pump speed is controlled by a VFD that receives a signal from a ΔP installed between the source inlet and source outlet piping at the heat recovery chiller. The ΔP measures differential pressure between the inlet and outlet piping to maintain the proper source water flow through the chiller depending on the number of modules that are operational. The VFD modulates the pump speed to maintain a preset differential pressure that was determined during Test and Balance operations.

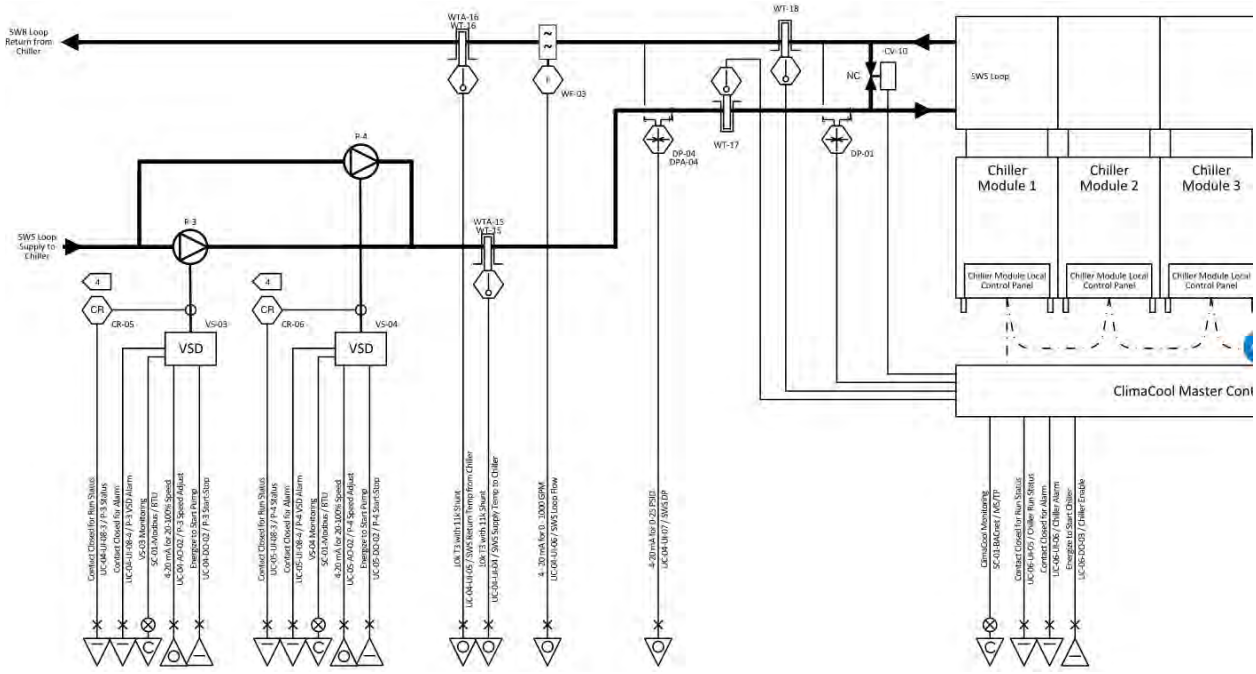


**Figure 2.3 Source Water System Diagram**

d. BTES Water System

The BTES water system operates as the secondary water loop for the source side of the chiller. When the source water is pumped into the BTES loop piping by the

source water pumps, the water is then pumped to the bore field by the BTES pumps (P-1 & P-2). The BTES water travels underground from the building to the bore field where the piping rises up to above grade. Once the piping rises to above grade, the BTES water encounters a three way, two position control valve (CV-07). CV-07 will either direct the water through the dry coolers, or bypass the dry coolers. After the BTES water passes through CV-07 (and dry coolers, if switched to dry coolers) the BTES water encounters a three way two position control valve (CV-08). CV-08, operating in unison with CV-09, can position to direct the BTES water to the bore field perimeter, or they can position to direct the water to the bore field core. The BTES pumps speed is controlled to allow the BTES to flow slightly more water than the source water (Approx. 30 GPM)

i. CV-07 (Dry Cooler) Logic

The Direct Digital Control system (DDC) uses an algorithm to determine when heat can be transferred from the BTES water to the air efficiently enough to warrant using fan energy to dissipate the heat in lieu of injecting the heat into the ground. As stated above, there are two reasons to do this:

1. To help to balance the heating/cooling load into the bore field so as to not overheat the bore field over time.
2. To reject heat from the core of the bore field and therefore store cooling capacity in the earth.

To perform this algorithm, the DDC compares the outside air temperature as sensed by sensor OA-1 with the temperature of the BTES water from the building sensed by sensor WT-14. If WT-14 minus OA-1 $\geq$ 12°F, then CV-07 will position to direct the BTES return water from the building into the dry coolers. After CV-07 opens to the dry coolers, if dry cooler entering water temperature sensor WT-06 minus OA-1 $\leq$ 2° F then CV-07 will change positions to bypass the dry coolers.

ii. Dry Cooler Fan Logic

When CV-07 positions to allow the BTES return water from the building to pass through the dry coolers, the following logic is used to determine the appropriate fan speed. The dry cooler fans will de-energize if the supply water temperature leaving the dry coolers sensed at any of the water temperature sensors (WT-01, 02, 03, 04) falls below 35°F. (Note: The dry cooler will lower the fan speed first to raise the water temperature leaving the dry cooler to be greater than 35°F, if this cannot be achieved then the fans will de-energize.) The dry cooler fans will also de-energize if the source water temperature entering the heat recovery chiller falls below 52° F.

Note: Available Positive Spread = (WT-06 minus OA-1)

Dry Cooler Temperature Differential Set Point % of Spread = (WT-06 minus WT-12)

| AVAILABLE POSITIVE SPREAD (DEGREES F) | DRY COOLER TEMPERATURE DIFFERENTIAL SET-POINT PERCENT OF SPREAD (%) | DRY COOLER MAXIMUM FAN SPEED LIMIT (%) |
|---|---|---|
| GREATER THAN 12 DEGREES F | 75 | 50 |
| 10 TO 12 DEGREES F | 65 | 40 |
| 8 TO 10 DEGREES F | 55 | 30 |
| 6 TO 8 DEGREES F | 45 | 25 |
| 4 TO 6 DEGREES F | 35 | 20 |
| 3 TO 4 DEGREES F | 25 | 10 |
| LESS THAN 3 DEGREES F | N/A | OFF |

**Figure 2.4 Dry Cooler Fan Logic**

iii. Charging/Discharging Logic

The DDC system uses an algorithm to determine if the BTES water downstream of CV-07 sensed at temperature sensor WT-12 is colder than the water temperature from the core of bore field (sensed at WT-11 during discharging mode). If this is true, the temperature at WT-11 is saved and the valves CV-08 & CV-09 will position to direct the BTES water to the core of the bore field (Charging Mode). After valves CV-08 & CV-09 position to charging, the DDC system then uses an algorithm to determine when to stop directing the BTES water to the core and start directing the BTES water to the perimeter of the bore field (Discharging Mode). To determine when to switch from charging to discharging the DDC compares the last saved temperature value from WT-11 during discharging mode with the current temperature reading sensed at WT-12. When WT-12 is greater than the saved value from WT-11, CV-08 & CV-09 will position from charging mode to discharging mode.

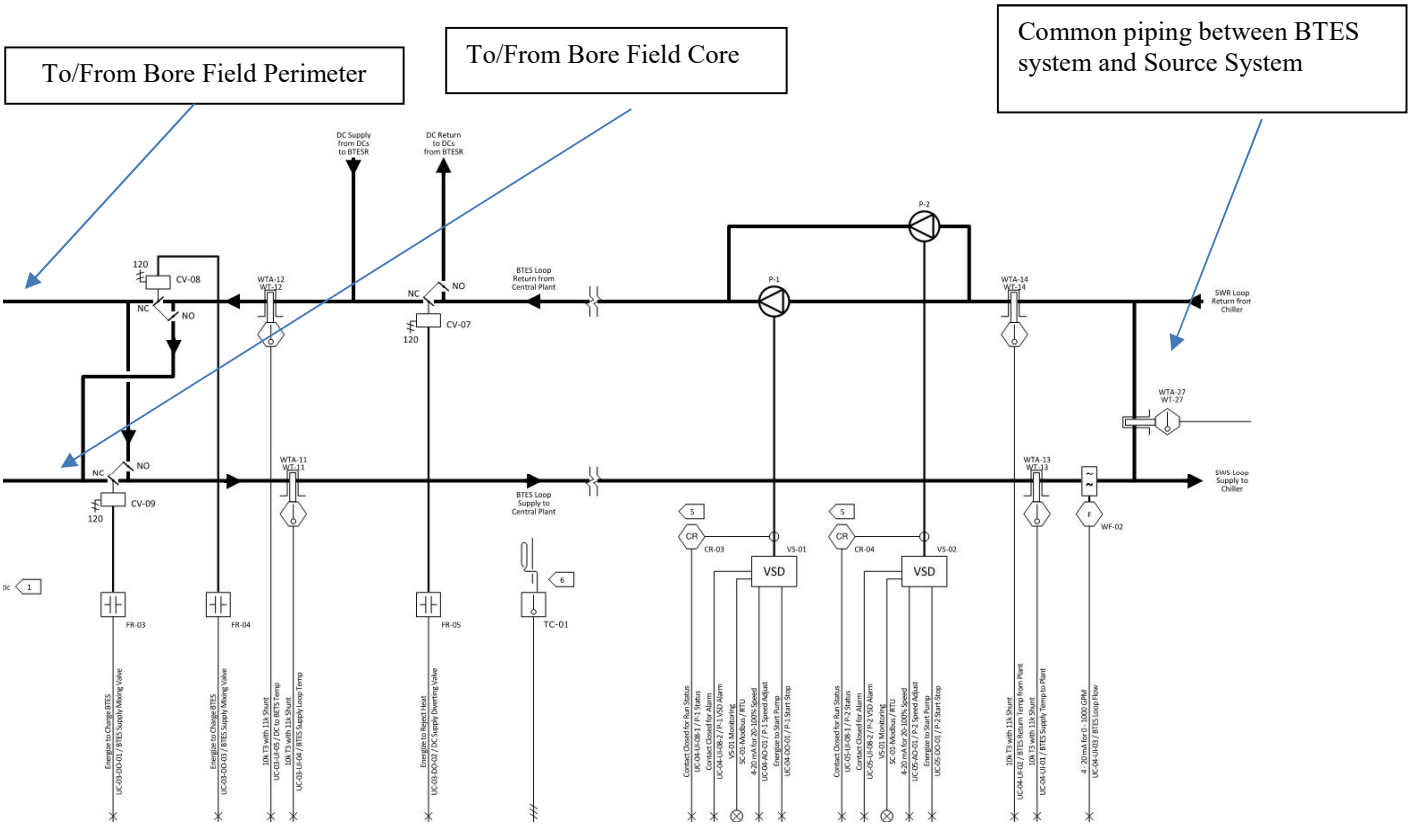


**Figure 2.9 BTES System Diagram**

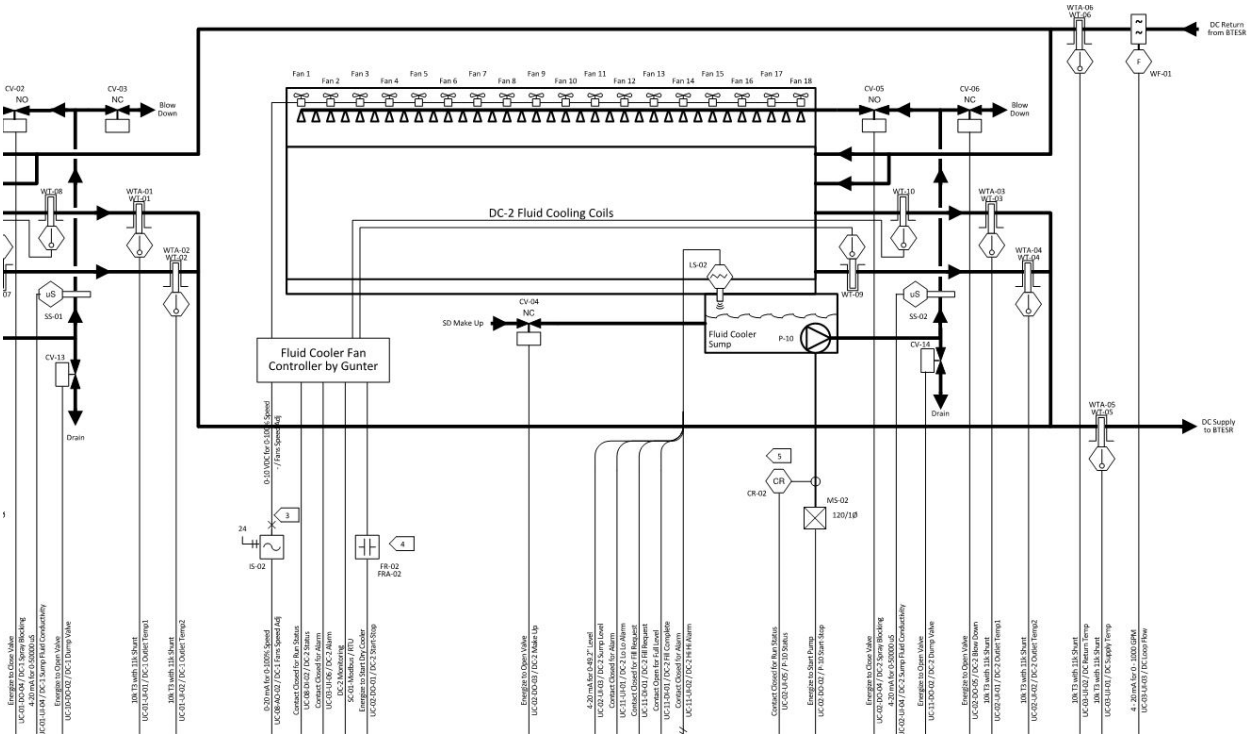


**Figure 2.5 Dry Cooler Diagram Part 1**

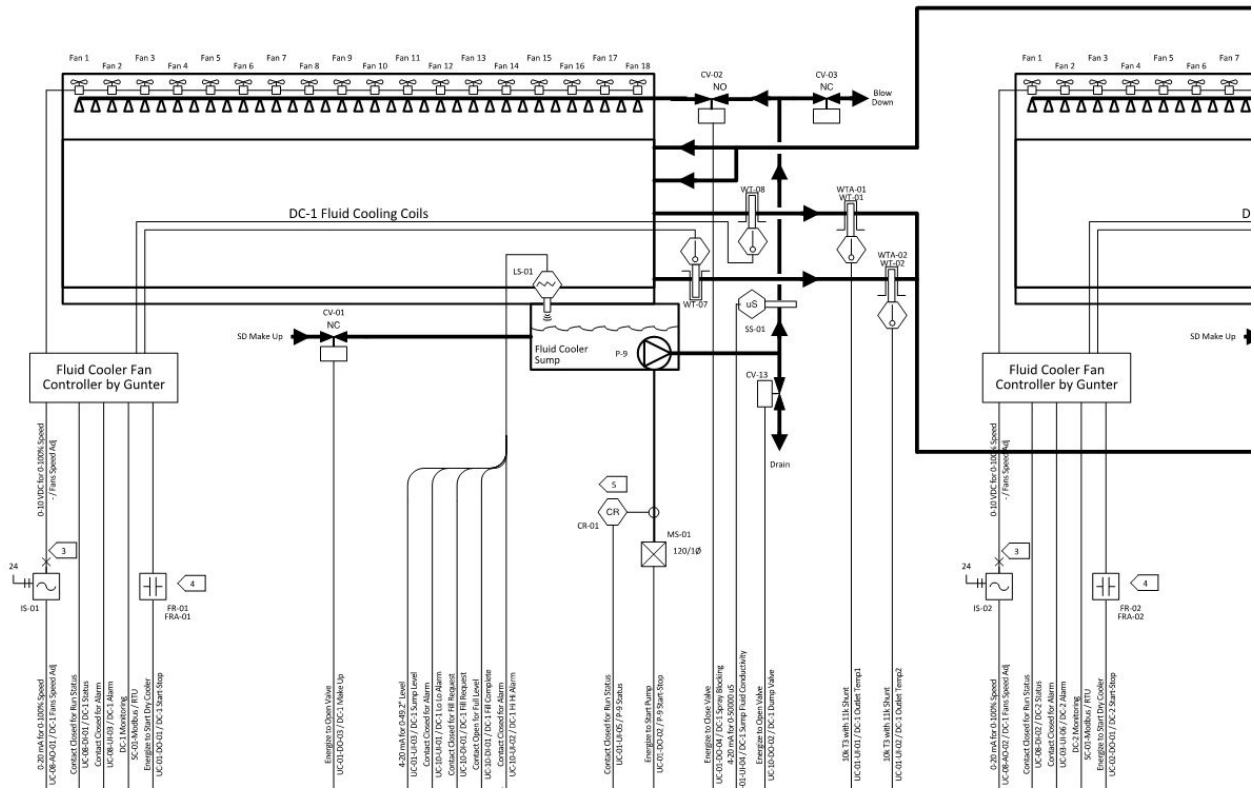


**Figure 2.6 Dry Cooler Diagram Part 2**

## 2. ATES System Detailed Configurations & Diagrams

Water Source Heat Pumps

Heating and cooling of the space is achieved by utilizing seven water source heat pumps located in a central mechanical room. The sizes of the heat pumps range from approximately 3 tons to 6 tons for a total of approximately 30 tons.

ATES, Dry Cooler, and Loop Water Distribution System

a. ATES System

As stated above, the ATES system consists of a warm well and a cold well. In cooling mode, cool water is pumped via a submersible well pump from the cold well and is directed to the loop water plate and frame heat exchanger (HX-1). The cool water extracts heat from the loop water as it passes through the heat exchanger, and is then routed to the warm well. The water is then injected into the warm well aquifer via an injection valve located above the submersible pump in the warm well. In heating mode, warm water is pumped from the warm well and is then directed to HX-1. The ATES loop rejects heat to the building loop as it passes through the heat exchanger. After leaving the heat exchanger, the ATES water then has the option of either flowing through the dry cooler or flowing directly into the cold well. If the difference between outside air temperature and ATES water temperature is great enough, then additional heat can efficiently be dumped to the air, in this case the ATES water would be directed to the dry cooler. After leaving the dry cooler, the cold water is then injected directly into the aquifer via an injection valve located directly above the submersible pump.

b. Dry Cooler

The dry cooler installed for the ATES project is similar to the two dry coolers installed for the BTES project, except that the ATES system dry cooler does not have an adiabatic cooling option. The dry cooler however does have the ability to utilize the Low Capacity Motor Management (LCMM) to reduce fan speed and stage fans to maintain tight control of the discharge water temperature set point. Water is pumped from the dry cooler plate and frame heat exchanger (HX-2) by two inline centrifugal pumps (lead/standby) located in the mechanical room into the inlet of the dry cooler. The ECM fan motors modulate their speed and stage their fans to cool the water to the desired set point. After the water leaves the cooling tower it is directed back to HX-2 where it removes heat from the ATES water and the cycle restarts.



**Figure 2.7 - Dry Cooler**

c. Loop Water System

The loop water is cooled and heated by flowing through HX-1. HX-1 is adding or removing heat depending on whether water from the warm well or cold well is flowing through the opposite side of HX-2. Each individual water source heat pump contains an internal variable speed water pump that pumps the required amount of water from the loop through the heat pumps internal coaxial heat exchanger. The speed of the pump is controlled to maintain a pre-set ΔT between entering and leaving loop water. Each pump contains an internal check valve to eliminate the possibility of one pump pumping water through the inactive heat pumps.

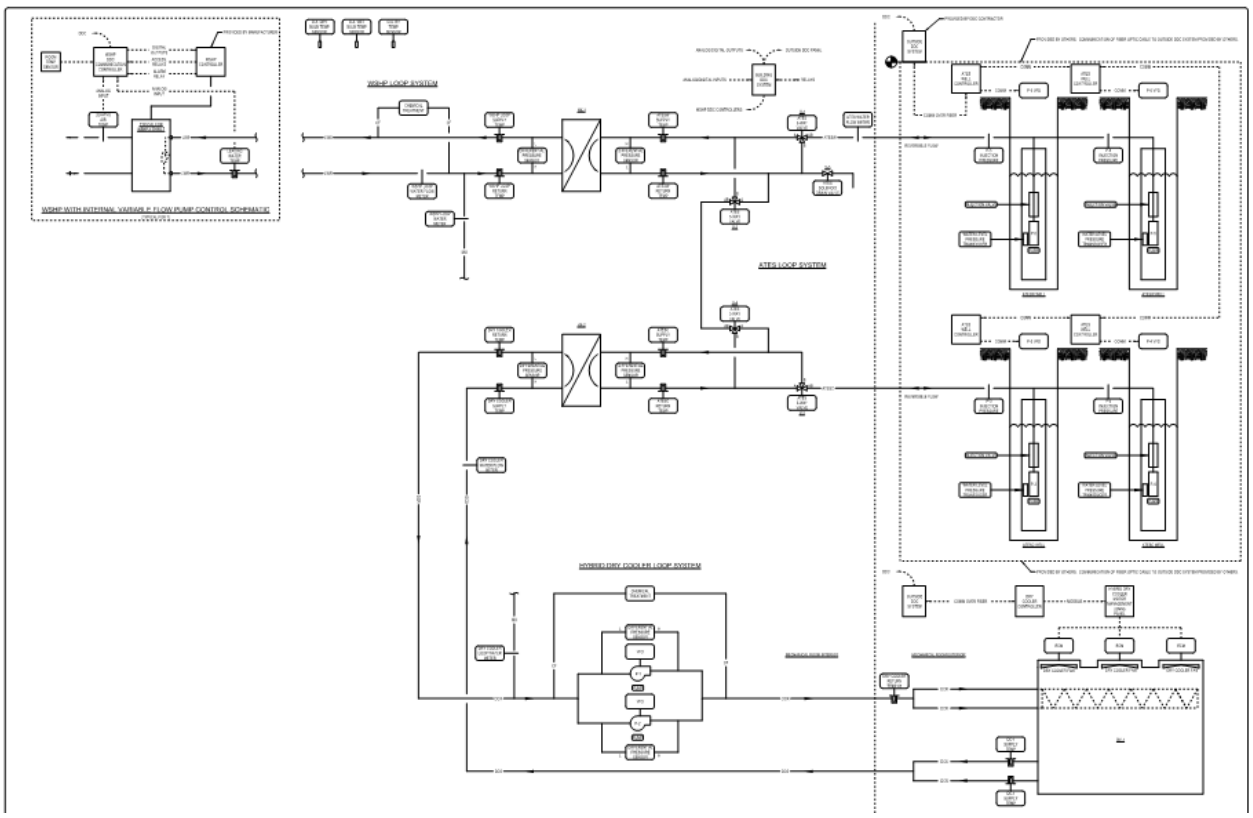

**Figure 2.12 ATES System Schematic**

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# APPENDIX C CLASS V UIC PERMIT APPLICATION & GA EPD PERMIT #W000691 FOR ATES PROJECT

**ANDREWS, HAMMOCK, & POWELL, INC.**
250 Charter Lane, Suite 100
Macon, GA 31210
Telephone (478) 405-8301, Ext. 6362
Fax (478) 405-8210
www.ahpengr.com
chammock@ahpengr.com

# Proposed Class V Injection Wells

- UIC Permit Application Checklist
- UIC Permit Application (Part I)
- UIC Application Documents (Part II) Including Appendices A, B & C

For the

**Non-Contact Ground Water Cooling System Serving the Aquifer Thermal Energy Storage (ATES) System**

Proposed for

## Building 3215
## Ft. Benning, GA

Revision 2.0 - 19 October 2016

**UIC PERMIT APPLICATION CHECKLIST**
(to be completed by applicant)

APPLICANT: Ft.Benning,COL Andrew C.Hilmes DATE: April 25, 2016

ADDRESS: Building 3215,11th Airborne Div. Road TELEPHONE NUMBER: 706-545-1500
Ft. Benning, GA 31905 (Project Location)

| REQUIREMENTS | CODE SECTION | INCLUDED | NOT INCLUDED | NOT/ APPLI-CABLE | COMMENTS (e.g. reference pg.no. in report) |
|---|---|---|---|---|---|
| 1. Name, mailing address and facility location | 391-3-6-.13 (11) (C)1. | X | | | Page 1 of Permit Application |
| 2. Name and address of the owner/operator if different than the facility | 391-3-6-.13 (11) (C)2. | X | | | Page 1 of Permit Application |
| 3. Proposed or existing injection rate and and injection pressure or gravity flow | 391-3-6-.13 (11) (C)5. | X | | | Page 2 of Permit Application |
| 4. The chemical, physical and radioactive characteristics of the injected fluid | 391-3-6-.13 (11) (c)6. | X | | | Basic water chemistry info. of the natively present groundwater is included in Part 2, Item 2 of the Application & Appendix A |
| 5. A diagram detailing the construction of existing and/or proposed injection wells | 391-3-6-.13 (11) (C)4. | X | | | Schematic & detailed drawings provided in Part 2, Items 1 & 3 with detailed drawing of the injection well in Appendix B, Sheet Number UIC406 |

| REQUIREMENTS | CODE SECTION | INCLUDED | NOT INCLUDED | NOT/ APPLI-CABLE | COMMENTS (e.g. reference pg.no. in report) |
|---|---|---|---|---|---|
| 6. Activities requiring the applicant to apply for a UIC permit | 40 CFR 144.31 (e)(1) | X | | | Application page 2, non-contact cooling water |
| 7. Up to 4 SIC Codes describing the principle products of the facility | 40 CFR 144.31 (e)(3) | X | | | 9711 National Security (US Army) |
| 8. Status as Federal, State, private, or public entity | 40 CFR 144.31 (e)(4) | X | | | Federal |
| 9. Is the facility located on Indian Lands | 40 CFR 144.31 (e)(5) | | | X | |
| 10. A listing of all permits or construction approvals received or applied for under any of the following programs: | 40 CFR 144.31 (e)(6) | | | | |
| a. Hazardous Waste (RCRA) | | | | x | |
| b. UIC | | X | | | |
| c. NPDES | | | | X | |
| d. PSD under Clean Air Act | | | | x | |
| e. Nonattainment program under the Clean Air Act | | | | x | |

| REQUIREMENTS | CODE SECTION | INCLUDED | NOT INCLUDED | NOT/ APPLI-CABLE | COMMENTS (e.g. reference pg.no. in report) |
|---|---|---|---|---|---|
| f. National Emission Standards for Hazardous Pollutants | | | | x | |
| g. Ocean Dumping under Marine Protection | | | | x | |
| h. Dredge and fill permits under 404 of CWA | | | | x | |
| i. other relevant environmental permits including State permits | | | | X | |
| 11. A topomap, extending 1 mi. beyond the property boundaries depicting the facility, intake and discharge structures including the injection wells, and all other items mentioned in the code section | 40 CFR 144.31(e)(7) | X | | | Appd. B, sheet UIC001 shows GA Map location, Key plan with the building location, 1"=30' site plan and Item 6 of the Application Documents provides a detailed satellite image showing property lines and nearby rivers, creeks, etc. |
| 12. A brief description of the nature of the business | | X | | | See "Executive Summary",(the 2nd page after the 3 page "Permit Application") |

| REQUIREMENTS | CODE SECTION | INCLUDED | NOT INCLUDED | NOT/ APPLI-CABLE | COMMENTS (e.g. reference pg.no. in report) |
|---|---|---|---|---|---|
| 13. Signature of the applicant, or a responsible corporate officer (i.e. president,secretary, treasurer, or vice president in charge of a principle business function, or a manager meeting the conditions in 40 CFR 144.32(a)(1)) | 40 CFR 144.32(a)(1)<br>391-3-6-.13(11)(C)7. | X | | | See Page 2 of the Permit Application. COL Andrew C. Hilmes (the signatory) is the Garrison Commander of Ft. Benning. |
| 14. Other reports or information necessary to evaluate the facility including but not limited to: | 391-3-6-.13(11)(D)2. | | | | |
| a. geological report | | X | | | See Item 4 of Application Docs. |
| b. hydrogeological reports | | X | | | See Item 4 of Application Docs. |
| c. engineering reports | | X | | | See Item 4 of Application Docs. |
| d. chemical reports | | X | | | See Item 2 of Application Docs. |
| 15. Driller's water well contractor number or bond number | Water Well Standards Act of 1985 | X | | | See page 1 of Permit App. (Kevin Colwell,Mid.GA,Lisc.#598) |

Reviewer:
Date:

STATE OF GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

# Underground Injection Control Program

## *Class V Injection Well Permit Application*

## *Part 1. Permit Application*

### SECTION I. FACILITY INFORMATION

| | | |
|---|---|---|
| Facility Name: Building 3215, Ft. Benning, Georgia | | |
| Phone: Not Applicable | River Basin: Chattahoochee | |
| Facility Address: 11th Airborne Division Rd. | | |
| City: Ft. Benning | State: GA | ZIP Code: 31905 |
| Latitude (DD/MM/SS): 32d/24m/35.1936s N (32.409776) | Longitude (DD/MM/SS): 84d/54m/8.5176s | County: Muscogee |

Is the unground injection part of a corrective action or remediation plan to be included in another Georgia EPD permit? If yes, please explain:

No. This is a energy/water savings project (Aquifer Thermal Energy Storage-ATES) of the Army intended to reduce this building's energy consumption via a non-contact groundwater cooling system.

### SECTION II. OWNER CONTACT INFORMATION

| | | |
|---|---|---|
| Name of Owner or Authorized Representative: Ft. Benning; COL Andrew C. Hilmes, | | |
| Title: Garrison Commander, Ft. Benning | | |
| Phone: 706-545-1500 | E-mail: | Fax: |
| Owner Mailing Address: HQ, US Army Garrison, Karker St., Building 4, Suite 5900 | | |
| City: Ft. Benning | State: GA | ZIP Code: 31905-5000 |

### SECTION III. DRILLER INFORMATION

GA Licensed Water Well Contractor or Bonded Environmental Drilling Company Name:

Middle Georgia Water Systems, Inc.

| | | |
|---|---|---|
| Phone: 770-567-3400 | E-mail: jkcolwell@middlegawater.com | Fax: 770-567-3428 |
| Address: 11 Williamson Rd. | | |
| City: Zebulon | State: GA | ZIP Code: 30295 |
| License No.: 598 and 35 | Bond No.: | |

### SECTION IV. INJECTION WELL INFORMATION

1. Are the wells or devices proposed or existing: Proposed
2. No. of injection wells: Four total, but only one or two would be functioning as cooling water return wells at any moment in time.
3. Classification of injection well(s) or devices (check box): ☐ Class I ☐ Class II ☐ Class III ☐ Class IV ■ Class V

STATE OF GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

## *Part 1. Permit Application*

| | | |
|---|---|---|
| 4. Well Depth: 400' | 5. Borehole Diameter: 15-7/8" | 6. Csg. Depth: 400' |
| 7. Csg. Diameter: Nominal 8" | 8. Csg. Material: Schedule 80 PVC | |
| 9. Screen Type: SDR-21 PVC slotted screen | 10. Screen Diameter: Nominal 8" | |
| 11. Screen Interval from 250' to 400' | 12. Grout Type: Bentonite Grout | |
| 13. Grout Interval from 0' to 250' | 14. Grout Thickness: Nominal 3-5/8" thick grouted annulus | |

### SECTION V. INJECTION SYSTEM DATA

1. Type of Fluid: Natively present groundwater
2. Source of Fluid: Local/Site Aquifer
3. Purpose of the Injection/source of the contamination: Non-contact ground water cooling return well/Not Applicable
4. Proposed Injection Rate (daily max) (gallons/minute/well) (SCFM for air): 46 GPM/well (max)
5. Proposed Injection Volume (daily max) (gallons/minute/well) (SCFM for air): 66,440 gal/day/well(max.)
6. Proposed Injection Pressure (max daily) ( lbs./sq. inch) (psi)): 5 PSIG at injection pipe (0 PSIG at the top of the casing)

### SECTION VI. CERTIFICATION

I certify under the penalty of law that I have examined and am familiar with the information contained in this document and attachments and the information is true, accurate and complete. I am aware of the associated penalties for submitting false documentation, including but not limited to monetary penalties and or imprisonment

| | |
|---|---|
| **Name of Applicant:** COL Andrew C. Hilmes | **Date:** NOV 09 2016 |
| **Signature of Applicant:** | **Date:** 9 NOV 2016 |

## ***Part II. Application Documents[1]***

Please include the following documentation with the application:

1. A detailed diagram of the injection well(s) or device(s) showing the items described in Part I. Section IV of this Application.

2. A chemical analysis of the injected fluid. The analysis must include all constituents specified in the currently applicable Georgia Rules for Safe Drink Water, as amended.

3. A detailed diagram showing the engineering layout of the injection equipment and all piping associated with the system.

4. A comprehensive subsurface report, prepared by a Georgia registered Professional Geologist (PG) or Professional Engineer (PE), including all the geological and hydrogeological parameters of the site.

5. A notarized statement from the applicable local government stating the injection project is consistent with the local land use plan or zoning requirements.

6. A detailed map orientating the injection well (s) and any other wells to two (2) nearby reference points such as roads, streams, or nearby structures, etc. Please clearly mark the distances from the wells to the reference points.

7. If applicable, the approved Corrective Action Plan for the UIC File.

**Submit the Completed Application to:**

Georgia Environmental Protection Division
Underground Injection Control Program
2 Martin Luther King Jr. Drive
Suite 1152
Atlanta, Georgia 30334

[1] Please refer to the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.13.

# Part II-UIC Application Documents

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**Item 1:** Detailed diagram of the injection well ..... 14

**Item 2:** Chemical analysis of the injected fluid ..... 15

**Item 3:** Detailed diagrams of the engineering layout of the injection equipment and piping ..... 17

**Item 4:** Comprehensive Sub-Surface Report with Geological and Hydrogeological Parameters ..... 18

**Item 5:** Notarized Zoning/Land Use Statement from Applicable Local Gov. (not applicable) ..... 23

**Item 6:** Detailed Map ..... 23

**Item 7:** Corrective Action Plan-Not Applicable ..... 24

Appendix A: Water Chemistry Analysis ..... 25

Appendix B: Detailed Diagrams/Engineering Layout (Drawings) ..... 46

Appendix C: Drilling Logs/Sieve Analysis from the Geo./Hydrogeological Subsurface Report ..... 51

# Executive Summary

(Item 12 of the UIC Permit Application Checklist)

**Introduction:** Andrews, Hammock and Powell, Inc. (AH&P), a Consulting Engineering firm located in Macon, GA, was Contracted by the Department of Defense's (DoD) ESTCP office to engineer and demonstrate a non-contact cooling water system that would significantly reduce the energy and potable water consumption at a DoD facility. DoD and AH&P selected a small (+/-10,000 $ft^2$) Brigade Headquarters at Ft. Benning (Building # 3215 in the Sand Hill area of Ft. Benning) to demonstrate this technology. The technology, called Aquifer Thermal Energy Storage (ATES), is in use throughout the world but very rare in the US. Project goals include a 100% reduction in the drinking water currently used for this building's pro-rata share of make-up water to its cooling tower at the nearby chiller plant and 30-60% reduction of this building's HVAC energy consumption. DoD consumes over $4B/year in building energy and billions of gallons of potable water and is keenly interested in reducing both.

**System Description:** There are four wells involved in the system with two designated ATES Warm Well #1 & #2 and two designated ATES Cold Well #1 & #2. All wells contain a variable speed stainless steel submersible well pump capable of 45 GPM (maximum). Typically, only one of the four pumps operate at a time. Each well/pump also has a modulating stainless steel injection valve mounted on the discharge of the pump which remains closed during pump operation, but, modulates open when needed for injection, while maintaining positive pressure in the discharge piping. Water flows down the drop pipe and then into the casing and screen via the injection valve openings in its side with gravity ("mounding") being the force the produces the flow into the injection zone. In other words, *unlike* other (typically non-Class V) injection wells, it is not necessary to use a "packer" at the injection zone to force water into the aquifer via high positive pressure (i.e. flow is induced by gravity as water "mounds" inside the casing above the native groundwater level). As water is injected, it can "mound" above the static groundwater level, but due to its conservative design (confirmed by computer modeling) the top of the casing is never positively pressurized at the surface and is in fact open to atmosphere via a screened vented opening. This is why the original application stated the injection pressure as zero psi. In the revised application, the results of the computer analysis show only "mounding" occurs and the casing is not positively pressurized at the surface: however, it is desired to maintain some positive pressure in the injection piping itself at the surface to overcome the friction of the injection drop pipe and the pressure drop of the modulating injection valve at the bottom of the pipe and accordingly have revised the permit application to show a nominal 5 psig "injection pressure". This pressure will serve as the "setpoint" to control the modulating injection valve so a slight positive pressure will always be maintained in the piping system. A pressure transducer in the injection piping/casing annulus, as described herein under "Mechanical Integrity Testing", will continuously monitor the water level in the casing and slow down or shut-down the injection pump in the event the water level ever rises to the surface. Typically, one pump will be supplying the water to the building and two wells will be receiving the non-contact cooling water return to minimize "mounding" and energy consumption. All piping is NSF rated HDPE, PPT-RCT, or PVC pipe and the plate and frame heat exchangers are Type 304 Stainless steel with potable water on the opposite side of the plates.

**System Design Concept:** Groundwater is typically extracted from one or both of the "cold wells" during the warmer months to cool the building and the slightly warmed water is injected into the ground via one or both of the "warm wells". During the cooler months the flow reverses, and the same water is now extracted from the "warm wells" and a dry-cooler (outdoor coil with a fan) extracts heat from its potable water heat transfer loop on the other side of a plate and frame heat exchanger from the groundwater and rejects the heat to the atmosphere. If needed, the building also can provide "free cooling" of the water by extracting heat from its potable water heat transfer loop on the other side of its plate and frame heat

exchanger. In this way the non-contact ground water cooling system can be kept as cold as possible and remain at peak efficiency.

**Environmental Considerations:** Non-contact ground water cooling ATES Systems are favored worldwide due to their environmental and energy virtues. They can reduce energy consumption by 30-60% and save hundreds of thousands of gallons/year in potable water consumption for cooling tower make-up in small buildings and millions of gallons/year in large buildings. By utilizing potable water rated piping, stainless steel equipment, and only transferring a small amount of heat, the groundwater remains in its original condition. The reversibility of the ATES system and heat rejection capability of the dry-cooler also allow for a more closely balanced thermal load on the ground than provided by traditional non-reversible non-contract groundwater cooling water systems by means of its capability for wintertime heat rejection from the groundwater previously used for cooling.

***Non-Contact* Vs. Direct Contact Cooling Water System Overview:**

*Direct "Contact" type cooling water systems* utilize cooling water that literally comes in direct "contact" with an actual product to remove heat from the product. The product mixes with and/or "contacts" the cooling water and could be in liquid, gas or solid form, although it is typically in a solid form. In the example of direct contact cooling of a solid object, the product could be a manufactured product or an agricultural product. While there are many examples of Direct Contact cooling, one type particularly prevalent in Georgia is a drag or auger type "bird chiller" found in chicken processing. In this application, the cooling water directly contacts the eviscerated bird and becomes contaminated with material and organisms from the product. The cooling water is typically then discharged into the sanitary sewer after it serves it purpose of dropping the bird temperature to around 40° F. The proposed system in this UIC application is ***not*** a Direct Contact type cooling system.



Auger Type Direct-Contact Bird Chiller

*Non-Contact type cooling water systems* ***do not*** contact any solid products or liquids or gases. EPA states that "Non-Contact cooling water is used to reduce temperature and does not come into direct contact with any raw material, intermediate product, waste product (other than heat) or finished product." The proposed non-contact cooling water system serving the ATES system for Building 3215 at Ft. Benning is non-contact in its design, with the groundwater merely passing through potable water rated pipes, pumps, valves and a stainless steel plate and frame heat exchanger. The groundwater is then returned to the same aquifer it left minutes earlier and is only altered by a few degrees Fahrenheit. It *does not* come in contact with any products, nor are any additives (or anything whatsoever for that matter) introduced into the groundwater fluid stream.

**Mechanical Integrity Testing:**

*Overview:* This project involves the transfer of groundwater from one side of the site to the other side of the site for reinjection after it has performed its non-contract groundwater cooling purpose. The aquifer at the site is not used for drinking water as the Ft. Benning potable water system has been disconnected from its water wells and is now owned and operated by the Columbus Water Works (CWW) since 2004. CWW utilizes surface water to serve both the City of Columbus and Ft. Benning. Ft. Benning is so large that there are a few remote gun ranges served by wells (the nearest being 6 miles away from Building 3215), but the Department of Public Works (DPW) at Ft. Benning advises new water mains are being run to these remote locations and their isolated water systems will be off their wells within the next two years and connected to the CWW water mains. Accordingly, the aquifer at the project site is not utilized as an

Underground Source of Drinking Water (USDW) nor anticipated to ever be utilized as such. The existing aquifer at the site is comprised of a mixture of sand and clay down to the bedrock at approximately 400' with a semi-confining layer at around 250' below grade. The groundwater level at the site is typically found between 30' and 41' below grade, based primarily on the ground elevation where the reading is taken and the rainfall received that year/season. This project utilizes native groundwater being extracted and reinjected via gravity flow. Accordingly, the motivation for vertical movement of injected water in the annulus of the injection wells is limited and there appears to be no negative consequences of the upward vertical water movement if this extremely unlikely event were to occur. Still, proposed herein are two mechanical integrity test procedures to insure the integrity of the casing and its grouted external annulus.

The specifics of the injection well design are two warm (or cold), low-intensity gravity injection wells, typically operating simultaneously, with each well consisting of an ultra-conservative 8" diameter PVC well screen, approximately 150' long, with its top elevation approximately 250' below grade. At peak cooling conditions (a few hours per day in the summer, on the hottest days), the total water flow needed is 45 GPM and therefore each of the two active injection wells (warm or cold) would only handle 22.5 GPM. However, if needed for maintenance or other purposes, one well could handle all the flow on an intermittent basis hence 45 gpm is listed for each well in the permit application. In reality, the wells would only operate at these full flows for few hours per day, and only at the full volumetric flow rate on the hottest days of a few months per year. For modeling purposes only, as described in the Part III of this application, the injection wells were simulated to operate at full flow for 1,250 *continuous* hours in an attempt to deliberately fill the casing completely with "mounded" water, but still insure the injection well would not overflow at the surface. The modeling results indicated it would not overflow in this extreme (non-reality) situation. For that reason, (and many others) it was decided not to utilize a packer so as to never over-pressurize the aquifer and allow for continuous water level monitoring in the annulus. Specifically, a pressure transducer will be suspended by stainless steel cable in the annulus between the injection pipe and the casing in order to continuously *monitor* the water level in the annulus and to be able to automatically shut down the injection pump in the event the water in the annulus reaches the surface. The results of these modeling efforts are more fully described and illustrated in Part II, Item 4 (Comprehensive Subsurface Report) of this UIC Application.

*Mechanical Integrity Testing of the Casing:* The design of the wells utilizes an 8" Schd. 80 PVC casing that will be fully grouted with bentonite grout from the surface to the gravel pack/screen at approximately 250' below the surface. Schd. 80 PVC or stronger discharge/injection piping will be installed down the center of the casing, terminating at the injection valve/pump suspended above the well screen. As described above, the planned design will not require a "packer" and water will be allowed to "mound" inside the casing during injection. A complete description of the hydraulic modeling that determined the projected amount of mounding is found in Part 4, Comprehensive Sub-Surface Investigation. To insure the integrity of the casing it is proposed that the following test be accomplished by AH&P personnel under the supervision of a PE:

1. After completion of the well casing, screen, gravel pack and annulus grouting to the surface, the top of the casing will be temporarily sealed off in an airtight manner with fittings that will allow the injection of air into the top of the casing while simultaneously monitoring the air pressure in the casing.
2. Compressed air will then be delivered to the interior of the casing until the pressure has risen to approximately 10-20 PSIG.
3. Due to the compressed air being potentially hotter than the PVC casing/geology/groundwater temperature, the pressure will naturally drop due to the Ideal Gas Law. Accordingly, additional air will be added over the next few hours to maintain the pressure in the casing. When it is determined that fluctuations in pressure due to temperature changes, atmospheric pressure or

water table movement are minimal, the compressed air line will be removed and the pressure transducer activated to begin logging the air pressure in the casing.

4. Air pressure will be logged for a minimum of one hour. If the gauge pressure in the casing is observed to remain with +/-5% of its initial reading, the pressure test will be deemed successful.
5. All work will be accomplished under the direction of a licensed Georgia PE or PG and a report of the results of this testing shall be submitted to the Georgia EPD for their review and records.
6. It is proposed that the mechanical integrity of the casing be tested upon completion of the well and submitted to GA EPD for review. At or around the 1-year anniversary of that test, it is proposed the same test be conducted and submitted again. If that test is successful, it is proposed the well casing shall be tested 2-3 years later (within 1 year of the expiration date of the UIC permit). If this third test is successful; it is proposed the test is only performed for subsequent permit renewals within one year of the expiration date of the current UIC permit. As an alternate to the above pressure test, it is proposed that *either* the above pressure test or a video camera inspection be allowed for subsequent test.

*Mechanical Integrity Testing of the Annulus Grout:* The design of the injection wells includes the use of bentonite grout from the surface down to the gravel pack at the well screen. The bentonite grout will be placed in the annulus by means of a pressure pump and a tremie tube as described herein. The following **Volumetric Annulus Grout Integrity Test/Measurement** is proposed to insure the casing is fully grouted:

1. After the well screen and casing is placed in the borehole and gravel pack is installed around the screened interval, a weighted probe ("tag line") shall be lowered into the annulus and the depth of the gravel pack shall be determined. The net available volume of the annulus in cubic ft. shall then be calculated.
2. Grout shall be mixed in accordance with the manufacturer's recommendations and placed downhole by means of a tremie tube and a pressure grouting pump. As the grout rises in the annulus, the tremie tube will be withdrawn at the same rate at grout rises in the annulus.
3. During all procedures, the quantity of grout and water used in the mix will be tabulated on a mass and volumetric bases. When the grout reaches the surface, the volume of the grout will be calculated.
4. If the actual volume of the grout utilized is within 5% of the calculated net volume of the annulus between the casing and the net borehole wall, the well's annulus grout mechanical integrity test shall be considered "passed".

**Part II, Item 1**: Detailed Diagram of the Injection Wells or Devices

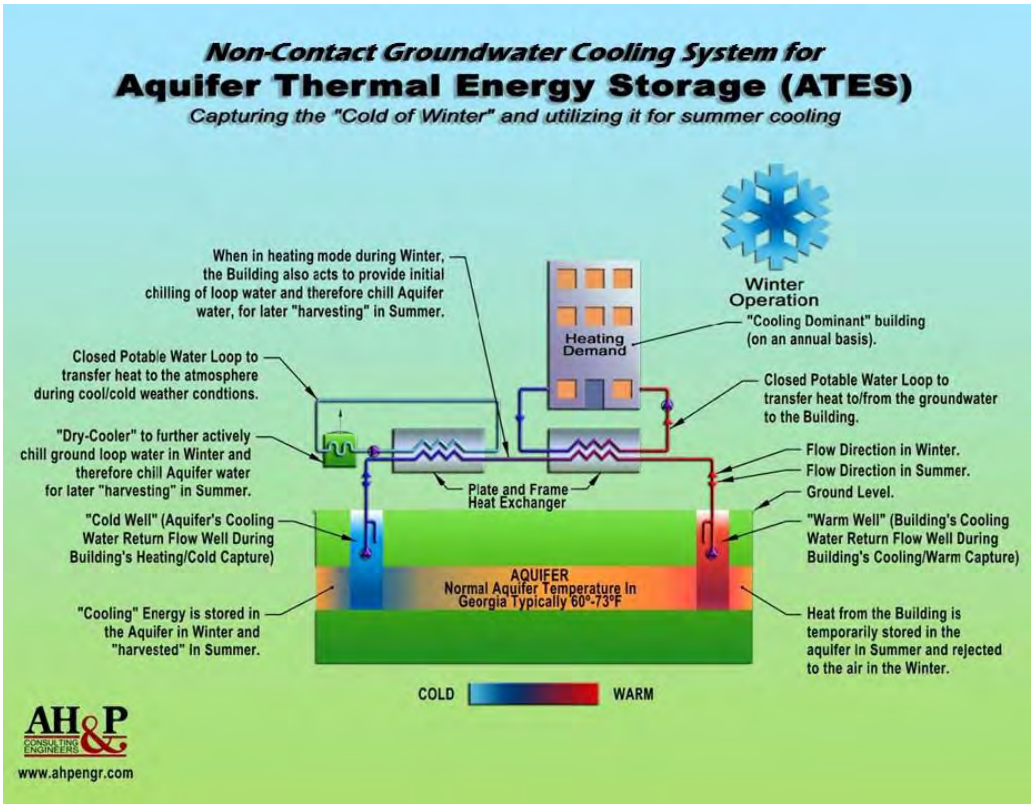



**Fig.1 Non-Contact Cooling Water ATES Diagram-B3215 Ft. Benning**

The above illustration provides an overview of how the system is configured. Detailed drawings of the four Injection Wells (each are identical) are shown on drawing UIC 406 which is included under Item 3 and Appendix B. In Fig. 3 below, the blue fluid is the groundwater and the red fluid is the potable water on the building side delivering heat, ***in a non-contact manner*** to the groundwater.



**Fig. 2 Submersible pump with injection valve**

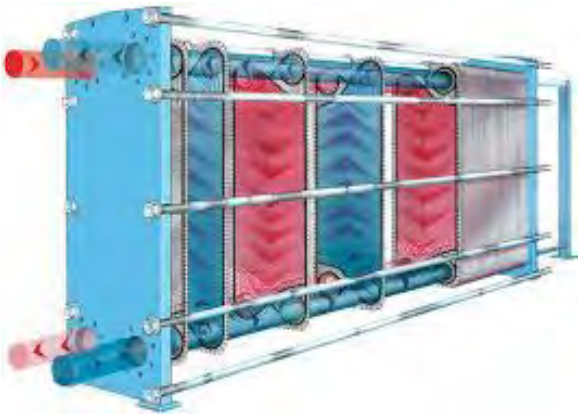


**Fig 3 SS Plate/Frame Heat Exchanger**

**Part II, Item 2:** Chemical Analysis of the Injection Fluid

When Ft. Benning's Environmental Management Division contacted Georgia EPD regarding Item 2, EPD advised they would inform Ft. Benning what chemicals were needed to be tested after receipt of the initial UIC Permit Application. Therefore, a submission of water sample testing results was not needed with the *initial* UIC Application. However, since AH&P's driller (Middle GA Water Systems) had previously installed two sets of nested monitoring/testing wells at the site and Test America in Savannah had also previously completed some basic water chemistry testing for AH&P, that information is therefore included for reference. It can be found in ***Appendix A "Water Chemistry Analysis"*** near the end of this UIC Application document.

The potable water system on Ft. Benning is now owned by the Columbus Water Works (CWW) and Ft. Benning purchases their potable water from them. CWW uses surface water for the vast majority of the water supply to Ft. Benning (and Columbus for that matter) with the exception being a few remote locations/firing ranges on the Installation which are not yet piped to the central distribution and still utilize groundwater from potable wells. Projects are underway to eliminate even those few wells in the next few years. The three closest Ft. Benning potable wells to the project site are each approximately 6 miles away and are shown on the map included under Item 6 herein. The Environmental Management Division at Ft. Benning has advised there are no plans to utilize the aquifer at Building 3215 for potable water purposes in the short or long term. Accordingly, it would seem that the initial and periodic testing could be limited in scope and frequency at described below

As illustrated in the documents herein, the non-contact groundwater cooling system proposed for Building 3215 utilizes stainless steel pumps, motors, injection valves and heat exchangers inside Building 3215 whose other heat exchange fluid is potable water. Due to the unique architecture of an ATES system, the groundwater is actually returned to its original location at least once per year. In other words, groundwater is simply transferred back and forth from the western half of the site to the eastern half in a process that is repeated based on the cooling water needs of the building. Ft. Benning will test the water initially and periodically for whatever constituents are of concern to the Georgia EPD; however, given the benign nature of the system, it is respectfully requested that consideration be given to minimizing both the frequency and spectrum of chemical analysis required of the Army under this permit, as is proposed herein in this revised UIC application. On a daily, yearly or lifetime basis, there is no ***net*** extraction or injection of groundwater proposed, no transfer of water from one aquifer to another, and the maximum distance between the furthest apart wells will not exceed 1,000 ft. For the ATES wells, it is proposed that, after the wells are drilled, developed and ready for use, that a groundwater sample be taken and submitted to an approved lab, for testing of the following potential contaminants:

1. **Inorganic Metals:**
    a. Antimony
    b. Arsenic
    c. Barium
    d. Beryllium
    e. Cadmium
    f. Chromium

g. Lead
h. Mercury
i. Nickel
j. Thallium

**2. Semi-Volatile Organic Compounds (Semi-VOCs)**

a. Alachor
b. Atrazine
c. Benzo(a) Pyrene
d. Di (2-ethylhexyl) adipate
e. Di (2-ethylhexyl) phthalate
f. Endrin
g. Lindane (gamma-BHC)
h. Heptachlor
i. Heptachlor Epoxide
j. Hexachlorobenzene
k. Hexachlorocyclopentadiene
l. Methoxychlor
m. Simazine

**3. VOCs:**

a. Vinyl Chloride
b. Benzene
c. Carbon Tetrachloride
d. 1,2-Dichloroethane
e. Trichloroethylene
f. para-Dichloroethane
g. 1,1-Dichloroethylene
h. 1,1,1-Trichloroethane
i. cis-1,2-Dichloroethylene
j. 1,2-Dichloropropane
k. Ethylbenzene
l. Monochlorobenzene
m. O-Dichlorobenzene
n. Styrene
o. Tetrachloroethylene
p. Toluene
q. Trans-1,2-Dichloroethylene
r. Xylenes (total)
s. Dichloromethane
t. 1,2,4-Trichlorobenzene
u. 1,1,2-Trichloroethane

The results of the above testing would be submitted to the GA EPD. It is proposed that the above testing be conducted initially with only the inorganic metals being further submitted again quarterly during the first year. All the above testing is proposed to be repeated approximately one year later. If all of these test are negative, it is proposed that the well be tested next within one year of the expiration date of the UIC permit and the results of that test be submitted with the application for the

renewal of the UIC permit. It the test accomplished just prior to the permit renewal is successful, it is proposed it be conducted again in each subsequent permit renewals application submitted that is submitted within one year of the expiration date of UIC permit.

**Part II, Item 3**: Detailed Diagrams Showing the Engineering Layout of the Injection Equipment/All Piping

The Contract Documents that will be used to construct the non-contact ground water cooling system for Building 3215 are attached near the end of this UIC Application document in ***Appendix B, Detailed Diagrams/Engineering Layout (Drawings***). Drawing UIC001 shows maps and the site plan with the four combination supply/injection wells identified at ATES Cold Wells #1 & #2 and ATES Warm Wells #1 & #3. Typically, in late-fall/winter, the warm return water from the building (received by the aquifer the previous summer) is extracted from normally just one of the warm wells (the active warm well is swapped periodically to equalize pump run time, etc.), then cooled by the dry-cooler (and sometimes by the building) and injected into both of the Cold Wells to minimize mounding and energy consumption. In the summer, this same water is extracted from the Cold Wells, used to cool the building and then non-contact cooling water returned/injected into the Warm wells. This process is repeated annually (and even daily if conditions permit).

UIC002 is a close up of where the underground pipes will connect to the building's pipes at an underground enclosure just outside the mechanical room. UIC301 continues the piping into the building where the two plate and frame stainless steel heat exchangers are located. The fluid passing through the building/dry-cooler side of the heat exchangers is potable water. Groundwater passes through these two heat exchangers in series, exits the building and traveling from/to the supply or injection wells respectively. UIC406 provides details of the wells themselves and adjacent electrical panels. All piping is NSF Approved HDPE, PP-RCT or PVC piping and all equipment (pumps, motors, plate and frame Heat Exchangers and the injection valves) are constructed of stainless steel.

**Part II, Item 4:** Comprehensive Sub-Surface Report

# Geological and Hydrogeological Report

## April 25, 2016

For the Proposed Non-Contact Cooling Water System
Serving the Aquifer Thermal Energy Storage (ATES) System
At Building 3215
11th Airborne Division Rd., Ft. Benning, GA 31905

Prepared by Charles W. Hammock, Jr. PE (17080)
Andrews, Hammock & Powell, Inc. –Consulting Engineers

Consultants:

- IF Technology B.V., Armhem, The Netherlands
- Jon Spaller, PG, Senior Geologist,
  Geotechnical & Environmental Consultants (GEC)
  Macon, GA




COMPREHENSIVE SUBSURFACE REPORT

UIC Permit Application
Part II-Documents
Item 4

**Introduction:** Andrews, Hammock and Powell, Inc. was Contracted by the Department of Defense (DoD) to engineer a non-contact cooling water system that would significantly reduce the energy and potable water consumption at a DoD facility. Building 3215 in the Sand Hill area of Ft. Benning was chosen to be the demonstration site. This building is currently served by a large centralized (off-site) water-cooled chilled water plant that consumes 10's of millions of gallons of potable water each year to operate its cooling towers. The Central Plant is currently scheduled to be decommissioned within the next five years. As described previously, it is proposed that a non-contact ground water cooling system be installed to serve a new Aquifer Thermal Energy Storage (ATES) system at this building's site to significantly reduce the buildings energy consumption and eliminate its need to consume domestic water via the makeup water needed for its current centralized cooling tower. In commercial building with cooling towers, the tower water usage normally accounts for the vast majority of the buildings water consumption, far outweighing domestic water consumption for handwashing, toilets, and cooking.

**Basic Geology and Hydrogeology at the site:** Ft. Benning abuts the city of Columbus which generally marks the western end of the "Fall Line" in Georgia where the Piedmont meets the Coastal Plain. The project site is positioned 5 to 10 miles south of the Fall Line and the literal first water "fall" of the Chattahoochee River can be observed about 7 miles NW of the site. During AH&P's drilling activities at the site, which were associated with the investigation of the geology and for the purpose of installing monitoring wells, bedrock was encountered approximately 400' below the surface. As can be seen in the included Drilling Logs and Sieve Analysis by Jon Spaller, PG of GEC, the bedrock is overlaid by a mixture of generally silty fine to coarse sand and sandy clay.

The USGS (http://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=GAKt;1) describes the surface geology at the site as being Kt: Tuscaloosa Formation (Cretaceous) with the primary "rock" type as sand with the secondary as clay and it major lithologic constituents as unconsolidated, coarse-detrital sand and fine-detrital clay, which is consistent with the field observations.

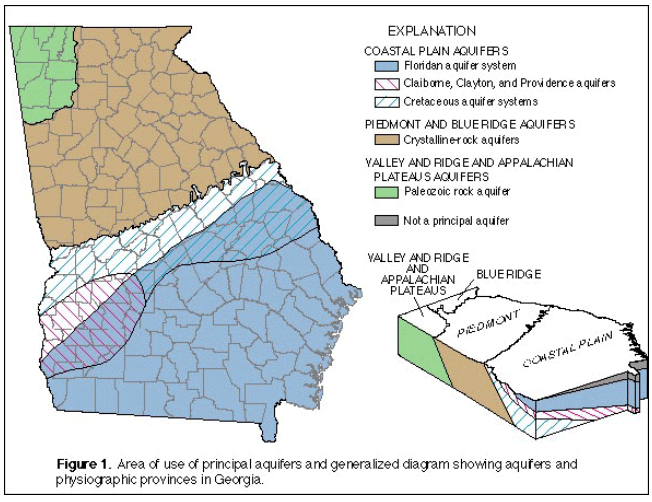


Figure 1. Area of use of principal aquifers and generalized diagram showing aquifers and physiographic provinces in Georgia.

Fig. 4: Generalized Diagram of Georgia Aquifers

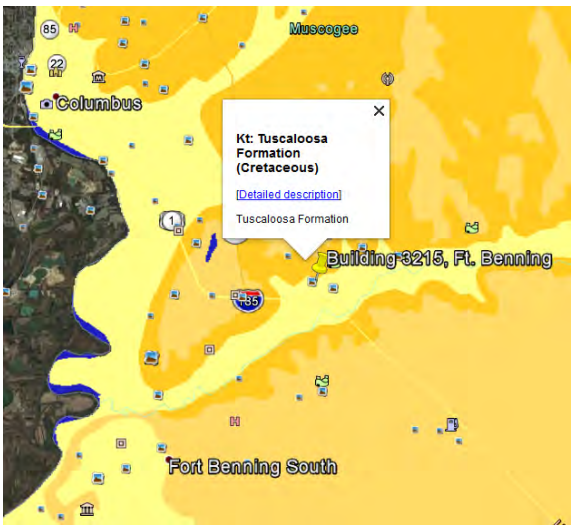



Fig.5: USGS Geological Classification of the B3215 Site

Lying just south of the Fall Line, the aquifer at the site is part of the Coastal Plain Aquifers of Georgia and specifically, it is considered part of the Cretaceous Aquifer system. The ground water level was generally observed to be in the range of 34-43' below grade and it did not experience significant fluctuations during the multiple years it was monitored with in-situ pressure transducers. Water levels were monitored at two on-site monitoring wells and at one pre-existing monitoring well south-southeast of the site and the average slope (or dh/dl) was determined to be around 0.0117 ft/ft. An aquifer pumping test was performed by AH&P and analyzed by our Dutch Consultant IF Technology. They estimated the average hydraulic conductivity (k) to be around 1.575 ft./day and the porosity (n) of the formation to be 0.3. The average annual groundwater velocity was therefore estimated to be approximately:

$$V=k * (dh/dl)/n =(1.575 \text{ ft/day} * 0.0117 * 365 \text{ days/year})/0.3 = 22 \text{ ft/year}$$

In the recently published Advances in Thermal Energy Storage Systems book edited by Cabeza, the upper recommended limit for groundwater velocity for a non-contact ground water cooling based ATES system is 360 ft/year with a typical (preferred) maximum of 120 ft/year. With the expected groundwater velocities much lower than this range, the ATES system should perform with high efficiencies.

AH&P performed electric logging and natural gamma ray radiation logging measurements downhole to further understand the geology of the site. The gamma logs revealed a distinctive spike of natural gamma radiation at around 235' below grade indicating the probable presence of a distinct clay layer that was approximately 10' thick as can be seen in the graph at right.

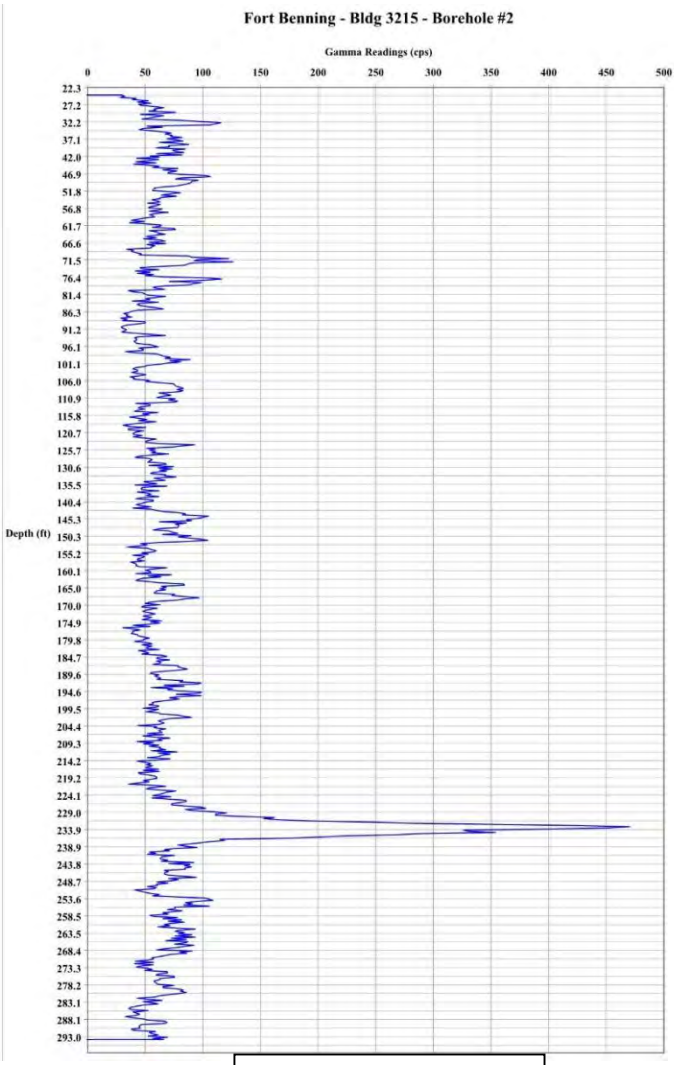



Fig. 6: Gamma Logs

A subsequent pumping test, conducted by extracting water from beneath the clay layer confirmed the clay indeed formed a semi-confining layer as monitoring wells installed above the clay layer showed very little change in their potentiometric surface while there was significant drawdown of the hydrostatic pressure beneath the clay layer as it was being pumped. While a confining layer is not a necessity for a successful non-contact ground water cooling system serving the ATES, it is desirable as it provides a source of ground water typically free from surface contaminates like nitrates, while also having low levels of dissolved oxygen present in the groundwater. Iron is not normally an issue with an ATES system as the water is kept under pressure and not exposed to atmospheric oxygen, but testing for total iron (Fe) and by Species

(Fe+2/Ferrous or Fe+3/Ferric) resulted in a Below Detectable Levels result (basically a "non-detect" finding) with the lab capable of detecting iron in the three forms above at levels as low as 0.05, 0.1 and 0.1 mg/L respectively.

During the drilling of the monitoring/test wells, the cuttings were periodically collected. These were then sent to GEC in Macon GA where Jon Spaller, PG classified each of them.

Sieve analysis was also performed on periodic samples.

Those results follow this section of the supporting documents and are included in **Appendix D-Drilling Logs and Sieve Analysis**.

**Computer Modeling of Proposed Injection Wells:** The design of the injection wells is based on gravity flow of the injected water into the formation being motivated by "mounding" of the water inside the well casing without the need for a packer or annulus seal about the injection zone. Accordingly, in the original UIC application, the injection pressure was listed as zero as the casing would not be pressurized above atmospheric pressure; however, since injection pressure can also be measured as the internal pressure of the water inside the injection piping at the surface, and there is a pressure drop associated with the friction in drop piping and the modulating injection valve at the bottom of the drop pipe, the UIC application has been amended herein to show an injection pressure of 5 psig to cover these friction loses.

In order to insure the formation could accept the injected water without mounding of the injected water in the casing above the surface elevation of the top of each well, computer modeling was utilized as described herein under the Executive Summary, Mechanical Integrity Testing, *Overview*. Specifically, the program MLU, Version 2.25.66 from Microfem was utilized, as described previously, to model the operation of the system under extreme conditions to design the injection wells conservatively. It was found that under flow durations deliberately set significantly beyond the intermittent operation of the real system (1,250 hours of continuous at maximum flow), the water at the well mounded between 26.8 ft and 28.7 ft. The plot on the next page (Figure 7) reflects the potentiometric contours of the well operating after 1,250 hours where the numbers at the "blue" injection wells represent the potentiometric "mounding" in feet out beyond the wells for several hundred feet horizontally and the red wells potentiometric lines represent the drawdown in feet of the supply wells.

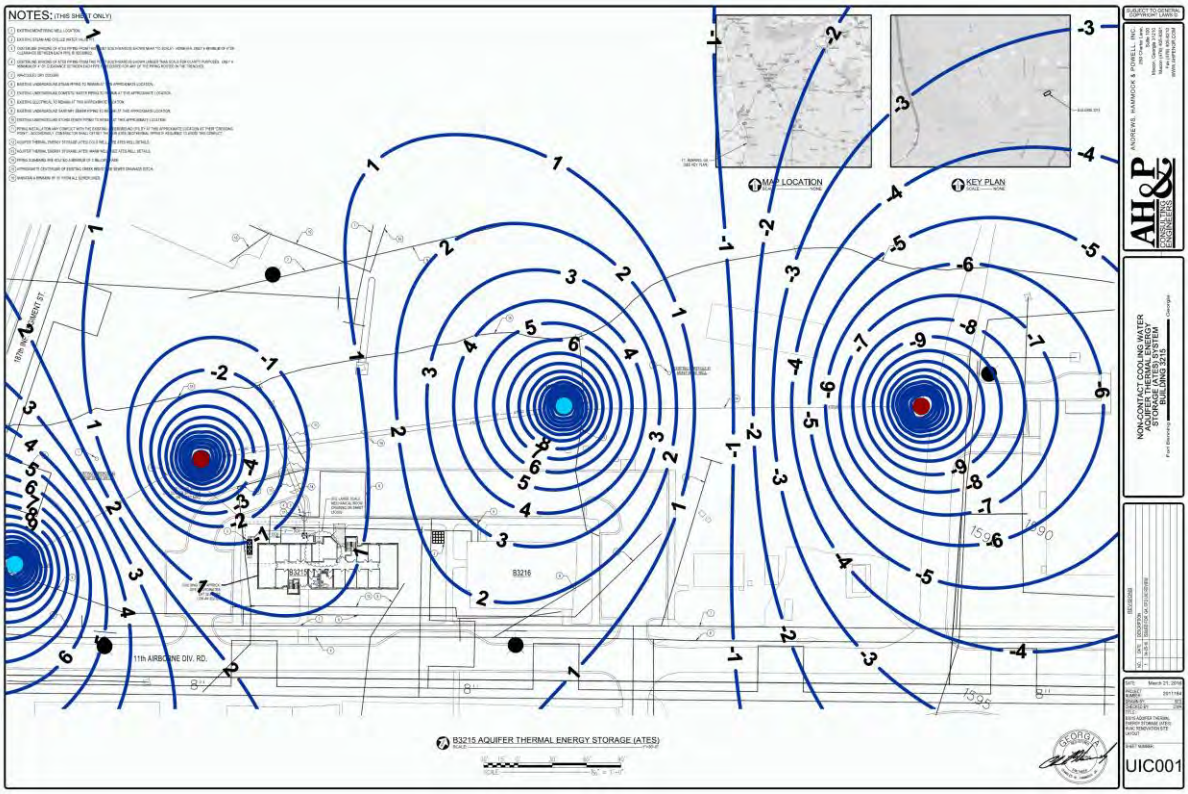


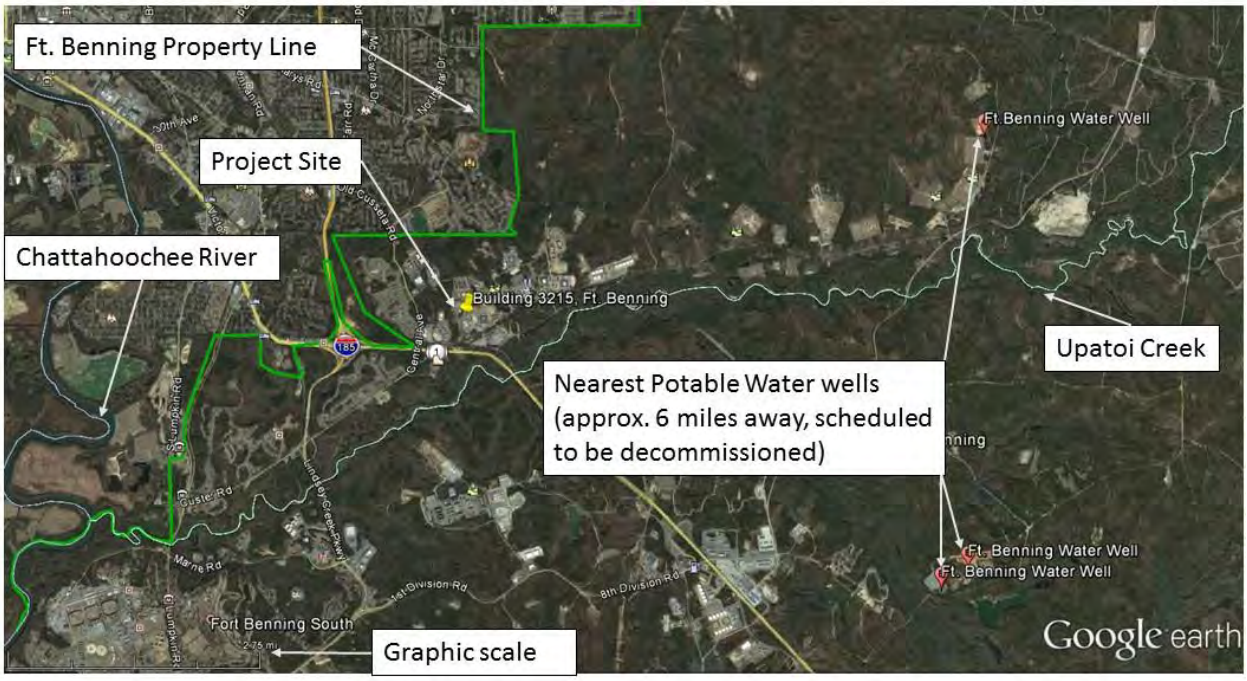

Fig. 7: Potentiometric Contours During Injection from Computer Model

**Item 5:** Notarized Statement for Applicable Local Government Regarding Local Land Use Plan/Zoning:

This project is being accomplished on Federal Land by the Federal Government (US Army) and therefore does not fall under the jurisdiction on any Local Government or Local Authority.

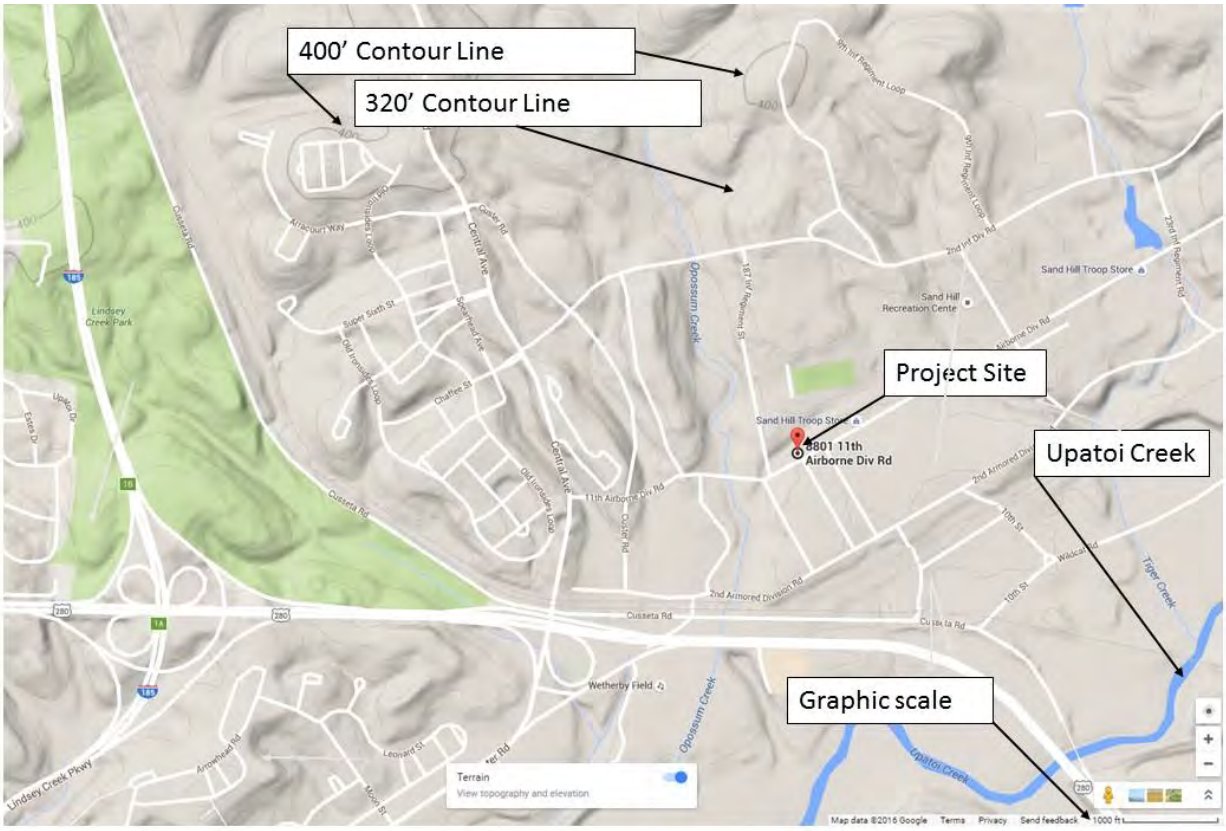
**Item 6:** Detailed Map.

In the upper right hand corner of drawing # UIC001, that is included with Item 3 (Detailed Engineering Drawings), and is specifically found in Appendix B, is a Georgia map showing the general location of Ft. Benning. There is also a Key Plan that shows the project site in respect to the surrounding roads of Ft. Benning and the Interstate Highway I-185 whose southern terminus is at the main gate for Ft. Benning. Furthermore, this drawing shows the location of the four proposed wells and Building 3215 that they serve. Below is a Google Earth image of the site. It shows the project site in relationship to the Ft. Benning property line, Interstate I-185, the Chattahoochee River, Upatoi Creek, and the nearest Ft. Benning potable water wells (6 miles away). The topology is generally reasonably flat with rolling hills at Ft. Benning. The next map (following page) shows the relief at the site and topographic information (contour lines).




Site Map of Non-Contact Groundwater Cooling System
Serving the Aquifer Thermal Energy Storage (ATES) System
At Building 3215, Ft. Benning, GA

Fig. 8: Detailed Map




Relief/Contour Map of Non-Contact Groundwater Cooling System
Serving the Aquifer Thermal Energy Storage (ATES) System
At Building 3215, Ft. Benning, GA

**Item 7:** Corrective Action Plan-Not Applicable

End of Narrative
Appendices A- C follow

# Appendix A
# Water Chemistry Analysis

Included herein is TestAmerica Laboratories, Inc.'s (Savannah GA) Analytical Report #680-105922-1. This firm was contracted by AH&P to analyze the groundwater samples collected on 3 OCT 2014 from the nested monitoring wells previously installed at the site. These monitoring wells consist of one borehole on the eastern side of the site that contains four nested wells and one borehole on the western side of the site containing three wells. Althrough the report shows four samples (wells) that were tested ("2W", "2B", "2C" and "1W"), wells 2B and 1W, with their screened intervals at 172'-182' and 147'-187' below grade (respectively) are above the aforementioned confining clay layer and are therefore ***not relevant*** to the UIC permit as only water beneath the clay layer is being contemplated being used for non-contact ground water cooling ATES system. The relevant data come from the other two wells 2W and 2C which have their screened intervals at 247'-297' and 247'-257' below grade respectively, and are below the clay layer. These relevant wells (2W and 2C) are highlighted herein for easy identification on pages 8/10/11 of 20 of the following report.

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING



# ANALYTICAL REPORT

TestAmerica Laboratories, Inc.
TestAmerica Savannah
5102 LaRoche Avenue
Savannah, GA 31404
Tel: (912)354-7858

TestAmerica Job ID: 680-105922-1
Client Project/Site: 10/3/14 AHP
Revision: 1

For:
Andrews, Hammock & Powell, Inc
250 Charter Lane
Macon, Georgia 31210

Attn: Stephen Greer

Jerry Lanier

*Authorized for release by:*
*4/5/2016 9:01:29 AM*

Jerry Lanier, Project Manager I
(912)354-7858 e.3410
jerry.lanier@testamericainc.com

LINKS

Review your project results through TotalAccess

Have a Question? Ask The Expert

Visit us at: www.testamericainc.com

*The test results in this report meet all 2003 NELAC and 2009 TNI requirements for accredited parameters, exceptions are noted in this report. This report may not be reproduced except in full, and with written approval from the laboratory. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.*

*This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.*

*Results relate only to the items tested and the sample(s) as received by the laboratory.*

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## Job ID: 680-105922-1

**Laboratory: TestAmerica Savannah**

**Narrative**

# CASE NARRATIVE

## Client: Andrews, Hammock & Powell, Inc

## Project: 10/3/14 AHP

## Report Number: 680-105922-1

With the exceptions noted as flags or footnotes, standard analytical protocols were followed in the analysis of the samples and no problems were encountered or anomalies observed. In addition all laboratory quality control samples were within established control limits, with any exceptions noted below. Each sample was analyzed to achieve the lowest possible reporting limit within the constraints of the method. In the event of interference or analytes present at high concentrations, samples may be diluted. For diluted samples, the reporting limits are adjusted relative to the dilution required.

**RECEIPT**
The samples were received on 10/03/2014; the samples arrived in good condition, properly preserved and on ice. The temperature of the coolers at receipt was 4.2º C and 4.4º C.

The final report was revised to include additional verbiage in the case narrative.

**TOTAL METALS (ICP)**
Samples 2W (680-105922-1), 2B (680-105922-2), 2C (680-105922-3) and 1W (680-105922-4) were analyzed for total metals (ICP) in accordance with EPA Method 200.7. The samples were prepared and analyzed on 10/09/2014.

No analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

**AMMONIA**
Samples 2W (680-105922-1), 2B (680-105922-2) and 2C (680-105922-3) were analyzed for ammonia in accordance with EPA Method 350.1. The samples were analyzed on 10/15/2014.

The MS/MSD % recoveries were slightly higher than our upper limit of 110%, which could theoretically result in us reporting sample results that could potentially be slightly biased high for ammonia. However, since the result is “non-detect”, any factors that may have contributed to a high bias become irrelevant. Slightly high MS/MSD % recoveries while important in understandin the “quality” of the reported data are not applicable in this particular (non-detect) situation. The associated LCS % recovery for ammonia was also within control criteria, which is used more to assess method performance. In summary, we do believe the “nc detect” value reported herein for ammonium (NH4+) is accurate.

Refer to the QC report for details.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

**FERROUS IRON**
Samples 2W (680-105922-1), 2B (680-105922-2), 2C (680-105922-3) and 1W (680-105922-4) were analyzed for ferrous iron in accordance with SM 3500-Fe-D. The samples were analyzed on 10/03/2014.

This analysis is normally performed in the field and has a method-defined holding time of 15 minutes. This sample(s) was performed in the laboratory outside the 15 minute timeframe.

No analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

**FERROUS IRON**

## Job ID: 680-105922-1 (Continued)

### Laboratory: TestAmerica Savannah (Continued)

Samples 2W (680-105922-1), 2B (680-105922-2), 2C (680-105922-3) and 1W (680-105922-4) were analyzed for ferrous iron in accordance with SM 3500 FE D. The samples were analyzed on 10/15/2014.

This analysis is normally performed in the field and has a method-defined holding time of 15 minutes. This sample(s) was performed in the laboratory outside the 15 minute timeframe.

No analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

**DISSOLVED OXYGEN**

Samples 2W (680-105922-1), 2B (680-105922-2), 2C (680-105922-3) and 1W (680-105922-4) were analyzed for Dissolved Oxygen in accordance with SM 4500_O_C. The samples were analyzed on 10/03/2014.

The following sample was received outside of holding time:680-105922-1

No analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

**UNIONIZED AMMONIA**

Samples 2W (680-105922-1), 2B (680-105922-2) and 2C (680-105922-3) were analyzed for unionized ammonia in accordance with FL DEP SOP. The samples were analyzed on 10/14/2014.

No analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

# Sample Summary

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

| Lab Sample ID | Client Sample ID | Matrix | Collected | Received |
|---|---|---|---|---|
| 680-105922-1 | 2W | Water | 10/03/14 06:55 | 10/03/14 15:30 |
| 680-105922-2 | 2B | Water | 10/03/14 08:30 | 10/03/14 15:30 |
| 680-105922-3 | 2C | Water | 10/03/14 09:30 | 10/03/14 15:30 |
| 680-105922-4 | 1W | Water | 10/03/14 10:15 | 10/03/14 15:30 |

# Method Summary

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

| Method | Method Description | Protocol | Laboratory |
|---|---|---|---|
| 200.7 Rev 4.4 | Metals (ICP) | EPA | TAL SAV |
| 350.1 | Nitrogen, Ammonia | MCAWW | TAL SAV |
| 4500 O C-2011 | Dissolved Oxygen; Azide Modification | SM | TAL SAV |
| Calculation | Ammonium | FL-DEP | TAL SAV |
| SM 3500 FE D | Iron, Ferrous | SM | TAL SAV |
| SM 3500 FE D | Iron, Ferrous and Ferric | SM | TAL SAV |

**Protocol References:**

EPA = US Environmental Protection Agency

FL-DEP = State Of Florida Department Of Environmental Protection, Florida Administrative Code.

MCAWW = "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.

SM = "Standard Methods For The Examination Of Water And Wastewater",

**Laboratory References:**

TAL SAV = TestAmerica Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Qualifiers

### General Chemistry

| Qualifier | Qualifier Description |
|---|---|
| H | Sample was prepped or analyzed beyond the specified holding time |
| HF | Field parameter with a holding time of 15 minutes. Test performed by laboratory at client's request. |
| F1 | MS and/or MSD Recovery exceeds the control limits |

## Glossary

| Abbreviation | These commonly used abbreviations may or may not be present in this report. |
|---|---|
| ¤ | Listed under the "D" column to designate that the result is reported on a dry weight basis |
| %R | Percent Recovery |
| CFL | Contains Free Liquid |
| CNF | Contains no Free Liquid |
| DER | Duplicate error ratio (normalized absolute difference) |
| Dil Fac | Dilution Factor |
| DL, RA, RE, IN | Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample |
| DLC | Decision level concentration |
| MDA | Minimum detectable activity |
| EDL | Estimated Detection Limit |
| MDC | Minimum detectable concentration |
| MDL | Method Detection Limit |
| ML | Minimum Level (Dioxin) |
| NC | Not Calculated |
| ND | Not detected at the reporting limit (or MDL or EDL if shown) |
| PQL | Practical Quantitation Limit |
| QC | Quality Control |
| RER | Relative error ratio |
| RL | Reporting Limit or Requested Limit (Radiochemistry) |
| RPD | Relative Percent Difference, a measure of the relative difference between two points |
| TEF | Toxicity Equivalent Factor (Dioxin) |
| TEQ | Toxicity Equivalent Quotient (Dioxin) |

# Detection Summary

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Client Sample ID: 2W — Lab Sample ID: 680-105922-1

| Analyte | Result | Qualifier | RL | MDL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Calcium | 10800 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Potassium | 4030 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Magnesium | 1210 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Manganese | 98.7 | | 10.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Sodium | 13400 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |

| Analyte | Result | Qualifier | RL | RL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Oxygen, Dissolved | 1.13 | H | 0.100 | | mg/L | 1 | | 4500 O C-2011 | Total/NA |
| pH | 5.70 | | 1.00 | | SU | 1 | | Calculation | Total/NA |
| Temperature | 20.5 | | 1.00 | | Degrees C | 1 | | Calculation | Total/NA |

## Client Sample ID: 2B — Lab Sample ID: 680-105922-2

| Analyte | Result | Qualifier | RL | MDL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Iron | 134 | | 50.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Calcium | 20700 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Potassium | 7580 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Magnesium | 1780 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Manganese | 219 | | 10.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Sodium | 23500 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |

| Analyte | Result | Qualifier | RL | RL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Oxygen, Dissolved | 0.640 | | 0.100 | | mg/L | 1 | | 4500 O C-2011 | Total/NA |
| pH | 7.04 | | 1.00 | | SU | 1 | | Calculation | Total/NA |
| Temperature | 21.2 | | 1.00 | | Degrees C | 1 | | Calculation | Total/NA |
| Ferric Iron | 0.134 | HF | 0.100 | | mg/L | 1 | | SM 3500 FE D | Total/NA |
| Fe | 0.134 | HF | 0.0500 | | mg/L | 1 | | SM 3500 FE D | Total/NA |

## Client Sample ID: 2C — Lab Sample ID: 680-105922-3

| Analyte | Result | Qualifier | RL | MDL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Calcium | 11300 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Potassium | 4120 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Magnesium | 1220 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Manganese | 104 | | 10.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Sodium | 13600 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |

| Analyte | Result | Qualifier | RL | RL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Oxygen, Dissolved | 0.590 | | 0.100 | | mg/L | 1 | | 4500 O C-2011 | Total/NA |
| pH | 5.75 | | 1.00 | | SU | 1 | | Calculation | Total/NA |
| Temperature | 21.2 | | 1.00 | | Degrees C | 1 | | Calculation | Total/NA |

## Client Sample ID: 1W — Lab Sample ID: 680-105922-4

| Analyte | Result | Qualifier | RL | MDL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Iron | 699 | | 50.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Calcium | 24100 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Potassium | 7600 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Magnesium | 2550 | | 500 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Manganese | 270 | | 10.0 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Sodium | 25600 | | 1000 | | ug/L | 1 | | 200.7 Rev 4.4 | Total/NA |
| Ferrous Iron | 0.203 | HF | 0.100 | | mg/L | 1 | | SM 3500 FE D | Total/NA |

This Detection Summary does not include radiochemical test results.

## Client Sample ID: 1W (Continued)

## Lab Sample ID: 680-105922-4

| Analyte | Result | Qualifier | RL | RL | Unit | Dil Fac | D | Method | Prep Type |
|---|---|---|---|---|---|---|---|---|---|
| Oxygen, Dissolved | 2.25 | | 0.100 | | mg/L | 1 | | 4500 O C-2011 | Total/NA |
| Ferric Iron | 0.496 | HF | 0.100 | | mg/L | 1 | | SM 3500 FE D | Total/NA |
| Fe | 0.699 | HF | 0.0500 | | mg/L | 1 | | SM 3500 FE D | Total/NA |
| Ferrous Iron | 0.203 | HF | 0.100 | | mg/L | 1 | | SM 3500 FE D | Total/NA |

This Detection Summary does not include radiochemical test results.

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Client Sample ID: 2W

**Lab Sample ID: 680-105922-1**

**Date Collected: 10/03/14 06:55**
**Matrix: Water**
**Date Received: 10/03/14 15:30**

### Method: 200.7 Rev 4.4 - Metals (ICP)

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Iron | <50.0 | | 50.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |
| **Calcium** | **10800** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |
| **Potassium** | **4030** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |
| **Magnesium** | **1210** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |
| **Manganese** | **98.7** | | 10.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |
| **Sodium** | **13400** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:55 | 1 |

### General Chemistry

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/15/14 14:42 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/03/14 16:11 | 1 |

| Analyte | Result | Qualifier | RL | RL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Oxygen, Dissolved** | **1.13** | **H** | 0.100 | | mg/L | | | 10/03/14 15:50 | 1 |
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| Ammonium ion | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| **pH** | **5.70** | | 1.00 | | SU | | | 10/14/14 13:35 | 1 |
| **Temperature** | **20.5** | | 1.00 | | Degrees C | | | 10/14/14 13:35 | 1 |
| Unionized Ammonia | <0.0000170 | | 0.0000170 | | mg/L | | | 10/14/14 13:35 | 1 |
| Ferric Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |
| Fe | <0.0500 | HF | 0.0500 | | mg/L | | | 10/15/14 15:55 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |

## Client Sample ID: 2B

**Lab Sample ID: 680-105922-2**

**Date Collected: 10/03/14 08:30**
**Matrix: Water**
**Date Received: 10/03/14 15:30**

### Method: 200.7 Rev 4.4 - Metals (ICP)

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Iron** | **134** | | 50.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |
| **Calcium** | **20700** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |
| **Potassium** | **7580** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |
| **Magnesium** | **1780** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |
| **Manganese** | **219** | | 10.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |
| **Sodium** | **23500** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:59 | 1 |

### General Chemistry

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/15/14 14:42 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/03/14 16:11 | 1 |

| Analyte | Result | Qualifier | RL | RL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Oxygen, Dissolved** | **0.640** | | 0.100 | | mg/L | | | 10/03/14 15:50 | 1 |
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| Ammonium ion | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| **pH** | **7.04** | | 1.00 | | SU | | | 10/14/14 13:35 | 1 |
| **Temperature** | **21.2** | | 1.00 | | Degrees C | | | 10/14/14 13:35 | 1 |
| Unionized Ammonia | <0.0000170 | | 0.0000170 | | mg/L | | | 10/14/14 13:35 | 1 |
| **Ferric Iron** | **0.134** | **HF** | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |
| **Fe** | **0.134** | **HF** | 0.0500 | | mg/L | | | 10/15/14 15:55 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Client Sample ID: 2C

**Lab Sample ID: 680-105922-3**

**Date Collected: 10/03/14 09:30**
**Matrix: Water**
**Date Received: 10/03/14 15:30**

### Method: 200.7 Rev 4.4 - Metals (ICP)

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Iron | <50.0 | | 50.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |
| **Calcium** | **11300** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |
| **Potassium** | **4120** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |
| **Magnesium** | **1220** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |
| **Manganese** | **104** | | 10.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |
| **Sodium** | **13600** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:12 | 1 |

### General Chemistry

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/15/14 14:50 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/03/14 16:11 | 1 |

| Analyte | Result | Qualifier | RL | RL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Oxygen, Dissolved** | **0.590** | | 0.100 | | mg/L | | | 10/03/14 15:50 | 1 |
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| Ammonium ion | <0.0500 | | 0.0500 | | mg/L | | | 10/14/14 13:35 | 1 |
| **pH** | **5.75** | | 1.00 | | SU | | | 10/14/14 13:35 | 1 |
| **Temperature** | **21.2** | | 1.00 | | Degrees C | | | 10/14/14 13:35 | 1 |
| Unionized Ammonia | <0.0000170 | | 0.0000170 | | mg/L | | | 10/14/14 13:35 | 1 |
| Ferric Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |
| Fe | <0.0500 | HF | 0.0500 | | mg/L | | | 10/15/14 15:55 | 1 |
| Ferrous Iron | <0.100 | HF | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |

## Client Sample ID: 1W

**Lab Sample ID: 680-105922-4**

**Date Collected: 10/03/14 10:15**
**Matrix: Water**
**Date Received: 10/03/14 15:30**

### Method: 200.7 Rev 4.4 - Metals (ICP)

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Iron** | **699** | | 50.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |
| **Calcium** | **24100** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |
| **Potassium** | **7600** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |
| **Magnesium** | **2550** | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |
| **Manganese** | **270** | | 10.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |
| **Sodium** | **25600** | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 20:16 | 1 |

### General Chemistry

| Analyte | Result | Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Ferrous Iron** | **0.203** | **HF** | 0.100 | | mg/L | | | 10/03/14 16:11 | 1 |

| Analyte | Result | Qualifier | RL | RL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| **Oxygen, Dissolved** | **2.25** | | 0.100 | | mg/L | | | 10/03/14 15:50 | 1 |
| **Ferric Iron** | **0.496** | **HF** | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |
| **Fe** | **0.699** | **HF** | 0.0500 | | mg/L | | | 10/15/14 15:55 | 1 |
| **Ferrous Iron** | **0.203** | **HF** | 0.100 | | mg/L | | | 10/15/14 15:55 | 1 |

## Method: 200.7 Rev 4.4 - Metals (ICP)

**Lab Sample ID: MB 680-352858/1-A**
**Matrix: Water**
**Analysis Batch: 352949**

**Client Sample ID: Method Blank**
**Prep Type: Total/NA**
**Prep Batch: 352858**

| Analyte | MB Result | MB Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Iron | <50.0 | | 50.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |
| Calcium | <500 | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |
| Potassium | <1000 | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |
| Magnesium | <500 | | 500 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |
| Manganese | <10.0 | | 10.0 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |
| Sodium | <1000 | | 1000 | | ug/L | | 10/09/14 15:01 | 10/09/14 19:21 | 1 |

**Lab Sample ID: LCS 680-352858/4-A**
**Matrix: Water**
**Analysis Batch: 352949**

**Client Sample ID: Lab Control Sample**
**Prep Type: Total/NA**
**Prep Batch: 352858**

| Analyte | Spike Added | LCS Result | LCS Qualifier | Unit | D | %Rec | %Rec. Limits |
|---|---|---|---|---|---|---|---|
| Iron | 5000 | 4968 | | ug/L | | 99 | 85 - 115 |
| Calcium | 5000 | 5026 | | ug/L | | 101 | 85 - 115 |
| Potassium | 10000 | 10320 | | ug/L | | 103 | 85 - 115 |
| Magnesium | 5000 | 4916 | | ug/L | | 98 | 85 - 115 |
| Manganese | 5000 | 5094 | | ug/L | | 102 | 85 - 115 |
| Sodium | 7500 | 7745 | | ug/L | | 103 | 85 - 115 |

## Method: 350.1 - Nitrogen, Ammonia

**Lab Sample ID: MB 680-353779/21**
**Matrix: Water**
**Analysis Batch: 353779**

**Client Sample ID: Method Blank**
**Prep Type: Total/NA**

| Analyte | MB Result | MB Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 0.0500 | | mg/L | | | 10/15/14 15:43 | 1 |

**Lab Sample ID: LCS 680-353779/1**
**Matrix: Water**
**Analysis Batch: 353779**

**Client Sample ID: Lab Control Sample**
**Prep Type: Total/NA**

| Analyte | Spike Added | LCS Result | LCS Qualifier | Unit | D | %Rec | %Rec. Limits |
|---|---|---|---|---|---|---|---|
| Ammonia | 1.00 | 1.045 | | mg/L | | 104 | 90 - 110 |

**Lab Sample ID: 680-105922-1 MS**
**Matrix: Water**
**Analysis Batch: 353779**

**Client Sample ID: 2W**
**Prep Type: Total/NA**

| Analyte | Sample Result | Sample Qualifier | Spike Added | MS Result | MS Qualifier | Unit | D | %Rec | %Rec. Limits |
|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 1.00 | 1.160 | F1 | mg/L | | 116 | 90 - 110 |

**Lab Sample ID: 680-105922-1 MSD**
**Matrix: Water**
**Analysis Batch: 353779**

**Client Sample ID: 2W**
**Prep Type: Total/NA**

| Analyte | Sample Result | Sample Qualifier | Spike Added | MSD Result | MSD Qualifier | Unit | D | %Rec | %Rec. Limits | RPD | RPD Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ammonia | <0.0500 | | 1.00 | 1.158 | F1 | mg/L | | 116 | 90 - 110 | 0 | 30 |

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Method: 4500 O C-2011 - Dissolved Oxygen; Azide Modification

**Lab Sample ID: 680-105922-1 DU**
**Matrix: Water**
**Analysis Batch: 351990**

**Client Sample ID: 2W**
**Prep Type: Total/NA**

| Analyte | Sample Result | Sample Qualifier | | DU Result | DU Qualifier | Unit | D | | | RPD | RPD Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oxygen, Dissolved | 1.13 | H | | 1.160 | | mg/L | | | | 3 | 20 |

## Method: SM 3500 FE D - Iron, Ferrous

**Lab Sample ID: MB 680-351996/2**
**Matrix: Water**
**Analysis Batch: 351996**

**Client Sample ID: Method Blank**
**Prep Type: Total/NA**

| Analyte | MB Result | MB Qualifier | RL | MDL | Unit | D | Prepared | Analyzed | Dil Fac |
|---|---|---|---|---|---|---|---|---|---|
| Ferrous Iron | <0.100 | | 0.100 | | mg/L | | | 10/03/14 14:45 | 1 |

**Lab Sample ID: LCS 680-351996/1**
**Matrix: Water**
**Analysis Batch: 351996**

**Client Sample ID: Lab Control Sample**
**Prep Type: Total/NA**

| Analyte | | | Spike Added | LCS Result | LCS Qualifier | Unit | D | %Rec | %Rec. Limits | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ferrous Iron | | | 2.00 | 1.987 | | mg/L | | 99 | 80 - 120 | | |

## Metals

### Prep Batch: 352858

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | 200 | |
| 680-105922-2 | 2B | Total/NA | Water | 200 | |
| 680-105922-3 | 2C | Total/NA | Water | 200 | |
| 680-105922-4 | 1W | Total/NA | Water | 200 | |
| LCS 680-352858/4-A | Lab Control Sample | Total/NA | Water | 200 | |
| MB 680-352858/1-A | Method Blank | Total/NA | Water | 200 | |

### Analysis Batch: 352949

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | 200.7 Rev 4.4 | 352858 |
| 680-105922-2 | 2B | Total/NA | Water | 200.7 Rev 4.4 | 352858 |
| 680-105922-3 | 2C | Total/NA | Water | 200.7 Rev 4.4 | 352858 |
| 680-105922-4 | 1W | Total/NA | Water | 200.7 Rev 4.4 | 352858 |
| LCS 680-352858/4-A | Lab Control Sample | Total/NA | Water | 200.7 Rev 4.4 | 352858 |
| MB 680-352858/1-A | Method Blank | Total/NA | Water | 200.7 Rev 4.4 | 352858 |

## General Chemistry

### Analysis Batch: 351990

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | 4500 O C-2011 | |
| 680-105922-1 DU | 2W | Total/NA | Water | 4500 O C-2011 | |
| 680-105922-2 | 2B | Total/NA | Water | 4500 O C-2011 | |
| 680-105922-3 | 2C | Total/NA | Water | 4500 O C-2011 | |
| 680-105922-4 | 1W | Total/NA | Water | 4500 O C-2011 | |

### Analysis Batch: 351996

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | SM 3500 FE D | |
| 680-105922-2 | 2B | Total/NA | Water | SM 3500 FE D | |
| 680-105922-3 | 2C | Total/NA | Water | SM 3500 FE D | |
| 680-105922-4 | 1W | Total/NA | Water | SM 3500 FE D | |
| LCS 680-351996/1 | Lab Control Sample | Total/NA | Water | SM 3500 FE D | |
| MB 680-351996/2 | Method Blank | Total/NA | Water | SM 3500 FE D | |

### Analysis Batch: 353520

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | Calculation | |
| 680-105922-2 | 2B | Total/NA | Water | Calculation | |
| 680-105922-3 | 2C | Total/NA | Water | Calculation | |

### Analysis Batch: 353779

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | 350.1 | |
| 680-105922-1 MS | 2W | Total/NA | Water | 350.1 | |
| 680-105922-1 MSD | 2W | Total/NA | Water | 350.1 | |
| 680-105922-2 | 2B | Total/NA | Water | 350.1 | |
| 680-105922-3 | 2C | Total/NA | Water | 350.1 | |
| LCS 680-353779/1 | Lab Control Sample | Total/NA | Water | 350.1 | |
| MB 680-353779/21 | Method Blank | Total/NA | Water | 350.1 | |

## General Chemistry (Continued)

### Analysis Batch: 353784

| Lab Sample ID | Client Sample ID | Prep Type | Matrix | Method | Prep Batch |
|---|---|---|---|---|---|
| 680-105922-1 | 2W | Total/NA | Water | SM 3500 FE D | |
| 680-105922-2 | 2B | Total/NA | Water | SM 3500 FE D | |
| 680-105922-3 | 2C | Total/NA | Water | SM 3500 FE D | |
| 680-105922-4 | 1W | Total/NA | Water | SM 3500 FE D | |

# Lab Chronicle

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Client Sample ID: 2W

**Lab Sample ID: 680-105922-1**

**Date Collected: 10/03/14 06:55**

**Matrix: Water**

**Date Received: 10/03/14 15:30**

| Prep Type | Batch Type | Batch Method | Run | Dil Factor | Initial Amount | Final Amount | Batch Number | Prepared or Analyzed | Analyst | Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| Total/NA | Prep | 200 | | | 50 mL | 50 mL | 352858 | 10/09/14 15:01 | BJB | TAL SAV |
| Total/NA | Analysis | 200.7 Rev 4.4 | | 1 | 50 mL | 50 mL | 352949 | 10/09/14 19:55 | BCB | TAL SAV |
| | Instrument ID: ICPE | | | | | | | | | |
| Total/NA | Analysis | 350.1 | | 1 | 2 mL | 2 mL | 353779 | 10/15/14 14:42 | JME | TAL SAV |
| | Instrument ID: KONELAB1 | | | | | | | | | |
| Total/NA | Analysis | 4500 O C-2011 | | 1 | 200 mL | 200 mL | 351990 | 10/03/14 15:50 | OLB | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | Calculation | | 1 | | | 353520 | 10/14/14 13:35 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | 2 mL | 2 mL | 351996 | 10/03/14 16:11 | GRX | TAL SAV |
| | Instrument ID: KONELAB2 | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | | | 353784 | 10/15/14 15:55 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |

## Client Sample ID: 2B

**Lab Sample ID: 680-105922-2**

**Date Collected: 10/03/14 08:30**

**Matrix: Water**

**Date Received: 10/03/14 15:30**

| Prep Type | Batch Type | Batch Method | Run | Dil Factor | Initial Amount | Final Amount | Batch Number | Prepared or Analyzed | Analyst | Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| Total/NA | Prep | 200 | | | 50 mL | 50 mL | 352858 | 10/09/14 15:01 | BJB | TAL SAV |
| Total/NA | Analysis | 200.7 Rev 4.4 | | 1 | 50 mL | 50 mL | 352949 | 10/09/14 19:59 | BCB | TAL SAV |
| | Instrument ID: ICPE | | | | | | | | | |
| Total/NA | Analysis | 350.1 | | 1 | 2 mL | 2 mL | 353779 | 10/15/14 14:42 | JME | TAL SAV |
| | Instrument ID: KONELAB1 | | | | | | | | | |
| Total/NA | Analysis | 4500 O C-2011 | | 1 | 200 mL | 200 mL | 351990 | 10/03/14 15:50 | OLB | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | Calculation | | 1 | | | 353520 | 10/14/14 13:35 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | 2 mL | 2 mL | 351996 | 10/03/14 16:11 | GRX | TAL SAV |
| | Instrument ID: KONELAB2 | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | | | 353784 | 10/15/14 15:55 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |

## Client Sample ID: 2C

**Lab Sample ID: 680-105922-3**

**Date Collected: 10/03/14 09:30**

**Matrix: Water**

**Date Received: 10/03/14 15:30**

| Prep Type | Batch Type | Batch Method | Run | Dil Factor | Initial Amount | Final Amount | Batch Number | Prepared or Analyzed | Analyst | Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| Total/NA | Prep | 200 | | | 50 mL | 50 mL | 352858 | 10/09/14 15:01 | BJB | TAL SAV |
| Total/NA | Analysis | 200.7 Rev 4.4 | | 1 | 50 mL | 50 mL | 352949 | 10/09/14 20:12 | BCB | TAL SAV |
| | Instrument ID: ICPE | | | | | | | | | |
| Total/NA | Analysis | 350.1 | | 1 | 2 mL | 2 mL | 353779 | 10/15/14 14:50 | JME | TAL SAV |
| | Instrument ID: KONELAB1 | | | | | | | | | |

# Lab Chronicle

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Client Sample ID: 2C

**Lab Sample ID: 680-105922-3**

**Date Collected: 10/03/14 09:30**

**Matrix: Water**

**Date Received: 10/03/14 15:30**

| Prep Type | Batch Type | Batch Method | Run | Dil Factor | Initial Amount | Final Amount | Batch Number | Prepared or Analyzed | Analyst | Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| Total/NA | Analysis | 4500 O C-2011 | | 1 | 200 mL | 200 mL | 351990 | 10/03/14 15:50 | OLB | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | Calculation | | 1 | | | 353520 | 10/14/14 13:35 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | 2 mL | 2 mL | 351996 | 10/03/14 16:11 | GRX | TAL SAV |
| | Instrument ID: KONELAB2 | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | | | 353784 | 10/15/14 15:55 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |

## Client Sample ID: 1W

**Lab Sample ID: 680-105922-4**

**Date Collected: 10/03/14 10:15**

**Matrix: Water**

**Date Received: 10/03/14 15:30**

| Prep Type | Batch Type | Batch Method | Run | Dil Factor | Initial Amount | Final Amount | Batch Number | Prepared or Analyzed | Analyst | Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| Total/NA | Prep | 200 | | | 50 mL | 50 mL | 352858 | 10/09/14 15:01 | BJB | TAL SAV |
| Total/NA | Analysis | 200.7 Rev 4.4 | | 1 | 50 mL | 50 mL | 352949 | 10/09/14 20:16 | BCB | TAL SAV |
| | Instrument ID: ICPE | | | | | | | | | |
| Total/NA | Analysis | 4500 O C-2011 | | 1 | 200 mL | 200 mL | 351990 | 10/03/14 15:50 | OLB | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | 2 mL | 2 mL | 351996 | 10/03/14 16:11 | GRX | TAL SAV |
| | Instrument ID: KONELAB2 | | | | | | | | | |
| Total/NA | Analysis | SM 3500 FE D | | 1 | | | 353784 | 10/15/14 15:55 | JER | TAL SAV |
| | Instrument ID: NOEQUIP | | | | | | | | | |

**Laboratory References:**

TAL SAV = TestAmerica Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858

Serial Number 88572

# ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING


◯ TestAmerica Savannah
5102 LaRoche Avenue
Savannah, GA 31404

Website: www.testamericainc.com
Phone: (912) 354-7858
Fax: (912) 352-0165

◯ Alternate Laboratory Name/Location

Phone:
Fax:


| PROJECT REFERENCE | PROJECT NO. | PROJECT LOCATION (STATE) |
|---|---|---|
| 10/3/14 AHP | | |
| TAL (LAB) PROJECT MANAGER | P.O. NUMBER | CONTRACT NO. |
| CLIENT (SITE) PM | CLIENT PHONE | CLIENT FAX |
| CLIENT NAME | CLIENT E-MAIL | |
| CLIENT ADDRESS | | |
| COMPANY CONTRACTING THIS WORK (if applicable) | | |

MATRIX TYPE (COMPOSITE (C) OR GRAB (G) INDICATE; AQUEOUS (WATER); SOLID OR SEMISOLID; AIR; NONAQUEOUS LIQUID (OIL, SOLVENT, ...))

REQUIRED ANALYSIS

PAGE | OF

STANDARD REPORT DELIVERY ◯
DATE DUE
EXPEDITED REPORT DELIVERY (SURCHARGE) ◯
DATE DUE

NUMBER OF COOLERS SUBMITTED PER SHIPMENT:

| SAMPLE DATE | SAMPLE TIME | SAMPLE IDENTIFICATION | NUMBER OF CONTAINERS SUBMITTED | REMARKS |
|---|---|---|---|---|
| 10/3/14 | 6:55 | ½ 2W | | |
| " | 8:30 | 2B | | |
| " | 9:30 | 2C | | |
| " | 10:15 | 1W | | |

680-105922 Chain of Custody

| RELINQUISHED BY: (SIGNATURE) | DATE | TIME | RELINQUISHED BY: (SIGNATURE) | DATE | TIME | RELINQUISHED BY: (SIGNATURE) | DATE | TIME |
|---|---|---|---|---|---|---|---|---|
| | 10/03/14 | 1530 | | | | | | |
| RECEIVED BY: (SIGNATURE) | DATE | TIME | RECEIVED BY: (SIGNATURE) | DATE | TIME | RECEIVED BY: (SIGNATURE) | DATE | TIME |
| | | | | | | | | |

LABORATORY USE ONLY

| RECEIVED FOR LABORATORY BY: (SIGNATURE) | DATE | TIME | CUSTODY INTACT | CUSTODY SEAL NO. | SAVANNAH LOG NO. | LABORATORY REMARKS |
|---|---|---|---|---|---|---|
| | 10/03/14 | 1530 | YES ◯ NO ◯ | | 680-105922 | 4.4/2.2°C |

TAL8240-680 (1008)



4/5/2016

# Login Sample Receipt Checklist

Client: Andrews, Hammock & Powell, Inc

Job Number: 680-105922-1

**Login Number: 105922**

**List Source: TestAmerica Savannah**

**List Number: 1**

**Creator: Conner, Keaton**

| Question | Answer | Comment |
|---|---|---|
| Radioactivity wasn't checked or is </= background as measured by a survey meter. | N/A | |
| The cooler's custody seal, if present, is intact. | True | |
| Sample custody seals, if present, are intact. | True | |
| The cooler or samples do not appear to have been compromised or tampered with. | True | |
| Samples were received on ice. | True | |
| Cooler Temperature is acceptable. | True | |
| Cooler Temperature is recorded. | True | |
| COC is present. | True | |
| COC is filled out in ink and legible. | True | |
| COC is filled out with all pertinent information. | True | |
| Is the Field Sampler's name present on COC? | N/A | |
| There are no discrepancies between the containers received and the COC. | True | NO AMMONIA -4 PER COC |
| Samples are received within Holding Time. | True | |
| Sample containers have legible labels. | True | |
| Containers are not broken or leaking. | True | |
| Sample collection date/times are provided. | True | |
| Appropriate sample containers are used. | True | |
| Sample bottles are completely filled. | True | |
| Sample Preservation Verified. | True | |
| There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs | True | |
| Containers requiring zero headspace have no headspace or bubble is <6mm (1/4"). | N/A | |
| Multiphasic samples are not present. | True | |
| Samples do not require splitting or compositing. | True | |
| Residual Chlorine Checked. | N/A | |

# Certification Summary

Client: Andrews, Hammock & Powell, Inc
Project/Site: 10/3/14 AHP

TestAmerica Job ID: 680-105922-1

## Laboratory: TestAmerica Savannah

The certifications listed below are applicable to this report.

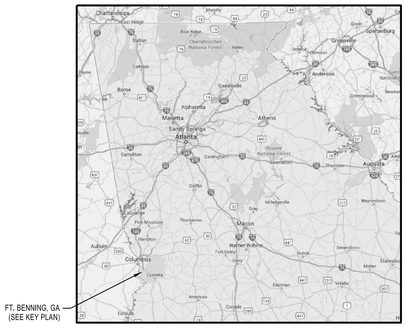
| Authority | Program | EPA Region | Certification ID | Expiration Date |
|---|---|---|---|---|
| Georgia | State Program | 4 | 803 | 06-30-15 |

# Appendix B

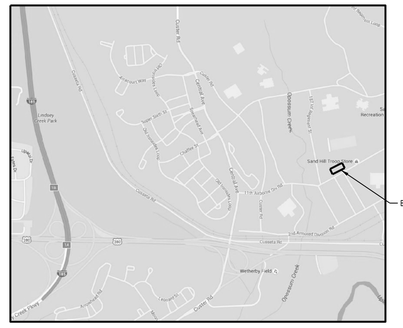
# Detailed Diagrams/ Engineering Layout (Drawings) of the System

# NOTES: (THIS SHEET ONLY)

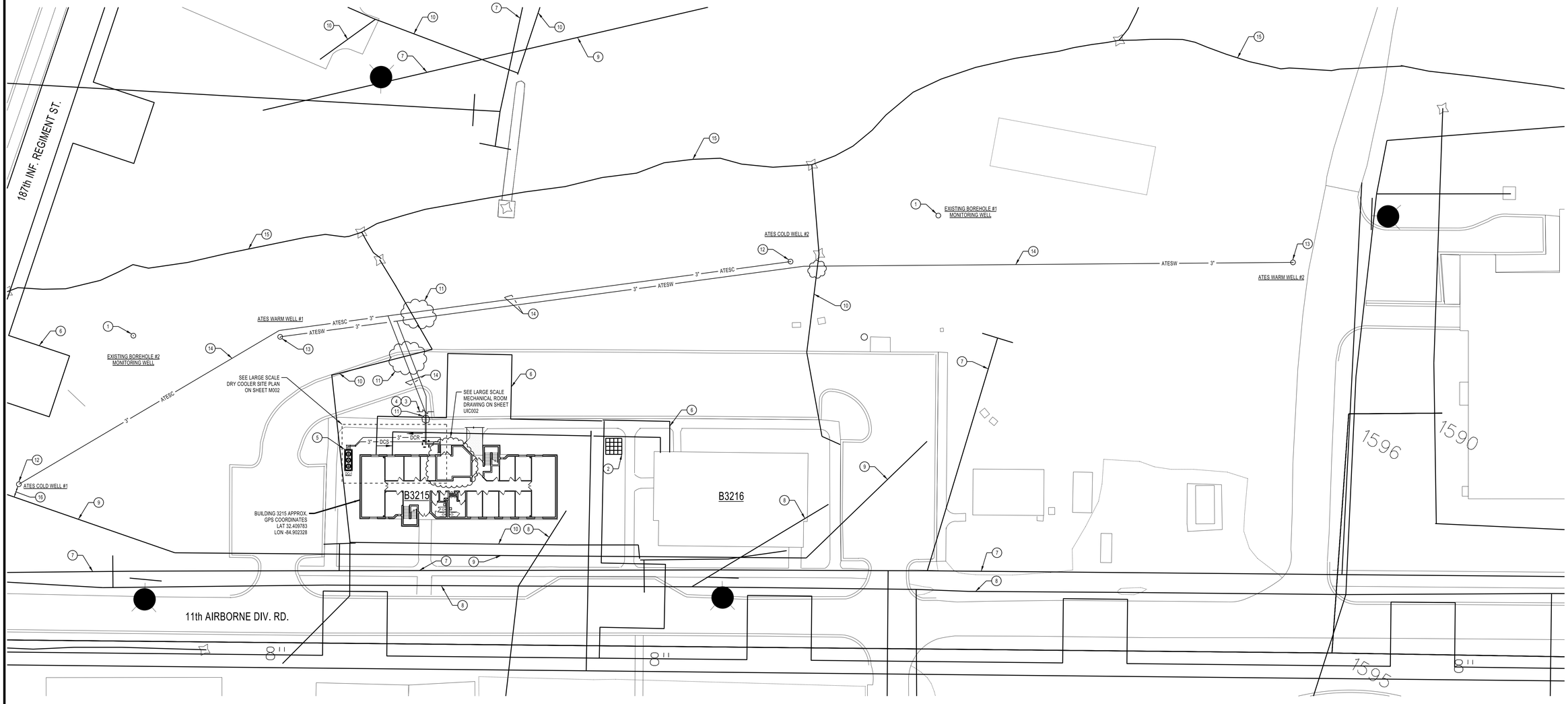
1. EXISTING MONITORING WELL LOCATION.
2. EXISTING STEAM AND CHILLED WATER VALVE PIT.
3. CENTERLINE SPACING OF ATES PIPING FROM THIS POINT SOUTHWARD IS SHOWN NEAR "TO SCALE"; HOWEVER, ONLY A MINIMUM OF 4" OF CLEARANCE BETWEEN EACH PIPE IS REQUIRED.
4. CENTERLINE SPACING OF ATES PIPING FROM THIS POINT SOUTHWARD IS SHOWN LARGER THAN SCALE FOR CLARITY PURPOSES. ONLY A MINIMUM OF 4" OF CLEARANCE BETWEEN EACH PIPE IS REQUIRED FOR ANY OF THE PIPING ROUTED IN THE TRENCHES.
5. AIR-COOLED DRY COOLER.
6. EXISTING UNDERGROUND STEAM PIPING TO REMAIN AT THIS APPROXIMATE LOCATION.
7. EXISTING UNDERGROUND DOMESTIC WATER PIPING TO REMAIN AT THIS APPROXIMATE LOCATION.
8. EXISTING ELECTRICAL TO REMAIN AT THIS APPROXIMATE LOCATION.
9. EXISTING UNDERGROUND SANITARY SEWER PIPING TO REMAIN AT THIS APPROXIMATE LOCATION.
10. EXISTING UNDERGROUND STORM SEWER PIPING TO REMAIN AT THIS APPROXIMATE LOCATION.
11. PIPING INSTALLATION MAY CONFLICT WITH THE EXISTING UNDERGROUND UTILITY AT THIS APPROXIMATE LOCATION AT THEIR "CROSSING POINT". ACCORDINGLY, CONTRACTOR SHALL OFFSET THE NEW ATES GEOTHERMAL PIPING IF REQUIRED TO AVOID THIS CONFLICT.
12. AQUIFER THERMAL ENERGY STORAGE (ATES) COLD WELL. SEE ATES WELL DETAILS.
13. AQUIFER THERMAL ENERGY STORAGE (ATES) WARM WELL. SEE ATES WELL DETAILS.
14. PIPING SUB-MAINS ARE ROUTED A MINIMUM OF 3' BELOW GRADE.
15. APPROXIMATE CENTERLINE OF EXISTING CREEK BED/STORM SEWER DRAINAGE DITCH.
16. MAINTAIN A MINIMUM OF 10' FROM ALL SEWER LINES.




MAP LOCATION
SCALE: NONE




KEY PLAN
SCALE: NONE




B3215 AQUIFER THERMAL ENERGY STORAGE (ATES)
SCALE: 1"=30'-0"

30' 15' 0' 30' 60' 90'
SCALE: 1/30" = 1'-0"

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250 Charter Lane,
Suite 100
Macon, Georgia 31210
Macon (478) 405-8301
Fax (478) 405-8210
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AH&P CONSULTING ENGINEERS

NON-CONTACT COOLING WATER
AQUIFER THERMAL ENERGY
STORAGE (ATES) SYSTEM
BUILDING 3215
Fort Benning Georgia

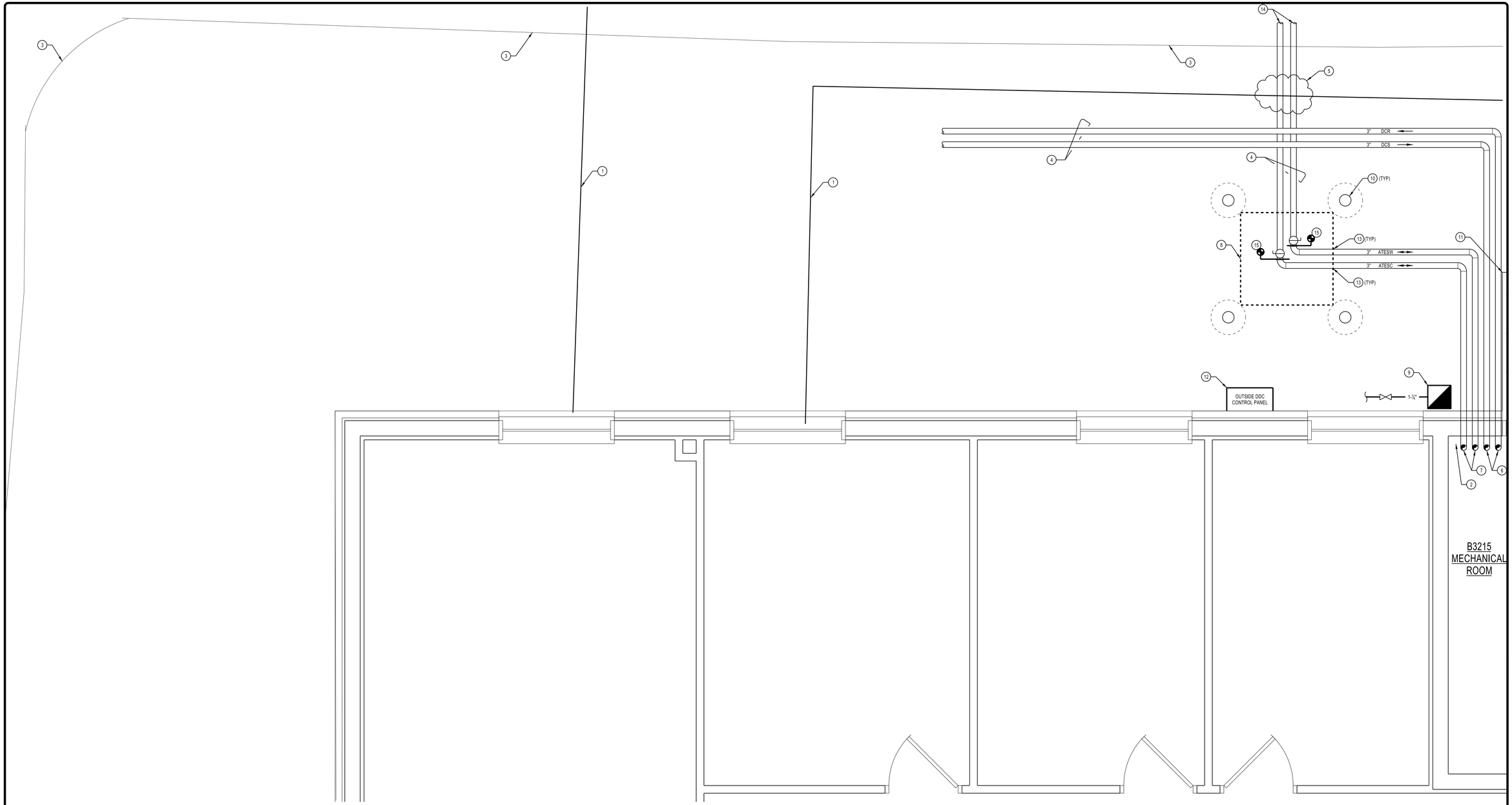
REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| 1 | 04-25-16 | ISSUED FOR GA. EPD UIC REVIEW |

DATE: March 21, 2016
PROJECT NUMBER: 2011184
DRAWN BY: SES
CHECKED BY: CWH
TITLE:
B3215 AQUIFER THERMAL ENERGY STORAGE (ATES) HVAC RENOVATION SITE LAYOUT

SHEET NUMBER:
UIC001

GEORGIA REGISTERED PROFESSIONAL ENGINEER CHARLES W. HAMMOCK JR.




## NOTES: (THIS SHEET ONLY)

1. EXISTING UNDERGROUND STEAM PIPING TO REMAIN AT THIS APPROXIMATE LOCATION.
2. EXISTING UNDERGROUND DOMESTIC WATER PIPING PENETRATES FLOOR SLAB AT THIS APPROXIMATE LOCATION AND ENTERS MECHANICAL ROOM. SEE SHEET M201 FOR PIPE CONTINUATION.
3. EDGE OF EXISTING SIDEWALK.
4. PIPING SUB-MAINS ARE ROUTED A MINIMUM OF 3' BELOW GRADE.
5. PIPING CROSSES OVER/UNDER EXISTING PIPE AT THIS APPROXIMATE LOCATION.
6. DRY COOLER PIPING PENETRATES FLOOR SLAB AT THIS APPROXIMATE LOCATION AND ENTERS MECHANICAL ROOM.
7. ATES PIPING PENETRATES FLOOR SLAB AT THIS APPROXIMATE LOCATION AND ENTERS MECHANICAL ROOM.
8. PRECAST POLYMER CONCRETE ENCLOSURE WITH WATERTIGHT LID.
9. EXISTING NATURAL GAS (NG) METER SET.
10. STEEL BOLLARD.
11. EXISTING MECHANICAL ROOM EXTERIOR CONCRETE PAD.
12. EXTERIOR DDC CONTROL PANEL
13. PROVIDE PIPE SLEEVE IN OPENING TO ALLOW FOR INSTALLATION OF PIPE EXIT/ENTRANCE.
14. SEE SHEET UIC001 FOR PIPE CONTINUATION.
15. PIPING INSTALLED UNDER THIS CONTRACT CONNECT TO THE BUILDING'S INTERCONNECTING PIPING AT THIS APPROXIMATE LOCATION.

## LARGE SCALE SITE PLAN AT MECHANICAL ROOM

SCALE: ½"=1'-0"

2' 1' 0' 2' 4' 6'

SCALE: ½" = 1'-0"

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AH&P CONSULTING ENGINEERS

NON-CONTACT COOLING WATER
AQUIFER THERMAL ENERGY
STORAGE (ATES) SYSTEM
BUILDING 3215
Fort Benning Georgia

REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| 1 | 04-25-16 | ISSUED FOR GA. EPD UIC REVIEW |

| | |
|---|---|
| DATE: | March 21, 2016 |
| PROJECT NUMBER: | 2011184 |
| DRAWN BY: | SES |
| CHECKED BY: | CWH |

TITLE:
LARGE SCALE SITE PLAN AT MECHANICAL ROOM

SHEET NUMBER:

UIC002

GEORGIA REGISTERED PROFESSIONAL ENGINEER CHARLES W. HAMMOCK, JR.

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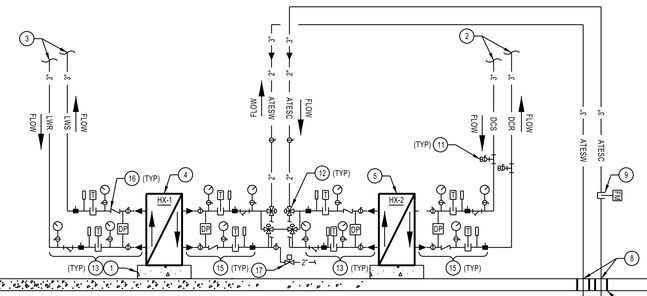
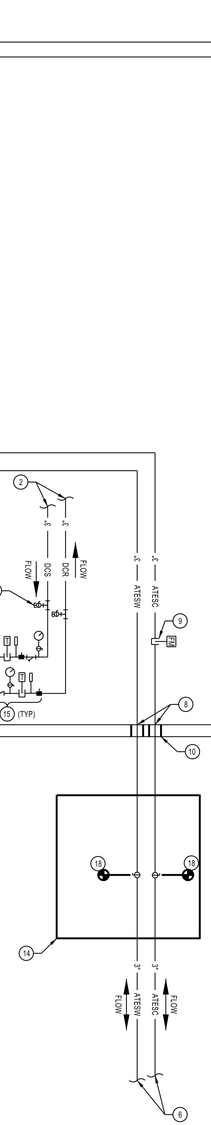
# NON-CONTACT COOLING WATER AQUIFER THERMAL ENERGY STORAGE (ATES) SYSTEM BUILDING 3215

Fort Benning Georgia



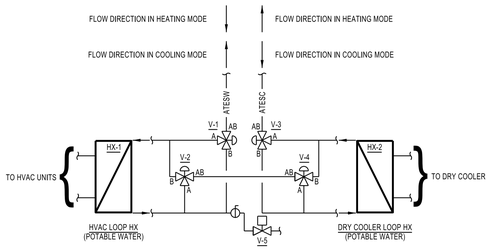




## NOTES: (THIS SHEET ONLY)

1. CONCRETE PAD.
2. NSF APPROVED PP-RCT DRY COOLER LOOP PIPING TO DRY COOLER.
3. NSF APPROVED PP-RCT WSHP LOOP WATER PIPING TO HVAC EQUIPMENT.
4. HVAC LOOP TO ATES LOOP TYPE 304 STAINLESS STEEL PLATE AND FRAME HEAT EXCHANGER. GROUND WATER IS ON THE ATES SIDE AND POTABLE WATER IS ON THE HVAC SIDE.
5. DRY COOLER TO ATES LOOP TYPE 304 STAINLESS STEEL PLATE AND FRAME HEAT EXCHANGER. GROUND WATER IS ON THE ATES SIDE AND POTABLE WATER IS ON THE DRY COOLER SIDE.
6. NSF APPROVED PP-RCT ATES LOOP WATER PIPING FROM MECHANICAL ROOM TO ATES WELLS. SEE SHEET UIC001 FOR PIPE CONTINUATION.
7. MECHANICAL ROOM EXTERIOR WALL.
8. NSF APPROVED PP-RCT ATES LOOP PIPING THRU MECHANICAL ROOM FLOOR.
9. LOCATION OF ELECTROMAGNETIC FLOW SENSOR.
10. PIPE SLEEVE THRU FLOOR.
11. TEE WITH BUTTERFLY VALVE TERMINATED WITH BLIND FLANGE.
12. 3-WAY CONTROL VALVE.
13. PRESSURE GAUGE, STRAINER, P&T PORT, THERMOMETER WELL, TEMPERATURE SENSOR, PRESSURE GAUGE, PRESSURE DIFFERENTIAL TRANSMITTER, BALL VALVE AND REDUCER.
14. TIER 15 48" X 48" X 48" DEEP PRECAST POLYMER CONCRETE ENCLOSURE WITH WATERTIGHT LID RATED FOR 15,000 LBS VERTICAL DESIGN LOAD EQUIPPED WITH HEX HEAD BOLTS. COVER BOTTOM OF ENCLOSURE WITH HEAVY DUTY LANDSCAPE FABRIC AND FILL BOTTOM OF ENCLOSURE WITH 6" OF PEA GRAVEL..
15. P&T PORT, THERMOMETER WELL, TEMPERATURE SENSOR, PRESSURE GAUGE, CHECK VALVE, PRESSURE DIFFERENTIAL TRANSMITTER, BALL VALVE AND REDUCER.
16. CHECK VALVE.
17. SOLENOID VALVE.
18. PIPING INSTALLED UNDER THIS CONTRACT CONNECT TO THE BUILDING'S INTERCONNECTING PIPING AT THIS APPROXIMATE LOCATION.

## ATES LOOP SYSTEM WATER PIPING SCHEMATIC

SCALE: NONE




| CONTROL VALVE POSITION BASED ON MODE OF OPERATION | | | | | | |
|---|---|---|---|---|---|---|
| # | OPERATING MODE | VALVE PORT IN CLOSED POSTION | | | | |
| | | V-1 | V-2 | V-3 | V-4 | V-5 |
| 1 | COOLING MODE (THRU BOTH HXs) | A | A | A | A | CLOSED |
| 2 | COOLING MODE (THRU HX-1 ONLY) | A | A | A | B | CLOSED |
| 3 | COOLING MODE (THRU HX-2 ONLY) | A | B | A | A | CLOSED |
| 4 | COOLING MODE (BYPASS BOTH HXs) | A | B | A | B | CLOSED |
| 5 | COOLING MODE (EMERGENCY MODE #1; ATES WATER TO DRAIN) | A | A | A | B | OPEN |
| 6 | COOLING MODE (EMERGENCY MODE #2; HEAT REJECTION BY DRY COOLER) | A | A | A | B | CLOSED |
| 7 | HEATING MODE (THRU BOTH HXs) | B | B | B | B | CLOSED |
| 8 | HEATING MODE (BYPASS HX-2 ONLY) | B | B | A | B | CLOSED |
| 9 | HEATING MODE (BYPASS HX-1 ONLY) | A | B | B | B | CLOSED |
| 10 | HEATING MODE (BYPASS BOTH HXs) | A | B | A | B | CLOSED |
| 11 | HEATING MODE (EMERGENCY MODE #1; ATES WATER TO DRAIN) | B | B | B | B | OPEN |
| 12 | HEATING MODE (EMERGENCY MODE #2; HEAT INJECTION BY DRY COOLER) | A | A | A | B | CLOSED |

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 04-25-16 | ISSUED FOR GA. EPD UIC REVIEW |

DATE: March 21, 2016
PROJECT NUMBER: 2011184
DRAWN BY: SES
CHECKED BY: CWH
TITLE: ATES LOOP SYSTEM WATER PIPING SCHEMATIC

SHEET NUMBER:

# UIC301

GEORGIA REGISTERED Number PROFESSIONAL ENGINEER CHARLES W. HAMMOCK, JR.

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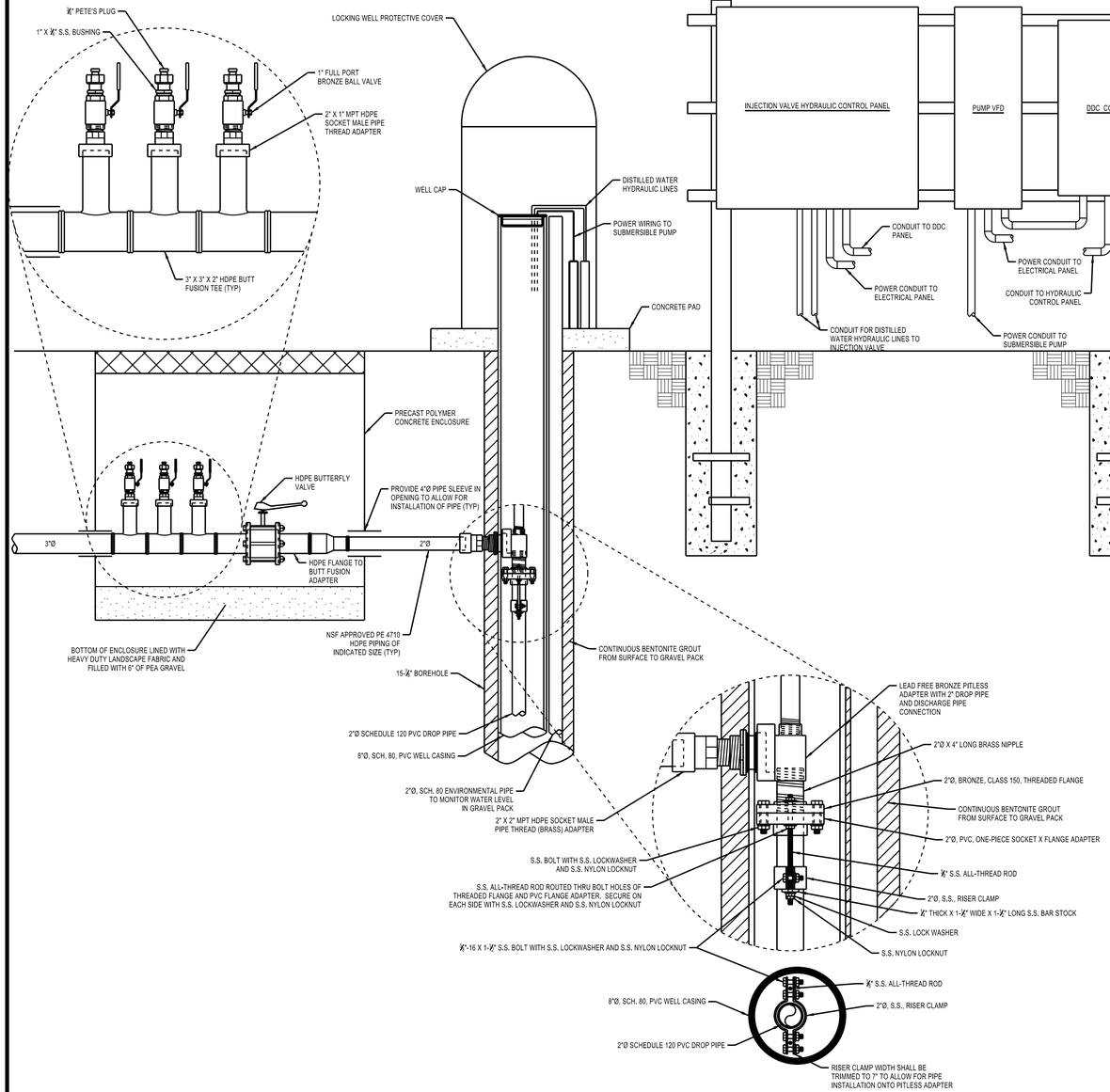
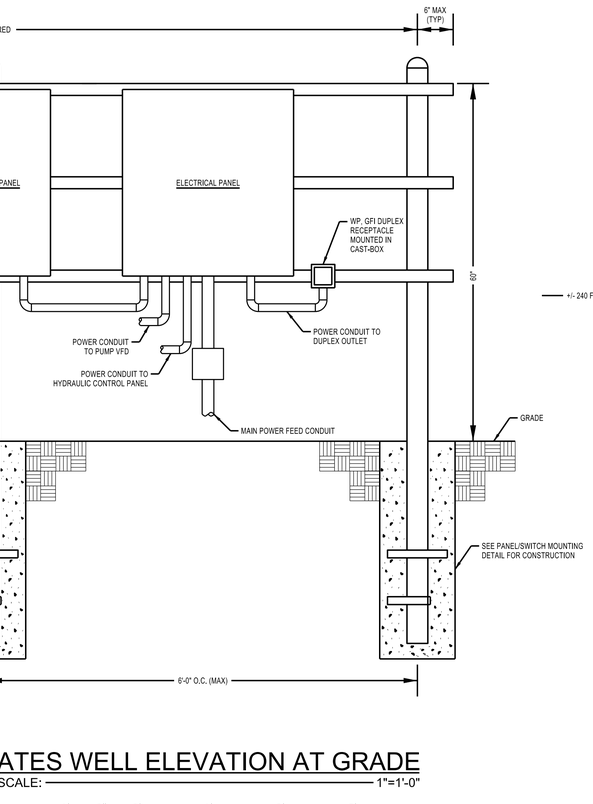
# NON-CONTACT COOLING WATER AQUIFER THERMAL ENERGY STORAGE (ATES) SYSTEM BUILDING 3215

Fort Benning — Georgia




## RISER CLAMP TOP VIEW

SCALE: 1"=1'-0"

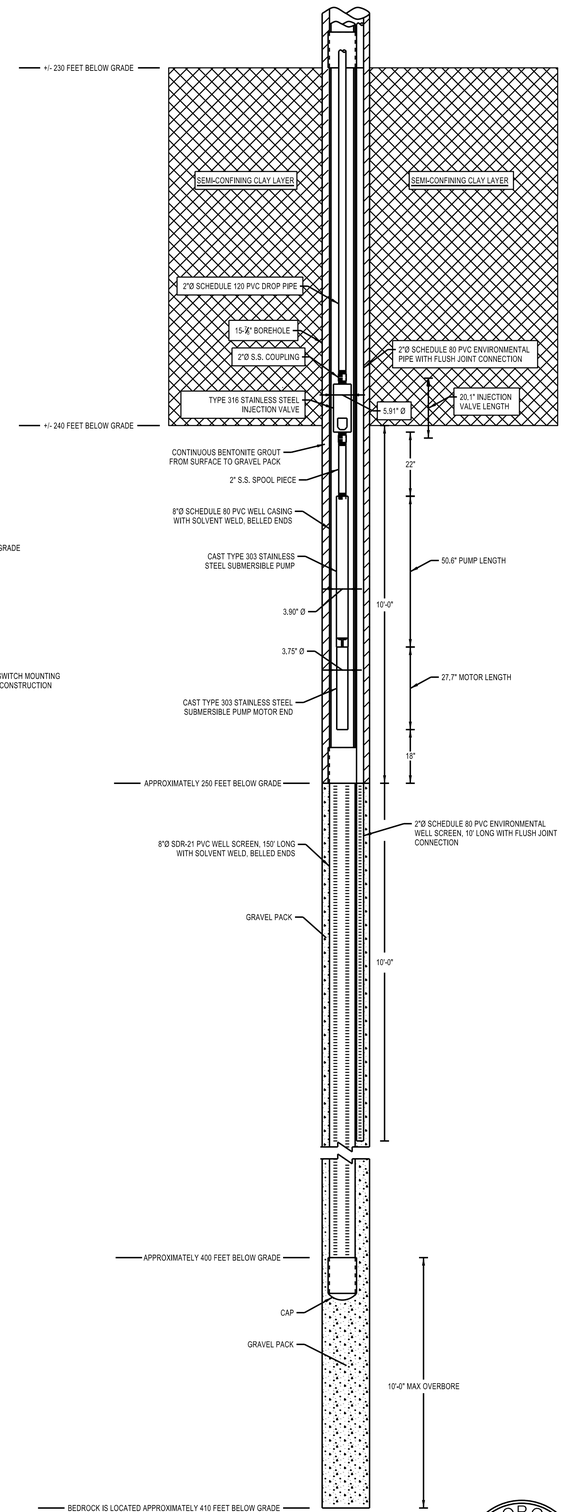



## ATES WELL ELEVATION AT GRADE

SCALE: 1"=1'-0"

1' 6" 0' 1' 2' 3'

SCALE: 1" = 1'-0"




## ATES WELL ELEVATION/DETAIL BELOW GRADE

SCALE: 1"=1'-0"

2' 1' 0' 2' 4' 6'

SCALE: ½" = 1'-0"

REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| 1 | 04-25-16 | ISSUED FOR GA. EPD UIC REVIEW |
| 2 | 09-30-16 | REVISED/RESSUED TO GA EPD FOR UIC REVIEW |
| 3 | 10-13-16 | "REVIEW DRAFT ONLY" LABEL REMOVED |

DATE: March 21, 2016
PROJECT NUMBER: 2011184
DRAWN BY: SES
CHECKED BY: CWH
TITLE: ATES WELL DETAILS

SHEET NUMBER:

UIC406

GEORGIA REGISTERED PROFESSIONAL ENGINEER CHARLES W. HAMMOCK JR.

# Appendix C

# Drilling Logs/Sieve Analysis Associated with the Geological/Hydrogeological Sub-surface Report

Borehole #1

| | Depth | Description | Remarks |
|---|---|---|---|
| | 10 | Gray, brown, and red fine sandy CLAY | |
| | 20 | Light brown medium to fine sandy CLAY | |
| | 30 | Light brown medium to fine sandy CLAY | |
| | 40 | Light brown medium to fine sandy CLAY | |
| | 50 | Gray medium to fine sandy CLAY | |
| | 60 | Light brown silty medium to fine SAND | |
| | 70 | Gray and brown silty coarse to fine SAND, trace of clay and gravel | |
| | 80 | Gray and brown silty coarse to fine SAND, trace of clay and gravel | |
| | 90 | Gray and brown silty coarse to fine SAND, trace of clay and gravel | |
| * | 100 | Gray silty medium to fine SAND | |
| | 110 | Tan brown silty medium to fine SAND | |
| | 120 | Tan brown silty medium to fine SAND | |
| | 130 | Reddish brown silty coarse to fine SAND | |
| | 140 | Reddish brown silty coarse to fine SAND | |
| * | 150 | Pink silty coarse to fine SAND, trace of gravel | |
| | 160 | Reddish brown silty coarse to fine SAND, trace of gravel | increasing coarse sand |
| | 170 | Reddish brown silty coarse to fine SAND, trace of gravel | |
| | 180 | Reddish brown silty coarse to fine SAND, trace of gravel | |
| * | 190 | Brown silty coarse to fine SAND, trace of gravel | |
| | 200 | Brown silty coarse to fine SAND, trace of gravel | |
| | 210 | Brown silty coarse to fine SAND, trace of gravel | |
| * | 220 | Tan silty medium to fine SAND | |
| | 230 | Tan brown silty medium to fine SAND | |
| | 240 | Tan brown silty medium to fine SAND | |
| | 250 | Tan brown silty medium to fine SAND | |
| | 260 | Tan brown silty medium to fine SAND | |
| | 270 | Tan brown silty medium to fine SAND | |
| | 280 | Tan brown silty medium to fine SAND | |
| | 290 | Tan brown silty medium to fine SAND | |
| | 300 | Brown silty medium to fine SAND | |
| | 310 | Brown silty medium to fine SAND | clay blebs |
| | 320 | Brown silty medium to fine SAND | clay blebs |
| * | 330 | Brown silty medium to fine SAND | |
| | 340 | Reddish brown silty medium to fine SAND | |
| | 350 | Tan brown silty coarse to fine SAND | |
| | 360 | Tan brown silty coarse to fine SAND | |
| | 370 | Tan brown silty coarse to fine SAND | |
| | 380 | Tan brown silty coarse to fine SAND | |
| | 390 | Tan brown silty coarse to fine SAND | |
| | 398 | Tan brown silty coarse to fine SAND | |

* Denotes sieve analysis performed

Jon A. Spaller, P.G.
Geotechnical & Environmental Consultants, Inc.

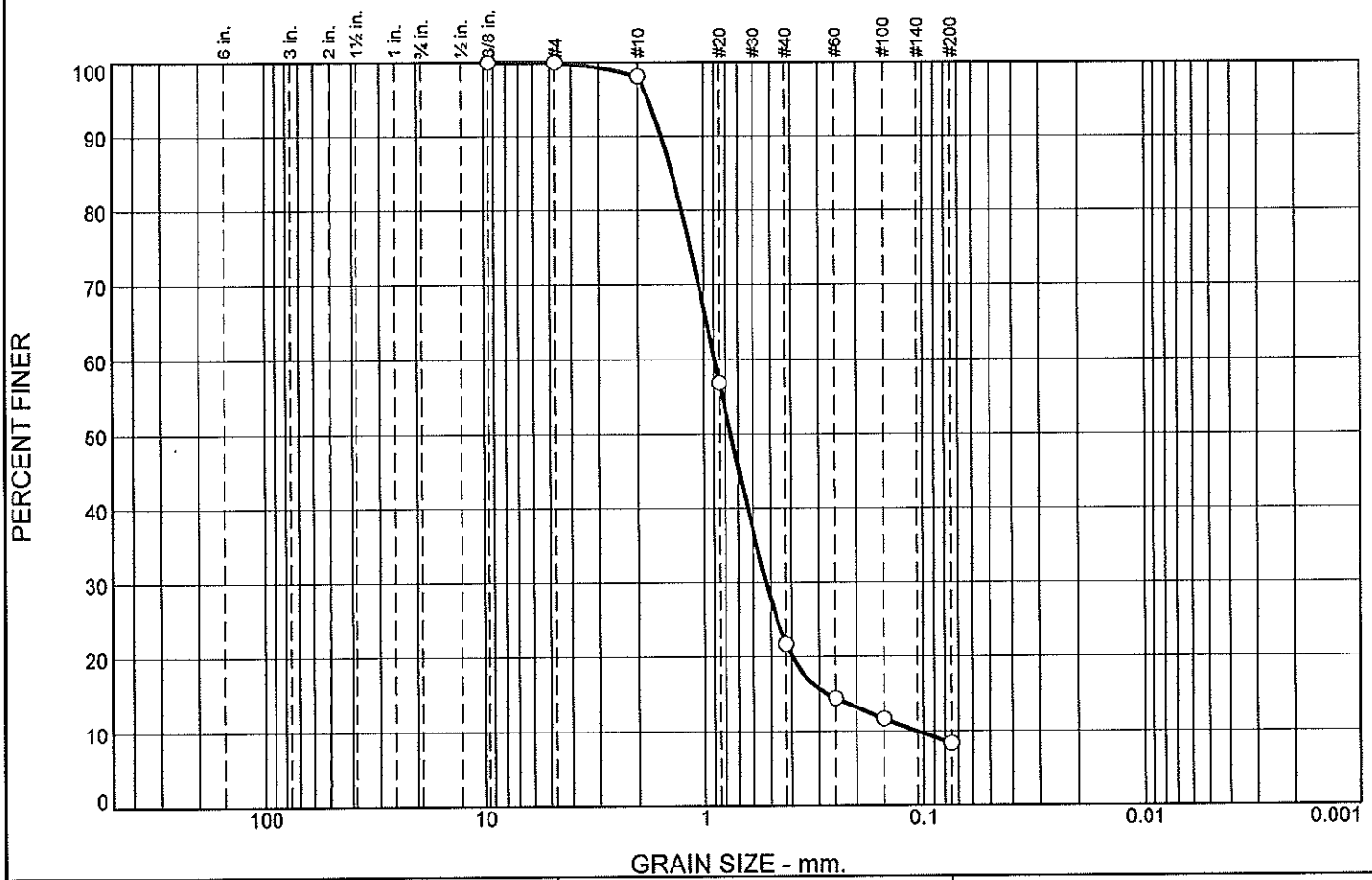
Borehole #2

| | Depth | Description | Remarks |
|---|---|---|---|
| | 40 | Brown silty medium to fine SAND, trace of clay | |
| | 50 | Light brown silty medium to fine SAND, trace of gravel | |
| | 60 | Light brown silty medium to fine SAND, trace of gravel | |
| | 70 | Light brown silty medium to fine SAND, trace of gravel | |
| | 80 | Light brown silty medium to fine SAND, trace of gravel | |
| * | 90 | Yellow tan silty coarse to fine SAND, trace of gravel | |
| | 100 | Yellow tan silty coarse to fine SAND, trace of gravel | |
| | 110 | Yellow tan silty coarse to fine SAND, trace of gravel | |
| | 120 | Yellow tan silty coarse to fine SAND, trace of gravel | |
| | 130 | Light brown silty medium to fine SAND, trace of gravel | |
| | 140 | Light brown silty medium to fine SAND, trace of gravel | clay blebs |
| | 150 | Light brown silty medium to fine SAND, trace of gravel | |
| | 160 | Gray medium to fine sandy CLAY | |
| | 170 | Light brown silty medium to fine SAND, trace of gravel | |
| * | 180 | Gray brown silty medium to fine SAND, trace of gravel and clay | |
| | 190 | Gray brown silty medium to fine SAND, trace of gravel and clay | |
| | 200 | Gray brown silty medium to fine SAND, trace of gravel and clay | |
| * | 210 | Gray brown silty medium to fine SAND, trace of clay and gravel | |
| | 220 | Brown silty coarse to fine SAND | |
| | 230 | Light brown medium to fine SAND with some coarse sand | |
| | 240 | Light brown medium to fine SAND with some coarse sand | clay blebs |
| * | 250 | Brown silty coarse to fine SAND | |
| | 260 | Brown silty medium to fine SAND, trace of clay | |
| | 270 | Brown silty medium to fine SAND, trace of clay and gravel | slightly clayey |
| | 280 | Brown silty medium to fine SAND, trace of clay and gravel | |
| * | 290 | Brown silty coarse to fine SAND | |
| | 300 | Brown silty coarse to fine SAND | clay blebs |

* Denotes sieve analysis performed

Jon A. Spaller, P.G.
Geotechnical & Environmental Consultants, Inc.

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 1.9 | 76.3 | 13.4 | 8.4 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 98.1 | | |
| #20 | 56.9 | | |
| #40 | 21.8 | | |
| #60 | 14.5 | | |
| #100 | 11.7 | | |
| #200 | 8.4 | | |

* (no specification provided)

**Material Description**

Gray silty m-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.5658 $D_{85}$= 1.4001 $D_{60}$= 0.8941
$D_{50}$= 0.7582 $D_{30}$= 0.5261 $D_{15}$= 0.2739
$D_{10}$= 0.1065 $C_u$= 8.40 $C_c$= 2.91

**Classification**

USCS= SP AASHTO=

**Remarks**

**Sample Number:** B-1 **Depth:** 100'

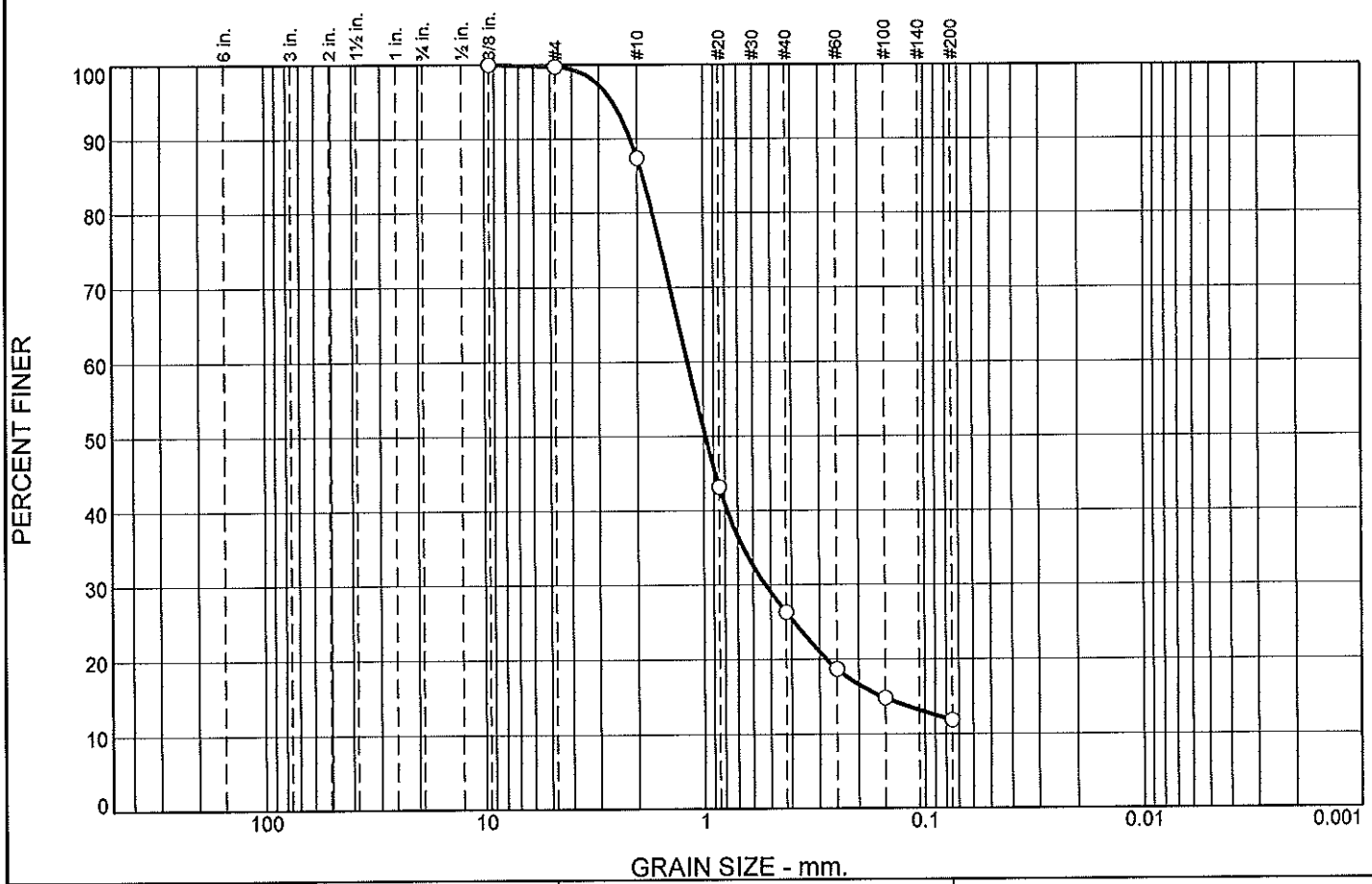
**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.3 | 12.3 | 61.1 | 14.4 | 11.9 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 99.7 | | |
| #10 | 87.4 | | |
| #20 | 43.2 | | |
| #40 | 26.3 | | |
| #60 | 18.7 | | |
| #100 | 14.9 | | |
| #200 | 11.9 | | |

* (no specification provided)

**Material Description**

Pink silty c-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 2.1495 $D_{85}$= 1.8859 $D_{60}$= 1.1815
$D_{50}$= 0.9830 $D_{30}$= 0.5300 $D_{15}$= 0.1536
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

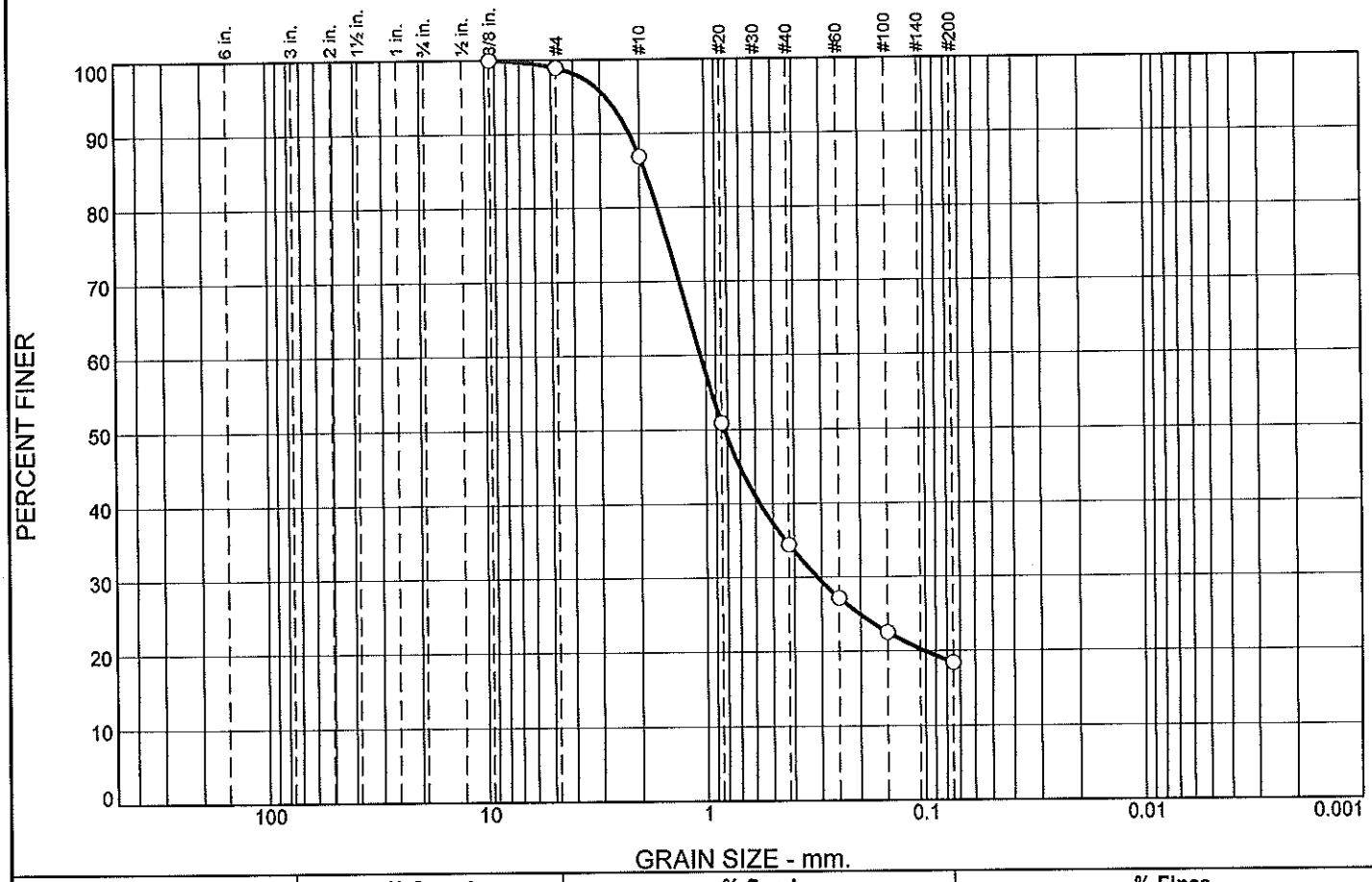
**Sample Number:** B-1 **Depth:** 150'

**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning
**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 1.1 | 12.0 | 52.4 | 16.0 | 18.5 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 98.9 | | |
| #10 | 86.9 | | |
| #20 | 50.9 | | |
| #40 | 34.5 | | |
| #60 | 27.2 | | |
| #100 | 22.6 | | |
| #200 | 18.5 | | |

* (no specification provided)

**Material Description**

Brown silty c-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 2.2234 $D_{85}$= 1.8897 $D_{60}$= 1.0614
$D_{50}$= 0.8279 $D_{30}$= 0.3135 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

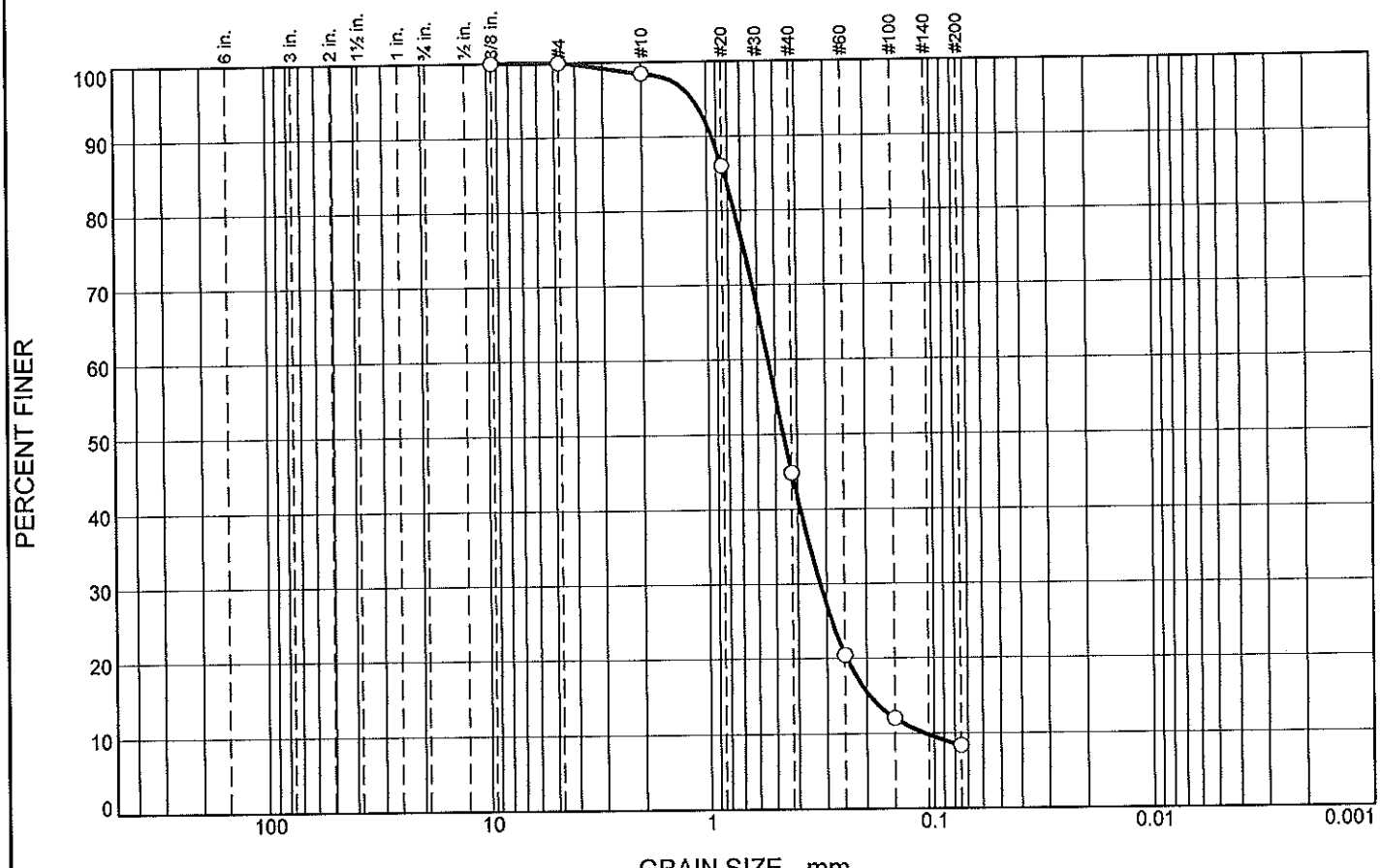
**Sample Number:** B-1 **Depth:** 190'

**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning
**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 1.5 | 53.6 | 36.5 | 8.4 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 98.5 | | |
| #20 | 86.0 | | |
| #40 | 44.9 | | |
| #60 | 20.5 | | |
| #100 | 12.1 | | |
| #200 | 8.4 | | |

* (no specification provided)

**Material Description**

Tan silty m-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 0.9460 $D_{85}$= 0.8298 $D_{60}$= 0.5389
$D_{50}$= 0.4617 $D_{30}$= 0.3213 $D_{15}$= 0.1945
$D_{10}$= 0.1092 $C_u$= 4.94 $C_c$= 1.75

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

**Sample Number:** B-1 **Depth:** 220'

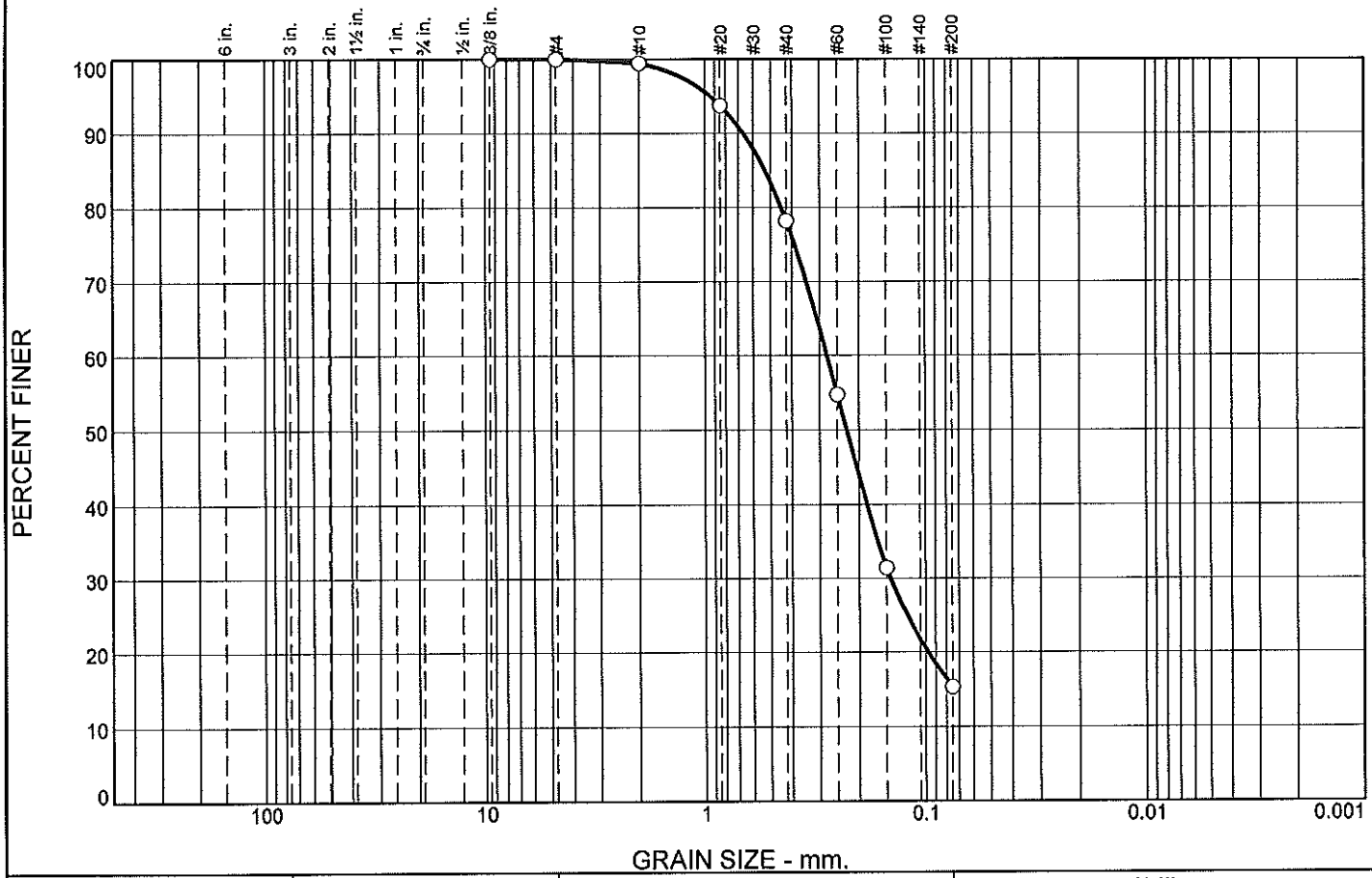
**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 0.5 | 21.3 | 62.8 | 15.4 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 99.5 | | |
| #20 | 93.8 | | |
| #40 | 78.2 | | |
| #60 | 54.8 | | |
| #100 | 31.5 | | |
| #200 | 15.4 | | |

* (no specification provided)

**Material Description**

Brown silty m-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 0.6661 $D_{85}$= 0.5310 $D_{60}$= 0.2782
$D_{50}$= 0.2271 $D_{30}$= 0.1439 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

**Sample Number:** B-1 **Depth:** 330'

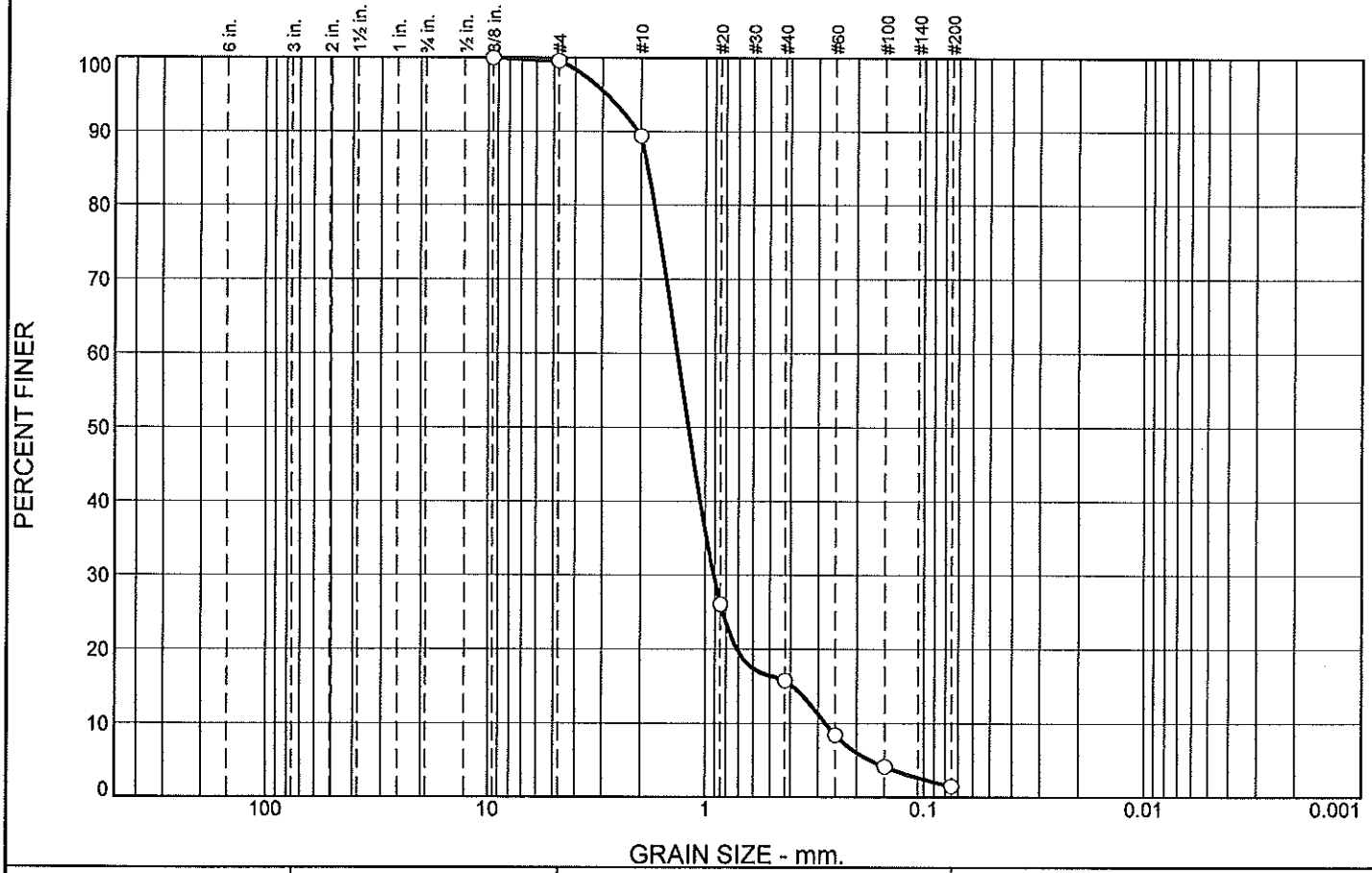
**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.4 | 10.2 | 73.6 | 14.3 | 1.5 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 99.6 | | |
| #10 | 89.4 | | |
| #20 | 26.1 | | |
| #40 | 15.8 | | |
| #60 | 8.5 | | |
| #100 | 4.2 | | |
| #200 | 1.5 | | |

* (no specification provided)

**Material Description**

Yellow tan c-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 2.0674 $D_{85}$= 1.8560 $D_{60}$= 1.3478
$D_{50}$= 1.1983 $D_{30}$= 0.9139 $D_{15}$= 0.3897
$D_{10}$= 0.2777 $C_u$= 4.85 $C_c$= 2.23

**Classification**

USCS= SP AASHTO=

**Remarks**

**Sample Number:** B-2 **Depth:** 90'

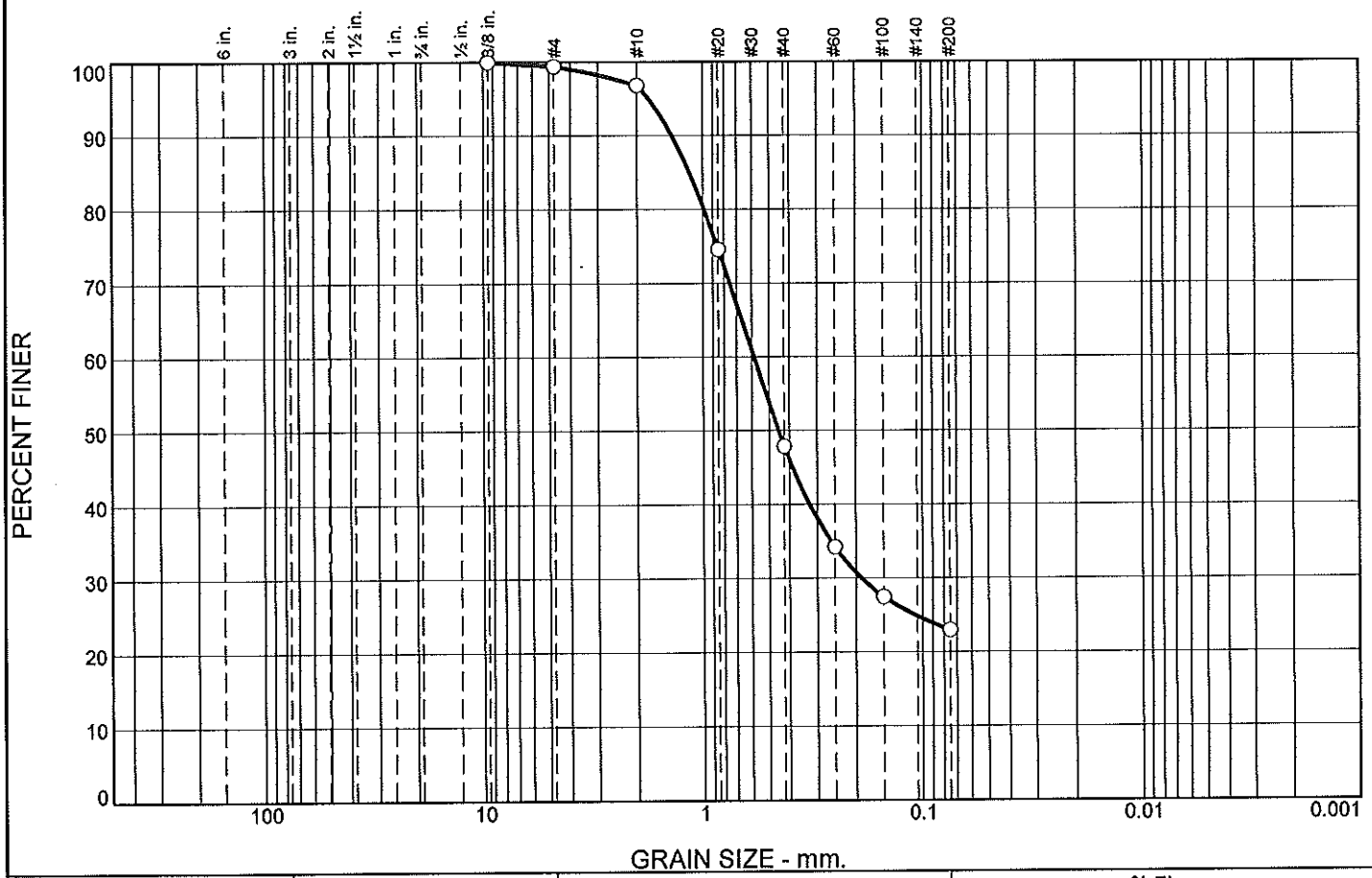
**Date:** 11-1-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.6 | 2.6 | 48.9 | 24.9 | 23.0 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 99.4 | | |
| #10 | 96.8 | | |
| #20 | 74.6 | | |
| #40 | 47.9 | | |
| #60 | 34.3 | | |
| #100 | 27.5 | | |
| #200 | 23.0 | | |

* (no specification provided)

**Material Description**

Gray brown silty m-f SAND trace of clay and gravel

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.3904 $D_{85}$= 1.1576 $D_{60}$= 0.5875
$D_{50}$= 0.4519 $D_{30}$= 0.1893 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SM-SC AASHTO=

**Remarks**

**Sample Number:** B-2 **Depth:** 180'

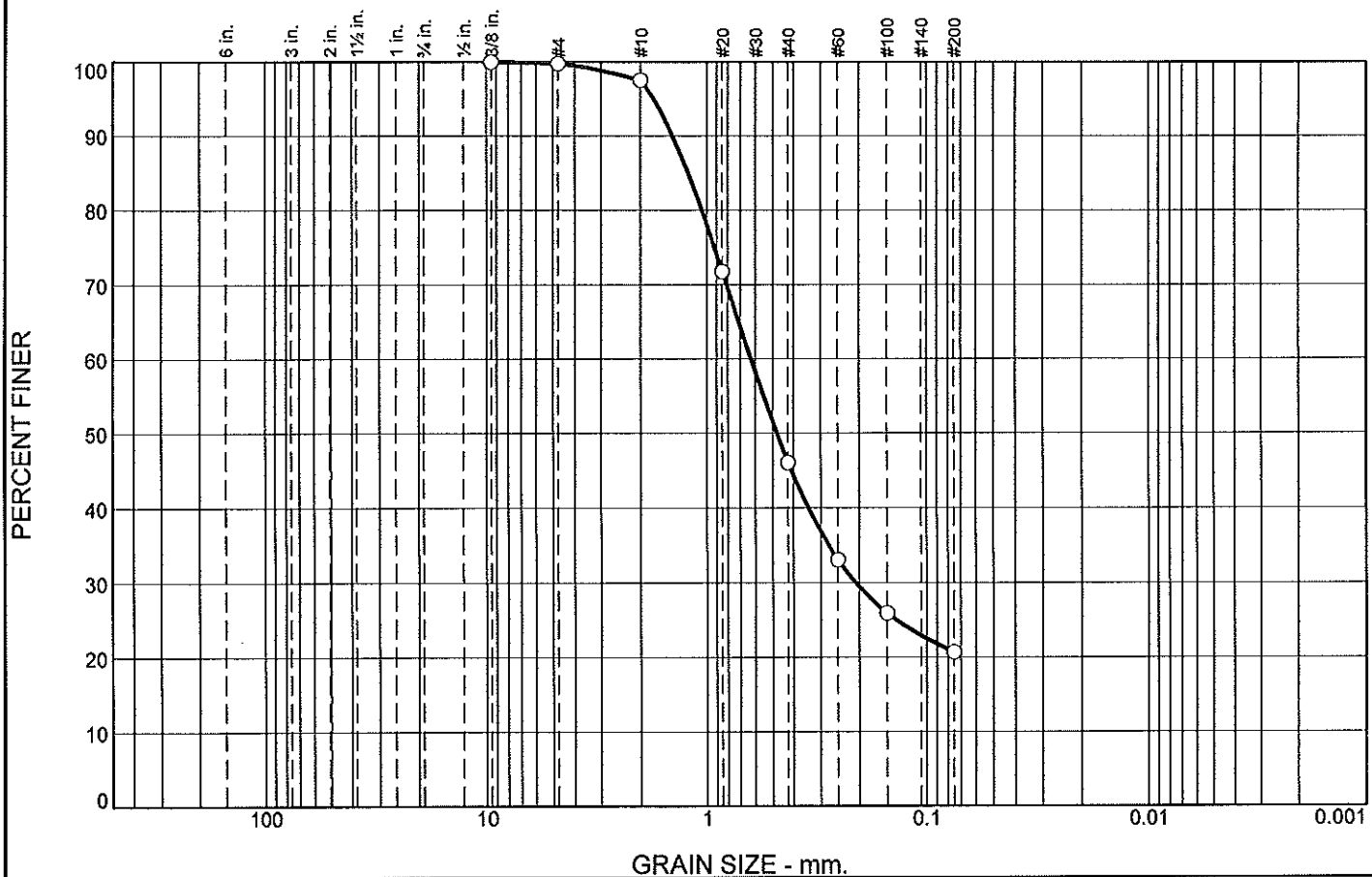
**Date:** 11-1-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.2 | 2.3 | 51.4 | 25.4 | 20.7 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 99.8 | | |
| #10 | 97.5 | | |
| #20 | 71.8 | | |
| #40 | 46.1 | | |
| #60 | 33.1 | | |
| #100 | 26.0 | | |
| #200 | 20.7 | | |

* (no specification provided)

**Material Description**

Gray brown silty m-f SAND trace of clay and gravel

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.4314 $D_{85}$= 1.2191 $D_{60}$= 0.6289
$D_{50}$= 0.4792 $D_{30}$= 0.2074 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SM-SC AASHTO=

**Remarks**

**Sample Number:** B-2 **Depth:** 210'

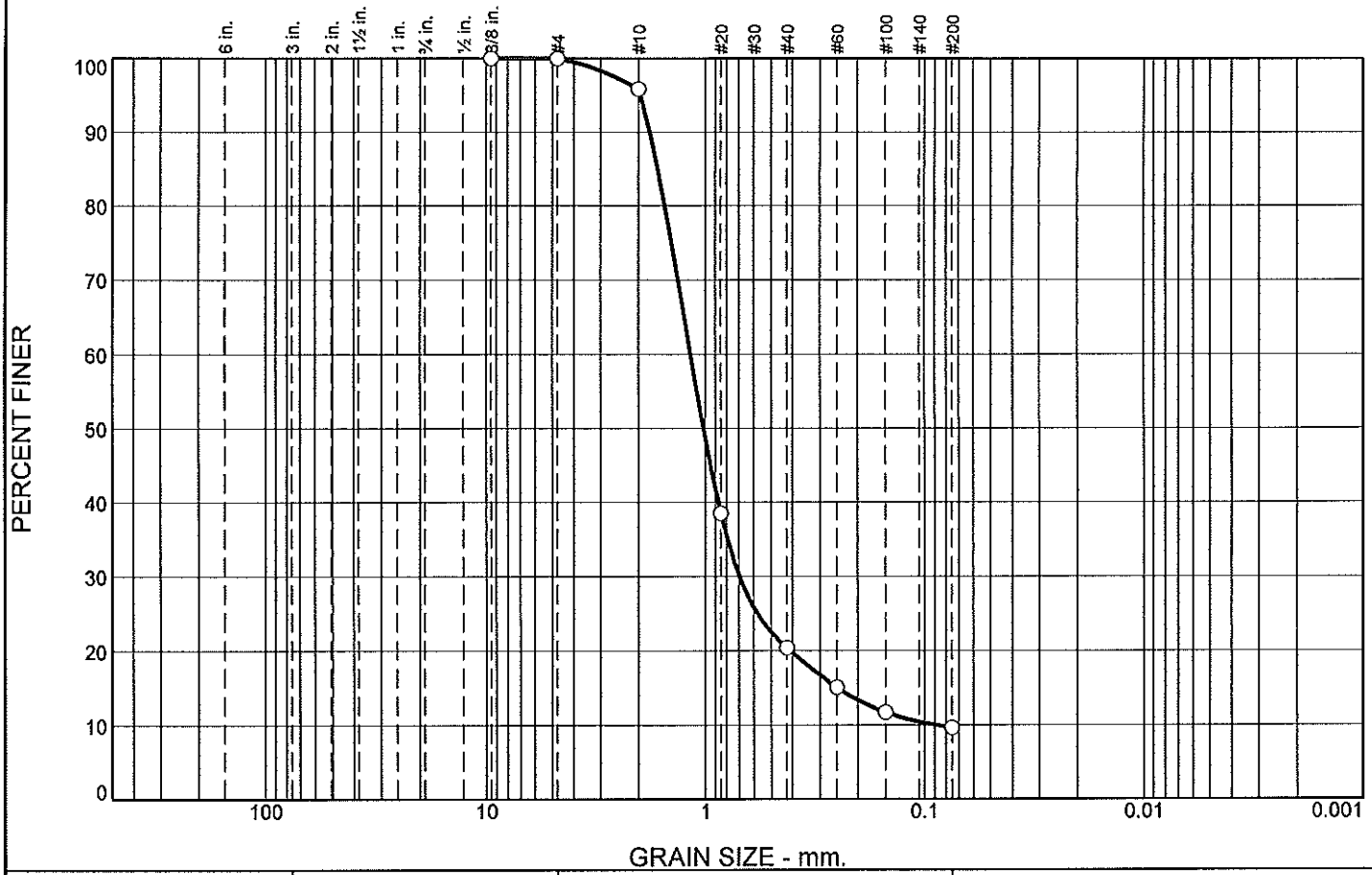
**Date:** 11-1-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 4.1 | 75.5 | 10.7 | 9.7 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 95.9 | | |
| #20 | 38.5 | | |
| #40 | 20.4 | | |
| #60 | 15.1 | | |
| #100 | 11.7 | | |
| #200 | 9.7 | | |

* (no specification provided)

**Material Description**

Brown silty c-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.7791 $D_{85}$= 1.6401 $D_{60}$= 1.1681
$D_{50}$= 1.0200 $D_{30}$= 0.6989 $D_{15}$= 0.2471
$D_{10}$= 0.0875 $C_u$= 13.36 $C_c$= 4.78

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

**Sample Number:** B-2 **Depth:** 250'

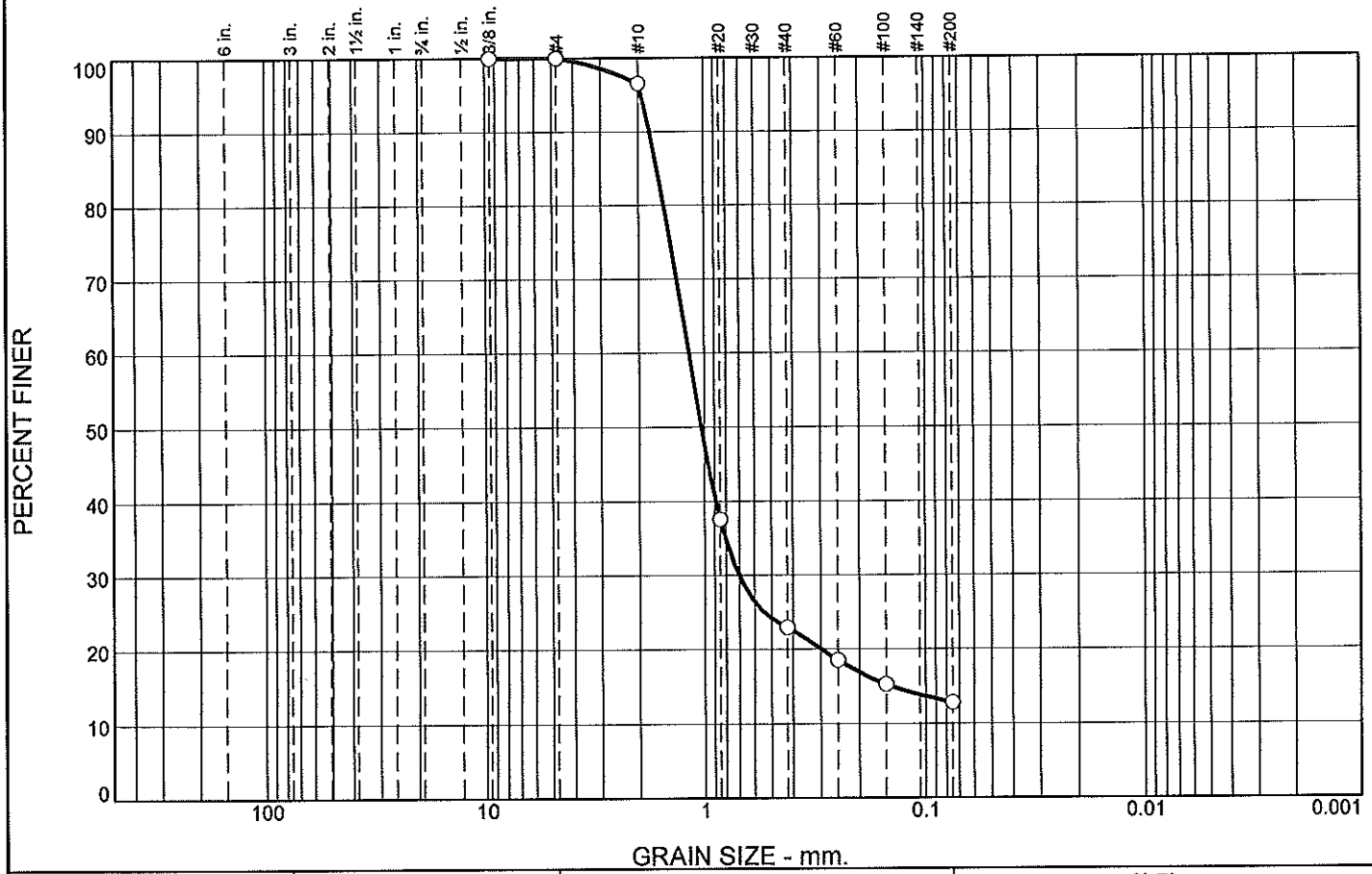
**Date:** 11-1-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 3.4 | 73.6 | 10.1 | 12.9 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 96.6 | | |
| #20 | 37.6 | | |
| #40 | 23.0 | | |
| #60 | 18.6 | | |
| #100 | 15.3 | | |
| #200 | 12.9 | | |

* (no specification provided)

**Material Description**

Brown silty c-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.7664 $D_{85}$= 1.6352 $D_{60}$= 1.1801
$D_{50}$= 1.0346 $D_{30}$= 0.7037 $D_{15}$= 0.1404
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SP-SM AASHTO=

**Remarks**

**Sample Number:** B-2 **Depth:** 290'

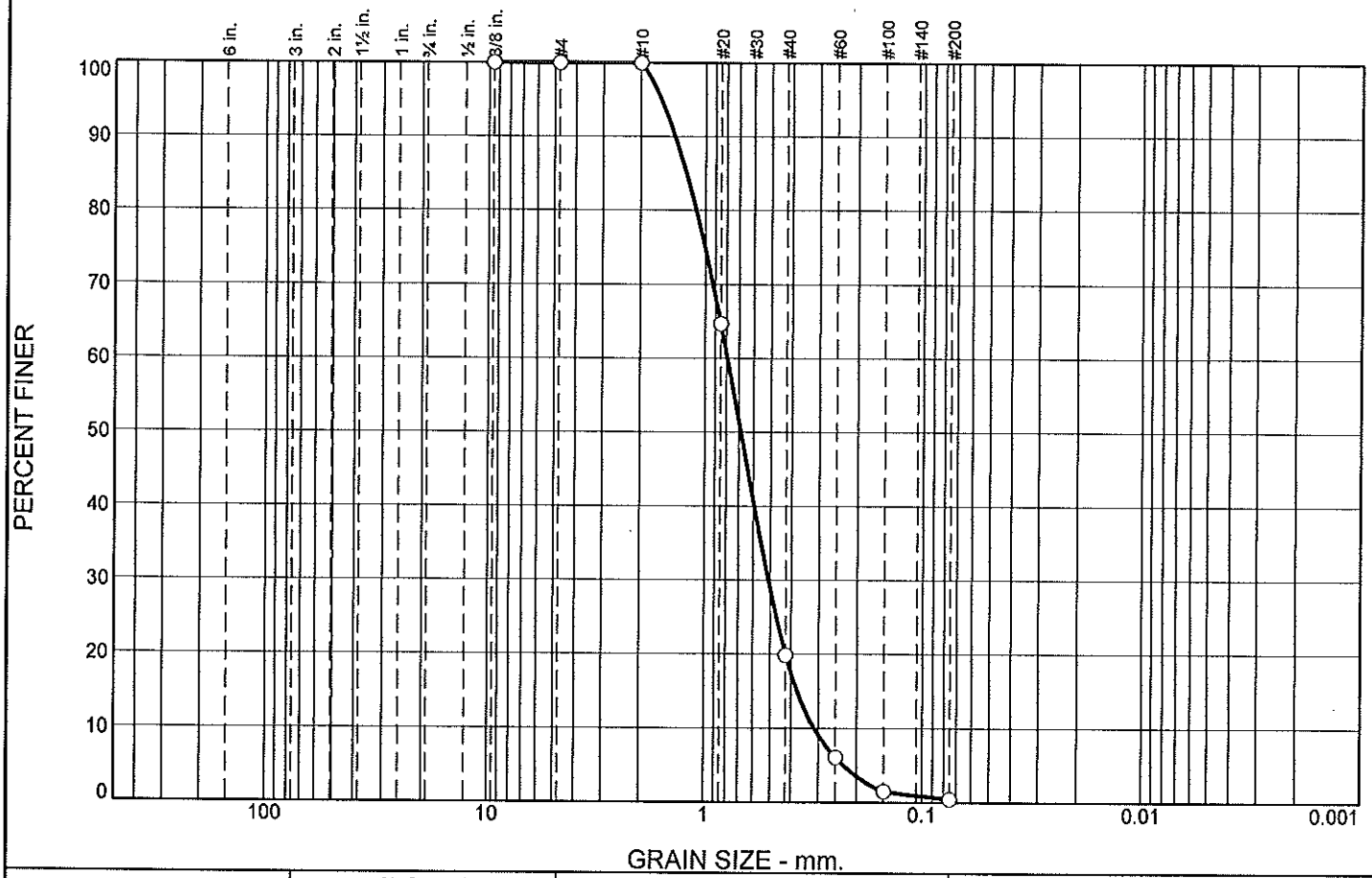
**Date:** 11-1-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hamnock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 0.0 | 80.1 | 19.4 | 0.5 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .375 | 100.0 | | |
| #4 | 100.0 | | |
| #10 | 100.0 | | |
| #20 | 64.7 | | |
| #40 | 19.9 | | |
| #60 | 6.1 | | |
| #100 | 1.5 | | |
| #200 | 0.5 | | |

* (no specification provided)

**Material Description**

Tan m-f SAND

**Atterberg Limits**

PL= LL= PI=

**Coefficients**

$D_{90}$= 1.3844 $D_{85}$= 1.2280 $D_{60}$= 0.7922
$D_{50}$= 0.6865 $D_{30}$= 0.5115 $D_{15}$= 0.3767
$D_{10}$= 0.3151 $C_u$= 2.51 $C_c$= 1.05

**Classification**

USCS= SP AASHTO=

**Remarks**

**Sample Number:** DSI GP 1A

**Date:** 10-31-12

**Geotechnical and Environmental Consultants**

**Client:** Andrews Hammock and Powell
**Project:** 2011184-ESTCP-Fort Benning

**Project No:** 120704.230 **Figure**

End of UIC Permit Application
Revision 2.0

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

**Richard E. Dunn, Director**

**EPD Director's Office**
2 Martin Luther King, Jr. Drive
Suite 1456, East Tower
Atlanta, Georgia 30334
404-656-4713

JAN 3 1 2017

Mr. Andrew C. Hilmes
Colonel, U.S. Army
Garrison Commander
1 Karker Street
Building 4, Suite 5900
Fort Benning, GA 31905

RE: Permit Issuance
Fort Benning, Building 3215
Permit No. GAW000691
Fort Benning, Muscogee County

Dear Mr. Hilmes:

Pursuant to the Georgia Rules for Underground Injection Control, Chapter 391-3-6-.13 (Amended), and the Georgia Rules for Safe Drinking Water (Amended), and the Rules and Regulations promulgated thereunder, we have issued the attached permit for the above-referenced facility.

Your facility has been assigned to the following EPD office for reporting and compliance. Signed copies of all required reports shall be submitted to the following address:

Environmental Protection Division
Watershed Protection Branch
Underground Injection Program
2 Martin Luther King Jr. Drive, Suite 1152
Atlanta, Georgia 30334

Please be advised that on and after the effective date indicated in the permit, the permittee must comply with all terms, conditions, and limitations of the permit. If you have questions concerning this correspondence, please contact Mr. Bijan Rahbar at 404.656.3229 or bijan.rahbar@dnr.ga.gov.

Sincerely,

Richard E. Dunn
Director

cc: UIC Permit GAW000691 file
Chuck Hammock, Andrews, Hammock & Powell, Inc.

Permit No. GAW000691
Issuance Date: JAN 31 2017

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

## Underground Injection Control Well Operating Permit

**Injection Well Type:** Class V (type 5X26)

**Facility Address:** Building 3215
11th Airborne Division Road
Fort Benning, GA 31905
Muscogee County

**Operator Address:** Fort Benning
U.S. Army Garrison
1 Karker Street
Building 4, Suite 5900
Ft. Benning, GA 31905

**Facility Location:** 32° 24' 35.19" N / 84° 54' 08.51" W

In accordance with the provisions of the Georgia Rules for Underground Injection Control, Chapter 391-3-6-.13, as amended 2001, this permit is issued for the operation of the herein described injection system.

This permit is issued in reliance upon the permit application signed on November 9, 2016, any other applications upon which this permit is based, supporting data entered therein or attached thereto, and any subsequent submittal of supporting data.

The injection operation plan is hereby approved, and is based on the statements and supporting data entered herein or attached thereto, all of which are filed with the Environmental Protection Division of the Georgia Department of Natural Resources and hereby made a part of this permit.

The permit is subject to revocation for noncompliance with aforementioned conditions.

The permit shall become effective on January 31, 2017.

The permit and the authorization to discharge shall expire at midnight on January 30, 2022.

STATE OF GEORGIA
CONSTITUTION
WISDOM JUSTICE MODERATION
1776

Richard E. Dunn, Director
Environmental Protection Division

# INJECTION WELL OPERATING PERMIT

## 1. Permit Condition

The Permittee's continued compliance with the Georgia Rules for Underground Injection Control, Chapter 391-3-6-.13 (Amended) and the Georgia Rules for Safe Drinking Water (Amended).

## 2. Injection Plan System Parameters

This permit is issued to the Operator for the purpose of operating a 5-year pilot project to inject non-contact cooling water into the Cretaceous aquifer.

a. Number of Class V injection wells: four (4). This permit only authorizes the use of two (2) injection wells at any one time.

b. Injected fluid: groundwater from Cretaceous aquifer used for non-contact cooling system..

c. Maximum injection rate per well: 46 gallons/min. (gpm)/well.
Maximum total system injection rate: 92 gpm.

d. Maximum injection volume per well: 66,240 gallons/day/w.
Maximum total system injection volume: 132,480 gallons/day.

e. Maximum daily average injection pressure (at well head): 5 psi.

## 3. Monitoring and Reporting Requirements

a. The Operator shall submit reports to the Underground Injection Control (UIC) Program of the Environmental Protection Division (EPD) the number and exact location (provide geographical coordinates) of all Class V injection wells it installs or plugs on a quarterly basis. The reports are to be submitted to the UIC Program.

b. The Operator shall collect water samples on a quarterly basis of the injection water for laboratory analysis of volatile organic compounds by EPA Method 524.2, semi-volatile organic compounds by EPA Method 526, and Metals by EPA Method 200.8. Additionally, the operator shall also measure and record dissolved oxygen, conductivity, temperature, and pH on a quarterly basis. When maintenance is performed on any portion of the system, a water sample must also be collected within 120 minutes of the startup of the injection system and analyzed for the above referenced parameters.

c. The Operator shall submit to the UIC Program quarterly reports that will contain the following information.

1. Status of the injection system operation;

2. Results of any ground-water sampling and analyses;

3. Results of any soil sampling and analyses;

4. Comparisons of analyses to determine any changes in concentrations.

d. The Operator shall perform Mechanical Integrity Tests of the injection system pursuant to Chapter 391-3-6.13(13) of the Rules and Regulations for Water Quality Control. The first Mechanical Integrity Test must be conducted within the first 12 months of the injection system operation. The second Mechanical Integrity Test must be conducted one year prior to the expiration date of this permit. The Operator shall submit a test procedure at least three months prior to conducting the Mechanical Integrity Test to the Underground Injection Program for review.

**4. Transfer of Ownership or Control**

This permit is not transferable until any new operator shall agree in writing to all permit conditions. Any new operator also shall provide the EPD with appropriate documentation that they have adequate financial assurances to plug all existing Class V wells.

**5. Notification of Noncompliance**

The Operator shall report any instances of noncompliance with permit conditions to the EPD in writing within five (5) working days of such noncompliance, and shall take all reasonable steps to minimize the impact on the environment resulting from noncompliance with this permit and the Georgia Rules for Underground Injection Control.

**6. Notification of Changes**

The Operator shall notify the EPD of any proposed changes to the performance of the injection system in writing at least thirty (30) days prior to the changes.

**7. Signatory Requirements**

All reports submitted to the EPD shall be signed and stamped by a Georgia Registered Professional Engineer or Professional Geologist.

**8. Monitoring Procedures**

All analyses shall be performed by a laboratory approved or accredited by EPD in accordance with the Georgia Rules for Commercial Laboratory Accreditation, Chapter 391-3-26. Analytical methods, sample containers, sample preservation techniques, and sample holding times must be consistent with the techniques and methods listed in 40 CFR Part 136. The analytical method use shall be sufficiently sensitive.

**9. Emergency Situations**

a. The Operator is to immediately notify the EPD of any emergency situation that affects the injection system and describe the remedial activity that the Operator is utilizing to correct the situation.

b. The Operator is to immediately notify the EPD when the emergency situation ceases to exist.

**10. Right of Entry**

The Operator shall grant the EPD permission to enter the facility property to conduct inspections of the injection system.

**11. Records**

The Operator shall maintain a copy of this permit at the facility site.

**12. Permit Renewal**

The Operator/Owner shall submit a permit application to EPD to renew the permit at least ninety (90) days prior to the expiration date of the permit.

**13. Permit Termination**

The Operator shall, upon termination of the approved injection fluids at this site, properly plug and abandon all Class V wells constructed on this site in accordance with EPD's *Manual for Groundwater Monitoring* (September 1991) and notify the EPD in writing within thirty (30) days of such termination and abandonment.

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# APPENDIX D IF TECH HYDROGEOLOGICAL EVALUATION FT BENNING

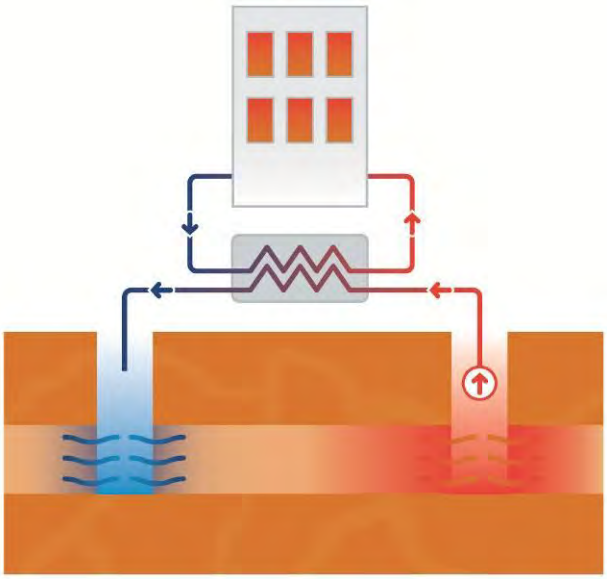
# Hydrogeological assessment
# Ft Benning, Columbus, GA, USA



IF Technology
Velperweg 37
6824 BE Arnhem
The Netherlands
PO Box 605
6800 AP Arnhem
The Netherlands
T +31 (0)26 35 35 555
F +31 (0)26 35 35 599
E info@iftechnology.com
I www.iftechnology.com

The hydrogeology at the site of Ft Benning, in Columbus, Georgia is reviewed.

The main conclusion is that an Aquifer Thermal Energy Storage (ATES) system can be applied for the heating and cooling of the Ft Benning building.



Engineering the earth

**INTERNATIONAL COOPERATION ON ATES AT THE FT BENNING SITE**





## Client

Andrews, Hammock & Powell, Inc.
Consulting Engineers
250 Charter Lane
MACON, GA 31210
USA
T +1 478 405 8301
F +1 478 405 8210
E CHammock@ahpengr.com
Contact: Chuck Hammock, PE, LEED AP, CGD

## Consultant ATES system

IF Technology B.V.
Velperweg 37
6824 BE ARNHEM
The Netherlands
T +31 26 35 35 555
F +31 26 35 35 599
E b.godschalk@iftechnology.nl
Contact : M.S. (Bas) Godschalk

## Project team IF Technology

M.S. (Bas) Godschalk, MSc
International Business Manager

M. (Mariene) Gutierrez Neri, Ph.D.
Senior consultant hydrogeology

T. (Tim) Aalten, B Eng
Civil engineer

M.M. (Marcel) Swets eur.ing., B Eng
Chief technical officer

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Appendices
I Example of an ATES well
II IF Technology

# 1 Introduction

We are pleased to present you this hydrogeological evaluation for the demonstration project DoD in the USA. The purpose of the project is to demonstrate the high-efficiency of ATES and BTES systems for space heating and cooling in buildings.

Andrews, Hammock & Powell, Inc. Consulting Engineers (AH&P) has IF Technology (IF) requested to support in the design and supervision during realization of the demonstration of the ATES system.

The scope of the project is to demonstrate the efficiency of an ATES-HP system at an existing building in relation to a traditional heating and cooling concept. The building selected is probably 17 Ft Benning. The expected flow rate of the ATES system on this site is 110 GPM (25 $m^3$/h).

In this report, the hydrogeology at the site of Ft Benning, in Columbus, Georgia is reviewed and the feasibility of the underlying aquifers for the development of an Aquifer Thermal Energy Storage (ATES) system is assessed.

The work has been done according to our proposal 26.080/60317/BG, d.d. February 14$^{th}$ 2012.

The assessment is focused on the information which is required and critical for the design of an ATES system.

**Main conclusion**
Aquifer Thermal Energy Storage seems to be applicable on the Ft Benning site. Further investigation should focus on the redox interface.

# 2 Starting points

## 2.1 Site location

The project location is situated at the Ft Benning (Army) site in Columbus, GA.

GPS coordinates:
32° 24.585'N
84° 54.141'W




Figure 2.1 Map United States of America (source: South Travels)



Figure 2.2 Map of Georgia (source: National Atlas of the United States)



Figure 2.3 Geogle Earth map of the site

## 2.2 Aquifer Thermal Energy Storage

The way ATES works for cooling or low temperature heating is that energy is stored in aquifers 70 to 800 ft below the surface. Water is pumped up from an aquifer, heat is extracted and relatively cold water is re-infiltrated in the same aquifer. A cold groundwater zone (41 to 50° F (5 to 10° C)) develops around the infiltration well, which can be used for cooling in the summer. This water then absorbs heat from the building and energy can be stored in a corresponding warm water zone (59 to 86° F(15 to 30° C)) and used to heat the building in winter. See Figure 2.4. For heating in general, a heat pump (not shown) will be used to boost the temperature for the in the building's loop.

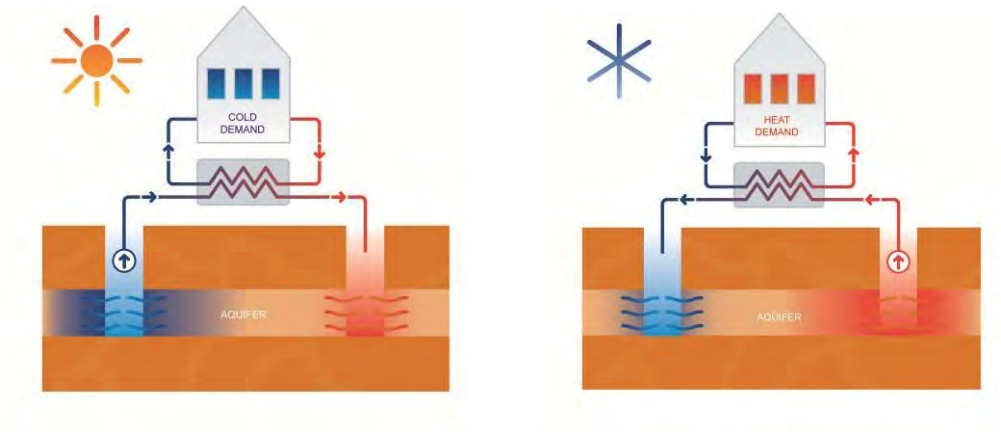


Figure 2.4. ATES in the cooling and heating mode

## 2.3 Characteristics of ATES

The following characteristic apply on ATES:

- Seasonal storage of energy, resulting in a “free” supply of heat and cold.
- Open loop system, but separated from the building circuit by a heat exchanger. This prevents pollution of the groundwater.
- Groundwater is extracted and infiltrated simultaneously: 100% is re-injected!
- Applicable depth: 70 to 800 ft (low temperature) and 350 to 3,500 ft (high temperature), depending on the hydrogeological local situation.
- High energy savings: up to 90% in cooling mode; 60% in heating mode.
- Average energy saving based on many realized systems: 50 – 70 %.
- Average $CO_2$-emission reduction: 50 - 90 %.
- ATES is the most economically profitable sustainable energy technology (far better than solar and wind).
- Payback time without subsidies or rebates for larger systems is < 10 years.
- ATES is a proven and reliable technology (more than 1,500 systems are in operation).
- Scale: Small (office buildings) and large scale (district projects) are all common.
- Connection to a local existing heating and cooling grid is possible.
- Construction can be done with local labor and equipment.
- No noise, no smoke, no smell.  The installation is invisible.

## 2.4 ATES system set up

An basic ATES system consists of one cold well and one warm well (doublet), when can be extended easily.
The cold water wells and warm water wells will be installed along with the plate heat exchangers. The plate heat exchangers are located in the main plant room.

The operation of the system can be described by means of the following two main operation modes:

*Cold supply /cooling / summer operation*
As soon as there is a demand for cold, groundwater is extracted from the cold well. The cold from the extracted water is transferred by the heat exchangers to the cooling system where it is used for cooling purposes. This heat transfer causes the temperature of the groundwater to raise. The warmer groundwater is then re-injected into the aquifer by the warm well.

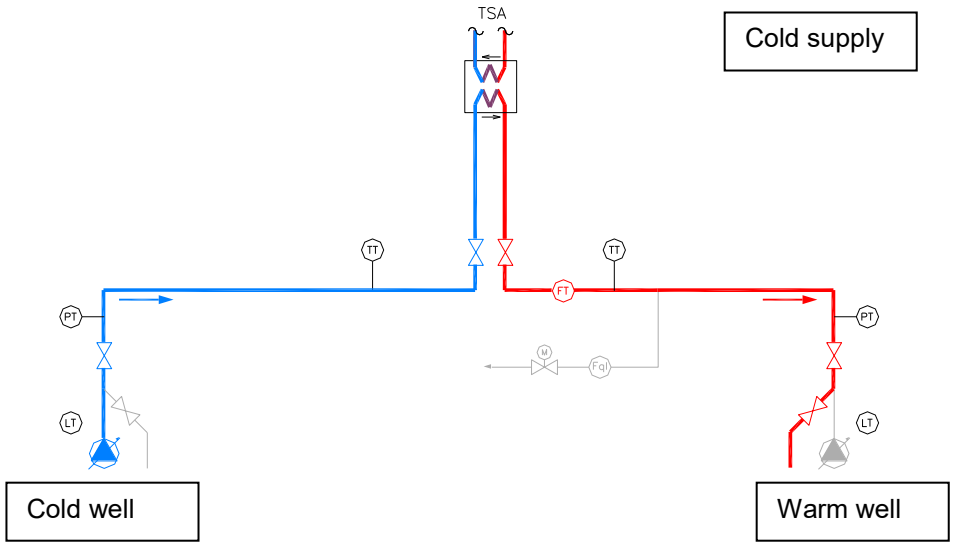


Figure 2.5. Cold supply / cooling / summer operation

*Cooling storage / winter operation*
In winter the ATES system transfer heat from the well to the building, for which groundwater is extracted from the warm well. The extracted water transfer its heat to the cooling system through the heat exchangers. This energy transfer causes the groundwater to cool down. The cooler groundwater is then re-injected into the aquifer by the cold wells.

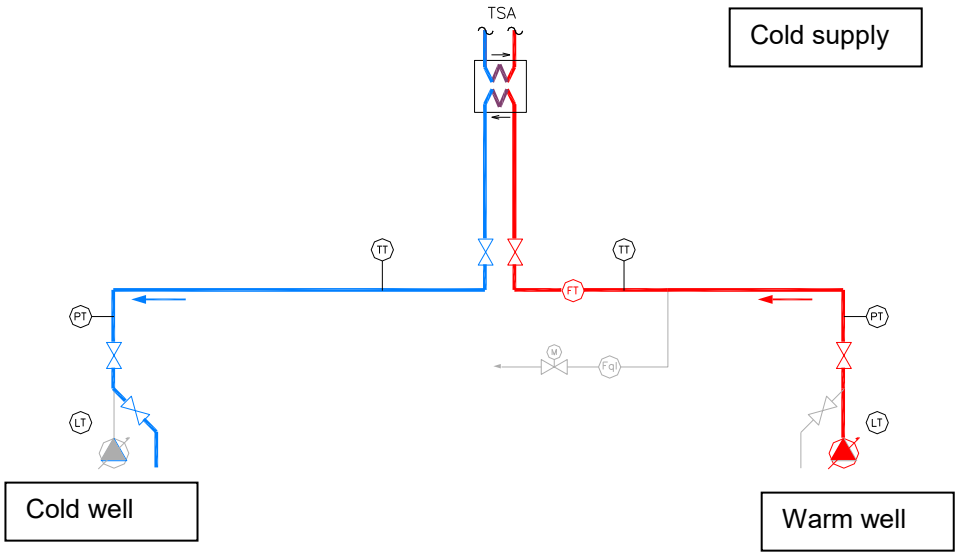


Figure 2.6. Cooling storage / winter operation

An example of a well is presented in Appendix I.

# 3 Site description

## 3.1 General

A geological fault (also referred to as the Fall Line), runs along Columbus and creates within the city two completely different aquifers systems. North of the fall line, the Crystal-line-rock aquifers (Piedmont  Provinces) occur, and south from the line the Cretaceous aquifer system occurs. This is depicted in Figure 3.1 and 3.2. The site is indicated by the green star. Based on the location of the site with respect to the fall line, no influence is expected to occur.




Figure 3.1. Site location and the estimated Fall Line occurrence.

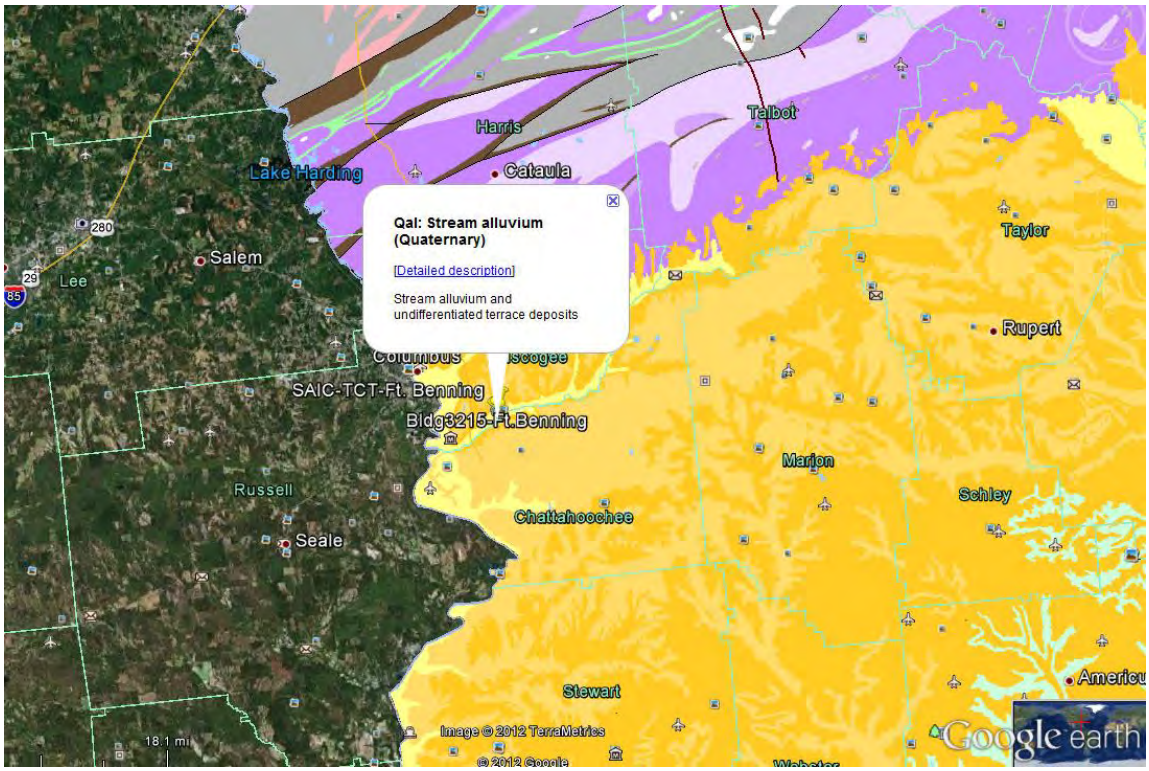

Figure 3.2 Geological overview (source USGS)

## 3.2 Built-up of the soil

The expected geological sequence beneath the site is outlined in Table 3.1. The description is based on the following sources:

a. Formation Thermal Conductivity Test and Data Analysis, 2011. Fort Benning, GA. Report prepared by Andrews, Hammock and Powell, Inc.
b. Groundwater Conditions and Studies in Georgia, 2008-2009. US Geological Survey Water Resources Investigations Report 99-4140
c. Online resources http://waterdata.usgs.gov/ga/nwis/

Table 3.1 Hydrogeological schematisation

| Depth (ft-bgl)* | lithology | Formation | Hydrogeology |
|---|---|---|---|
| 0 – 395 (120 m)** | Intercalation of layers of medium to coarse sands and gravels with of silty clays and silty sands | Cretaceous aquifer (Tuscaloosa) | Aquifer |

* feet below ground level
** This aquifer is expected to extend to depths of about 720 ft-bgl (220 m-bgl).

The Cretaceous aquifer is in general reported to be of medium to high permeability with well discharges up to 530 GPM (120 $m^3$/h) which makes it a suitable aquifer for ATES. However, the exact capacity of the aquifer at the site needs to be confirmed. The pres-

ence of layers of silts and clays (low permeable layers) in between the medium to coarse sandy layers (high permeability) could reduce the capacity of the aquifer for abstraction/injection. Therefore it is recommended to drill (at test drilling phase) to depths of minimum 655 ft-bgl (200 m-bgl) to determine where the sandy horizons occur.

# 4 Groundwater conditions

## 4.1 Groundwater level

The groundwater level at the site is expected to be of around 56 ft-bgl (17 m-bgl). Changes in water levels (drop) are reported to be in the order of 3 ft/y (1 m/y).

## 4.2. Groundwater velocity and flow direction

No other measurements of water levels in the cretaceous aquifer could be obtained at the time of reporting. Therefore the hydraulic gradient and flow direction (and resulting groundwater velocity) is not reported here. However, based on the geological setting of the Cretaceous aquifer a general groundwater flow direction of N-NW -> S-SE may be inferred.

## 4.3 Groundwater quality and temperature

The average measured groundwater temperature is 70°F (21°C). At the time of reporting, no site-specific water quality data was available. However, the water quality should be determined to identify potential clogging risk due to redox reactions. The aquifer at the site (see Table 3.1) is considered to be unconfined and the groundwater in the shallow parts is expected to be of oxic nature. If during abstraction/re-injection oxygen-rich groundwater is mixed with e.g., iron-containing groundwater, it can lead to the formation of iron precipitates and can cause clogging in the well.

It is strongly recommended to take water samples at discrete depths to determined the water compositions trends with depth.

# 5 Conclusions and recommendations

From previous reports the Cretaceous aquifer at the site is expected to deliver the expected well discharge (~ 110 GPM, 25 $m^3$/h). However, this can only be confirmed through pumping test. Given the layering nature of the aquifer (sandy horizons intercalated by silty clay layers) a drilling depth of minimum 655 ft-bgl (200 m-bgl) is recommended. Given the unconfined nature of the Cretaceous aquifer at the sire, groundwater chemistry variations with depth are expected. It is therefore of major importance to determined where the redox interface (transition from oxic to reduce water) lies at depth. This should be one of the main focus of the test drilling program. In addition, supplementary, but less important information on local the groundwater levels may be gathered for a better estimation of the general flow direction and velocity.

# Appendix I

# Example of an ATES well

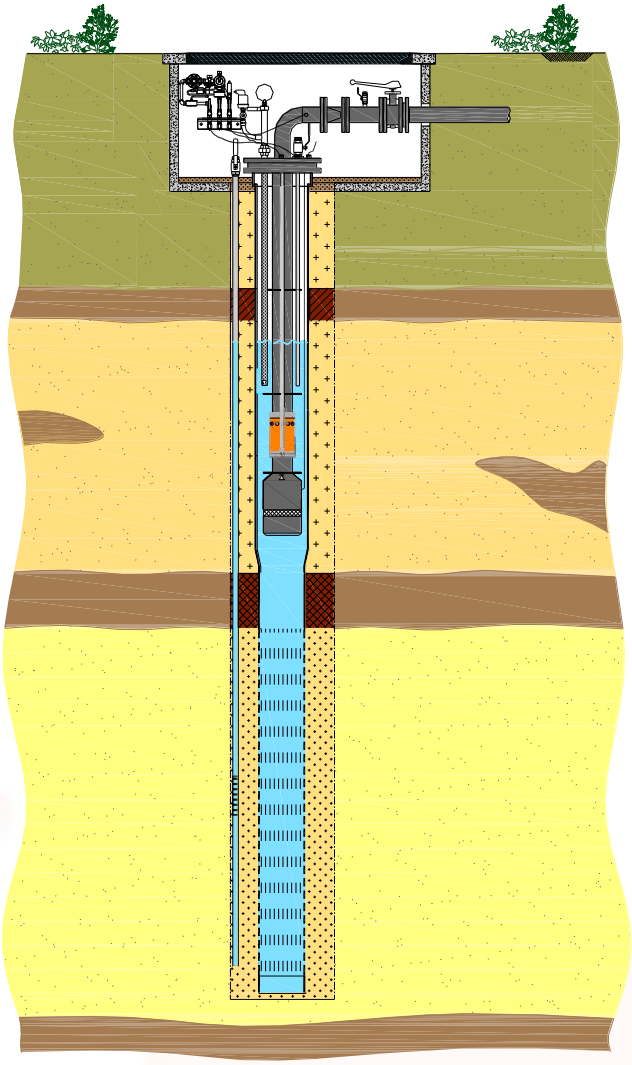

Figure A1: Impression of a typical well

# Appendix II

# IF Technology

## IF Technology

We are a leading geothermal energy consultancy and engineering company, based in Arnhem in the Netherlands. We take a multi-disciplinary approach to projects, bringing in our experienced geologists, hydrogeologists, civil & mechanical engineers and well engineers, as required. If you wish to explore the potential of geothermal energy, we can carry out a feasibility study. We also have all the skills in-house to provide a one-stop shop, including risk assessment, permitting, technical and financial analysis and system design.




We have special expertise in Aquifer Thermal Energy Storage, Borehole Thermal Energy Storage, Deep Geothermal Energy Systems, High Temperature Storage and Well Engineering.

**Key notes**

- We have more than 20 years of experience with design and commissioning.
- We have 90 highly educated specialists and project managers.
- Over 1,500 of our medium and large scale projects are in operation.
- Our operational projects are in the Netherlands, Belgium, Canada, Spain, Norway, UK, and US.
- New projects underway in Germany, UK and China.

**Consultant engineers in green technology**

We advise local authorities, developers and building services consultants on a broad range of geothermal energy solutions, including energy extraction and storage projects as well as energy master plans. We also advise policymakers on underground storage of compressed energy, $CO_2$ and water. Services we offer:

**Preparatory phase**

- Quick scan
- Feasibility studies
- Total energy concepts
- Hydrogeological studies
- Test drilling consultancy
- Technical design system
- Licensing
- Tendering
- Permitting
- Process Control & Risk Management

**Execution phase**

- Project Management
- Reservoir Engineering
- Well Engineering
- Mechanical & Electrical Engineering
- Construction Supervision
- Commissioning
- Operation & Maintenance
- Monitoring
- Second Opinion
- Data Management

**ATES in the Netherlands**

Since 1989 the first ATES systems are realized in the Netherlands. Now more than 20 years later, over 1,500 IF ATES systems have been made with success. ATES systems are used for a wide variety of purposes. Most common users are: Hospitals, schools, public buildings, residential buildings and office buildings. IF is market leader in ATES systems in The Netherlands.




Figure A2: IF ATES systems in the Netherlands (designed systems and realised systems)

**International ATES systems**

IF has designed and developed many ATES systems all over the world.

**United Kingdoms**

- Westway Housing Londen, 1 MW ATES system, in operation since 2006
- Leamouth Londen, realized 2 wells
- Beorma Quarter Birmingham, test drilling performed
- Dartford Campus, test drilling performed
- Nat. Maritime museum Greenwich, 2 wells ATES system, realization 2010/2011
- East Indian Road Londen, realized 2 wells
- Wandsworth Londen, realized 8 wells, full system realization 2011
- Tottenham Hotspur, pre-design ATES system
- Imperial College, test drilling performed
- Astra Zeneca, test drilling performed

**Belgium**

- Cera Bank Leuven, 1 MW ATES sytstem, 1999
- Janssen Pharmaceutica Geel
- Janssen Pharmaceutica Beerse
- Zwan Schoten
- ETAP
- Kortman Intraldal St. Truiden
- Tessas
- Vito Mol
- Maria ziekenhuis Overspelt
- Cipala / Innotek Geel, 1 MW ATES system, 2001
- oesterzwammenteler Vandenhove Rijkel
- Proefcentrum Sierteelt
- St. Dimpna Geel
- Philips Hasselt
- Eco Print Center Lokeren
- Astro Toren Brussel

**Spain**

- Metro Madrid, complete BTES power plant for cooling of the metro station
- Mollet Hospital, Barcelona, complete BTES power plant

**USA**

- Richard Stockton College. Six well ATES system, 1 MW, 2008

**Norway**

- Gardermoen Airport, Oslo. 10 MW, 1996

**China**

- Suntech Wuxi, Jiangsu, test drilling ATES system
- SAAS, Shanghai. Design ATES system greenhouse. Realization 2011
- Headquarter Air-CBD, Beijing. Test drilling ATES system. Realization 2011

**India**

- Deep geothermal electricity production. Feasibility and pre-design.

**Germany**

- Berlin, deep geothermal heating and electricity production potential study

**Russia**

- Sochi, Olympic Winter Games. Feasibility study for the application of ATES

**Canada**

- Solar City Okotoks, combination solar collectors and BTES. In operation.

**Denmark**

- Copenhagen towers. ATES system, 2009

**Synopsis**

A thorough design in combination with regular quality checks at set times by IF during the construction phase, results in a guaranteed en good working ATES system.
IF-style ATES systems demonstrated themselves over the last 20 years as a proven technology as well as energy saving and sustainable systems with serious contribution to $CO_2$ emission reduction.

Frequent maintenance of the system and system monitoring, will ensured a high reliability of the system for many years.

IF Technology is able to support and give contribution to all project phases from pre-design, detailed design, environmental risk assessment, tendering, project management during construction to system monitoring and data management.

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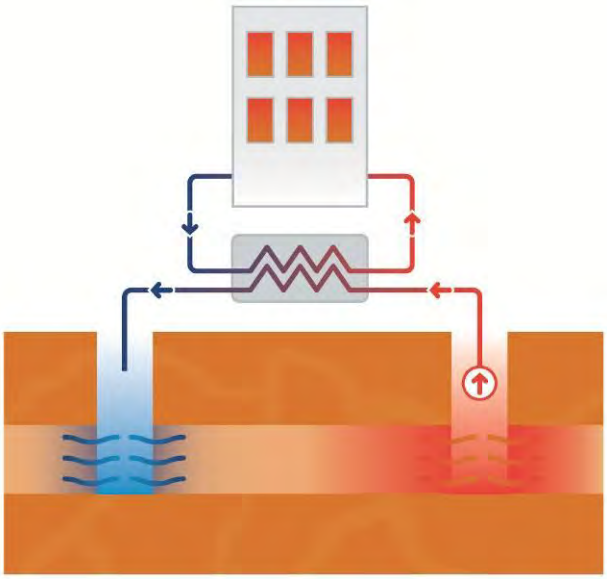
# APPENDIX E IF TECH DRILLING PROGRAM FT BENNING

# Test drilling program
# Ft Benning, Columbus, GA, USA



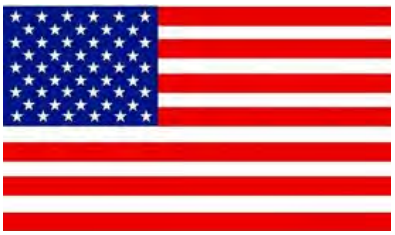
IF Technology
Velperweg 37
6824 BE Arnhem
The Netherlands
PO Box 605
6800 AP Arnhem
The Netherlands
T +31 (0)26 35 35 555
F +31 (0)26 35 35 599
E info@iftechnology.com
I www.iftechnology.com

For the design of the ATES system, the characteristics of the aquifer must be investigated onsite.
This test drilling program describes how to perform the investigation.



Engineering the earth

**INTERNATIONAL COOPERATION ON ATES AT THE FT BENNING SITE**





## Client

Andrews, Hammock & Powell, Inc.
Consulting Engineers
250 Charter Lane
MACON, GA 31210
USA
T +1 478 405 8301
F +1 478 405 8210
E CHammock@ahpengr.com
Contact: Chuck Hammock, PE, LEED AP, CGD

## Consultant ATES system

IF Technology B.V.
Velperweg 37
6824 BE ARNHEM
The Netherlands
T +31 26 35 35 555
F +31 26 35 35 599
E b.godschalk@iftechnology.nl
Contact : M.S. (Bas) Godschalk

## Project team IF Technology

M.S. (Bas) Godschalk, MSc
International Business Manager

M. (Mariene) Gutierrez Neri, Ph.D.
Senior consultant hydrogeology

T. (Tim) Aalten, B Eng
Well engineer

M.M. (Marcel) Swets eur.ing., B Eng
Chief technical officer

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Appendix
I Principle of rotary drilling technique

# 1 Introduction

The scope of the project is to demonstrate the efficiency of an ATES-HP system (Aquifer Thermal Energy Storage-Heat Pump) at an existing building in relation to a traditional heating and cooling concept. The selected building is 17 Ft Benning. The estimated flow rate of the ATES system on this site is 110 GPM (25 $m^3$/h).

The main purpose of the test drilling is to reduce risks or to be able to manage the risk during the design and realization phase. Therefore, the approach is to focus on only the (technical) risk parts. Of course an extended test drilling will deliver more information, which may result in a more refined design. In the next Table is presented the actual uncertainty (risk) and the test drilling options to reduce the risk.

Table 1.1 Risk overview and test drilling options

| Test drilling program, risk management | | Redox | Aquifer properties | Well locations |
|---|---|---|---|---|
| Actual risk | | | | |
| Minimal required | Borehole with 4 observation wells | | | |
| Option 1 | Water well | | | |
| Option 2 | Extra observation well | | | |

legend risk:

= high
= medium
= small
= very small

Table 1.1 shows that redox is the major risk for the realization of an proper working ATES system. Therefore, we suggest to perform the minimal test drilling program as described in Chapter 3.
If there is a demand for more accurate information or an obligation to the founder of the demonstration project, extra test drilling options can be performed, as described in chapter 4. The first option is to extend the test by an extra water well for a pumping test (extra aquifer properties will be determined) and second an additional observation well for groundwater direction and speed measurements.

Our recommendation is to perform the minimal test drilling program.

For each step of the test drilling it is strongly recommended that an IF well engineer is on site during the (main) activities.

As discussed, this test drilling program doesn't include the local requirements or demands for the permit and verification of the (drinking) water quality for injection. AH&P will take care for this requirements and they can be added to the total test drilling program.

# 2 Project information

## 2.1 Ft Benning site

The project location is situated at the Ft Benning (Army) site in Columbus, GA.

GPS coordinates:
32° 24.585'N
84° 54.141'W




Figure 2.1 Google Earth map of the site

## 2.2 Geological sequence

The expected geological sequence beneath the site is outlined in Table 2.1. The description is based on the following sources:

a. Formation Thermal Conductivity Test and Data Analysis, 2011. Fort Benning, GA. Report prepared by Andrews, Hammock and Powell, Inc.
b. Groundwater Conditions and Studies in Georgia, 2008-2009. US Geological Survey Water Resources Investigations Report 99-4140
c. Online resources http://waterdata.usgs.gov/ga/nwis/
d. Hydrogeological evaluation Ft. Benning, IF Technology, ref.nr. 26.383/60317/BG, 6 April 2012.

Table 2.1 Hydrogeological schematisation

| Depth (ft-bgl)* | lithology | Formation | Hydrogeology |
|---|---|---|---|
| 0 – 395 (120 m)** | Intercalation of layers of medium to coarse sands and gravels with of silty clays and silty sands | Cretaceous aquifer (Tuscaloosa) | Aquifer |

* feet below ground level
** This aquifer is expected to extend to depths of about 720 ft-bgl (220 m-bgl).

**Water level**
Expected water level in the aquifer: 56 feet (17 meters) below ground level.

# 3 Minimal test drilling program

## 3.1 General

It is essential to measure the groundwater quality on the location at several depts. Therefore 1 borehole with 4 observation wells must be realized.

Location




Details:

- The preferred piping material is PVC.
- Drilling method: rotary drilling.
- Figure 3.1 presents the dimensions of the borehole with 4 observation wells.
- Drilling borehole to 656 feet (200 meter) below ground level.
- Borehole diameter: 12 inch (300 mm).
- 4 observation wells:

| Name | Depth filter screen (feet-gl) | Depth filter screen (meter-gl) |
|---|---|---|
| OW1 | 157 – 164 | 48 – 50 |
| OW2 | 321 – 238 | 98 – 100 |
| OW3 | 485 – 492 | 148 – 150 |
| OW4 | 649 – 656 | 198 – 200 |

- Minimal ID observation wells 2.25 inch (57 mm).
- OD observation wells about: 2.48 inch (63 mm)*.
- Slot size filter screen 0.024 inch (0.6 mm)*.

- The annulus must be backfilled with the use of a tremie pipe.
- The borehole must be backfilled with filter gravel (filter pack) and clay:
    - grain size filter pack gravel between 0.031 and 0.049 inch (0.8 – 1.25 mm)*.
    - 13 feet (4 meter) filter pack gravel per observation well.
    - 604 feet (184 meter) swelling clay.
    - The borehole cannot be backfilled with the cuttings (out coming sand/clay) of the drilling

*NOTE: The exact dimensions of the materials shall be tuned to local available materials.

The well engineer of IF Technology shall give onsite instructions about the final depths of the filter screens and backfilling materials.

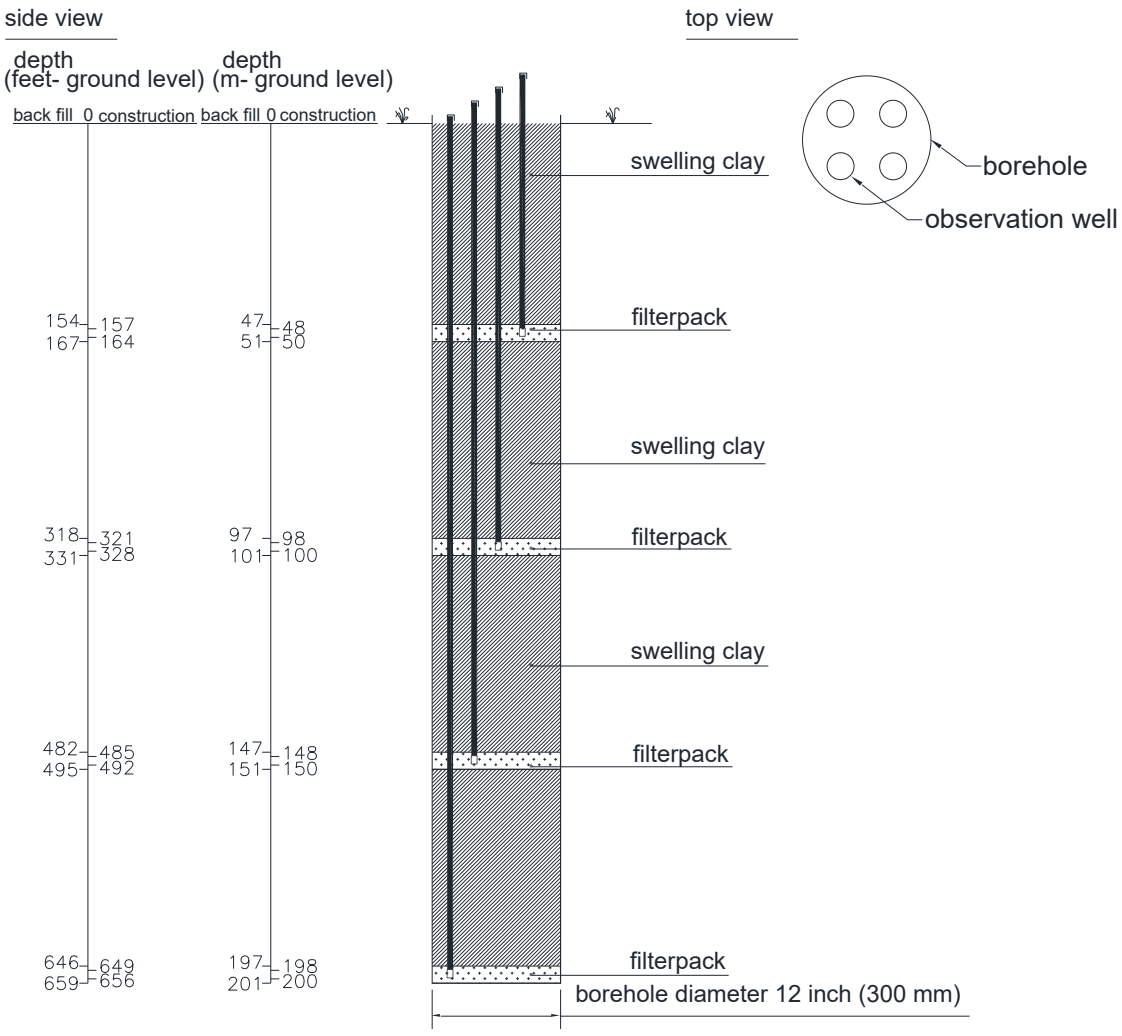



Figure 3.1 Schematic borehole with 4 observation wells

## 3.2 Drilling

- The drilling shall be done with the rotary drilling technology (appendix I presents the principle of intended rotary drilling method).
- Drilling samples (disturbed) from the cuttings must be taken by the driller of at least every 10 feet (3 meter) of the soil. IF shall collect the samples and makes a description of the soil.
- A geophysical well log must be performed in the open borehole. The following items must be measured, by the drilling company or specialist company:
    - Spontaneous Potential Log (mV versus depth)
    - Resistivity Log (Ω m versus depth)
    - Natural Gamma Ray Log
- The measured curves must be plotted in a diagram.

## 3.3 Clean pumping observation wells

- The observation wells must be clean pumped. IF will tell when the drilling company can stop with clean pumping of the observation wells.
- The driller must provide a submersible pomp with an OD of 2 inch (50 mm), minimal flow rate of 9 GPM (2 $m^3$/h) for extracting water from the observation wells.
- The driller must provide electricity for the submersible pump.

## 3.4 Measurements and analysis

- The well engineer of IF Technology shall take water samples with the submersible pump.
- The well engineer of IF Technology shall perform level and temperature measurements in the observation wells.
- AH&P shall take care for the right bottles/flask for sampling and the water chemistry analysis by a certified laboratory.

## 3.5 Results

The borehole with 4 observation wells must deliver the following results:

- Description of geological strata.
- Indication of maximum yield of the aquifer.
- Water quality at several depths to determine the depth of the redox zone ($Fe^{2+}$, $Fe^{3+}$, $Mn^{2+}$, $NO_3^-$)
- Results field measurements: water temperature, dissolved oxygen, pH.
- Input for final well design.

# 4 Optional extended test drilling program

## 4.1 Option 1: Water well

### 4.1.1 General

Next to the borehole with 4 observation wells, it is possible to perform one additional water well to determine the maximum yield of the aquifer.

Location




Details water well

- The preferred piping material for the well is PVC.
- Drilling method: rotary drilling.
- Drilling borehole to 656 feet (200 meter) below ground level.
- Borehole diameter: 11.8 inch (300 mm).
- 1 water well:

| Name | Depth filter screen (feet-gl) | Depth filter screen (meter-gl) |
|---|---|---|
| Water well | 541 – 639 | 165 – 195 |

- Minimal ID filter screen 5.7 inch (144.6 mm).
- OD filter screen about: 6.3 inch (160 mm)*.
- Slot size filter screen 0.024 inch (0.6 mm)*.
- Casing length (filter – ground level) 541 feet (165 meter).
- Sump
- The annulus must be backfilled with the use of a tremie pipe.

- The borehole must be backfilled with filter gravel (filter pack) and clay:
  - grain size gravel filter between 0.031 and 0.049 inch (0.8 – 1.25 mm)*.
  - 112 feet (34 meter) gravel filter.
  - 538 feet (164 meter) swelling clay.

*NOTE: The exact dimensions of the materials shall be tuned to local available materials.

The well engineer of IF Technology shall give onsite instructions about the final depths of the filter screens and backfilling materials.

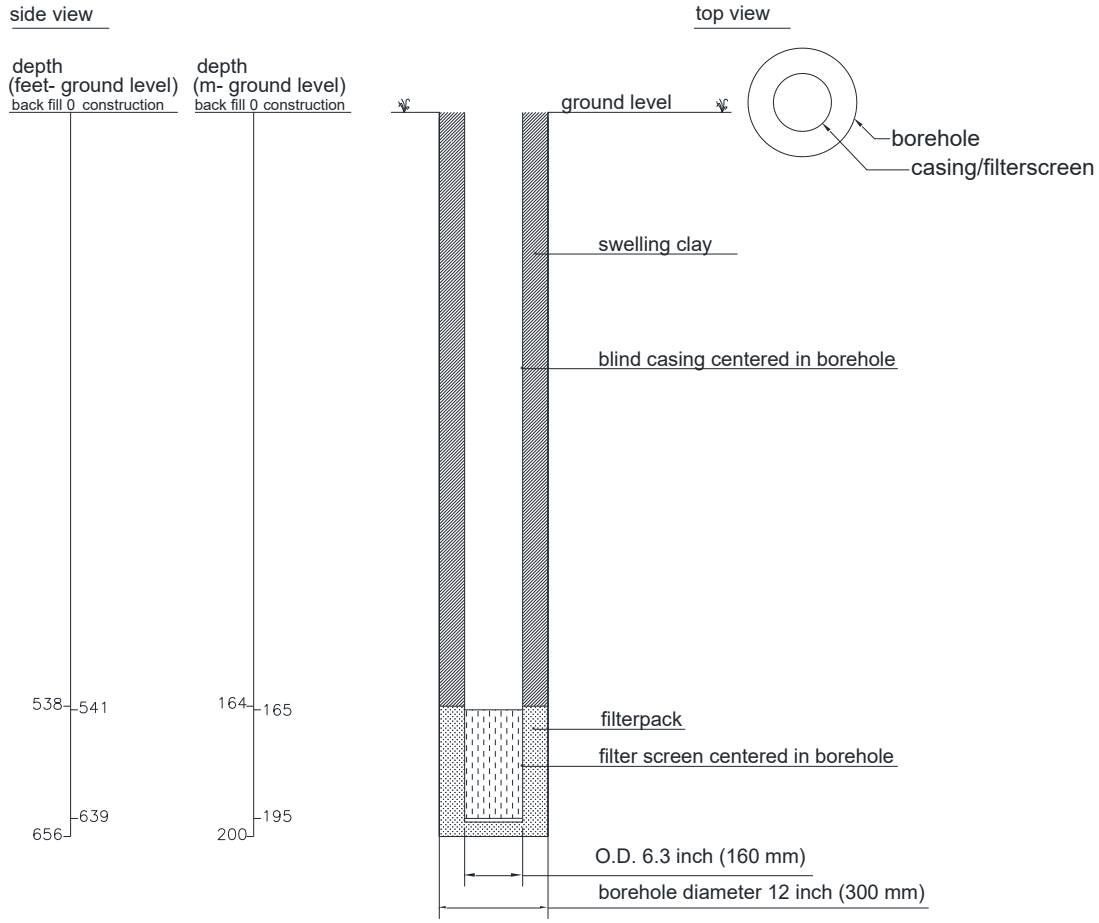



Figure 4.1 Schematic borehole with water well

### 4.1.2 Drilling

- The drilling shall be done with the rotary drilling technology (appendix I presents the principle of intended rotary drilling method).
- Drilling samples (disturbed) from the cuttings must be taken by the driller of at least every 10 feet (3 meter) of the soil. IF shall collect the samples and makes a description of the soil.
- A geophysical well log must be performed in the open borehole. The following items must be measured, by the drilling company or specialist company:
    - Spontaneous Potential Log (mV versus depth)
    - Resistivity Log (Ω m versus depth)
    - Natural Gamma Ray Log
- The borehole cannot be backfilled with the cuttings (out coming sand/clay) of the drilling.

### 4.1.3 Clean pumping well

- The well must be clean pumped. The amount of sand and silt in the extracted water must be limited. The well engineer from IF Technology shall perform a sand and silt test and shall decide when the drilling company can stop with clean pumping of the well.
- The driller must provide the following see also figure 4.2:
    a. a submersible pomp which fits in the well and is suitable for extracting with a flow of 110 gallons per minute GPM (25 $m^3$/h). The submersible pump must be placed 82 feet (25 meter) below ground level.
    b. Pipe work from submersible pump to sewage.
    c. Water meter (that measures the water amount).
    d. Valve to adjust the water flow.

### 4.1.4 Pumping test

- The well engineer of IF Technology will perform the pumping test and will do the measurements, with the same setup as used with clean pumping. The driller must assist IF during the test (for 3 days).
- The well engineer of IF Technology is responsible for placing the pressure data collectors, for registration of the water levels during the pumping test.

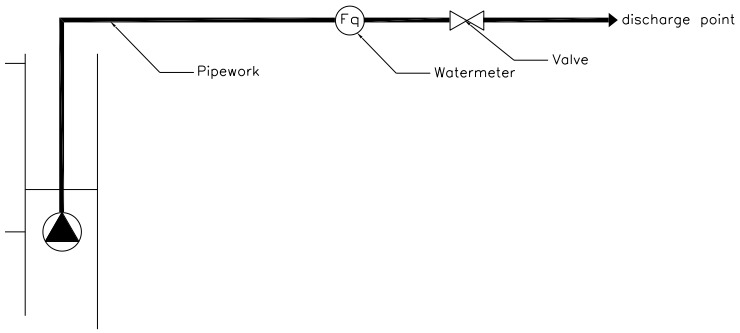



Figure 4.2 Set up for the pumping test

### 4.1.5 Results

The borehole with the water well must deliver the following results:

- Additional information of the geological strata.
- Maximum yield of the aquifer.
- Specific yield.
- Water quality (sand and silt content of extracted water after development).
- Input for final well design.

## 4.2 Option 2: Extra observation well

### 4.2.1 General

The groundwater flow velocity and the direction of the groundwater flow can be determined by the installation of an additional observation well in a triangle with the water well and borehole with four observation wells.

Location




Details observation well:

- All piping material is of PVC
- Drilling method: rotary drilling.
- Drilling borehole to 331 feet (101 meter) below ground level.
- Borehole diameter: 5.9 inch (150 mm).
- 1 observation well:

| Name | **Depth filter screen (feet-gl)** | **Depth filter screen (meter-gl)** |
|---|---|---|
| Observation well 5 | 321 – 328 | 98 – 100 |

- Minimal ID observation well 1.1 inch (28 mm).
- OD observation wells about: 1.3 inch (32 mm)*.

- slot size filter screen 0.024 inch (0.6 mm)*.
- The annulus must be backfilled with the use of a tremie pipe.
- The borehole must be backfilled with filter gravel (filter pack) and clay:
    - grain size gravel filter between 0.031 and 0.049 inch (0.8 – 1.25 mm)*.
    - 13 feet (4 meter) filter gravel.
    - 318 feet (97 meter) swelling clay.

*NOTE: The exact dimensions of the materials shall be tuned to local available materials.

The well engineer of IF Technology shall give onsite instructions about the final depths of the filter screens and backfilling materials.

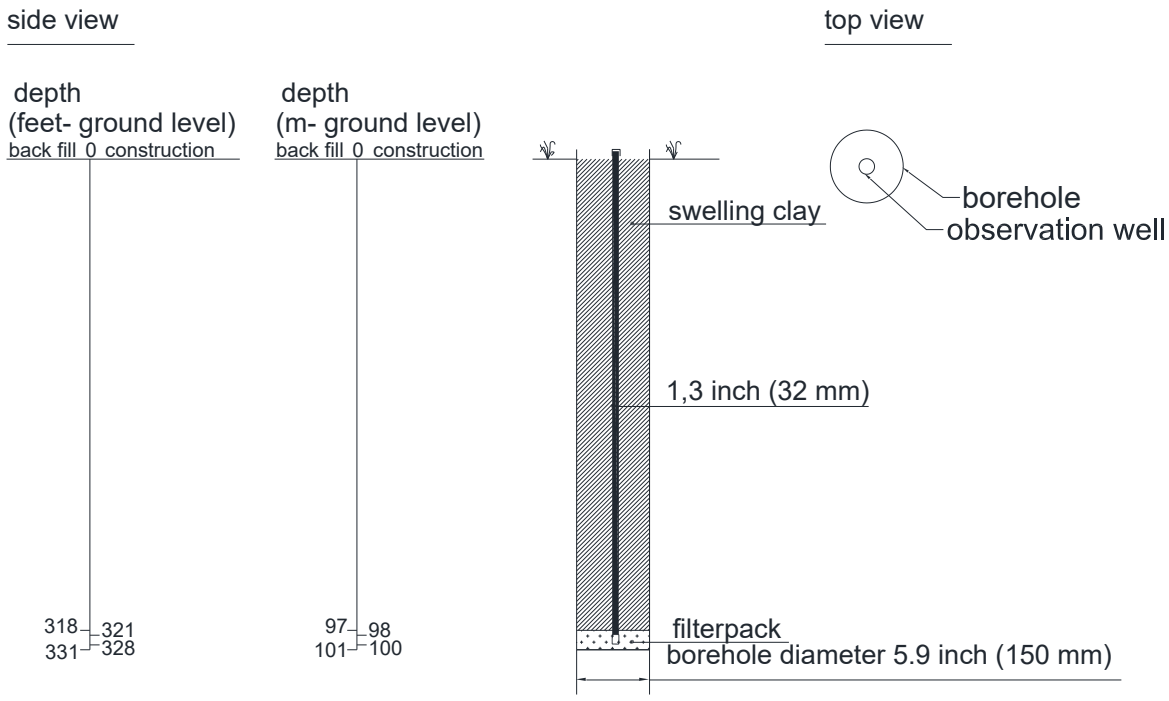



Figure 4.3 Schematic borehole with 1 observation well

### 4.2.2 Drilling

- The drilling shall be done with the rotary drilling technology (appendix I presents the principle of intended rotary drilling method).
- Drilling samples (disturbed) from the cuttings must be taken by the driller of at least every 10 feet (3 meter) of the soil. IF shall collect the samples and makes a description of the soil.
- The borehole cannot be backfilled with the cuttings (out coming sand/clay) of the drilling.

### 4.2.3 Clean pumping observation well

- The observation well must be clean pumped. IF will decide when the drilling company can stop with clean pumping of the observation well.

### 4.2.4 Measurements

- The drilling company or a specialist company shall measure the altitude of the top of the screens and locations (Borehole with four observation wells, water well and the extra observation well) in relation to a fix point (building).
- IF shall determine the water levels of the observation wells and water well.

### 4.2.5 Results

The extra observation well must deliver the following results:

- Groundwater direction
- Groundwater flow velocity
- Input for optimized well lay out for the ATES system

# 5 Organization and planning

## 5.1 Organization

By performing the test drilling, three major companies are involved. First of all is AH&P who initiate the demonstration project and has the contacts with the client and is the central point of all the communication as the project manager.
Second, is the drilling company who will arrange the drillings and installation of wells or pipes and support with the tests.
Last, IF Technology will guide and support the test drilling and will take samples, perform measurements and will work out all the gathered data into input data for the design of the ATES system.

In order to make a clear demarcation between the companies, a Table has been prepared, which can help to get a clear idea of the roles and tasks. Of course it has to be discussed and some parts need to be clarified later.

Table 5.1 (part 1)

| Activities | Required or option | AH&P | Drilling company | IF Technology |
|---|---|---|---|---|
| **Preparations** | | | | |
| Setting up test drilling plan | Required | | | NL |
| Decision options test drilling plan | Required | | | |
| Proposal request drilling company | Required | | | |
| Proposals drilling company | Required | | | |
| Judgement proposals drilling company | Required | | | NL |
| Order test drilling | Required | | | |
| Obtaining right permits | Required | | ? | |
| Preparations test drilling | Required | | | NL |
| Providing submersible pump(s) | Required | | | |
| Access to electricity and water on site | Required | ? | | |
| Access point for discharge water + permit | Required | ? | | |
| **Drilling** | | | | |
| Determination final well location | Required | | | OS |
| Drilling well | Required | | | |
| | Opt. 1 / 2 | | | |
| Sampling drilling mud | Required | | | OS |
| Logs (Pot., Resis. Gamma) | Required | | | |
| Determination final screen depths | Required | | | OS |
| Installation screens | Required | | | |

Table 5.1 (part 2)

| Activities | Required or option | AH&P | Drilling company | IF Technology |
|---|---|---|---|---|
| **Observation well development** | | | | |
| Cleaning well by pumping | Required | | | |
| | Opt. 1 / 2 | | | |
| Check cleanness of observation well | Required | | | OS |
| | Opt. 1 / 2 | | | OS |
| **Sampling and testing** | | | | |
| Providing bottles/flask conform lab. | Required | | | |
| Taking water samples | Required | | | OS |
| Shipment to laboratory of samples | Required | | | |
| Performing measurements (pH, T, level, O2) | Required | | | OS |
| Performing pumping test | Opt. 1 | | | OS |
| Theodolit measurement | Opt. 2 | ? | | |
| Water level measurements | Opt. 2 | | | OS |
| **Results** | | | | |
| Description geological strata | Required | | | OS |
| Spontaneous Potential Log | Required | | | |
| Resistivity Log | Required | | | |
| Natural Gamma Ray Log | Required | | | |
| Water chemistry analysis | Required | | | |
| Water temperature | Required | | | NL |
| Water level | Required | | | NL |
| Water pH | Required | | | NL |
| Interpretation pumping test | Opt. 1 | | | NL |
| Specific yield | Opt. 1 | | | NL |
| Sand and silt content well | Opt. 1 | | | NL |
| Interpretation water direction and velocity | Opt. 1 | | | NL |
| **Final test drilling report** | **Required** | | | **NL** |

? = maybe this partner can perform/arrange this item.

OS = on site
NL = office IF in NL

## 5.2 Materials

The drilling company should take care for all the materials and equipment for the test drilling. However, for some measurements AH&P and IF shall bring materials and/or equipment. In Table 5.2 the required materials are presented and the company who shall bring the materials on time on site.

Table 5.2 Materials for the test drilling

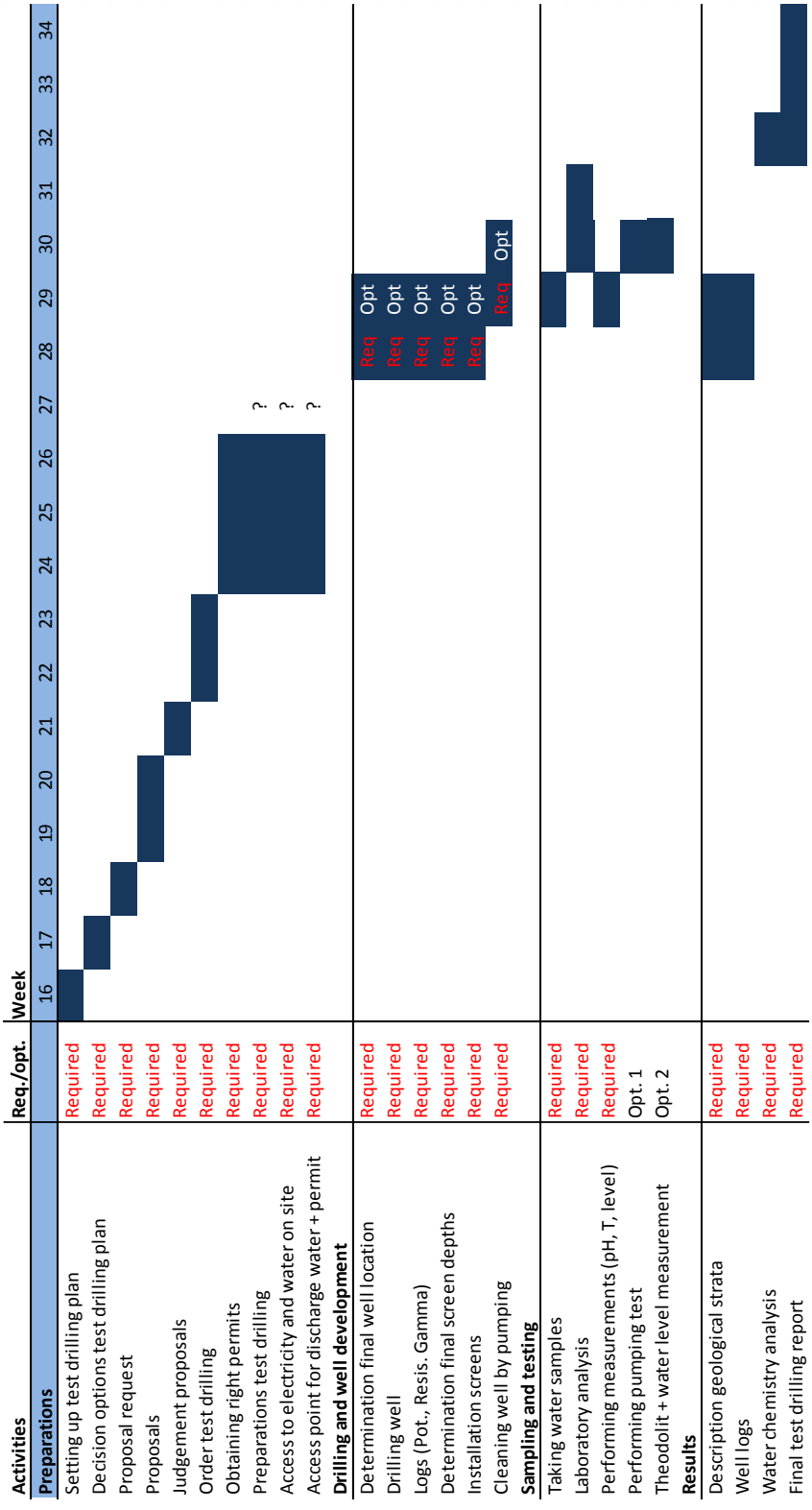
| Materials | Required or option | More details | AH&P | Drilling company | IF Technology |
|---|---|---|---|---|---|
| Screens, filter pack etc | Required | | | | |
| Log meters | Required | § 3.2 | | | |
| pH, Ec meter | Required | § 3.4 | | | |
| Water level meter 200 m | Required | § 3.4 | | ? | |
| Submersible pump 9 GPM | Required | § 3.3 | | | |
| Bottles and flask conform specs laboratorium | Required | § 3.4 | | | |
| Divers | Required | § 3.4 | | | |
| Submergible pump 110 GPM pumping test | Opt. 1 | § 4.1.3 | | | |
| Water meter pumping test | Opt. 1 | § 4.1.3 | | | |
| Valve pumping test | Opt. 1 | § 4.1.3 | | | |
| Pipework pumping test | Opt. 1 | § 4.1.3 | | | |
| Filter mesh | Opt. 1 | § 4.1.3 | | | |
| Theodolit | Opt. 2 | § 4.2.4 | ? | | |

## 5.3 Planning

In Table 5.3 an indicative planning has been presented. The time for preparations might be shortened if the drilling company has already been selected and if an order can be given quickly. The time for arranging permits is unsure and may strongly depend on the type, amount and the procedure time of permits required.

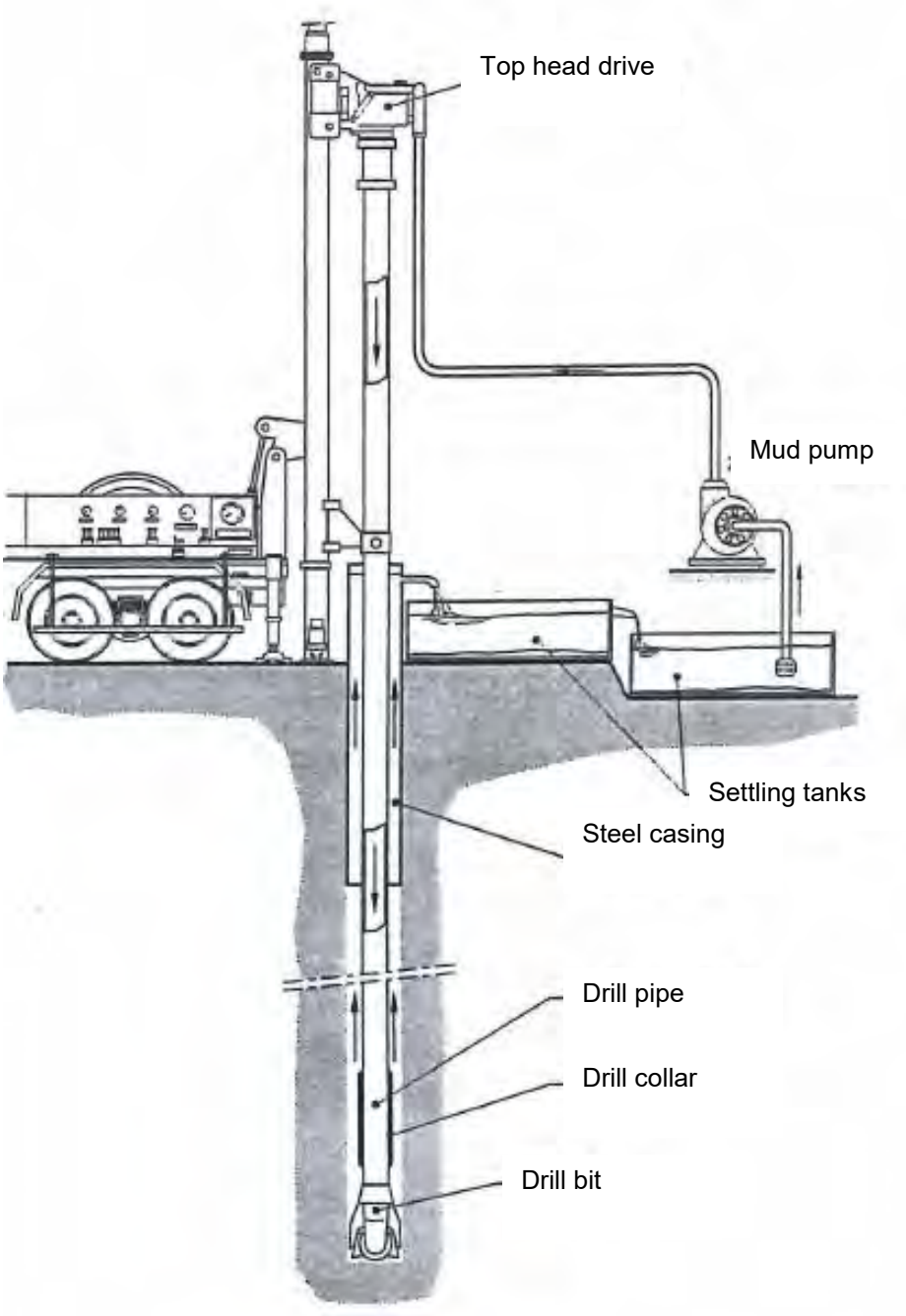
The final planning needs to be discussed with the partners and client involved.

Table 5.3 Planning test drilling



# Appendix I

## Principle of rotary drilling technique



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# APPENDIX F ATES TEST WELL DEVELOPMENT LOG

ANDREWS, HAMMOCK, & POWELL INC
250 Charter Lane, Suite 100
Macon, Georgia 31210
Telephone: (478) 405-8301
Fax: (478) 405-8210

# Well Development Log

## Ft Benning

## Columbus, Ga

March 2013

# Water Chemistry

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH1 W** | **2.11.13** | 2:40 | 17.9 | 7.43 | 0.306 | 242 | 10.12 | 110 | All Horiba meter readings |
| | | 2:50 | 17.92 | 7.23 | 0.297 | 115 | 9.69 | 105.6 | |
| | | 3:00 | 18.11 | 7.14 | 0.316 | 132 | 9.42 | 102.8 | |
| | | 3:10 | 18.32 | 7.12 | 0.322 | 159 | 9.29 | 101.7 | |
| | | 3:20 | 18.5 | 7.07 | 0.322 | 143 | 9.14 | 100.8 | |
| | | 3:30 | 18.75 | 7.06 | 0.32 | 130 | 8.93 | 98.7 | |
| | | 3:40 | 18.79 | 7.04 | 0.319 | 129 | 8.85 | 98 | |
| | | | | | | | | | |
| | **2.21.13** | 9:50 | 17.62 | 7.05 | 0.287 | 28.1 | 1.79 | 19.3 | |
| | | 10:00 | 17.45 | 7 | 0.287 | 16.6 | 1.77 | 19.3 | |
| | | 10:10 | 17.75 | 7.03 | 0.288 | 9.8 | 1.6 | 17.3 | |
| | | 10:20 | 18.36 | 7.06 | 0.289 | 6.8 | 1.35 | 14.8 | |
| | | 10:30 | 18.98 | 7.05 | 0.288 | 4.4 | 1.04 | 11.5 | |
| | | 10:40 | 18.84 | 7.06 | 0.288 | 3.2 | 1.12 | 12.4 | |
| | | | | | | | | | |
| | **2.25.13** | 11:55 | 12.48 | 7.1 | 0.312 | 11.9 | 5.27 | 51.2 | |
| | | 12:05 | 11.91 | 7.01 | 0.308 | 9.2 | 5.41 | 51.8 | |
| | | 12:15 | 11.59 | 7.01 | 0.307 | 9.8 | 4.69 | 44.6 | |
| | | 12:25 | 11.66 | 7.01 | 0.306 | 31 | 5.46 | 52.8 | |
| | | 12:35 | 11.96 | 7.05 | 0.303 | 19.5 | 4.35 | 41.7 | |
| | | 12:45 | 12.46 | 7.04 | 0.301 | 24 | 4.5 | 43 | |
| | | | | | | | | | |
| | **2.27.13** | 10:15 | 18.64 | 7.1 | 0.282 | 42.3 | 1.18 | 12.9 | |
| | | 10:25 | 18.15 | 7.04 | 0.283 | 19.7 | 0.73 | 8 | |
| | | 10:35 | 18.06 | 7.04 | 0.282 | 17 | 0.61 | 6.7 | |
| | | 10:45 | 17.83 | 7.04 | 0.283 | 12.2 | 0.52 | 5.6 | |
| | | 10:55 | 17.5 | 7.05 | 0.286 | 11.2 | 0.48 | 5.2 | |
| | | 11:05 | 18 | 6.97 | 0.287 | 10.9 | 0.43 | 4.7 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH1 B** | **11.20.12** | N/A | 20 | 8.46 | 1.53 | N/A | N/A | N/A | Hanna Meter |
| | | | | | | | | | |
| | **11.20.12** | N/A | N/A | 8.14 | 1.54 | 0 | 7 | N/A | Horiba Meter |
| | | | | | | | | | |
| | **2.11.13** | 1:48 | 19.38 | 7.03 | 0.315 | 470 | 0.75 | 8.3 | Horiba Meter |
| | | 1:58 | 19.19 | 7.02 | 0.321 | 529 | 0.74 | 8.3 | |
| | | 2:08 | 19.01 | 6.98 | 0.323 | 400 | 0.75 | 8.3 | |
| | | 2:18 | 18.82 | 7.07 | 0.323 | 304 | 0.76 | 8.4 | |
| | | 2:28 | 18.56 | 7.01 | 0.324 | 238 | 0.76 | 8.4 | |
| | | 2:38 | 18.36 | 7.01 | 0.324 | 203 | 0.76 | 8.4 | |
| | | | | | | | | | |
| | **2.21.13** | 11:15 | 20.61 | 6.97 | 0.293 | >800 | 5.26 | 59.9 | Horiba Meter |
| | | 11:25 | 21.2 | 7 | 0.295 | 445 | 4.78 | 55.3 | |
| | | 11:35 | 21.31 | 7.02 | 0.296 | 314 | 4.61 | 53.5 | |
| | | 11:45 | 21.35 | 7.03 | 0.296 | 280 | 4.51 | 52.2 | |
| | | | | | | | | | |
| | **2.25.13** | 10:25 | 14.74 | 7.06 | 0.29 | 54.9 | 1.42 | 14.4 | Horiba Meter |
| | | 10:35 | 13.03 | 6.96 | 0.292 | 47.6 | 2 | 19.5 | |
| | | 10:45 | 12.38 | 6.87 | 0.303 | 34 | 1.11 | 10.7 | |
| | | 10:55 | 11.82 | 6.92 | 0.306 | 29 | 1.14 | 10.9 | |
| | | 11:05 | 11.57 | 6.9 | 0.304 | 25.7 | 0.92 | 8.1 | |
| | | 11.15 | 11.45 | 6.84 | 0.299 | 39 | 0.86 | 8.1 | |
| | | 11:25 | 11.44 | 6.79 | 0.298 | 35 | 0.77 | 7.3 | |
| | | | | | | | | | |
| | **3.1.13** | 9:15 | 14.69 | 7.23 | 0.265 | 16.3 | 7.98 | 81.1 | Horiba Meter |
| | | 9:25 | 13.66 | 6.79 | 0.257 | 7.8 | 6.83 | 67.7 | |
| | | 9:35 | 12.01 | 6.85 | 0.26 | 5.7 | 6.72 | 64.5 | |
| | | 9:45 | 12.04 | 6.66 | 0.258 | 5.1 | 5.81 | 55.8 | |
| | | 9:55 | 13.34 | 6.62 | 0.261 | 11.2 | 5.4 | 53.4 | Meter turned off |
| | | | | | | | | | |
| | | 3:45 | 19.02 | 7.15 | 0.326 | 190 | 1.07 | 11.9 | Horiba Meter |
| | | 3:55 | 18.1 | 7.14 | 0.325 | 146 | 0.72 | 7.9 | |
| | | 4:05 | 16.98 | 7.13 | 0.325 | 141 | 0.66 | 7 | |
| | | 4:15 | 16.46 | 7.01 | 0.324 | 144 | 0.63 | 6.7 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH1 C** | **11.20.12** | N/A | N/A | 8.2 | 0.43 | N/A | N/A | N/A | Hanna Meter |
| | | | | | | | | | |
| | **11.20.12** | N/A | N/A | 7.6 | 0.362 | 0 | 11.13 | N/A | Horiba Meter |
| | | | | | | | | | |
| | **2.6.13** | 2:06 | 22.11 | 6.97 | 0.335 | 161 | 9.5 | 111.7 | Horiba Meter |
| | | 2:13 | 22.85 | 6.92 | 0.347 | 59 | 0.91 | 10.7 | |
| | | 2:23 | 25.93 | 6.97 | 0.348 | 66 | 0.61 | 7.9 | |
| | | 2:33 | 27.09 | 6.96 | 0.35 | 60 | 0.56 | 7.7 | |
| | | 2:43 | 26 | 6.95 | 0.349 | 29 | 0.41 | 5.2 | |
| | | 2:53 | 25.5 | 6.96 | 0.351 | 9.7 | 0.36 | 4.4 | |
| | | 3:03 | 25.4 | 6.98 | 0.351 | 4.1 | 0.33 | 4.1 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | **2.8.13** | 10:15 | 17.3 | 7.15 | 0.256 | 100 | 2.94 | 31.4 | Horiba Meter |
| | | 10:25 | 16.42 | 7.12 | 0.251 | 56.3 | 2.4 | 25.6 | |
| | | 10:35 | 15.96 | 7.11 | 0.248 | 39.6 | 3.06 | 30.8 | |
| | | 10:45 | 15.53 | 7.11 | 0.248 | 35.7 | 2.16 | 22.3 | |
| | | 10:55 | 15.32 | 7.1 | 0.247 | 25.9 | 1.86 | 19.1 | |
| | | 11:05 | 14.95 | 7.1 | 0.246 | 19.7 | 1.62 | 16.6 | |
| | | 11:15 | 14.9 | 7.1 | 0.245 | 17.6 | 1.47 | 15 | Meter turned off |
| | | 11:25 | 15.19 | 7.1 | 0.254 | 22.8 | 1.3 | 13.3 | |
| | | | | | | | | | |
| | **2.11.13** | 9:55 | 19.31 | 7.1 | 0.357 | 46.4 | 11.05 | 123.2 | Horiba Meter |
| | | 10:05 | 19.67 | 7.12 | 0.34 | 11.9 | 8.16 | 92 | |
| | | 10:15 | 19.79 | 7.11 | 0.34 | 7.9 | 8.41 | 94.5 | |
| | | 10:25 | 19.59 | 7.09 | 0.34 | 1.5 | 8.48 | 95 | |
| | | 10:35 | 19.17 | 7.07 | 0.34 | 0 | 8.1 | 90.3 | |
| | | 10:45 | 19.05 | 7.06 | 0.341 | 0 | 7.77 | 86.2 | |
| | | | | | | | | | |
| | **2.27.13** | 1:30 | 19.6 | 7.06 | 0.356 | 72.1 | 8.15 | 91.5 | Horiba Meter |
| | | 1:50 | 21.4 | 7.11 | 0.355 | 26.5 | 1.97 | 23.1 | |
| | | 2:00 | 22.73 | 7.12 | 0.35 | 23.9 | 2.16 | 25.6 | |
| | | 2:10 | 23.03 | 7.12 | 0.354 | 19.1 | 2.32 | 27.7 | |
| | | 2:20 | 21.5 | 7.1 | 0.353 | 14.1 | 3.62 | 42.1 | |
| | | 2:30 | 22 | 7.09 | 0.353 | 19.6 | 3.33 | 39.1 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH1 D** | **12.4.12** | 9:15 | 16.7 | 8.36 | 0.419 | 0 | 6.48 | 68.6 | Horiba Meter |
| | | 9:20 | 16.98 | 8.35 | 0.416 | 0 | 6.05 | 64.5 | |
| | | 9:25 | 17.43 | 8.35 | 0.412 | 0 | 5.77 | 62.2 | |
| | | 9:30 | 18.13 | 8.35 | 0.406 | 0 | 5.47 | 59.9 | |
| | | | | | | | | | |
| | | 1:15 | 25.81 | 8.6 | 0.393 | 195 | 7.07 | 88.2 | Airlift sample cup. Horiba meter |
| | | 1:20 | N/A | N/A | N/A | N/A | N/A | N/A | Meter turned off |
| | | 1:35 | 26.46 | 8.59 | 0.398 | 187 | 6.9 | 87.2 | |
| | | 1:40 | 26.35 | 8.6 | 0.397 | 182 | 6.92 | 87.2 | |
| | | 1:45 | 26.23 | 8.59 | 0.398 | 177 | 6.95 | 87.4 | |
| | | | | | | | | | |
| | | 3:45 | 22.02 | 6.87 | 0.163 | 135 | 7.24 | 85.2 | Airlift sample cup. Horiba meter |
| | | 3:50 | 22.04 | 6.86 | 0.161 | 132 | 7.26 | 85.3 | |
| | | 3:55 | 22.21 | 6.7 | 0.161 | 121 | 7.22 | 85 | |
| | | 4:00 | 22.34 | 7.06 | 0.163 | 114 | 7.16 | 84.5 | |
| | | | | | | | | | |
| | **2.1.13** | 12:50 | 20.48 | 6.7 | 0.358 | 17.6 | 10.54 | 120.3 | This row only - Pre Purge reading. Horiba meter |
| | | 1:45 | 17.89 | 6.86 | 0.352 | 0 | 5.52 | 60.2 | Other rows below are Flow cell readings |
| | | 1:55 | 17.25 | 6.85 | 0.353 | 0 | 5.19 | 55.6 | |
| | | 2:05 | 18.02 | 6.84 | 0.345 | 2.6 | 4.68 | 50.8 | |
| | | 2:15 | 17.43 | 6.87 | 0.353 | 3.7 | 4.98 | 53.8 | |
| | | 2:25 | 17.2 | 6.87 | 0.354 | 9.9 | 4.79 | 51.4 | |
| | | 2:35 | 17.24 | 6.87 | 0.354 | 7.1 | 4.45 | 47.7 | |
| | | | | | | | | | |
| | **2.27.13** | 11:30 | 19.02 | 7.02 | 0.352 | 20.7 | 7.75 | 86.1 | Horiba Meter |
| | | 11:50 | 20.34 | 7.01 | 0.357 | 17 | 1.41 | 16 | |
| | | 12:00 | 21.17 | 6.99 | 0.358 | 10.3 | 1.47 | 17 | |
| | | 12:10 | 19.98 | 6.97 | 0.355 | 5.9 | 2.85 | 32.1 | |
| | | 12:20 | 19.87 | 6.94 | 0.356 | 5 | 2.75 | 31.2 | |
| | | 12:30 | 20.41 | 6.95 | 0.357 | 5.2 | 2.45 | 28 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH2 W** | **11.15.12** | N/A | 68.5F | 7.5 | 0.37 | N/A | N/A | N/A | Hanna Meter |
| | | N/A | 68.5F | 7.63 | 0.44 | N/A | N/A | N/A | Hanna Meter. Before pump till clear. |
| | | N/A | 64.4F | 7.42 | 0.37 | N/A | N/A | N/A | Hanna Meter. After pump till clear. |
| | | | | | | | | | |
| | **11.16.12** | N/A | 20.2 | 7.5 | 0.34 | N/A | N/A | N/A | Horiba Meter. Before sand test |
| | | N/A | 20.2 | 7.3 | 0.34 | N/A | N/A | N/A | Horiba Meter. After sand test |
| | | | | | | | | | |
| | **2.4.13** | 10:45 | 19.2 | 7.28 | 0.378 | 0 | 9.47 | 106.2 | Horiba Meter. Bucket test - this row only |
| | | 11:00 | 19.16 | 6.98 | 0.369 | 0 | 1.07 | 11.3 | Horiba Meter. Flow cell - remaining rows. |
| | | 11:10 | 18.14 | 6.92 | 0.367 | 0 | 0.73 | 8 | |
| | | 11:20 | 18.1 | 6.92 | 0.367 | 0 | 0.66 | 7.2 | |
| | | 11:30 | 17.09 | 6.91 | 0.367 | 0 | 0.61 | 6.5 | |
| | | 11:40 | 16.08 | 6.9 | 0.367 | 0 | 0.57 | 6 | |
| | | 11:50 | 15.48 | 6.89 | 0.367 | 0 | 0.52 | 5.4 | |
| | | 12:00 | 15.46 | 6.88 | 0.367 | 0 | 0.48 | 5 | |
| | | | | | | | | | |
| | **2.5.13** | 3:05 | 23.56 | 7.1 | 0.363 | 0 | 9.5 | 114.5 | Horiba Meter |
| | | 3:15 | 21.09 | 7 | 0.365 | 0 | 4.29 | 49.6 | |
| | | 3:25 | 22.14 | 6.99 | 0.367 | 0 | 5.34 | 62.9 | |
| | | 3:35 | 23.46 | 7.02 | 0.367 | 0 | 5.98 | 71.5 | |
| | | 3:45 | 23.76 | 7.02 | 0.368 | 0 | 5.92 | 71.4 | |
| | | 3:55 | 23.39 | 7.02 | 0.368 | 0 | 5.98 | 71.9 | |
| | | 4:05 | 22.66 | 7 | 0.367 | 0 | 6.03 | 71.6 | |
| | | | | | | | | | |
| | **2.19.13** | 1:15 | 19.42 | 7.26 | 0.373 | 5.1 | 8.59 | 96.1 | Horiba Meter. Pre purge - this row only |
| | | 2:12 | 20.39 | 7.1 | 0.369 | 0 | 1.36 | 15.2 | Horiba Meter. Flow cell - remaining rows. |
| | | 2:22 | 21.89 | 7 | 0.369 | 0 | 0.57 | 6.7 | |
| | | 2:32 | 22.85 | 7 | 0.369 | 1.2 | 0.47 | 5.7 | |
| | | 2:42 | 22.47 | 6.99 | 0.369 | 0 | 0.41 | 4.8 | |
| | | | | | | | | | |
| | **2.1.13** | 1:20 | 21.21 | 7.27 | 0.374 | 4.2 | 8.24 | 95.2 | Horiba Meter. Pre purge - this row only |
| | | 1:30 | 19.97 | 7.05 | 0.369 | 0 | 0.6 | 6.8 | Horiba Meter. Flow cell - remaining rows. |
| | | 1:40 | 18.88 | 6.99 | 0.369 | 0 | 0.49 | 5.4 | |
| | | 1:50 | 18.13 | 6.9 | 0.369 | 0 | 0.4 | 4.4 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH2 B** | **12.4.12** | 10:50 | 25.26 | 7.96 | 0.328 | 234 | 7.1 | 87.9 | Sample cup. Horiba meter |
| | | 10:55 | 25.79 | 7.95 | 0.333 | 225 | 7.02 | 87.7 | |
| | | 0:00 | 26.49 | 7.95 | 0.343 | 221 | 6.87 | 86.8 | |
| | | 11:05 | N/A | N/A | N/A | N/A | N/A | N/A | Meter turned off. |
| | | 11:29 | 27.34 | 7.96 | 0.348 | 160 | 6.78 | 86.6 | |
| | | | | | | | | | |
| | | 2:55 | 24.36 | 7.85 | 0.315 | 163 | 0.4 | 4.9 | Horiba Meter |
| | | 3:00 | 24.77 | 7.86 | 0.315 | 172 | 0.36 | 4.4 | |
| | | 3:05 | 24.97 | 7.86 | 0.314 | 178 | 0.33 | 4 | |
| | | 3:10 | 25.11 | 7.87 | 0.314 | 171 | 0.29 | 3.6 | |
| | | | | | | | | | |
| | **2.5.13** | 12:25 | 18.07 | 7.15 | 0.248 | 16.4 | 10.26 | 112 | Horiba Meter |
| | | 12:35 | 20.84 | 7.1 | 0.245 | 10 | 7.72 | 88.5 | |
| | | 12:45 | 21.35 | 7.07 | 0.246 | 4.1 | 6.87 | 79.6 | |
| | | 12:55 | 23.06 | 7.06 | 0.248 | 2.2 | 5.68 | 67.9 | |
| | | 1:05 | 24.82 | 7.06 | 0.249 | 4 | 3.77 | 46.2 | |
| | | 1:15 | 26.21 | 7.06 | 0.258 | 26.4 | 2.15 | 27 | |
| | | 1:25 | 26.32 | 7.06 | 0.261 | 42.1 | 1.93 | 24.2 | |
| | | | | | | | | | |
| | **2.18.13** | 3:00 | 19.65 | 6.91 | 0.772 | 57 | 9.08 | 102.1 | Horiba Meter. Pre purge - this row only |
| | | 3:15 | 21.16 | 7.55 | 0.329 | 20 | 5.71 | 65.3 | Horiba Meter. Flow cell - remaining rows. |
| | | 3:25 | 20.55 | 7.35 | 0.325 | 17.9 | 5.38 | 61.5 | |
| | | 3:35 | 20.34 | 7.32 | 0.325 | 13.4 | 5.17 | 58.5 | |
| | | 3:45 | 19.99 | 7.25 | 0.324 | 13.3 | 5.1 | 57.5 | |
| | | | | | | | | | |
| | **3.1.13** | 9:40 | 14.81 | 7.24 | 0.401 | 39.9 | 8.7 | 88.7 | Horiba Meter. Pre purge - this row only |
| | | 9:50 | 17.34 | 7.29 | 0.333 | 41.6 | 0.6 | 6.4 | Horiba Meter. Flow cell - remaining rows. |
| | | 10:00 | 16.29 | 7.27 | 0.332 | 26.1 | 0.51 | 5.4 | |
| | | 10:10 | 15.56 | 7.28 | 0.332 | 23 | 0.47 | 4.9 | |
| | | 10:20 | 16.43 | 7.29 | 0.332 | 22.2 | 0.22 | 4.6 | |
| | | 10:30 | 16.9 | 7.3 | 0.331 | 21 | 0.42 | 4.5 | |
| | | 10:40 | 16.69 | 7.31 | 0.331 | 21.8 | 0.41 | 4.4 | |

**Water Chemistry**

| Well | Date | Time | Temp | PH | Ms/Cm | NTU | mg/L DO | % DO | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **BH2 C** | **11.20.12** | 2:27 | 20.39 | 7.51 | 0.339 | 0.4 | 0.38 | 4.3 | Horiba meter |
| | | | | | | | | | |
| | **2.4.13** | 2:35 | 14.7 | 7.27 | 0.208 | 0 | 11.94 | 119.9 | Horiba Meter. Pre purge - this row only |
| | | 2:43 | 17.76 | 7.53 | 0.365 | 0 | 8.36 | 90.3 | Horiba Meter. Flow cell - remaining rows. |
| | | 2:53 | 16.93 | 7.25 | 0.366 | 0 | 9.57 | 102.4 | |
| | | 3:03 | 16.26 | 7.08 | 0.366 | 0 | 10.22 | 107.7 | |
| | | 3:23 | 14.59 | 7 | 0.366 | 0 | 10.39 | 105.6 | |
| | | 3:33 | 14.78 | 6.98 | 0.366 | 0 | 10.28 | 105.2 | |
| | | 3:43 | 14.89 | 6.98 | 0.366 | 0 | 10.34 | 105.7 | |
| | | 3:53 | 14.66 | 6.96 | 0.366 | 0 | 10.3 | 104.9 | |
| | | | | | | | | | |
| | **2.6.13** | 9:20 | 16.61 | 7.12 | 0.366 | 0 | 10.66 | 112.9 | Horiba meter |
| | | 9:30 | 17.84 | 6.99 | 0.368 | 0 | 0.67 | 7.3 | |
| | | 9:40 | 17.12 | 6.97 | 0.366 | 0 | 0.63 | 6.7 | |
| | | 9:50 | 16.71 | 6.97 | 0.366 | 0 | 0.56 | 6 | |
| | | 10:00 | 16.68 | 6.97 | 0.366 | 0 | 0.51 | 5.3 | |
| | | 10:10 | 16.97 | 6.98 | 0.366 | 0 | 0.48 | 5.1 | |
| | | 10:20 | 18.9 | 6.97 | 0.366 | 0 | 0.48 | 5.3 | |
| | | | | | | | | | |
| | **2.19.13** | 11:15 | 17.95 | 7.07 | 0.373 | 0 | 1.25 | 13.5 | Horiba meter |
| | | 11:25 | 16.63 | 6.98 | 0.371 | 0 | 0.72 | 7.6 | |
| | | 11:35 | 15.99 | 6.95 | 0.369 | 0 | 0.63 | 6.6 | |
| | | 11:45 | 16.03 | 6.95 | 0.369 | 0 | 0.61 | 6.4 | |
| | | | | | | | | | |
| | **3.1.13** | 2:30 | 24.31 | 7.19 | 0.383 | 43.2 | 7.62 | 93.2 | Horiba Meter. Pre purge - this row only |
| | | 2:40 | 19.03 | 7.14 | 0.37 | 0 | 0.43 | 4.7 | Horiba Meter. Flow cell - remaining rows. |
| | | 2:50 | 18.57 | 7.01 | 0.37 | 0 | 0.4 | 4.4 | |
| | | 3:00 | 18.3 | 6.99 | 0.369 | 0 | 0.33 | 3.6 | |

# Chronological Well Log

11/15/12 @ 8:15 AM

- BH-#1 static water level before sectional pumping or airlifting
    - Pipe A = 48’-3”
    - Pipe B = 49’-0”
    - Pipe C = 46’-0”
    - Pipe D = 46’-9”

8:25 AM

- BH-#1 GPM during sectional pump of Pipe A (pumping of section 170’ – 175’)
    - Pipe A = 6 GPM

8:30 AM

- BH #1 GPM during airlift of Pipe C until clear simultaneously with sectional pumping of Pipe A
    - Pipe C = 5 GPM

9:08 AM

- Measured water level @ BH #1 during airlift of pipe C and sectional pump of pipe A
    - Pipe-A = 102’-0”
    - Pipe B = 102’-6”
    - Pipe C = 100’-0” (Measured with airlift off due to inaccessibility of well during airlift)
    - Pipe D = 72’-0”

9:25-9:30 AM

- Measured GPM at BH #1
    - Pipe A = 1.8 GPM
    - Pipe C = 5 GPM

9:34 AM

- Rechecked water level at BH #1
    - Pipe A = 102’-0”

9:35 AM

- Turned air off to pipe C @ BH #1

10:10 AM

- Measured GPM at BH #1 during sectional pumping of pipe A (no airlift of pipe C)
    - Pipe A = 3.3 GPM

10:12 AM

- Measured water level at BH #1 during sectional pumping of pipe A (no airlift of pipe C)
    - Pipe A = 99’-9”
    - Pipe B = 100’-4”
    - Pipe C = 71’-0”
    - Pipe D = 61’-0”

11:00 AM

- Measured GPM at BH #1 during sectional pump of pipe A
    - Pipe A = 3.3 GPM

11:05 AM

- Moved sectional pump at BH #1 down pipe A to 175’ – 180’

11:10 AM

- Measured GPM at BH #1 during sectional pump of pipe A
    - Pipe A = 8.3 GPM

11:12 AM

- Measured water level at BH #1 during sectional pump of pipe A
    - Pipe A = 103’-0”
    - Pipe B = 92’-0”
    - Pipe C = 71’-0”
    - Pipe D = 58’-6”

12:58 PM

- Measured GPM at BH #1 while sectional pumping pipe A
    - Pipe A = 5 GPM
- Measured water level at BH #1 while sectional pumping pipe A
    - Pipe A = 105’-4”
    - Pipe B = 106’-0’
    - Pipe C = 71’-0”
    - Pipe D = 58’-6”

1:15 PM

- Lowered sectional pump of BH #1 pipe A to 180’-185’

1:20 PM

- Measured GPM at BH #1 while sectional pumping pipe A
    - Pipe A = 3 GPM

1:30 PM

- Restarted airlift at BH #1 for pipe C and measured GPM
    - Pipe C = 5 GPM

2:00 PM

- Measured GPM at BH #1 while sectional pumping pipe A and airlifting pipe C
    - Pipe A = 1.7 GPM
    - Pipe C = 4.5 GPM

2:15 PM

- Measured water level at BH #1 sectional pumping pipe A and airlifting pipe C
    - Pipe A = 109’-6”
    - Pipe B = 85’-0”
    - Pipe C = 110’-0” (Measured with airlift off due to inaccessibility of well during airlift)
    - Pipe D = 74’-3”

2:30 PM

- Turned off airlift at pipe C.

2:30 PM

Stopped 48 Hr Pump test at BH #2 and measured GPM and temp, took water sample.

- 4” well = 92 GPM
- Water Temp = 68.5° F

5:15 PM

- re-measured new water sample from BH #2 after 48 hr pump test
    - 68.5° F
    - PH = 7.5
    - MS = .37
    - Ppt = .18
- Note: BH #2 water sample before pump until clear
    - 68.5° F
    - PH = 7.63
    - MS = 0.44
    - Ppt = 0.2
- BH #2 after pump until clear
    - 64.4° F
    - PH=7.42
    - MS = .37
    - Ppt = .2

11/16/12

10:52 PM

- Measure water level at BH #1
    - Pipe A = 49.5’
    - Pipe B = 49.9’
    - Pipe C = 47.0’
    - Pipe D = 46.9’

12:14 PM

- Measured water level at BH #1
    - Pipe C = 7.5 GPM

1:52 PM

- Started airlift of Pipe D at BH #1 and measured GPM
    - Pipe D = 8 GPM

2:17 PM

- Checked water level at BH #2 before sand test.
    - Pipe W = 48.0’
    - Pipe B = 41.5’
    - Pipe C = 48.4’

2:47 PM

- Measured water sample at BH #2 before sand test
    - 20.2° C
    - PH = 7.5
    - MS = 0.34
    - Ppt = 0.16

3:15 PM

- Started sand test at BH #2 and monitored GPM for entire duration with ultrasonic meter
    - 29 minutes 35 seconds @ 90 GPM

3:40 PM

- Measured water level at BH #2 before the end of the sand test.
    - Pipe W = 117.9’
    - Pipe B = 41.0’
    - Pipe C = 105.0’

3:54 PM

- Measured water sample at BH #2 after sand test
    - 20.2° C
    - PH = 7.3
    - MS = 0.34
    - Ppt = 0.17

4:30 PM

- Stopped airlift at BH #1 on pipe C & D water is still muddy.

11/19/12

9:10 AM

- Water level at BH #1
    - Pipe A = 48.3’
    - Pipe B = 48.3’
    - Pipe C = 45.5’
    - Pipe D = 44.5’
- GPM at BH #1
    - Pipe C = 6 GPM
    - Pipe D = 11 GPM

11:03 AM

- Water level at BH #1
    - A = 66.0’
    - B = 66.0’
    - C = 114.5’
    - D = 96.0’

1:43 AM

- Water level at BH #1
    - A = 68’
    - B = 68.8’
    - C = 120.0’
    - D = 98.0’
- GPM at BH #1
    - C = 3.1 GPM
    - D = 6 GPM

3:42

- Water level at BH #1
    - A = 67’
    - B = 67.6’
    - C = 120.6’
    - D = 102.6’
- GPM at BH #1
    - B = 5.9 GPM
    - C = 3.9 GPM

11/20/12

8:45 AM

- Water level at BH #1
  - A = 87.0’
  - B = 126.4’
  - C = 87.0’
  - D = 75.3’
- GPM at BH #1
  - B = 1 GPM
  - C = 6 GPM

9:18

- Water sample readings

  Hanna Meter
  - B = MS-1.53 / .76 Ppt / 20° C / 8.46PH
  - C = .43MS / 0.17 Ppt / 20° C / 8.2 PH

    Horiba Meter
  - C= 7.6 PH / -58 PHMP / 286 ORPmV / 0.362 MS per cm / 0 NTU / 11.13 MG/L DO / 0.235 G/L TDS / 0.2 PPT / 0 σt

    B= 8.14 PH / -89 PHMP / 145ORPmV / 1.54 MS per cm / 0 NTU / 7 MG/L DO / 0.983 G/T TDS / 0.8 PPT / 0 σt

8:50 AM

- Restarted airlift of pipe B at BH #2 and measured water level for Pipe W & B
    - Pipe W =39.7’
    - Pipe C = 39.3’
    - Pipe B = 10 GPM (Airlift in progress)

9:46 AM

- Re-measured water level at BH #2 with airlift of pipe B in progress and before purging of pipe W
    - Pipe W = 39.5
    - Pipe C = 39.5

9:55 AM

- Started purging of pipe W and measured GPM (Note loggers are at 230’ for pipe W & C)
    - Pipe W=8 GPM for 1Hr 43 Min
    - Pipe B = 10 GPM

10:20 AM

- Measured water level at BH #2 while airlifting pipe B and purging pipe W
    - Pipe W = 42.9’
    - Pipe C = 42.9’

10:45

- Started clay test for pipe W at BH #2

11:50 AM

- Measured GPM of pipe W at BH #2 and stopped purge
    - Pipe W = 7.5 GPM

12:15 PM

- Started flow cell water quality test for pipe W at BH #2

1:00 PM

- Recorded water quality at BH #2
    - Pipe W = 19.89° C / 7.48PH / -24PHmv / -65 ORPMV / 0.328 MS/CM / 0 NTU / 0.58 MG/LDO / 6.0 % DO / .213 g/L TDS / 0.2PPT / 0 Sigma T

1:20 PM

- Pulled pump from Pipe W and put down pipe C at BH #2

1:45 PM

- Measured water level at BH #2 while airlifting pipe B and before purging of pipe C
    - Pipe W = 39.8’
    - Pipe C = 39.8’

1:48 PM

- Started purge of pipe C at BH #2 while still airlifting pipe B
    - Pipe C = 8 GPM for 5 Minutes

2:03

- Started flowcell test of pipe C at BH #2 while airlifting pipe B

2:05

- Retrieved water sample from BH #2 pipe B during airlift, water is slightly opaque. (Air compressor is low on fuel)



2:27 PM

- Measured water quality at BH #2
    - Pipe C 20.39° C / 7.51 PH / -26 PHMV / -52 ORPMV / 0.339 MS/cm / 0.4 NTU / 0.38 MG/L DO / 4.3 % DO / 0.220 g/l TDS / 0.2 PPT / 0.0 Sigma T

2:50 PM

- Removed pump from pipe C and inserted into pipe B at BH #2 (Pump is at 165’ / top of screen is 175’ / logger is at 155’)

2:55 PM

- Measured water level at BH #2
    - Pipe B = 53.0’

3:12 PM

- Started pump til clear using Grundfos pump in pipe B at BH #2. (Note: Generator trips overload at 20 amps when VFD is at 400 Hz. We turned VFD down to 321 Hz and generator was pulling 11 Amps to eliminate tripping. Probable cause of additional amps from pipe C to pipe D is likely due to dirty water.)
    - Slightly clear water sample after airlifting, and muddy water sample at the beginning of pumping with the Grundfos Pump. (Not sure of why water gets dirty after sitting for a while.)



11/30/12

7:30 AM

- Measured water level at BH #2 with no pumping. (small generator appears to have run for approx 6 Hrs pumping pipe B and is out of gas)
    - Pipe W = 39.5’
    - Pipe B = 44.3’
    - Pipe C = 39.4’

7:45 AM

- Connected Grundfos to big Gen Set and the GFCI receptacle trips. Reconnected Grundfos to small generator and water pumped clear for approx 3 minutes then got muddy again. Amps increased to 20 and small generator tripped overload. Turned VFD down to approx 375 HZ and water is still very muddy from pipe B at BH #2. (VFD fault code: DC Bus Low)



9:00AM-10:00 AM

- Trip to Lowes

10:00

2:00 PM

- Restarted grundfos pump of pipe B at BH #2
    - Pipe B = 32.6’

2:05 PM

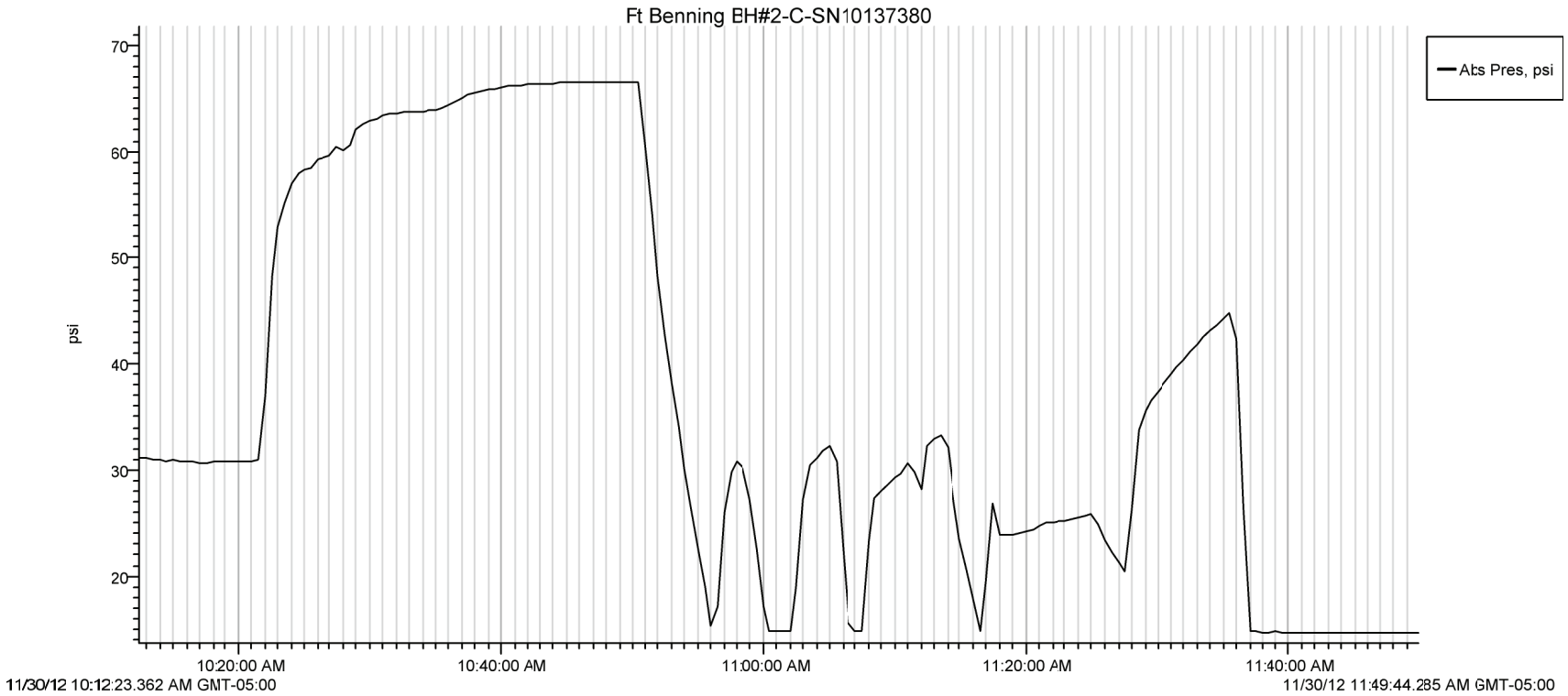
- Grundfos stopped pumping

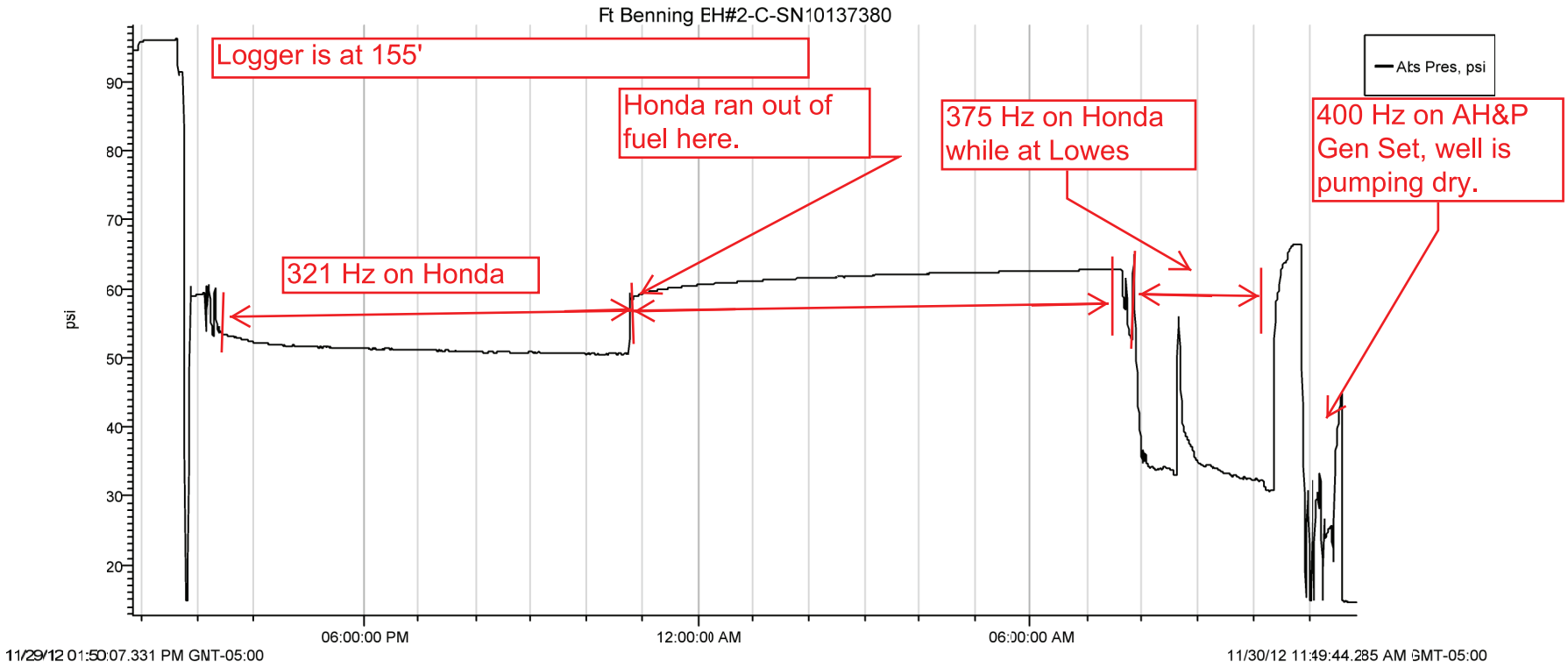
2:10 PM

- Restarted Grundfos Measured water level at pipe B

- Pipe B = approx 130’ and drops to pump level at 165’ within a couple of minutes, flow stoped. Stopped pump and flushed with fresh water.

Close up view of pump going dry at BH #2 pipe B on 11/30/12




Ft Benning EH#2-C-SN10137380
Logger is at 155'
Honda ran out of fuel here.
375 Hz on Honda while at Lowes
400 Hz on AH&P Gen Set, well is pumping dry.
321 Hz on Honda
Ats Pres, psi
psi
90
80
70
60
50
40
30
20
06:00:00 PM
12:00:00 AM
06:00:00 AM
11/29/12 01:50:07.331 PM GMT-05:00
11/30/12 11:49:44.285 AM GMT-05:00

12/3/12

8:30 AM

- Put 50 Gallons of diesel into compressor (Not quite full)
- Restarted airlift at BH #1 Pipe B & C after weekend. (Airlift ran on fri. night until compressor ran out of fuel)
- Took water sample from pipe C & D at BH #1. (C & D ran clear for approx 2 minutes then became muddy again)
- Measured GPM at BH #1
    - Pipe C = 5 GPM
    - Pipe D = 10 GPM




9:45 AM

- Took water sample at BH #1 Pipe C & D. (Water is slightly clearer)



10:00 AM– 11:00 AM

- Inserted Grundfos pump into pipe B at BH #2 and measured depth of well
    - Pipe B = 185’ Deep
- Raised pump to 170’
- Measured water level at BH #2
    - Pipe B = 27.9’
- Lowered probe to 77.9’

11:14 AM

- Started Grundfos at 301 Hzin Pipe B of BH #2.
- Measured GPM and monitored water level indicator.
    - Pipe B = 4 GPM

11:15 AM

- Water level in pipe B at BH #2 reached 77.9’

11:18 AM

- Water level in pipe B at BH #2 reached 120.0’
- Water level indicator hanging up on PEX unable to drop down

11:20 AM

- Water stopped flowing, shut pump off.

11:25 AM

- Recovery of pipe B at BH #2 (Based on recovery we should only be able to pump at a rate of approx .3 GPM_
    - 11:25 AM – 81’
    - 11:27 AM – 76.6’
    - 11:30 AM – 67.8’
    - 11:32 AM – 63’
    - 11:51 AM – 42.4’

12:00 PM -1:00 PM

- Lunch and Diesel Run.

1:00 PM

- Poured in 27 gallons into compressor (Gauge was reading empty before filling, gauge is not correct.) Compressor is now full. Took Water Sample at BH #1 Pipe C & D.




1:22 PM

- Measured water level at BH #2
    - Pipe B = 40.9'

1:33 PM

- Started Grundfos at BH #2 pipe B at 220 Hz (too fast well probably is drawing down quickly.) Quickly turn VFD down to 185 Hz
    - Pipe B = approx .5 GPM
- Retrieved water sample at BH #2 Pipe B



1:37 PM

- Monitoring water level at BH #2 Pipe B.
    - 1:37 PM – 66.7’
    - 1:39 PM – 67.7’
    - 1:46 PM – 68.3’

1:48 PM – 1:53 PM

- Increased VFD to 209 Hz at BH #2 pipe B and measured flow
    - Pipe B = 1 GPM

1:54 PM

- Monitored water level at BH #2 Pipe B
    - 1:54 PM - 78.4’
    - 1:58 PM – 78.8’
    - 2:04 PM – 78.8’
    - 2:08 PM – 78.0’

2:10 PM

- Increased VFD at BH #2 Pipe B to 231 Hz
    - Pipe B = 2 GPM

2:12 PM

- Monitored water level at BH #2 Pipe B
    - 2:12 PM – 85.0’
    - 2:14 PM – 86.9’
    - 2:21 PM – 86.9’
    - 2:28 PM – 85.6’

2:18 PM

- Re-measured flow at BH #2
    - Pipe B – 1.8 GPM

2:30 PM

- Increased VFD at BH #2 Pipe B to 251 Hz
    - Pipe B = 2.5 GPM

2:33 PM

- Monitored water level at BH #2 Pipe B
    - 2:33 PM – 92.5’
    - 2:40 PM – 98.5’
    - 2:50 PM – 97.6’

2:53 PM

- Re-measured flow at BH #2.
    - Pipe B – 2 GPM

3:15 PM

- Monitored water level at BH #2 Pipe B
    - 3:15 PM – 97.6’
    - 3:40 PM – 99.0’

3:45 PM

- Took water sample at BH #2 Pipe B

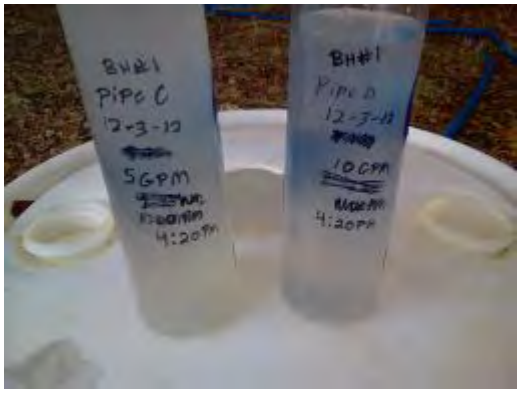



3:49 PM

- Re-measured flow at BH #2.
    - Pipe B = 1.6 GPM
- Monitored water level at BH #2 Pipe B
    - 3:49 PM – 106.5’
    - 3:54 PM – 112.0’
    - 4:11 PM – 111.6’

4:20 PM

- Topped off the air compressor with diesel
    - Added 13 gallons (compressor is full)
- Took water sample at BH #1 for Pipe C & D




4:27 PM

- Monitored water level at BH #2
    - 4:27 PM – 109.0’
    - 4:33 pm - 108.0’

12/4/12

8:10 AM

- Took water sample from BH #2 Pipe B and measured water level (Pump ran all night at 251 Hz and approx. 1.6 GPM)
    - Pipe B = 114.0'




8:20 AM

- Put 50 gallons of fuel in compressor after it ran out of fuel last night.

8:45 AM

- Took water sample from BH #1 and measured flow.
    - Pipe C – 2.5 GPM
    - Pipe D – 5 GPM



9:00 AM

- Set up water meter to monitor water quality of pipe D as it clears throughout the day while airlifting. (Measuring quality of water pictured above)

| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9:15 AM | 16.7 | 8.36 | -75 | 164 | 0.419 | 0 | 6.48 | 68.6 | 0.272 | 0.2 | 0 |
| 9:20 AM | 16.98 | 8.35 | -74 | 169 | 0.416 | 0 | 6.05 | 64.5 | 0.27 | 0.2 | 0 |
| 9:25 AM | 17.43 | 8.35 | -74 | 174 | 0.412 | 0 | 5.77 | 62.2 | 0.267 | 0.2 | 0 |
| 9:30 AM | 18.13 | 8.35 | -74 | 178 | 0.406 | 0 | 5.47 | 59.9 | 0.264 | 0.2 | 0 |
| Notes: Sample from airlift using sample cup | | | | | | | | | | | |

9:40 AM

- Got water sample from BH #1 Pipe C & D and set up meter to monitor water quality of pipe D.




| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:05 AM | 22.17 | 8.6 | -90 | 142 | 0.417 | 800 (1) | 4.35 | 51.3 | 0.271 | 0.2 | 0 |
| 10:10 AM | 22.72 | 8.59 | -90 | 146 | 0.417 | 800 (1) | 4.27 | 50.7 | 0.271 | 0.2 | 0 |
| 10:15 AM | 23.32 | 8.58 | -90 | 150 | 0.422 | 800 (1) | 4.58 | 55 | 0.274 | 0.2 | 0 |
| 10:20 AM | 23.82 | 8.57 | -89 | 153 | 0.49 | 800 (1) | 4.49 | 54.2 | 0.272 | 0.2 | 0 |
| Notes | (1)Parameter is flashing, possible high limit range | | | | | | | | | | |
| | Sample from airlift using sample cup | | | | | | | | | | |

10:28 AM

- Measured water level at BH #2 and took water sample.
  - Pipe B = 113.0'




| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:50 AM | 25.26 | 7.96 | -53 | 146 | 0.328 | 234 | 7.1 | 87.9 | 0.213 | 0.2 | 0 |
| 10:55 AM | 25.79 | 7.95 | -53 | 153 | 0.333 | 225 | 7.02 | 87.7 | 0.217 | 0.2 | 0 |
| 11:00 AM | 26.49 | 7.95 | -53 | 158 | 0.343 | 221 | 6.87 | 86.8 | 0.223 | 0.2 | 0 |
| 11:05 AM | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| 11:29 AM | 27.34 | 7.96 | -53 | 175 | .348 | 160 | 6.78 | 86.6 | .226 | .2 | 0 |
| Notes | Sample from Grundfos Pump using sampling cup | | | | | | | | | | |
| | (1) Meter went off for unknown reason. After meter turns off it takes 15 minutes to stabilize again. | | | | | | | | | | |

12:50 PM

- Put 28 gallons of fuel in air compressor, air compressor is now full.

12:55 PM

- Took water sample at BH #1 Pipe C & D and started water quality test for pipe D.




| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | Σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:15 PM | 25.81 | 8.6 | -91 | 155 | 0.393 | 195 | 7.07 | 88.2 | 0.256 | 0.2 | 0 |
| 1:20 PM | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| 1:35 PM | 26.46 | 8.59 | -91 | 168 | 0.398 | 187 | 6.9 | 87.2 | 0.259 | 0.2 | 0 |
| 1:40 PM | 26.35 | 8.6 | -91 | 169 | .397 | 182 | 6.92 | 87.2 | .258 | .2 | 0 |
| 1:45 PM | 26.23 | 8.59 | -91 | 171 | .398 | 177 | 6.95 | 87.4 | .258.20 | | |
| 1:50 PM | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Notes | Sample from airlift using sampling cup | | | | | | | | | | |
| | (1)Meter turned off for unknown reason, battery level indicator is full. Waiting 15 more minutes for readings to stabilize. | | | | | | | | | | |

1:20 PM

- Topped off AH&P Genset with 9 gallons of fuel. (Burned approx 9 gallons in 26 Hrs)

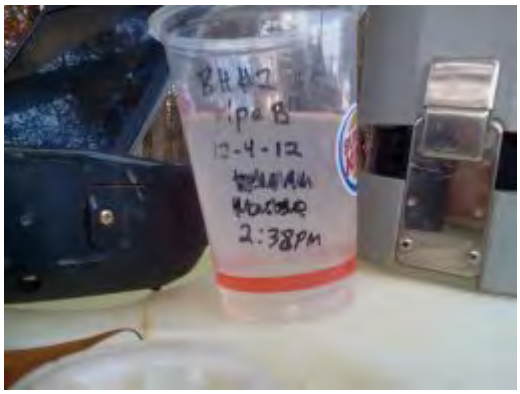
2:00 PM

Attempted flowcell water quality reading at BH #2 with Grundfos. Turned flow down from 1.6 GPM to 0.1-0.5 L/min. As well begins recovery the flow steadily increases and therefore the VFD needs to be turned down periodically to maintain 0.1 – 0.5 L/min. This process takes at least 40 minutes- 1 Hr, and

we feel that the time would be better spent by measuring water quality using the sampling cup instead of the flowcell. This allows the well to flow at max rate for longer, instead of flowing at a very low rate for approx. 1 Hr just to get 1 sample reading.

2:38 PM

- Started flowcell reading of Pipe B at BH #2.




| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2:55 PM | 24.36 | 7.85 | -47 | -26 | 0.315 | 163 | 0.4 | 4.9 | 0.205 | 0.1 | 0 |
| 3:00 PM | 24.77 | 7.86 | -47 | -22 | .315 | 172 | .36 | 4.4 | .205 | .1 | 0 |
| 3:05 PM | 24.97 | 7.86 | -47 | -18 | .314 | 178 | .33 | 4.0 | .204 | .1 | 0 |
| 3:10 PM | 25.11 | 7.87 | -48 | -13 | .314 | 171 | .29 | 3.6 | .204 | .1 | 0 |
| Notes | Sample from Grundfos using flowcell. | | | | | | | | | | |
| | | | | | | | | | | | |

3:30 PM

- Took water sample from BH #1 pipe C & D, and started water quality test for pipe D.



| Time | °C | PH | pHmV | ORPmV | mS/cm | NTU | mg/L DO | % DO | g/L TDS | ppt | σt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3:45 PM | 22.02 | 6.87 | -6 | 219 | 0.163 | 135 | 7.24 | 85.2 | 0.105 | 0.1 | 0 |
| 3:50 PM | 22.04 | 6.86 | -1 (1) | 222 | .161 | 132 | 7.26 | 85.3 | .105 | .1 | 0 |
| 3:55 PM | 22.21 | 6.7 | 15 | 233 | .161 | 121 | 7.22 | 85 | .105 | .1 | 0 |
| 4:00 PM | 22.34 | 7.06 | 32 | 221 | .163 | 114 | 7.16 | 84.5 | .105 | .1 | 0 |
| Notes | Sample from airlift using sample cup. | | | | | | | | | | |
| | (1) Data is ranging from -6 to +32 | | | | | | | | | | |

3:45 PM

- Topped off air compressor.

Comparison

- BH #1 from start to finish on 12/4/12

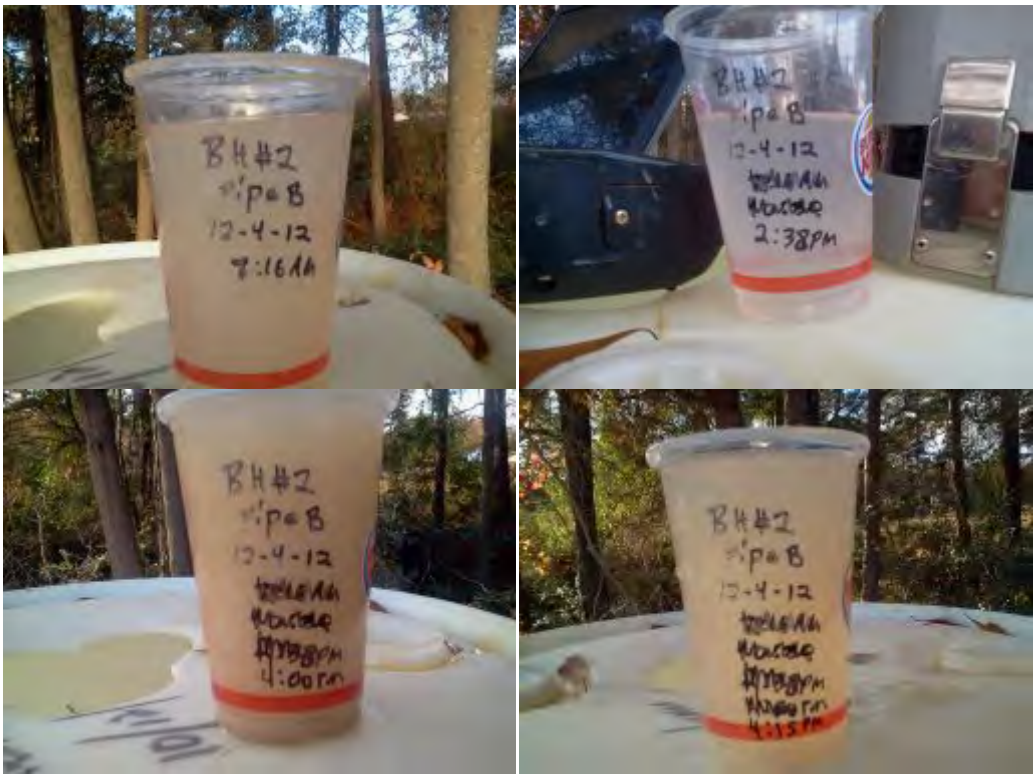








- BH #2 from start to finish on 12/4/12. (After sampling at low flow with flowcell water became muddy again after resuming pump to 2 GPM.)



# Airlifting of BH #1

| | Pipe A (1) | Pipe B | Pipe C | Pipe D | | |
|---|---|---|---|---|---|---|
| Top of Screen | 150 | 150 | 220 | 255 | | |
| Depth of Air Pipe | 150 | 140 | 210 | 245 | | |
| | | | | | | |
| **Static Water Level** | 48.25 | 49 | 46 | 46.75 | | |
| Total Lift @ Static Water Level | 48.25 | 49 | 46 | 46.75 | | |
| Submergence @ Static Water Level | 67.83% | 65.00% | 78.10% | 80.92% | | |
| GPM per CFM at Static Water Level | 4.3 | 3.9 | 5.6 | 5.8 | | |
| CFM applied to well at Static Water Level | 1.4 | 1.3 | 0.9 | 1.9 | Total CFM | 5.5 |
| GPM Produced | 6 | 5 | 5 | 11 | | |
| Minimum Air Pressure Required at Static Water Level | 44.05 | 39.39 | 71.00 | 85.82 | | |
| | | | | | | |
| **Initial Drawdown** | **102** | **102** | **100** | **96** | | |
| **GPM/ft Drawdown** | **0.11** | **0.09** | **0.09** | **0.22** | | |
| Total Lift @ Initial Drawdown | 102 | 102 | 100 | 96 | | |
| Submergence @ Initial Drawdown | 32.00% | 27.14% | 52.38% | 60.82% | | |
| GPM per CFM at Initial Drawdown | 0.85 | 0.65 | 1.54 | 2.3 | | |
| CFM applied to well at Initial Drawdown | 7.1 | 7.7 | 3.2 | 4.8 | Total CFM | 22.8 |
| GPM Produced | 6 | 5 | 5 | 11 | | |
| Minimum Air Pressure Required at Initial Drawdown | 20.78 | 16.45 | 47.62 | 64.50 | | |
| | | | | | | |
| **Maximum Drawdown** | **120** | **114** | **160** | **190** | | |
| Total Lift @ Optimum Drawdown | 120 | 114 | 160 | 190 | | |
| Submergence @ Optimum Drawdown | 20.00% | 18.57% | 23.81% | 22.45% | | |
| GPM per CFM at Optimum Drawdown | 0.4 | 0.4 | 0.4 | 0.4 | | |
| CFM applied to well at Optimum Drawdown | 20.0 | 15.3 | 26.4 | 80.0 | Total CFM | 141.7 |
| GPM Produced | 8 | 6 | 11 | 32 | | |
| Minimum Air Pressure Required at Optimum Drawdown | 12.99 | 11.26 | 21.65 | 23.81 | | |

Notes (1) Air fitting is at the top of the screen

# Airlifting of BH #2

| | | | Pipe B | | | |
|---|---|---|---|---|---|---|
| Top of Screen | | | 175 | | | |
| Depth of Air Pipe | | | 165 | | | |
| | | | | | | |
| **Static Water Level** | | | 27.9 | | | |
| Total Lift @ Static Water Level | | | 27.9 | | | |
| Submergence @ Static Water Level | | | 83.09% | | | |
| GPM per CFM at Static Water Level | | | 9.5 | | | |
| CFM applied to well at Static Water Level | | | 0.2 | | Total CFM | 0.2 |
| GPM Produced | | | 2 | | | |
| Minimum Air Pressure Required at Static Water Level | | | 59.35 | | | |
| | | | | | | |
| **Initial Drawdown** | | | **87** | | | |
| **GPM/ft Drawdown** | | | **0.03** | | | |
| Total Lift @ Initial Drawdown | | | 87 | | | |
| Submergence @ Initial Drawdown | | | 47.27% | | | |
| GPM per CFM at Initial Drawdown | | | 1.54 | | | |
| CFM applied to well at Initial Drawdown | | | 1.3 | | Total CFM | 1.3 |
| GPM Produced | | | 2 | | | |
| Minimum Air Pressure Required at Initial Drawdown | | | 33.77 | | | |
| | | | | | | |
| **Maximum Drawdown** | | | **135** | | | |
| Total Lift @ Optimum Drawdown | | | 135 | | | |
| Submergence @ Optimum Drawdown | | | 18.18% | | | |
| GPM per CFM at Optimum Drawdown | | | 0.4 | | | |
| CFM applied to well at Optimum Drawdown | | | 9.1 | | Total CFM | 9.1 |
| GPM Produced | | | 4 | | | |
| Minimum Air Pressure Required at Optimum Drawdown | | | 12.99 | | | |

Notes

BH#1 pipe c GPM per CFM during airlifting. 2.4.13

| Time | On/Off | Water level | GPM | Raw CFM | PSIG | Temp | SCFM | Top of Screen | Length of Airline | % Submersion | GPM per CFM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 46 | | | 71 | | | 220 | 210 | 78.10% | |
| 3:45 | | 46 | | | | | | 220 | 210 | 78.10% | |
| 3:46 | | 46 | | | | | | 220 | 210 | 78.10% | |
| 3:47 | On | 50 | | | | | | 220 | 210 | 75.98% | |
| 3:48 | On | 55 | | | | | | 220 | 210 | 73.87% | |
| 3:49 | On | 59 | | | | | | 220 | 210 | 71.75% | |
| 3:50 | On | 64 | 3.2 | 8.5 | 57 | 70 | 18.77 | 220 | 210 | 69.64% | 0.17 |
| 3:51 | On | 68 | 3.3 | 10 | 49 | 71 | 20.80 | 220 | 210 | 67.52% | 0.16 |
| 3:52 | On | 73 | 2.9 | 10 | 49 | 72 | 20.78 | 220 | 210 | 65.41% | 0.14 |
| 3:53 | On | 77 | 3.1 | 10 | 49 | 72 | 20.78 | 220 | 210 | 63.30% | 0.15 |
| 3:54 | On | 82 | 3.2 | 10 | 49 | 80 | 20.62 | 220 | 210 | 61.18% | 0.16 |
| 3:55 | On | 86 | 2.5 | 10 | 48 | 88 | 20.31 | 220 | 210 | 59.07% | 0.12 |
| 3:56 | On | 90 | 3.6 | 10 | 48 | 92 | 20.24 | 220 | 210 | 56.95% | 0.18 |
| 3:57 | On | 95 | 3.3 | 10 | 48 | 94 | 20.20 | 220 | 210 | 54.84% | 0.16 |
| 3:58 | On | 99 | 3.4 | 10 | 48 | 96 | 20.16 | 220 | 210 | 52.72% | 0.17 |
| 3:59 | On | 104 | 3.2 | 10 | 48 | 96 | 20.16 | 220 | 210 | 50.61% | 0.16 |
| 4:00 | On | 108 | 2.6 | 10 | 48 | 97 | 20.15 | 220 | 210 | 48.50% | 0.13 |
| 4:01 | On | 113 | 2.9 | 10 | 48 | 98 | 20.13 | 220 | 210 | 46.38% | 0.14 |
| 4:02 | On | 117 | 3.2 | 10 | 48 | 98 | 20.13 | 220 | 210 | 44.27% | 0.16 |
| 4:03 | On | 121 | 3.2 | 10 | 48 | 98 | 20.13 | 220 | 210 | 42.15% | 0.16 |
| 4:04 | On | 126 | 2.9 | 10 | 48 | 99 | 20.11 | 220 | 210 | 40.04% | 0.14 |
| 4:05 | On | 130 | 2.9 | 10 | 48 | 100 | 20.09 | 220 | 210 | 37.92% | 0.14 |
| 4:06 | On | 135 | 3.1 | 10 | 47.5 | 100 | 20.01 | 220 | 210 | 35.81% | 0.15 |
| 4:07 | On | 139 | 2.6 | 10 | 47.5 | 100 | 20.01 | 220 | 210 | 33.70% | 0.13 |
| 4:08 | On | 144 | 3.4 | 10 | 47.5 | 100 | 20.01 | 220 | 210 | 31.58% | 0.17 |
| 4:09 | On | 148 | 2.9 | 10 | 47.5 | 100 | 20.01 | 220 | 210 | 29.47% | 0.14 |
| 4:10 | On | 153 | 3.1 | 10 | 47.5 | 101 | 19.99 | 220 | 210 | 27.35% | 0.16 |
| 4:11 | On | 157 | 3.1 | 10 | 47.5 | 101 | 19.99 | 220 | 210 | 25.24% | 0.16 |
| 4:12 | On | 161 | 3.1 | 10 | 47.5 | 101 | 19.99 | 220 | 210 | 23.12% | 0.16 |
| 4:13 | On | 166 | 3.1 | 10 | 47.5 | 101 | 19.99 | 220 | 210 | 21.01% | 0.16 |
| 4:14 | Off | 166 | | | 19 | | | | | | |
| 4:15 | Off | 152 | | | 25 | | | | | | |
| 4:16 | Off | 115 | | | 41 | | | | | | |
| 4:17 | Off | 97 | | | 49 | | | | | | |
| 4:18 | Off | 90 | | | 52 | | | | | | |
| 4:19 | Off | 81 | | | 56 | | | | | | |
| 4:20 | Off | 76 | | | 58 | | | | | | |
| 4:21 | Off | 71 | | | 60 | | | | | | |
| 4:22 | Off | 69 | | | 61 | | | | | | |
| 4:23 | Off | 67 | | | 62 | | | | | | |
| 4:24 | Off | 64 | | | 63 | | | | | | |
| 4:25 | Off | 60 | | | 65 | | | | | | |
| 4:26 | Off | 60 | | | 65 | | | | | | |
| 4:27 | Off | 58 | | | 66 | | | | | | |
| 4:28 | Off | 58 | | | 66 | | | | | | |
| 4:29 | Off | 56 | | | 67 | | | | | | |
| Notes: | Interpolated Data | | | | | | | | | | |

**BH#2 pipe b GPM per CFM during airlifting 2.4.13**

| Time | On/Off | Water level | GPM | Raw CFM | PSIG | Temp | SCFM | Top of Screen | Length of Airline | % Submersion | GPM per CFM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Off | 73 | | | 40 | | | 175 | 165 | 55.76% | |
| 4:35 | On | 75 | 6 | 5 | 56 | 64 | 11.03 | 175 | 165 | 54.44% | 0.54 |
| 4:36 | On | 77 | 5.5 | 8 | 40 | 66 | 15.49 | 175 | 165 | 53.13% | 0.36 |
| 4:37 | On | 80 | 5.8 | 8 | 40 | 67 | 15.48 | 175 | 165 | 51.81% | 0.37 |
| 4:38 | On | 82 | 5.6 | 8 | 40 | 70 | 15.43 | 175 | 165 | 50.50% | 0.36 |
| 4:39 | On | 84 | 5.5 | 8 | 40 | 71 | 15.42 | 175 | 165 | 49.18% | 0.36 |
| 4:40 | On | 86 | 5.6 | 8 | 40 | 75 | 15.36 | 175 | 165 | 47.87% | 0.36 |
| 4:41 | On | 88 | 6 | 8 | 40 | 80 | 15.29 | 175 | 165 | 46.55% | 0.39 |
| 4:42 | On | 90 | 5.3 | 8 | 40 | 84 | 15.23 | 175 | 165 | 45.24% | 0.35 |
| 4:43 | On | 93 | 5.8 | 8 | 40 | 88 | 15.18 | 175 | 165 | 43.92% | 0.38 |
| 4:44 | On | 95 | 5.3 | 8 | 40 | 90 | 15.15 | 175 | 165 | 42.61% | 0.35 |
| 4:45 | On | 97 | 5.1 | 8 | 40 | 93 | 15.11 | 175 | 165 | 41.29% | 0.34 |
| 4:46 | On | 99 | 5.5 | 8 | 40 | 95 | 15.08 | 175 | 165 | 39.98% | 0.36 |
| 4:47 | On | 101 | 5.6 | 8 | 40 | 95 | 15.08 | 175 | 165 | 38.66% | 0.37 |
| 4:48 | On | 103 | 5.5 | 8 | 40 | 96 | 15.07 | 175 | 165 | 37.35% | 0.37 |
| 4:49 | On | 106 | 5.6 | 8 | 40 | 97 | 15.05 | 175 | 165 | 36.03% | 0.37 |
| 4:50 | On | 108 | 5.6 | 8 | 40 | 97 | 15.05 | 175 | 165 | 34.72% | 0.37 |
| 4:51 | On | 110 | 5.6 | 8 | 40 | 98 | 15.04 | 175 | 165 | 33.40% | 0.37 |
| 4:52 | On | 112 | 5.6 | 8 | 40 | 99 | 15.03 | 175 | 165 | 32.08% | 0.37 |
| 4:53 | On | 114 | 5.6 | 8 | 40 | 100 | 15.01 | 175 | 165 | 30.77% | 0.37 |
| 4:54 | On | 116 | 5.6 | 8 | 40 | 100 | 15.01 | 175 | 165 | 29.45% | 0.37 |
| 4:55 | On | 119 | 5.6 | 8 | 40 | 100 | 15.01 | 175 | 165 | 28.14% | 0.37 |
| 4:56 | On | 121 | 5.6 | 8 | 40 | 100 | 15.01 | 175 | 165 | 26.82% | 0.37 |
| 4:57 | On | 123 | 5.6 | 8 | 40 | 100 | 15.01 | 175 | 165 | 25.51% | 0.37 |
| 4:58 | Off | 123 | | | 18 | | | | | | |
| 4:59 | Off | 119 | | | 20 | | | | | | |
| 5:00 | Off | 107 | | | 25 | | | | | | |
| 5:01 | Off | 105 | | | 26 | | | | | | |
| 5:02 | Off | 103 | | | 27 | | | | | | |
| 5:03 | Off | 84 | | | 35 | | | | | | |
| 5:04 | Off | 61 | | | 45 | | | | | | |
| 5:05 | Off | 61 | | | 45 | | | | | | |
| 5:06 | Off | 61 | | | 45 | | | | | | |
| 5:07 | Off | 61 | | | 45 | | | | | | |
| 5:08 | Off | 61 | | | 45 | | | | | | |
| 5:09 | Off | 61 | | | 45 | | | | | | |
| 5:10 | Off | 61 | | | 45 | | | | | | |
| 5:11 | Off | 61 | | | 45 | | | | | | |
| 5:12 | Off | 61 | | | 45 | | | | | | |
| 5:13 | Off | 61 | | | 45 | | | | | | |

**Notes:** **Interpolated Data**

BH#1 pipe w GPM per CFM during airlifting 2.4.13

| Time | On/Off | Water level | GPM | Raw CFM | PSIG | Temp ° F | SCFM | Top of Screen | Length of Airline | % Submersion | GPM per CFM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2:58 | Off | 46 | | | | | | 150 | 150 | 69.33% | |
| 3:02 | On | 49 | 17.7 | 14 | 24 | 75 | 22.61 | 150 | 150 | 67.10% | 0.78 |
| 3:03 | On | 53 | 7.7 | 15 | 22 | 78 | 23.52 | 150 | 150 | 64.98% | 0.33 |
| 3:04 | On | 56 | 7.7 | 15 | 21 | 80 | 23.16 | 150 | 150 | 62.75% | 0.33 |
| 3:05 | On | 59 | 4.1 | 16 | 21 | 81 | 24.68 | 150 | 150 | 60.51% | 0.17 |
| 3:06 | On | 63 | 4.6 | 16 | 21 | 84 | 24.61 | 150 | 150 | 58.28% | 0.19 |
| 3:07 | On | 66 | 7 | 16 | 21 | 87 | 24.54 | 150 | 150 | 56.05% | 0.29 |
| 3:08 | On | 69 | 5.7 | 16 | 21 | 90 | 24.48 | 150 | 150 | 53.81% | 0.23 |
| 3:09 | On | 73 | 5.1 | 16 | 21 | 94 | 24.39 | 150 | 150 | 51.58% | 0.21 |
| 3:10 | On | 76 | 5.9 | 16 | 21 | 96 | 24.34 | 150 | 150 | 49.35% | 0.24 |
| 3:11 | On | 79 | 4.5 | 16 | 21 | 98 | 24.30 | 150 | 150 | 47.11% | 0.19 |
| 3:12 | On | 83 | 4.6 | 16 | 21 | 100 | 24.26 | 150 | 150 | 44.88% | 0.19 |
| 3:13 | On | 86 | 4.3 | 16.5 | 20 | 102 | 24.62 | 150 | 150 | 42.65% | 0.17 |
| 3:14 | On | 89 | 5 | 16.5 | 20 | 103 | 24.60 | 150 | 150 | 40.41% | 0.20 |
| 3:15 | On | 93 | 3.9 | 16.5 | 20 | 104 | 24.57 | 150 | 150 | 38.18% | 0.16 |
| 3:16 | On | 96 | 4.7 | 16.5 | 20 | 104 | 24.57 | 150 | 150 | 35.95% | 0.19 |
| 3:17 | On | 99 | 4.4 | 16.5 | 20 | 105 | 24.55 | 150 | 150 | 33.71% | 0.18 |
| 3:18 | On | 103 | 4.8 | 16.5 | 20 | 105 | 24.55 | 150 | 150 | 31.48% | 0.20 |
| 3:19 | On | 106 | 4.4 | 16.5 | 20 | 106 | 24.53 | 150 | 150 | 29.25% | 0.18 |
| 3:20 | On | 109 | 4.5 | 16.5 | 20 | 106 | 24.53 | 150 | 150 | 27.01% | 0.18 |
| 3:21 | On | 113 | 4.6 | 16.5 | 20 | 106 | 24.53 | 150 | 150 | 24.78% | 0.19 |
| 3:22 | Off | 113 | | | 16 | | | | | | |
| 3:23 | Off | 113 | | | 16 | | | | | | |
| 3:24 | Off | 108 | | | 18 | | | | | | |
| 3:25 | Off | 104 | | | 20 | | | | | | |
| 3:26 | Off | 99 | | | 22 | | | | | | |
| 3:27 | Off | 95 | | | 24 | | | | | | |
| 3:28 | Off | 90 | | | 26 | | | | | | |
| 3:29 | Off | 88 | | | 27 | | | | | | |
| 3:30 | Off | 83 | | | 29 | | | | | | |
| 3:31 | Off | 83 | | | 29 | | | | | | |
| 3:32 | Off | 81 | | | 30 | | | | | | |
| 3:33 | Off | 81 | | | 30 | | | | | | |
| 3:34 | Off | 81 | | | 30 | | | | | | |
| 3:35 | Off | 78 | | | 31 | | | | | | |
| 3:36 | Off | 76 | | | 32 | | | | | | |

**Notes:** *** 2" eductor pipe used**

**Interpolated Data**

**Borehole 1 Pipe W**

4.5 gpm 275hz

**2.11.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/lTDS | ppt | st |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2:40 | 17.9 | 7.43 | -56 | 163 | 0.306 | 242 | 10.12 | 110 | 0.198 | 0.1 | 0 |
| 2:50 | 17.92 | 7.23 | -45 | 181 | 0.297 | 115 | 9.69 | 105.6 | 0.194 | 0.1 | 0 |
| 3:00 | 18.11 | 7.14 | -40 | 192 | 0.316 | 132 | 9.42 | 102.8 | 0.206 | 0.2 | 0 |
| 3:10 | 18.32 | 7.12 | -39 | 197 | 0.322 | 159 | 9.29 | 101.7 | 0.209 | 0.2 | 0 |
| 3:20 | 18.5 | 7.07 | -36 | 200 | 0.322 | 143 | 9.14 | 100.8 | 0.209 | 0.2 | 0 |
| 3:30 | 18.75 | 7.06 | -35 | 203 | 0.32 | 130 | 8.93 | 98.7 | 0.208 | 0.2 | 0 |
| 3:40 | 18.79 | 7.04 | -34 | 206 | 0.319 | 129 | 8.85 | 98 | 0.207 | 0.2 | 0 |

Left 1W pumping at 4.5gpm for 48h on/off test.

**2.14.13**

Pumped 8 55g drums of water with aqua clear down hole using pex to tremmie down to the top of the screen

**2.15.13**

Air surged from 10psi to 30psi going up as slowly as possible in increments of 5psi X5 and holding for 5mins each
Left W on 48h on/off test all weekend

**2.18.13**

Pumped 4 55g drums of water with aqua clear down hole using pex to tremmie down to the top of the screen
Air surged from 10psi to 20psi going up as slowly as possible in increments of 5psi X5 and holding for 5mins each
During air surging W, water comes out of B around 5psi. Screwed cap onto B to prevent this.
Left aquaclear for 24h in the well

**2.19.13**

Pumped 1W wide open at 7gpm for 80mins and left for 48h on/off pumping.

**2.21.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9:50 | 17.62 | 7.05 | -37 | 68 | 0.287 | 28.1 | 1.79 | 19.3 | 0.187 | 0.1 | 0 |
| 10:00 | 17.45 | 7 | -35 | 65 | 0.287 | 16.6 | 1.77 | 19.3 | 0.186 | 0.1 | 0 |
| 10:10 | 17.75 | 7.03 | -36 | 58 | 0.288 | 9.8 | 1.6 | 17.3 | 0.187 | 0.1 | 0 |
| 10:20 | 18.36 | 7.06 | -38 | 48 | 0.289 | 6.8 | 1.35 | 14.8 | 0.188 | 0.1 | 0 |
| 10:30 | 18.98 | 7.05 | -37 | 43 | 0.288 | 4.4 | 1.04 | 11.5 | 0.187 | 0.1 | 0 |
| 10:40 | 18.84 | 7.06 | -38 | 46 | 0.288 | 3.2 | 1.12 | 12.4 | 0.187 | 0.1 | 0 |

Pumped 4 55 gallon drums with aquaclear down W. Air surged 10-25psi and let sit over night.

**2.22.13**

Pumped 1W for 2 hours and left 1B pumping all weekend

**2.25.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | g/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11:55 | 12.48 | 7.1 | -40 | 133 | 0.312 | 11.9 | 5.27 | 51.2 | 0.203 | 0.1 | 0 |
| 12:05 | 11.91 | 7.01 | -35 | 140 | 0.308 | 9.2 | 5.41 | 51.8 | 0.2 | 0.1 | 0 |
| 12:15 | 11.59 | 7.01 | -35 | 139 | 0.307 | 9.8 | 4.69 | 44.6 | 0.2 | 0.1 | 0 |
| * 12:25 | 11.66 | 7.01 | -34 | 140 | 0.306 | 31 | 5.46 | 52.8 | 0.199 | 0.1 | 0 |
| 12:35 | 11.96 | 7.05 | -37 | 134 | 0.303 | 19.5 | 4.35 | 41.7 | 0.197 | 0.1 | 0 |
| 12:45 | 12.46 | 7.04 | -37 | 133 | 0.301 | 24 | 4.5 | 43 | 0.196 | 0.1 | 0 |

Left 1W pumping for 48h on/off test
*Bubbles coming out, water sputtering for 10 seconds, water got murky for 20 seconds, NTUs shot up.

**2.27.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:15 | 18.64 | 7.1 | -40 | 108 | 0.282 | 42.3 | 1.18 | 12.9 | 0.184 | 0.1 | 0 |
| 10:25 | 18.15 | 7.04 | -36 | 64 | 0.283 | 19.7 | 0.73 | 8 | 0.183 | 0.1 | 0 |
| 10:35 | 18.06 | 7.04 | -37 | 45 | 0.282 | 17 | 0.61 | 6.7 | 0.183 | 0.1 | 0 |
| 10:45 | 17.83 | 7.04 | -37 | 30 | 0.283 | 12.2 | 0.52 | 5.6 | 0.184 | 0.1 | 0 |
| 10:55 | 17.5 | 7.05 | -38 | 45 | 0.286 | 11.2 | 0.48 | 5.2 | 0.186 | 0.1 | 0 |
| 11:05 | 18 | 6.97 | -32 | 27 | 0.287 | 10.9 | 0.43 | 4.7 | 0.187 | 0.1 | 0 |

**Borehole 1 Pipe B**

**2.11.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ϖt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:48 | 19.38 | 7.03 | -33 | 183 | 0.315 | 470 | 0.75 | 8.3 | 0.205 | 0.1 | 0 |
| 1:58 | 19.19 | 7.02 | -32 | 157 | 0.321 | 529 | 0.74 | 8.3 | 0.209 | 0.2 | 0 |
| 2:08 | 19.01 | 6.98 | -31 | 133 | 0.323 | 400 | 0.75 | 8.3 | 0.21 | 0.2 | 0 |
| 2:18 | 18.82 | 7.07 | -35 | 120 | 0.323 | 304 | 0.76 | 8.4 | 0.21 | 0.2 | 0 |
| 2:28 | 18.56 | 7.01 | -33 | 116 | 0.324 | 238 | 0.76 | 8.4 | 0.21 | 0.2 | 0 |
| 2:38 | 18.36 | 7.01 | -32 | 114 | 0.324 | 203 | 0.76 | 8.4 | 0.21 | 0.2 | 0 |

**2.18.13**

Pumped 1 55g drum of water with aqua clear down hole using pex to tremmie down to the top of the screen
Air surged from 10psi to 20psi going up as slowly as possible in increments of 5psi X5 and holding for 5mins each
Left aquaclear for 24h in the well

**2.19.13**

Pumped 1B wide open.

**2.21.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | g/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11:15 | 20.61 | 6.97 | -33 | 144 | 0.293 | >800 | 5.26 | 59.9 | 0.191 | 0.1 | 0 |
| 11:25 | 21.2 | 7 | -34 | 153 | 0.295 | 445 | 4.78 | 55.3 | 0.192 | 0.1 | 0 |
| 11:35 | 21.31 | 7.02 | -36 | 153 | 0.296 | 314 | 4.61 | 53.5 | 0.192 | 0.1 | 0 |
| 11:45 | 21.35 | 7.03 | -37 | 149 | 0.296 | 280 | 4.51 | 52.2 | 0.193 | 0.1 | 0 |

Pumped B almost dry to trimmie 1 55 gallon drum of water with aqua clear down B then 4 55 gallon drums with aquaclear down W.
Air surged both 10-25psi and let W sit over night.
1B pumped overnight

**2.22.13**

Pumped 1W for 2 hours and left 1B pumping all weekend

**2.25.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | g/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:25 | 14.74 | 7.06 | -38 | 78 | 0.29 | 54.9 | 1.42 | 14.4 | 0.188 | 0.1 | 0 |
| 10:35 | 13.03 | 6.96 | -32 | 84 | 0.292 | 47.6 | 2 | 19.5 | 0.19 | 0.1 | 0 |
| 10:45 | 12.38 | 6.87 | -27 | 89 | 0.303 | 34 | 1.11 | 10.7 | 0.197 | 0.1 | 0 |
| 10:55 | 11.82 | 6.92 | -30 | 83 | 0.306 | 29 | 1.14 | 10.9 | 0.199 | 0.1 | 0 |
| 11:05 | 11.57 | 6.9 | -29 | 81 | 0.304 | 25.7 | 0.92 | 8.1 | 0.198 | 0.1 | 0 |
| 11.15 | 11.45 | 6.84 | -26 | 80 | 0.299 | 39 | 0.86 | 8.1 | 0.194 | 0.1 | 0 |
| 11:25 | 11.44 | 6.79 | -23 | 81 | 0.298 | 35 | 0.77 | 7.3 | 0.194 | 0.1 | 0 |

**3.1.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9:15 | 14.69 | 7.23 | -47 | 108 | 0.265 | 16.3 | 7.98 | 81.1 | 0.173 | 0.1 | 0 | |
| 9:25 | 13.66 | 6.79 | -23 | 137 | 0.257 | 7.8 | 6.83 | 67.7 | 0.167 | 0.1 | 0 | |
| 9:35 | 12.01 | 6.85 | -26 | 137 | 0.26 | 5.7 | 6.72 | 64.5 | 0.169 | 0.1 | 0 | |
| 9:45 | 12.04 | 6.66 | -15 | 147 | 0.258 | 5.1 | 5.81 | 55.8 | 0.168 | 0.1 | 0 | |
| 9:55 | 13.34 | 6.62 | -13 | 145 | 0.261 | 11.2 | 5.4 | 53.4 | 0.17 | 0.1 | 0 | Meter turned off. |

**3.1.13 #2**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3:45 | 19.02 | 7.15 | -44 | 33 | 0.326 | 190 | 1.07 | 11.9 | 0.211 | 0.2 | 0 |
| 3:55 | 18.1 | 7.14 | -43 | 26 | 0.325 | 146 | 0.72 | 7.9 | 0.21 | 0.2 | 0 |
| 4:05 | 16.98 | 7.13 | -42 | 27 | 0.325 | 141 | 0.66 | 7 | 0.211 | 0.2 | 0 |
| 4:15 | 16.46 | 7.01 | -35 | 35 | 0.324 | 144 | 0.63 | 6.7 | 0.211 | 0.2 | 0 |

Left 1B pumping all weekend on/off pumping.

**Borehole 1 Pipe C**

Initial height of 52.7, Purge began at 1:15 pm

**2.6.13**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⌀t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2:06 | 22.11 | 6.97 | -30 | 161 | 0.335 | 161 | 9.5 | 111.7 | 0.218 | 0.2 | 0 |
| 2:13 | 22.85 | 6.92 | -27 | 106 | 0.347 | 59 | 0.91 | 10.7 | 0.226 | 0.2 | 0 |
| 2:23 | 25.93 | 6.97 | -30 | 64 | 0.348 | 66 | 0.61 | 7.9 | 0.227 | 0.2 | 0 |
| 2:33 | 27.09 | 6.96 | -29 | 48 | 0.35 | 60 | 0.56 | 7.7 | 0.227 | 0.2 | 0 |
| 2:43 | 26 | 6.95 | -29 | 33 | 0.349 | 29 | 0.41 | 5.2 | 0.227 | 0.2 | 0 |
| 2:53 | 25.5 | 6.96 | -29 | 19 | 0.351 | 9.7 | 0.36 | 4.4 | 0.228 | 0.2 | 0 |
| 3:03 | 25.4 | 6.98 | -30 | 19 | 0.351 | 4.1 | 0.33 | 4.1 | 0.228 | 0.2 | 0 |

**2.8.13**

Borehole 1 Well C has a gpm of 3.3 and holding at a head of 139 ft. 300 hertz is the operation freq. Pumped all weekend on/off

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⌀t | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:15 | 17.3 | 7.15 | -41 | 35 | 0.256 | 100 | 2.94 | 31.4 | 0.165 | 0.1 | 0 | |
| 10:25 | 16.42 | 7.12 | -39 | 35 | 0.251 | 56.3 | 2.4 | 25.6 | 0.163 | 0.1 | 0 | |
| 10:35 | 15.96 | 7.11 | -38 | 37 | 0.248 | 39.6 | 3.06 | 30.8 | 0.162 | 0.1 | 0 | |
| 10:45 | 15.53 | 7.11 | -38 | 32 | 0.248 | 35.7 | 2.16 | 22.3 | 0.161 | 0.1 | 0 | |
| 10:55 | 15.32 | 7.1 | -38 | 28 | 0.247 | 25.9 | 1.86 | 19.1 | 0.161 | 0.1 | 0 | |
| 11:05 | 14.95 | 7.1 | -38 | 25 | 0.246 | 19.7 | 1.62 | 16.6 | 0.16 | 0.1 | 0 | |
| 11:15 | 14.9 | 7.1 | -38 | 21 | 0.245 | 17.6 | 1.47 | 15 | 0.159 | 0.1 | 0 | ***Meter went off.** |
| 11:25 | 15.19 | 7.1 | -38 | 17 | 0.254 | 22.8 | 1.3 | 13.3 | 0.166 | 0.1 | 0 | |

**2.11.13**

Gpm 6.8

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⌀t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9:55 | 19.31 | 7.1 | -38 | 188 | 0.357 | 46.4 | 11.05 | 123.2 | 0.232 | 0.2 | 0 |
| 10:05 | 19.67 | 7.12 | -39 | 123 | 0.34 | 11.9 | 8.16 | 92 | 0.221 | 0.2 | 0 |
| 10:15 | 19.79 | 7.11 | -38 | 121 | 0.34 | 7.9 | 8.41 | 94.5 | 0.221 | 0.2 | 0 |
| 10:25 | 19.59 | 7.09 | -37 | 125 | 0.34 | 1.5 | 8.48 | 95 | 0.221 | 0.2 | 0 |
| 10:35 | 19.17 | 7.07 | -36 | 126 | 0.34 | 0 | 8.1 | 90.3 | 0.221 | 0.2 | 0 |
| 10:45 | 19.05 | 7.06 | -35 | 129 | 0.341 | 0 | 7.77 | 86.2 | 0.222 | 0.2 | 0 |

**2.27.13**

7.5 gpm purge rate. Purge time of 17 min

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:30 | 19.6 | 7.06 | -38 | 175 | 0.356 | 72.1 | 8.15 | 91.5 | 0.232 | 0.2 | 0 |
| 1:50 | 21.4 | 7.11 | -41 | 129 | 0.355 | 26.5 | 1.97 | 23.1 | 0.231 | 0.2 | 0 |
| 2:00 | 22.73 | 7.12 | -42 | 111 | 0.35 | 23.9 | 2.16 | 25.6 | 0.228 | 0.2 | 0 |
| 2:10 | 23.03 | 7.12 | -42 | 110 | 0.354 | 19.1 | 2.32 | 27.7 | 0.23 | 0.2 | 0 |
| 2:20 | 21.5 | 7.1 | -41 | 120 | 0.353 | 14.1 | 3.62 | 42.1 | 0.229 | 0.2 | 0 |
| 2:30 | 22 | 7.09 | -40 | 124 | 0.353 | 19.6 | 3.33 | 39.1 | 0.23 | 0.2 | 0 |

**Borehole 1 Pipe D**

Started purge at 12:05 6.7 GPM for 23 min total 153 gallons water level dropped to 148' by 1:00

| | | Time | C | Ph | Phmv | ORPmv | MS/cm | NTU | mg/LDO | %DO | G/L TDS | Ppt | ϖt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1.13 | Pre purge | 12:50 | 20.48 | 6.7 | -15 | 100 | 0.358 | 17.6 | 10.54 | 120.3 | 0.233 | 0.2 | 0 |
| | Flow cell | 1:45 | 17.89 | 6.86 | -24 | 149 | 0.352 | 0 | 5.52 | 60.2 | 0.229 | 0.2 | 0 |
| | | 1:55 | 17.25 | 6.85 | -23 | 150 | 0.353 | 0 | 5.19 | 55.6 | 0.229 | 0.2 | 0 |
| | | 2:05 | 18.02 | 6.84 | -23 | 148 | 0.345 | 2.6 | 4.68 | 50.8 | 0.23 | 0.2 | 0 |
| | | 2:15 | 17.43 | 6.87 | -24 | 151 | 0.353 | 3.7 | 4.98 | 53.8 | 0.229 | 0.2 | 0 |
| | | 2:25 | 17.2 | 6.87 | -24 | 153 | 0.354 | 9.9 | 4.79 | 51.4 | 0.23 | 0.2 | 0 |
| | | 2:35 | 17.24 | 6.87 | -24 | 150 | 0.354 | 7.1 | 4.45 | 47.7 | 0.23 | 0.2 | 0 |

7.5 gpm purge rate will operate for a run time of 19.3 min

| | | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.27.13 | Pre purge | 11:30 | 19.02 | 7.02 | -36 | 103 | 0.352 | 20.7 | 7.75 | 86.1 | 0.228 | 0.2 | 0 |
| | | 11:50 | 20.34 | 7.01 | -35 | 151 | 0.357 | 17 | 1.41 | 16 | 0.232 | 0.2 | 0 |
| | | 12:00 | 21.17 | 6.99 | -34 | 146 | 0.358 | 10.3 | 1.47 | 17 | 0.232 | 0.2 | 0 |
| | | 12:10 | 19.98 | 6.97 | -33 | 157 | 0.355 | 5.9 | 2.85 | 32.1 | 0.231 | 0.2 | 0 |
| | | 12:20 | 19.87 | 6.94 | -31 | 167 | 0.356 | 5 | 2.75 | 31.2 | 0.231 | 0.2 | 0 |
| | | 12:30 | 20.41 | 6.95 | -32 | 170 | 0.357 | 5.2 | 2.45 | 28 | 0.232 | 0.2 | 0 |

**Borehole 2 Pipe W**

Started purge at 9:50 8.8 GPM. Water level 38ft. Purging for 30 min. Water level after 38ft

| Date | | Time | C | Ph | Phmv | ORPmv | MS/cm | NTU | mg/LDO | %DO | G/L TDS | Ppt | ʊt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.4.13 | Bucket | 10:45 | 19.2 | 7.28 | -48 | 164 | 0.378 | 0 | 9.47 | 106.2 | 0.246 | 0.2 | 0 |
| | Flow cell | 11:00 | 19.16 | 6.98 | -31 | 112 | 0.369 | 0 | 1.07 | 11.3 | 0.24 | 0.2 | 0 |
| | | 11:10 | 18.14 | 6.92 | -27 | 45 | 0.367 | 0 | 0.73 | 8 | 0.239 | 0.2 | 0 |
| | | 11:20 | 18.1 | 6.92 | -27 | 30 | 0.367 | 0 | 0.66 | 7.2 | 0.239 | 0.2 | 0 |
| | | 11:30 | 17.09 | 6.91 | -26 | 25 | 0.367 | 0 | 0.61 | 6.5 | 0.238 | 0.2 | 0 |
| | | 11:40 | 16.08 | 6.9 | -26 | 23 | 0.367 | 0 | 0.57 | 6 | 0.238 | 0.2 | 0 |
| | | 11:50 | 15.48 | 6.89 | -25 | 21 | 0.367 | 0 | 0.52 | 5.4 | 0.238 | 0.2 | 0 |
| | | 12:00 | 15.46 | 6.88 | -25 | 18 | 0.367 | 0 | 0.48 | 5 | 0.238 | 0.2 | 0 |

37.4 initial well height, purge beginning at 2:08 and ran till 2:50 pm. Height at 2:50 was 41.7

| 2.5.13 | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ʊt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3:05 | 23.56 | 7.1 | -38 | 177 | 0.363 | 0 | 9.5 | 114.5 | 0.236 | 0.2 | 0 |
| | 3:15 | 21.09 | 7 | -32 | 141 | 0.365 | 0 | 4.29 | 49.6 | 0.238 | 0.2 | 0 |
| | 3:25 | 22.14 | 6.99 | -32 | 136 | 0.367 | 0 | 5.34 | 62.9 | 0.238 | 0.2 | 0 |
| | 3:35 | 23.46 | 7.02 | -30 | 140 | 0.367 | 0 | 5.98 | 71.5 | 0.239 | 0.2 | 0 |
| | 3:45 | 23.76 | 7.02 | -33 | 140 | 0.368 | 0 | 5.92 | 71.4 | 0.239 | 0.2 | 0 |
| | 3:55 | 23.39 | 7.02 | -33 | 139 | 0.368 | 0 | 5.98 | 71.9 | 0.239 | 0.2 | 0 |
| | 4:05 | 22.66 | 7 | -32 | 140 | 0.367 | 0 | 6.03 | 71.6 | 0.239 | 0.2 | 0 |

| 2.19.13 | | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/ITDS | ppt | ʊt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pre purge | 1:15 | 19.42 | 7.26 | -49 | 152 | 0.373 | 5.1 | 8.59 | 96.1 | 0.242 | 0.2 | 0 |
| | | 2:12 | 20.39 | 7.1 | -41 | 66 | 0.369 | 0 | 1.36 | 15.2 | 0.24 | 0.2 | 0 |
| | | 2:22 | 21.89 | 7 | -35 | 44 | 0.369 | 0 | 0.57 | 6.7 | 0.24 | 0.2 | 0 |
| | | 2:32 | 22.85 | 7 | -34 | 32 | 0.369 | 1.2 | 0.47 | 5.7 | 0.24 | 0.2 | 0 |
| | | 2:42 | 22.47 | 6.99 | -34 | 25 | 0.369 | 0 | 0.41 | 4.8 | 0.24 | 0.2 | 0 |

| 3.1.13 | | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ʊt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pre purge | 1:20 | 21.21 | 7.27 | -51 | 134 | 0.374 | 4.2 | 8.24 | 95.2 | 0.243 | 0.2 | 0 |
| | | 1:30 | 19.97 | 7.05 | -38 | 122 | 0.369 | 0 | 0.6 | 6.8 | 0.24 | 0.2 | 0 |
| | | 1:40 | 18.88 | 6.99 | -34 | 107 | 0.369 | 0 | 0.49 | 5.4 | 0.24 | 0.2 | 0 |
| | | 1:50 | 18.13 | 6.9 | -29 | 96 | 0.369 | 0 | 0.4 | 4.4 | 0.24 | 0.2 | 0 |

**Borehole 2 Pipe B**

8.34 gpm initial gpm. Purge started at 11:25 am, ran for 45 minutes. Water quality testing began at 12:25 pm

**2.5.13**

| Time | C | pH | pHmv | OPRmv | mS/cm | NTU | mg/l DO | %DO | g/l TDS | ppt | ⍉t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12:25 | 18.07 | 7.15 | -41 | 69 | 0.248 | 16.4 | 10.26 | 112 | 0.161 | 0.1 | 0 |
| 12:35 | 20.84 | 7.1 | -38 | 2 | 0.245 | 10 | 7.72 | 88.5 | 0.159 | 0.1 | 0 |
| 12:45 | 21.35 | 7.07 | -36 | -2 | 0.246 | 4.1 | 6.87 | 79.6 | 0.16 | 0.1 | 0 |
| 12:55 | 23.06 | 7.06 | -35 | -6 | 0.248 | 2.2 | 5.68 | 67.9 | 0.161 | 0.1 | 0 |
| 1:05 | 24.82 | 7.06 | -35 | -14 | 0.249 | 4 | 3.77 | 46.2 | 0.162 | 0.1 | 0 |
| 1:15 | 26.21 | 7.06 | -36 | -22 | 0.258 | 26.4 | 2.15 | 27 | 0.168 | 0.1 | 0 |
| 1:25 | 26.32 | 7.06 | -36 | -20 | 0.261 | 42.1 | 1.93 | 24.2 | 0.17 | 0.1 | 0 |

2B ran for a 48h on/off pump.

**2.18.13**

**Pre purge**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/lTDS | ppt | ⍉t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3:00 | 19.65 | 6.91 | -30 | 188 | 0.772 | 57 | 9.08 | 102.1 | 0.494 | 0.4 | 0 |
| 3:15 | 21.16 | 7.55 | -67 | 128 | 0.329 | 20 | 5.71 | 65.3 | 0.213 | 0.2 | 0 |
| 3:25 | 20.55 | 7.35 | -55 | 142 | 0.325 | 17.9 | 5.38 | 61.5 | 0.211 | 0.2 | 0 |
| 3:35 | 20.34 | 7.32 | -53 | 143 | 0.325 | 13.4 | 5.17 | 58.5 | 0.211 | 0.2 | 0 |
| 3:45 | 19.99 | 7.25 | -49 | 150 | 0.324 | 13.3 | 5.1 | 57.5 | 0.211 | 0.2 | 0 |

**3.1.13**

**Pre-purge**

| Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⍉t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9:40 | 14.81 | 7.24 | -49 | 120 | 0.401 | 39.9 | 8.7 | 88.7 | 0.261 | 0.2 | 0 |
| 9:50 | 17.34 | 7.29 | -51 | 65 | 0.333 | 41.6 | 0.6 | 6.4 | 0.216 | 0.2 | 0 |
| 10:00 | 16.29 | 7.27 | -50 | 54 | 0.332 | 26.1 | 0.51 | 5.4 | 0.216 | 0.2 | 0 |
| 10:10 | 15.56 | 7.28 | -51 | 43 | 0.332 | 23 | 0.47 | 4.9 | 0.216 | 0.2 | 0 |
| 10:20 | 16.43 | 7.29 | -51 | 33 | 0.332 | 22.2 | 0.22 | 4.6 | 0.216 | 0.2 | 0 |
| 10:30 | 16.9 | 7.3 | -52 | 25 | 0.331 | 21 | 0.42 | 4.5 | 0.215 | 0.2 | 0 |
| 10:40 | 16.69 | 7.31 | -53 | 17 | 0.331 | 21.8 | 0.41 | 4.4 | 0.215 | 0.2 | 0 |

**Borehole 2 Pipe C**

Started purge at 1:50 8.8 GPM. Water level 38ft. Purging for 30 min.

| Date 2/4/13 | | Time | C | Ph | Phmv | ORPmv | MS/cm | NTU | mg/LDO | %DO | G/L TDS | Ppt | ⌀t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre purge | 2:35 | 14.7 | 7.27 | -50 | 206 | 0.208 | 0 | 11.94 | 119.9 | 0.135 | 0.1 | 0 |
| | Flow cell | 2:43 | 17.76 | 7.53 | -62 | 162 | 0.365 | 0 | 8.36 | 90.3 | 0.237 | 0.2 | 0 |
| | | 2:53 | 16.93 | 7.25 | -46 | 122 | 0.366 | 0 | 9.57 | 102.4 | 0.238 | 0.2 | 0 |
| | | 3:03 | 16.26 | 7.08 | -36 | 129 | 0.366 | 0 | 10.22 | 107.7 | 0.238 | 0.2 | 0 |
| | | 3:23 | 14.59 | 7 | -32 | 146 | 0.366 | 0 | 10.39 | 105.6 | 0.238 | 0.2 | 0 |
| | | 3:33 | 14.78 | 6.98 | -31 | 149 | 0.366 | 0 | 10.28 | 105.2 | 0.238 | 0.2 | 0 |
| | | 3:43 | 14.89 | 6.98 | -31 | 149 | 0.366 | 0 | 10.34 | 105.7 | 0.238 | 0.2 | 0 |
| | | 3:53 | 14.66 | 6.96 | -30 | 149 | 0.366 | 0 | 10.3 | 104.9 | 0.238 | 0.2 | 0 |

Initial height of 37.5 ft, purge began at 8:35 am and will run for 10.7 min. Initial gpm is 8.8.

| 2.6.13 | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⌀t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9:20 | 16.61 | 7.12 | -39 | 108 | 0.366 | 0 | 10.66 | 112.9 | 0.238 | 0.2 | 0 |
| | 9:30 | 17.84 | 6.99 | -31 | 48 | 0.368 | 0 | 0.67 | 7.3 | 0.239 | 0.2 | 0 |
| | 9:40 | 17.12 | 6.97 | -30 | 27 | 0.366 | 0 | 0.63 | 6.7 | 0.239 | 0.2 | 0 |
| | 9:50 | 16.71 | 6.97 | -30 | 19 | 0.366 | 0 | 0.56 | 6 | 0.238 | 0.2 | 0 |
| | 10:00 | 16.68 | 6.97 | -30 | 16 | 0.366 | 0 | 0.51 | 5.3 | 0.238 | 0.2 | 0 |
| | 10:10 | 16.97 | 6.98 | -31 | 13 | 0.366 | 0 | 0.48 | 5.1 | 0.238 | 0.2 | 0 |
| | 10:20 | 18.9 | 6.97 | -30 | 7 | 0.366 | 0 | 0.48 | 5.3 | 0.238 | 0.2 | 0 |

| 2.19.13 | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | ⌀t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11:15 | 17.95 | 7.07 | -39 | 62 | 0.373 | 0 | 1.25 | 13.5 | 0.242 | 0.2 | 0 |
| | 11:25 | 16.63 | 6.98 | -33 | 35 | 0.371 | 0 | 0.72 | 7.6 | 0.241 | 0.2 | 0 |
| | 11:35 | 15.99 | 6.95 | -32 | 25 | 0.369 | 0 | 0.63 | 6.6 | 0.24 | 0.2 | 0 |
| | 11:45 | 16.03 | 6.95 | -32 | 18 | 0.369 | 0 | 0.61 | 6.4 | 0.24 | 0.2 | 0 |

| 3.1.13 | | Time | C | pH | pHmv | ORPmv | mS/cm | NTU | mg/l DO | % DO | g/l TDS | ppt | t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pre purge | 2:30 | 24.31 | 7.19 | -46 | 64 | 0.383 | 43.2 | 7.62 | 93.2 | 0.248 | 0.2 | 0 |
| | | 2:40 | 19.03 | 7.14 | -43 | 56 | 0.37 | 0 | 0.43 | 4.7 | 0.241 | 0.2 | 0 |
| | | 2:50 | 18.57 | 7.01 | -35 | 46 | 0.37 | 0 | 0.4 | 4.4 | 0.24 | 0.2 | 0 |
| | | 3:00 | 18.3 | 6.99 | -34 | 38 | 0.369 | 0 | 0.33 | 3.6 | 0.24 | 0.2 | 0 |

**Notes:**
**48h on/off pumping test was not exactly 48h, usually 65-70h for our weekend testing. We also has a variety of 24h testing.**

**The on/off pumping test times were changed to 15min on and 20min off to allow the wells with lower yield to recover and to avoid running the pump dry**

**The auto off function on the Horiba water quality meter several times activated and turned the meter off during testing.**
**When we turn it back on, the meter takes 15mins to 'warm up' again to give us the correct readings, all cases were noted.**

**Pre purge was water from the beginning of the purge which was put into a bucket and scooped from the bottom meaning the water was not or had very little exposure to oxygen.**

**Aqua clear was added at a 2X ratio. Each 55g drum of water had aprox 700ml of aqua clear added to it.**

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# APPENDIX G ATES WELL PUMPING TEST

# Memo

| | |
|---|---|
| Project: | DOD (USA) |
| Subject: | Interpretation of Pumping Test results and recommendations |
| Date: | 13 May 2015 |
| Version: | Final draft |
| Reference: | 60317/TA/20150513 |
| Author: | BD |
| Checked by: | TA |

## 1 Introduction

At Fort Benning a pumping test was conducted on the test boreholes to investigate the opportunities for an ATES system. IF Technology was asked to make an interpretation of the pumping test and deduce the suitability of the aquifer for ATES. This memo describes the findings.

## 2 Pumping Test Results

On April 9, 2015 the pumping test was started. During three days groundwater was extracted with an average flow rate of 19 m³/h (equal to 84 GPM) from the well screen that was installed in borehole #2. Before, during and after these 3 days, the hydraulic head was monitored in the well itself and several monitoring wells in boreholes #1 and #2. Figure 1 shows the locations of borehole 1 and 2. The distance between both boreholes is 164 m (537 feet). The measured drawdown for each monitoring point is shown in Figure 2.




*Figure 2*
*Locations of boreholes nr. 1 and 2 (Well 1 and Well 2).*

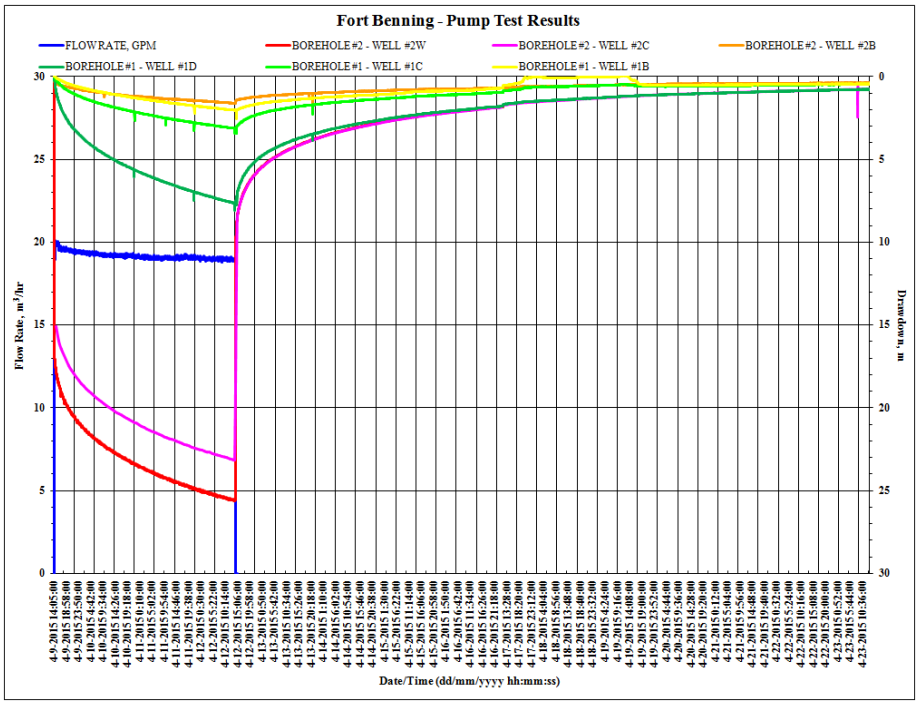


*Figure 1*
*Measured flow rate and drawdown versus date and time. The date and time on the left side of the graph correspond with the start of the pumping test.*

# 3 Interpretation of pumping test

For the interpretation of the pumping test the ground water modelling software MLU was used. MLU was developed for interpretation of pumping tests (more information can be found on www.microfem.com). Input that is needed in MLU is:

1) The setup of the layered aquifer system
   The setup of the layered aquifer system was deduced from the received data. Important is the presence of a clay layer at a depth of 230-235 feet in borehole 1 and 235-242 feet in borehole 2. The well screen that was used for groundwater extraction during the pumping test is situated below this clay layer. Monitoring wells 1D and 2C are also situated below this clay layer. All other monitoring wells are located above the clay layer.

2) Information on the pumping well
   The flow rates that were logged during the pumping test were used to generate input for MLU. Furthermore the radius of the casing and the borehole are needed.

3) Information on the monitoring wells
   For the analysis a selection was made of the measured drawdown's in the monitoring wells 1D, 2B and 2C. The location of borehole 1 (distance to borehole 2) is also needed.

First, the drawdown measured in monitoring well 1D was used for analysis. The fit that was found with MLU is shown in Figure 3.

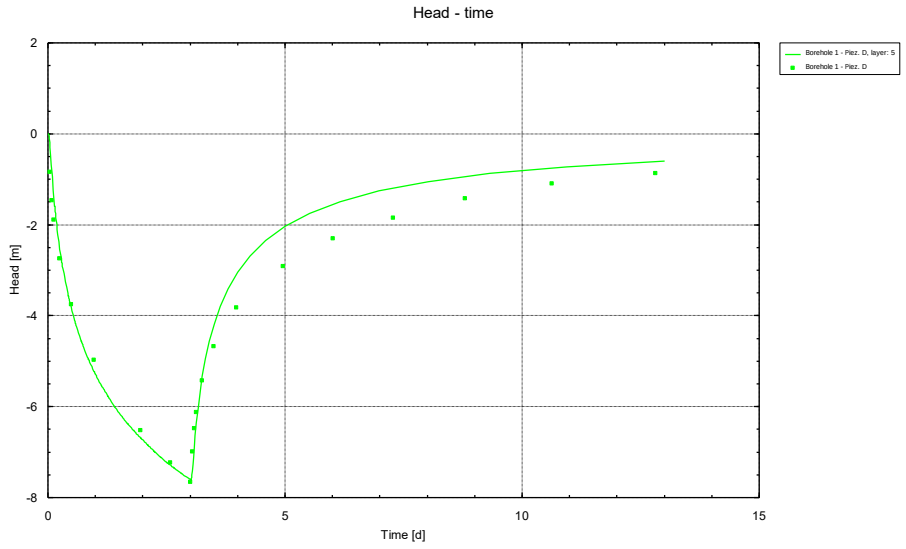


*Figure 3 Calculated change in hydraulic head after optimization (line) and measured hydraulic head (squares) in monitoring well 1D. Optimization was based on measurements in monitoring well 1D only.*

Next the fitted model was used to calculate the drawdown in monitoring well 2C and these results were compared with the measured drawdown (Figure 4).

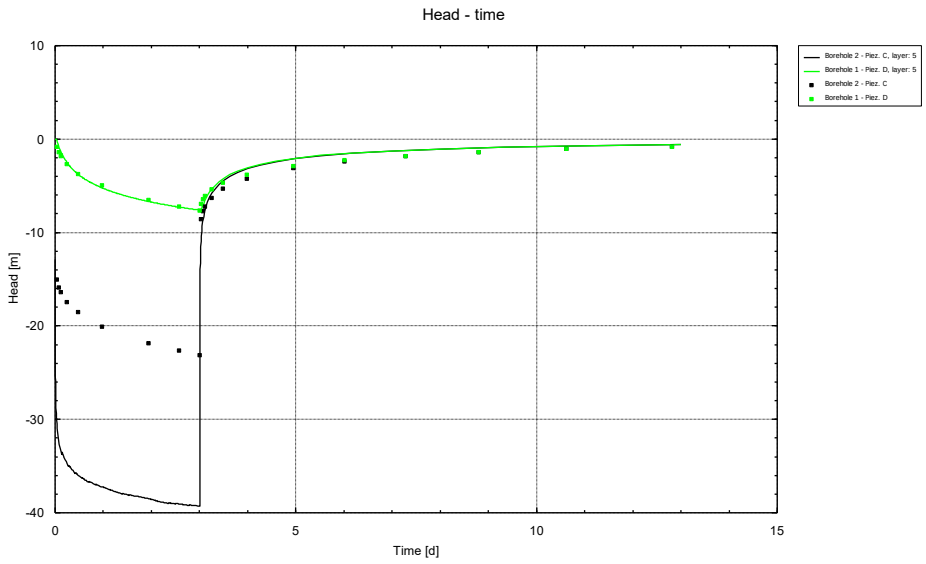


*Figure 4*
*Calculated change in hydraulic head after optimization (lines) and measured hydraulic head (squares) in monitoring well 1D and 2C. Optimization was based on measurements in monitoring well 1D only.*

Figure 4 shows that the calculated drawdown for monitoring well 2C is bigger than the measured drawdown. The most likely explanation is that the hydraulic conductivity of the aquifer is higher near borehole 2 than in the area further away from borehole 2. A possible explanation is the removal of fines from the aquifer during well development. This would mean that a natural gravel pack has been created during well development, which increases the apparent diameter of the well (negative skin). By increasing the borehole diameter in the MLU model this effect can be mimicked. A good fit was found for a well radius of 5.5 m. This suggests that a natural gravel pack has been formed up to a distance of at least 5.5 m from the well. However we cannot be sure that a natural gravel pack formed during development of the well. Another explanation could be that the hydraulic conductivity near borehole #2 is higher than the average between boreholes #1 and #2. Probably both explanations are partly contributing.

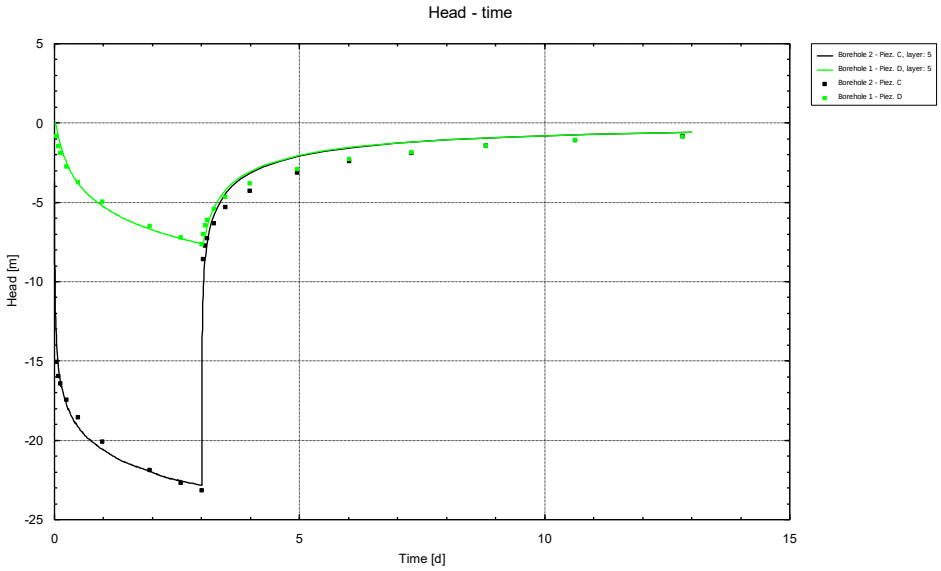


*Figure 5*
*Calculated change in hydraulic head after optimization (lines) and measured hydraulic head (squares) in monitoring well 1D and 2C. Optimization of the transmissivity of the aquifer was based on measurements in monitoring well 1D. The increased hydraulic conductivity near borehole 2 was simulated by an increased diameter of borehole 2.*

Last step was to add a more shallow peizometer in borehole 2 (2B). The measurements show that a change in hydraulic head occurs, but according to the model the change in hydraulic head is insignificant. It is not possible to decrease the resistance of the confining clay layer, without ruining the fit for the deep monitoring wells. Probably the hole that was drilled in the confining clay layer was not closed properly (gravel pack at depth of clay layer).

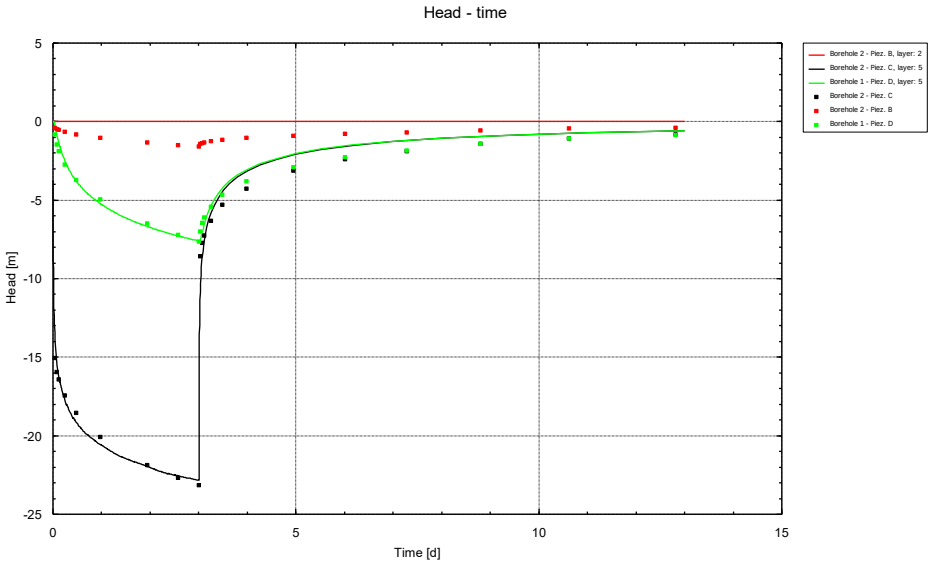


*Figure 6*
*Same as Figure 5, but now with monitoring well 2B added.*

Depending on the depth of the bottom of the aquifer (approximately 400 ft) the average hydraulic conductivity according to the model results is between 0.3 and 0.66 m/d for the aquifer. The hydraulic conductivity is much lower than was expected based on the M50 number of the grain size of the aquifer. If we look at the results of the sieve analysis we see next to the big grains a significant percentage of fines and silt in the grain size distribution curves. This is probably the reason for the relatively low hydraulic conductivity. The M50 number gives in this case a significant overestimate of the hydraulic conductivity.

The phenomenon that the calculated drawdown for monitoring well 2C is higher than the measured drawdown can also be explained by the presence of fines. The effective hydraulic conductivity close to borehole 2 is significantly higher. This can be caused by the removal of fines during well development and/or by a locally increased (initial) hydraulic conductivity. Unfortunately can not be demonstrated what the real reason is.

Based on the results of only three sieve analysis that are available below the confining clay layer. We have no reason to assume that the aquifer is less permeable at borehole #1 than at borehole #2. However, this expectation is based on a (very) limited amount of sieve analysis.

# 4 Maximum well capacity

The maximum well capacity was derived for borehole #2. For wells in aquifers with a low hydraulic conductivity there are two limiting factors: 1) maximum extraction rate and 2) the maximum injection pressure.

**Design standard for extraction wells**

The maximum Darcy velocity at the borehole wall for extraction wells according to the design standards for the Dutch situation is 2 times the hydraulic conductivity. In this case the maximum Darcy velocity would be between 0.6 and 1.32 m/d. Using the borehole radius of 0.15 m and 25 m of gravel pack (83 feet), the maximum flow rate of the well would be 14 to 31 $m^3/d$. However, the model results suggest an effective well radius of 5.5 m. Using an effective well radius of 5.5 m, the maximum flow rate of the well would be 520 to 1140 $m^3/d$ (=21.6 to 47.5 $m^3/h$).

**Maximum injection pressure**

The top of the gravel pack is located at 72 m (237 feet) depth. The maximum initial injection pressure (included some safety for well clogging) based on a rule of thumb would be 9.6 m (31 feet). Measured drawdown for 19 $m^3/h$ was 23 m after 5 days. This would suggest a maximum flow rate of 7.9 $m^3/h$ per well. In that case 3 injection wells would be needed to be

able to reach a total flow rate of 20 m³/h. Assuming an equal maximum flow rate during the winter and summer season, this would mean three cold wells and three warm wells.

**Extending the well screen length**

The maximum flow rate given above is based on the well characteristics of borehole #2. Since the lower part of the aquifer was not used at borehole #2, it is possible to increase the length of the well screen. By doing this the well capacity will increase. In the worst-case the well capacity is expected to increase to 120%. In the best case this could be 300%.

**Recommendations**

During the Skype calls of May 4th and 6th we discussed about to continue or to stop the project due to the relative low hydraulic conductivity in relation to the budget. We eventually decided to use two warm and two cold wells (by using existing well #2) extend the length of the well screens (for the new wells) and to lower the maximum flow rate for the system. Three new wells should be made. The best drilling technique and well construction for this situation in relation to the budget should be further determined. Important for this decision is that we should be able to determine the grain size of the formation. Placing the (extended) filter screen in the lower and probably finer sands of the aquifer can cause sand delivery of the well.

Development of the new wells is crucial for the properties of the wells because we can probably create a natural gravel pack, with a higher hydraulic conductivity around the well. Better development leads to a lower drawdown / hydraulic mount and results in a higher flow rate per well. The best way to create a natural gravel pack needs to investigated more in detail.

**Risk analysis**

There are certain risks for the ATES system we would like to describe here. There isn't much long term experience in The Netherlands with the use of aquifers with this relatively low hydraulic conductivity for ATES. We don't know if it is possible to make durable, low maintenance wells. We do know that wells which are located in fine sandy aquifers are more sensitive to clogging. For the aquifer at Fort Benning, we estimate that the risk for clogging is high, due to the fine particles in the aquifer. Unfortunately if this occurs we cannot predict how rapid this clogging will occur and how easy or difficult it would be to remove the clogging material. When the well(s) are clogged too much, it is not possible to deliver (the total) demanded heat or cold to the building. If AH&P have agreed a delivery obligation with the client this might be a risk. We recommend to anticipate on frequent preventive maintenance (like frequent short time back flushing without reinjection: long enough to pump e.g. twice the volume between the borehole wall and the point where the water is discharged). It is recommended to provide back-up equipment to deliver heat and cold in all circumstances to the building.

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# APPENDIX H INDUSTRY PARTNER SUPPORT

**ABB:**

ABB, is one of the largest manufacturer of variable frequency drives in the world. When the local ABB sales representative, Mike Shepp with Borie Davis, was made aware of the unique energy saving design of an ATES project, he contacted ABB. ABB then committed to providing a substantial discount for the VFDs utilized for the submersible pump motors designed for the ATES project. Both ABB and Borie Davis provided excellent technical support of the VFD to insure a successful design. A submittal of their VFD utilized for this demonstration follow and more information can be found at http://new.abb.com/drives

# ABB VARIABLE FREQUENCY DRIVES

**Project Name:  Aquifer Thermal Energy Storage (ATES) Project**

**Engineering Contact:  Andrews, Hammock & Powell**

**End Customer (User):  US Dept. of Defense (DoD) ESTCP Program**

**Location:  Building 3215 - Ft. Benning, Georgia**

**Submitted By:  Mike Shepp, PE - Borie-Davis, Inc.**

**Date:  January 26, 2017**

# Submittal Schedule

This schedule includes the products supplied as part of this submittal.

| Schedule | | | Motor Data[1] | | | Drive Data | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Tagging / | | | | | Output | | |
| Item | Qty | Equipment ID | HP | FLA | Voltage | Product ID | HP | Amps | Voltage |
| 1 | 4 | P-1 thru 4 | 7.5 | 24.2 | 208 VAC | ACH550-PCR-024A-2+B058+K452 | 7.5 | 24.2 | 208 VAC |

**Notes:** 1. AC Motor Data is per National Electrical Code Table 430.250 for typical motors used in most applications and is provided as typical data only. DC motor data is per typical industry standards. Actual motor data may vary.

**Includes Transcoil (TCI) DV/DT VFD output filter in NEMA 3R enclosure. Field installed between VFDs and motors. Details at end of this submittal.**

## Submittal Schedule Details for P-1 thru 4

| Item | Tag / Equipment ID | Product ID |
|---|---|---|
| 1 | P-1 thru 4 | ACH550-PCR-024A-2+B058+K452 |

| Item Description |
|---|
| **Input Voltage:** 208 VAC<br>**Rated Output Current:** 24.2 AMPS<br>**Construction:** Drive with Circuit Breaker<br>**Enclosure:** NEMA/UL Type 3R<br>**Nominal Horsepower:** 7.5<br>**Frame Size:** R2<br>**Input Disconnecting Means:** Circuit Breaker<br>**Bypass:** None<br>**Input Impedance:** 5%<br>**Short Circuit Current Rating:** 100 kA<br>**Communication Protocols:** Johnson Controls N2, Siemens Buildings Technologies FLN (P1), Modbus RTU, BACnet, LonWork<br>**Other Options:**<br>**Recommended Spare Parts Package :** |

| Drive Input Fuse Ratings | |
|---|---|
| (Note: Drive is UL approved without the need for input fuses. Fuse rating information provided for customer reference) | |
| **Amps (600 V)** | **Bussmann Type** |
| N/A | N/A |

| Wire Size Capacities of Power Terminals | | | | |
|---|---|---|---|---|
| **Circuit Breaker** | **Disconnect Switch** | **Terminal Block** | **Overload Relay** | **Ground Lug** |
| #6<br>45 in-lbs | N/A<br>N/A | #6<br>12 in-lbs | N/A<br>N/A | #6<br>35 in-lbs |

| Dimensions and Weights | | | | |
|---|---|---|---|---|
| **Height in / mm** | **Width in / mm** | **Depth in / mm** | **Weight lbs / kg** | **Dimension Drawing** |
| 34 / 865 | 17.8 / 452 | 13.5 / 343 | 134 / 61 | 3AUA0000016377<br>Sheet 1 |

| Heat Dissipation & Airflow Requirements | | | |
|---|---|---|---|
| **Power Losses** | | **Airflow** | |
| **Watts** | **BTU/Hr** | **CFM** | **CM/Hr** |
| 227 | 776 | 52 | 88 |

| Reference Drawings | | |
|---|---|---|
| **Power Wiring** | **Connection Diagram** | **Dimension Detail** |
| PC00R312PW-A | PCPDR316CC-B<br>RLONR018CC | 3AUA0000016377<br>Sheet 1 |

# ACH550 Product Overview

## *Description*

The ACH550 series is a microprocessor based Pulse Width Modulated (PWM) adjustable speed AC drive. The ACH550 drive takes advantage of sophisticated microprocessor control and advanced IGBT power switching technology to deliver high-performance control of AC motors for a wide range of HVAC applications.

With drives ranging from 1 to 550 HP, the ACH550 series features a universal full graphic interface that “speaks” to the operator in plain English phrases, greatly simplifying set-up, operation, and fault diagnosis. The ACH550 is also programmable in fourteen other languages.

Each ACH550 drive comes equipped with an extensive library of pre-programmed HVAC application macros which, at a touch of a button, allow rapid configuration of inputs, outputs, and performance parameters for specific HVAC applications to maximize convenience and minimize start-up time. The ACH550 series can handle the most demanding commercial applications in an efficient, dependable, and economic manner.



# *ACH550 Standard Features*

- UL, cUL labeled, CE marked, BTL listed (BACnet Testing Lab) & UL Plenum Rated
- EMI/RFI Filter (1st Environment, Restricted Distribution) EN 61800-3
- Seismic Certification in accordance to IBC 2000, 2003, 2006, 2009 and 2012 referencing ASCE 7-98, 7-02, 7-05, 7-05, and 7-10 (respectively) and ICC AC156 with an importance factor of 1.5
- Start-Up Assistants
- Maintenance Assistants
- Diagnostic Assistants
- Real Time Clock Includes Day, Date and Time
- Operator Panel Parameter Backup (read/write)
- Full Graphic and Multilingual Display for Operator Control, Parameter Set-Up and Operating Data Display:
  - Output Frequency (Hz)
  - Speed (RPM)
  - Motor Current
  - Calculated % Motor Torque
  - Calculated Motor Power (kW)
  - DC Bus Voltage
  - Output Voltage
  - Heatsink Temperature
  - Elapsed Time Meter (resettable)
  - KWh (resettable)
  - Input / Output Terminal Monitor
  - PID Actual Value (Feedback) & Error Fault Text
  - Warning Text
  - Three (3) Scalable Process Variable Displays
  - User Definable Engineering Units
- Two (2) Programmable Analog Inputs
- Six (6) Programmable Digital Inputs
- Two (2) Programmable Analog Outputs
- Up to six (6) Programmable Relay Outputs (Three (3) Standard)
- Adjustable Filters on Analog Inputs and Outputs
- Mathematical Functions on Analog Reference Signals
- All Control Inputs Isolated from Ground and Power
- Four (4) Resident Serial Communication Protocols
  - Johnson Controls N2
  - Siemens Buildings Technologies FLN (P1)
  - Modbus RTU
  - BACnet (MS/TP)
- Input Speed Signals
  - Current 0 (4) to 20 mA
  - Voltage 0 (2) to 10 VDC
  - Increase/Decrease Reference Contacts (Floating Point)
  - Serial Communications
- Start/Stop
  - 2 Wire (Dry Contact Closure)
  - 3 Wire (Momentary Contact)
  - Application of Input Power
  - Application of Reference Signal (PID Sleep/Wake-Up)
  - Serial Communications
- Start Functions
  - Ramp
    - Flying Start
    - Premagnetization (DC brake) on Start
  - Automatic Torque Boost
  - Automatic Torque Boost with Flying Start
  - Auto Restart (Reset) – Customer Selectable and Adjustable
- Stop Functions
  - Ramp or Coast to Stop
  - Emergency Stop
  - DC Braking / Hold at Stop
  - Flux Braking
- Accel/Decel
  - Two (2) sets of Independently Adjustable Ramps
  - Linear or Adjustable 'S' Curve Accel/Decel Ramps
- HVAC Specific Application Macros
- Separate Safeties (2) and Run Permissive Inputs
- Damper Control
- Override Input (Fire Mode)
- Timer Functions
  - Four (4) Daily Start/Stop Time Periods
  - Four (4) Weekly Start/Stop Time Periods
  - Four Timers for Collecting Time Periods and Overrides
- Seven (7) Preset Speeds
- Supervision Functions
- Adjustable Current Limit
- Electronic Reverse
- Automatic Extended Power Loss Ride Through (Selectable)
- Programmable Maximum Frequency to 500 Hz
- PID Control
  - Two (2) Integral Independent Programmable PID
  - Setpoint Controllers (Process and External)
  - External Selection between Two (2) Sets of Process PID Controller Parameters
  - PID Sleep/Wake-Up
- Motor Control Features
  - Scalar (V/Hz) and Vector Modes of Motor Control
  - V/Hz Shapes
    - Linear
    - Squared
  - Energy Optimization
  - IR Compensation
  - Slip Compensation
  - Three (3) Critical Frequency Lockout Bands
- Preprogrammed Protection Circuits
  - Overcurrent
  - Short Circuit
  - Ground Fault
  - Overvoltage
  - Undervoltage
    - Input Phase Loss
  - Output Device (IGBT) Overtemperature
  - Adjustable Current Limit Regulator
  - UL508C approved Electronic Motor Overload (I2T)
- Programmable Fault Functions for Protection Include
  - Loss of Analog Input
  - Panel Loss
  - External Fault
  - Motor Thermal Protection
  - Stall
  - Underload
  - Motor Phase Loss
  - Ground Fault
- 5% Equivalent Impedance
  - 5% Equivalent Impedance with Internal Reactor(s)
  - Patented Swinging Choke Design for Superior Harmonic Mitigation in frame sizes (R1 to R6)
  - 3% Equivalent Impedance for frame R8

# *ACH550 Specifications*

### Input Connection

| | |
|---|---|
| Input Voltage (U1) | 208/220/230/240 VAC 3-phase +/-10% |
| | ~~208/220/230/240 VAC 1-phase +/-10%~~ |
| | ~~380/400/415/440/460/480 VAC 3-phase +/-10%~~ |
| | ~~500/575/600 VAC 3-phase +/- 10%~~ |
| Frequency: | 48 - 63 Hz |
| Line Limitations: | Max +/-3% of nominal phase to phase input voltage |
| Fundamental Power Factor (cos θ): | 0.98 at nominal load |
| Connection: | U1, V1, W1 (U1, V1, 1-phase) |

### Output (Motor) Connection

| | |
|---|---|
| Output Voltage: | 0 to U1, 3-phase symmetrical, U2 at the field weakening point |
| Output Frequency: | -500 to 500 Hz |
| Frequency Resolution: | 0.01 Hz |
| Continuous Output Current: | |
| Variable Torque: | 1.0 * $I^2N$ (Nominal rated output current, Variable Torque) |
| Short Term Overload Capacity: | |
| Variable Torque: | 1.1 * $I^2N$, (1 min/10 min) |
| Peak Overload Capacity: | |
| Variable Torque: | 1.35 * $I^2N$, (2 sec/1 min) |
| Base Motor Frequency Range | 10 to 500 Hz |
| Switching Frequency: | 1, 4, 8 or 12 kHz |
| Acceleration Time: | 0.1 to 1800 s |
| Deceleration Time: | 0.1 to 1800 s |
| Efficiency: | 0.98 at nominal power level |
| Short Circuit Withstand Rating: | 100,000 AIC (UL) w/o fuses |
| Connection: | U2, V2, W2 |
| Enclosure Style: | UL (NEMA) Type 1, Type 12, or Type 3R |
| Agency Approval Listing and Compliance: | UL, cUL, CE, BTL (BACnet Testing Laboratory), IBC, OSHPD |

### Ambient Conditions, Operation

| | |
|---|---|
| Air Temperature: | -15° to 40°C (5° to 104°F), -18° (0°F) UL Type (NEMA) 3R above 40°C the maximum output current is de-rated 1% for every additional 1°C (up to 50°C (122°F) maximum limit. |
| Relative Humidity: | 5 to 95%, no condensation allowed, maximum relative humidity is 60% in the presence of corrosive gasses |
| Contamination Levels: | |
| IEC: | 60721-3-1, 60721-3-2 and 60721-3-3 |
| Chemical Gasses: | 3C1 and 3C2 |
| Solid Particles: | 3S2 |
| Installation Site Altitude: | 0 to 1000 m (3300 ft) above sea level. At sites over 1000 m (3300 ft) above sea level, the maximum power is de-rated 1% for every additional 100 m (330 ft). If the installation site is higher than 2000 m (6600 ft) above sea level, please contact your local ABB distributor or representative for further information |
| Vibration: | Max 0.3 mm 2 to 9 Hz, Max 1 m/s2 9 to 200 Hz sinusoidal IEC 60068-2-6 |
| Seismic: | Seismic Certified referencing IBC 2000, 2003, 2006, 2009, 2012 |

### Ambient Conditions, Storage (in Protective Shipping Package)

| | |
|---|---|
| Air Temperature: | -40° to 70°C (-40° to 158°F) |
| Relative Humidity: | Less than 95%, no condensation allowed |
| Vibration: | In accordance with ISTA 1A and 1B specifications |
| Shock (IEC 60068-2-27): | Max 100 m/s2 (330 ft/s2) 11 ms |

### Ambient Conditions, Transportation (in Protective Shipping Package)

| | |
|---|---|
| Air Temperature: | -40° to 70°C (-40° to 158°F) |
| Relative Humidity: | Less than 95%, no condensation allowed |
| Atmospheric Pressure: | 60 to 106 kPa (8.7 to 15.4 PSI) |
| Vibration: | Max 3.5 mm (0.14 in) 2 to 9 Hz, Max 15 m/s2 (49 ft/s2) 9 to 200 Hz sinusoidal |
| Shock (IEC 60068-2-27): | Max 100 m/s2 (330 ft/s2) 11 ms |
| R1: | 76 cm (30 in) |
| R2: | 61 cm (24 in) |
| R3: | 46 cm (18 in) |
| R4: | 31 cm (12 in) |
| R5 & 6: | 25 cm (10 in) |

### Cooling Information

| | |
|---|---|
| Cooling Method: | Integral fan(s) |
| Power Loss: | Approximately 3% of rated power |

# *ACH550 Specifications (continued)*

**Analog Inputs**

| | |
|---|---|
| Quantity | Two (2) programmable |
| Voltage Reference | 0 (2) to 10 V, 250kOhm, single ended |
| Current Reference | 0 (4) to 20 mA, 100Ohm, single ended |
| Potentiometer | 10 VDC, 10 mA (1K to 10KOhms) |
| Input Updating Time | 8 ms |
| Terminal Block Size | 2.3mm$^2$ / 14AWG |

**Reference Power Supply**

| | |
|---|---|
| Reference Voltage | +10 VDC, 1% at 25°C (77°F) |
| Maximum Load | 10 mA |
| Applicable Potentiometer | 1 kOhm to 10 kOhm |
| Terminal Block Size | 2.3mm$^2$ / 14AWG |

**Analog Outputs**

| | |
|---|---|
| Quantity | Two (2) programmable current outputs |
| Signal Level | 0 (4) to 20 mA |
| Accuracy | +/- 1% full scale range at 25°C (77°F) |
| Maximum Load Impedance | 500 Ohms |
| Output Updating Time | 2 ms |
| Terminal Block Size | 2.3mm$^2$ / 14AWG |

**Digital Inputs**

| | |
|---|---|
| Quantity | Six (6) programmable digital inputs |
| Isolation | Isolated as one group |
| Signal Level | 24 VDC, (10V Logic 0) |
| Input Current | 15 mA at 24 VDC |
| Input Updating Time | 4 ms |
| Terminal Block Size | 2.3mm$^2$ / 14AWG |

**Internal Power Supply**

| | |
|---|---|
| Primary Use | Internal supply for digital inputs |
| Voltage | +24 VDC, max 250 mA |
| Maximum Current. | 250 mA |
| Protection | Short circuit protected |

**Relay Outputs**

| | |
|---|---|
| Quantity | Three (3) programmable relay (Form C) outputs |
| Switching Capacity | 8A at 24 VDC or 250 VAC, 0.4 A at 120 VDC |
| Max Continuous Current | 2A RMS |
| Contact Material | Silver Cadmium Oxide (AgCdO) |
| Isolation Test Voltage | 4 kVAC, 1 minute |
| Output Updating Time | 12 ms |
| Terminal Block Size | 2.3mm2 / 14AWG |

**Protections**

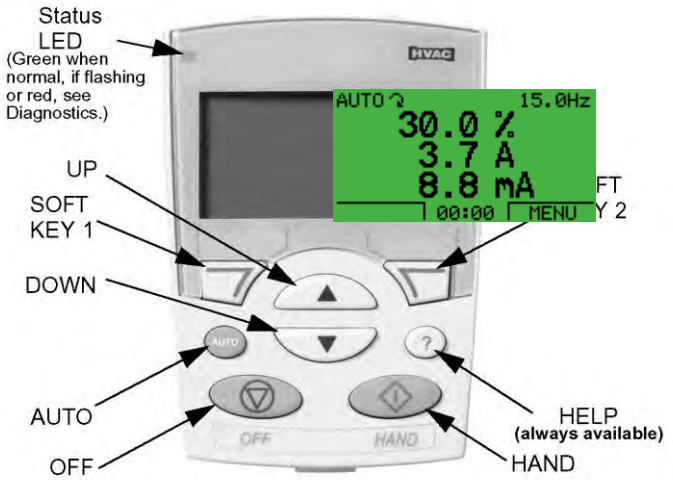
| | |
|---|---|
| Single Phase | Protected (input & output) |
| Overcurrent Trip Limit | 3.5 x $I^2N$ instantaneous |
| Adjustable Current Regulation Limit | 1.3 x $I^2N$ (RMS) max. |
| Overvoltage Trip Limit. | 1.30 x $U_N$ |
| Undervoltage Trip Limit | 0.65 x $U_N$ |
| Overtemperature (Heatsink) | +115°C (+239°F) |
| Auxiliary Voltage | Short Circuit Protected |
| Ground Fault | Protected |
| Short Circuit | Protected |
| Microprocessor fault | Protected |
| Motor Stall Protection | Protected |
| Motor Overtemperature Protection ($I^2t$) | Protected |
| Input Power Loss of Phase. | Protected |
| Loss of Reference | Protected |
| Short Circuit Current Rating | 100,000 RMS symmetrical Amperes |
| 5% Equivalent Impedance | 5% Equivalent Input Impedance with internal reactor(s)<br>Patented swinging choke design for superior harmonic mitigation in frame sizes R1-R6<br>3% Equivalent Impedance for frame R8 |
| Printed Circuit Boards | Conformal coated |

$U_1$ = Input Voltage
$U_2$ = Output Voltage
$P_N$ = Power – Normal Duty (HP)
$U_N$ = Nominal Motor Voltage
$f_N$ = Nominal Motor Frequency
$I_{2N}$ = Nominal Motor Current – Normal Duty

Specifications are subject to change without notice. Please consult the factory when specifications are critical.

## *ACH550 Control Panel*

The ACH550 Control Panel is a multifunction control panel with full graphic LCD display and multiple language capability. The control panel can be connected to and detached from the ACH550 at any time. The panel can be used to upload and copy parameters to other ACH550 drives.




**Run Indication and Shaft Direction ↷ located in upper left corner of display.**

| Control Panel Display | Significance |
|---|---|
| Rotating arrow (clockwise or counterclockwise) | Drive is running and at set point<br>Shaft direction is forward or reverse |
| Rotating arrow blinking | Drive is operating but not at setpoint |
| Stationary arrow | Drive is stopped |

**LED Indicators**

The green LED indicates that the power is on and the drive is operating normally. The red LED indicates a fault. A blinking green LED indicates an alarm condition. A blinking red LED indicates a fault that requires power to be cycled off and on to reset the drive.

**Fault Indications**

The ACH550 Control Panel can display over 20 alarm and fault messages. The last fault and previous faults (1 to 9) are retained in memory. The last fault and previous faults (1 & 2) also record important diagnostic information to assist in troubleshooting. Most faults can be reset by pressing the RESET key (Soft Key 1).

**Parameters**

Application specific parameters are immediately accessible through a selection of start-up “Assistants”. A complete list of parameters is also available grouped by function in approximately 33 menu groups. One of the basic menu functions can be used to display the complete list of changed parameters.

**Real Time Clock**

The Operator Control Panel includes a real time clock which provides Day, Date and Time information, displayed in a choice of formats. The real time clock has a 10-year battery backup and provides time and date stamping of drive faults and other events. The clock is also used by the ACH550s internal timer functions, providing an integral time clock for start/stop control as well as other control operations.

## *Control Modes*

When the HAND key is pressed, the drive starts and pressing the UP/DOWN keys can modify the reference frequency. The HAND (keypad) control mode is indicated.

When the OFF key is pressed, the drive stops and the OFF control mode is indicated.

When the AUTO key is pressed, the AUTO control mode is indicated. The drive can be started and stopped using whichever remote start/stop command has been configured, a contact closure applied to the start/stop input, a serial communication command or a process feedback signal. In AUTO mode the drive speed is typically controlled by the external speed reference input or by the PID controller.

If the HAND key is pressed while the drive is running in the AUTO control mode, the drive continues to run without changing speed, but ceases to respond to external input or PID speed reference changes. (Bumpless transfer) Pressing the UP/DOWN keys can modify the reference frequency.

If the AUTO key is pressed while the drive is running in the HAND control mode and an external start command is present, the drive continues to run and follows the acceleration or deceleration control ramp to the speed set by the external input or PID speed reference. (Bumpless transfer)

## *Cable Connections*

| Terminal | Description | Note |
|---|---|---|
| U1, V1, W1 | 3~ power supply input | Use of 1~ supply requires 50% derate of output current and is applicable for 208 to 240 VAC operation only. |
| PE / GND | Protective Ground | Follow local rules for cable size. |
| U2, V2, W2 | Power output to motor | |
| Uc+, Uc- | DC bus | |
| X1 1 to 18 | Control Wiring | Low voltage control – Use shielded cable |
| X1 19 to 27 | Control Wiring | Low voltage or 115VAC |
| X1 28 to 32 | Serial Communications | Use shielded cable |

Follow local codes for cable size. To avoid electromagnetic interference, use separate metallic conduits for input power wiring, motor wiring, control and communications wiring. Keep these four classes of wiring separated in situations where the wiring is not enclosed in metallic conduit. Also, keep 115VAC control wiring separated from low voltage control wiring and power wiring.

Use shielded cable for control wiring.

Ampacity is based on the use of 60 °C rated power cable up to 100 Amps (75 °C over 100 Amps).

Refer to the included tables for current ratings, fuse recommendations and maximum wire size capacities and tightening torques for the terminals. The ACH550 is suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes, 480 V maximum. The ACH550 has an electronic motor protection feature that complies with the requirements of the National Electric Code (NEC). When this feature is selected and properly adjusted. Additional overload protection is not required unless more than one motor is connected to the drive or unless additional protection is required by applicable safety regulations.

For CE installation requirements, see ABB publication CE-US-02 “CE Council Directives and Variable Speed Drives.” Contact your local ABB representative for specific IEC installation instructions.

## *ACH550 Control Terminals - Main I/O Terminal X1*

| X1 | Identification | Description | |
|---|---|---|---|
| 1 | SCR | Terminal for signal cable screen. (Connected internally to chassis ground.) | |
| 2 | AI 1 | Analog input channel 1, programmable. Default[2] = External reference<br>Resolution 0.1 % accuracy ±1 %.<br>0 (4) - 20 mA ($R_i$ = 312 kΩ) (J1:AI1 ON)<br>0 (2) - 10 V ($R_i$ = 100 Ω) (J1:AI1 OFF) | |
| 3 | AGND | Analog input common. (Connected internally to chassis ground through 1 MΩ) | |
| 4 | 10 V | 10 V/10 mA reference voltage output for analog input potentiometer, accuracy ±2 %.<br>(1 kΩ ≤ R ≤ 10 kΩ) | |
| 5 | AI 2 | Analog input channel 2, programmable. Default[2] = PID Feedback<br>Resolution 0.1 % accuracy ±1 %.<br>0 (4) - 20 mA ($R_i$ = 312 kΩ) (J1:AI2 ON)<br>0 (2) - 10 V ($R_i$ = 100 Ω) (J1:AI2 OFF) | |
| 6 | AGND | Analog input common. (Connected internally to chassis ground through 1 MΩ) | |
| 7 | AO1 | Analog output channel 1, programmable. Default[2] = Output frequency<br>0 (4) - 20 mA (load < 500 Ω), accuracy ±3% full scale. | |
| 8 | AO2 | Analog output channel 2, programmable. Default[2] = Output current<br>0 (4) - 20 mA (load < 500 Ω), accuracy ±3% full scale. | |
| 9 | AGND | Analog output common. Connected internally to chassis ground through 1 MΩ) | |
| 10 | 24 V | Auxiliary voltage output 24 V DC / 250 mA (Reference to AGND).<br>Short circuit protected. | |
| 11 | GND | Common for digital input (DI) return signals. | |
| 12 | DCOM | Digital input circuit common for all digital inputs (DIs). Connected internally as floating. | |
| DI Configuration[1] | | To activate a digital input, there must be ≥ +10 V (or ≤ -10 V) between that input and DCOM. The 24 V may be provided by the ACH550 (X1:10) or by an external 12-24 V source of either polarity. | |
| 13 | DI 1 | Digital input 1, programmable. Default[2] = Start/Stop (AUTO mode)<br>Activation starts the drive | |
| 14 | DI 2 | Digital input 2, programmable. Default[2] = Not configured. | |
| 15 | DI 3 | Digital input 3, programmable. Default[2] = Constant (Preset) speed.<br>Activation selects constant speed 1 | |
| 16 | DI 4 | Digital input 4, programmable. Default[2] = Start enable 1 (safety interlock)<br>Deactivation stops the drive. | |
| 17 | DI 5 | Digital input 5, programmable. Default[2] = Not configured. | |
| 18 | DI 6 | Digital input 5, programmable. Default[2] = Not configured. | |
| 19 | RO1C | Common | Relay output 1, programmable<br>(Default[2] = Ready – 19 connected to 21).<br>12 - 250 V AC / 30 V DC, 10 mA - 2 A |
| 20 | RO1A | Normally Closed (NC) | |
| 21 | RO1B | Normally Open (NO) | |
| 22 | RO2C | Common | Relay output 2, programmable<br>(Default[2] = Running - 22 connected to 24).<br>12 - 250 V AC / 30 V DC, 10 mA - 2 A |
| 23 | RO2A | Normally Closed (NC) | |
| 24 | RO2B | Normally Open (NO) | |
| 25 | RO3C | Common | Relay output 3, programmable<br>(Default[2] = Fault (-1)[3]- 25 connected to 27).<br>12 - 250 V AC / 30 V DC, 10 mA - 2 A |
| 26 | RO3A | Normally Closed (NC) | |
| 27 | RO3B | Normally Open (NO) | |
| 28 | Screen | Terminal for signal cable screen. (Connected internally to chassis ground.) | |
| 29 | B | RS-485 Serial Communications Positive input connection | |
| 30 | A | RS-485 Serial Communications Negative input connection | |
| 31 | AGND | Analog input common. (Connected internally to chassis ground through 1 MΩ.) | |
| 32 | Screen | Terminal for signal cable screen. (Connected internally to chassis ground.) | |

Notes: 1. Digital input impedance 1.5 kΩ. Maximum voltage for digital inputs is 30 V. Use multi-strand wire, size range: 20-16 AWG (0.5-1.5 $mm^2$)
2. Default values depend on the macro used. Values specified are for the HVAC default macro.
3. For fail-safe reasons, the Fault (-1) Relay signals a “Fault”, when the ACH550 is powered down.

# Drive Pack Standard Features

## *ACH550 Drive Pack - Overview*

The ACH550 Drive Pack is an ACH550 Variable Frequency Drive enclosed with an input circuit breaker (ACH550-PCR). The ACH550 Drive Pack provides a door-mounted input disconnect operator (padlockable in the OFF position), electronic motor overload protection, local operator keypad with graphics display, and provisions for external control connections. The operator keypad is mounted on the door of the enclosure.

For outdoor applications, UL Type 3R (NEMA) 3R enclosed ACH550-PCR Drive Pack packages are available from 1 to 100 HP at 208/240V, 1 to 200 HP at 480V and 2 to 150 HP at 600V. Construction is double-wall sheet steel with a tough powder coat paint finish for corrosion resistance. A thermostatically controlled space heater and thermostatic control of the force ventilated cooling system are standard.

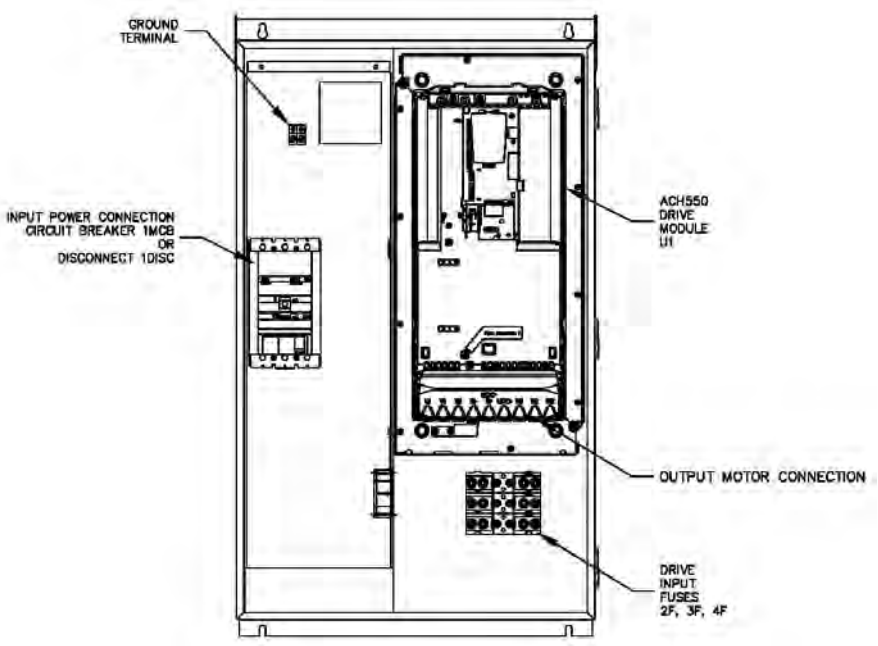
## *Cable Connections*

The following illustrations show the ACH550 Drive Pack cable connection points for the various enclosure styles. The illustrations indicate the location of input and output power connections as well as equipment and motor grounding connection points.

ACH550-PCR UL Type 3R enclosures are configured for bottom access. At least three separate metallic conduits are required, one for input power, one for output power to the motor and one for control signals.

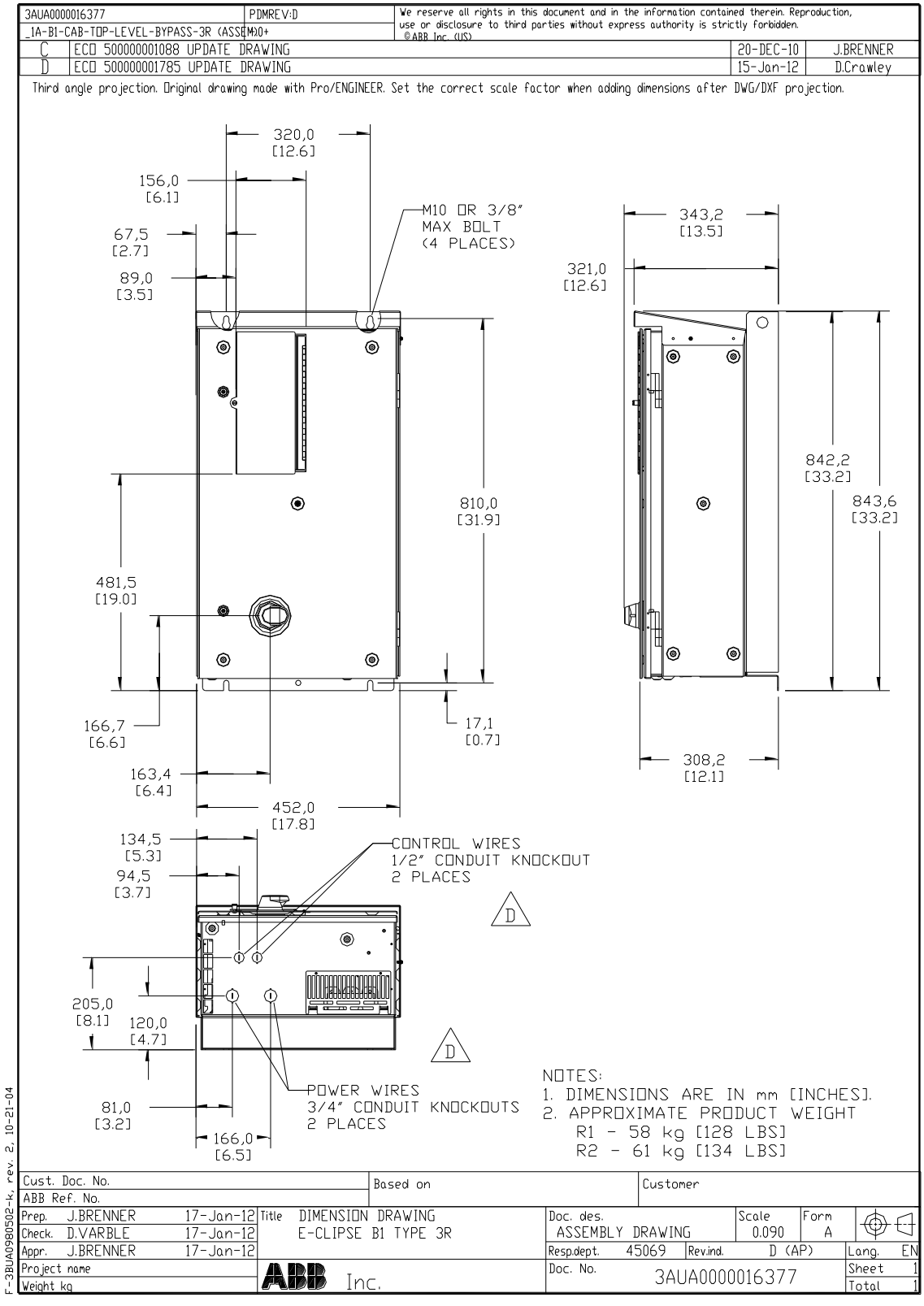
## *Terminal Sizes*

Power and motor cable terminal sizes are shown in the *Submittal Schedule Details* and in the *Wire Size Capacities of Power Terminals* Table. The information provided is for connections to an input circuit breaker or disconnect switch, a motor terminal block and ground lugs. The table also lists torque that should be applied when tightening the connections.




Standard Wall Mount Drive Pack Internal View (UL Type 3R)

# Dimension Drawing for P-1 thru 4



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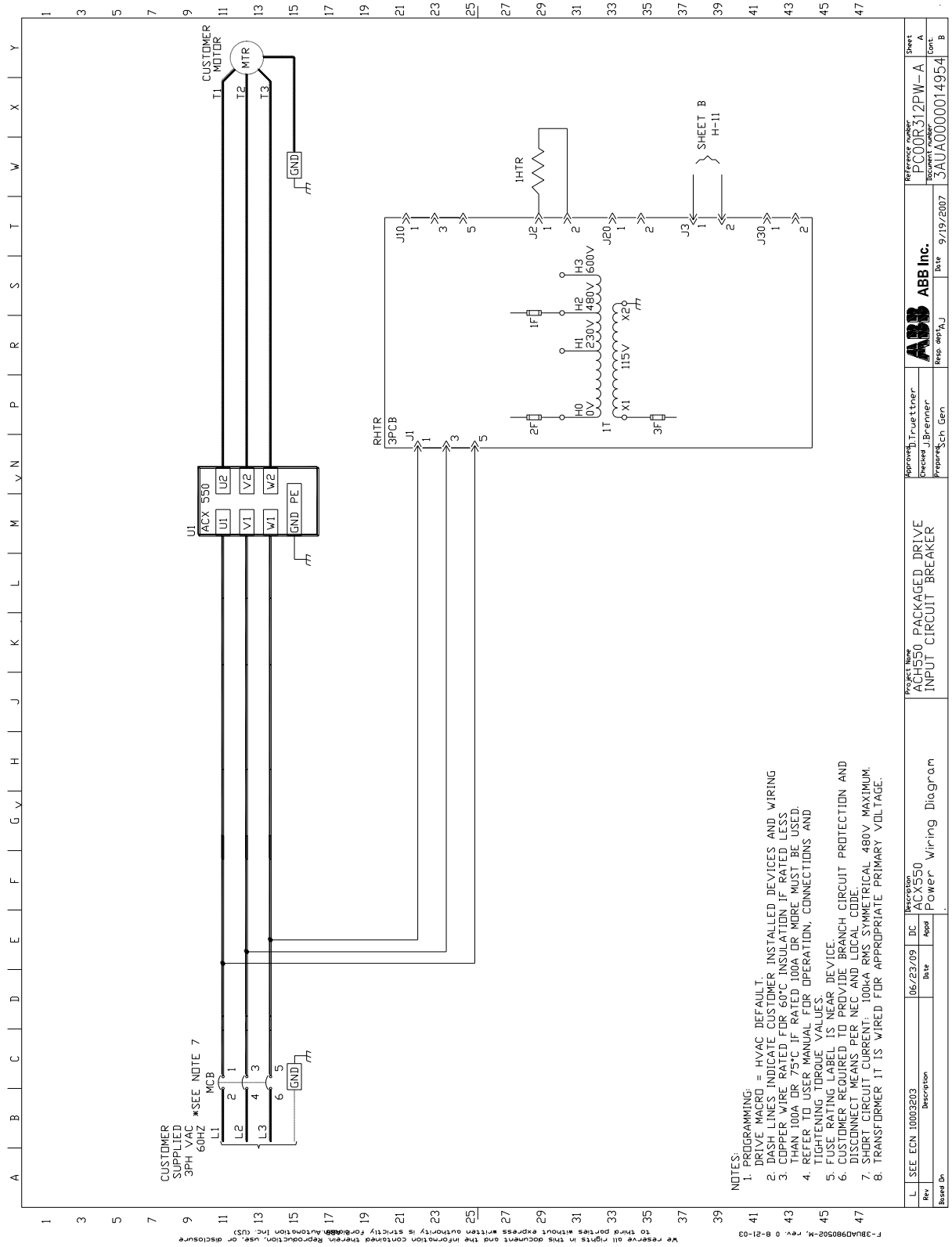
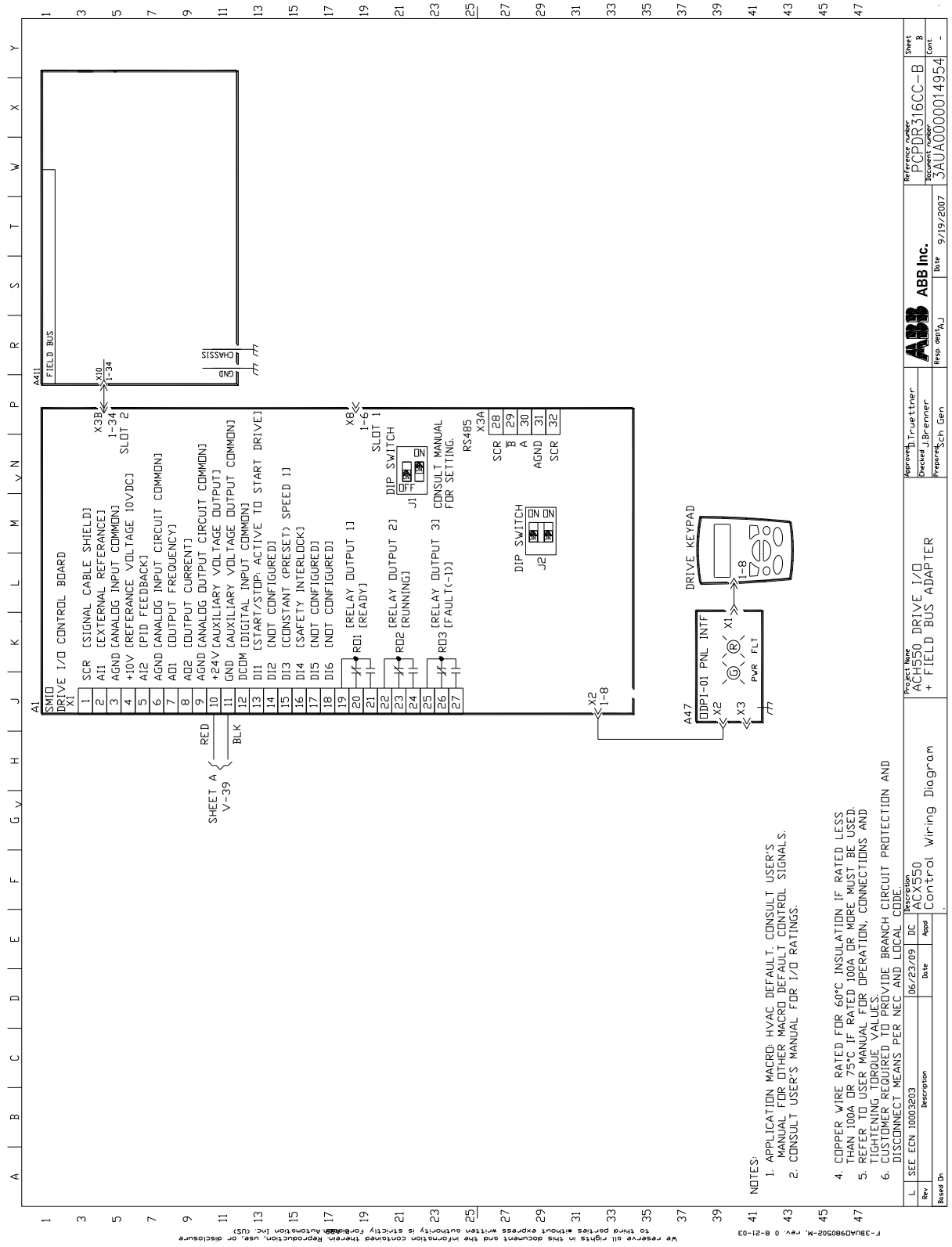
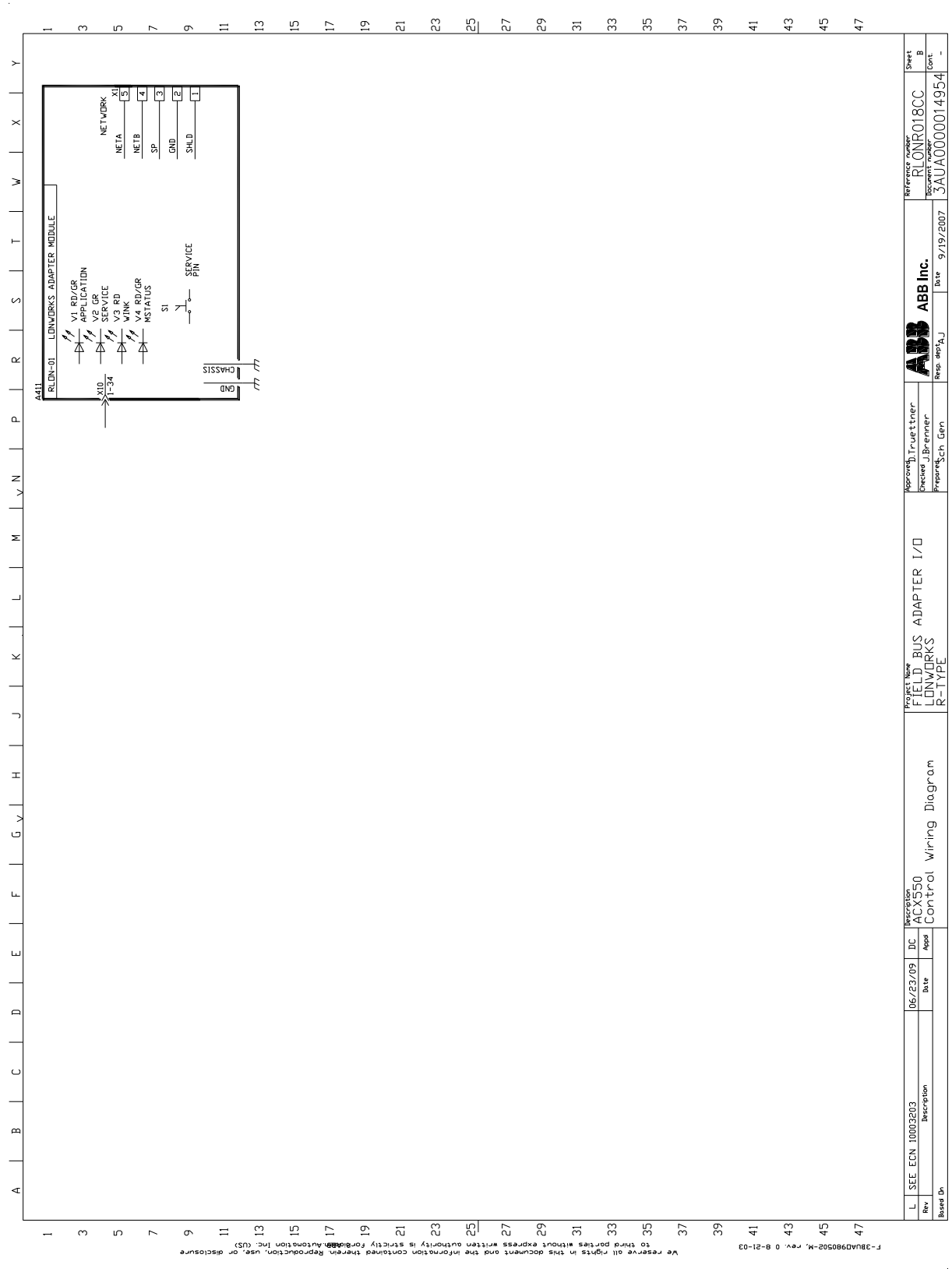
## Power Drawing for P-1 thru 4



# Connection Drawing for P-1 thru 4



## Connection Drawing for P-1 thru 4



# Engineering Data and Ratings Tables

## *Fuses*

Drive input fuses are recommended to disconnect the drive from power in the event that a component fails in the drive's power circuitry. Recommended drive input fuse specifications are listed in the *Submittal Schedule Details* and in the *Fuse Ratings* Table. Fuse rating information is provided for customer reference.

| Item | Catalog Number | Drive Input Fuse Ratings | |
|---|---|---|---|
| | | Amps (600V) | Bussmann Type |
| 1 | ACH550-PCR-024A-2+B058+K452 | N/A | N/A |

## *Terminal Sizes / Cable Connection Requirements*

Power and motor cable terminal sizes and connection requirements are shown in the *Submittal Schedule Details* and in the *Terminal Sizes / Cable Connection Requirements* Table. The information provided below is for connections to input power and motor cables. These connections may be made to an input circuit breaker or disconnect switch, a motor terminal block, overload relay, and/or directly to bus bars and ground lugs. The table also lists torque that should be applied when tightening terminals and spacing requirements where multiple mounting holes are provided in the bus bar.

| Item | Catalog Number | Circuit Breaker | Disconnect Switch | Terminal Block | Overload Relay | Ground Lug |
|---|---|---|---|---|---|---|
| 1 | ACH550-PCR-024A-2+B058+K452 | #6<br>45 in-lbs | N/A<br>N/A | #6<br>12 in-lbs | N/A<br>N/A | #6<br>35 in-lbs |

## *Heat Dissipation Requirements*

The cooling air entering the drive must be clean and free from corrosive materials. The *Submittal Schedule Details* and the *Heat Dissipation Requirements* table below give the heat dissipated into the hot air exhausted from the drives. If the drives are installed in a confined space, the heat must be removed from the area by ventilation or air conditioning equipment.

| Item | Catalog Number | Power Losses | | Airflow | |
|---|---|---|---|---|---|
| | | Watts | BTU/Hr | CFM | CM/Hr |
| 1 | ACH550-PCR-024A-2+B058+K452 | 227 | 776 | 52 | 88 |

## *Dimensions and Weights*

| Item | Catalog Number | Height mm / in | Width mm / in | Depth mm / in | Weight kg / lbs | Dimension Drawing |
|---|---|---|---|---|---|---|
| 1 | ACH550-PCR-024A-2+B058+K452 | 865 / 34 | 452 / 17.8 | 343 / 13.5 | 61 / 134 | 3AUA0000016377-1 |

## *Schematics and Wire Diagrams*

Detailed wiring diagrams and schematics may be included for the products covered in this submittal. Please reference the following ABB part numbers for the drawings included with this submittal:

| Item | Catalog Number | Power Wiring | Connection Diagram | Dimension Detail |
|---|---|---|---|---|
| 1 | ACH550-PCR-024A-2+B058+K452 | PC00R312PW-A | PCPDR316CC-B<br>RLONR018CC | 3AUA0000016377-1 |

## *Product short Circuit Current Rating*

Short circuit ratings shown below are as show on the device rating label.

| Item | Catalog Number | Short Circuit Current Rating |
|---|---|---|
| 1 | ACH550-PCR-024A-2+B058+K452 | 100 kA |

## The V1000 KLC-Series output filters provide exceptional motor and cable protection in a compact design



The next installment of the KLC-Series Filter provides excellent protection in a user-friendly package. This compact design has been developed with space sensitive applications in mind. The V1000 greatly reduces motor failures on VFD applications by limiting the magnitude of voltage spikes to levels below 1000 volts and slows down the rate of change of PWM switching by a factor of three. The V1000 has demonstrated success in protecting the cable and motor insulation by reducing the damaging effects of reflected wave.

Common Mode currents, which can lead to bearing pitting and fluting, are typically reduced by 30%. Extensive testing has demonstrated that TCI's V1000 filter is effective at reducing Common Mode currents, without costly machine modifications.

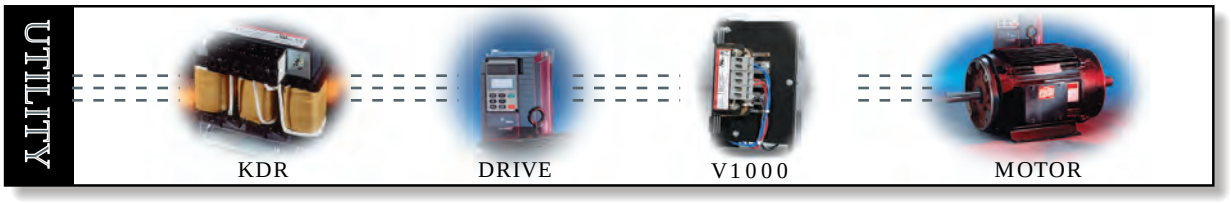
Designed to be installed within ten feet of the drive output terminals, V1000 Filters are easily accessible for both installation and maintenance. The superior performance increases process uptime and motor life. The V1000 provides the outstanding performance that our customers have come to expect from the KLC-Series Output Filters.

### Manufacturer's Warranty

V1000 KLC-Series Output Filters are warranted against Manufacturer's defect for one year from the date of original purchase.

### Drawings/Specifications

Autocad compatible *.dxf drawings and Acrobat Reader compatible *.pdf drawings of all V1000 Series KLC Output Filters are available at www.transcoil.com or by contacting TCI at (800) 824-8282.




### Typical Problems, Superior Solutions with KLC-Series Products

*The Reflective Wave Phenomenon*

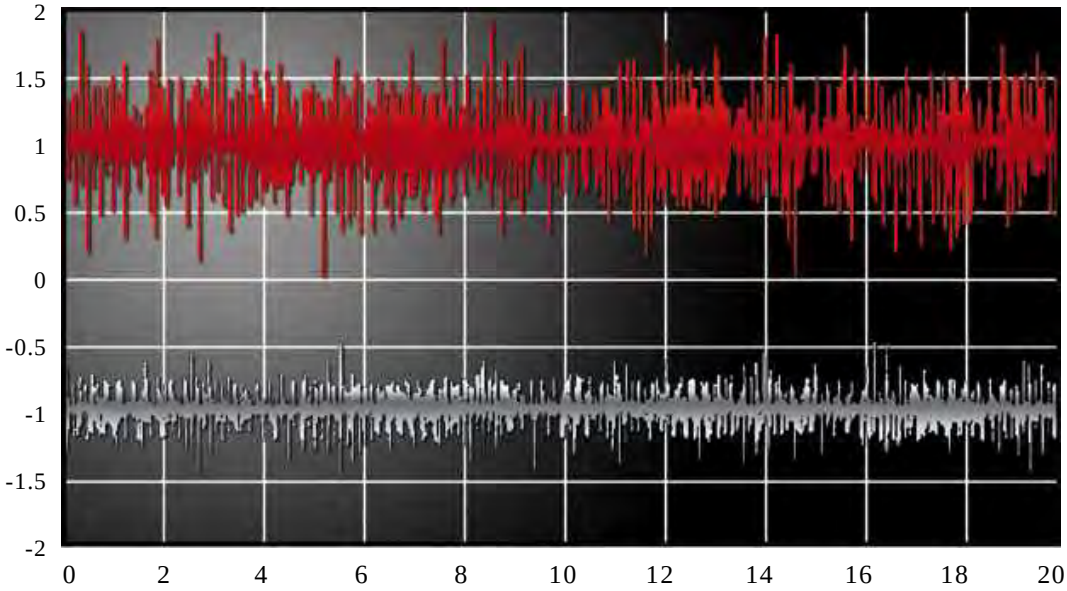
Variable Frequency Drives generate useful "fundamental" voltage and frequency using Pulse Width Modulation (PWM) for adjusting the speed of an AC motor. The Drive's inverter circuit "switches" (transitions from the off state to the on state) rapidly, producing a carrier containing the fundamental voltage and frequency. Voltage wave reflection is a function of the voltage rise time (dV/dT) and the length of the motor cables. The impedance on either end of the cable run does not match, causing voltage pulses to be reflected back in the direction from which it arrived. As these reflected waves encounter incoming waves, their values add, causing higher peak voltage. As wire length or carrier frequency increases, the overshoot peak voltage also increases. The KLC-Series Output Filters have been designed to limit peak voltage and increase voltage rise time. In specific applications, the V1000 has performed with cable runs of up to 3,000 feet.

*The Resonant Circuit Phenomenon*

Electrical systems of every nature have a natural frequency at which they operate. The natural frequency is determined by the equation: $Fr = \frac{1}{2\Pi * \sqrt{L * C}}$. Individual components within a system also operate at frequencies specific unto themselves. When system components have a resonant frequency that matches the natural resonant frequency of the entire system, peak voltages can quickly exceed standard reflective wave overshoots. The insertion of a V1000 ensures that the system resonance frequency remains sufficiently high in order to avoid matching the resonant frequency of any single component.

# Common Mode Motor Bearing Current

Common mode voltage occurs when the voltages on the three output lines of a drive do not sum “instantaneously” to zero. The V1000 substantially slows down the rate of change of PWM switching as seen by the load. This reduction in the rate of change results in increased capacitive coupling impedance between bearings and bearing races. This increase in impedance, in turn, reduces the damaging Common Mode currents and increases motor up-time.




30% Reduction in rms Common Mode Current with V1000 Applied

## dV/dT and Reflective Wave unsuppressed causes Motor failures

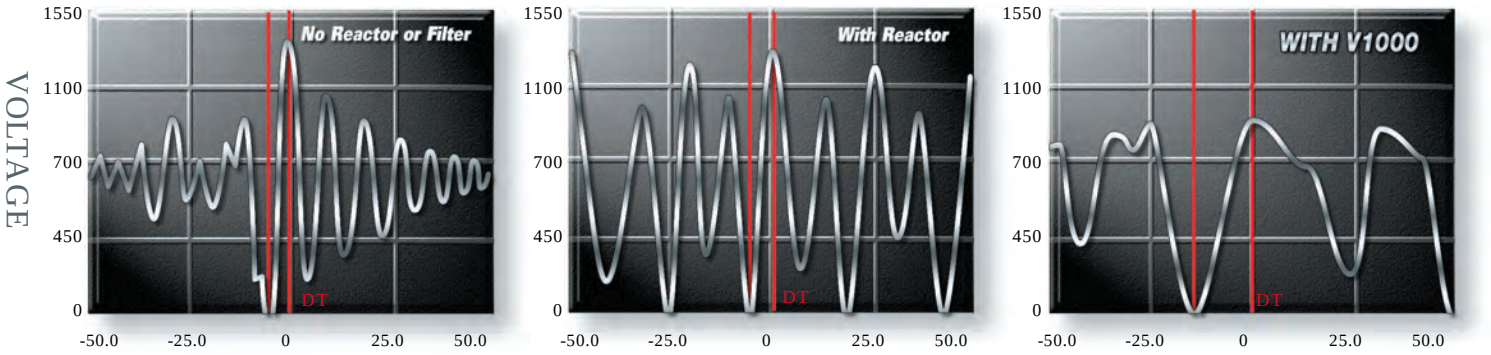
- Peak Voltages on a 460V system can commonly exceed 1500V, causing rapid breakdown of motor insulation, leading to motor failure. On 575 V systems, the peak voltages can easily reach 2100 V. If this is left uncontrolled, insulation failure may occur.
- The same peak voltages that damage the motor can also damage the cable. Since the V1000 filters are designed to be placed at the output of the Drive, these units will also protect the cable runs.

  The added inductance of a V1000 filter will also help reduce motor heating, motor noise, and motor vibration by reducing the current harmonics in the system.

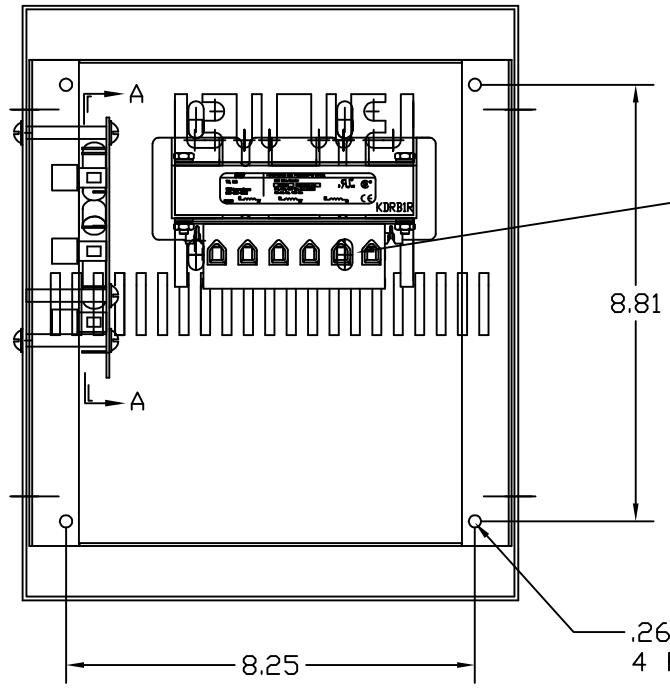
# Voltage Rise Time

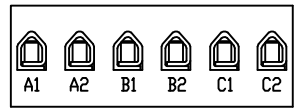
While peak voltages can commonly exceed 1500V, it is important to note that these same spikes can have a rise time, dV/dT, in excess of 7500V/µs. Such high rise times can cause significant damage to the motor windings and the insulation system, resulting in premature motor failure. The life of the motor can be greatly extended by limiting both the magnitude of the voltage spikes to levels below 1000V and the dV/dT at the motor terminals to levels less than 1000V/µs on 480V systems.

Carrier Frequency 8KHZ; 500 Feet of Cable Rate of voltage rise at motor terminals

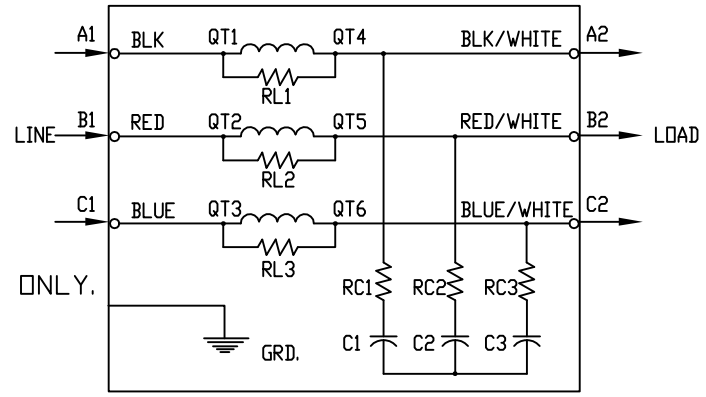


"SEE V1K INSTALLATION GUIDE FOR TERMINAL WIRE SIZE AND TORQUE"

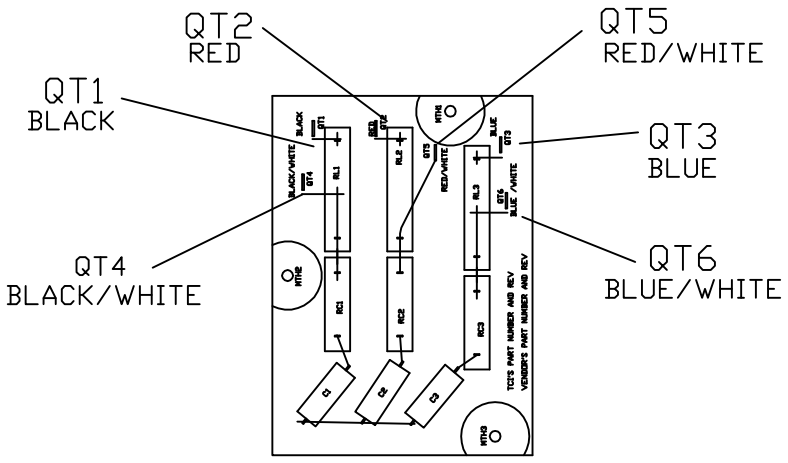


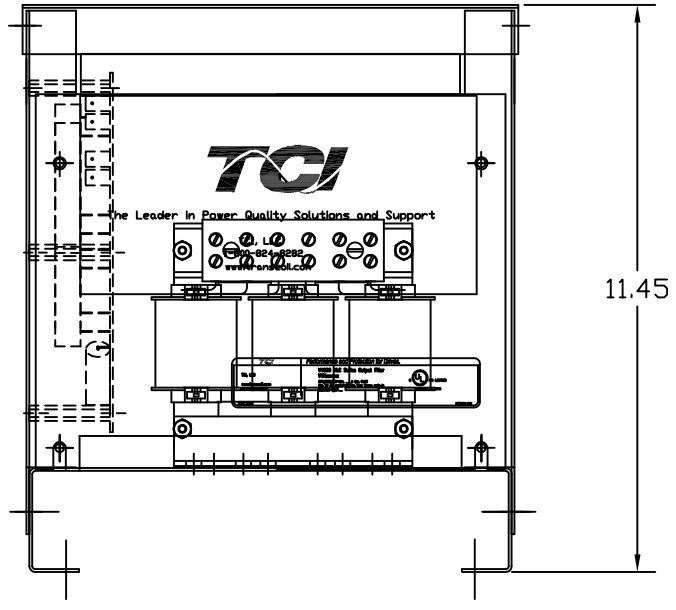

MARKINGS ON TERMINAL BLOCK
A1,A2,B1,B2,C1,C2 FOR REFERENCE ONLY.

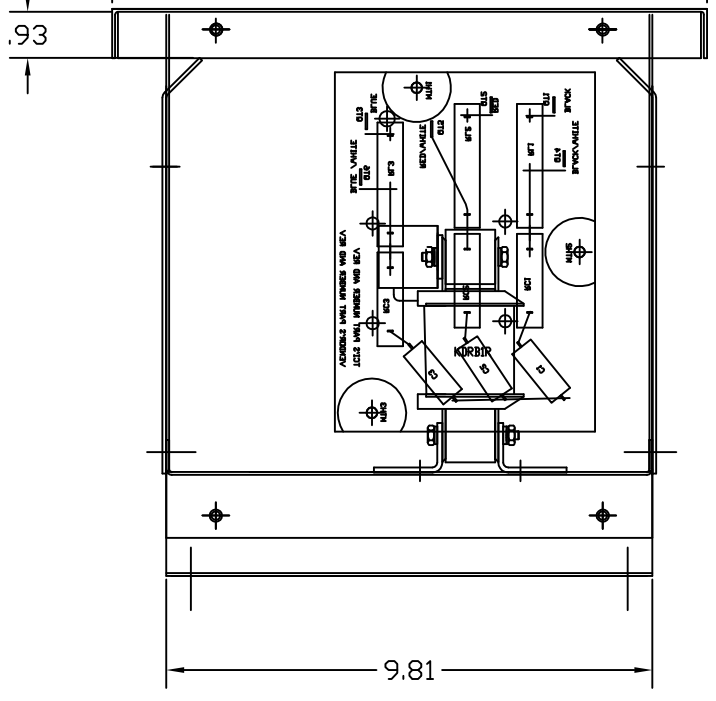



| SPECIFICATIONS: | |
|---|---|
| AMP. | 25 |
| VOLT | 240-600 |
| PHASE | 3 |
| HZ | 60 |
| WEIGHT, LBS. | 29 |
| ENCLOSURE | TYPE 3R |




P.C.BOARD
VIEW A-A

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| NO | REVISION | DATE | BY |
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| 3 | 3216 ADD SEE GUIDE | 12/6/2014 | DSW |

TOLERANCES (EXCEPT AS NOTED)
DECIMAL
.XX ±.03
.XXX±.01
FRACTIONAL
± 1/32
ANGULAR
± 1/2°

W132 N10611 GRANT DRIVE
GERMANTOWN, WI 53022

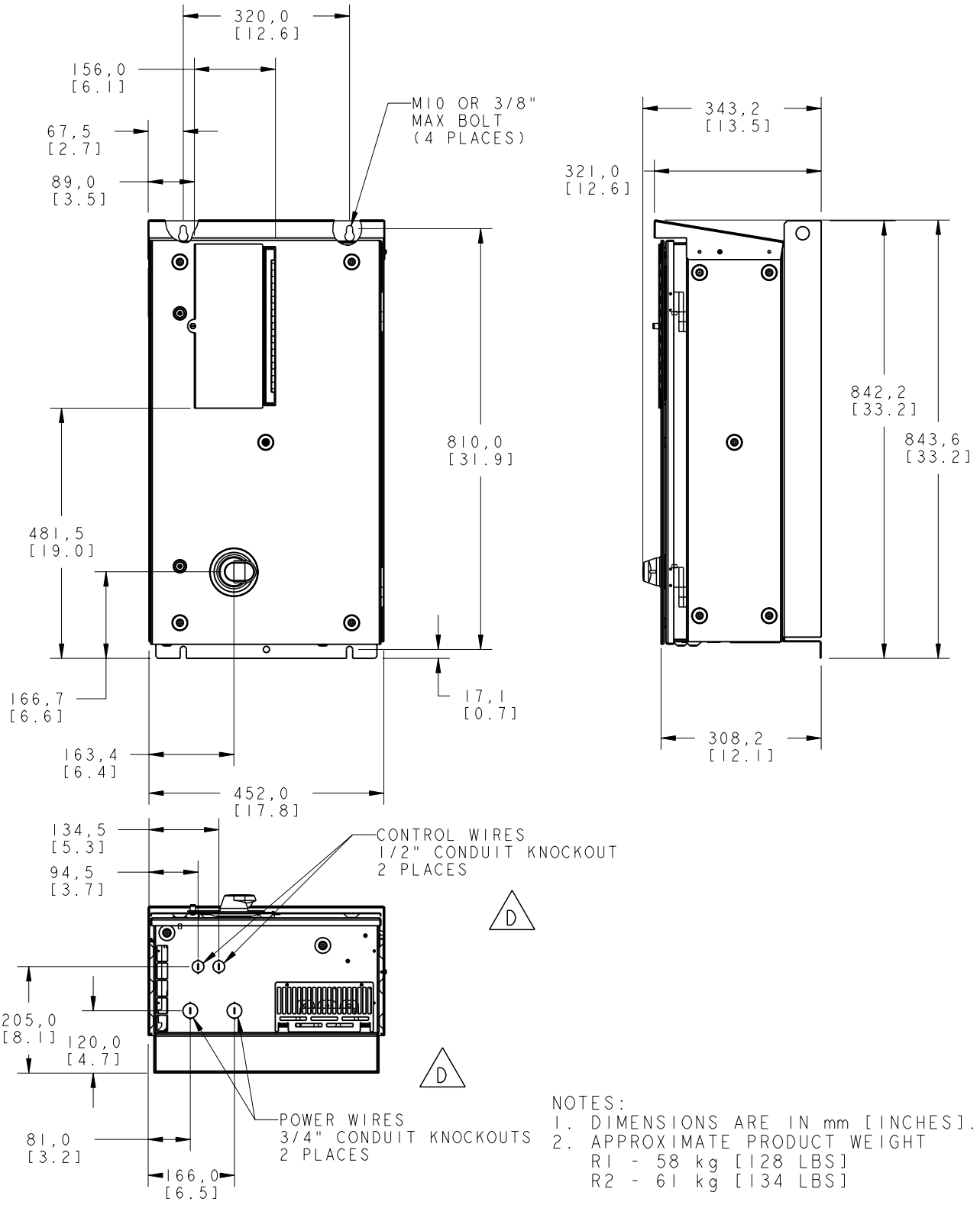
# V1K25A03, OUTPUT FILTER

## 25 AMP, ENCLOSED TYPE 3R

DRN. BY RJC
DATE 2/1/05
DWG. NO. 104224DG
SCALE NONE
SIZE B
SHT. 1 OF 1

| | | | |
|---|---|---|---|
| 3AUA0000016377 | PDMREV:D | We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Inc. (US) | |
| _IA-BI-CAB-TOP-LEVEL-BYPASS-3R (ASSEMJO+ | | | |
| C | ECO 500000001088 UPDATE DRAWING | 20-DEC-10 | J.BRENNER |
| D | ECO 500000001785 UPDATE DRAWING | 15-Jan-12 | D.Crawley |

Third angle projection. Original drawing made with Pro/ENGINEER. Set the correct scale factor when adding dimensions after DWG/DXF projection.

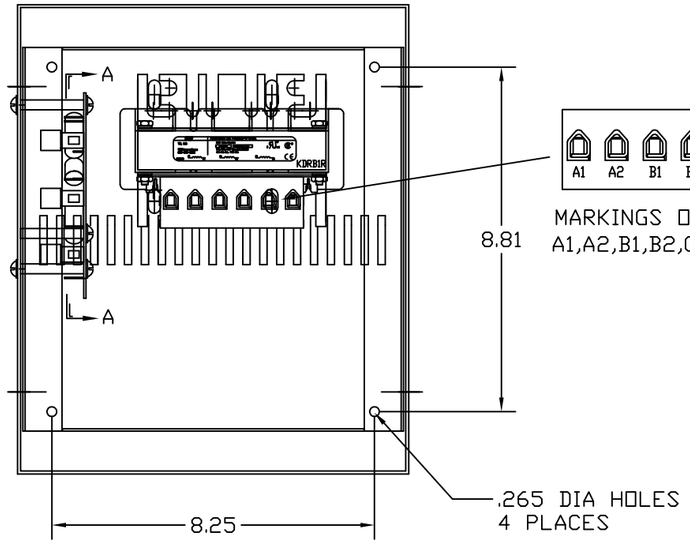



NOTES:
1. DIMENSIONS ARE IN mm [INCHES].
2. APPROXIMATE PRODUCT WEIGHT
   R1 - 58 kg [128 LBS]
   R2 - 61 kg [134 LBS]

| | | | | | |
|---|---|---|---|---|---|
| Cust. Doc. No. | | Based on | | Customer | |
| ABB Ref. No. | | | | | |
| Prep. J.BRENNER | 17-Jan-12 | Title DIMENSION DRAWING E-CLIPSE BI TYPE 3R | Doc. des. ASSEMBLY DRAWING | Scale 0.090 | Form A |
| Check. D.VARBLE | 17-Jan-12 | | | | |
| Appr. J.BRENNER | 17-Jan-12 | | Resp.dept. 45069 | Rev.ind. D (AP) | Lang. EN |
| Project name | | ABB Inc. | Doc. No. 3AUA0000016377 | | Sheet 1 |
| Weight kg | | | | | Total 1 |

F-3BUA0980502-k, rev. 2, 10-21-04

"SEE V1K INSTALLATION GUIDE FOR TERMINAL WIRE SIZE AND TORQUE"







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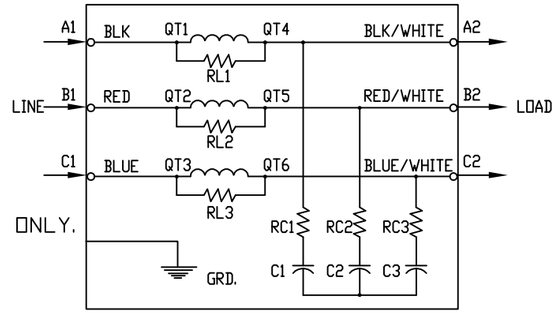
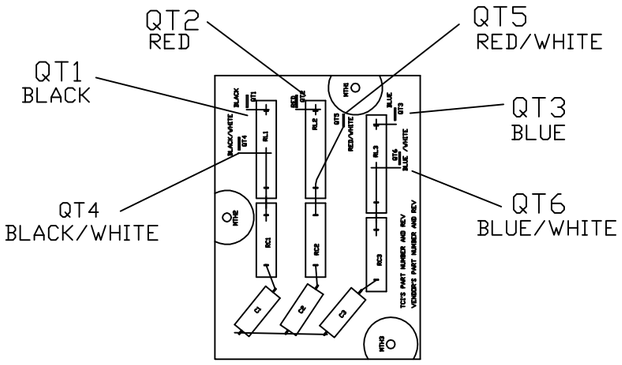
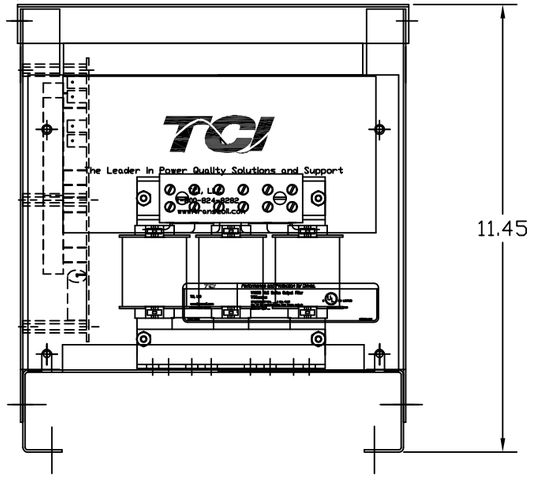
A1,A2,B1,B2,C1,C2 FOR REFERENCE ONLY.

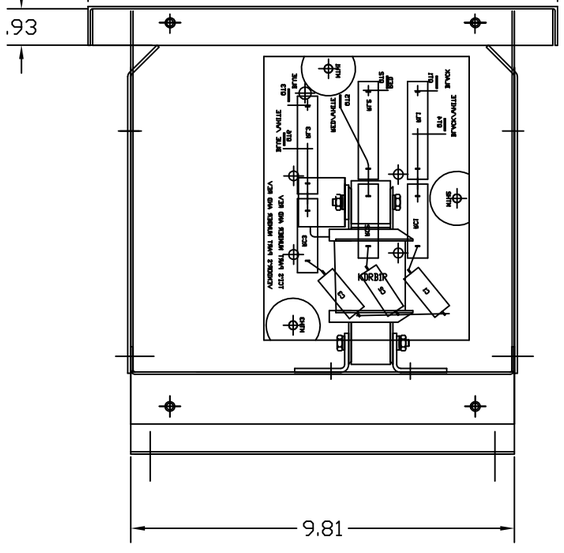



| SPECIFICATIONS: | |
|---|---|
| AMP. | 25 |
| VOLT | 240-600 |
| PHASE | 3 |
| HZ | 60 |
| WEIGHT, LBS. | 29 |
| ENCLOSURE | TYPE 3R |




P.C.BOARD
VIEW A-A

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| NO | REVISION | DATE | BY |
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| 3 | 3216 ADD SEE GUIDE | 12/6/2014 | DSW |

TOLERANCES (EXCEPT AS NOTED)
DECIMAL
.XX ±.03
.XXX±.01
FRACTIONAL
± 1/32
ANGULAR
± 1/2°

W132 N10611 GRANT DRIVE
GERMANTOWN, WI 53022

# V1K25A03, OUTPUT FILTER

## 25 AMP, ENCLOSED TYPE 3R

| DRN. BY | DATE | DWG. NO. |
|---|---|---|
| RJC | 2/1/05 | 104224DG |
| SCALE NONE | SIZE B | SHT. 1 OF 1 |

**ClimateMaster:**

ClimateMaster, Inc., currently a Division of LSB Industries and future Division of NIBE, is a manufacturer of HVAC equipment, but well respected for their high quality geothermal water-source heat pumps (WSHP). When ClimateMaster was made aware of the opportunity to participate in the unique energy saving design of an ATES project, they committed to providing substantial discounts for the WSHPs designed for the ATES project and provided technical support for their equipment to insure a successful deployment. A submittal data document of their WSHPs utilized for this demonstration follow and more information can be found at http://www.climatemaster.com.

# Tranquility® 30 Digital (TE) Series Submittal Data

## Models TED/H/V 026 - 072 60Hz - HFC-410A

English Language/I-P Units



**Rev.: 09 July, 2015**

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LC991 Rev.: 09 July, 2015

ClimateMaster
Water-Source Heat Pump Systems

### *SUBMITTAL DATA - I-P UNITS*

Unit Designation: _____

Job Name: _____

Architect: _____

Engineer: _____

Contractor: _____

### *PERFORMANCE DATA*

Cooling Capacity: _____ Btuh

EER: _____

Heating Capacity: _____ Btuh

COP: _____

Ambient Air Temp: _____ °F

Entering Water Temp (Clg): _____ °F

Entering Air Temp (Clg): _____ °F

Entering Water Temp (Htg): _____ °F

Entering Air Temp (Htg): _____ °F

Airflow: _____ CFM

Fan Speed or Motor/RPM/Turns: _____

Operating Weight: _____ (lb)

### *ELECTRICAL DATA*

Power Supply: _____ Volts

_____ Phase _____ Hz

Minimum Circuit Ampacity: _____

Maximum Overcurrent Protection: _____

# Tranquility® 30 Digital (TE) Series Submittal Data

## Models TED/H/V 026 - 072 60Hz - HFC-410A

English Language/S-I Units



**Rev.: 09 July, 2015**

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LC991 Rev.: 09 July, 2015

ClimateMaster
Water-Source Heat Pump Systems

### *SUBMITTAL DATA - S-I UNITS*

Unit Designation: _____

Job Name: _____

Architect: _____

Engineer: _____

Contractor: _____

### *PERFORMANCE DATA*

Cooling Capacity: _____ kW

EER: _____

Heating Capacity: _____ kW

COP: _____

Ambient Air Temp: _____ °C

Entering Water Temp (Clg): _____ °C

Entering Air Temp (Clg): _____ °C

Entering Water Temp (Htg): _____ °C

Entering Air Temp (Htg): _____ °C

Airflow: _____ l/s

Fan Speed or Motor/RPM/Turns: _____

Operating Weight: _____ (kg)

### *ELECTRICAL DATA*

Power Supply: _____ Volts

_____ Phase _____ Hz

Minimum Circuit Ampacity: _____

Maximum Overcurrent Protection: _____

# TE Series 60Hz - HFC-410A Submittal Data Eng/I-P

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*Document page number is shown next to part number (e.g. LC991 - 3 = page 3). Since not all pages are typically used in the submittals process, the page number in the lower right corner can still be used (page ____of_____).


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## Unit Features

### THE TRANQUILITY® 30 DIGITAL (TE) SERIES

As one of the highest efficiency water-source heat pump on the planet, the Tranquility® 30 Digital Series raises the bar for water-source heat pump efficiencies, features and application flexibility. Not only does the Tranquility® 30 Digital Series far exceed ASHRAE 90.1 efficiencies, but it also uses EarthPure® (HFC-410A) zero ozone depletion refrigerant, making it an extremely environmentally-friendly option. Tranquility® 30 Digital is eligible for additional LEED® (Leadership in Energy and Environmental Design) points because of its "green" technology design.

Available in sizes 2 tons (7.0 kW) through 6 tons (19.3 kW) with multiple cabinet options (vertical upflow, vertical downflow and horizontal) the Tranquility® 30 Digital offers a wide range of units for most any installation. The Tranquility® 30 Digital has an extended range refrigerant circuit, capable of ground loop (geothermal) applications as well as water loop (boiler-tower) applications. Standard features are many. Copeland UltraTech™ two-stage unloading scroll compressor, ECM variable communicating fan motor, communicating microprocessor controls, galvanized steel cabinet, polyester powder coat paint, stainless steel drain pan and foil-backed air handler insulation are just some of the features of the innovative Tranquility® 30 Digital Series.

ClimateMaster's exclusive double isolation compressor mounting system makes the Tranquility® 30 Digital one of the quietest units on the market. Compressors are mounted on specially engineered sound tested EPDM grommets or spring vibration isolaters to a heavy gauge mounting plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration/sound attenuation. User friendly installation and maintenance are provided by the multiple removable access panels and easy access control box. Options such as DDC controls, internal variable speed pumps, modulating water valves, and high efficiency MERV rated air filters allow customized design solutions.

iGate® technology is the next generation in intelligent control by using two-way communication to provide a gateway into the system. The iGate® control system allows end-users and contractors to monitor the performance of the unit, custom tailor its operation, and diagnose any issues, right from the thermostat.

The iGate® communications hub is the DXM2 intelligent controller, which analyzes the status of sensors and smart components (which are also two-way communicating) to determine how best to operate the system for optimal comfort, efficiency and long-term reliability. All of this information is passed to the iGate® thermostat (or diagnostic tool), where it can be displayed in plain English. And since communication is both ways, the iGate® thermostat can also be used to configure and tailor the system without even touching the unit.

vFlow® variable water flow technology represents a major advance in geothermal system performance made possible through the iGate® system. vFlow® not only builds the major water circulation components into the unit for a clean installation, it also intelligently varies the water flow to minimize pump energy consumption and improve system reliability.

The heart of vFlow® is either a variable-speed pump (for ground loops) or modulating water valve (for ground water or central variable speed pumps) directly linked into the iGate® system. Water flow is automatically varied based on changes in unit capacity level (stage) and source water temperature to maintain optimum system performance. vFlow® allows the use of direct return piping, while eliminating external two-ways valves and automatic flow regulators. vFlow® systems are inherently self-balancing.

vFlow® systems provide reduced water pumping power compared to traditional fixed-speed pumping and protects the unit against extreme operating conditions, extending the life of the compressor and air coil. Since vFlow® is built inside the unit, it also saves on installation time and makes for a very clean and compact installation. The Tranquility® 30 Digital Series water-source heat pumps are designed to meet the challenges of today's HVAC demands with one of the most innovative products available on the market.

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## Unit Features

UNIT FEATURES

- Sizes 026 (2 ton, 7.0 kW) through 072 (6 tons, 19.3 kW)
- EarthPure® (HFC-410A) refrigerant
- Copeland UltraTech™ two-stage unloading scroll compressors
- ECM variable speed communicating fan motor with soft start
- Exceeds ASHRAE 90.1 efficiencies
- Part load operation significantly lowers annual operating costs
- Galvanized steel construction with attractive black mat polyester powder coat paint and silver accents
- Stainless steel drain pan
- Foil-backed insulation in air handler section
- Unique double isolation compressor mounting with vibration isolation for quiet operation
- Insulated divider and separate compressor/air handler compartments
- TXV metering device
- Extended range (20 to 120°F, -6.7 to 48.9°C) operation
- **Advanced Controls -** iGate® communicating control provides advanced unit functionality and comprehensive configuration, monitoring and diagnostic capabilities through digital communication links with the variable-speed fan motor, variable-speed source pump (or modulating valve) and communicating thermostat or Configuration/Diagnostic tool.
  - 7 temperature sensor inputs for system protection and control
  - Anti-short cycle and over/under voltage protection
  - High pressure, loss of charge, and condensate overflow protection
  - LED fault and status indication at controller
  - Service tool port for optional setup and diagnostics at unit
- LonWorks, BACnet, Modbus and Johnson N2 compatibility options for DDC controls
- Field convertible discharge air arrangement for horizontal units
- Easy access control box
- Flush securely-mounted corner post water connections (no backup wrench required)
- Unit Performance Sentinel performance monitoring system
- Eight Safeties Standard
- Wide variety of options including ultra quiet sound insulation, extended range insulation, return air filter frames, variable and fixed speed circulating pumps, modulating motorized valves, hot water generator, and cupro-nickel water coil

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## iGate® Communicating Controls

### iGate® Information gateway to monitor, control and diagnose your system

Tranquility® 30 Digital is equipped with industry-first, iGate® – Information Gateway – 2-way communicating system that allows users to interact with their geothermal system in plain English AND delivers improved reliability and efficiency by precisely controlling smart variable speed components. iGate® makes Tranquility® Digital series the easiest geothermal products to install and service.

**Monitor/Configure** – Installers can configure Tranquility® 30 Digital units from the iGate® communicating thermostat or configuration/diagnostic tool, including: Air flow, loop △T, water-flow option configuration, unit configuration, accessory configuration, and demand reduction (optional, to limit unit operation during peak times). Users can look up the current system status: temperature sensor readings and operational status of the blower and pump.

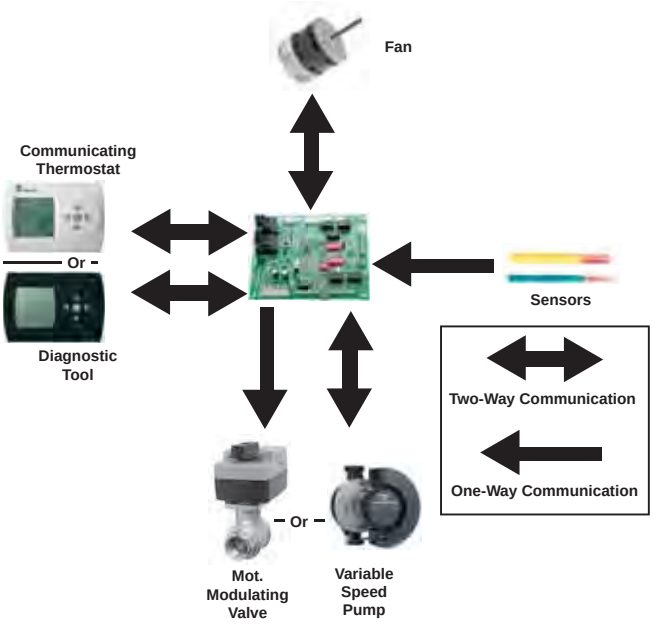
**Precise Control** – The new DXM2 board enables intelligent, 2-way communication between the DXM2 board and smart components like the communicating thermostat, fan motor, and water pump. The DXM2 control can also directly control the modulating valve and accepts various feedback/input (see figure). The Intelligent DXM2 board uses information received from the smart components and sensors to precisely control operation of variable speed fan, variable speed water pump (or modulating valve) to deliver higher efficiency, reliability and increased comfort.

**Diagnostics** – iGate® takes diagnosing geothermal units to a next level of simplicity, by providing a dashboard of system and fault information, in plain English, on the iGate thermostat/ service tool.

iGate® Service Warning warns the occupant of a fault and displays fault description, possible causes and current system status (temperature readings, fan RPM and water flow status) which may be reported to service personnel.

In iGate® Service Mode, the service personnel can access fault description, possible causes and most importantly, the conditions (temp, flow, i/o conditions, configuration) at the time of the fault. Manual Operation mode allows the service personnel to manually command operation for any of the thermostat outputs, blower speed, as well as pump speed or valve position from the thermostat, to help troubleshoot specific components.

With iGate® communicating system, users and contractors have a gateway to system information never before available.




| AIRFLOW SELECTION | CFM |
|---|---|
| HEAT STAGE 1 | 600 |
| HEAT STAGE 2 | 750 |
| AUXILIARY HEAT | 850 |
| EMERGENCY HEAT | 850 |
| COOL STAGE 1 | 525 |
| COOL STAGE 2 | 700 |
| COOL DEHUMID 1 | 425 |
| COOL DEHUMID 2 | 550 |
| CONTINUOUS FAN | 350 |
| HEAT OFF DELAY | 60 |
| COOL OFF DELAY | 30 |

◀ PREVIOUS NEXT ▶

POSSIBLE FAULT CAUSES
LOW WATER COIL TEMP

LOW WATER TEMP - HTG

LOW WATER FLOW - HTG

LOW REFRIG CHARGE - HTG

INCORRECT LT1 SETTING

BAD LT1 THERMISTOR

◀ PREVIOUS

FAULT TEMPERATURE CONDITIONS
LT1 LOW WATER TEMP
HEAT 1 11:11 AM 11/14

| | |
|---|---|
| LT1 TEMP | 28.1 |
| LT2 TEMP | 97.3 |
| HOT WATER EWT | 121.5 |
| COMP DISCHARGE | 157.7 |
| LEAVING AIR | 92.7 |
| LEAVING WATER | 34.9 |
| ENTERING WATER | 42.1 |
| CONTROL VOLTAGE | 26.4 |

◀ PREVIOUS

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## vFlow® Internal Variable Water Flow Control

### vFlow® Internal Variable Water Flow

Industry-first, Built-in vFlow® provide an ultra-high-efficient, variable speed, internal water flow system. It saves installers time and labor by avoiding installing bulky external pumps, valves, or flow regulators. Multi-unit installations are also much simpler with vFlow® systems, as the units automatically adjust water flow across the system.

vFlow® is enabled by iGate®, which facilitates intelligent communication between the thermostat, DXM2 control, sensors and internal water pump/valve to make true variable water flow a reality.

### vFlow® is available in four variations:

1. Low System Pressure Drop Modulating Valve – High CV motorized valve for central pumping.
2. High System Pressure Drop Modulating Valve – Motorized valve for higher pressure water system such as water well pumps.
3. Standard Head Variable Pump – multi unit/central pumping.
4. High Head Variable Pump – multi/individual unit pumping.

### vFlow® delivers three main benefits:

1. Easier and quicker unit installation as the flow control is built in to the unit.
2. Superior reliability by varying the water flow to deliver more stable operation.
3. Higher cost savings by varying the flow (and pump watt consumption) to match the unit's mode of operation.

### Internal components

Tranquility® 30 Digital can be installed more easily and compactly than its predecessors because water-flow components are internal to the unit. It also saves installing contractors labor and time by eliminating the need for an external flow regulator or a bulky external pumping module.

### Variable flow

vFlow® technology enables variable water flow through the unit, with the DXM2 control adjusting the pump speed to maintain an installer-set loop delta T. By controlling the water flow, the system is able to operate at its optimal capacity and efficiency. vFlow® provides a lower flow rate for part load where units typically operate 80% of the time and a higher, more normal flow rate for full load operation.

### Energy Savings with water circulation control

Units with vFlow® deliver higher operating cost savings by varying the water flow to match the unit's operation (ex: lower water flow when unit is in part load operation). Lowering the flow results in lower energy consumption by the water pump (=higher cost savings) in vFlow® units.



Variable speed pump or motorized modulating valve delivers variable water-flow, controlled by DXM2 control, based on loop water ΔT.

In applications using vFlow® with internal variable-speed (ECM) pump, the ECM pump uses fewer watts than a fixed speed (PSC) pump, even at full load (see chart). The ECM pump excels in energy savings in part load, saving 70-80% watts compared to fixed speed pumps. The ECM pump can operate with independent flow rates for heating and cooling, further saving more energy.

In applications using vFlow® with modulating valve, when the motorized modulating valve slows down the water flow during part load operation, the external pump consumes fewer watts, thus saving more energy.

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## Selection Procedure

### Reference Calculations

**Heating**

$$LWT = EWT - \frac{HE}{GPM \times 500}$$

$$LAT = EAT + \frac{HC}{CFM \times 1.08}$$

**Cooling**

$$LWT = EWT + \frac{HR}{GPM \times 500}$$

$$LAT\ (DB) = EAT\ (DB) - \frac{SC}{CFM \times 1.08}$$

$$LC = TC - SC$$

$$S/T = \frac{SC}{TC}$$

### Legend and Glossary of Abbreviations

BTUH = BTU( British Thermal Unit) per hour
CFM = airflow, cubic feet/minute
COP = coefficient of performance = BTUH output/BTUH input
DB = dry bulb temperature (°F)
EAT = entering air temperature, Fahrenheit (dry bulb/wet bulb)
EER = energy efficiency ratio = BTUH output/Watt input
MPT = male pipe thread
ESP = external static pressure (inches w.g.)
EWT = entering water temperature
GPM = water flow in U.S. gallons/minute
HE = total heat of extraction, BTUH
HC = air heating capacity, BTUH
HR = total heat of rejection, BTUH
HWC = hot water generator (desuperheater) capacity, Mbtuh
FPT = female pipe thread
KW = total power unit input, kilowatts
LAT = leaving air temperature, °F
LC = latent cooling capacity, BTUH
LWT = leaving water temperature, °F
MBTUH = 1000 BTU per hour
S/T = sensible to total cooling ratio
SC = sensible cooling capacity, BTUH
TC = total cooling capacity, BTUH
WB = wet bulb temperature (°F)
WPD = waterside pressure drop (psi & ft. of hd.)

### Conversion Table - to convert inch-pound (English) to S-I (Metric)

| Air Flow | Water Flow | Ext Static Pressure | Water Pressure Drop |
|---|---|---|---|
| Airflow (L/s) = CFM x 0.472 | Water Flow (L/s) = gpm x 0.0631 | ESP (Pa) = ESP (in of wg) x 249 | PD (kPa) = PD (ft of hd) x 2.99 |

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## Selection Procedure

Step 1 Determine the actual heating and cooling loads at the desired dry bulb and wet bulb conditions.

Step 2 Obtain the following design parameters: Entering water temperature, water flow rate in GPM, air flow in CFM, water flow pressure drop and design wet and dry bulb temperatures. Air flow CFM should be between 300 and 450 CFM per ton. Unit water pressure drop should be kept as close as possible to each other to make water balancing easier. Go to the appropriate tables and find the proper indicated water flow and water temperature.

Step 3 Select a unit based on total and sensible cooling conditions. Select a unit which is closest to, but no larger than, the actual cooling load.

Step 4 Enter tables at the design water flow and water temperature. Read the total and sensible cooling capacities (Note: interpolation is permissible, extrapolation is not).

Step 5 Read the heating capacity. If it exceeds the design criteria it is acceptable. It is quite normal for Water-Source Heat Pumps to be selected on cooling capacity only since the heating output is usually greater than the cooling capacity.

Step 6 Determine the correction factors associated with the variable factors of dry bulb and wet bulb.

Corrected Total Cooling =
tabulated total cooling x wet bulb correction.
Corrected Sensible Cooling =
tabulated sensible cooling x wet/dry bulb correction.

Step 7 Compare the corrected capacities to the load requirements. Normally if the capacities are within 10% of the loads, the equipment is acceptable. It is better to undersize than oversize, as undersizing improves humidity control, reduces sound levels and extends the life of the equipment.

Step 8 When completed, calculate water temperature rise and assess the selection. If the units selected are not within 10% of the load calculations, then review what effect changing the GPM, water temperature and/or air flow and air temperature would have on the corrected capacities. If the desired capacity cannot be achieved, select the next larger or smaller unit and repeat the procedure. Remember, when in doubt, undersize slightly for best performance.

### Example Equipment Selection For Cooling

Step 1 Load Determination:

Assume we have determined that the appropriate cooling load at the desired dry bulb 80°F and wet bulb 65°F conditions is as follows:

Total Cooling .....22,100 BTUH
Sensible Cooling.....16,500 BTUH
Entering Air Temp.....80°F Dry Bulb / 65°F Wet Bulb

Step 2 Design Conditions:

Similarly, we have also obtained the following design parameters:

Entering Water Temp.....90°F
Water Flow (Based upon 10°F rise in temp.) .....6.0 GPM
Air Flow.....730 CFM

Step 3, 4 & 5 HP Selection:

After making our preliminary selection (TEH026 - Full Load), we enter the tables at design water flow and water temperature and read Total Cooling, Sens. Cooling and Heat of Rej. capacities:

Total Cooling.....24,200 BTUH
Sensible Cooling.....16,300 BTUH
Heat of Rejection.....29,900 BTUH

Step 6 & 7 Entering Air and Airflow Corrections:

Next, we determine our correction factors.

| | Table | Ent Air | Air Flow | Corrected |
|---|---|---|---|---|
| Corrected Total Cooling = | 24,200 | x 0.975 | x 0.978 | = 23,076 |
| Corrected Sens Cooling = | 16,300 | x 1.096 | x 0.926 | = 16,543 |
| Corrected Heat of Reject = | 29,900 | x 0.979 | x 0.978 | = 28,628 |

Step 8 Water Temperature Rise Calculation & Assessment:

Actual Temperature Rise.....9.5°F

When we compare the Corrected Total Cooling and Corrected Sensible Cooling figures with our load requirements stated in Step 1, we discover that our selection is within +/- 10% of our sensible load requirement. Furthermore, we see that our Corrected Total Cooling figure is within 1,000 Btuh of the actual indicated load.

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## TE Series Nomenclature

| 1 2 | 3 | 4 5 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TE | V | 026 | B | G | D | 1 | 0 | B | L | T | S |

**SERIES**
TE = Tranquility® 30 Digital

**CONFIGURATION**
V = Vertical Up
H = Horizontal
D = Downflow

**UNIT SIZE**
026 E,F,G,H
038 E,F,G,H
049 E,F,G,H
064 E,F,G,H
072 F,G,H

**REVISION LEVEL**
B = Current Revision

**VOLTAGE**
G = 208/230/60/1
E = 265/60/1
F = 460/60/3
H = 208/230/60/3

**CONTROLS**
D = DXM2
M = DXM2 w/LON
P = DXM2 w/MPC

B = DXM2
K = DXM2 w/LON
S = DXM2 w/MPC
} With Disconnect

**CABINET**

| OPTION | RANGE | ULTRA QUIET | 1" FILTER RACK | 2" FILTER RACK | 1" FILTER FRAME | 2" FILTER FRAME |
|---|---|---|---|---|---|---|
| 1 | EXTENDED RANGE | NO | YES | NO | | |
| A | | | NO | | | YES |
| J | | | NO | YES | NO | |
| K | | | NO | | YES | NO |
| 2 | | YES | YES | NO | | |
| C | | | NO | | | YES |
| L | | | NO | YES | NO | |
| M | | | NO | | YES | NO |
| 3 | STANDARD RANGE | NO | YES | NO | | |
| E | | | NO | | | YES |
| N | | | NO | YES | NO | |
| P | | | NO | | YES | NO |
| 4 | | YES | YES | NO | | |
| G | | | NO | | | YES |
| R | | | NO | YES | NO | |
| S | | | NO | | YES | NO |

**SUPPLY AIR FLOW & MOTOR CONFIGURATION**

| | Supply | Configuration | Motor |
|---|---|---|---|
| T | Top | TEV | ECM |
| B | Back | TEH | ECM |
| S | Straight | TEH | ECM |
| D | Down | TED | ECM |

**RETURN AIR FLOW CONFIGURATION**
L = Left Return
R = Right Return

**HEAT EXCHANGER OPTIONS**

| | Uncoated Copper Air Coil | | Tin Plated Copper/Micro-Channel Aluminuum Air Coil | |
|---|---|---|---|---|
| | Copper | Cupro-Nickel | Copper | Cupro-Nickel |
| Standard | B | G | A | J |
| HWG (Coil Only) | T | V | U | W |

Sizes 026 to 049 always have an all-aluminum microchannel air coil.
Sizes 064 and 072 have an aluminum fin copper tube air coil with an option for tin plated copper tubes for added corrosion protection.

**WATER CIRCUIT OPTIONS**
0 = None
3 = Internal Pump Standard Head (Variable) UPM-Geo
4 = Internal Pump High Head (Variable) Magna Pump
5 = Motorized Valve (Modulating) Closed Loop Applications, Low System Pressure Drop
6 = Motorized Valve (Modulating) Open Loop Applications, High System Pressure Drop
7 = Internal Secondary Pump - Single Speed

**STANDARD**
S = Standard

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## Performance Data AHRI/ASHRAE/ISO 13256-1

### ASHRAE/AHRI/ISO 13256-1. English (I-P) Units

| Model | Water Loop Heat Pump | | | | Ground Water Heat Pump | | | | Ground Loop Heat Pump | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cooling 86°F | | Heating 68°F | | Cooling 59°F | | Heating 50°F | | Full Cool 77°F Part Cool 68°F | | Full Heat 32°F Part Heat 41°F | |
| | Capacity Btuh | EER Btuh/W | Capacity Btuh | COP | Capacity Btuh | EER Btuh/W | Capacity Btuh | COP | Capacity Btuh | EER Btuh/W | Capacity Btuh | COP |
| **TE026 Part** | 19,200 | 19.8 | 23,600 | 7.0 | 22,000 | 34.1 | 19,000 | 5.8 | 20,800 | 28.0 | 16,800 | 5.0 |
| **TE026 Full** | 25,000 | 17.4 | 31,400 | 6.0 | 28,500 | 26.4 | 25,800 | 5.3 | 26,000 | 19.9 | 20,200 | 4.1 |
| **TE038 Part** | 27,400 | 20.1 | 32,600 | 6.5 | 30,700 | 34.4 | 27,300 | 5.5 | 29,700 | 29.6 | 23,800 | 4.8 |
| **TE038 Full** | 37,700 | 17.9 | 45,700 | 5.8 | 42,100 | 26.1 | 37,900 | 5.2 | 39,000 | 20.3 | 29,700 | 4.4 |
| **TE049 Part** | 36,300 | 18.8 | 42,200 | 6.1 | 41,800 | 32.9 | 34,800 | 5.0 | 39,100 | 27.4 | 29,800 | 4.4 |
| **TE049 Full** | 48,600 | 16.8 | 56,700 | 5.1 | 55,000 | 25.3 | 46,800 | 4.6 | 49,600 | 19.3 | 36,400 | 4.0 |
| **TE064 Part** | 46,300 | 18.7 | 54,700 | 6.0 | 53,100 | 32.4 | 44,000 | 5.0 | 51,200 | 26.7 | 38,100 | 4.4 |
| **TE064 Full** | 61,500 | 16.2 | 77,400 | 5.4 | 71,500 | 24.4 | 63,200 | 4.8 | 66,200 | 18.8 | 48,700 | 3.9 |
| **TE072 Part** | 53,000 | 16.8 | 64,600 | 5.2 | 60,800 | 28.6 | 53,200 | 4.5 | 58,100 | 23.2 | 46,000 | 3.9 |
| **TE072 Full** | 68,300 | 15.1 | 85,300 | 4.8 | 77,700 | 22.5 | 71,400 | 4.4 | 71,700 | 16.9 | 55,800 | 3.7 |

Cooling capacities based upon 80.6°F DB, 66.2°F WB entering air temperature
Heating capacities based upon 68°F DB, 59°F WB entering air temperature
Ground Loop Heat Pump ratings based on 15% antifreeze solution
All ratings based upon operation at lower voltage of dual voltage rated models

### ASHRAE/AHRI/ISO 13256-1. Metric (S-I) Units

| Model | Water Loop Heat Pump | | | | Ground Water Heat Pump | | | | Ground Loop Heat Pump | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cooling 30°C | | Heating 20°C | | Cooling 15°C | | Heating 10°C | | Full Cool 25°C Part Cool 20°C | | Full Heat 0°C Part Heat 5°C | |
| | Capacity kW | EER W/W | Capacity kW | COP | Capacity kW | EER W/W | Capacity kW | COP | Capacity kW | EER W/W | Capacity kW | COP |
| **TE026 Part** | 5.63 | 5.8 | 6.91 | 7.0 | 6.45 | 10 | 5.57 | 5.8 | 6.09 | 8.2 | 4.92 | 5.0 |
| **TE026 Full** | 7.32 | 5.1 | 9.20 | 6.0 | 8.35 | 7.7 | 7.56 | 5.3 | 7.62 | 5.8 | 5.92 | 4.1 |
| **TE038 Part** | 8.03 | 5.9 | 9.55 | 6.5 | 9.00 | 10.1 | 8.00 | 5.5 | 8.70 | 8.7 | 6.97 | 4.8 |
| **TE038 Full** | 11.05 | 5.2 | 13.39 | 5.8 | 12.34 | 7.7 | 11.10 | 5.2 | 11.43 | 5.9 | 8.70 | 4.4 |
| **TE049 Part** | 10.64 | 5.5 | 12.36 | 6.1 | 12.25 | 9.6 | 10.20 | 5.0 | 11.46 | 8.0 | 8.73 | 4.4 |
| **TE049 Full** | 14.24 | 4.9 | 16.61 | 5.1 | 16.11 | 7.4 | 13.71 | 4.6 | 14.53 | 5.7 | 10.67 | 4.0 |
| **TE064 Part** | 13.57 | 5.5 | 16.03 | 6.0 | 15.56 | 9.5 | 12.90 | 5.0 | 15.01 | 7.8 | 11.17 | 4.4 |
| **TE064 Full** | 18.02 | 4.7 | 22.68 | 5.4 | 20.96 | 7.2 | 18.52 | 4.8 | 19.40 | 5.5 | 14.27 | 3.9 |
| **TE072 Part** | 15.53 | 4.9 | 18.93 | 5.2 | 17.82 | 8.4 | 15.59 | 4.5 | 17.03 | 6.8 | 13.48 | 3.9 |
| **TE072 Full** | 20.02 | 4.4 | 25.00 | 4.8 | 22.77 | 6.6 | 20..93 | 4.4 | 21.01 | 5.0 | 16.35 | 3.7 |

Cooling capacities based upon 27°C DB, 19°C WB entering air temperature
Heating capacities based upon 20°C DB, 15°C WB entering air temperature
Ground Loop Heat Pump ratings based on 15% antifreeze solution
All ratings based upon operation at lower voltage of dual voltage rated models

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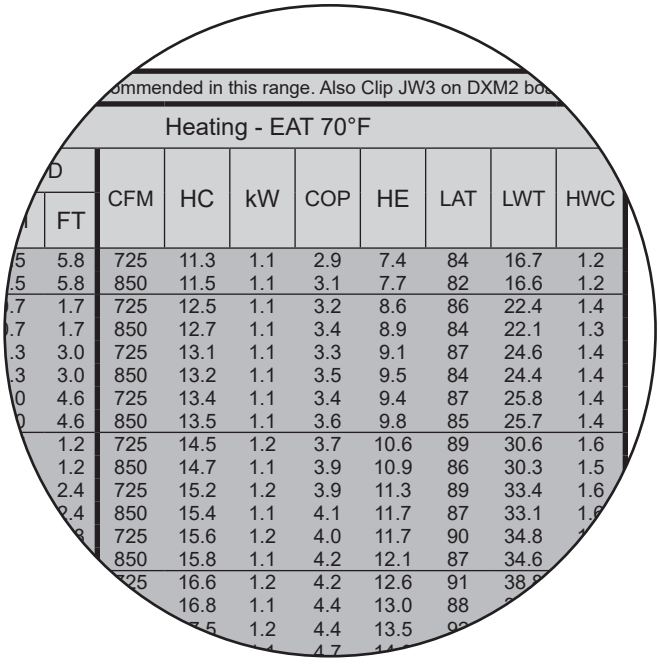
## Performance Data Selection Notes - vFlow® Models

### Operation in Shaded Area: Closed Loop Application

For operation in the shaded area, appropriate levels of a proper antifreeze should be used in systems with leaving water temperatures of 40°F or below and the JW3 jumper should be clipped. This is due to the potential of the refrigerant temperature being as low as 32°F [0°C] with 40°F [4.4°C] LWT, which may lead to a nuisance cutout due to the activation of the Low Temperature Protection. JW3 should never be clipped for systems without antifreeze.

### Open Loop Application:

For operation in shaded area (below 40°F LWT) in open loop applications, ΔT (on DXM2) should be set such that the LWT (=EWT - ΔT) doesn't drop below 40°F. JW3 should NEVER be clipped for systems without antifreeze.



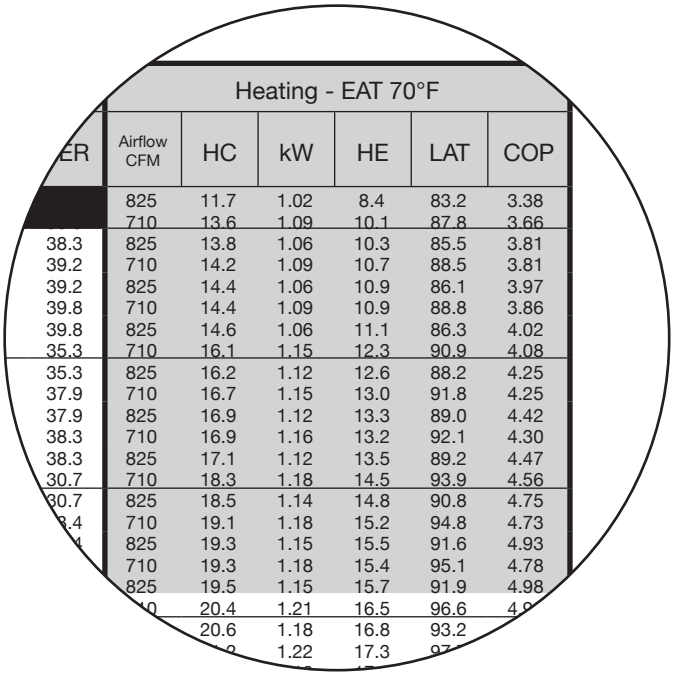
ommended in this range. Also Clip JW3 on DXM2 bo

Heating - EAT 70°F

| D FT | CFM | HC | kW | COP | HE | LAT | LWT | HWC |
|---|---|---|---|---|---|---|---|---|
| 5 5.8 | 725 | 11.3 | 1.1 | 2.9 | 7.4 | 84 | 16.7 | 1.2 |
| .5 5.8 | 850 | 11.5 | 1.1 | 3.1 | 7.7 | 82 | 16.6 | 1.2 |
| .7 1.7 | 725 | 12.5 | 1.1 | 3.2 | 8.6 | 86 | 22.4 | 1.4 |
| .7 1.7 | 850 | 12.7 | 1.1 | 3.4 | 8.9 | 84 | 22.1 | 1.3 |
| .3 3.0 | 725 | 13.1 | 1.1 | 3.3 | 9.1 | 87 | 24.6 | 1.4 |
| .3 3.0 | 850 | 13.2 | 1.1 | 3.5 | 9.5 | 84 | 24.4 | 1.4 |
| 0 4.6 | 725 | 13.4 | 1.1 | 3.4 | 9.4 | 87 | 25.8 | 1.4 |
| 0 4.6 | 850 | 13.5 | 1.1 | 3.6 | 9.8 | 85 | 25.7 | 1.4 |
| 1.2 | 725 | 14.5 | 1.2 | 3.7 | 10.6 | 89 | 30.6 | 1.6 |
| 1.2 | 850 | 14.7 | 1.1 | 3.9 | 10.9 | 86 | 30.3 | 1.5 |
| 2.4 | 725 | 15.2 | 1.2 | 3.9 | 11.3 | 89 | 33.4 | 1.6 |
| 2.4 | 850 | 15.4 | 1.1 | 4.1 | 11.7 | 87 | 33.1 | 1.6 |
| 3 | 725 | 15.6 | 1.2 | 4.0 | 11.7 | 90 | 34.8 | 1 |
| | 850 | 15.8 | 1.1 | 4.2 | 12.1 | 87 | 34.6 | |
| | 725 | 16.6 | 1.2 | 4.2 | 12.6 | 91 | 38 | |
| | | 16.8 | 1.1 | 4.4 | 13.0 | 88 | | |
| | | 17.5 | 1.2 | 4.4 | 13.5 | 92 | | |
| | | | 1 | 4.7 | 14 | | | |

## Performance Data Selection Notes - Models without vFlow®

For operation in the shaded area when water is used in lieu of an antifreeze solution, the LWT (Leaving Water Temperature) must be calculated. Flow must be maintained to a level such that the LWT is maintained above 40°F [4.4°C] when the JW3 jumper is not clipped (see example below). Otherwise, appropriate levels of a proper antifreeze solution should be used in systems with leaving water temperatures of 40°F [4.4°C] or below and the JW3 jumper should be clipped. This is due to the potential of the refrigerant temperature being as low as 32°F [0°C] with 40°F [4.4°C] LWT, which may lead to a nuisance cutout due to the activation of the Low Temperature Protection. JW3 should never be clipped for standard range equipment or systems without antifreeze.



Heating - EAT 70°F

| ER | Airflow CFM | HC | kW | HE | LAT | COP |
|---|---|---|---|---|---|---|
| | 825 | 11.7 | 1.02 | 8.4 | 83.2 | 3.38 |
| | 710 | 13.6 | 1.09 | 10.1 | 87.8 | 3.66 |
| 38.3 | 825 | 13.8 | 1.06 | 10.3 | 85.5 | 3.81 |
| 39.2 | 710 | 14.2 | 1.09 | 10.7 | 88.5 | 3.81 |
| 39.2 | 825 | 14.4 | 1.06 | 10.9 | 86.1 | 3.97 |
| 39.8 | 710 | 14.4 | 1.09 | 10.9 | 88.8 | 3.86 |
| 39.8 | 825 | 14.6 | 1.06 | 11.1 | 86.3 | 4.02 |
| 35.3 | 710 | 16.1 | 1.15 | 12.3 | 90.9 | 4.08 |
| 35.3 | 825 | 16.2 | 1.12 | 12.6 | 88.2 | 4.25 |
| 37.9 | 710 | 16.7 | 1.15 | 13.0 | 91.8 | 4.25 |
| 37.9 | 825 | 16.9 | 1.12 | 13.3 | 89.0 | 4.42 |
| 38.3 | 710 | 16.9 | 1.16 | 13.2 | 92.1 | 4.30 |
| 38.3 | 825 | 17.1 | 1.12 | 13.5 | 89.2 | 4.47 |
| 30.7 | 710 | 18.3 | 1.18 | 14.5 | 93.9 | 4.56 |
| 30.7 | 825 | 18.5 | 1.14 | 14.8 | 90.8 | 4.75 |
| 3.4 | 710 | 19.1 | 1.18 | 15.2 | 94.8 | 4.73 |
| 4 | 825 | 19.3 | 1.15 | 15.5 | 91.6 | 4.93 |
| | 710 | 19.3 | 1.18 | 15.4 | 95.1 | 4.78 |
| | 825 | 19.5 | 1.15 | 15.7 | 91.9 | 4.98 |
| | 0 | 20.4 | 1.21 | 16.5 | 96.6 | 4.9 |
| | | 20.6 | 1.18 | 16.8 | 93.2 | |
| | | 1.2 | 1.22 | 17.3 | 97 | |

Example:

At 50°F EWT (Entering Water Temperature) and 1.5 gpm/ton, a 3 ton unit has a HE of 22,500 Btuh. To calculate LWT, rearrange the formula for HE as follows:

HE = TD x GPM x 500, where HE = Heat of Extraction (Btuh); TD = temperature difference (EWT - LWT) and GPM = U.S. Gallons per Minute.

TD = HE / (GPM x 500)

TD = 22,500 / (4.5 x 500)

TD = 10°F

LWT = EWT - TD

LWT = 50 - 10 = 40°F

In this example, as long as the EWT does not fall below 50°F, the system will operate as designed. For EWTs below 50°F, higher flow rates will be required (open loop systems, for example, require at least 2 gpm/ton when EWT is below 50°F).

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## Performance Data – TE H/V/D 026 (Part Load), No vFlow®

850 CFM Nominal (Rated) Airflow Heating, 750 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 4.5 | 1.2 | 2.9 | | | | | | | | 750 | 11.5 | 1.25 | 7.4 | 84.2 | 2.7 | 1.2 |
| | 4.5 | 1.2 | 2.9 | | | | | | | | 850 | 11.7 | 1.20 | 7.6 | 82.7 | 2.9 | 1.2 |
| 30 | 2.3 | 0.5 | 1.1 | 660 | 23.1 | 14.6 | 0.60 | 25.2 | 38.8 | 0.7 | 750 | 13.0 | 1.23 | 8.9 | 86.0 | 3.1 | 1.3 |
| | 2.3 | 0.5 | 1.1 | 750 | 23.6 | 15.6 | 0.61 | 25.6 | 38.8 | 0.7 | 850 | 13.2 | 1.18 | 9.2 | 84.4 | 3.3 | 1.3 |
| | 3.4 | 0.8 | 1.8 | 660 | 22.8 | 14.0 | 0.55 | 24.7 | 41.1 | 0.7 | 750 | 13.6 | 1.22 | 9.5 | 86.8 | 3.3 | 1.3 |
| | 3.4 | 0.8 | 1.8 | 750 | 23.2 | 14.9 | 0.56 | 25.2 | 41.2 | 0.7 | 850 | 13.8 | 1.17 | 9.8 | 85.0 | 3.5 | 1.4 |
| | 4.5 | 1.1 | 2.6 | 660 | 22.5 | 13.5 | 0.54 | 24.3 | 41.9 | 0.7 | 750 | 13.9 | 1.22 | 9.9 | 87.2 | 3.4 | 1.4 |
| | 4.5 | 1.1 | 2.6 | 750 | 22.9 | 14.5 | 0.55 | 24.8 | 41.9 | 0.7 | 850 | 14.1 | 1.16 | 10.2 | 85.4 | 3.6 | 1.4 |
| 40 | 2.3 | 0.4 | 1.0 | 660 | 23.0 | 14.9 | 0.67 | 25.3 | 34.4 | 0.8 | 750 | 15.2 | 1.20 | 11.2 | 88.8 | 3.7 | 1.5 |
| | 2.3 | 0.4 | 1.0 | 750 | 23.5 | 16.0 | 0.68 | 25.8 | 34.4 | 0.8 | 850 | 15.4 | 1.15 | 11.5 | 86.8 | 3.9 | 1.5 |
| | 3.4 | 0.7 | 1.7 | 660 | 23.2 | 14.7 | 0.61 | 25.2 | 37.7 | 0.7 | 750 | 16.0 | 1.19 | 12.0 | 89.7 | 3.9 | 1.5 |
| | 3.4 | 0.7 | 1.7 | 750 | 23.6 | 15.8 | 0.63 | 25.7 | 37.7 | 0.7 | 850 | 16.2 | 1.14 | 12.3 | 87.6 | 4.2 | 1.6 |
| | 4.5 | 1.1 | 2.5 | 660 | 23.1 | 14.5 | 0.59 | 25.1 | 39.1 | 0.7 | 750 | 16.4 | 1.18 | 12.4 | 90.2 | 4.1 | 1.6 |
| | 4.5 | 1.1 | 2.5 | 750 | 23.5 | 15.5 | 0.60 | 25.6 | 39.2 | 0.7 | 850 | 16.6 | 1.13 | 12.8 | 88.1 | 4.3 | 1.6 |
| 50 | 2.3 | 0.4 | 1.0 | 660 | 22.4 | 14.9 | 0.76 | 25.0 | 29.6 | 1.1 | 750 | 17.4 | 1.17 | 13.4 | 91.5 | 4.4 | 1.7 |
| | 2.3 | 0.4 | 1.0 | 750 | 22.9 | 15.9 | 0.77 | 25.5 | 29.6 | 1.1 | 850 | 17.7 | 1.12 | 13.8 | 89.2 | 4.6 | 1.7 |
| | 3.4 | 0.7 | 1.6 | 660 | 22.9 | 15.0 | 0.69 | 25.3 | 33.1 | 0.9 | 750 | 18.3 | 1.16 | 14.4 | 92.6 | 4.6 | 1.7 |
| | 3.4 | 0.7 | 1.6 | 750 | 23.3 | 16.0 | 0.70 | 25.7 | 33.1 | 0.9 | 850 | 18.6 | 1.11 | 14.8 | 90.3 | 4.9 | 1.8 |
| | 4.5 | 1.0 | 2.3 | 660 | 23.1 | 14.9 | 0.66 | 25.3 | 34.9 | 0.8 | 750 | 18.9 | 1.16 | 14.9 | 93.3 | 4.8 | 1.8 |
| | 4.5 | 1.0 | 2.3 | 750 | 23.5 | 16.0 | 0.67 | 25.8 | 34.9 | 0.8 | 850 | 19.1 | 1.11 | 15.4 | 90.8 | 5.1 | 1.8 |
| 60 | 2.3 | 0.4 | 1.0 | 660 | 21.5 | 14.5 | 0.86 | 24.4 | 24.9 | 1.5 | 750 | 19.6 | 1.15 | 15.7 | 94.3 | 5.0 | 1.8 |
| | 2.3 | 0.4 | 1.0 | 750 | 21.9 | 15.5 | 0.88 | 24.9 | 24.9 | 1.5 | 850 | 19.9 | 1.10 | 16.2 | 91.7 | 5.3 | 1.9 |
| | 3.4 | 0.7 | 1.6 | 660 | 22.2 | 14.8 | 0.79 | 24.9 | 28.2 | 1.2 | 750 | 20.8 | 1.14 | 16.9 | 95.6 | 5.3 | 1.9 |
| | 3.4 | 0.7 | 1.6 | 750 | 22.6 | 15.8 | 0.80 | 25.3 | 28.3 | 1.2 | 850 | 21.1 | 1.09 | 17.3 | 92.9 | 5.6 | 1.9 |
| | 4.5 | 1.0 | 2.3 | 660 | 22.5 | 14.9 | 0.75 | 25.0 | 30.0 | 1.1 | 750 | 21.4 | 1.14 | 17.5 | 96.4 | 5.5 | 2.0 |
| | 4.5 | 1.0 | 2.3 | 750 | 22.9 | 15.9 | 0.76 | 25.5 | 30.0 | 1.1 | 850 | 21.7 | 1.09 | 18.0 | 93.6 | 5.8 | 2.0 |
| 70 | 2.3 | 0.4 | 1.0 | 660 | 20.3 | 14.0 | 0.98 | 23.6 | 20.7 | 2.0 | 750 | 21.9 | 1.14 | 18.0 | 97.1 | 5.7 | 2.0 |
| | 2.3 | 0.4 | 1.0 | 750 | 20.7 | 15.0 | 1.00 | 24.1 | 20.7 | 2.0 | 850 | 22.2 | 1.09 | 18.5 | 94.2 | 6.0 | 2.0 |
| | 3.4 | 0.7 | 1.6 | 660 | 21.1 | 14.4 | 0.90 | 24.2 | 23.6 | 1.6 | 750 | 23.2 | 1.13 | 19.3 | 98.7 | 6.0 | 2.1 |
| | 3.4 | 0.7 | 1.6 | 750 | 21.5 | 15.4 | 0.91 | 24.6 | 23.6 | 1.6 | 850 | 23.6 | 1.09 | 19.9 | 95.7 | 6.4 | 2.1 |
| | 4.5 | 1.0 | 2.2 | 660 | 21.5 | 14.5 | 0.85 | 24.4 | 25.2 | 1.4 | 750 | 24.0 | 1.13 | 20.1 | 99.6 | 6.2 | 2.2 |
| | 4.5 | 1.0 | 2.2 | 750 | 21.9 | 15.6 | 0.87 | 24.9 | 25.2 | 1.4 | 850 | 24.3 | 1.09 | 20.6 | 96.5 | 6.6 | 2.2 |
| 80 | 2.3 | 0.4 | 1.0 | 660 | 18.9 | 13.4 | 1.12 | 22.7 | 16.9 | 2.6 | 750 | 24.3 | 1.13 | 20.4 | 100.0 | 6.3 | 2.2 |
| | 2.3 | 0.4 | 1.0 | 750 | 19.3 | 14.3 | 1.14 | 23.2 | 16.9 | 2.6 | 850 | 24.6 | 1.09 | 20.9 | 96.8 | 6.6 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 660 | 19.8 | 13.8 | 1.02 | 23.3 | 19.4 | 2.2 | 750 | 25.8 | 1.14 | 21.8 | 101.9 | 6.6 | 2.3 |
| | 3.4 | 0.7 | 1.5 | 750 | 20.2 | 14.8 | 1.04 | 23.8 | 19.4 | 2.2 | 850 | 26.2 | 1.09 | 22.4 | 98.5 | 7.0 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 660 | 20.3 | 14.0 | 0.98 | 23.6 | 20.7 | 1.9 | 750 | 26.7 | 1.14 | 22.7 | 102.9 | 6.8 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 750 | 20.7 | 15.0 | 1.00 | 24.1 | 20.8 | 2.0 | 850 | 27.1 | 1.10 | 23.3 | 99.5 | 7.2 | 2.3 |
| 85 | 2.3 | 0.4 | 1.0 | 660 | 18.2 | 13.0 | 1.2 | 22.3 | 15.3 | 3.0 | 750 | 25.5 | 1.14 | 21.5 | 101.5 | 6.6 | 2.2 |
| | 2.3 | 0.4 | 1.0 | 750 | 18.5 | 14.0 | 1.22 | 22.7 | 15.3 | 3.0 | 850 | 25.9 | 1.1 | 22.1 | 98.2 | 6.9 | 2.3 |
| | 3.4 | 0.7 | 1.5 | 660 | 19.1 | 13.5 | 1.10 | 22.9 | 17.5 | 2.5 | 750 | 27.1 | 1.1 | 23.1 | 103.5 | 6.9 | 2.3 |
| | 3.4 | 0.7 | 1.5 | 750 | 19.5 | 14.4 | 1.12 | 23.3 | 17.5 | 2.6 | 850 | 27.5 | 1.1 | 23.8 | 100.0 | 7.3 | 2.4 |
| | 4.5 | 0.9 | 2.1 | 660 | 19.6 | 13.7 | 1.05 | 23.2 | 18.8 | 2.3 | 750 | 28.1 | 1.2 | 24.0 | 104.7 | 7.1 | 2.4 |
| | 4.5 | 0.9 | 2.1 | 750 | 20.0 | 14.6 | 1.07 | 23.6 | 18.8 | 2.3 | 850 | 28.5 | 1.1 | 24.7 | 101.0 | 7.5 | 2.4 |
| 90 | 2.3 | 0.4 | 1.0 | 660 | 17.5 | 12.7 | 1.27 | 21.8 | 13.7 | 3.4 | 750 | 26.7 | 1.14 | 22.7 | 103.0 | 6.8 | 2.3 |
| | 2.3 | 0.4 | 1.0 | 750 | 17.8 | 13.6 | 1.30 | 22.2 | 13.7 | 3.4 | 850 | 27.1 | 1.10 | 23.3 | 99.5 | 7.2 | 2.3 |
| | 3.4 | 0.7 | 1.5 | 660 | 18.4 | 13.1 | 1.17 | 22.4 | 15.7 | 2.9 | 750 | 28.5 | 1.16 | 24.4 | 105.1 | 7.2 | 2.4 |
| | 3.4 | 0.7 | 1.5 | 750 | 18.7 | 14.1 | 1.19 | 22.8 | 15.7 | 2.9 | 850 | 28.9 | 1.11 | 25.1 | 101.4 | 7.6 | 2.4 |
| | 4.5 | 0.9 | 2.2 | 660 | 18.9 | 13.4 | 1.12 | 22.7 | 16.8 | 2.6 | 750 | 29.5 | 1.17 | 25.4 | 106.4 | 7.4 | 2.5 |
| | 4.5 | 0.9 | 2.2 | 750 | 19.2 | 14.3 | 1.14 | 23.1 | 16.9 | 2.7 | 850 | 29.9 | 1.12 | 26.1 | 102.6 | 7.8 | 2.5 |
| 100 | 2.3 | 0.4 | 1.0 | 660 | 16.0 | 12.1 | 1.45 | 21.0 | 11.0 | 4.3 | | | | | | | |
| | 2.3 | 0.4 | 1.0 | 750 | 16.3 | 13.0 | 1.48 | 21.4 | 11.1 | 4.3 | | | | | | | |
| | 3.4 | 0.7 | 1.5 | 660 | 16.9 | 12.5 | 1.34 | 21.5 | 12.6 | 3.7 | | | | | | | |
| | 3.4 | 0.7 | 1.5 | 750 | 17.2 | 13.4 | 1.36 | 21.9 | 12.6 | 3.8 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 660 | 17.4 | 12.7 | 1.28 | 21.8 | 13.5 | 3.4 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 750 | 17.7 | 13.6 | 1.31 | 22.2 | 13.6 | 3.5 | | | | | | | |
| 110 | 2.3 | 0.4 | 0.9 | 660 | 14.6 | 11.6 | 1.65 | 20.3 | 8.9 | 5.3 | | | | | | | |
| | 2.3 | 0.4 | 0.9 | 750 | 14.9 | 12.4 | 1.68 | 20.6 | 8.9 | 5.4 | | | | | | | |
| | 3.4 | 0.7 | 1.5 | 660 | 15.4 | 11.9 | 1.53 | 20.6 | 10.1 | 4.7 | | | | | | | |
| | 3.4 | 0.7 | 1.5 | 750 | 15.7 | 12.7 | 1.56 | 21.0 | 10.1 | 4.8 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 660 | 15.9 | 12.1 | 1.47 | 20.9 | 10.8 | 4.3 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 750 | 16.2 | 12.9 | 1.49 | 21.3 | 10.8 | 4.4 | | | | | | | |
| 120 | 2.3 | 0.4 | 0.9 | 660 | 13.4 | 11.3 | 1.87 | 19.8 | 7.2 | 6.5 | | | | | | | |
| | 2.3 | 0.4 | 0.9 | 750 | 13.7 | 12.1 | 1.91 | 20.2 | 7.2 | 6.6 | | | | | | | |
| | 3.4 | 0.6 | 1.4 | 660 | 14.1 | 11.5 | 1.74 | 20.0 | 8.1 | 5.8 | | | | | | | |
| | 3.4 | 0.6 | 1.4 | 750 | 14.4 | 12.3 | 1.77 | 20.4 | 8.1 | 5.9 | | | | | | | |
| | 4.5 | 0.9 | 2.0 | 660 | 14.5 | 11.6 | 1.67 | 20.2 | 8.6 | 5.4 | | | | | | | |
| | 4.5 | 0.9 | 2.0 | 750 | 14.7 | 12.4 | 1.71 | 20.6 | 8.6 | 5.5 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 026 (Full Load), No vFlow®

950 CFM Nominal (Rated) Airflow Heating, 850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 6.0 | 1.9 | 4.4 | | | | | | | | 840 | 16.5 | 1.73 | 10.7 | 82.7 | 2.7 | 1.1 |
| | 6.0 | 1.9 | 4.4 | | | | | | | | 950 | 16.8 | 1.68 | 11.0 | 81.4 | 2.9 | 1.2 |
| 30 | 3.0 | 0.7 | 1.6 | 750 | 30.1 | 18.1 | 0.99 | 33.4 | 30.3 | 0.8 | 840 | 18.2 | 1.70 | 12.6 | 84.3 | 3.1 | 1.3 |
| | 3.0 | 0.7 | 1.6 | 850 | 30.6 | 19.4 | 1.03 | 34.1 | 29.7 | 0.8 | 950 | 18.5 | 1.64 | 12.9 | 82.8 | 3.3 | 1.3 |
| | 4.5 | 1.1 | 2.6 | 750 | 29.8 | 17.6 | 0.93 | 32.8 | 32.1 | 0.7 | 840 | 19.1 | 1.68 | 13.4 | 85.0 | 3.3 | 1.3 |
| | 4.5 | 1.1 | 2.6 | 850 | 30.3 | 18.9 | 0.96 | 33.6 | 31.5 | 0.7 | 950 | 19.4 | 1.63 | 13.8 | 83.4 | 3.5 | 1.4 |
| | 6.0 | 1.8 | 4.0 | 750 | 29.4 | 17.3 | 0.90 | 32.4 | 32.8 | 0.7 | 840 | 19.5 | 1.68 | 13.9 | 85.4 | 3.4 | 1.4 |
| | 6.0 | 1.8 | 4.0 | 850 | 29.9 | 18.6 | 0.93 | 33.1 | 32.2 | 0.7 | 950 | 19.8 | 1.62 | 14.3 | 83.8 | 3.6 | 1.4 |
| 40 | 3.0 | 0.6 | 1.5 | 750 | 29.8 | 18.2 | 1.08 | 33.5 | 27.5 | 1.1 | 840 | 21.0 | 1.66 | 15.4 | 86.7 | 3.8 | 1.5 |
| | 3.0 | 0.6 | 1.5 | 850 | 30.4 | 19.6 | 1.12 | 34.2 | 27.0 | 1.1 | 950 | 21.3 | 1.61 | 15.8 | 85.0 | 3.9 | 1.5 |
| | 4.5 | 1.1 | 2.5 | 750 | 30.1 | 18.1 | 1.01 | 33.5 | 29.6 | 0.9 | 840 | 22.0 | 1.65 | 16.5 | 87.6 | 4.0 | 1.5 |
| | 4.5 | 1.1 | 2.5 | 850 | 30.6 | 19.5 | 1.05 | 34.2 | 29.1 | 0.9 | 950 | 22.4 | 1.60 | 16.9 | 85.8 | 4.2 | 1.6 |
| | 6.0 | 1.6 | 3.8 | 750 | 30.0 | 18.0 | 0.98 | 33.3 | 30.6 | 0.8 | 840 | 22.6 | 1.64 | 17.1 | 88.0 | 4.1 | 1.6 |
| | 6.0 | 1.6 | 3.8 | 850 | 30.6 | 19.3 | 1.02 | 34.0 | 30.1 | 0.8 | 950 | 23.0 | 1.59 | 17.5 | 86.2 | 4.3 | 1.6 |
| 50 | 3.0 | 0.6 | 1.4 | 750 | 29.1 | 18.0 | 1.19 | 33.1 | 24.5 | 1.5 | 840 | 23.8 | 1.64 | 18.2 | 89.2 | 4.4 | 1.7 |
| | 3.0 | 0.6 | 1.4 | 850 | 29.6 | 19.4 | 1.23 | 33.8 | 24.1 | 1.5 | 950 | 24.1 | 1.59 | 18.7 | 87.2 | 4.6 | 1.7 |
| | 4.5 | 1.0 | 2.3 | 750 | 29.7 | 18.2 | 1.11 | 33.4 | 26.8 | 1.2 | 840 | 25.1 | 1.64 | 19.5 | 90.2 | 4.7 | 1.7 |
| | 4.5 | 1.0 | 2.3 | 850 | 30.2 | 19.6 | 1.15 | 34.1 | 26.3 | 1.2 | 950 | 25.4 | 1.59 | 20.0 | 88.1 | 4.9 | 1.8 |
| | 6.0 | 1.6 | 3.6 | 750 | 29.9 | 18.2 | 1.07 | 33.5 | 27.9 | 1.1 | 840 | 25.8 | 1.64 | 20.2 | 90.8 | 4.8 | 1.8 |
| | 6.0 | 1.6 | 3.6 | 850 | 30.4 | 19.6 | 1.11 | 34.2 | 27.4 | 1.1 | 950 | 26.2 | 1.59 | 20.7 | 88.6 | 5.1 | 1.8 |
| 60 | 3.0 | 0.6 | 1.3 | 750 | 27.9 | 17.6 | 1.30 | 32.3 | 21.5 | 1.9 | 840 | 26.7 | 1.64 | 21.1 | 91.6 | 5.1 | 1.8 |
| | 3.0 | 0.6 | 1.3 | 850 | 28.4 | 18.9 | 1.35 | 33.0 | 21.1 | 1.9 | 950 | 27.1 | 1.59 | 21.6 | 89.4 | 5.3 | 1.9 |
| | 4.5 | 1.0 | 2.3 | 750 | 28.8 | 17.9 | 1.21 | 32.9 | 23.7 | 1.6 | 840 | 28.2 | 1.65 | 22.5 | 92.9 | 5.4 | 1.9 |
| | 4.5 | 1.0 | 2.3 | 850 | 29.3 | 19.3 | 1.26 | 33.6 | 23.3 | 1.6 | 950 | 28.6 | 1.60 | 23.1 | 90.5 | 5.6 | 1.9 |
| | 6.0 | 1.5 | 3.5 | 750 | 29.2 | 18.1 | 1.17 | 33.1 | 24.9 | 1.4 | 840 | 29.0 | 1.66 | 23.3 | 93.6 | 5.6 | 1.9 |
| | 6.0 | 1.5 | 3.5 | 850 | 29.7 | 19.4 | 1.22 | 33.8 | 24.4 | 1.4 | 950 | 29.4 | 1.61 | 24.0 | 91.1 | 5.8 | 2.0 |
| 70 | 3.0 | 0.6 | 1.3 | 750 | 26.4 | 17.0 | 1.43 | 31.3 | 18.5 | 2.3 | 840 | 29.6 | 1.67 | 23.9 | 94.2 | 5.7 | 2.0 |
| | 3.0 | 0.6 | 1.3 | 850 | 26.9 | 18.3 | 1.48 | 32.0 | 18.2 | 2.4 | 950 | 30.1 | 1.61 | 24.6 | 91.7 | 6.0 | 2.0 |
| | 4.5 | 1.0 | 2.2 | 750 | 27.5 | 17.5 | 1.33 | 32.0 | 20.6 | 2.1 | 840 | 31.4 | 1.69 | 25.6 | 95.6 | 6.1 | 2.1 |
| | 4.5 | 1.0 | 2.2 | 850 | 28.0 | 18.8 | 1.38 | 32.7 | 20.3 | 2.1 | 950 | 31.8 | 1.64 | 26.2 | 93.0 | 6.4 | 2.1 |
| | 6.0 | 1.5 | 3.4 | 750 | 28.0 | 17.7 | 1.29 | 32.4 | 21.8 | 1.9 | 840 | 32.3 | 1.71 | 26.5 | 96.4 | 6.3 | 2.2 |
| | 6.0 | 1.5 | 3.4 | 850 | 28.5 | 19.0 | 1.33 | 33.1 | 21.4 | 1.9 | 950 | 32.8 | 1.66 | 27.2 | 93.7 | 6.6 | 2.2 |
| 80 | 3.0 | 0.6 | 1.3 | 750 | 24.8 | 16.3 | 1.58 | 30.2 | 15.7 | 2.9 | 840 | 32.6 | 1.72 | 26.7 | 96.7 | 6.3 | 2.2 |
| | 3.0 | 0.6 | 1.3 | 850 | 25.2 | 17.5 | 1.64 | 30.8 | 15.4 | 3.0 | 950 | 33.1 | 1.66 | 27.5 | 94.0 | 6.6 | 2.2 |
| | 4.5 | 0.9 | 2.2 | 750 | 26.0 | 16.8 | 1.47 | 31.0 | 17.6 | 2.5 | 840 | 34.7 | 1.77 | 28.6 | 98.4 | 6.7 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 850 | 26.4 | 18.1 | 1.53 | 31.6 | 17.3 | 2.6 | 950 | 35.2 | 1.71 | 29.4 | 95.5 | 7.0 | 2.3 |
| | 6.0 | 1.4 | 3.3 | 750 | 26.5 | 17.0 | 1.42 | 31.4 | 18.7 | 2.3 | 840 | 35.8 | 1.80 | 29.6 | 99.4 | 6.9 | 2.3 |
| | 6.0 | 1.4 | 3.3 | 850 | 27.0 | 18.3 | 1.47 | 32.0 | 18.3 | 2.4 | 950 | 36.3 | 1.74 | 30.4 | 96.4 | 7.2 | 2.3 |
| 85 | 3.0 | 0.6 | 1.3 | 750 | 23.9 | 15.9 | 1.7 | 29.6 | 14.4 | 3.3 | 840 | 34.2 | 1.76 | 28.2 | 98.1 | 6.6 | 2.2 |
| | 3.0 | 0.6 | 1.3 | 850 | 24.4 | 17.1 | 1.73 | 30.2 | 14.2 | 3.4 | 950 | 34.7 | 1.7 | 28.9 | 95.2 | 6.9 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 750 | 25.1 | 16.4 | 1.55 | 30.4 | 16.3 | 2.9 | 840 | 36.4 | 1.8 | 30.1 | 99.9 | 7.0 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 850 | 25.5 | 17.7 | 1.61 | 31.0 | 16.0 | 2.9 | 950 | 36.9 | 1.8 | 30.9 | 96.8 | 7.3 | 2.4 |
| | 6.0 | 1.4 | 3.3 | 750 | 25.7 | 16.7 | 1.50 | 30.8 | 17.2 | 2.7 | 840 | 37.6 | 1.9 | 31.2 | 100.9 | 7.2 | 2.3 |
| | 6.0 | 1.4 | 3.3 | 850 | 26.1 | 17.9 | 1.55 | 31.4 | 16.9 | 2.7 | 950 | 38.2 | 1.8 | 32.0 | 97.8 | 7.5 | 2.4 |
| 90 | 3.0 | 0.6 | 1.3 | 750 | 23.1 | 15.5 | 1.75 | 29.0 | 13.2 | 3.7 | 840 | 35.8 | 1.80 | 29.6 | 99.4 | 6.9 | 2.3 |
| | 3.0 | 0.6 | 1.3 | 850 | 23.5 | 16.7 | 1.81 | 29.7 | 12.9 | 3.7 | 950 | 36.3 | 1.74 | 30.4 | 96.4 | 7.2 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 750 | 24.3 | 16.1 | 1.63 | 29.8 | 14.9 | 3.2 | 840 | 38.1 | 1.87 | 31.6 | 101.3 | 7.3 | 2.3 |
| | 4.5 | 0.9 | 2.2 | 850 | 24.7 | 17.3 | 1.69 | 30.4 | 14.6 | 3.3 | 950 | 38.7 | 1.81 | 32.5 | 98.1 | 7.6 | 2.4 |
| | 6.0 | 1.4 | 3.2 | 750 | 24.9 | 16.3 | 1.57 | 30.2 | 15.8 | 3.0 | 840 | 39.4 | 1.92 | 32.8 | 102.5 | 7.4 | 2.4 |
| | 6.0 | 1.4 | 3.2 | 850 | 25.3 | 17.5 | 1.63 | 30.9 | 15.5 | 3.0 | 950 | 40.0 | 1.86 | 33.6 | 99.1 | 7.8 | 2.5 |
| 100 | 3.0 | 0.6 | 1.3 | 750 | 21.3 | 14.8 | 1.95 | 28.0 | 10.9 | 4.4 | | | | | | | |
| | 3.0 | 0.6 | 1.3 | 850 | 21.7 | 15.9 | 2.02 | 28.6 | 10.7 | 4.5 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 750 | 22.5 | 15.3 | 1.82 | 28.7 | 12.4 | 3.9 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 850 | 22.9 | 16.4 | 1.88 | 29.3 | 12.1 | 4.0 | | | | | | | |
| | 6.0 | 1.4 | 3.2 | 750 | 23.1 | 15.5 | 1.75 | 29.0 | 13.2 | 3.7 | | | | | | | |
| | 6.0 | 1.4 | 3.2 | 850 | 23.5 | 16.7 | 1.82 | 29.7 | 12.9 | 3.7 | | | | | | | |
| 110 | 3.0 | 0.6 | 1.3 | 750 | 19.7 | 14.2 | 2.18 | 27.1 | 9.0 | 5.3 | | | | | | | |
| | 3.0 | 0.6 | 1.3 | 850 | 20.0 | 15.2 | 2.26 | 27.7 | 8.8 | 5.4 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 750 | 20.7 | 14.6 | 2.03 | 27.7 | 10.2 | 4.7 | | | | | | | |
| | 4.5 | 0.9 | 2.1 | 850 | 21.1 | 15.7 | 2.11 | 28.2 | 10.0 | 4.8 | | | | | | | |
| | 6.0 | 1.4 | 3.1 | 750 | 21.3 | 14.8 | 1.96 | 28.0 | 10.8 | 4.4 | | | | | | | |
| | 6.0 | 1.4 | 3.1 | 850 | 21.6 | 15.9 | 2.03 | 28.6 | 10.6 | 4.5 | | | | | | | |
| 120 | 3.0 | 0.5 | 1.2 | 750 | 18.2 | 13.7 | 2.46 | 26.6 | 7.4 | 6.2 | | | | | | | |
| | 3.0 | 0.5 | 1.2 | 850 | 18.5 | 14.7 | 2.55 | 27.2 | 7.3 | 6.4 | | | | | | | |
| | 4.5 | 0.9 | 2.0 | 750 | 19.1 | 14.0 | 2.28 | 26.9 | 8.3 | 5.6 | | | | | | | |
| | 4.5 | 0.9 | 2.0 | 850 | 19.4 | 15.0 | 2.37 | 27.5 | 8.2 | 5.8 | | | | | | | |
| | 6.0 | 1.3 | 3.1 | 750 | 19.5 | 14.1 | 2.20 | 27.1 | 8.9 | 5.3 | | | | | | | |
| | 6.0 | 1.3 | 3.1 | 850 | 19.9 | 15.2 | 2.28 | 27.7 | 8.7 | 5.5 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 038 (Part Load), No vFlow®

1000 CFM Nominal (Rated) Airflow Heating, 1000 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 6.0 | 2.5 | 5.7 | | | | | | | | 880 | 16.9 | 1.65 | 11.5 | 87.8 | 3.0 | 1.6 |
| | 6.0 | 2.5 | 5.7 | | | | | | | | 1000 | 17.2 | 1.58 | 11.8 | 85.9 | 3.2 | 1.7 |
| 30 | 3.0 | 0.9 | 2.1 | 880 | 32.7 | 19.9 | 0.82 | 35.5 | 39.6 | 0.9 | 880 | 18.9 | 1.65 | 13.4 | 89.8 | 3.4 | 1.8 |
| | 3.0 | 0.9 | 2.1 | 1000 | 33.3 | 21.3 | 0.84 | 36.2 | 39.7 | 0.9 | 1000 | 19.1 | 1.58 | 13.7 | 87.7 | 3.5 | 1.8 |
| | 4.5 | 1.5 | 3.5 | 880 | 31.0 | 18.3 | 0.74 | 33.5 | 42.1 | 1.0 | 880 | 19.9 | 1.64 | 14.4 | 90.9 | 3.6 | 1.9 |
| | 4.5 | 1.5 | 3.5 | 1000 | 31.6 | 19.6 | 0.75 | 34.1 | 42.1 | 1.0 | 1000 | 20.2 | 1.57 | 14.8 | 88.7 | 3.8 | 1.9 |
| | 6.0 | 2.2 | 5.1 | 880 | 29.6 | 17.3 | 0.71 | 32.1 | 41.9 | 1.1 | 880 | 20.4 | 1.64 | 14.9 | 91.5 | 3.7 | 1.9 |
| | 6.0 | 2.2 | 5.1 | 1000 | 30.2 | 18.5 | 0.72 | 32.7 | 42.0 | 1.1 | 1000 | 20.7 | 1.57 | 15.4 | 89.2 | 3.9 | 2.0 |
| 40 | 3.0 | 0.8 | 1.9 | 880 | 33.1 | 20.7 | 0.94 | 36.4 | 35.2 | 0.9 | 880 | 21.9 | 1.64 | 16.4 | 93.1 | 3.9 | 2.1 |
| | 3.0 | 0.8 | 1.9 | 1000 | 33.8 | 22.2 | 0.96 | 37.1 | 35.2 | 0.9 | 1000 | 22.2 | 1.57 | 16.9 | 90.6 | 4.2 | 2.1 |
| | 4.5 | 1.4 | 3.2 | 880 | 32.9 | 20.1 | 0.84 | 35.8 | 39.0 | 0.8 | 880 | 23.1 | 1.64 | 17.6 | 94.3 | 4.1 | 2.2 |
| | 4.5 | 1.4 | 3.2 | 1000 | 33.6 | 21.5 | 0.86 | 36.5 | 39.0 | 0.8 | 1000 | 23.5 | 1.57 | 18.1 | 91.7 | 4.4 | 2.2 |
| | 6.0 | 2.0 | 4.7 | 880 | 32.4 | 19.6 | 0.80 | 35.1 | 40.7 | 0.8 | 880 | 23.8 | 1.64 | 18.3 | 95.1 | 4.3 | 2.2 |
| | 6.0 | 2.0 | 4.7 | 1000 | 33.0 | 20.9 | 0.81 | 35.8 | 40.8 | 0.9 | 1000 | 24.1 | 1.57 | 18.8 | 92.4 | 4.5 | 2.3 |
| 50 | 3.0 | 0.8 | 1.8 | 880 | 32.3 | 20.7 | 1.08 | 36.0 | 29.9 | 1.1 | 880 | 24.9 | 1.64 | 19.4 | 96.2 | 4.5 | 2.3 |
| | 3.0 | 0.8 | 1.8 | 1000 | 33.0 | 22.2 | 1.10 | 36.7 | 30.0 | 1.1 | 1000 | 25.3 | 1.57 | 19.9 | 93.4 | 4.7 | 2.4 |
| | 4.5 | 1.3 | 3.0 | 880 | 33.1 | 20.7 | 0.96 | 36.4 | 34.4 | 0.9 | 880 | 26.3 | 1.64 | 20.7 | 97.7 | 4.7 | 2.5 |
| | 4.5 | 1.3 | 3.0 | 1000 | 33.7 | 22.2 | 0.98 | 37.1 | 34.4 | 0.9 | 1000 | 26.7 | 1.57 | 21.3 | 94.7 | 5.0 | 2.5 |
| | 6.0 | 1.9 | 4.4 | 880 | 33.2 | 20.6 | 0.91 | 36.3 | 36.3 | 0.9 | 880 | 27.1 | 1.64 | 21.5 | 98.5 | 4.8 | 2.5 |
| | 6.0 | 1.9 | 4.4 | 1000 | 33.8 | 22.0 | 0.93 | 37.0 | 36.4 | 0.9 | 1000 | 27.5 | 1.57 | 22.1 | 95.4 | 5.1 | 2.6 |
| 60 | 3.0 | 0.8 | 1.8 | 880 | 30.8 | 20.2 | 1.24 | 35.0 | 24.9 | 1.5 | 880 | 27.9 | 1.65 | 22.3 | 99.3 | 5.0 | 2.6 |
| | 3.0 | 0.8 | 1.8 | 1000 | 31.4 | 21.6 | 1.26 | 35.7 | 24.9 | 1.5 | 1000 | 28.3 | 1.58 | 22.9 | 96.2 | 5.2 | 2.6 |
| | 4.5 | 1.3 | 2.9 | 880 | 32.1 | 20.6 | 1.11 | 35.9 | 28.9 | 1.2 | 880 | 29.5 | 1.65 | 23.8 | 101.0 | 5.2 | 2.7 |
| | 4.5 | 1.3 | 2.9 | 1000 | 32.7 | 22.1 | 1.13 | 36.6 | 29.0 | 1.3 | 1000 | 29.9 | 1.58 | 24.5 | 97.7 | 5.5 | 2.8 |
| | 6.0 | 1.8 | 4.2 | 880 | 32.6 | 20.8 | 1.05 | 36.2 | 31.0 | 1.1 | 880 | 30.4 | 1.65 | 24.7 | 102.0 | 5.4 | 2.8 |
| | 6.0 | 1.8 | 4.2 | 1000 | 33.2 | 22.2 | 1.07 | 36.9 | 31.1 | 1.2 | 1000 | 30.8 | 1.58 | 25.4 | 98.5 | 5.7 | 2.8 |
| 70 | 3.0 | 1.2 | 2.7 | 880 | 28.8 | 19.4 | 1.41 | 33.6 | 20.4 | 2.1 | 880 | 30.8 | 1.66 | 25.2 | 102.4 | 5.4 | 2.8 |
| | 3.0 | 1.2 | 2.7 | 1000 | 29.4 | 20.7 | 1.44 | 34.3 | 20.4 | 2.2 | 1000 | 31.3 | 1.59 | 25.9 | 99.0 | 5.8 | 2.9 |
| | 4.5 | 1.9 | 4.4 | 880 | 30.4 | 20.0 | 1.28 | 34.7 | 23.8 | 1.8 | 880 | 32.7 | 1.67 | 27.0 | 104.4 | 5.7 | 2.9 |
| | 4.5 | 1.9 | 4.4 | 1000 | 31.0 | 21.4 | 1.30 | 35.4 | 23.8 | 1.8 | 1000 | 33.2 | 1.60 | 27.7 | 100.7 | 6.1 | 3.0 |
| | 6.0 | 2.9 | 6.6 | 880 | 31.1 | 20.3 | 1.21 | 35.2 | 25.8 | 1.6 | 880 | 33.7 | 1.67 | 28.0 | 105.5 | 5.9 | 3.0 |
| | 6.0 | 2.9 | 6.6 | 1000 | 31.7 | 21.7 | 1.23 | 35.9 | 25.8 | 1.6 | 1000 | 34.2 | 1.60 | 28.7 | 101.7 | 6.3 | 3.1 |
| 80 | 3.0 | 1.2 | 2.7 | 880 | 26.6 | 18.4 | 1.61 | 32.1 | 16.5 | 3.0 | 880 | 33.9 | 1.67 | 28.1 | 105.6 | 5.9 | 3.0 |
| | 3.0 | 1.2 | 2.7 | 1000 | 27.1 | 19.7 | 1.64 | 32.7 | 16.5 | 3.0 | 1000 | 34.3 | 1.60 | 28.9 | 101.8 | 6.3 | 3.1 |
| | 4.5 | 1.9 | 4.3 | 880 | 28.3 | 19.1 | 1.46 | 33.2 | 19.3 | 2.5 | 880 | 36.0 | 1.69 | 30.2 | 107.9 | 6.2 | 3.2 |
| | 4.5 | 1.9 | 4.3 | 1000 | 28.8 | 20.5 | 1.49 | 33.9 | 19.3 | 2.6 | 1000 | 36.5 | 1.62 | 31.0 | 103.8 | 6.6 | 3.2 |
| | 6.0 | 2.8 | 6.5 | 880 | 29.1 | 19.5 | 1.38 | 33.8 | 21.0 | 2.3 | 880 | 37.2 | 1.70 | 31.3 | 109.2 | 6.4 | 3.3 |
| | 6.0 | 2.8 | 6.5 | 1000 | 29.7 | 20.9 | 1.41 | 34.5 | 21.0 | 2.3 | 1000 | 37.8 | 1.63 | 32.2 | 105.0 | 6.8 | 3.3 |
| 85 | 3.0 | 1.2 | 2.7 | 880 | 25.5 | 17.9 | 1.7 | 31.4 | 14.9 | 3.5 | 880 | 35.4 | 1.68 | 29.6 | 107.3 | 6.2 | 3.1 |
| | 3.0 | 1.2 | 2.7 | 1000 | 26.0 | 19.2 | 1.76 | 32.0 | 14.9 | 3.6 | 1000 | 35.9 | 1.6 | 30.4 | 103.3 | 6.5 | 3.2 |
| | 4.5 | 1.9 | 4.3 | 880 | 27.1 | 18.6 | 1.57 | 32.4 | 17.4 | 3.0 | 880 | 37.8 | 1.7 | 31.8 | 109.7 | 6.5 | 3.3 |
| | 4.5 | 1.9 | 4.3 | 1000 | 27.6 | 19.9 | 1.60 | 33.1 | 17.5 | 3.0 | 1000 | 38.3 | 1.6 | 32.7 | 105.5 | 6.9 | 3.4 |
| | 6.0 | 2.8 | 6.4 | 880 | 28.0 | 19.0 | 1.49 | 33.0 | 18.9 | 2.7 | 880 | 39.1 | 1.7 | 33.1 | 111.1 | 6.7 | 3.4 |
| | 6.0 | 2.8 | 6.4 | 1000 | 28.5 | 20.3 | 1.52 | 33.7 | 19.0 | 2.8 | 1000 | 39.7 | 1.7 | 34.0 | 106.7 | 7.0 | 3.4 |
| 90 | 3.0 | 1.2 | 2.7 | 880 | 24.4 | 17.4 | 1.84 | 30.7 | 13.3 | 4.0 | 880 | 37.0 | 1.70 | 31.1 | 108.9 | 6.4 | 3.3 |
| | 3.0 | 1.2 | 2.7 | 1000 | 24.9 | 18.7 | 1.87 | 31.3 | 13.3 | 4.1 | 1000 | 37.5 | 1.63 | 32.0 | 104.7 | 6.7 | 3.3 |
| | 4.5 | 1.9 | 4.3 | 880 | 26.0 | 18.1 | 1.67 | 31.7 | 15.6 | 3.4 | 880 | 39.5 | 1.72 | 33.5 | 111.6 | 6.7 | 3.4 |
| | 4.5 | 1.9 | 4.3 | 1000 | 26.5 | 19.4 | 1.70 | 32.3 | 15.6 | 3.5 | 1000 | 40.1 | 1.65 | 34.4 | 107.1 | 7.1 | 3.5 |
| | 6.0 | 2.8 | 6.3 | 880 | 26.8 | 18.5 | 1.59 | 32.2 | 16.9 | 3.2 | 880 | 41.0 | 1.74 | 34.9 | 113.1 | 6.9 | 3.5 |
| | 6.0 | 2.8 | 6.3 | 1000 | 27.3 | 19.8 | 1.62 | 32.9 | 16.9 | 3.2 | 1000 | 41.5 | 1.67 | 35.8 | 108.5 | 7.3 | 3.6 |
| 100 | 3.0 | 1.2 | 2.7 | 880 | 22.5 | 16.6 | 2.09 | 29.6 | 10.7 | 5.2 | | | | | | | |
| | 3.0 | 1.2 | 2.7 | 1000 | 22.9 | 17.8 | 2.13 | 30.1 | 10.7 | 5.3 | | | | | | | |
| | 4.5 | 1.8 | 4.2 | 880 | 23.8 | 17.1 | 1.91 | 30.3 | 12.5 | 4.6 | | | | | | | |
| | 4.5 | 1.8 | 4.2 | 1000 | 24.2 | 18.4 | 1.94 | 30.9 | 12.5 | 4.7 | | | | | | | |
| | 6.0 | 2.7 | 6.3 | 880 | 24.5 | 17.5 | 1.83 | 30.7 | 13.4 | 4.3 | | | | | | | |
| | 6.0 | 2.7 | 6.3 | 1000 | 25.0 | 18.7 | 1.86 | 31.3 | 13.4 | 4.4 | | | | | | | |
| 110 | 3.0 | 1.1 | 2.6 | 880 | 21.0 | 16.3 | 2.39 | 29.1 | 8.8 | 6.7 | | | | | | | |
| | 3.0 | 1.1 | 2.6 | 1000 | 21.4 | 17.4 | 2.43 | 29.7 | 8.8 | 6.8 | | | | | | | |
| | 4.5 | 1.8 | 4.2 | 880 | 21.9 | 16.4 | 2.19 | 29.3 | 10.0 | 5.9 | | | | | | | |
| | 4.5 | 1.8 | 4.2 | 1000 | 22.3 | 17.6 | 2.23 | 29.9 | 10.0 | 6.1 | | | | | | | |
| | 6.0 | 2.7 | 6.2 | 880 | 22.5 | 16.6 | 2.09 | 29.6 | 10.7 | 5.6 | | | | | | | |
| | 6.0 | 2.7 | 6.2 | 1000 | 22.9 | 17.8 | 2.13 | 30.2 | 10.7 | 5.7 | | | | | | | |
| 120 | 3.0 | 1.1 | 2.5 | 880 | 20.4 | 16.8 | 2.75 | 29.8 | 7.4 | 8.4 | | | | | | | |
| | 3.0 | 1.1 | 2.5 | 1000 | 20.8 | 17.9 | 2.80 | 30.4 | 7.4 | 8.6 | | | | | | | |
| | 4.5 | 1.7 | 4.0 | 880 | 20.7 | 16.3 | 2.50 | 29.2 | 8.3 | 7.6 | | | | | | | |
| | 4.5 | 1.7 | 4.0 | 1000 | 21.1 | 17.5 | 2.55 | 29.8 | 8.3 | 7.7 | | | | | | | |
| | 6.0 | 2.6 | 6.0 | 880 | 21.0 | 16.3 | 2.40 | 29.1 | 8.8 | 7.2 | | | | | | | |
| | 6.0 | 2.6 | 6.0 | 1000 | 21.4 | 17.4 | 2.44 | 29.7 | 8.8 | 7.3 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 038 (Full Load), No vFlow®

1250 CFM Nominal (Rated) Airflow Heating, 1250 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 9.0 | 4.3 | 9.9 | | | | | | | | 1100 | 25.2 | 2.23 | 17.8 | 91.2 | 3.3 | 2.0 |
| | 9.0 | 4.3 | 9.9 | | | | | | | | 1250 | 25.6 | 2.16 | 18.2 | 89.0 | 3.5 | 2.1 |
| 30 | 4.5 | 1.5 | 3.5 | 1100 | 45.4 | 26.4 | 1.46 | 50.2 | 31.0 | 1.1 | 1100 | 27.7 | 2.25 | 20.1 | 93.3 | 3.6 | 2.3 |
| | 4.5 | 1.5 | 3.5 | 1250 | 46.1 | 28.4 | 1.52 | 51.3 | 30.4 | 1.1 | 1250 | 28.1 | 2.18 | 20.7 | 90.8 | 3.8 | 2.4 |
| | 6.8 | 2.6 | 6.0 | 1100 | 45.1 | 25.9 | 1.36 | 49.6 | 33.2 | 0.9 | 1100 | 29.0 | 2.26 | 21.4 | 94.4 | 3.8 | 2.5 |
| | 6.8 | 2.6 | 6.0 | 1250 | 45.9 | 27.8 | 1.41 | 50.7 | 32.6 | 0.9 | 1250 | 29.5 | 2.19 | 22.0 | 91.8 | 3.9 | 2.5 |
| | 9.0 | 3.9 | 9.1 | 1100 | 44.8 | 25.5 | 1.31 | 49.2 | 34.2 | 0.8 | 1100 | 29.7 | 2.26 | 22.1 | 95.0 | 3.9 | 2.6 |
| | 9.0 | 3.9 | 9.1 | 1250 | 45.6 | 27.4 | 1.36 | 50.2 | 33.6 | 0.8 | 1250 | 30.2 | 2.19 | 22.7 | 92.4 | 4.0 | 2.6 |
| 40 | 4.5 | 1.4 | 3.2 | 1100 | 44.9 | 26.7 | 1.60 | 50.3 | 28.1 | 1.4 | 1100 | 31.8 | 2.29 | 24.0 | 96.7 | 4.1 | 2.8 |
| | 4.5 | 1.4 | 3.2 | 1250 | 45.7 | 28.7 | 1.66 | 51.4 | 27.6 | 1.5 | 1250 | 32.2 | 2.21 | 24.7 | 93.9 | 4.3 | 2.9 |
| | 6.8 | 2.4 | 5.5 | 1100 | 45.3 | 26.5 | 1.50 | 50.3 | 30.3 | 1.1 | 1100 | 33.3 | 2.30 | 25.5 | 98.1 | 4.2 | 3.0 |
| | 6.8 | 2.4 | 5.5 | 1250 | 46.1 | 28.5 | 1.55 | 51.4 | 29.8 | 1.2 | 1250 | 33.8 | 2.23 | 26.2 | 95.1 | 4.4 | 3.1 |
| | 9.0 | 3.6 | 8.4 | 1100 | 45.4 | 26.3 | 1.44 | 50.2 | 31.4 | 1.0 | 1100 | 34.2 | 2.31 | 26.3 | 98.8 | 4.3 | 3.1 |
| | 9.0 | 3.6 | 8.4 | 1250 | 46.1 | 28.3 | 1.50 | 51.2 | 30.8 | 1.0 | 1250 | 34.7 | 2.24 | 27.1 | 95.7 | 4.5 | 3.2 |
| 50 | 4.5 | 1.3 | 3.0 | 1100 | 43.9 | 26.6 | 1.74 | 49.7 | 25.2 | 2.0 | 1100 | 35.8 | 2.34 | 27.9 | 100.1 | 4.5 | 3.3 |
| | 4.5 | 1.3 | 3.0 | 1250 | 44.6 | 28.6 | 1.80 | 50.8 | 24.7 | 2.0 | 1250 | 36.3 | 2.26 | 28.6 | 96.9 | 4.7 | 3.4 |
| | 6.8 | 2.2 | 5.1 | 1100 | 44.7 | 26.7 | 1.63 | 50.2 | 27.4 | 1.5 | 1100 | 37.6 | 2.36 | 29.6 | 101.6 | 4.7 | 3.5 |
| | 6.8 | 2.2 | 5.1 | 1250 | 45.5 | 28.7 | 1.69 | 51.3 | 26.9 | 1.6 | 1250 | 38.2 | 2.29 | 30.3 | 98.3 | 4.9 | 3.6 |
| | 9.0 | 3.4 | 7.9 | 1100 | 45.0 | 26.7 | 1.58 | 50.3 | 28.5 | 1.4 | 1100 | 38.6 | 2.38 | 30.5 | 102.5 | 4.8 | 3.6 |
| | 9.0 | 3.4 | 7.9 | 1250 | 45.8 | 28.7 | 1.64 | 51.4 | 28.0 | 1.4 | 1250 | 39.2 | 2.31 | 31.3 | 99.0 | 5.0 | 3.7 |
| 60 | 4.5 | 1.3 | 2.9 | 1100 | 42.3 | 26.1 | 1.90 | 48.7 | 22.3 | 2.6 | 1100 | 39.8 | 2.40 | 31.6 | 103.5 | 4.9 | 3.7 |
| | 4.5 | 1.3 | 2.9 | 1250 | 43.0 | 28.1 | 1.97 | 49.8 | 21.9 | 2.7 | 1250 | 40.4 | 2.33 | 32.5 | 99.9 | 5.1 | 3.8 |
| | 6.8 | 2.1 | 4.9 | 1100 | 43.5 | 26.5 | 1.78 | 49.5 | 24.5 | 2.1 | 1100 | 41.9 | 2.44 | 33.5 | 105.2 | 5.0 | 4.0 |
| | 6.8 | 2.1 | 4.9 | 1250 | 44.3 | 28.5 | 1.84 | 50.6 | 24.0 | 2.2 | 1250 | 42.5 | 2.37 | 34.4 | 101.5 | 5.3 | 4.1 |
| | 9.0 | 3.3 | 7.5 | 1100 | 44.0 | 26.6 | 1.72 | 49.8 | 25.6 | 1.9 | 1100 | 43.0 | 2.47 | 34.6 | 106.2 | 5.1 | 4.1 |
| | 9.0 | 3.3 | 7.5 | 1250 | 44.8 | 28.6 | 1.78 | 50.9 | 25.1 | 1.9 | 1250 | 43.7 | 2.39 | 35.5 | 102.3 | 5.4 | 4.2 |
| 70 | 4.5 | 1.2 | 2.9 | 1100 | 40.4 | 25.4 | 2.08 | 47.4 | 19.4 | 3.4 | 1100 | 43.9 | 2.49 | 35.4 | 106.9 | 5.2 | 4.2 |
| | 4.5 | 1.2 | 2.9 | 1250 | 41.1 | 27.4 | 2.15 | 48.4 | 19.1 | 3.5 | 1250 | 44.5 | 2.41 | 36.3 | 103.0 | 5.4 | 4.3 |
| | 6.8 | 2.1 | 4.8 | 1100 | 41.8 | 26.0 | 1.94 | 48.4 | 21.5 | 2.8 | 1100 | 46.2 | 2.54 | 37.5 | 108.9 | 5.3 | 4.5 |
| | 6.8 | 2.1 | 4.8 | 1250 | 42.6 | 27.9 | 2.02 | 49.4 | 21.1 | 2.9 | 1250 | 46.9 | 2.47 | 38.5 | 104.8 | 5.6 | 4.6 |
| | 9.0 | 3.1 | 7.2 | 1100 | 42.5 | 26.2 | 1.88 | 48.8 | 22.6 | 2.5 | 1100 | 47.6 | 2.58 | 38.7 | 110.0 | 5.4 | 4.6 |
| | 9.0 | 3.1 | 7.2 | 1250 | 43.2 | 28.2 | 1.95 | 49.9 | 22.2 | 2.6 | 1250 | 48.3 | 2.50 | 39.7 | 105.8 | 5.7 | 4.7 |
| 80 | 4.5 | 1.2 | 2.9 | 1100 | 38.2 | 24.6 | 2.29 | 45.9 | 16.7 | 4.3 | 1100 | 48.0 | 2.59 | 39.2 | 110.4 | 5.4 | 4.6 |
| | 4.5 | 1.2 | 2.9 | 1250 | 38.8 | 26.4 | 2.37 | 46.9 | 16.4 | 4.4 | 1250 | 48.8 | 2.51 | 40.2 | 106.1 | 5.7 | 4.7 |
| | 6.8 | 2.0 | 4.7 | 1100 | 39.8 | 25.2 | 2.14 | 47.0 | 18.6 | 3.6 | 1100 | 50.8 | 2.67 | 41.6 | 112.7 | 5.6 | 4.9 |
| | 6.8 | 2.0 | 4.7 | 1250 | 40.5 | 27.1 | 2.21 | 48.0 | 18.3 | 3.7 | 1250 | 51.5 | 2.59 | 42.7 | 108.2 | 5.8 | 5.0 |
| | 9.0 | 3.1 | 7.1 | 1100 | 40.5 | 25.5 | 2.06 | 47.5 | 19.6 | 3.9 | 1100 | 52.3 | 2.72 | 42.9 | 114.0 | 5.6 | 5.1 |
| | 9.0 | 3.1 | 7.1 | 1250 | 41.2 | 27.4 | 2.14 | 48.5 | 19.3 | 4.0 | 1250 | 53.1 | 2.64 | 44.1 | 109.3 | 5.9 | 5.2 |
| 85 | 4.5 | 1.2 | 2.9 | 1100 | 37.0 | 24.1 | 2.4 | 45.2 | 15.4 | 4.8 | 1100 | 50.2 | 2.66 | 41.1 | 112.3 | 5.5 | 4.8 |
| | 4.5 | 1.2 | 2.9 | 1250 | 37.6 | 25.9 | 2.50 | 46.2 | 15.1 | 4.9 | 1250 | 51.0 | 2.6 | 42.2 | 107.8 | 5.8 | 5.0 |
| | 6.8 | 2.0 | 4.6 | 1100 | 38.6 | 24.7 | 2.25 | 46.2 | 17.2 | 4.1 | 1100 | 53.1 | 2.8 | 43.7 | 114.7 | 5.7 | 5.1 |
| | 6.8 | 2.0 | 4.6 | 1250 | 39.3 | 26.6 | 2.33 | 47.2 | 16.9 | 4.2 | 1250 | 53.9 | 2.7 | 44.8 | 110.0 | 5.9 | 5.3 |
| | 9.0 | 3.0 | 7.0 | 1100 | 39.4 | 25.1 | 2.17 | 46.8 | 18.2 | 4.1 | 1100 | 54.8 | 2.8 | 45.1 | 116.1 | 5.7 | 5.3 |
| | 9.0 | 3.0 | 7.0 | 1250 | 40.1 | 27.0 | 2.25 | 47.8 | 17.9 | 4.2 | 1250 | 55.6 | 2.7 | 46.3 | 111.2 | 6.0 | 5.4 |
| 90 | 4.5 | 1.2 | 2.9 | 1100 | 35.8 | 23.6 | 2.54 | 44.4 | 14.1 | 5.3 | 1100 | 52.4 | 2.73 | 43.0 | 114.1 | 5.6 | 5.1 |
| | 4.5 | 1.2 | 2.9 | 1250 | 36.4 | 25.4 | 2.63 | 45.4 | 13.9 | 5.5 | 1250 | 53.2 | 2.64 | 44.2 | 109.4 | 5.9 | 5.2 |
| | 6.8 | 2.0 | 4.6 | 1100 | 37.4 | 24.3 | 2.36 | 45.5 | 15.9 | 4.6 | 1100 | 55.5 | 2.84 | 45.7 | 116.7 | 5.7 | 5.4 |
| | 6.8 | 2.0 | 4.6 | 1250 | 38.1 | 26.1 | 2.45 | 46.4 | 15.6 | 4.7 | 1250 | 56.3 | 2.75 | 47.0 | 111.7 | 6.0 | 5.5 |
| | 9.0 | 3.0 | 6.9 | 1100 | 38.3 | 24.6 | 2.28 | 46.0 | 16.8 | 4.3 | 1100 | 57.3 | 2.90 | 47.3 | 118.2 | 5.8 | 5.5 |
| | 9.0 | 3.0 | 6.9 | 1250 | 38.9 | 26.5 | 2.36 | 47.0 | 16.5 | 4.3 | 1250 | 58.1 | 2.81 | 48.5 | 113.1 | 6.1 | 5.6 |
| 100 | 4.5 | 1.2 | 2.8 | 1100 | 33.3 | 22.5 | 2.83 | 43.0 | 11.8 | 6.5 | | | | | | | |
| | 4.5 | 1.2 | 2.8 | 1250 | 33.9 | 24.2 | 2.93 | 43.9 | 11.6 | 6.7 | | | | | | | |
| | 6.8 | 2.0 | 4.5 | 1100 | 35.0 | 23.2 | 2.63 | 43.9 | 13.3 | 5.7 | | | | | | | |
| | 6.8 | 2.0 | 4.5 | 1250 | 35.6 | 25.0 | 2.72 | 44.9 | 13.1 | 5.9 | | | | | | | |
| | 9.0 | 3.0 | 6.8 | 1100 | 35.8 | 23.6 | 2.53 | 44.4 | 14.1 | 5.3 | | | | | | | |
| | 9.0 | 3.0 | 6.8 | 1250 | 36.4 | 25.4 | 2.63 | 45.4 | 13.9 | 5.5 | | | | | | | |
| 110 | 4.5 | 1.2 | 2.8 | 1100 | 30.9 | 21.4 | 3.18 | 41.7 | 9.7 | 7.9 | | | | | | | |
| | 4.5 | 1.2 | 2.8 | 1250 | 31.4 | 23.0 | 3.29 | 42.6 | 9.5 | 8.0 | | | | | | | |
| | 6.8 | 1.9 | 4.5 | 1100 | 32.4 | 22.1 | 2.95 | 42.5 | 11.0 | 7.0 | | | | | | | |
| | 6.8 | 1.9 | 4.5 | 1250 | 33.0 | 23.8 | 3.05 | 43.4 | 10.8 | 7.1 | | | | | | | |
| | 9.0 | 2.9 | 6.7 | 1100 | 33.3 | 22.5 | 2.84 | 42.9 | 11.7 | 6.6 | | | | | | | |
| | 9.0 | 2.9 | 6.7 | 1250 | 33.8 | 24.2 | 2.94 | 43.9 | 11.5 | 6.7 | | | | | | | |
| 120 | 4.5 | 1.1 | 2.6 | 1100 | 28.5 | 20.3 | 3.59 | 40.8 | 7.9 | 9.4 | | | | | | | |
| | 4.5 | 1.1 | 2.6 | 1250 | 29.0 | 21.9 | 3.72 | 41.7 | 7.8 | 9.6 | | | | | | | |
| | 6.8 | 1.9 | 4.3 | 1100 | 29.9 | 21.0 | 3.32 | 41.3 | 9.0 | 8.4 | | | | | | | |
| | 6.8 | 1.9 | 4.3 | 1250 | 30.5 | 22.6 | 3.44 | 42.2 | 8.8 | 8.6 | | | | | | | |
| | 9.0 | 2.9 | 6.6 | 1100 | 30.7 | 21.3 | 3.20 | 41.7 | 9.6 | 8.0 | | | | | | | |
| | 9.0 | 2.9 | 6.6 | 1250 | 31.3 | 23.0 | 3.31 | 42.6 | 9.4 | 8.1 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 049 (Part Load), No vFlow®

1350 CFM Nominal (Rated) Airflow Heating, 1350 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 9.0 | 2.3 | 5.4 | | | | | | | | 1190 | 22.8 | 2.37 | 14.9 | 87.7 | 2.8 | 2.5 |
| | 9.0 | 2.3 | 5.4 | | | | | | | | 1350 | 23.1 | 2.28 | 15.3 | 85.8 | 3.0 | 2.5 |
| 30 | 4.5 | 0.2 | 0.6 | 1190 | 40.9 | 25.0 | 1.11 | 44.7 | 37.0 | 1.0 | 1190 | 25.0 | 2.35 | 17.2 | 89.4 | 3.1 | 2.5 |
| | 4.5 | 0.2 | 0.6 | 1350 | 41.7 | 26.7 | 1.13 | 45.6 | 37.0 | 1.0 | 1350 | 25.3 | 2.25 | 17.6 | 87.4 | 3.3 | 2.6 |
| | 6.8 | 1.2 | 2.8 | 1190 | 39.5 | 22.6 | 1.02 | 43.0 | 38.6 | 1.0 | 1190 | 25.9 | 2.34 | 18.1 | 90.2 | 3.2 | 2.5 |
| | 6.8 | 1.2 | 2.8 | 1350 | 40.3 | 24.2 | 1.04 | 43.8 | 38.6 | 1.1 | 1350 | 26.3 | 2.24 | 18.6 | 88.0 | 3.4 | 2.6 |
| | 9.0 | 2.1 | 4.9 | 1190 | 38.5 | 21.2 | 0.99 | 41.9 | 38.9 | 1.1 | 1190 | 26.5 | 2.33 | 18.7 | 90.6 | 3.3 | 2.6 |
| | 9.0 | 2.1 | 4.9 | 1350 | 39.3 | 22.7 | 1.01 | 42.7 | 38.9 | 1.1 | 1350 | 26.8 | 2.24 | 19.2 | 88.4 | 3.5 | 2.6 |
| 40 | 4.5 | 0.2 | 0.4 | 1190 | 41.7 | 27.1 | 1.26 | 46.0 | 33.1 | 1.1 | 1190 | 28.5 | 2.32 | 20.8 | 92.2 | 3.6 | 2.6 |
| | 4.5 | 0.2 | 0.4 | 1350 | 42.5 | 29.1 | 1.28 | 46.9 | 33.1 | 1.2 | 1350 | 28.9 | 2.23 | 21.3 | 89.8 | 3.8 | 2.7 |
| | 6.8 | 1.1 | 2.5 | 1190 | 41.3 | 25.8 | 1.15 | 45.3 | 35.9 | 1.0 | 1190 | 29.8 | 2.32 | 22.0 | 93.2 | 3.8 | 2.7 |
| | 6.8 | 1.1 | 2.5 | 1350 | 42.1 | 27.6 | 1.17 | 46.2 | 35.9 | 1.0 | 1350 | 30.2 | 2.23 | 22.6 | 90.7 | 4.0 | 2.7 |
| | 9.0 | 2.0 | 4.6 | 1190 | 40.9 | 24.9 | 1.11 | 44.7 | 37.0 | 1.0 | 1190 | 30.5 | 2.32 | 22.7 | 93.7 | 3.9 | 2.7 |
| | 9.0 | 2.0 | 4.6 | 1350 | 41.7 | 26.7 | 1.13 | 45.6 | 37.0 | 1.0 | 1350 | 30.9 | 2.22 | 23.3 | 91.2 | 4.1 | 2.7 |
| 50 | 4.5 | 0.1 | 0.3 | 1190 | 41.2 | 28.0 | 1.45 | 46.1 | 28.5 | 1.5 | 1190 | 32.3 | 2.32 | 24.5 | 95.2 | 4.1 | 2.7 |
| | 4.5 | 0.1 | 0.3 | 1350 | 42.0 | 30.0 | 1.47 | 47.0 | 28.6 | 1.5 | 1350 | 32.8 | 2.22 | 25.2 | 92.5 | 4.3 | 2.8 |
| | 6.8 | 1.0 | 2.3 | 1190 | 41.7 | 27.5 | 1.31 | 46.1 | 31.7 | 1.2 | 1190 | 33.9 | 2.32 | 26.1 | 96.4 | 4.3 | 2.8 |
| | 6.8 | 1.0 | 2.3 | 1350 | 42.5 | 29.5 | 1.34 | 47.0 | 31.7 | 1.2 | 1350 | 34.4 | 2.23 | 26.8 | 93.6 | 4.5 | 2.9 |
| | 9.0 | 1.9 | 4.3 | 1190 | 41.7 | 27.1 | 1.25 | 46.0 | 33.2 | 1.1 | 1190 | 34.8 | 2.32 | 26.9 | 97.1 | 4.4 | 2.8 |
| | 9.0 | 1.9 | 4.3 | 1350 | 42.5 | 29.0 | 1.28 | 46.9 | 33.3 | 1.1 | 1350 | 35.3 | 2.23 | 27.7 | 94.2 | 4.6 | 2.9 |
| 60 | 4.5 | 0.1 | 0.2 | 1190 | 39.8 | 27.8 | 1.66 | 45.5 | 24.0 | 2.0 | 1190 | 36.3 | 2.33 | 28.4 | 98.3 | 4.6 | 2.9 |
| | 4.5 | 0.1 | 0.2 | 1350 | 40.6 | 29.8 | 1.69 | 46.4 | 24.1 | 2.1 | 1350 | 36.8 | 2.23 | 29.2 | 95.3 | 4.8 | 3.0 |
| | 6.8 | 1.0 | 2.2 | 1190 | 40.9 | 28.0 | 1.51 | 46.0 | 27.1 | 1.6 | 1190 | 38.2 | 2.34 | 30.3 | 99.7 | 4.8 | 3.0 |
| | 6.8 | 1.0 | 2.2 | 1350 | 41.7 | 30.0 | 1.53 | 46.9 | 27.2 | 1.7 | 1350 | 38.7 | 2.24 | 31.1 | 96.6 | 5.1 | 3.1 |
| | 9.0 | 1.8 | 4.2 | 1190 | 41.3 | 28.0 | 1.44 | 46.2 | 28.7 | 1.5 | 1190 | 39.2 | 2.34 | 31.3 | 100.5 | 4.9 | 3.0 |
| | 9.0 | 1.8 | 4.2 | 1350 | 42.1 | 29.9 | 1.46 | 47.0 | 28.8 | 1.5 | 1350 | 39.8 | 2.25 | 32.1 | 97.3 | 5.2 | 3.1 |
| 70 | 4.5 | 0.1 | 0.2 | 1190 | 37.9 | 27.1 | 1.90 | 44.4 | 19.9 | 2.5 | 1190 | 40.4 | 2.35 | 32.4 | 101.4 | 5.0 | 3.1 |
| | 4.5 | 0.1 | 0.2 | 1350 | 38.6 | 29.0 | 1.94 | 45.2 | 19.9 | 2.5 | 1350 | 41.0 | 2.25 | 33.3 | 98.1 | 5.3 | 3.2 |
| | 6.8 | 0.9 | 2.1 | 1190 | 39.3 | 27.7 | 1.73 | 45.2 | 22.7 | 2.1 | 1190 | 42.6 | 2.36 | 34.5 | 103.1 | 5.3 | 3.2 |
| | 6.8 | 0.9 | 2.1 | 1350 | 40.0 | 29.6 | 1.76 | 46.1 | 22.7 | 2.1 | 1350 | 43.2 | 2.26 | 35.5 | 99.6 | 5.6 | 3.3 |
| | 9.0 | 1.8 | 4.0 | 1190 | 39.9 | 27.9 | 1.65 | 45.5 | 24.2 | 1.9 | 1190 | 43.8 | 2.37 | 35.7 | 104.1 | 5.4 | 3.3 |
| | 9.0 | 1.8 | 4.0 | 1350 | 40.7 | 29.8 | 1.68 | 46.4 | 24.2 | 1.9 | 1350 | 44.4 | 2.27 | 36.7 | 100.5 | 5.7 | 3.4 |
| 80 | 4.5 | 0.1 | 0.3 | 1190 | 35.5 | 26.0 | 2.18 | 42.9 | 16.3 | 3.3 | 1190 | 44.6 | 2.37 | 36.4 | 104.7 | 5.5 | 3.3 |
| | 4.5 | 0.1 | 0.3 | 1350 | 36.2 | 27.8 | 2.22 | 43.7 | 16.3 | 3.4 | 1350 | 45.2 | 2.27 | 37.4 | 101.0 | 5.8 | 3.4 |
| | 6.8 | 0.9 | 2.1 | 1190 | 37.1 | 26.7 | 1.99 | 43.9 | 18.6 | 2.8 | 1190 | 47.0 | 2.38 | 38.8 | 106.6 | 5.8 | 3.5 |
| | 6.8 | 0.9 | 2.1 | 1350 | 37.8 | 28.6 | 2.03 | 44.7 | 18.6 | 2.9 | 1350 | 47.7 | 2.29 | 39.9 | 102.7 | 6.1 | 3.6 |
| | 9.0 | 1.7 | 4.0 | 1190 | 37.9 | 27.1 | 1.90 | 44.4 | 19.9 | 2.6 | 1190 | 48.3 | 2.39 | 40.1 | 107.6 | 5.9 | 3.8 |
| | 9.0 | 1.7 | 4.0 | 1350 | 38.6 | 29.0 | 1.94 | 45.2 | 19.9 | 2.7 | 1350 | 49.0 | 2.29 | 41.2 | 103.6 | 6.3 | 3.9 |
| 85 | 4.5 | 0.1 | 0.3 | 1190 | 34.2 | 25.4 | 2.3 | 42.1 | 14.7 | 3.8 | 1190 | 46.6 | 2.38 | 38.4 | 106.3 | 5.7 | 3.5 |
| | 4.5 | 0.1 | 0.3 | 1350 | 34.8 | 27.1 | 2.38 | 43.0 | 14.8 | 3.9 | 1350 | 47.3 | 2.3 | 39.5 | 102.4 | 6.1 | 3.5 |
| | 6.8 | 0.9 | 2.1 | 1190 | 35.8 | 26.1 | 2.14 | 43.1 | 16.9 | 3.3 | 1190 | 49.2 | 2.4 | 40.9 | 108.3 | 6.0 | 3.7 |
| | 6.8 | 0.9 | 2.1 | 1350 | 36.5 | 28.0 | 2.18 | 44.0 | 16.9 | 3.4 | 1350 | 49.9 | 2.3 | 42.0 | 104.2 | 6.4 | 3.7 |
| | 9.0 | 1.7 | 4.0 | 1190 | 36.6 | 26.5 | 2.04 | 43.6 | 18.1 | 3.1 | 1190 | 50.6 | 2.4 | 42.3 | 109.4 | 6.2 | 3.9 |
| | 9.0 | 1.7 | 4.0 | 1350 | 37.4 | 28.4 | 2.08 | 44.5 | 18.1 | 3.1 | 1350 | 51.3 | 2.3 | 43.4 | 105.2 | 6.5 | 3.9 |
| 90 | 4.5 | 0.1 | 0.3 | 1190 | 32.9 | 24.7 | 2.49 | 41.4 | 13.2 | 4.4 | 1190 | 48.7 | 2.39 | 40.4 | 107.9 | 6.0 | 3.6 |
| | 4.5 | 0.1 | 0.3 | 1350 | 33.5 | 26.5 | 2.54 | 42.2 | 13.2 | 4.4 | 1350 | 49.4 | 2.30 | 41.5 | 103.9 | 6.3 | 3.7 |
| | 6.8 | 0.9 | 2.1 | 1190 | 34.6 | 25.5 | 2.29 | 42.4 | 15.1 | 3.8 | 1190 | 51.4 | 2.41 | 43.0 | 110.0 | 6.3 | 3.8 |
| | 6.8 | 0.9 | 2.1 | 1350 | 35.2 | 27.3 | 2.33 | 43.2 | 15.1 | 3.9 | 1350 | 52.1 | 2.31 | 44.2 | 105.7 | 6.6 | 3.9 |
| | 9.0 | 1.7 | 3.9 | 1190 | 35.4 | 25.9 | 2.19 | 42.9 | 16.2 | 3.5 | 1190 | 52.8 | 2.41 | 44.4 | 111.1 | 6.4 | 3.9 |
| | 9.0 | 1.7 | 3.9 | 1350 | 36.1 | 27.8 | 2.23 | 43.7 | 16.2 | 3.6 | 1350 | 53.6 | 2.31 | 45.7 | 106.7 | 6.8 | 4.0 |
| 100 | 4.5 | 0.1 | 0.3 | 1190 | 30.2 | 23.5 | 2.84 | 39.9 | 10.6 | 5.6 | | | | | | | |
| | 4.5 | 0.1 | 0.3 | 1350 | 30.8 | 25.2 | 2.89 | 40.7 | 10.6 | 5.7 | | | | | | | |
| | 6.8 | 0.9 | 2.1 | 1190 | 31.9 | 24.3 | 2.62 | 40.8 | 12.2 | 5.0 | | | | | | | |
| | 6.8 | 0.9 | 2.1 | 1350 | 32.5 | 26.0 | 2.67 | 41.6 | 12.2 | 5.1 | | | | | | | |
| | 9.0 | 1.7 | 3.8 | 1190 | 32.7 | 24.6 | 2.51 | 41.3 | 13.0 | 4.7 | | | | | | | |
| | 9.0 | 1.7 | 3.8 | 1350 | 33.3 | 26.4 | 2.56 | 42.1 | 13.0 | 4.7 | | | | | | | |
| 110 | 4.5 | 0.1 | 0.2 | 1190 | 27.7 | 22.6 | 3.24 | 38.7 | 8.5 | 7.1 | | | | | | | |
| | 4.5 | 0.1 | 0.2 | 1350 | 28.2 | 24.2 | 3.30 | 39.5 | 8.6 | 7.2 | | | | | | | |
| | 6.8 | 0.9 | 2.0 | 1190 | 29.2 | 23.1 | 3.00 | 39.4 | 9.7 | 6.3 | | | | | | | |
| | 6.8 | 0.9 | 2.0 | 1350 | 29.7 | 24.7 | 3.05 | 40.1 | 9.7 | 6.5 | | | | | | | |
| | 9.0 | 1.6 | 3.7 | 1190 | 30.0 | 23.4 | 2.88 | 39.8 | 10.4 | 6.0 | | | | | | | |
| | 9.0 | 1.6 | 3.7 | 1350 | 30.5 | 25.1 | 2.93 | 40.5 | 10.4 | 6.1 | | | | | | | |
| 120 | 4.5 | 0.1 | 0.1 | 1190 | 25.4 | 22.0 | 3.69 | 38.0 | 6.9 | 8.7 | | | | | | | |
| | 4.5 | 0.1 | 0.1 | 1350 | 25.9 | 23.6 | 3.75 | 38.7 | 6.9 | 8.9 | | | | | | | |
| | 6.8 | 0.8 | 1.9 | 1190 | 26.7 | 22.3 | 3.42 | 38.3 | 7.8 | 7.9 | | | | | | | |
| | 6.8 | 0.8 | 1.9 | 1350 | 27.2 | 23.9 | 3.48 | 39.1 | 7.8 | 8.1 | | | | | | | |
| | 9.0 | 1.6 | 3.6 | 1190 | 27.4 | 22.5 | 3.29 | 38.6 | 8.3 | 7.5 | | | | | | | |
| | 9.0 | 1.6 | 3.6 | 1350 | 27.9 | 24.1 | 3.35 | 39.3 | 8.3 | 7.7 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 049 (Full Load), No vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1550 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 12.0 | 4.1 | 9.4 | | | | | | | | 1450 | 31.4 | 3.17 | 20.9 | 90.1 | 2.9 | 3.3 |
| | 12.0 | 4.1 | 9.4 | | | | | | | | 1650 | 31.9 | 3.07 | 21.4 | 87.9 | 3.0 | 3.3 |
| 30 | 6.0 | 0.9 | 2.1 | 1364 | 48.8 | 27.0 | 1.80 | 54.8 | 27.0 | 1.8 | 1450 | 34.7 | 3.16 | 24.2 | 92.2 | 3.2 | 3.4 |
| | 6.0 | 0.9 | 2.1 | 1550 | 49.6 | 29.1 | 1.87 | 56.0 | 26.6 | 1.8 | 1650 | 35.3 | 3.06 | 24.8 | 89.8 | 3.4 | 3.5 |
| | 9.0 | 2.1 | 4.9 | 1364 | 44.1 | 23.2 | 1.64 | 49.7 | 26.8 | 1.8 | 1450 | 36.2 | 3.16 | 25.7 | 93.1 | 3.4 | 3.5 |
| | 9.0 | 2.1 | 4.9 | 1550 | 44.9 | 25.0 | 1.70 | 50.7 | 26.3 | 1.9 | 1650 | 36.8 | 3.06 | 26.3 | 90.6 | 3.5 | 3.5 |
| | 12.0 | 3.8 | 8.8 | 1364 | 41.5 | 21.3 | 1.57 | 46.8 | 26.4 | 1.9 | 1450 | 37.1 | 3.16 | 26.5 | 93.7 | 3.4 | 3.5 |
| | 12.0 | 3.8 | 8.8 | 1550 | 42.2 | 22.9 | 1.63 | 47.8 | 25.9 | 1.9 | 1650 | 37.6 | 3.06 | 27.2 | 91.1 | 3.6 | 3.6 |
| 40 | 6.0 | 0.8 | 1.8 | 1364 | 53.0 | 31.2 | 2.05 | 59.8 | 25.8 | 1.9 | 1450 | 39.9 | 3.18 | 29.2 | 95.5 | 3.7 | 3.6 |
| | 6.0 | 0.8 | 1.8 | 1550 | 53.9 | 33.6 | 2.12 | 61.1 | 25.4 | 2.0 | 1650 | 40.5 | 3.08 | 30.0 | 92.7 | 3.8 | 3.7 |
| | 9.0 | 2.0 | 4.6 | 1364 | 50.7 | 28.8 | 1.89 | 57.1 | 26.8 | 1.8 | 1450 | 41.7 | 3.20 | 30.9 | 96.6 | 3.8 | 3.7 |
| | 9.0 | 2.0 | 4.6 | 1550 | 51.6 | 31.0 | 1.96 | 58.3 | 26.3 | 1.8 | 1650 | 42.3 | 3.11 | 31.7 | 93.8 | 4.0 | 3.8 |
| | 12.0 | 3.6 | 8.4 | 1364 | 49.1 | 27.4 | 1.82 | 55.2 | 27.0 | 1.8 | 1450 | 42.7 | 3.22 | 31.8 | 97.3 | 3.9 | 3.8 |
| | 12.0 | 3.6 | 8.4 | 1550 | 50.0 | 29.4 | 1.88 | 56.4 | 26.5 | 1.8 | 1650 | 43.3 | 3.12 | 32.7 | 94.3 | 4.1 | 3.9 |
| 50 | 6.0 | 0.7 | 1.7 | 1364 | 54.0 | 33.2 | 2.28 | 61.7 | 23.7 | 2.3 | 1450 | 45.0 | 3.26 | 34.0 | 98.8 | 4.0 | 3.9 |
| | 6.0 | 0.7 | 1.7 | 1550 | 54.9 | 35.7 | 2.37 | 63.0 | 23.2 | 2.3 | 1650 | 45.7 | 3.16 | 34.9 | 95.7 | 4.2 | 4.0 |
| | 9.0 | 1.9 | 4.3 | 1364 | 53.5 | 32.0 | 2.12 | 60.7 | 25.2 | 2.0 | 1450 | 47.2 | 3.30 | 36.0 | 100.1 | 4.2 | 4.1 |
| | 9.0 | 1.9 | 4.3 | 1550 | 54.5 | 34.5 | 2.20 | 62.0 | 24.8 | 2.1 | 1650 | 47.9 | 3.20 | 37.0 | 96.9 | 4.4 | 4.1 |
| | 12.0 | 3.5 | 8.0 | 1364 | 52.9 | 31.2 | 2.05 | 59.8 | 25.9 | 1.9 | 1450 | 48.3 | 3.33 | 37.1 | 100.9 | 4.3 | 4.1 |
| | 12.0 | 3.5 | 8.0 | 1550 | 53.8 | 33.5 | 2.12 | 61.1 | 25.4 | 2.0 | 1650 | 49.1 | 3.23 | 38.1 | 97.5 | 4.5 | 4.2 |
| 60 | 6.0 | 0.7 | 1.6 | 1364 | 53.1 | 33.6 | 2.52 | 61.6 | 21.1 | 2.9 | 1450 | 50.2 | 3.38 | 38.8 | 102.1 | 4.4 | 4.3 |
| | 6.0 | 0.7 | 1.6 | 1550 | 54.0 | 36.1 | 2.61 | 62.9 | 20.7 | 2.9 | 1650 | 51.0 | 3.27 | 39.8 | 98.6 | 4.6 | 4.4 |
| | 9.0 | 1.8 | 4.2 | 1364 | 53.9 | 33.4 | 2.35 | 61.8 | 22.9 | 2.4 | 1450 | 52.7 | 3.44 | 41.0 | 103.6 | 4.5 | 4.4 |
| | 9.0 | 1.8 | 4.2 | 1550 | 54.8 | 36.0 | 2.44 | 63.1 | 22.5 | 2.5 | 1650 | 53.5 | 3.33 | 42.1 | 100.0 | 4.7 | 4.5 |
| | 12.0 | 3.4 | 7.8 | 1364 | 54.0 | 33.1 | 2.27 | 61.6 | 23.8 | 2.3 | 1450 | 54.0 | 3.48 | 42.2 | 104.5 | 4.6 | 4.5 |
| | 12.0 | 3.4 | 7.8 | 1550 | 54.9 | 35.6 | 2.35 | 63.0 | 23.3 | 2.3 | 1650 | 54.8 | 3.37 | 43.3 | 100.8 | 4.8 | 4.6 |
| 70 | 6.0 | 0.7 | 1.5 | 1364 | 51.0 | 33.0 | 2.78 | 60.4 | 18.4 | 3.6 | 1450 | 55.5 | 3.52 | 43.5 | 105.4 | 4.6 | 4.6 |
| | 6.0 | 0.7 | 1.5 | 1550 | 51.9 | 35.5 | 2.88 | 61.7 | 18.0 | 3.7 | 1650 | 56.3 | 3.41 | 44.7 | 101.6 | 4.8 | 4.7 |
| | 9.0 | 1.8 | 4.0 | 1364 | 52.6 | 33.5 | 2.60 | 61.3 | 20.2 | 3.1 | 1450 | 58.2 | 3.60 | 46.0 | 107.2 | 4.7 | 4.9 |
| | 9.0 | 1.8 | 4.0 | 1550 | 53.5 | 36.0 | 2.69 | 62.7 | 19.9 | 3.1 | 1650 | 59.1 | 3.49 | 47.2 | 103.2 | 5.0 | 5.0 |
| | 12.0 | 3.3 | 7.6 | 1364 | 53.2 | 33.6 | 2.51 | 61.6 | 21.2 | 2.8 | 1450 | 59.7 | 3.65 | 47.3 | 108.1 | 4.8 | 5.0 |
| | 12.0 | 3.3 | 7.6 | 1550 | 54.1 | 36.1 | 2.60 | 63.0 | 20.8 | 2.9 | 1650 | 60.6 | 3.53 | 48.6 | 104.0 | 5.0 | 5.1 |
| 80 | 6.0 | 0.7 | 1.5 | 1364 | 48.1 | 31.8 | 3.07 | 58.6 | 15.7 | 4.5 | 1450 | 60.7 | 3.68 | 48.2 | 108.8 | 4.8 | 5.1 |
| | 6.0 | 0.7 | 1.5 | 1550 | 49.0 | 34.2 | 3.18 | 59.8 | 15.4 | 4.6 | 1650 | 61.6 | 3.56 | 49.5 | 104.6 | 5.1 | 5.2 |
| | 9.0 | 1.7 | 4.0 | 1364 | 50.1 | 32.7 | 2.87 | 59.9 | 17.5 | 3.8 | 1450 | 63.8 | 3.77 | 50.9 | 110.7 | 5.0 | 5.4 |
| | 9.0 | 1.7 | 4.0 | 1550 | 51.0 | 35.1 | 2.97 | 61.1 | 17.2 | 3.9 | 1650 | 64.8 | 3.65 | 52.3 | 106.3 | 5.2 | 5.5 |
| | 12.0 | 3.2 | 7.5 | 1364 | 51.1 | 33.0 | 2.77 | 60.4 | 18.4 | 3.6 | 1450 | 65.5 | 3.82 | 52.4 | 111.8 | 5.0 | 5.9 |
| | 12.0 | 3.2 | 7.5 | 1550 | 51.9 | 35.5 | 2.87 | 61.7 | 18.1 | 3.6 | 1650 | 66.5 | 3.70 | 53.8 | 107.3 | 5.3 | 6.0 |
| 85 | 6.0 | 0.7 | 1.5 | 1364 | 46.5 | 31.0 | 3.2 | 57.5 | 14.5 | 5.0 | 1450 | 63.4 | 3.76 | 50.6 | 110.5 | 4.9 | 5.3 |
| | 6.0 | 0.7 | 1.5 | 1550 | 47.3 | 33.3 | 3.35 | 58.8 | 14.2 | 5.1 | 1650 | 64.3 | 3.6 | 51.9 | 106.1 | 5.2 | 5.4 |
| | 9.0 | 1.7 | 3.9 | 1364 | 48.6 | 32.0 | 3.02 | 58.9 | 16.2 | 4.3 | 1450 | 66.6 | 3.8 | 53.5 | 112.5 | 5.1 | 5.6 |
| | 9.0 | 1.7 | 3.9 | 1550 | 49.4 | 34.4 | 3.13 | 60.1 | 15.9 | 4.4 | 1650 | 67.6 | 3.7 | 54.9 | 108.0 | 5.3 | 5.8 |
| | 12.0 | 3.2 | 7.4 | 1364 | 49.6 | 32.4 | 2.92 | 59.5 | 17.1 | 4.0 | 1450 | 68.4 | 3.9 | 55.1 | 113.7 | 5.1 | 6.0 |
| | 12.0 | 3.2 | 7.4 | 1550 | 50.5 | 34.8 | 3.02 | 60.8 | 16.8 | 4.1 | 1650 | 69.4 | 3.8 | 56.5 | 109.0 | 5.4 | 6.1 |
| 90 | 6.0 | 0.7 | 1.5 | 1364 | 44.9 | 30.2 | 3.39 | 56.5 | 13.2 | 5.5 | 1450 | 66.0 | 3.83 | 52.9 | 112.2 | 5.0 | 5.6 |
| | 6.0 | 0.7 | 1.5 | 1550 | 45.7 | 32.5 | 3.52 | 57.7 | 13.0 | 5.6 | 1650 | 67.0 | 3.72 | 54.3 | 107.6 | 5.3 | 5.7 |
| | 9.0 | 1.7 | 3.9 | 1364 | 47.1 | 31.3 | 3.17 | 57.9 | 14.8 | 4.8 | 1450 | 69.4 | 3.93 | 56.0 | 114.3 | 5.2 | 5.9 |
| | 9.0 | 1.7 | 3.9 | 1550 | 47.9 | 33.6 | 3.29 | 59.1 | 14.6 | 4.9 | 1650 | 70.5 | 3.81 | 57.5 | 109.6 | 5.4 | 6.0 |
| | 12.0 | 3.2 | 7.4 | 1364 | 48.1 | 31.8 | 3.07 | 58.5 | 15.7 | 4.5 | 1450 | 71.3 | 3.98 | 57.7 | 115.5 | 5.3 | 6.1 |
| | 12.0 | 3.2 | 7.4 | 1550 | 49.0 | 34.2 | 3.18 | 59.8 | 15.4 | 4.6 | 1650 | 72.4 | 3.86 | 59.2 | 110.6 | 5.5 | 6.2 |
| 100 | 6.0 | 0.6 | 1.5 | 1364 | 41.7 | 28.6 | 3.78 | 54.6 | 11.1 | 6.8 | | | | | | | |
| | 6.0 | 0.6 | 1.5 | 1550 | 42.5 | 30.8 | 3.91 | 55.8 | 10.8 | 6.9 | | | | | | | |
| | 9.0 | 1.7 | 3.8 | 1364 | 43.7 | 29.6 | 3.53 | 55.8 | 12.4 | 6.0 | | | | | | | |
| | 9.0 | 1.7 | 3.8 | 1550 | 44.5 | 31.8 | 3.65 | 57.0 | 12.2 | 6.1 | | | | | | | |
| | 12.0 | 3.2 | 7.3 | 1364 | 44.8 | 30.1 | 3.41 | 56.4 | 13.2 | 5.6 | | | | | | | |
| | 12.0 | 3.2 | 7.3 | 1550 | 45.6 | 32.4 | 3.53 | 57.6 | 12.9 | 5.7 | | | | | | | |
| 110 | 6.0 | 0.6 | 1.4 | 1364 | 38.9 | 27.3 | 4.23 | 53.4 | 9.2 | 8.2 | | | | | | | |
| | 6.0 | 0.6 | 1.4 | 1550 | 39.5 | 29.3 | 4.38 | 54.5 | 9.0 | 8.4 | | | | | | | |
| | 9.0 | 1.6 | 3.7 | 1364 | 40.6 | 28.0 | 3.94 | 54.0 | 10.3 | 7.3 | | | | | | | |
| | 9.0 | 1.6 | 3.7 | 1550 | 41.3 | 30.2 | 4.09 | 55.2 | 10.1 | 7.4 | | | | | | | |
| | 12.0 | 3.1 | 7.2 | 1364 | 41.5 | 28.5 | 3.81 | 54.5 | 10.9 | 6.9 | | | | | | | |
| | 12.0 | 3.1 | 7.2 | 1550 | 42.2 | 30.6 | 3.94 | 55.7 | 10.7 | 7.0 | | | | | | | |
| 120 | 6.0 | 0.6 | 1.3 | 1364 | 36.8 | 26.6 | 4.78 | 53.2 | 7.7 | 9.9 | | | | | | | |
| | 6.0 | 0.6 | 1.3 | 1550 | 37.4 | 28.6 | 4.96 | 54.3 | 7.6 | 10.1 | | | | | | | |
| | 9.0 | 1.6 | 3.6 | 1364 | 37.9 | 26.9 | 4.44 | 53.1 | 8.5 | 8.8 | | | | | | | |
| | 9.0 | 1.6 | 3.6 | 1550 | 38.6 | 28.9 | 4.60 | 54.3 | 8.4 | 9.0 | | | | | | | |
| | 12.0 | 3.0 | 7.0 | 1364 | 38.6 | 27.2 | 4.28 | 53.3 | 9.0 | 8.3 | | | | | | | |
| | 12.0 | 3.0 | 7.0 | 1550 | 39.3 | 29.2 | 4.43 | 54.4 | 8.9 | 8.5 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 064 (Part Load), No vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1500 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 12.0 | 5.2 | 11.9 | | | | | | | | 1450 | 28.2 | 2.87 | 18.7 | 88.0 | 2.9 | 3.1 |
| | 12.0 | 5.2 | 11.9 | | | | | | | | 1650 | 28.6 | 2.75 | 19.3 | 86.1 | 3.1 | 3.1 |
| 30 | 6.0 | 0.9 | 2.1 | 1320 | 56.0 | 38.9 | 1.47 | 61.1 | 38.0 | 1.0 | 1450 | 31.7 | 2.88 | 22.1 | 90.2 | 3.2 | 3.1 |
| | 6.0 | 0.9 | 2.1 | 1500 | 57.1 | 41.6 | 1.50 | 62.2 | 38.1 | 1.1 | 1650 | 32.2 | 2.76 | 22.7 | 88.0 | 3.4 | 3.2 |
| | 9.0 | 2.5 | 5.7 | 1320 | 55.8 | 39.5 | 1.42 | 60.6 | 39.2 | 1.0 | 1450 | 33.1 | 2.89 | 23.5 | 91.1 | 3.4 | 3.2 |
| | 9.0 | 2.5 | 5.7 | 1500 | 56.9 | 42.3 | 1.45 | 61.8 | 39.2 | 1.0 | 1650 | 33.6 | 2.77 | 24.1 | 88.8 | 3.6 | 3.2 |
| | 12.0 | 4.2 | 9.6 | 1320 | 55.4 | 39.8 | 1.41 | 60.2 | 39.2 | 1.0 | 1450 | 33.9 | 2.89 | 24.2 | 91.6 | 3.4 | 3.2 |
| | 12.0 | 4.2 | 9.6 | 1500 | 56.5 | 42.6 | 1.44 | 61.4 | 39.2 | 1.0 | 1650 | 34.4 | 2.77 | 24.9 | 89.3 | 3.6 | 3.2 |
| 40 | 6.0 | 0.5 | 1.1 | 1320 | 55.3 | 38.0 | 1.61 | 60.8 | 34.4 | 1.3 | 1450 | 37.0 | 2.91 | 27.3 | 93.6 | 3.7 | 3.2 |
| | 6.0 | 0.5 | 1.1 | 1500 | 56.4 | 40.7 | 1.64 | 62.0 | 34.4 | 1.3 | 1650 | 37.6 | 2.79 | 28.0 | 91.1 | 3.9 | 3.3 |
| | 9.0 | 1.9 | 4.4 | 1320 | 55.9 | 38.6 | 1.51 | 61.1 | 37.0 | 1.1 | 1450 | 38.8 | 2.92 | 29.0 | 94.8 | 3.9 | 3.3 |
| | 9.0 | 1.9 | 4.4 | 1500 | 57.0 | 41.3 | 1.54 | 62.3 | 37.0 | 1.1 | 1650 | 39.4 | 2.80 | 29.8 | 92.1 | 4.1 | 3.4 |
| | 12.0 | 3.4 | 7.9 | 1320 | 56.0 | 38.9 | 1.47 | 61.0 | 38.0 | 1.0 | 1450 | 39.8 | 2.93 | 30.0 | 95.4 | 4.0 | 3.3 |
| | 12.0 | 3.4 | 7.9 | 1500 | 57.1 | 41.7 | 1.50 | 62.2 | 38.1 | 1.1 | 1650 | 40.4 | 2.81 | 30.8 | 92.7 | 4.2 | 3.4 |
| 50 | 6.0 | 0.2 | 0.6 | 1320 | 53.7 | 37.2 | 1.82 | 59.9 | 29.6 | 1.8 | 1450 | 42.5 | 2.94 | 32.6 | 97.1 | 4.2 | 3.4 |
| | 6.0 | 0.2 | 0.6 | 1500 | 54.8 | 39.8 | 1.85 | 61.1 | 29.6 | 1.8 | 1650 | 43.1 | 2.82 | 33.5 | 94.2 | 4.5 | 3.5 |
| | 9.0 | 1.5 | 3.5 | 1320 | 54.9 | 37.8 | 1.67 | 60.6 | 32.9 | 1.4 | 1450 | 44.7 | 2.96 | 34.7 | 98.5 | 4.4 | 3.5 |
| | 9.0 | 1.5 | 3.5 | 1500 | 56.0 | 40.4 | 1.70 | 61.8 | 32.9 | 1.5 | 1650 | 45.3 | 2.84 | 35.7 | 95.4 | 4.7 | 3.5 |
| | 12.0 | 3.0 | 6.9 | 1320 | 55.4 | 38.1 | 1.60 | 60.9 | 34.6 | 1.3 | 1450 | 45.9 | 2.97 | 35.9 | 99.3 | 4.5 | 3.5 |
| | 12.0 | 3.0 | 6.9 | 1500 | 56.5 | 40.8 | 1.63 | 62.0 | 34.6 | 1.3 | 1650 | 46.6 | 2.85 | 36.9 | 96.1 | 4.8 | 3.6 |
| 60 | 6.0 | 0.2 | 0.4 | 1320 | 51.4 | 36.3 | 2.07 | 58.5 | 24.8 | 2.4 | 1450 | 48.1 | 2.98 | 37.9 | 100.7 | 4.7 | 3.6 |
| | 6.0 | 0.2 | 0.4 | 1500 | 52.4 | 38.9 | 2.11 | 59.6 | 24.8 | 2.5 | 1650 | 48.8 | 2.86 | 39.0 | 97.4 | 5.0 | 3.7 |
| | 9.0 | 1.4 | 3.2 | 1320 | 53.0 | 36.9 | 1.90 | 59.5 | 28.0 | 2.0 | 1450 | 50.6 | 3.01 | 40.4 | 102.3 | 4.9 | 3.7 |
| | 9.0 | 1.4 | 3.2 | 1500 | 54.1 | 39.5 | 1.93 | 60.6 | 28.0 | 2.0 | 1650 | 51.4 | 2.89 | 41.5 | 98.8 | 5.2 | 3.8 |
| | 12.0 | 2.7 | 6.3 | 1320 | 53.8 | 37.2 | 1.81 | 59.9 | 29.8 | 1.8 | 1450 | 52.1 | 3.02 | 41.7 | 103.2 | 5.0 | 3.8 |
| | 12.0 | 2.7 | 6.3 | 1500 | 54.8 | 39.9 | 1.84 | 61.1 | 29.8 | 1.8 | 1650 | 52.8 | 2.90 | 42.9 | 99.6 | 5.3 | 3.8 |
| 70 | 6.0 | 0.2 | 0.4 | 1320 | 48.6 | 35.4 | 2.38 | 56.7 | 20.5 | 3.3 | 1450 | 53.6 | 3.04 | 43.3 | 104.2 | 5.2 | 3.8 |
| | 6.0 | 0.2 | 0.4 | 1500 | 49.6 | 37.9 | 2.42 | 57.8 | 20.5 | 3.3 | 1650 | 54.4 | 2.91 | 44.5 | 100.5 | 5.5 | 3.9 |
| | 9.0 | 1.3 | 3.0 | 1320 | 50.5 | 36.0 | 2.17 | 57.9 | 23.3 | 2.7 | 1450 | 56.5 | 3.07 | 46.0 | 106.1 | 5.4 | 4.0 |
| | 9.0 | 1.3 | 3.0 | 1500 | 51.5 | 38.6 | 2.21 | 59.0 | 23.3 | 2.7 | 1650 | 57.3 | 2.94 | 47.3 | 102.2 | 5.7 | 4.1 |
| | 12.0 | 2.6 | 6.0 | 1320 | 51.4 | 36.3 | 2.07 | 58.5 | 24.8 | 2.4 | 1450 | 58.1 | 3.09 | 47.5 | 107.1 | 5.5 | 4.1 |
| | 12.0 | 2.6 | 6.0 | 1500 | 52.4 | 38.9 | 2.11 | 59.6 | 24.8 | 2.5 | 1650 | 58.9 | 2.96 | 48.8 | 103.1 | 5.8 | 4.2 |
| 80 | 6.0 | 0.3 | 0.6 | 1320 | 45.6 | 34.3 | 2.73 | 54.9 | 16.7 | 4.3 | 1450 | 59.1 | 3.10 | 48.5 | 107.7 | 5.6 | 4.1 |
| | 6.0 | 0.3 | 0.6 | 1500 | 46.5 | 36.7 | 2.78 | 56.0 | 16.7 | 4.4 | 1650 | 59.9 | 2.97 | 49.8 | 103.6 | 5.9 | 4.2 |
| | 9.0 | 1.3 | 3.1 | 1320 | 47.5 | 35.0 | 2.50 | 56.1 | 19.0 | 3.6 | 1450 | 62.2 | 3.13 | 51.5 | 109.7 | 5.8 | 4.3 |
| | 9.0 | 1.3 | 3.1 | 1500 | 48.5 | 37.5 | 2.55 | 57.2 | 19.0 | 3.7 | 1650 | 63.1 | 3.00 | 52.9 | 105.4 | 6.2 | 4.4 |
| | 12.0 | 2.6 | 5.9 | 1320 | 48.5 | 35.3 | 2.40 | 56.7 | 20.2 | 3.3 | 1450 | 63.9 | 3.16 | 53.0 | 110.8 | 5.9 | 4.4 |
| | 12.0 | 2.6 | 5.9 | 1500 | 49.5 | 37.8 | 2.44 | 57.8 | 20.3 | 3.4 | 1650 | 64.8 | 3.03 | 54.5 | 106.4 | 6.3 | 4.5 |
| 85 | 6.0 | 0.3 | 0.7 | 1320 | 44.0 | 33.6 | 2.9 | 54.0 | 15.1 | 4.9 | 1450 | 61.8 | 3.13 | 51.0 | 109.4 | 5.8 | 4.3 |
| | 6.0 | 0.3 | 0.7 | 1500 | 44.9 | 36.0 | 2.98 | 55.0 | 15.2 | 5.0 | 1650 | 62.6 | 3.0 | 52.4 | 105.1 | 6.1 | 4.4 |
| | 9.0 | 1.4 | 3.2 | 1320 | 46.0 | 34.4 | 2.69 | 55.1 | 17.2 | 4.2 | 1450 | 65.0 | 3.2 | 54.0 | 111.5 | 6.0 | 4.5 |
| | 9.0 | 1.4 | 3.2 | 1500 | 46.8 | 36.8 | 2.74 | 56.2 | 17.2 | 4.2 | 1650 | 65.9 | 3.0 | 55.5 | 107.0 | 6.4 | 4.6 |
| | 12.0 | 2.6 | 5.9 | 1320 | 46.9 | 34.8 | 2.58 | 55.7 | 18.3 | 3.8 | 1450 | 66.7 | 3.2 | 55.6 | 112.6 | 6.1 | 4.6 |
| | 12.0 | 2.6 | 5.9 | 1500 | 47.9 | 37.2 | 2.63 | 56.8 | 18.4 | 3.9 | 1650 | 67.6 | 3.1 | 57.2 | 108.0 | 6.5 | 4.7 |
| 90 | 6.0 | 0.3 | 0.7 | 1320 | 42.4 | 33.0 | 3.12 | 53.1 | 13.6 | 5.5 | 1450 | 64.4 | 3.16 | 53.5 | 111.1 | 6.0 | 4.5 |
| | 6.0 | 0.3 | 0.7 | 1500 | 43.3 | 35.3 | 3.18 | 54.1 | 13.6 | 5.6 | 1650 | 65.3 | 3.03 | 55.0 | 106.7 | 6.3 | 4.6 |
| | 9.0 | 1.4 | 3.2 | 1320 | 44.4 | 33.8 | 2.88 | 54.2 | 15.4 | 4.7 | 1450 | 67.7 | 3.21 | 56.6 | 113.2 | 6.2 | 4.7 |
| | 9.0 | 1.4 | 3.2 | 1500 | 45.2 | 36.2 | 2.93 | 55.2 | 15.4 | 4.8 | 1650 | 68.7 | 3.08 | 58.2 | 108.5 | 6.5 | 4.8 |
| | 12.0 | 2.6 | 6.0 | 1320 | 45.4 | 34.2 | 2.76 | 54.8 | 16.4 | 4.4 | 1450 | 69.4 | 3.24 | 58.2 | 114.3 | 6.3 | 4.9 |
| | 12.0 | 2.6 | 6.0 | 1500 | 46.2 | 36.6 | 2.81 | 55.8 | 16.5 | 4.4 | 1650 | 70.4 | 3.11 | 59.8 | 109.5 | 6.6 | 4.9 |
| 100 | 6.0 | 0.3 | 0.8 | 1320 | 39.4 | 31.6 | 3.55 | 51.5 | 11.1 | 6.9 | | | | | | | |
| | 6.0 | 0.3 | 0.8 | 1500 | 40.2 | 33.9 | 3.62 | 52.5 | 11.1 | 7.0 | | | | | | | |
| | 9.0 | 1.4 | 3.2 | 1320 | 41.2 | 32.4 | 3.30 | 52.4 | 12.5 | 6.0 | | | | | | | |
| | 9.0 | 1.4 | 3.2 | 1500 | 42.0 | 34.7 | 3.36 | 53.4 | 12.5 | 6.1 | | | | | | | |
| | 12.0 | 2.6 | 6.0 | 1320 | 42.1 | 32.9 | 3.17 | 52.9 | 13.3 | 5.6 | | | | | | | |
| | 12.0 | 2.6 | 6.0 | 1500 | 43.0 | 35.2 | 3.23 | 54.0 | 13.3 | 5.7 | | | | | | | |
| 110 | 6.0 | 0.3 | 0.6 | 1320 | 36.7 | 30.2 | 4.02 | 50.4 | 9.1 | 8.5 | | | | | | | |
| | 6.0 | 0.3 | 0.6 | 1500 | 37.4 | 32.4 | 4.09 | 51.3 | 9.1 | 8.7 | | | | | | | |
| | 9.0 | 1.3 | 3.1 | 1320 | 38.2 | 31.0 | 3.74 | 51.0 | 10.2 | 7.5 | | | | | | | |
| | 9.0 | 1.3 | 3.1 | 1500 | 38.9 | 33.2 | 3.81 | 52.0 | 10.2 | 7.7 | | | | | | | |
| | 12.0 | 2.5 | 5.8 | 1320 | 39.0 | 31.4 | 3.61 | 51.4 | 10.8 | 7.1 | | | | | | | |
| | 12.0 | 2.5 | 5.8 | 1500 | 39.8 | 33.7 | 3.68 | 52.3 | 10.8 | 7.2 | | | | | | | |
| 120 | 6.0 | 0.0 | 0.0 | 1320 | 34.4 | 28.9 | 4.51 | 49.8 | 7.6 | 10.3 | | | | | | | |
| | 6.0 | 0.0 | 0.0 | 1500 | 35.1 | 31.0 | 4.59 | 50.8 | 7.6 | 10.5 | | | | | | | |
| | 9.0 | 1.1 | 2.6 | 1320 | 35.6 | 29.6 | 4.22 | 50.0 | 8.4 | 9.3 | | | | | | | |
| | 9.0 | 1.1 | 2.6 | 1500 | 36.3 | 31.7 | 4.30 | 51.0 | 8.4 | 9.4 | | | | | | | |
| | 12.0 | 2.4 | 5.4 | 1320 | 36.3 | 30.0 | 4.09 | 50.2 | 8.9 | 8.7 | | | | | | | |
| | 12.0 | 2.4 | 5.4 | 1500 | 37.0 | 32.2 | 4.16 | 51.2 | 8.9 | 8.9 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 064 (Full Load), No vFlow®

2050 CFM Nominal (Rated) Airflow Heating, 1850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 15.0 | 7.3 | 16.8 | | | | | | | | 1800 | 42.8 | 3.89 | 29.8 | 92.0 | 3.2 | 3.8 |
| | 15.0 | 7.3 | 16.8 | | | | | | | | 2050 | 43.5 | 3.77 | 30.6 | 89.6 | 3.4 | 3.8 |
| 30 | 7.5 | 1.7 | 3.9 | 1630 | 75.3 | 49.7 | 2.68 | 84.3 | 28.1 | 1.9 | 1800 | 46.9 | 3.94 | 33.6 | 94.1 | 3.5 | 3.9 |
| | 7.5 | 1.7 | 3.9 | 1850 | 76.6 | 53.4 | 2.78 | 86.1 | 27.5 | 2.0 | 2050 | 47.6 | 3.82 | 34.5 | 91.5 | 3.7 | 4.0 |
| | 11.3 | 3.7 | 8.6 | 1630 | 74.9 | 50.3 | 2.58 | 83.5 | 29.1 | 1.8 | 1800 | 49.1 | 3.98 | 35.8 | 95.3 | 3.6 | 4.0 |
| | 11.3 | 3.7 | 8.6 | 1850 | 76.2 | 54.0 | 2.67 | 85.3 | 28.5 | 1.8 | 2050 | 49.9 | 3.86 | 36.7 | 92.5 | 3.8 | 4.1 |
| | 15.0 | 6.1 | 14.1 | 1630 | 74.2 | 50.5 | 2.53 | 82.7 | 29.4 | 1.8 | 1800 | 50.4 | 4.00 | 36.9 | 95.9 | 3.7 | 4.0 |
| | 15.0 | 6.1 | 14.1 | 1850 | 75.5 | 54.3 | 2.62 | 84.5 | 28.8 | 1.8 | 2050 | 51.2 | 3.88 | 37.9 | 93.1 | 3.9 | 4.1 |
| 40 | 7.5 | 1.2 | 2.7 | 1630 | 74.4 | 48.8 | 2.87 | 84.0 | 26.0 | 2.3 | 1800 | 53.9 | 4.07 | 40.2 | 97.7 | 3.9 | 4.2 |
| | 7.5 | 1.2 | 2.7 | 1850 | 75.7 | 52.5 | 2.97 | 85.8 | 25.5 | 2.3 | 2050 | 54.7 | 3.94 | 41.3 | 94.7 | 4.1 | 4.2 |
| | 11.3 | 3.0 | 7.0 | 1630 | 75.2 | 49.5 | 2.72 | 84.3 | 27.6 | 2.0 | 1800 | 56.7 | 4.12 | 42.8 | 99.2 | 4.0 | 4.3 |
| | 11.3 | 3.0 | 7.0 | 1850 | 76.5 | 53.2 | 2.82 | 86.1 | 27.1 | 2.1 | 2050 | 57.6 | 3.99 | 44.0 | 96.0 | 4.2 | 4.4 |
| | 15.0 | 5.3 | 12.2 | 1630 | 75.3 | 49.8 | 2.66 | 84.2 | 28.3 | 1.9 | 1800 | 58.3 | 4.15 | 44.3 | 100.0 | 4.1 | 4.3 |
| | 15.0 | 5.3 | 12.2 | 1850 | 76.6 | 53.6 | 2.76 | 86.0 | 27.7 | 1.9 | 2050 | 59.2 | 4.02 | 45.5 | 96.7 | 4.3 | 4.4 |
| 50 | 7.5 | 0.9 | 2.0 | 1630 | 72.4 | 47.8 | 3.09 | 82.8 | 23.4 | 2.8 | 1800 | 61.1 | 4.21 | 46.9 | 101.5 | 4.3 | 4.5 |
| | 7.5 | 0.9 | 2.0 | 1850 | 73.6 | 51.4 | 3.20 | 84.5 | 23.0 | 2.9 | 2050 | 62.1 | 4.08 | 48.2 | 98.0 | 4.5 | 4.6 |
| | 11.3 | 2.6 | 6.0 | 1630 | 74.0 | 48.6 | 2.91 | 83.8 | 25.4 | 2.4 | 1800 | 64.5 | 4.28 | 50.0 | 103.2 | 4.4 | 4.6 |
| | 11.3 | 2.6 | 6.0 | 1850 | 75.3 | 52.2 | 3.02 | 85.6 | 24.9 | 2.5 | 2050 | 65.5 | 4.15 | 51.3 | 99.6 | 4.6 | 4.7 |
| | 15.0 | 4.7 | 10.8 | 1630 | 74.6 | 48.9 | 2.84 | 84.1 | 26.3 | 2.2 | 1800 | 66.3 | 4.32 | 51.7 | 104.1 | 4.5 | 4.7 |
| | 15.0 | 4.7 | 10.8 | 1850 | 75.9 | 52.6 | 2.94 | 85.9 | 25.8 | 2.3 | 2050 | 67.3 | 4.19 | 53.0 | 100.4 | 4.7 | 4.8 |
| 60 | 7.5 | 0.8 | 1.7 | 1630 | 69.5 | 46.7 | 3.35 | 80.9 | 20.8 | 3.5 | 1800 | 68.5 | 4.38 | 53.6 | 105.2 | 4.6 | 4.9 |
| | 7.5 | 0.8 | 1.7 | 1850 | 70.7 | 50.3 | 3.47 | 82.6 | 20.4 | 3.6 | 2050 | 69.5 | 4.24 | 55.1 | 101.4 | 4.8 | 5.0 |
| | 11.3 | 2.4 | 5.4 | 1630 | 71.7 | 47.6 | 3.15 | 82.3 | 22.8 | 3.0 | 1800 | 72.3 | 4.47 | 57.1 | 107.2 | 4.7 | 5.1 |
| | 11.3 | 2.4 | 5.4 | 1850 | 73.0 | 51.1 | 3.26 | 84.1 | 22.4 | 3.1 | 2050 | 73.4 | 4.33 | 58.6 | 103.2 | 5.0 | 5.2 |
| | 15.0 | 4.3 | 10.0 | 1630 | 72.7 | 48.0 | 3.05 | 83.0 | 23.8 | 2.8 | 1800 | 74.4 | 4.52 | 59.0 | 108.3 | 4.8 | 5.2 |
| | 15.0 | 4.3 | 10.0 | 1850 | 74.0 | 51.6 | 3.16 | 84.8 | 23.4 | 2.8 | 2050 | 75.5 | 4.38 | 60.6 | 104.1 | 5.1 | 5.3 |
| 70 | 7.5 | 0.7 | 1.7 | 1630 | 66.1 | 45.5 | 3.68 | 78.6 | 18.0 | 4.4 | 1800 | 75.8 | 4.55 | 60.3 | 109.0 | 4.9 | 5.3 |
| | 7.5 | 0.7 | 1.7 | 1850 | 67.3 | 48.9 | 3.81 | 80.3 | 17.7 | 4.5 | 2050 | 77.0 | 4.41 | 61.9 | 104.8 | 5.1 | 5.4 |
| | 11.3 | 2.3 | 5.2 | 1630 | 68.6 | 46.4 | 3.44 | 80.3 | 20.0 | 3.8 | 1800 | 80.1 | 4.66 | 64.2 | 111.2 | 5.0 | 5.6 |
| | 11.3 | 2.3 | 5.2 | 1850 | 69.8 | 49.9 | 3.56 | 82.0 | 19.6 | 3.8 | 2050 | 81.3 | 4.52 | 65.9 | 106.7 | 5.3 | 5.7 |
| | 15.0 | 4.1 | 9.6 | 1630 | 69.9 | 46.9 | 3.32 | 81.1 | 21.0 | 3.5 | 1800 | 82.4 | 4.74 | 66.3 | 112.4 | 5.1 | 5.7 |
| | 15.0 | 4.1 | 9.6 | 1850 | 71.1 | 50.4 | 3.44 | 82.8 | 20.7 | 3.5 | 2050 | 83.7 | 4.59 | 68.0 | 107.8 | 5.3 | 5.8 |
| 80 | 7.5 | 0.8 | 1.8 | 1630 | 62.5 | 44.1 | 4.04 | 76.2 | 15.4 | 5.5 | 1800 | 83.1 | 4.76 | 66.9 | 112.8 | 5.1 | 5.8 |
| | 7.5 | 0.8 | 1.8 | 1850 | 63.5 | 47.5 | 4.19 | 77.8 | 15.2 | 5.6 | 2050 | 84.4 | 4.61 | 68.7 | 108.1 | 5.4 | 5.9 |
| | 11.3 | 2.2 | 5.2 | 1630 | 65.1 | 45.1 | 3.77 | 77.9 | 17.2 | 4.7 | 1800 | 87.8 | 4.89 | 71.1 | 115.2 | 5.3 | 6.1 |
| | 11.3 | 2.2 | 5.2 | 1850 | 66.2 | 48.5 | 3.91 | 79.6 | 16.9 | 4.8 | 2050 | 89.1 | 4.74 | 73.0 | 110.3 | 5.5 | 6.2 |
| | 15.0 | 4.1 | 9.4 | 1630 | 66.4 | 45.6 | 3.65 | 78.7 | 18.2 | 4.3 | 1800 | 90.3 | 4.96 | 73.3 | 116.5 | 5.3 | 6.7 |
| | 15.0 | 4.1 | 9.4 | 1850 | 67.5 | 49.0 | 3.78 | 80.4 | 17.9 | 4.4 | 2050 | 91.7 | 4.81 | 75.3 | 111.4 | 5.6 | 6.9 |
| 85 | 7.5 | 0.6 | 1.3 | 1630 | 60.6 | 43.4 | 4.3 | 75.1 | 14.3 | 6.1 | 1800 | 86.7 | 4.86 | 70.1 | 114.6 | 5.2 | 6.0 |
| | 7.5 | 0.6 | 1.3 | 1850 | 61.6 | 46.7 | 4.42 | 76.7 | 14.0 | 6.2 | 2050 | 88.0 | 4.7 | 72.0 | 109.8 | 5.5 | 6.2 |
| | 11.3 | 1.8 | 4.2 | 1630 | 63.2 | 44.4 | 3.98 | 76.7 | 16.0 | 5.3 | 1800 | 91.5 | 5.0 | 74.4 | 117.1 | 5.4 | 6.4 |
| | 11.3 | 1.8 | 4.2 | 1850 | 64.3 | 47.7 | 4.12 | 78.3 | 15.7 | 5.4 | 2050 | 92.9 | 4.9 | 76.3 | 112.0 | 5.6 | 6.5 |
| | 15.0 | 3.3 | 7.7 | 1630 | 64.5 | 44.9 | 3.84 | 77.5 | 16.9 | 4.9 | 1800 | 94.1 | 5.1 | 76.7 | 118.4 | 5.4 | 6.8 |
| | 15.0 | 3.3 | 7.7 | 1850 | 65.6 | 48.3 | 3.98 | 79.2 | 16.6 | 5.0 | 2050 | 95.5 | 4.9 | 78.7 | 113.1 | 5.7 | 7.0 |
| 90 | 7.5 | 0.3 | 0.7 | 1630 | 58.7 | 42.6 | 4.49 | 74.0 | 13.1 | 6.7 | 1800 | 90.3 | 4.96 | 73.3 | 116.4 | 5.3 | 6.3 |
| | 7.5 | 0.3 | 0.7 | 1850 | 59.8 | 45.8 | 4.65 | 75.6 | 12.8 | 6.8 | 2050 | 91.7 | 4.81 | 75.2 | 111.4 | 5.6 | 6.4 |
| | 11.3 | 1.4 | 3.2 | 1630 | 61.3 | 43.7 | 4.18 | 75.5 | 14.7 | 5.8 | 1800 | 95.2 | 5.12 | 77.7 | 119.0 | 5.5 | 6.7 |
| | 11.3 | 1.4 | 3.2 | 1850 | 62.3 | 47.0 | 4.33 | 77.1 | 14.4 | 6.0 | 2050 | 96.7 | 4.96 | 79.7 | 113.7 | 5.7 | 6.9 |
| | 15.0 | 2.6 | 6.0 | 1630 | 62.6 | 44.2 | 4.03 | 76.3 | 15.5 | 5.4 | 1800 | 97.9 | 5.21 | 80.0 | 120.3 | 5.5 | 7.0 |
| | 15.0 | 2.6 | 6.0 | 1850 | 63.7 | 47.5 | 4.18 | 77.9 | 15.2 | 5.5 | 2050 | 99.4 | 5.05 | 82.1 | 114.9 | 5.8 | 7.1 |
| 100 | 7.5 | 0.3 | 0.8 | 1630 | 55.2 | 41.1 | 5.00 | 72.3 | 11.0 | 8.1 | | | | | | | |
| | 7.5 | 0.3 | 0.8 | 1850 | 56.2 | 44.2 | 5.18 | 73.9 | 10.8 | 8.3 | | | | | | | |
| | 11.3 | 1.4 | 3.2 | 1630 | 57.5 | 42.1 | 4.65 | 73.4 | 12.4 | 7.2 | | | | | | | |
| | 11.3 | 1.4 | 3.2 | 1850 | 58.5 | 45.3 | 4.82 | 75.0 | 12.1 | 7.3 | | | | | | | |
| | 15.0 | 2.6 | 6.0 | 1630 | 58.8 | 42.6 | 4.49 | 74.0 | 13.1 | 6.7 | | | | | | | |
| | 15.0 | 2.6 | 6.0 | 1850 | 59.8 | 45.9 | 4.65 | 75.6 | 12.9 | 6.8 | | | | | | | |
| 110 | 7.5 | 0.3 | 0.6 | 1630 | 52.2 | 39.6 | 5.60 | 71.4 | 9.3 | 9.8 | | | | | | | |
| | 7.5 | 0.3 | 0.6 | 1850 | 53.1 | 42.6 | 5.80 | 72.9 | 9.2 | 10.0 | | | | | | | |
| | 11.3 | 1.3 | 3.1 | 1630 | 54.1 | 40.6 | 5.20 | 71.9 | 10.4 | 8.7 | | | | | | | |
| | 11.3 | 1.3 | 3.1 | 1850 | 55.0 | 43.6 | 5.39 | 73.4 | 10.2 | 8.9 | | | | | | | |
| | 15.0 | 2.5 | 5.8 | 1630 | 55.2 | 41.1 | 5.01 | 72.3 | 11.0 | 8.2 | | | | | | | |
| | 15.0 | 2.5 | 5.8 | 1850 | 56.1 | 44.2 | 5.19 | 73.8 | 10.8 | 8.3 | | | | | | | |
| 120 | 7.5 | 0.0 | 0.0 | 1630 | 50.0 | 38.5 | 6.30 | 71.6 | 7.9 | 11.7 | | | | | | | |
| | 7.5 | 0.0 | 0.0 | 1850 | 50.8 | 41.4 | 6.53 | 73.1 | 7.8 | 11.9 | | | | | | | |
| | 11.3 | 1.1 | 2.6 | 1630 | 51.3 | 39.2 | 5.83 | 71.3 | 8.8 | 10.4 | | | | | | | |
| | 11.3 | 1.1 | 2.6 | 1850 | 52.2 | 42.1 | 6.04 | 72.8 | 8.6 | 10.6 | | | | | | | |
| | 15.0 | 2.4 | 5.4 | 1630 | 52.1 | 39.6 | 5.62 | 71.3 | 9.3 | 9.8 | | | | | | | |
| | 15.0 | 2.4 | 5.4 | 1850 | 53.0 | 42.6 | 5.82 | 72.9 | 9.1 | 10.0 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 072 (Part Load), No vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1550 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 14.0 | 6.5 | 15.1 | | | | | | | | 1450 | 32.9 | 3.66 | 20.9 | 91.0 | 2.6 | 4.1 |
| | 14.0 | 6.5 | 15.1 | | | | | | | | 1650 | 33.4 | 3.51 | 21.4 | 88.7 | 2.8 | 4.1 |
| 30 | 7.0 | 1.4 | 3.3 | 1360 | 65.1 | 40.9 | 1.82 | 71.3 | 35.8 | 2.2 | 1450 | 37.2 | 3.72 | 24.8 | 93.7 | 2.9 | 4.2 |
| | 7.0 | 1.4 | 3.3 | 1550 | 66.4 | 43.8 | 1.85 | 72.7 | 35.9 | 2.2 | 1650 | 37.7 | 3.57 | 25.5 | 91.1 | 3.1 | 4.3 |
| | 10.5 | 3.3 | 7.6 | 1360 | 65.5 | 41.3 | 1.72 | 71.3 | 38.1 | 2.2 | 1450 | 38.7 | 3.74 | 26.3 | 94.7 | 3.0 | 4.2 |
| | 10.5 | 3.3 | 7.6 | 1550 | 66.7 | 44.2 | 1.75 | 72.7 | 38.1 | 2.2 | 1650 | 39.3 | 3.59 | 27.0 | 92.0 | 3.2 | 4.3 |
| | 14.0 | 5.4 | 12.5 | 1360 | 65.5 | 41.4 | 1.68 | 71.2 | 39.0 | 2.2 | 1450 | 39.6 | 3.75 | 27.1 | 95.3 | 3.1 | 4.2 |
| | 14.0 | 5.4 | 12.5 | 1550 | 66.7 | 44.4 | 1.71 | 72.6 | 39.0 | 2.3 | 1650 | 40.1 | 3.60 | 27.8 | 92.5 | 3.3 | 4.3 |
| 40 | 7.0 | 0.9 | 2.2 | 1360 | 63.8 | 40.1 | 2.01 | 70.7 | 31.7 | 2.3 | 1450 | 43.3 | 3.81 | 30.6 | 97.6 | 3.3 | 4.4 |
| | 7.0 | 0.9 | 2.2 | 1550 | 65.0 | 43.0 | 2.05 | 72.0 | 31.7 | 2.4 | 1650 | 43.9 | 3.65 | 31.4 | 94.6 | 3.5 | 4.5 |
| | 10.5 | 2.6 | 6.1 | 1360 | 64.8 | 40.7 | 1.88 | 71.2 | 34.5 | 2.2 | 1450 | 45.2 | 3.84 | 32.4 | 98.9 | 3.5 | 4.4 |
| | 10.5 | 2.6 | 6.1 | 1550 | 66.0 | 43.6 | 1.91 | 72.5 | 34.6 | 2.2 | 1650 | 45.8 | 3.68 | 33.3 | 95.7 | 3.7 | 4.5 |
| | 14.0 | 4.6 | 10.7 | 1360 | 65.1 | 40.9 | 1.81 | 71.3 | 36.0 | 2.2 | 1450 | 46.3 | 3.85 | 33.4 | 99.5 | 3.5 | 4.4 |
| | 14.0 | 4.6 | 10.7 | 1550 | 66.4 | 43.8 | 1.84 | 72.7 | 36.1 | 2.2 | 1650 | 46.9 | 3.69 | 34.3 | 96.3 | 3.7 | 4.5 |
| 50 | 7.0 | 0.7 | 1.5 | 1360 | 61.7 | 39.2 | 2.28 | 69.5 | 27.1 | 2.6 | 1450 | 49.4 | 3.90 | 36.3 | 101.5 | 3.7 | 4.7 |
| | 7.0 | 0.7 | 1.5 | 1550 | 62.9 | 41.9 | 2.32 | 70.8 | 27.1 | 2.7 | 1650 | 50.1 | 3.74 | 37.4 | 98.1 | 3.9 | 4.8 |
| | 10.5 | 2.2 | 5.1 | 1360 | 63.2 | 39.8 | 2.09 | 70.3 | 30.2 | 2.4 | 1450 | 51.7 | 3.93 | 38.5 | 103.0 | 3.9 | 4.8 |
| | 10.5 | 2.2 | 5.1 | 1550 | 64.4 | 42.7 | 2.13 | 71.7 | 30.3 | 2.5 | 1650 | 52.5 | 3.77 | 39.6 | 99.4 | 4.1 | 4.9 |
| | 14.0 | 4.1 | 9.4 | 1360 | 63.8 | 40.2 | 2.01 | 70.7 | 31.7 | 2.4 | 1450 | 53.0 | 3.94 | 39.7 | 103.8 | 3.9 | 4.8 |
| | 14.0 | 4.1 | 9.4 | 1550 | 65.1 | 43.0 | 2.05 | 72.1 | 31.7 | 2.5 | 1650 | 53.8 | 3.78 | 40.8 | 100.2 | 4.2 | 4.9 |
| 60 | 7.0 | 0.5 | 1.3 | 1360 | 59.1 | 38.1 | 2.60 | 68.0 | 22.7 | 3.2 | 1450 | 55.6 | 3.98 | 42.2 | 105.5 | 4.1 | 5.1 |
| | 7.0 | 0.5 | 1.3 | 1550 | 60.2 | 40.8 | 2.65 | 69.3 | 22.7 | 3.2 | 1650 | 56.4 | 3.82 | 43.3 | 101.6 | 4.3 | 5.2 |
| | 10.5 | 2.0 | 4.6 | 1360 | 60.9 | 38.8 | 2.38 | 69.0 | 25.6 | 2.8 | 1450 | 58.3 | 4.03 | 44.7 | 107.2 | 4.2 | 5.2 |
| | 10.5 | 2.0 | 4.6 | 1550 | 62.1 | 41.6 | 2.42 | 70.4 | 25.7 | 2.9 | 1650 | 59.1 | 3.86 | 46.0 | 103.2 | 4.5 | 5.3 |
| | 14.0 | 3.8 | 8.7 | 1360 | 61.8 | 39.2 | 2.28 | 69.5 | 27.1 | 2.7 | 1450 | 59.8 | 4.05 | 46.1 | 108.2 | 4.3 | 5.3 |
| | 14.0 | 3.8 | 8.7 | 1550 | 63.0 | 42.0 | 2.32 | 70.9 | 27.1 | 2.7 | 1650 | 60.6 | 3.88 | 47.4 | 104.0 | 4.6 | 5.4 |
| 70 | 7.0 | 0.5 | 1.3 | 1360 | 56.0 | 36.9 | 2.99 | 66.2 | 18.8 | 4.2 | 1450 | 61.8 | 4.07 | 48.0 | 109.4 | 4.4 | 5.5 |
| | 7.0 | 0.5 | 1.3 | 1550 | 57.1 | 39.5 | 3.04 | 67.5 | 18.8 | 4.3 | 1650 | 62.6 | 3.90 | 49.3 | 105.1 | 4.7 | 5.6 |
| | 10.5 | 1.9 | 4.5 | 1360 | 58.1 | 37.7 | 2.73 | 67.4 | 21.3 | 3.6 | 1450 | 64.8 | 4.12 | 50.9 | 111.4 | 4.6 | 5.7 |
| | 10.5 | 1.9 | 4.5 | 1550 | 59.2 | 40.3 | 2.78 | 68.7 | 21.3 | 3.7 | 1650 | 65.8 | 3.95 | 52.3 | 106.9 | 4.9 | 5.8 |
| | 14.0 | 3.6 | 8.3 | 1360 | 59.1 | 38.1 | 2.60 | 67.9 | 22.7 | 3.4 | 1450 | 66.5 | 4.14 | 52.5 | 112.5 | 4.7 | 5.8 |
| | 14.0 | 3.6 | 8.3 | 1550 | 60.2 | 40.7 | 2.65 | 69.3 | 22.7 | 3.5 | 1650 | 67.5 | 3.97 | 53.9 | 107.9 | 5.0 | 5.9 |
| 80 | 7.0 | 0.6 | 1.4 | 1360 | 52.7 | 35.6 | 3.42 | 64.3 | 15.4 | 5.7 | 1450 | 68.0 | 4.16 | 53.8 | 113.4 | 4.8 | 6.0 |
| | 7.0 | 0.6 | 1.4 | 1550 | 53.7 | 38.1 | 3.48 | 65.6 | 15.4 | 5.8 | 1650 | 68.9 | 3.99 | 55.3 | 108.7 | 5.1 | 6.1 |
| | 10.5 | 1.9 | 4.5 | 1360 | 54.8 | 36.4 | 3.13 | 65.5 | 17.5 | 4.9 | 1450 | 71.4 | 4.22 | 57.0 | 115.6 | 5.0 | 6.2 |
| | 10.5 | 1.9 | 4.5 | 1550 | 55.9 | 39.0 | 3.19 | 66.8 | 17.5 | 5.0 | 1650 | 72.4 | 4.05 | 58.6 | 110.6 | 5.2 | 6.3 |
| | 14.0 | 3.5 | 8.1 | 1360 | 55.9 | 36.8 | 3.00 | 66.1 | 18.7 | 4.5 | 1450 | 73.3 | 4.26 | 58.8 | 116.8 | 5.0 | 6.4 |
| | 14.0 | 3.5 | 8.1 | 1550 | 57.0 | 39.4 | 3.05 | 67.4 | 18.7 | 4.6 | 1650 | 74.3 | 4.08 | 60.4 | 111.7 | 5.3 | 6.5 |
| 85 | 7.0 | 0.6 | 1.5 | 1360 | 50.9 | 34.9 | 3.7 | 63.4 | 14.0 | 6.6 | 1450 | 71.1 | 4.21 | 56.7 | 115.4 | 4.9 | 6.2 |
| | 7.0 | 0.6 | 1.5 | 1550 | 51.9 | 37.4 | 3.73 | 64.6 | 14.0 | 6.7 | 1650 | 72.1 | 4.0 | 58.3 | 110.4 | 5.2 | 6.4 |
| | 10.5 | 1.9 | 4.5 | 1360 | 53.1 | 35.7 | 3.37 | 64.6 | 15.9 | 5.7 | 1450 | 74.7 | 4.3 | 60.1 | 117.7 | 5.1 | 6.5 |
| | 10.5 | 1.9 | 4.5 | 1550 | 54.1 | 38.2 | 3.43 | 65.8 | 15.9 | 5.8 | 1650 | 75.8 | 4.1 | 61.8 | 112.5 | 5.4 | 6.6 |
| | 14.0 | 3.5 | 8.1 | 1360 | 54.2 | 36.1 | 3.22 | 65.2 | 16.9 | 5.3 | 1450 | 76.7 | 4.3 | 61.9 | 119.0 | 5.2 | 6.7 |
| | 14.0 | 3.5 | 8.1 | 1550 | 55.2 | 38.7 | 3.28 | 66.4 | 17.0 | 5.4 | 1650 | 77.8 | 4.1 | 63.7 | 113.6 | 5.5 | 6.8 |
| 90 | 7.0 | 0.7 | 1.5 | 1360 | 49.1 | 34.2 | 3.91 | 62.5 | 12.6 | 7.5 | 1450 | 74.1 | 4.27 | 59.6 | 117.3 | 5.1 | 6.5 |
| | 7.0 | 0.7 | 1.5 | 1550 | 50.1 | 36.6 | 3.98 | 63.7 | 12.6 | 7.6 | 1650 | 75.2 | 4.09 | 61.2 | 112.2 | 5.4 | 6.6 |
| | 10.5 | 2.0 | 4.5 | 1360 | 51.3 | 35.0 | 3.60 | 63.6 | 14.2 | 6.5 | 1450 | 78.0 | 4.33 | 63.2 | 119.8 | 5.3 | 6.8 |
| | 10.5 | 2.0 | 4.5 | 1550 | 52.3 | 37.5 | 3.67 | 64.8 | 14.3 | 6.7 | 1650 | 79.1 | 4.15 | 64.9 | 114.4 | 5.6 | 7.0 |
| | 14.0 | 3.5 | 8.1 | 1360 | 52.4 | 35.5 | 3.45 | 64.2 | 15.2 | 6.1 | 1450 | 80.1 | 4.37 | 65.1 | 121.1 | 5.4 | 7.0 |
| | 14.0 | 3.5 | 8.1 | 1550 | 53.5 | 38.0 | 3.51 | 65.4 | 15.2 | 6.2 | 1650 | 81.2 | 4.19 | 66.9 | 115.6 | 5.7 | 7.1 |
| 100 | 7.0 | 0.7 | 1.6 | 1360 | 45.5 | 32.9 | 4.46 | 60.7 | 10.2 | 9.7 | | | | | | | |
| | 7.0 | 0.7 | 1.6 | 1550 | 46.4 | 35.2 | 4.54 | 61.9 | 10.2 | 9.9 | | | | | | | |
| | 10.5 | 2.0 | 4.5 | 1360 | 47.7 | 33.7 | 4.12 | 61.7 | 11.6 | 8.6 | | | | | | | |
| | 10.5 | 2.0 | 4.5 | 1550 | 48.6 | 36.0 | 4.20 | 62.9 | 11.6 | 8.8 | | | | | | | |
| | 14.0 | 3.5 | 8.1 | 1360 | 48.8 | 34.1 | 3.96 | 62.3 | 12.3 | 8.1 | | | | | | | |
| | 14.0 | 3.5 | 8.1 | 1550 | 49.7 | 36.5 | 4.03 | 63.5 | 12.3 | 8.2 | | | | | | | |
| 110 | 7.0 | 0.6 | 1.4 | 1360 | 42.0 | 31.5 | 5.06 | 59.3 | 8.3 | 12.4 | | | | | | | |
| | 7.0 | 0.6 | 1.4 | 1550 | 42.9 | 33.8 | 5.15 | 60.4 | 8.3 | 12.6 | | | | | | | |
| | 10.5 | 1.9 | 4.4 | 1360 | 44.1 | 32.3 | 4.69 | 60.1 | 9.4 | 11.1 | | | | | | | |
| | 10.5 | 1.9 | 4.4 | 1550 | 44.9 | 34.6 | 4.78 | 61.2 | 9.4 | 11.3 | | | | | | | |
| | 14.0 | 3.5 | 8.0 | 1360 | 45.1 | 32.7 | 4.53 | 60.5 | 10.0 | 10.5 | | | | | | | |
| | 14.0 | 3.5 | 8.0 | 1550 | 46.0 | 35.0 | 4.61 | 61.7 | 10.0 | 10.7 | | | | | | | |
| 120 | 7.0 | 0.4 | 0.9 | 1360 | 38.7 | 30.3 | 5.72 | 58.2 | 6.8 | 15.4 | | | | | | | |
| | 7.0 | 0.4 | 0.9 | 1550 | 39.5 | 32.5 | 5.82 | 59.4 | 6.8 | 15.7 | | | | | | | |
| | 10.5 | 1.7 | 3.9 | 1360 | 40.6 | 31.0 | 5.33 | 58.8 | 7.6 | 14.0 | | | | | | | |
| | 10.5 | 1.7 | 3.9 | 1550 | 41.4 | 33.2 | 5.43 | 59.9 | 7.6 | 14.3 | | | | | | | |
| | 14.0 | 3.3 | 7.6 | 1360 | 41.6 | 31.3 | 5.15 | 59.1 | 8.1 | 13.3 | | | | | | | |
| | 14.0 | 3.3 | 7.6 | 1550 | 42.4 | 33.6 | 5.24 | 60.2 | 8.1 | 13.6 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 072 (Full Load), No vFlow®

2050 CFM Nominal (Rated) Airflow Heating, 1850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | HEATING - 70°F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | HWC | CFM | HC | kW | HE | LAT | COP | HWC |
| 20 | 17.0 | 8.9 | 20.6 | | | | | | | | 1800 | 46.6 | 4.66 | 31.1 | 94.0 | 2.9 | 4.0 |
| | 17.0 | 8.9 | 20.6 | | | | | | | | 2050 | 47.3 | 4.52 | 31.9 | 91.4 | 3.1 | 4.1 |
| 30 | 8.5 | 2.2 | 5.1 | 1630 | 82.4 | 50.1 | 3.04 | 92.6 | 27.1 | 2.2 | 1800 | 51.6 | 4.78 | 35.6 | 96.5 | 3.2 | 4.2 |
| | 8.5 | 2.2 | 5.1 | 1850 | 83.8 | 53.9 | 3.15 | 94.6 | 26.6 | 2.2 | 2050 | 52.4 | 4.63 | 36.6 | 93.7 | 3.3 | 4.3 |
| | 12.8 | 4.6 | 10.6 | 1630 | 82.3 | 50.0 | 2.90 | 92.0 | 28.4 | 2.2 | 1800 | 54.0 | 4.83 | 37.8 | 97.8 | 3.3 | 4.1 |
| | 12.8 | 4.6 | 10.6 | 1850 | 83.7 | 53.8 | 3.00 | 93.9 | 27.9 | 2.2 | 2050 | 54.8 | 4.68 | 38.8 | 94.8 | 3.4 | 4.2 |
| | 17.0 | 7.6 | 17.6 | 1630 | 81.9 | 49.8 | 2.84 | 91.4 | 28.9 | 2.2 | 1800 | 55.3 | 4.86 | 39.0 | 98.4 | 3.3 | 4.1 |
| | 17.0 | 7.6 | 17.6 | 1850 | 83.3 | 53.5 | 2.94 | 93.3 | 28.3 | 2.3 | 2050 | 56.1 | 4.71 | 40.1 | 95.3 | 3.5 | 4.2 |
| 40 | 8.5 | 1.6 | 3.8 | 1630 | 81.3 | 49.8 | 3.27 | 92.3 | 24.9 | 2.4 | 1800 | 59.4 | 4.95 | 42.7 | 100.5 | 3.5 | 4.3 |
| | 8.5 | 1.6 | 3.8 | 1850 | 82.7 | 53.5 | 3.39 | 94.3 | 24.4 | 2.4 | 2050 | 60.3 | 4.80 | 43.9 | 97.2 | 3.7 | 4.4 |
| | 12.8 | 3.9 | 8.9 | 1630 | 82.2 | 50.1 | 3.10 | 92.6 | 26.5 | 2.2 | 1800 | 62.1 | 5.03 | 45.3 | 102.0 | 3.6 | 4.4 |
| | 12.8 | 3.9 | 8.9 | 1850 | 83.6 | 53.9 | 3.21 | 94.6 | 26.1 | 2.2 | 2050 | 63.1 | 4.87 | 46.5 | 98.5 | 3.8 | 4.5 |
| | 17.0 | 6.7 | 15.5 | 1630 | 82.4 | 50.1 | 3.02 | 92.5 | 27.3 | 2.2 | 1800 | 63.6 | 5.06 | 46.6 | 102.7 | 3.7 | 4.4 |
| | 17.0 | 6.7 | 15.5 | 1850 | 83.8 | 53.9 | 3.13 | 94.5 | 26.8 | 2.2 | 2050 | 64.6 | 4.90 | 47.9 | 99.2 | 3.9 | 4.5 |
| 50 | 8.5 | 1.3 | 3.0 | 1630 | 79.1 | 49.0 | 3.54 | 91.0 | 22.3 | 2.7 | 1800 | 66.9 | 5.15 | 49.6 | 104.4 | 3.8 | 4.6 |
| | 8.5 | 1.3 | 3.0 | 1850 | 80.5 | 52.6 | 3.67 | 93.0 | 21.9 | 2.8 | 2050 | 67.9 | 4.99 | 50.9 | 100.7 | 4.0 | 4.7 |
| | 12.8 | 3.4 | 7.8 | 1630 | 80.8 | 49.6 | 3.34 | 92.0 | 24.2 | 2.4 | 1800 | 70.1 | 5.23 | 52.5 | 106.1 | 3.9 | 4.7 |
| | 12.8 | 3.4 | 7.8 | 1850 | 82.2 | 53.3 | 3.46 | 94.0 | 23.8 | 2.5 | 2050 | 71.2 | 5.07 | 53.9 | 102.1 | 4.1 | 4.8 |
| | 17.0 | 6.0 | 13.9 | 1630 | 81.5 | 49.8 | 3.24 | 92.4 | 25.1 | 2.5 | 1800 | 71.8 | 5.27 | 54.0 | 106.9 | 4.0 | 4.8 |
| | 17.0 | 6.0 | 13.9 | 1850 | 82.9 | 53.6 | 3.36 | 94.3 | 24.7 | 2.5 | 2050 | 72.9 | 5.11 | 55.5 | 102.9 | 4.2 | 4.9 |
| 60 | 8.5 | 1.2 | 2.7 | 1630 | 76.1 | 47.8 | 3.87 | 89.2 | 19.7 | 3.3 | 1800 | 74.4 | 5.35 | 56.4 | 108.3 | 4.1 | 5.0 |
| | 8.5 | 1.2 | 2.7 | 1850 | 77.4 | 51.4 | 4.01 | 91.1 | 19.3 | 3.3 | 2050 | 75.5 | 5.18 | 57.9 | 104.1 | 4.3 | 5.1 |
| | 12.8 | 3.1 | 7.1 | 1630 | 78.3 | 48.7 | 3.63 | 90.6 | 21.6 | 2.9 | 1800 | 78.0 | 5.45 | 59.6 | 110.1 | 4.2 | 5.1 |
| | 12.8 | 3.1 | 7.1 | 1850 | 79.7 | 52.3 | 3.76 | 92.5 | 21.2 | 2.9 | 2050 | 79.2 | 5.28 | 61.2 | 105.8 | 4.4 | 5.2 |
| | 17.0 | 5.6 | 13.0 | 1630 | 79.3 | 49.1 | 3.51 | 91.2 | 22.6 | 2.7 | 1800 | 80.0 | 5.50 | 61.4 | 111.1 | 4.3 | 5.2 |
| | 17.0 | 5.6 | 13.0 | 1850 | 80.7 | 52.7 | 3.64 | 93.1 | 22.2 | 2.8 | 2050 | 81.2 | 5.33 | 63.0 | 106.7 | 4.5 | 5.3 |
| 70 | 8.5 | 1.1 | 2.6 | 1630 | 72.4 | 46.3 | 4.27 | 86.9 | 17.0 | 4.4 | 1800 | 81.9 | 5.55 | 63.1 | 112.1 | 4.3 | 5.4 |
| | 8.5 | 1.1 | 2.6 | 1850 | 73.7 | 49.8 | 4.42 | 88.7 | 16.7 | 4.5 | 2050 | 83.2 | 5.38 | 64.8 | 107.6 | 4.5 | 5.5 |
| | 12.8 | 3.0 | 6.8 | 1630 | 75.0 | 47.4 | 3.98 | 88.5 | 18.9 | 3.7 | 1800 | 86.0 | 5.68 | 66.7 | 114.2 | 4.4 | 5.6 |
| | 12.8 | 3.0 | 6.8 | 1850 | 76.3 | 50.9 | 4.12 | 90.4 | 18.5 | 3.8 | 2050 | 87.3 | 5.50 | 68.5 | 109.4 | 4.7 | 5.7 |
| | 17.0 | 5.4 | 12.4 | 1630 | 76.3 | 47.9 | 3.85 | 89.3 | 19.8 | 3.5 | 1800 | 88.2 | 5.75 | 68.7 | 115.4 | 4.5 | 5.7 |
| | 17.0 | 5.4 | 12.4 | 1850 | 77.6 | 51.5 | 3.99 | 91.2 | 19.5 | 3.5 | 2050 | 89.5 | 5.57 | 70.5 | 110.4 | 4.7 | 5.8 |
| 80 | 8.5 | 1.2 | 2.7 | 1630 | 68.4 | 44.7 | 4.72 | 84.4 | 14.5 | 5.9 | 1800 | 89.5 | 5.79 | 69.9 | 116.0 | 4.5 | 5.9 |
| | 8.5 | 1.2 | 2.7 | 1850 | 69.5 | 48.1 | 4.89 | 86.2 | 14.2 | 6.0 | 2050 | 90.9 | 5.61 | 71.7 | 111.0 | 4.7 | 6.0 |
| | 12.8 | 2.9 | 6.7 | 1630 | 71.2 | 45.8 | 4.40 | 86.1 | 16.2 | 5.0 | 1800 | 94.1 | 5.93 | 73.9 | 118.4 | 4.6 | 6.1 |
| | 12.8 | 2.9 | 6.7 | 1850 | 72.4 | 49.3 | 4.56 | 88.0 | 15.9 | 5.1 | 2050 | 95.5 | 5.75 | 75.9 | 113.2 | 4.9 | 6.3 |
| | 17.0 | 5.2 | 12.1 | 1630 | 72.6 | 46.4 | 4.25 | 87.0 | 17.1 | 4.6 | 1800 | 96.7 | 6.02 | 76.2 | 119.7 | 4.7 | 6.3 |
| | 17.0 | 5.2 | 12.1 | 1850 | 73.8 | 49.9 | 4.40 | 88.8 | 16.8 | 4.7 | 2050 | 98.1 | 5.83 | 78.2 | 114.3 | 4.9 | 6.4 |
| 85 | 8.5 | 1.2 | 2.7 | 1630 | 66.2 | 43.8 | 5.0 | 83.2 | 13.3 | 6.8 | 1800 | 93.4 | 5.91 | 73.3 | 118.0 | 4.6 | 6.1 |
| | 8.5 | 1.2 | 2.7 | 1850 | 67.4 | 47.1 | 5.17 | 85.0 | 13.1 | 6.9 | 2050 | 94.8 | 5.7 | 75.3 | 112.8 | 4.8 | 6.3 |
| | 12.8 | 2.9 | 6.7 | 1630 | 69.1 | 45.0 | 4.65 | 84.9 | 14.9 | 5.8 | 1800 | 98.3 | 6.1 | 77.7 | 120.6 | 4.7 | 6.4 |
| | 12.8 | 2.9 | 6.7 | 1850 | 70.3 | 48.4 | 4.82 | 86.7 | 14.7 | 6.0 | 2050 | 99.8 | 5.9 | 79.7 | 115.1 | 5.0 | 6.6 |
| | 17.0 | 5.2 | 12.1 | 1630 | 70.5 | 45.6 | 4.48 | 85.7 | 15.8 | 5.4 | 1800 | 101.1 | 6.2 | 80.1 | 122.0 | 4.8 | 6.6 |
| | 17.0 | 5.2 | 12.1 | 1850 | 71.7 | 49.0 | 4.64 | 87.6 | 15.5 | 5.5 | 2050 | 102.6 | 6.0 | 82.2 | 116.4 | 5.0 | 6.8 |
| 90 | 8.5 | 1.2 | 2.8 | 1630 | 64.1 | 43.0 | 5.26 | 82.0 | 12.2 | 7.7 | 1800 | 97.3 | 6.04 | 76.8 | 120.0 | 4.7 | 6.4 |
| | 8.5 | 1.2 | 2.8 | 1850 | 65.2 | 46.2 | 5.45 | 83.8 | 12.0 | 7.9 | 2050 | 98.8 | 5.85 | 78.8 | 114.6 | 4.9 | 6.5 |
| | 12.8 | 2.9 | 6.7 | 1630 | 67.0 | 44.1 | 4.89 | 83.6 | 13.7 | 6.7 | 1800 | 102.6 | 6.22 | 81.4 | 122.8 | 4.8 | 6.7 |
| | 12.8 | 2.9 | 6.7 | 1850 | 68.1 | 47.4 | 5.07 | 85.4 | 13.4 | 6.8 | 2050 | 104.1 | 6.03 | 83.6 | 117.0 | 5.1 | 6.9 |
| | 17.0 | 5.2 | 12.0 | 1630 | 68.4 | 44.7 | 4.71 | 84.5 | 14.5 | 6.2 | 1800 | 105.5 | 6.32 | 84.0 | 124.3 | 4.9 | 6.9 |
| | 17.0 | 5.2 | 12.0 | 1850 | 69.6 | 48.1 | 4.88 | 86.3 | 14.3 | 6.3 | 2050 | 107.1 | 6.12 | 86.2 | 118.4 | 5.1 | 7.1 |
| 100 | 8.5 | 1.2 | 2.8 | 1630 | 59.8 | 41.2 | 5.88 | 79.9 | 10.2 | 10.0 | | | | | | | |
| | 8.5 | 1.2 | 2.8 | 1850 | 60.9 | 44.3 | 6.09 | 81.6 | 10.0 | 10.2 | | | | | | | |
| | 12.8 | 2.9 | 6.7 | 1630 | 62.6 | 42.3 | 5.46 | 81.3 | 11.5 | 8.8 | | | | | | | |
| | 12.8 | 2.9 | 6.7 | 1850 | 63.7 | 45.5 | 5.66 | 83.0 | 11.3 | 9.0 | | | | | | | |
| | 17.0 | 5.2 | 12.0 | 1630 | 64.0 | 42.9 | 5.27 | 82.0 | 12.2 | 8.2 | | | | | | | |
| | 17.0 | 5.2 | 12.0 | 1850 | 65.1 | 46.2 | 5.46 | 83.8 | 11.9 | 8.4 | | | | | | | |
| 110 | 8.5 | 1.1 | 2.6 | 1630 | 55.7 | 39.5 | 6.61 | 78.3 | 8.4 | 12.7 | | | | | | | |
| | 8.5 | 1.1 | 2.6 | 1850 | 56.7 | 42.5 | 6.85 | 80.0 | 8.3 | 13.0 | | | | | | | |
| | 12.8 | 2.9 | 6.6 | 1630 | 58.3 | 40.6 | 6.14 | 79.3 | 9.5 | 11.3 | | | | | | | |
| | 12.8 | 2.9 | 6.6 | 1850 | 59.3 | 43.6 | 6.36 | 81.0 | 9.3 | 11.5 | | | | | | | |
| | 17.0 | 5.1 | 11.8 | 1630 | 59.6 | 41.1 | 5.91 | 79.9 | 10.1 | 10.6 | | | | | | | |
| | 17.0 | 5.1 | 11.8 | 1850 | 60.7 | 44.2 | 6.12 | 81.6 | 9.9 | 10.8 | | | | | | | |
| 120 | 8.5 | 0.9 | 2.1 | 1630 | 52.0 | 38.1 | 7.45 | 77.6 | 7.0 | 15.9 | | | | | | | |
| | 8.5 | 0.9 | 2.1 | 1850 | 52.9 | 41.0 | 7.72 | 79.2 | 6.8 | 16.2 | | | | | | | |
| | 12.8 | 2.7 | 6.2 | 1630 | 54.2 | 39.0 | 6.91 | 77.9 | 7.9 | 14.3 | | | | | | | |
| | 12.8 | 2.7 | 6.2 | 1850 | 55.2 | 41.9 | 7.16 | 79.6 | 7.7 | 14.6 | | | | | | | |
| | 17.0 | 5.0 | 11.5 | 1630 | 55.5 | 39.4 | 6.66 | 78.3 | 8.3 | 13.5 | | | | | | | |
| | 17.0 | 5.0 | 11.5 | 1850 | 56.4 | 42.4 | 6.90 | 80.0 | 8.2 | 13.8 | | | | | | | |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 026 (Part Load), With vFlow®

850 CFM Nominal (Rated) Airflow Heating, 750 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 1.0 | 0.2 | 0.3 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 4.5 | 1.2 | 2.9 | 750 | 11.5 | 1.25 | 7.4 | 2.7 | 84.2 | 16.7 | 1.2 |
| | 1.0 | 0.2 | 0.4 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 4.5 | 1.2 | 2.9 | 850 | 11.7 | 1.20 | 7.6 | 2.9 | 82.7 | 16.6 | 1.2 |
| 30 | 1.3 | 0.2 | 0.4 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 2.3 | 0.5 | 1.1 | 750 | 13.0 | 1.23 | 8.9 | 3.1 | 86.0 | 22.2 | 1.3 |
| | 1.3 | 0.2 | 0.4 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 2.3 | 0.5 | 1.1 | 850 | 13.2 | 1.18 | 9.2 | 3.3 | 84.4 | 22.0 | 1.3 |
| | 1.3 | 0.2 | 0.4 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 3.4 | 0.8 | 1.8 | 750 | 13.6 | 1.22 | 9.5 | 3.3 | 86.8 | 24.4 | 1.3 |
| | 1.3 | 0.2 | 0.4 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 3.4 | 0.8 | 1.8 | 850 | 13.8 | 1.17 | 9.8 | 3.5 | 85.0 | 24.2 | 1.4 |
| | 1.3 | 0.2 | 0.4 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 4.5 | 1.1 | 2.6 | 750 | 13.9 | 1.21 | 9.9 | 3.4 | 87.2 | 25.6 | 1.4 |
| | 1.3 | 0.2 | 0.4 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 4.5 | 1.1 | 2.6 | 850 | 14.1 | 1.16 | 10.2 | 3.6 | 85.4 | 25.5 | 1.4 |
| 40 | 1.7 | 0.3 | 0.6 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 2.3 | 0.4 | 1.0 | 750 | 15.2 | 1.20 | 11.2 | 3.7 | 88.8 | 30.3 | 1.5 |
| | 1.7 | 0.3 | 0.6 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 2.3 | 0.4 | 1.0 | 850 | 15.4 | 1.15 | 11.5 | 3.9 | 86.8 | 30.0 | 1.5 |
| | 1.7 | 0.3 | 0.6 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 3.4 | 0.7 | 1.7 | 750 | 16.0 | 1.19 | 12.0 | 3.9 | 89.7 | 33.0 | 1.5 |
| | 1.7 | 0.3 | 0.6 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 3.4 | 0.7 | 1.7 | 850 | 16.2 | 1.14 | 12.3 | 4.2 | 87.6 | 32.8 | 1.6 |
| | 1.7 | 0.3 | 0.6 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 4.5 | 1.1 | 2.5 | 750 | 16.4 | 1.18 | 12.4 | 4.1 | 90.2 | 34.5 | 1.6 |
| | 1.7 | 0.3 | 0.6 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 4.5 | 1.1 | 2.5 | 850 | 16.6 | 1.13 | 12.8 | 4.3 | 88.1 | 34.3 | 1.6 |
| 50 | 2.3 | 0.4 | 1.0 | 660 | 22.4 | 14.9 | 0.8 | 25.0 | 29.7 | 71.7 | 1.1 | 2.3 | 0.4 | 1.0 | 750 | 17.4 | 1.17 | 13.4 | 4.4 | 91.5 | 38.3 | 1.7 |
| | 2.3 | 0.4 | 1.0 | 750 | 22.9 | 15.9 | 0.77 | 25.5 | 29.7 | 72.2 | 1.1 | 2.3 | 0.4 | 1.0 | 850 | 17.7 | 1.12 | 13.8 | 4.6 | 89.2 | 38.0 | 1.7 |
| | 2.5 | 0.5 | 1.1 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 3.4 | 0.7 | 1.6 | 750 | 18.3 | 1.16 | 14.4 | 4.6 | 92.6 | 41.5 | 1.7 |
| | 2.6 | 0.5 | 1.1 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 3.4 | 0.7 | 1.6 | 850 | 18.6 | 1.11 | 14.8 | 4.9 | 90.3 | 41.3 | 1.8 |
| | 2.5 | 0.5 | 1.1 | 660 | 22.6 | 14.9 | 0.7 | 25.1 | 30.7 | 70.0 | 1.0 | 4.5 | 1.0 | 2.3 | 750 | 18.9 | 1.16 | 14.9 | 4.8 | 93.3 | 43.4 | 1.8 |
| | 2.6 | 0.5 | 1.1 | 750 | 23.0 | 16.0 | 0.75 | 25.6 | 30.7 | 70.0 | 1.0 | 4.5 | 1.0 | 2.3 | 850 | 19.1 | 1.11 | 15.4 | 5.1 | 90.8 | 43.2 | 1.8 |
| 60 | 2.3 | 0.4 | 1.0 | 660 | 21.5 | 14.5 | 0.9 | 24.4 | 24.8 | 81.2 | 1.4 | 2.3 | 0.4 | 1.0 | 750 | 19.6 | 1.15 | 15.7 | 5.0 | 94.3 | 46.3 | 1.8 |
| | 2.3 | 0.4 | 1.0 | 750 | 21.9 | 15.5 | 0.88 | 24.9 | 24.9 | 81.6 | 1.5 | 2.3 | 0.4 | 1.0 | 850 | 19.9 | 1.10 | 16.2 | 5.3 | 91.7 | 45.9 | 1.9 |
| | 3.4 | 0.7 | 1.6 | 660 | 22.2 | 14.8 | 0.8 | 24.9 | 28.2 | 74.6 | 1.2 | 3.4 | 0.7 | 1.6 | 750 | 20.8 | 1.14 | 16.9 | 5.3 | 95.6 | 50.1 | 1.9 |
| | 3.4 | 0.7 | 1.6 | 750 | 22.6 | 15.8 | 0.80 | 25.3 | 28.3 | 74.9 | 1.2 | 3.4 | 0.7 | 1.6 | 850 | 21.1 | 1.09 | 17.3 | 5.7 | 92.9 | 49.8 | 1.9 |
| | 4.5 | 1.0 | 2.3 | 660 | 22.5 | 14.9 | 0.7 | 25.0 | 30.1 | 71.1 | 1.0 | 4.5 | 1.0 | 2.3 | 750 | 21.4 | 1.14 | 17.5 | 5.5 | 96.4 | 52.2 | 2.0 |
| | 4.5 | 1.0 | 2.3 | 750 | 22.9 | 15.9 | 0.76 | 25.5 | 30.2 | 71.3 | 1.1 | 4.5 | 1.0 | 2.3 | 850 | 21.7 | 1.09 | 18.0 | 5.8 | 93.6 | 52.0 | 2.0 |
| 70 | 2.3 | 0.4 | 1.0 | 660 | 20.3 | 14.0 | 1.0 | 23.6 | 20.6 | 90.5 | 2.0 | 2.3 | 0.4 | 1.0 | 750 | 21.9 | 1.14 | 18.0 | 5.7 | 97.1 | 54.3 | 2.0 |
| | 2.3 | 0.4 | 1.0 | 750 | 20.7 | 15.0 | 1.00 | 24.1 | 20.7 | 90.9 | 2.0 | 2.3 | 0.4 | 1.0 | 850 | 22.3 | 1.09 | 18.5 | 6.0 | 94.2 | 53.9 | 2.0 |
| | 3.4 | 0.7 | 1.6 | 660 | 21.1 | 14.4 | 0.9 | 24.2 | 23.6 | 84.2 | 1.6 | 3.4 | 0.7 | 1.6 | 750 | 23.2 | 1.14 | 19.3 | 6.0 | 98.7 | 58.6 | 2.1 |
| | 3.4 | 0.7 | 1.6 | 750 | 21.5 | 15.4 | 0.91 | 24.6 | 23.7 | 84.5 | 1.6 | 3.4 | 0.7 | 1.6 | 850 | 23.6 | 1.09 | 19.9 | 6.3 | 95.7 | 58.3 | 2.1 |
| | 4.5 | 1.0 | 2.2 | 660 | 21.5 | 14.5 | 0.9 | 24.4 | 25.2 | 80.9 | 1.4 | 4.5 | 1.0 | 2.2 | 750 | 24.0 | 1.14 | 20.1 | 6.2 | 99.6 | 61.1 | 2.1 |
| | 4.5 | 1.0 | 2.2 | 750 | 21.9 | 15.6 | 0.87 | 24.9 | 25.2 | 81.1 | 1.4 | 4.5 | 1.0 | 2.2 | 850 | 24.3 | 1.09 | 20.6 | 6.5 | 96.5 | 60.8 | 2.2 |
| 80 | 2.3 | 0.4 | 1.0 | 660 | 18.9 | 13.4 | 1.1 | 22.7 | 16.9 | 99.8 | 2.6 | 2.3 | 0.4 | 1.0 | 750 | 24.3 | 1.14 | 20.4 | 6.3 | 100.0 | 62.3 | 2.1 |
| | 2.3 | 0.4 | 1.0 | 750 | 19.3 | 14.3 | 1.14 | 23.2 | 16.9 | 100.1 | 2.6 | 2.3 | 0.4 | 1.0 | 850 | 24.6 | 1.09 | 20.9 | 6.6 | 96.8 | 61.8 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 660 | 19.8 | 13.8 | 1.0 | 23.3 | 19.4 | 93.7 | 2.2 | 2.8 | 0.5 | 1.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 750 | 20.2 | 14.8 | 1.04 | 23.8 | 19.4 | 94.0 | 2.2 | 2.9 | 0.6 | 1.3 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.2 | 660 | 20.3 | 14.0 | 1.0 | 23.6 | 20.7 | 90.5 | 1.9 | 2.8 | 0.5 | 1.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.2 | 750 | 20.7 | 15.0 | 1.00 | 24.1 | 20.7 | 90.7 | 2.0 | 2.9 | 0.6 | 1.3 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| 90 | 2.3 | 0.4 | 1.0 | 660 | 17.5 | 12.7 | 1.3 | 21.8 | 13.7 | 109.0 | 3.4 | 1.7 | 0.3 | 0.6 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 2.3 | 0.4 | 1.0 | 750 | 17.8 | 13.6 | 1.30 | 22.2 | 13.7 | 109.3 | 3.4 | 1.7 | 0.3 | 0.7 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 660 | 18.4 | 13.1 | 1.2 | 22.4 | 15.7 | 103.2 | 2.9 | 1.7 | 0.3 | 0.6 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 750 | 18.7 | 14.1 | 1.19 | 22.8 | 15.8 | 103.4 | 2.9 | 1.7 | 0.3 | 0.7 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.2 | 660 | 18.9 | 13.4 | 1.1 | 22.7 | 16.9 | 100.1 | 2.6 | 1.7 | 0.3 | 0.6 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.2 | 750 | 19.2 | 14.3 | 1.14 | 23.1 | 16.9 | 100.3 | 2.7 | 1.7 | 0.3 | 0.7 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| 100 | 2.3 | 0.4 | 1.0 | 660 | 16.0 | 12.1 | 1.5 | 21.0 | 11.0 | 118.2 | 4.3 | 1.2 | 0.1 | 0.3 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 2.3 | 0.4 | 1.0 | 750 | 16.3 | 13.0 | 1.48 | 21.4 | 11.0 | 118.6 | 4.3 | 1.2 | 0.1 | 0.3 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 660 | 16.9 | 12.5 | 1.3 | 21.5 | 12.7 | 112.6 | 3.7 | 1.2 | 0.1 | 0.3 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 750 | 17.2 | 13.4 | 1.36 | 21.9 | 12.7 | 112.9 | 3.8 | 1.2 | 0.1 | 0.3 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.1 | 660 | 17.4 | 12.7 | 1.3 | 21.8 | 13.5 | 109.7 | 3.4 | 1.2 | 0.1 | 0.3 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.1 | 750 | 17.7 | 13.6 | 1.31 | 22.2 | 13.5 | 109.9 | 3.5 | 1.2 | 0.1 | 0.3 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| 110 | 2.3 | 0.4 | 0.9 | 660 | 14.6 | 11.6 | 1.6 | 20.3 | 8.9 | 127.6 | 5.3 | 0.9 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 2.3 | 0.4 | 0.9 | 750 | 14.9 | 12.4 | 1.68 | 20.6 | 8.9 | 128.0 | 5.4 | 1.0 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 660 | 15.4 | 11.9 | 1.5 | 20.6 | 10.1 | 122.1 | 4.7 | 0.9 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 3.4 | 0.7 | 1.5 | 750 | 15.7 | 12.7 | 1.56 | 21.0 | 10.1 | 122.4 | 4.8 | 1.0 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.1 | 660 | 15.9 | 12.1 | 1.5 | 20.9 | 10.9 | 119.3 | 4.3 | 0.9 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.1 | 750 | 16.2 | 12.9 | 1.49 | 21.3 | 10.9 | 119.5 | 4.4 | 1.0 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| 120 | 2.3 | 0.4 | 0.9 | 660 | 13.4 | 11.3 | 1.9 | 19.8 | 7.2 | 137.2 | 6.5 | 0.8 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 2.3 | 0.4 | 0.9 | 750 | 13.7 | 12.1 | 1.91 | 20.2 | 7.2 | 137.6 | 6.6 | 0.8 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 3.4 | 0.6 | 1.4 | 660 | 14.1 | 11.5 | 1.7 | 20.0 | 8.1 | 131.8 | 5.8 | 0.8 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 3.4 | 0.6 | 1.4 | 750 | 14.4 | 12.3 | 1.77 | 20.4 | 8.1 | 132.0 | 5.9 | 0.8 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.0 | 660 | 14.5 | 11.6 | 1.7 | 20.2 | 8.6 | 129.0 | 5.4 | 0.8 | 0.1 | 0.2 | 750 | 25.2 | 1.14 | 21.3 | 6.5 | 101.1 | 65.0 | 2.2 |
| | 4.5 | 0.9 | 2.0 | 750 | 14.8 | 12.4 | 1.71 | 20.6 | 8.6 | 129.1 | 5.5 | 0.8 | 0.1 | 0.2 | 850 | 25.6 | 1.09 | 21.9 | 6.9 | 97.9 | 65.0 | 2.2 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 026 (Full Load), With vFlow®

950 CFM Nominal (Rated) Airflow Heating, 850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 1.3 | 0.3 | 0.6 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 6.0 | 1.9 | 4.4 | 840 | 16.5 | 1.73 | 10.7 | 2.8 | 88.2 | 16.4 | 1.5 |
| | 1.4 | 0.3 | 0.6 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 6.0 | 1.9 | 4.4 | 950 | 16.8 | 1.68 | 11.0 | 2.9 | 86.3 | 16.3 | 1.5 |
| 30 | 1.7 | 0.3 | 0.7 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 3.0 | 0.7 | 1.6 | 840 | 18.2 | 1.69 | 12.6 | 3.2 | 90.1 | 21.6 | 1.7 |
| | 1.7 | 0.3 | 0.7 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 3.0 | 0.7 | 1.6 | 950 | 18.5 | 1.64 | 12.9 | 3.3 | 88.0 | 21.4 | 1.8 |
| | 1.7 | 0.3 | 0.7 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 4.5 | 1.1 | 2.6 | 840 | 19.1 | 1.68 | 13.4 | 3.3 | 91.0 | 24.0 | 1.8 |
| | 1.7 | 0.3 | 0.7 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 4.5 | 1.1 | 2.6 | 950 | 19.4 | 1.63 | 13.8 | 3.5 | 88.9 | 23.9 | 1.9 |
| | 1.7 | 0.3 | 0.7 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 6.0 | 1.8 | 4.0 | 840 | 19.5 | 1.67 | 13.9 | 3.4 | 91.5 | 25.4 | 1.9 |
| | 1.7 | 0.3 | 0.7 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 6.0 | 1.8 | 4.0 | 950 | 19.8 | 1.62 | 14.3 | 3.6 | 89.3 | 25.2 | 1.9 |
| 40 | 2.2 | 0.4 | 1.0 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 3.0 | 0.6 | 1.5 | 840 | 21.0 | 1.66 | 15.4 | 3.7 | 93.1 | 29.7 | 2.1 |
| | 2.3 | 0.4 | 1.0 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 3.0 | 0.6 | 1.5 | 950 | 21.3 | 1.61 | 15.8 | 3.9 | 90.8 | 29.5 | 2.1 |
| | 2.2 | 0.4 | 1.0 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 4.5 | 1.1 | 2.5 | 840 | 22.0 | 1.65 | 16.5 | 3.9 | 94.3 | 32.7 | 2.2 |
| | 2.3 | 0.4 | 1.0 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 4.5 | 1.1 | 2.5 | 950 | 22.4 | 1.60 | 16.9 | 4.1 | 91.8 | 32.5 | 2.3 |
| | 2.2 | 0.4 | 1.0 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 6.0 | 1.6 | 3.8 | 840 | 22.6 | 1.64 | 17.1 | 4.0 | 94.9 | 34.3 | 2.3 |
| | 2.3 | 0.4 | 1.0 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 6.0 | 1.6 | 3.8 | 950 | 23.0 | 1.59 | 17.5 | 4.2 | 92.4 | 34.2 | 2.3 |
| 50 | 3.0 | 0.6 | 1.4 | 750 | 29.1 | 18.0 | 1.2 | 33.1 | 24.5 | 72.0 | 1.4 | 3.0 | 0.6 | 1.4 | 840 | 23.8 | 1.64 | 18.2 | 4.2 | 96.2 | 37.8 | 2.4 |
| | 3.0 | 0.6 | 1.4 | 850 | 29.6 | 19.4 | 1.23 | 33.8 | 24.0 | 72.5 | 1.5 | 3.0 | 0.6 | 1.4 | 950 | 24.1 | 1.59 | 18.7 | 4.5 | 93.5 | 37.5 | 2.5 |
| | 3.3 | 0.7 | 1.6 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 4.5 | 1.0 | 2.3 | 840 | 25.1 | 1.64 | 19.5 | 4.5 | 97.6 | 41.3 | 2.6 |
| | 3.4 | 0.7 | 1.6 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 4.5 | 1.0 | 2.3 | 950 | 25.4 | 1.59 | 20.0 | 4.7 | 94.8 | 41.1 | 2.6 |
| | 3.3 | 0.7 | 1.6 | 750 | 29.3 | 18.1 | 1.2 | 33.2 | 25.3 | 70.0 | 1.4 | 6.0 | 1.6 | 3.6 | 840 | 25.8 | 1.64 | 20.2 | 4.6 | 98.4 | 43.3 | 2.7 |
| | 3.4 | 0.7 | 1.6 | 850 | 29.8 | 19.5 | 1.20 | 33.9 | 24.9 | 70.0 | 1.4 | 6.0 | 1.6 | 3.6 | 950 | 26.2 | 1.59 | 20.7 | 4.8 | 95.5 | 43.1 | 2.7 |
| 60 | 3.0 | 0.6 | 1.3 | 750 | 27.9 | 17.6 | 1.3 | 32.3 | 21.4 | 81.5 | 1.9 | 3.0 | 0.6 | 1.3 | 840 | 26.7 | 1.64 | 21.1 | 4.8 | 99.4 | 45.9 | 2.8 |
| | 3.0 | 0.6 | 1.3 | 850 | 28.4 | 18.9 | 1.35 | 33.0 | 21.0 | 82.0 | 1.9 | 3.0 | 0.6 | 1.3 | 950 | 27.1 | 1.59 | 21.6 | 5.0 | 96.4 | 45.6 | 2.8 |
| | 4.5 | 1.0 | 2.3 | 750 | 28.8 | 17.9 | 1.2 | 32.9 | 23.7 | 74.6 | 1.5 | 4.5 | 1.0 | 2.3 | 840 | 28.2 | 1.65 | 22.5 | 5.0 | 101.0 | 50.0 | 2.9 |
| | 4.5 | 1.0 | 2.3 | 850 | 29.3 | 19.3 | 1.26 | 33.6 | 23.3 | 74.9 | 1.6 | 4.5 | 1.0 | 2.3 | 950 | 28.6 | 1.60 | 23.1 | 5.2 | 97.9 | 49.7 | 3.0 |
| | 6.0 | 1.5 | 3.5 | 750 | 29.2 | 18.1 | 1.2 | 33.1 | 24.8 | 71.0 | 1.4 | 6.0 | 1.5 | 3.5 | 840 | 29.0 | 1.66 | 23.3 | 5.1 | 102.0 | 52.2 | 3.0 |
| | 6.0 | 1.5 | 3.5 | 850 | 29.7 | 19.4 | 1.22 | 33.8 | 24.3 | 71.3 | 1.4 | 6.0 | 1.5 | 3.5 | 950 | 29.4 | 1.61 | 24.0 | 5.4 | 98.7 | 52.0 | 3.1 |
| 70 | 3.0 | 0.6 | 1.3 | 750 | 26.4 | 17.0 | 1.4 | 31.3 | 18.5 | 90.9 | 2.4 | 3.0 | 0.6 | 1.3 | 840 | 29.6 | 1.66 | 23.9 | 5.2 | 102.6 | 54.1 | 3.1 |
| | 3.0 | 0.6 | 1.3 | 850 | 26.9 | 18.3 | 1.48 | 32.0 | 18.2 | 91.3 | 2.4 | 3.0 | 0.6 | 1.3 | 950 | 30.1 | 1.61 | 24.6 | 5.5 | 99.3 | 53.6 | 3.2 |
| | 4.5 | 1.0 | 2.2 | 750 | 27.5 | 17.5 | 1.3 | 32.0 | 20.7 | 84.2 | 2.0 | 4.5 | 1.0 | 2.2 | 840 | 31.4 | 1.69 | 25.6 | 5.4 | 104.6 | 58.6 | 3.3 |
| | 4.5 | 1.0 | 2.2 | 850 | 28.0 | 18.8 | 1.38 | 32.7 | 20.3 | 84.5 | 2.1 | 4.5 | 1.0 | 2.2 | 950 | 31.8 | 1.64 | 26.2 | 5.7 | 101.0 | 58.3 | 3.3 |
| | 6.0 | 1.5 | 3.4 | 750 | 28.0 | 17.7 | 1.3 | 32.4 | 21.8 | 80.8 | 1.8 | 6.0 | 1.5 | 3.4 | 840 | 32.3 | 1.71 | 26.5 | 5.5 | 105.7 | 61.2 | 3.4 |
| | 6.0 | 1.5 | 3.4 | 850 | 28.5 | 19.0 | 1.33 | 33.1 | 21.4 | 81.0 | 1.9 | 6.0 | 1.5 | 3.4 | 950 | 32.8 | 1.66 | 27.2 | 5.8 | 102.0 | 60.9 | 3.4 |
| 80 | 3.0 | 0.6 | 1.3 | 750 | 24.8 | 16.3 | 1.6 | 30.2 | 15.7 | 100.1 | 3.0 | 3.0 | 0.6 | 1.3 | 840 | 32.6 | 1.71 | 26.7 | 5.6 | 106.0 | 62.2 | 3.4 |
| | 3.0 | 0.6 | 1.3 | 850 | 25.2 | 17.5 | 1.64 | 30.8 | 15.4 | 100.5 | 3.0 | 3.0 | 0.6 | 1.3 | 950 | 33.1 | 1.66 | 27.5 | 5.8 | 102.3 | 61.7 | 3.5 |
| | 4.5 | 0.9 | 2.2 | 750 | 26.0 | 16.8 | 1.5 | 31.0 | 17.6 | 93.8 | 2.6 | 3.7 | 0.7 | 1.7 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 4.5 | 0.9 | 2.2 | 850 | 26.4 | 18.1 | 1.53 | 31.6 | 17.3 | 94.1 | 2.6 | 3.8 | 0.8 | 1.8 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 6.0 | 1.4 | 3.3 | 750 | 26.2 | 16.9 | 1.4 | 31.1 | 18.1 | 90.4 | 2.4 | 3.7 | 0.7 | 1.7 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 6.0 | 1.4 | 3.3 | 850 | 26.7 | 18.2 | 1.50 | 31.8 | 17.8 | 92.7 | 2.4 | 3.8 | 0.8 | 1.8 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| 90 | 3.0 | 0.6 | 1.3 | 750 | 23.1 | 15.5 | 1.7 | 29.0 | 13.2 | 109.4 | 3.7 | 2.2 | 0.4 | 0.9 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 3.0 | 0.6 | 1.3 | 850 | 23.5 | 16.7 | 1.81 | 29.7 | 13.0 | 109.8 | 3.7 | 2.3 | 0.4 | 1.0 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 4.5 | 0.9 | 2.2 | 750 | 24.3 | 16.1 | 1.6 | 29.8 | 14.9 | 103.2 | 3.2 | 2.2 | 0.4 | 0.9 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 4.5 | 0.9 | 2.2 | 850 | 24.7 | 17.3 | 1.69 | 30.4 | 14.6 | 103.5 | 3.3 | 2.3 | 0.4 | 1.0 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 6.0 | 1.4 | 3.2 | 750 | 24.9 | 16.3 | 1.6 | 30.2 | 15.8 | 100.1 | 3.0 | 2.2 | 0.4 | 0.9 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 6.0 | 1.4 | 3.2 | 850 | 25.3 | 17.5 | 1.63 | 30.9 | 15.5 | 100.3 | 3.0 | 2.3 | 0.4 | 1.0 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| 100 | 3.0 | 0.6 | 1.3 | 750 | 21.3 | 14.8 | 1.9 | 28.0 | 10.9 | 118.7 | 4.4 | 1.6 | 0.2 | 0.6 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 3.0 | 0.6 | 1.3 | 850 | 21.7 | 15.9 | 2.02 | 28.6 | 10.7 | 119.1 | 4.5 | 1.6 | 0.3 | 0.6 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 4.5 | 0.9 | 2.1 | 750 | 22.5 | 15.3 | 1.8 | 28.7 | 12.4 | 112.7 | 3.9 | 1.6 | 0.2 | 0.6 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 4.5 | 0.9 | 2.1 | 850 | 22.9 | 16.4 | 1.88 | 29.3 | 12.2 | 113.0 | 4.0 | 1.6 | 0.3 | 0.6 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 6.0 | 1.4 | 3.2 | 750 | 23.1 | 15.5 | 1.8 | 29.0 | 13.1 | 109.7 | 3.7 | 1.6 | 0.2 | 0.6 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 6.0 | 1.4 | 3.2 | 850 | 23.5 | 16.7 | 1.82 | 29.7 | 12.9 | 109.9 | 3.7 | 1.6 | 0.3 | 0.6 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| 110 | 3.0 | 0.6 | 1.3 | 750 | 19.7 | 14.2 | 2.2 | 27.1 | 9.0 | 128.1 | 5.3 | 1.2 | 0.1 | 0.3 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 3.0 | 0.6 | 1.3 | 850 | 20.0 | 15.2 | 2.26 | 27.7 | 8.9 | 128.5 | 5.4 | 1.3 | 0.1 | 0.3 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 4.5 | 0.9 | 2.1 | 750 | 20.7 | 14.6 | 2.0 | 27.7 | 10.2 | 122.3 | 4.7 | 1.2 | 0.1 | 0.3 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 4.5 | 0.9 | 2.1 | 850 | 21.1 | 15.7 | 2.11 | 28.2 | 10.0 | 122.6 | 4.8 | 1.3 | 0.1 | 0.3 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 6.0 | 1.4 | 3.1 | 750 | 21.3 | 14.8 | 2.0 | 28.0 | 10.8 | 119.3 | 4.4 | 1.2 | 0.1 | 0.3 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 6.0 | 1.4 | 3.1 | 850 | 21.6 | 15.9 | 2.03 | 28.6 | 10.6 | 119.5 | 4.5 | 1.3 | 0.1 | 0.3 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| 120 | 3.0 | 0.5 | 1.2 | 750 | 18.2 | 13.7 | 2.5 | 26.6 | 7.4 | 137.7 | 6.2 | 1.0 | 0.1 | 0.2 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 3.0 | 0.5 | 1.2 | 850 | 18.5 | 14.7 | 2.55 | 27.2 | 7.3 | 138.1 | 6.4 | 1.0 | 0.1 | 0.2 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 4.5 | 0.9 | 2.0 | 750 | 19.1 | 14.0 | 2.3 | 26.9 | 8.3 | 132.0 | 5.6 | 1.0 | 0.1 | 0.2 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 4.5 | 0.9 | 2.0 | 850 | 19.4 | 15.0 | 2.37 | 27.5 | 8.2 | 132.2 | 5.8 | 1.0 | 0.1 | 0.2 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |
| | 6.0 | 1.3 | 3.1 | 750 | 19.5 | 14.1 | 2.2 | 27.1 | 8.9 | 129.0 | 5.3 | 1.0 | 0.1 | 0.2 | 840 | 33.9 | 1.74 | 27.9 | 5.7 | 107.4 | 65.0 | 3.5 |
| | 6.0 | 1.3 | 3.1 | 850 | 19.9 | 15.2 | 2.28 | 27.7 | 8.7 | 129.2 | 5.5 | 1.0 | 0.1 | 0.2 | 950 | 34.4 | 1.69 | 28.7 | 6.0 | 103.6 | 65.0 | 3.6 |

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Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 038 (Part Load), With vFlow®

1000 CFM Nominal (Rated) Airflow Heating, 1000 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 1.5 | 0.4 | 1.0 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 6.0 | 2.5 | 5.7 | 880 | 16.9 | 1.65 | 11.5 | 3.0 | 87.8 | 16.2 | 1.7 |
| | 1.5 | 0.4 | 1.0 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 6.0 | 2.5 | 5.7 | 1000 | 17.2 | 1.58 | 11.8 | 3.2 | 85.9 | 16.1 | 1.7 |
| 30 | 1.8 | 0.5 | 1.1 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 3.0 | 0.9 | 2.1 | 880 | 18.9 | 1.65 | 13.4 | 3.4 | 89.8 | 21.1 | 1.8 |
| | 1.8 | 0.5 | 1.1 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 3.0 | 0.9 | 2.1 | 1000 | 19.1 | 1.58 | 13.7 | 3.5 | 87.7 | 20.8 | 1.8 |
| | 1.8 | 0.5 | 1.1 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 4.5 | 1.5 | 3.5 | 880 | 19.9 | 1.64 | 14.4 | 3.6 | 90.9 | 23.6 | 1.9 |
| | 1.8 | 0.5 | 1.1 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 4.5 | 1.5 | 3.5 | 1000 | 20.2 | 1.57 | 14.8 | 3.8 | 88.7 | 23.4 | 1.9 |
| | 1.8 | 0.5 | 1.1 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 6.0 | 2.2 | 5.1 | 880 | 20.4 | 1.64 | 14.9 | 3.7 | 91.5 | 25.0 | 2.0 |
| | 1.8 | 0.5 | 1.1 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 6.0 | 2.2 | 5.1 | 1000 | 20.7 | 1.57 | 15.4 | 3.9 | 89.2 | 24.9 | 2.0 |
| 40 | 2.4 | 0.6 | 1.4 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 3.0 | 0.8 | 1.9 | 880 | 21.9 | 1.64 | 16.4 | 3.9 | 93.1 | 29.1 | 2.1 |
| | 2.5 | 0.6 | 1.5 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 3.0 | 0.8 | 1.9 | 1000 | 22.2 | 1.57 | 16.9 | 4.2 | 90.6 | 28.8 | 2.1 |
| | 2.4 | 0.6 | 1.4 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 4.5 | 1.4 | 3.2 | 880 | 23.1 | 1.64 | 17.6 | 4.1 | 94.3 | 32.2 | 2.2 |
| | 2.5 | 0.6 | 1.5 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 4.5 | 1.4 | 3.2 | 1000 | 23.5 | 1.57 | 18.1 | 4.4 | 91.7 | 32.0 | 2.2 |
| | 2.4 | 0.6 | 1.4 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 6.0 | 2.0 | 4.7 | 880 | 23.8 | 1.64 | 18.3 | 4.3 | 95.1 | 33.9 | 2.3 |
| | 2.5 | 0.6 | 1.5 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 6.0 | 2.0 | 4.7 | 1000 | 24.1 | 1.57 | 18.8 | 4.5 | 92.4 | 33.7 | 2.3 |
| 50 | 3.0 | 0.8 | 1.8 | 880 | 32.3 | 20.7 | 1.1 | 36.0 | 29.9 | 74.0 | 1.4 | 3.0 | 0.8 | 1.8 | 880 | 24.9 | 1.64 | 19.4 | 4.5 | 96.2 | 37.1 | 2.4 |
| | 3.0 | 0.8 | 1.8 | 1000 | 33.0 | 22.2 | 1.10 | 36.7 | 30.0 | 74.5 | 1.4 | 3.0 | 0.8 | 1.8 | 1000 | 25.3 | 1.57 | 19.9 | 4.7 | 93.4 | 36.7 | 2.4 |
| | 3.6 | 1.0 | 2.3 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 4.5 | 1.3 | 3.0 | 880 | 26.3 | 1.64 | 20.7 | 4.7 | 97.7 | 40.8 | 2.5 |
| | 3.7 | 1.0 | 2.4 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 4.5 | 1.3 | 3.0 | 1000 | 26.7 | 1.57 | 21.3 | 5.0 | 94.7 | 40.5 | 2.5 |
| | 3.6 | 1.0 | 2.3 | 880 | 32.8 | 20.8 | 1.0 | 36.3 | 32.5 | 70.0 | 1.2 | 6.0 | 1.9 | 4.4 | 880 | 27.1 | 1.64 | 21.5 | 4.8 | 98.5 | 42.8 | 2.6 |
| | 3.7 | 1.0 | 2.4 | 1000 | 33.5 | 22.2 | 1.03 | 37.0 | 32.5 | 70.0 | 1.2 | 6.0 | 1.9 | 4.4 | 1000 | 27.5 | 1.57 | 22.1 | 5.1 | 95.4 | 42.6 | 2.6 |
| 60 | 3.0 | 0.8 | 1.8 | 880 | 30.8 | 20.2 | 1.2 | 35.0 | 24.9 | 83.3 | 2.0 | 3.0 | 0.8 | 1.8 | 880 | 27.9 | 1.65 | 22.3 | 5.0 | 99.3 | 45.2 | 2.6 |
| | 3.0 | 0.8 | 1.8 | 1000 | 31.4 | 21.6 | 1.26 | 35.7 | 24.9 | 83.8 | 2.0 | 3.0 | 0.8 | 1.8 | 1000 | 28.3 | 1.58 | 22.9 | 5.2 | 96.2 | 44.7 | 2.6 |
| | 4.5 | 1.3 | 2.9 | 880 | 32.1 | 20.6 | 1.1 | 35.9 | 28.9 | 75.9 | 1.5 | 4.5 | 1.3 | 2.9 | 880 | 29.5 | 1.65 | 23.8 | 5.2 | 101.0 | 49.4 | 2.7 |
| | 4.5 | 1.3 | 2.9 | 1000 | 32.7 | 22.1 | 1.13 | 36.6 | 29.0 | 76.3 | 1.5 | 4.5 | 1.3 | 2.9 | 1000 | 29.9 | 1.58 | 24.5 | 5.5 | 97.7 | 49.1 | 2.8 |
| | 6.0 | 1.8 | 4.2 | 880 | 32.6 | 20.8 | 1.1 | 36.2 | 31.0 | 72.1 | 1.3 | 6.0 | 1.8 | 4.2 | 880 | 30.4 | 1.65 | 24.7 | 5.4 | 102.0 | 51.8 | 2.7 |
| | 6.0 | 1.8 | 4.2 | 1000 | 33.2 | 22.2 | 1.07 | 36.9 | 31.1 | 72.3 | 1.3 | 6.0 | 1.8 | 4.2 | 1000 | 30.8 | 1.58 | 25.4 | 5.7 | 98.5 | 51.5 | 2.8 |
| 70 | 3.0 | 0.8 | 1.8 | 880 | 28.8 | 19.4 | 1.4 | 33.6 | 20.4 | 92.4 | 2.6 | 3.0 | 0.8 | 1.8 | 880 | 30.8 | 1.66 | 25.2 | 5.4 | 102.4 | 53.2 | 2.8 |
| | 3.0 | 0.8 | 1.8 | 1000 | 29.4 | 20.7 | 1.44 | 34.3 | 20.4 | 92.8 | 2.7 | 3.0 | 0.8 | 1.8 | 1000 | 31.3 | 1.59 | 25.9 | 5.8 | 99.0 | 52.8 | 2.9 |
| | 4.5 | 1.2 | 2.9 | 880 | 30.4 | 20.0 | 1.3 | 34.7 | 23.8 | 85.4 | 2.1 | 4.5 | 1.2 | 2.9 | 880 | 32.7 | 1.67 | 27.0 | 5.7 | 104.4 | 58.0 | 2.9 |
| | 4.5 | 1.2 | 2.9 | 1000 | 31.0 | 21.4 | 1.30 | 35.4 | 23.8 | 85.7 | 2.1 | 4.5 | 1.2 | 2.9 | 1000 | 33.2 | 1.60 | 27.7 | 6.1 | 100.7 | 57.7 | 3.0 |
| | 6.0 | 1.8 | 4.1 | 880 | 31.1 | 20.3 | 1.2 | 35.2 | 25.8 | 81.7 | 1.9 | 6.0 | 1.8 | 4.1 | 880 | 33.7 | 1.67 | 28.0 | 5.9 | 105.5 | 60.7 | 3.0 |
| | 6.0 | 1.8 | 4.1 | 1000 | 31.7 | 21.7 | 1.23 | 35.9 | 25.8 | 82.0 | 1.9 | 6.0 | 1.8 | 4.1 | 1000 | 34.2 | 1.60 | 28.7 | 6.3 | 101.7 | 60.4 | 3.1 |
| 80 | 3.0 | 0.8 | 1.9 | 880 | 26.6 | 18.4 | 1.6 | 32.1 | 16.5 | 101.4 | 3.6 | 3.0 | 0.8 | 1.9 | 880 | 33.9 | 1.67 | 28.1 | 5.9 | 105.6 | 61.3 | 3.0 |
| | 3.0 | 0.8 | 1.9 | 1000 | 27.1 | 19.7 | 1.64 | 32.7 | 16.5 | 101.8 | 3.7 | 3.0 | 0.8 | 1.9 | 1000 | 34.3 | 1.60 | 28.9 | 6.3 | 101.8 | 60.8 | 3.1 |
| | 4.5 | 1.2 | 2.9 | 880 | 28.3 | 19.1 | 1.5 | 33.2 | 19.3 | 94.8 | 2.9 | 4.0 | 1.1 | 2.5 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 4.5 | 1.2 | 2.9 | 1000 | 28.8 | 20.5 | 1.49 | 33.9 | 19.3 | 95.1 | 3.0 | 4.1 | 1.1 | 2.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 6.0 | 1.7 | 4.0 | 880 | 29.1 | 19.5 | 1.4 | 33.8 | 21.0 | 91.3 | 2.6 | 4.0 | 1.1 | 2.5 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 6.0 | 1.7 | 4.0 | 1000 | 29.7 | 20.9 | 1.41 | 34.5 | 21.0 | 91.5 | 2.6 | 4.1 | 1.1 | 2.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| 90 | 3.0 | 0.8 | 1.9 | 880 | 24.4 | 17.4 | 1.8 | 30.7 | 13.3 | 110.4 | 4.7 | 2.4 | 0.7 | 1.5 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 3.0 | 0.8 | 1.9 | 1000 | 24.9 | 18.7 | 1.87 | 31.3 | 13.3 | 110.8 | 4.8 | 2.4 | 0.7 | 1.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 4.5 | 1.2 | 2.9 | 880 | 26.0 | 18.1 | 1.7 | 31.7 | 15.6 | 104.1 | 3.9 | 2.4 | 0.7 | 1.5 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 4.5 | 1.2 | 2.9 | 1000 | 26.5 | 19.4 | 1.70 | 32.3 | 15.6 | 104.3 | 4.0 | 2.4 | 0.7 | 1.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 6.0 | 1.7 | 4.0 | 880 | 26.8 | 18.5 | 1.6 | 32.2 | 16.9 | 100.7 | 3.5 | 2.4 | 0.7 | 1.5 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 6.0 | 1.7 | 4.0 | 1000 | 27.3 | 19.8 | 1.62 | 32.9 | 16.9 | 101.0 | 3.6 | 2.4 | 0.7 | 1.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| 100 | 3.0 | 0.8 | 1.9 | 880 | 22.5 | 16.6 | 2.1 | 29.6 | 10.7 | 119.7 | 6.1 | 1.7 | 0.5 | 1.2 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 3.0 | 0.8 | 1.9 | 1000 | 22.9 | 17.8 | 2.13 | 30.1 | 10.7 | 120.1 | 6.2 | 1.7 | 0.5 | 1.2 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 4.5 | 1.2 | 2.8 | 880 | 23.8 | 17.1 | 1.9 | 30.3 | 12.5 | 113.5 | 5.1 | 1.7 | 0.5 | 1.2 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 4.5 | 1.2 | 2.8 | 1000 | 24.2 | 18.4 | 1.94 | 30.9 | 12.5 | 113.7 | 5.2 | 1.7 | 0.5 | 1.2 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 6.0 | 1.7 | 3.9 | 880 | 24.5 | 17.5 | 1.8 | 30.7 | 13.4 | 110.2 | 4.6 | 1.7 | 0.5 | 1.2 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 6.0 | 1.7 | 3.9 | 1000 | 25.0 | 18.7 | 1.86 | 31.3 | 13.4 | 110.4 | 4.7 | 1.7 | 0.5 | 1.2 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| 110 | 3.0 | 0.8 | 1.8 | 880 | 21.0 | 16.3 | 2.4 | 29.1 | 8.8 | 129.4 | 7.7 | 1.3 | 0.4 | 0.9 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 3.0 | 0.8 | 1.8 | 1000 | 21.4 | 17.4 | 2.43 | 29.7 | 8.8 | 129.8 | 7.8 | 1.4 | 0.4 | 0.9 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 4.5 | 1.2 | 2.8 | 880 | 21.9 | 16.4 | 2.2 | 29.3 | 10.0 | 123.0 | 6.6 | 1.3 | 0.4 | 0.9 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 4.5 | 1.2 | 2.8 | 1000 | 22.3 | 17.6 | 2.23 | 29.9 | 10.0 | 123.3 | 6.7 | 1.4 | 0.4 | 0.9 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 6.0 | 1.7 | 3.8 | 880 | 22.5 | 16.6 | 2.1 | 29.6 | 10.7 | 119.9 | 6.0 | 1.3 | 0.4 | 0.9 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 6.0 | 1.7 | 3.8 | 1000 | 22.9 | 17.8 | 2.13 | 30.2 | 10.7 | 120.1 | 6.1 | 1.4 | 0.4 | 0.9 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| 120 | 3.0 | 0.7 | 1.7 | 880 | 20.4 | 16.8 | 2.7 | 29.8 | 7.4 | 139.9 | 9.6 | 1.1 | 0.3 | 0.6 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 3.0 | 0.7 | 1.7 | 1000 | 20.8 | 17.9 | 2.80 | 30.4 | 7.4 | 140.2 | 9.8 | 1.1 | 0.3 | 0.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 4.5 | 1.1 | 2.6 | 880 | 20.7 | 16.3 | 2.5 | 29.2 | 8.3 | 133.0 | 8.2 | 1.1 | 0.3 | 0.6 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 4.5 | 1.1 | 2.6 | 1000 | 21.1 | 17.5 | 2.55 | 29.8 | 8.3 | 133.2 | 8.4 | 1.1 | 0.3 | 0.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |
| | 6.0 | 1.6 | 3.7 | 880 | 21.0 | 16.3 | 2.4 | 29.1 | 8.8 | 129.7 | 7.7 | 1.1 | 0.3 | 0.6 | 880 | 35.5 | 1.69 | 29.7 | 6.2 | 107.4 | 65.0 | 3.1 |
| | 6.0 | 1.6 | 3.7 | 1000 | 21.4 | 17.4 | 2.44 | 29.7 | 8.8 | 129.9 | 7.8 | 1.1 | 0.3 | 0.6 | 1000 | 36.0 | 1.62 | 30.5 | 6.5 | 103.4 | 65.0 | 3.2 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 038 (Full Load), With vFlow®

1250 CFM Nominal (Rated) Airflow Heating, 1250 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 2.0 | 0.6 | 1.5 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 9.0 | 4.3 | 9.9 | 1100 | 25.2 | 2.23 | 17.8 | 3.3 | 91.2 | 16.1 | 2.0 |
| | 2.0 | 0.7 | 1.5 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 9.0 | 4.3 | 9.9 | 1250 | 25.6 | 2.16 | 18.2 | 3.5 | 89.0 | 15.9 | 2.1 |
| 30 | 2.5 | 0.7 | 1.7 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 4.5 | 1.5 | 3.5 | 1100 | 27.7 | 2.25 | 20.1 | 3.6 | 93.3 | 21.0 | 2.3 |
| | 2.5 | 0.7 | 1.7 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 4.5 | 1.5 | 3.5 | 1250 | 28.1 | 2.18 | 20.7 | 3.8 | 90.8 | 20.8 | 2.4 |
| | 2.5 | 0.7 | 1.7 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 6.8 | 2.6 | 6.1 | 1100 | 29.0 | 2.26 | 21.4 | 3.8 | 94.4 | 23.7 | 2.5 |
| | 2.5 | 0.7 | 1.7 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 6.8 | 2.6 | 6.1 | 1250 | 29.5 | 2.19 | 22.0 | 3.9 | 91.8 | 23.5 | 2.5 |
| | 2.5 | 0.7 | 1.7 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 9.0 | 3.9 | 9.1 | 1100 | 29.7 | 2.26 | 22.1 | 3.9 | 95.0 | 25.1 | 2.6 |
| | 2.5 | 0.7 | 1.7 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 9.0 | 3.9 | 9.1 | 1250 | 30.2 | 2.19 | 22.7 | 4.0 | 92.4 | 25.0 | 2.6 |
| 40 | 3.3 | 0.9 | 2.2 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 4.5 | 1.4 | 3.2 | 1100 | 31.8 | 2.28 | 24.0 | 4.1 | 96.7 | 29.3 | 2.8 |
| | 3.4 | 1.0 | 2.2 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 4.5 | 1.4 | 3.2 | 1250 | 32.2 | 2.21 | 24.7 | 4.3 | 93.9 | 29.0 | 2.9 |
| | 3.3 | 0.9 | 2.2 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 6.8 | 2.4 | 5.6 | 1100 | 33.3 | 2.30 | 25.5 | 4.2 | 98.1 | 32.5 | 3.0 |
| | 3.4 | 1.0 | 2.2 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 6.8 | 2.4 | 5.6 | 1250 | 33.8 | 2.23 | 26.2 | 4.4 | 95.1 | 32.3 | 3.1 |
| | 3.3 | 0.9 | 2.2 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 9.0 | 3.6 | 8.4 | 1100 | 34.2 | 2.31 | 26.3 | 4.3 | 98.8 | 34.1 | 3.1 |
| | 3.4 | 1.0 | 2.2 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 9.0 | 3.6 | 8.4 | 1250 | 34.7 | 2.24 | 27.1 | 4.5 | 95.7 | 34.0 | 3.2 |
| 50 | 4.5 | 1.3 | 3.0 | 1100 | 43.9 | 26.6 | 1.7 | 49.7 | 25.3 | 72.1 | 2.0 | 4.5 | 1.3 | 3.0 | 1100 | 35.8 | 2.33 | 27.9 | 4.5 | 100.1 | 37.6 | 3.3 |
| | 4.5 | 1.3 | 3.0 | 1250 | 44.6 | 28.6 | 1.80 | 50.8 | 24.8 | 72.6 | 2.0 | 4.5 | 1.3 | 3.0 | 1250 | 36.3 | 2.26 | 28.6 | 4.7 | 96.9 | 37.3 | 3.4 |
| | 5.0 | 1.5 | 3.4 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 6.8 | 2.3 | 5.2 | 1100 | 37.6 | 2.36 | 29.6 | 4.7 | 101.6 | 41.3 | 3.5 |
| | 5.1 | 1.5 | 3.5 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 6.8 | 2.3 | 5.2 | 1250 | 38.2 | 2.29 | 30.3 | 4.9 | 98.3 | 41.1 | 3.6 |
| | 5.0 | 1.5 | 3.4 | 1100 | 44.2 | 26.6 | 1.7 | 49.9 | 26.0 | 70.0 | 1.8 | 9.0 | 3.4 | 7.9 | 1100 | 38.6 | 2.38 | 30.5 | 4.7 | 102.5 | 43.2 | 3.6 |
| | 5.1 | 1.5 | 3.5 | 1250 | 45.0 | 28.6 | 1.76 | 51.0 | 25.6 | 70.0 | 1.8 | 9.0 | 3.4 | 7.9 | 1250 | 39.2 | 2.31 | 31.3 | 5.0 | 99.0 | 43.0 | 3.7 |
| 60 | 4.5 | 1.3 | 2.9 | 1100 | 42.3 | 26.1 | 1.9 | 48.7 | 22.3 | 81.7 | 2.6 | 4.5 | 1.3 | 2.9 | 1100 | 39.8 | 2.40 | 31.6 | 4.9 | 103.5 | 45.9 | 3.7 |
| | 4.5 | 1.3 | 2.9 | 1250 | 43.0 | 28.1 | 1.97 | 49.8 | 21.9 | 82.1 | 2.7 | 4.5 | 1.3 | 2.9 | 1250 | 40.4 | 2.33 | 32.5 | 5.1 | 99.9 | 45.6 | 3.8 |
| | 6.8 | 2.1 | 4.9 | 1100 | 43.5 | 26.5 | 1.8 | 49.5 | 24.5 | 74.6 | 2.1 | 6.8 | 2.2 | 5.0 | 1100 | 41.9 | 2.45 | 33.5 | 5.0 | 105.2 | 50.1 | 4.0 |
| | 6.8 | 2.1 | 4.9 | 1250 | 44.3 | 28.5 | 1.84 | 50.6 | 24.1 | 75.0 | 2.2 | 6.8 | 2.2 | 5.0 | 1250 | 42.5 | 2.37 | 34.4 | 5.3 | 101.5 | 49.9 | 4.1 |
| | 9.0 | 3.3 | 7.5 | 1100 | 44.0 | 26.6 | 1.7 | 49.8 | 25.6 | 71.1 | 1.9 | 9.0 | 3.3 | 7.5 | 1100 | 43.0 | 2.47 | 34.6 | 5.1 | 106.2 | 52.3 | 4.1 |
| | 9.0 | 3.3 | 7.5 | 1250 | 44.8 | 28.6 | 1.78 | 50.9 | 25.2 | 71.3 | 1.9 | 9.0 | 3.3 | 7.5 | 1250 | 43.7 | 2.39 | 35.5 | 5.4 | 102.3 | 52.1 | 4.2 |
| 70 | 4.5 | 1.2 | 2.9 | 1100 | 40.4 | 25.4 | 2.1 | 47.4 | 19.5 | 91.1 | 3.4 | 4.5 | 1.2 | 2.9 | 1100 | 43.9 | 2.49 | 35.4 | 5.2 | 106.9 | 54.3 | 4.2 |
| | 4.5 | 1.2 | 2.9 | 1250 | 41.1 | 27.4 | 2.15 | 48.4 | 19.1 | 91.5 | 3.5 | 4.5 | 1.2 | 2.9 | 1250 | 44.5 | 2.41 | 36.3 | 5.4 | 103.0 | 53.9 | 4.3 |
| | 6.8 | 2.1 | 4.8 | 1100 | 41.8 | 26.0 | 1.9 | 48.4 | 21.5 | 84.2 | 2.8 | 6.8 | 2.1 | 4.8 | 1100 | 46.2 | 2.55 | 37.5 | 5.3 | 108.9 | 59.0 | 4.5 |
| | 6.8 | 2.1 | 4.8 | 1250 | 42.6 | 27.9 | 2.02 | 49.4 | 21.1 | 84.6 | 2.9 | 6.8 | 2.1 | 4.8 | 1250 | 46.9 | 2.47 | 38.5 | 5.6 | 104.8 | 58.7 | 4.6 |
| | 9.0 | 3.1 | 7.2 | 1100 | 42.5 | 26.2 | 1.9 | 48.8 | 22.6 | 80.9 | 2.5 | 9.0 | 3.1 | 7.2 | 1100 | 47.6 | 2.58 | 38.7 | 5.4 | 110.0 | 61.4 | 4.6 |
| | 9.0 | 3.1 | 7.2 | 1250 | 43.2 | 28.2 | 1.95 | 49.9 | 22.2 | 81.1 | 2.6 | 9.0 | 3.1 | 7.2 | 1250 | 48.3 | 2.50 | 39.8 | 5.7 | 105.8 | 61.2 | 4.7 |
| 80 | 4.5 | 1.2 | 2.9 | 1100 | 38.2 | 24.6 | 2.3 | 45.9 | 16.7 | 100.4 | 4.3 | 4.5 | 1.2 | 2.9 | 1100 | 48.0 | 2.59 | 39.2 | 5.4 | 110.4 | 62.6 | 4.6 |
| | 4.5 | 1.2 | 2.9 | 1250 | 38.8 | 26.4 | 2.37 | 46.9 | 16.4 | 100.9 | 4.4 | 4.5 | 1.2 | 2.9 | 1250 | 48.8 | 2.51 | 40.2 | 5.7 | 106.1 | 62.1 | 4.7 |
| | 6.8 | 2.0 | 4.7 | 1100 | 39.8 | 25.2 | 2.1 | 47.0 | 18.6 | 93.8 | 3.6 | 5.4 | 1.5 | 3.5 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 6.8 | 2.0 | 4.7 | 1250 | 40.5 | 27.1 | 2.21 | 48.0 | 18.3 | 94.2 | 3.7 | 5.5 | 1.6 | 3.6 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 9.0 | 3.1 | 7.1 | 1100 | 40.5 | 25.5 | 2.1 | 47.5 | 19.6 | 90.6 | 3.3 | 5.4 | 1.5 | 3.5 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 9.0 | 3.1 | 7.1 | 1250 | 41.2 | 27.4 | 2.14 | 48.5 | 19.3 | 90.8 | 3.4 | 5.5 | 1.6 | 3.6 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| 90 | 4.5 | 1.2 | 2.9 | 1100 | 35.8 | 23.6 | 2.5 | 44.4 | 14.1 | 109.7 | 5.3 | 3.2 | 0.9 | 2.0 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 4.5 | 1.2 | 2.9 | 1250 | 36.4 | 25.4 | 2.63 | 45.4 | 13.8 | 110.2 | 5.5 | 3.3 | 0.9 | 2.1 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 6.8 | 2.0 | 4.6 | 1100 | 37.4 | 24.3 | 2.4 | 45.5 | 15.8 | 103.4 | 4.6 | 3.2 | 0.9 | 2.0 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 6.8 | 2.0 | 4.6 | 1250 | 38.1 | 26.1 | 2.45 | 46.4 | 15.5 | 103.8 | 4.7 | 3.3 | 0.9 | 2.1 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 9.0 | 3.0 | 6.9 | 1100 | 38.3 | 24.6 | 2.3 | 46.0 | 16.8 | 100.2 | 4.3 | 3.2 | 0.9 | 2.0 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 9.0 | 3.0 | 6.9 | 1250 | 38.9 | 26.5 | 2.36 | 47.0 | 16.5 | 100.4 | 4.3 | 3.3 | 0.9 | 2.1 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| 100 | 4.5 | 1.2 | 2.8 | 1100 | 33.3 | 22.5 | 2.8 | 43.0 | 11.8 | 119.1 | 6.5 | 2.3 | 0.7 | 1.5 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 4.5 | 1.2 | 2.8 | 1250 | 33.9 | 24.2 | 2.93 | 43.9 | 11.6 | 119.5 | 6.7 | 2.4 | 0.7 | 1.5 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 6.8 | 2.0 | 4.5 | 1100 | 35.0 | 23.2 | 2.6 | 43.9 | 13.3 | 112.9 | 5.7 | 2.3 | 0.7 | 1.5 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 6.8 | 2.0 | 4.5 | 1250 | 35.6 | 25.0 | 2.72 | 44.9 | 13.1 | 113.3 | 5.9 | 2.4 | 0.7 | 1.5 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 9.0 | 3.0 | 6.8 | 1100 | 35.8 | 23.6 | 2.5 | 44.4 | 14.1 | 109.9 | 5.3 | 2.3 | 0.7 | 1.5 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 9.0 | 3.0 | 6.8 | 1250 | 36.4 | 25.4 | 2.63 | 45.4 | 13.9 | 110.1 | 5.5 | 2.4 | 0.7 | 1.5 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| 110 | 4.5 | 1.2 | 2.8 | 1100 | 30.9 | 21.4 | 3.2 | 41.7 | 9.7 | 128.5 | 7.9 | 1.8 | 0.5 | 1.2 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 4.5 | 1.2 | 2.8 | 1250 | 31.4 | 23.0 | 3.29 | 42.6 | 9.5 | 128.9 | 8.0 | 1.8 | 0.5 | 1.2 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 6.8 | 1.9 | 4.5 | 1100 | 32.4 | 22.1 | 2.9 | 42.5 | 11.0 | 122.5 | 7.0 | 1.8 | 0.5 | 1.2 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 6.8 | 1.9 | 4.5 | 1250 | 33.0 | 23.8 | 3.05 | 43.4 | 10.8 | 122.9 | 7.1 | 1.8 | 0.5 | 1.2 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 9.0 | 2.9 | 6.7 | 1100 | 33.3 | 22.5 | 2.8 | 42.9 | 11.7 | 119.5 | 6.6 | 1.8 | 0.5 | 1.2 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 9.0 | 2.9 | 6.7 | 1250 | 33.8 | 24.2 | 2.94 | 43.9 | 11.5 | 119.7 | 6.7 | 1.8 | 0.5 | 1.2 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| 120 | 4.5 | 1.1 | 2.6 | 1100 | 28.5 | 20.3 | 3.6 | 40.8 | 7.9 | 138.1 | 9.4 | 1.5 | 0.4 | 0.8 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 4.5 | 1.1 | 2.6 | 1250 | 29.0 | 21.9 | 3.72 | 41.7 | 7.8 | 138.5 | 9.6 | 1.5 | 0.4 | 0.8 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 6.8 | 1.9 | 4.3 | 1100 | 29.9 | 21.0 | 3.3 | 41.3 | 9.0 | 132.2 | 8.4 | 1.5 | 0.4 | 0.8 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 6.8 | 1.9 | 4.3 | 1250 | 30.5 | 22.6 | 3.44 | 42.2 | 8.9 | 132.5 | 8.6 | 1.5 | 0.4 | 0.8 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |
| | 9.0 | 2.9 | 6.6 | 1100 | 30.7 | 21.3 | 3.2 | 41.7 | 9.6 | 129.3 | 8.0 | 1.5 | 0.4 | 0.8 | 1100 | 49.5 | 2.63 | 40.5 | 5.5 | 111.7 | 65.0 | 4.8 |
| | 9.0 | 2.9 | 6.6 | 1250 | 31.3 | 23.0 | 3.31 | 42.6 | 9.4 | 129.5 | 8.1 | 1.5 | 0.4 | 0.8 | 1250 | 50.3 | 2.55 | 41.6 | 5.8 | 107.3 | 65.0 | 4.9 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 049 (Part Load), With vFlow®

1350 CFM Nominal (Rated) Airflow Heating, 1350 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | COOLING - EAT 80/67 °F | | | | | | | | | | HEATING - 70°F | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GPM | WPD | | CFM | TC | SC | kW | HR | EER | LWT | HWC | GPM | WPD | | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| | | PSI | FT | | | | | | | | | | PSI | FT | | | | | | | | |
| 20 | 1.8 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 9.0 | 2.3 | 5.4 | 1190 | 22.8 | 2.38 | 14.9 | 2.8 | 87.7 | 16.7 | 2.5 |
| | 1.9 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 9.0 | 2.3 | 5.4 | 1350 | 23.1 | 2.28 | 15.3 | 3.0 | 85.8 | 16.6 | 2.5 |
| 30 | 2.3 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 4.5 | 0.2 | 0.6 | 1190 | 25.0 | 2.35 | 17.2 | 3.1 | 89.4 | 22.4 | 2.6 |
| | 2.4 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 4.5 | 0.2 | 0.6 | 1350 | 25.3 | 2.25 | 17.6 | 3.3 | 87.4 | 22.2 | 2.6 |
| | 2.3 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 6.8 | 1.2 | 2.8 | 1190 | 25.9 | 2.34 | 18.1 | 3.3 | 90.2 | 24.7 | 2.6 |
| | 2.4 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 6.8 | 1.2 | 2.8 | 1350 | 26.3 | 2.24 | 18.6 | 3.4 | 88.0 | 24.5 | 2.6 |
| | 2.3 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 9.0 | 2.1 | 4.9 | 1190 | 26.5 | 2.34 | 18.7 | 3.3 | 90.6 | 25.9 | 2.6 |
| | 2.4 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 9.0 | 2.1 | 4.9 | 1350 | 26.8 | 2.24 | 19.2 | 3.5 | 88.4 | 25.7 | 2.6 |
| 40 | 3.1 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 4.5 | 0.2 | 0.4 | 1190 | 28.5 | 2.33 | 20.8 | 3.6 | 92.2 | 30.8 | 2.6 |
| | 3.1 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 4.5 | 0.2 | 0.4 | 1350 | 28.9 | 2.23 | 21.3 | 3.8 | 89.8 | 30.5 | 2.7 |
| | 3.1 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 6.8 | 1.1 | 2.5 | 1190 | 29.8 | 2.33 | 22.0 | 3.8 | 93.2 | 33.5 | 2.6 |
| | 3.1 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 6.8 | 1.1 | 2.5 | 1350 | 30.2 | 2.23 | 22.6 | 4.0 | 90.7 | 33.3 | 2.7 |
| | 3.1 | 0.1 | 0.1 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 9.0 | 2.0 | 4.6 | 1190 | 30.5 | 2.32 | 22.7 | 3.9 | 93.7 | 35.0 | 2.6 |
| | 3.1 | 0.1 | 0.1 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 9.0 | 2.0 | 4.6 | 1350 | 30.9 | 2.22 | 23.3 | 4.1 | 91.2 | 34.8 | 2.7 |
| 50 | 4.5 | 0.1 | 0.3 | 1190 | 41.2 | 28.0 | 1.4 | 46.1 | 28.6 | 70.5 | 1.5 | 4.5 | 0.1 | 0.3 | 1190 | 32.3 | 2.32 | 24.5 | 4.1 | 95.2 | 39.1 | 2.7 |
| | 4.5 | 0.1 | 0.3 | 1350 | 42.0 | 30.0 | 1.47 | 47.0 | 28.6 | 70.9 | 1.5 | 4.5 | 0.1 | 0.3 | 1350 | 32.8 | 2.22 | 25.2 | 4.3 | 92.5 | 38.8 | 2.8 |
| | 4.6 | 0.2 | 0.4 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 6.8 | 1.0 | 2.4 | 1190 | 33.9 | 2.33 | 26.1 | 4.3 | 96.4 | 42.3 | 2.8 |
| | 4.7 | 0.2 | 0.5 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 6.8 | 1.0 | 2.4 | 1350 | 34.4 | 2.23 | 26.8 | 4.5 | 93.6 | 42.1 | 2.9 |
| | 4.6 | 0.2 | 0.4 | 1190 | 41.3 | 27.9 | 1.4 | 46.2 | 29.0 | 70.0 | 1.5 | 9.0 | 1.9 | 4.3 | 1190 | 34.8 | 2.33 | 26.9 | 4.4 | 97.1 | 44.0 | 2.8 |
| | 4.7 | 0.2 | 0.5 | 1350 | 42.1 | 29.9 | 1.45 | 47.1 | 29.0 | 70.0 | 1.5 | 9.0 | 1.9 | 4.3 | 1350 | 35.3 | 2.23 | 27.7 | 4.6 | 94.2 | 43.9 | 2.9 |
| 60 | 4.5 | 0.1 | 0.2 | 1190 | 39.8 | 27.8 | 1.7 | 45.5 | 24.0 | 80.2 | 2.1 | 4.5 | 0.1 | 0.2 | 1190 | 36.3 | 2.33 | 28.4 | 4.6 | 98.3 | 47.4 | 2.9 |
| | 4.5 | 0.1 | 0.2 | 1350 | 40.6 | 29.8 | 1.69 | 46.4 | 24.0 | 80.6 | 2.1 | 4.5 | 0.1 | 0.2 | 1350 | 36.8 | 2.23 | 29.2 | 4.8 | 95.3 | 47.0 | 3.0 |
| | 6.8 | 1.0 | 2.2 | 1190 | 40.9 | 28.0 | 1.5 | 46.0 | 27.2 | 73.5 | 1.7 | 6.8 | 1.0 | 2.2 | 1190 | 38.2 | 2.34 | 30.3 | 4.8 | 99.7 | 51.1 | 3.0 |
| | 6.8 | 1.0 | 2.2 | 1350 | 41.7 | 30.0 | 1.53 | 46.9 | 27.2 | 73.9 | 1.7 | 6.8 | 1.0 | 2.2 | 1350 | 38.7 | 2.24 | 31.1 | 5.1 | 96.6 | 50.9 | 3.1 |
| | 9.0 | 1.8 | 4.2 | 1190 | 41.3 | 28.0 | 1.4 | 46.2 | 28.8 | 70.3 | 1.5 | 9.0 | 1.8 | 4.2 | 1190 | 39.2 | 2.35 | 31.3 | 4.9 | 100.5 | 53.1 | 3.0 |
| | 9.0 | 1.8 | 4.2 | 1350 | 42.1 | 29.9 | 1.46 | 47.0 | 28.8 | 70.5 | 1.5 | 9.0 | 1.8 | 4.2 | 1350 | 39.8 | 2.25 | 32.1 | 5.2 | 97.3 | 52.9 | 3.1 |
| 70 | 4.5 | 0.1 | 0.2 | 1190 | 37.9 | 27.1 | 1.9 | 44.4 | 19.9 | 89.7 | 2.7 | 4.5 | 0.1 | 0.2 | 1190 | 40.4 | 2.35 | 32.4 | 5.0 | 101.4 | 55.6 | 3.1 |
| | 4.5 | 0.1 | 0.2 | 1350 | 38.6 | 29.0 | 1.94 | 45.2 | 19.9 | 90.1 | 2.8 | 4.5 | 0.1 | 0.2 | 1350 | 41.0 | 2.25 | 33.3 | 5.3 | 98.1 | 55.2 | 3.2 |
| | 6.8 | 0.9 | 2.1 | 1190 | 39.3 | 27.7 | 1.7 | 45.2 | 22.7 | 83.3 | 2.3 | 6.8 | 0.9 | 2.2 | 1190 | 42.6 | 2.36 | 34.5 | 5.3 | 103.1 | 59.8 | 3.2 |
| | 6.8 | 0.9 | 2.1 | 1350 | 40.0 | 29.6 | 1.76 | 46.1 | 22.7 | 83.6 | 2.3 | 6.8 | 0.9 | 2.2 | 1350 | 43.2 | 2.26 | 35.5 | 5.6 | 99.6 | 59.6 | 3.3 |
| | 9.0 | 1.8 | 4.0 | 1190 | 39.9 | 27.9 | 1.6 | 45.5 | 24.2 | 80.1 | 2.1 | 9.0 | 1.8 | 4.0 | 1190 | 43.8 | 2.37 | 35.7 | 5.4 | 104.1 | 62.1 | 3.3 |
| | 9.0 | 1.8 | 4.0 | 1350 | 40.7 | 29.8 | 1.68 | 46.4 | 24.2 | 80.3 | 2.1 | 9.0 | 1.8 | 4.0 | 1350 | 44.4 | 2.27 | 36.7 | 5.7 | 100.5 | 61.9 | 3.4 |
| 80 | 4.5 | 0.1 | 0.3 | 1190 | 35.5 | 26.0 | 2.2 | 42.9 | 16.3 | 99.1 | 3.7 | 4.5 | 0.1 | 0.3 | 1190 | 44.6 | 2.37 | 36.4 | 5.5 | 104.7 | 63.8 | 3.3 |
| | 4.5 | 0.1 | 0.3 | 1350 | 36.2 | 27.8 | 2.22 | 43.7 | 16.3 | 99.4 | 3.8 | 4.5 | 0.1 | 0.3 | 1350 | 45.2 | 2.27 | 37.4 | 5.8 | 101.0 | 63.4 | 3.4 |
| | 6.8 | 0.9 | 2.1 | 1190 | 37.1 | 26.7 | 2.0 | 43.9 | 18.6 | 92.9 | 3.0 | 5.0 | 0.1 | 0.2 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 6.8 | 0.9 | 2.1 | 1350 | 37.8 | 28.6 | 2.03 | 44.7 | 18.6 | 93.3 | 3.1 | 5.1 | 0.3 | 0.8 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 9.0 | 1.7 | 3.9 | 1190 | 37.9 | 27.1 | 1.9 | 44.4 | 19.9 | 89.9 | 3.3 | 5.0 | 0.3 | 0.7 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.6 |
| | 9.0 | 1.7 | 3.9 | 1350 | 38.6 | 29.0 | 1.94 | 45.2 | 19.9 | 90.0 | 3.4 | 5.1 | 0.3 | 0.8 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.7 |
| 90 | 4.5 | 0.1 | 0.3 | 1190 | 32.9 | 24.7 | 2.5 | 41.4 | 13.2 | 108.4 | 4.8 | 3.0 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 4.5 | 0.1 | 0.3 | 1350 | 33.5 | 26.5 | 2.54 | 42.2 | 13.2 | 108.7 | 4.9 | 3.1 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 6.8 | 0.9 | 2.1 | 1190 | 34.6 | 25.5 | 2.3 | 42.4 | 15.1 | 102.5 | 4.0 | 3.0 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 6.8 | 0.9 | 2.1 | 1350 | 35.2 | 27.3 | 2.33 | 43.2 | 15.1 | 102.8 | 4.1 | 3.1 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 9.0 | 1.7 | 3.9 | 1190 | 35.4 | 25.9 | 2.2 | 42.9 | 16.2 | 99.5 | 3.7 | 3.0 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 9.0 | 1.7 | 3.9 | 1350 | 36.1 | 27.8 | 2.23 | 43.7 | 16.2 | 99.7 | 3.8 | 3.1 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| 100 | 4.5 | 0.1 | 0.3 | 1190 | 30.2 | 23.5 | 2.8 | 39.9 | 10.6 | 117.7 | 6.1 | 2.1 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 4.5 | 0.1 | 0.3 | 1350 | 30.8 | 25.2 | 2.89 | 40.7 | 10.7 | 118.1 | 6.2 | 2.2 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 6.8 | 0.9 | 2.1 | 1190 | 31.9 | 24.3 | 2.6 | 40.8 | 12.2 | 112.0 | 5.3 | 2.1 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 6.8 | 0.9 | 2.1 | 1350 | 32.5 | 26.0 | 2.67 | 41.6 | 12.2 | 112.3 | 5.4 | 2.2 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 9.0 | 1.7 | 3.8 | 1190 | 32.7 | 24.6 | 2.5 | 41.3 | 13.0 | 109.2 | 4.9 | 2.1 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 9.0 | 1.7 | 3.8 | 1350 | 33.3 | 26.4 | 2.56 | 42.1 | 13.0 | 109.3 | 5.0 | 2.2 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| 110 | 4.5 | 0.1 | 0.2 | 1190 | 27.7 | 22.6 | 3.2 | 38.7 | 8.5 | 127.2 | 7.6 | 1.7 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 4.5 | 0.1 | 0.2 | 1350 | 28.2 | 24.2 | 3.30 | 39.5 | 8.5 | 127.5 | 7.7 | 1.7 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 6.8 | 0.9 | 2.0 | 1190 | 29.2 | 23.1 | 3.0 | 39.4 | 9.7 | 121.6 | 6.7 | 1.7 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 6.8 | 0.9 | 2.0 | 1350 | 29.7 | 24.7 | 3.05 | 40.1 | 9.7 | 121.9 | 6.8 | 1.7 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 9.0 | 1.6 | 3.7 | 1190 | 30.0 | 23.4 | 2.9 | 39.8 | 10.4 | 118.8 | 6.2 | 1.7 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 9.0 | 1.6 | 3.7 | 1350 | 30.5 | 25.1 | 2.93 | 40.5 | 10.4 | 119.0 | 6.3 | 1.7 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| 120 | 4.5 | 0.1 | 0.1 | 1190 | 25.4 | 22.0 | 3.7 | 38.0 | 6.9 | 136.9 | 9.3 | 1.4 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 4.5 | 0.1 | 0.1 | 1350 | 25.9 | 23.6 | 3.75 | 38.7 | 6.9 | 137.2 | 9.5 | 1.4 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 6.8 | 0.8 | 1.9 | 1190 | 26.7 | 22.3 | 3.4 | 38.3 | 7.8 | 131.3 | 8.2 | 1.4 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 6.8 | 0.8 | 1.9 | 1350 | 27.2 | 23.9 | 3.48 | 39.1 | 7.8 | 131.6 | 8.4 | 1.4 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |
| | 9.0 | 1.6 | 3.6 | 1190 | 27.4 | 22.5 | 3.3 | 38.6 | 8.3 | 128.6 | 7.7 | 1.4 | 0.1 | 0.1 | 1190 | 45.4 | 2.38 | 37.2 | 5.6 | 105.3 | 65.0 | 3.4 |
| | 9.0 | 1.6 | 3.6 | 1350 | 27.9 | 24.1 | 3.35 | 39.3 | 8.3 | 128.7 | 7.9 | 1.4 | 0.1 | 0.1 | 1350 | 46.0 | 2.28 | 38.3 | 5.9 | 101.6 | 65.0 | 3.5 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 049 (Full Load), With vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1550 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 2.5 | 0.1 | 0.2 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 12.0 | 4.1 | 9.4 | 1450 | 31.4 | 3.17 | 20.9 | 2.9 | 90.1 | 16.5 | 3.3 |
| | 2.5 | 0.1 | 0.2 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 12.0 | 4.1 | 9.4 | 1650 | 31.9 | 3.07 | 21.4 | 3.0 | 87.9 | 16.4 | 3.3 |
| 30 | 3.1 | 0.1 | 0.2 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 6.0 | 0.9 | 2.1 | 1450 | 34.7 | 3.16 | 24.2 | 3.2 | 92.2 | 21.9 | 3.4 |
| | 3.1 | 0.1 | 0.2 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 6.0 | 0.9 | 2.1 | 1650 | 35.3 | 3.06 | 24.8 | 3.4 | 89.8 | 21.7 | 3.5 |
| | 3.1 | 0.1 | 0.2 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 9.0 | 2.1 | 4.9 | 1450 | 36.2 | 3.16 | 25.7 | 3.4 | 93.1 | 24.3 | 3.5 |
| | 3.1 | 0.1 | 0.2 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 9.0 | 2.1 | 4.9 | 1650 | 36.8 | 3.06 | 26.3 | 3.5 | 90.6 | 24.1 | 3.5 |
| | 3.1 | 0.1 | 0.2 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 12.0 | 3.8 | 8.8 | 1450 | 37.1 | 3.16 | 26.5 | 3.4 | 93.7 | 25.6 | 3.5 |
| | 3.1 | 0.1 | 0.2 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 12.0 | 3.8 | 8.8 | 1650 | 37.6 | 3.06 | 27.2 | 3.6 | 91.1 | 25.5 | 3.6 |
| 40 | 4.1 | 0.2 | 0.5 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 6.0 | 0.8 | 1.8 | 1450 | 39.9 | 3.18 | 29.2 | 3.7 | 95.5 | 30.3 | 3.6 |
| | 4.2 | 0.2 | 0.5 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 6.0 | 0.8 | 1.8 | 1650 | 40.5 | 3.08 | 30.0 | 3.9 | 92.7 | 30.0 | 3.7 |
| | 4.1 | 0.2 | 0.5 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 9.0 | 2.0 | 4.6 | 1450 | 41.7 | 3.21 | 30.9 | 3.8 | 96.6 | 33.1 | 3.7 |
| | 4.2 | 0.2 | 0.5 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 9.0 | 2.0 | 4.6 | 1650 | 42.3 | 3.11 | 31.7 | 4.0 | 93.8 | 32.9 | 3.8 |
| | 4.1 | 0.2 | 0.5 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 12.0 | 3.6 | 8.4 | 1450 | 42.7 | 3.22 | 31.8 | 3.9 | 97.3 | 34.7 | 3.8 |
| | 4.2 | 0.2 | 0.5 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 12.0 | 3.6 | 8.4 | 1650 | 43.3 | 3.12 | 32.7 | 4.1 | 94.3 | 34.6 | 3.9 |
| 50 | 6.0 | 0.7 | 1.7 | 1360 | 54.0 | 33.2 | 2.3 | 61.7 | 23.6 | 70.6 | 2.3 | 6.0 | 0.7 | 1.7 | 1450 | 45.0 | 3.26 | 34.0 | 4.0 | 98.8 | 38.7 | 3.9 |
| | 6.0 | 0.7 | 1.7 | 1550 | 54.9 | 35.7 | 2.37 | 63.0 | 23.2 | 71.0 | 2.3 | 6.0 | 0.7 | 1.7 | 1650 | 45.7 | 3.16 | 34.9 | 4.2 | 95.7 | 38.4 | 4.0 |
| | 6.2 | 0.8 | 1.8 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 9.0 | 1.9 | 4.3 | 1450 | 47.2 | 3.30 | 36.0 | 4.2 | 100.1 | 42.0 | 4.1 |
| | 6.3 | 0.8 | 1.9 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 9.0 | 1.9 | 4.3 | 1650 | 47.9 | 3.20 | 37.0 | 4.4 | 96.9 | 41.8 | 4.1 |
| | 6.2 | 0.8 | 1.8 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.9 | 70.0 | 2.3 | 12.0 | 3.5 | 8.0 | 1450 | 48.3 | 3.33 | 37.1 | 4.2 | 100.9 | 43.8 | 4.1 |
| | 6.3 | 0.8 | 1.9 | 1550 | 54.9 | 35.6 | 2.34 | 62.9 | 23.5 | 70.0 | 2.3 | 12.0 | 3.5 | 8.0 | 1650 | 49.1 | 3.23 | 38.1 | 4.5 | 97.5 | 43.7 | 4.2 |
| 60 | 6.0 | 0.7 | 1.6 | 1360 | 53.1 | 33.6 | 2.5 | 61.6 | 21.1 | 80.5 | 2.9 | 6.0 | 0.7 | 1.6 | 1450 | 50.2 | 3.37 | 38.8 | 4.4 | 102.1 | 47.1 | 4.3 |
| | 6.0 | 0.7 | 1.6 | 1550 | 54.0 | 36.1 | 2.61 | 62.9 | 20.7 | 81.0 | 2.9 | 6.0 | 0.7 | 1.6 | 1650 | 51.0 | 3.27 | 39.8 | 4.6 | 98.6 | 46.7 | 4.4 |
| | 9.0 | 1.8 | 4.2 | 1360 | 53.9 | 33.4 | 2.4 | 61.8 | 22.9 | 73.7 | 2.4 | 9.0 | 1.8 | 4.2 | 1450 | 52.7 | 3.44 | 41.0 | 4.5 | 103.6 | 50.9 | 4.4 |
| | 9.0 | 1.8 | 4.2 | 1550 | 54.8 | 36.0 | 2.44 | 63.1 | 22.5 | 74.0 | 2.5 | 9.0 | 1.8 | 4.2 | 1650 | 53.5 | 3.33 | 42.1 | 4.7 | 100.0 | 50.6 | 4.5 |
| | 12.0 | 3.4 | 7.8 | 1360 | 54.0 | 33.1 | 2.3 | 61.6 | 23.8 | 70.3 | 2.3 | 12.0 | 3.4 | 7.8 | 1450 | 54.0 | 3.48 | 42.2 | 4.5 | 104.5 | 53.0 | 4.5 |
| | 12.0 | 3.4 | 7.8 | 1550 | 54.9 | 35.6 | 2.35 | 63.0 | 23.4 | 70.5 | 2.3 | 12.0 | 3.4 | 7.8 | 1650 | 54.8 | 3.37 | 43.3 | 4.8 | 100.8 | 52.8 | 4.6 |
| 70 | 6.0 | 0.7 | 1.5 | 1360 | 51.0 | 33.0 | 2.8 | 60.4 | 18.3 | 90.1 | 3.6 | 6.0 | 0.7 | 1.5 | 1450 | 55.5 | 3.52 | 43.5 | 4.6 | 105.4 | 55.5 | 4.6 |
| | 6.0 | 0.7 | 1.5 | 1550 | 51.9 | 35.5 | 2.88 | 61.7 | 18.0 | 90.6 | 3.7 | 6.0 | 0.7 | 1.5 | 1650 | 56.3 | 3.41 | 44.7 | 4.8 | 101.6 | 55.1 | 4.7 |
| | 9.0 | 1.8 | 4.0 | 1360 | 52.6 | 33.5 | 2.6 | 61.3 | 20.2 | 83.6 | 3.1 | 9.0 | 1.8 | 4.0 | 1450 | 58.2 | 3.60 | 46.0 | 4.7 | 107.2 | 59.8 | 4.9 |
| | 9.0 | 1.8 | 4.0 | 1550 | 53.5 | 36.0 | 2.69 | 62.7 | 19.9 | 83.9 | 3.1 | 9.0 | 1.8 | 4.0 | 1650 | 59.1 | 3.49 | 47.2 | 5.0 | 103.2 | 59.5 | 5.0 |
| | 12.0 | 3.3 | 7.6 | 1360 | 53.2 | 33.6 | 2.5 | 61.6 | 21.2 | 80.3 | 2.8 | 12.0 | 3.3 | 7.6 | 1450 | 59.7 | 3.64 | 47.3 | 4.8 | 108.1 | 62.1 | 5.0 |
| | 12.0 | 3.3 | 7.6 | 1550 | 54.1 | 36.1 | 2.60 | 63.0 | 20.8 | 80.5 | 2.9 | 12.0 | 3.3 | 7.6 | 1650 | 60.6 | 3.53 | 48.6 | 5.0 | 104.0 | 61.9 | 5.1 |
| 80 | 6.0 | 0.7 | 1.5 | 1360 | 48.1 | 31.8 | 3.1 | 58.6 | 15.7 | 99.5 | 4.5 | 6.0 | 0.7 | 1.5 | 1450 | 60.7 | 3.67 | 48.2 | 4.8 | 108.8 | 63.9 | 5.1 |
| | 6.0 | 0.7 | 1.5 | 1550 | 49.0 | 34.2 | 3.18 | 59.8 | 15.4 | 99.9 | 4.6 | 6.0 | 0.7 | 1.5 | 1650 | 61.6 | 3.56 | 49.5 | 5.1 | 104.6 | 63.5 | 5.2 |
| | 9.0 | 1.7 | 4.0 | 1360 | 50.1 | 32.7 | 2.9 | 59.9 | 17.5 | 93.3 | 3.8 | 6.5 | 0.8 | 1.9 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 9.0 | 1.7 | 4.0 | 1550 | 51.0 | 35.1 | 2.97 | 61.1 | 17.2 | 93.6 | 3.9 | 6.7 | 0.9 | 2.1 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 12.0 | 3.2 | 7.5 | 1360 | 51.1 | 33.0 | 2.8 | 60.4 | 18.4 | 90.1 | 3.6 | 6.5 | 0.8 | 1.9 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 12.0 | 3.2 | 7.5 | 1550 | 51.9 | 35.5 | 2.87 | 61.7 | 18.1 | 90.3 | 3.6 | 6.7 | 0.9 | 2.1 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| 90 | 6.0 | 0.7 | 1.5 | 1360 | 44.9 | 30.2 | 3.4 | 56.5 | 13.2 | 108.8 | 4.8 | 3.9 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 6.0 | 0.7 | 1.5 | 1550 | 45.7 | 32.5 | 3.52 | 57.7 | 13.0 | 109.2 | 4.9 | 4.0 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 9.0 | 1.7 | 3.9 | 1360 | 47.1 | 31.3 | 3.2 | 57.9 | 14.8 | 102.9 | 4.5 | 3.9 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 9.0 | 1.7 | 3.9 | 1550 | 47.9 | 33.6 | 3.29 | 59.1 | 14.6 | 103.1 | 4.6 | 4.0 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 12.0 | 3.2 | 7.4 | 1360 | 48.1 | 31.8 | 3.1 | 58.5 | 15.7 | 99.8 | 5.6 | 3.9 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 12.0 | 3.2 | 7.4 | 1550 | 49.0 | 34.2 | 3.18 | 59.8 | 15.4 | 100.0 | 5.7 | 4.0 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| 100 | 6.0 | 0.6 | 1.5 | 1360 | 41.7 | 28.6 | 3.8 | 54.6 | 11.1 | 118.2 | 5.9 | 2.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 6.0 | 0.6 | 1.5 | 1550 | 42.5 | 30.8 | 3.91 | 55.8 | 10.9 | 118.6 | 6.0 | 2.9 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 9.0 | 1.7 | 3.8 | 1360 | 43.7 | 29.6 | 3.5 | 55.8 | 12.4 | 112.4 | 5.6 | 2.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 9.0 | 1.7 | 3.8 | 1550 | 44.5 | 31.8 | 3.65 | 57.0 | 12.2 | 112.7 | 5.7 | 2.9 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 12.0 | 3.2 | 7.3 | 1360 | 44.8 | 30.1 | 3.4 | 56.4 | 13.2 | 109.4 | 6.8 | 2.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 12.0 | 3.2 | 7.3 | 1550 | 45.6 | 32.4 | 3.53 | 57.6 | 12.9 | 109.6 | 7.0 | 2.9 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| 110 | 6.0 | 0.6 | 1.4 | 1360 | 38.9 | 27.3 | 4.2 | 53.4 | 9.2 | 127.8 | 7.3 | 2.2 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 6.0 | 0.6 | 1.4 | 1550 | 39.5 | 29.3 | 4.38 | 54.5 | 9.0 | 128.2 | 7.4 | 2.2 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 9.0 | 1.6 | 3.7 | 1360 | 40.6 | 28.0 | 3.9 | 54.0 | 10.3 | 122.0 | 6.8 | 2.2 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 9.0 | 1.6 | 3.7 | 1550 | 41.3 | 30.2 | 4.09 | 55.2 | 10.1 | 122.3 | 7.0 | 2.2 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 12.0 | 3.1 | 7.2 | 1360 | 41.5 | 28.5 | 3.8 | 54.5 | 10.9 | 119.1 | 8.3 | 2.2 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 12.0 | 3.1 | 7.2 | 1550 | 42.2 | 30.6 | 3.94 | 55.7 | 10.7 | 119.3 | 8.4 | 2.2 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| 120 | 6.0 | 0.6 | 1.3 | 1360 | 36.8 | 26.6 | 4.8 | 53.2 | 7.7 | 137.7 | 8.8 | 1.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 6.0 | 0.6 | 1.3 | 1550 | 37.4 | 28.6 | 4.96 | 54.3 | 7.5 | 138.1 | 9.0 | 1.8 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 9.0 | 1.6 | 3.6 | 1360 | 37.9 | 26.9 | 4.4 | 53.1 | 8.5 | 131.8 | 8.3 | 1.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 9.0 | 1.6 | 3.6 | 1550 | 38.6 | 28.9 | 4.60 | 54.3 | 8.4 | 132.1 | 8.5 | 1.8 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |
| | 12.0 | 3.0 | 7.0 | 1360 | 38.6 | 27.2 | 4.3 | 53.3 | 9.0 | 128.9 | 8.3 | 1.8 | 0.1 | 0.2 | 1450 | 61.6 | 3.70 | 49.0 | 4.9 | 109.4 | 65.0 | 5.2 |
| | 12.0 | 3.0 | 7.0 | 1550 | 39.3 | 29.2 | 4.43 | 54.4 | 8.9 | 129.1 | 8.5 | 1.8 | 0.1 | 0.2 | 1650 | 62.6 | 3.59 | 50.3 | 5.1 | 105.1 | 65.0 | 5.3 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 064 (Part Load), With vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1500 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 2.4 | 0.1 | 0.1 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 12.0 | 5.2 | 11.9 | 1450 | 28.2 | 2.87 | 18.7 | 2.9 | 88.0 | 16.9 | 3.1 |
| | 2.4 | 0.1 | 0.1 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 12.0 | 5.2 | 11.9 | 1650 | 28.6 | 2.75 | 19.3 | 3.1 | 86.1 | 16.8 | 3.1 |
| 30 | 3.0 | 0.1 | 0.1 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 6.0 | 0.9 | 2.1 | 1450 | 31.7 | 2.88 | 22.1 | 3.2 | 90.2 | 22.6 | 3.1 |
| | 3.1 | 0.1 | 0.1 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 6.0 | 0.9 | 2.1 | 1650 | 32.2 | 2.76 | 22.7 | 3.4 | 88.0 | 22.4 | 3.2 |
| | 3.0 | 0.1 | 0.1 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 9.0 | 2.5 | 5.7 | 1450 | 33.1 | 2.89 | 23.5 | 3.4 | 91.1 | 24.8 | 3.2 |
| | 3.1 | 0.1 | 0.1 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 9.0 | 2.5 | 5.7 | 1650 | 33.6 | 2.77 | 24.1 | 3.6 | 88.8 | 24.6 | 3.2 |
| | 3.0 | 0.1 | 0.1 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 12.0 | 4.1 | 9.6 | 1450 | 33.9 | 2.89 | 24.2 | 3.4 | 91.6 | 26.0 | 3.2 |
| | 3.1 | 0.1 | 0.1 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 12.0 | 4.1 | 9.6 | 1650 | 34.4 | 2.77 | 24.9 | 3.6 | 89.3 | 25.8 | 3.2 |
| 40 | 4.0 | 0.1 | 0.1 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 6.0 | 0.5 | 1.1 | 1450 | 37.0 | 2.91 | 27.3 | 3.7 | 93.6 | 30.9 | 3.2 |
| | 4.1 | 0.1 | 0.2 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 6.0 | 0.5 | 1.1 | 1650 | 37.6 | 2.79 | 28.0 | 3.9 | 91.1 | 30.7 | 3.3 |
| | 4.0 | 0.1 | 0.2 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 9.0 | 1.9 | 4.3 | 1450 | 38.8 | 2.92 | 29.0 | 3.9 | 94.8 | 33.6 | 3.3 |
| | 4.1 | 0.1 | 0.2 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 9.0 | 1.9 | 4.3 | 1650 | 39.4 | 2.80 | 29.8 | 4.1 | 92.1 | 33.4 | 3.4 |
| | 4.0 | 0.1 | 0.2 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 12.0 | 3.4 | 7.9 | 1450 | 39.8 | 2.93 | 30.0 | 4.0 | 95.4 | 35.0 | 3.3 |
| | 4.1 | 0.1 | 0.2 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 12.0 | 3.4 | 7.9 | 1650 | 40.4 | 2.81 | 30.8 | 4.2 | 92.7 | 34.9 | 3.4 |
| 50 | 6.0 | 0.2 | 0.6 | 1360 | 53.7 | 37.2 | 1.8 | 59.9 | 29.6 | 70.0 | 1.8 | 6.0 | 0.2 | 0.6 | 1450 | 42.5 | 2.95 | 32.6 | 4.2 | 97.1 | 39.1 | 3.4 |
| | 6.0 | 0.2 | 0.6 | 1550 | 54.8 | 39.8 | 1.85 | 61.1 | 29.7 | 70.4 | 1.8 | 6.0 | 0.2 | 0.6 | 1650 | 43.1 | 2.82 | 33.5 | 4.5 | 94.2 | 38.8 | 3.5 |
| | 6.0 | 0.2 | 0.5 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 9.0 | 1.5 | 3.5 | 1450 | 44.7 | 2.96 | 34.7 | 4.4 | 98.5 | 42.3 | 3.5 |
| | 6.1 | 0.3 | 0.7 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 9.0 | 1.5 | 3.5 | 1650 | 45.3 | 2.84 | 35.7 | 4.7 | 95.4 | 42.1 | 3.5 |
| | 6.0 | 0.2 | 0.5 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.8 | 70.0 | 1.8 | 12.0 | 3.0 | 6.9 | 1450 | 45.9 | 2.97 | 35.9 | 4.5 | 99.3 | 44.0 | 3.5 |
| | 6.1 | 0.3 | 0.7 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.9 | 70.0 | 1.8 | 12.0 | 3.0 | 6.9 | 1650 | 46.6 | 2.85 | 36.9 | 4.8 | 96.1 | 43.9 | 3.6 |
| 60 | 6.0 | 0.2 | 0.4 | 1360 | 51.4 | 36.3 | 2.1 | 58.5 | 24.8 | 79.5 | 2.4 | 6.0 | 0.2 | 0.4 | 1450 | 48.1 | 2.99 | 37.9 | 4.7 | 100.7 | 47.4 | 3.6 |
| | 6.0 | 0.2 | 0.4 | 1550 | 52.4 | 38.9 | 2.11 | 59.6 | 24.8 | 79.9 | 2.5 | 6.0 | 0.2 | 0.4 | 1650 | 48.8 | 2.86 | 39.0 | 5.0 | 97.4 | 47.0 | 3.7 |
| | 9.0 | 1.4 | 3.1 | 1360 | 53.0 | 36.9 | 1.9 | 59.5 | 28.0 | 73.2 | 2.0 | 9.0 | 1.4 | 3.1 | 1450 | 50.6 | 3.01 | 40.4 | 4.9 | 102.3 | 51.0 | 3.7 |
| | 9.0 | 1.4 | 3.1 | 1550 | 54.1 | 39.5 | 1.93 | 60.6 | 28.1 | 73.5 | 2.0 | 9.0 | 1.4 | 3.1 | 1650 | 51.4 | 2.89 | 41.5 | 5.2 | 98.8 | 50.8 | 3.8 |
| | 12.0 | 2.7 | 6.3 | 1360 | 53.8 | 37.2 | 1.8 | 59.9 | 29.7 | 70.0 | 1.8 | 12.0 | 2.7 | 6.3 | 1450 | 52.1 | 3.02 | 41.7 | 5.0 | 103.2 | 53.0 | 3.8 |
| | 12.0 | 2.7 | 6.3 | 1550 | 54.8 | 39.9 | 1.84 | 61.1 | 29.8 | 70.2 | 1.8 | 12.0 | 2.7 | 6.3 | 1650 | 52.8 | 2.90 | 42.9 | 5.3 | 99.6 | 52.8 | 3.8 |
| 70 | 6.0 | 0.2 | 0.4 | 1360 | 48.6 | 35.4 | 2.4 | 56.7 | 20.4 | 88.9 | 3.3 | 6.0 | 0.2 | 0.4 | 1450 | 53.6 | 3.04 | 43.3 | 5.2 | 104.2 | 55.6 | 3.8 |
| | 6.0 | 0.2 | 0.4 | 1550 | 49.6 | 37.9 | 2.42 | 57.8 | 20.4 | 89.3 | 3.3 | 6.0 | 0.2 | 0.4 | 1650 | 54.4 | 2.91 | 44.5 | 5.5 | 100.5 | 55.2 | 3.9 |
| | 9.0 | 1.3 | 3.0 | 1360 | 50.5 | 36.0 | 2.2 | 57.9 | 23.2 | 82.9 | 2.7 | 9.0 | 1.3 | 3.0 | 1450 | 56.5 | 3.07 | 46.0 | 5.4 | 106.1 | 59.8 | 4.0 |
| | 9.0 | 1.3 | 3.0 | 1550 | 51.5 | 38.6 | 2.21 | 59.0 | 23.3 | 83.1 | 2.7 | 9.0 | 1.3 | 3.0 | 1650 | 57.3 | 2.94 | 47.3 | 5.7 | 102.2 | 59.5 | 4.1 |
| | 12.0 | 2.6 | 6.0 | 1360 | 51.4 | 36.3 | 2.1 | 58.5 | 24.8 | 79.7 | 2.4 | 12.0 | 2.6 | 6.0 | 1450 | 58.1 | 3.08 | 47.5 | 5.5 | 107.1 | 62.1 | 4.1 |
| | 12.0 | 2.6 | 6.0 | 1550 | 52.4 | 38.9 | 2.11 | 59.6 | 24.8 | 79.9 | 2.5 | 12.0 | 2.6 | 6.0 | 1650 | 58.9 | 2.96 | 48.8 | 5.8 | 103.1 | 61.9 | 4.2 |
| 80 | 6.0 | 0.2 | 0.6 | 1360 | 45.6 | 34.3 | 2.7 | 54.9 | 16.7 | 98.3 | 4.3 | 6.0 | 0.3 | 0.6 | 1450 | 59.1 | 3.10 | 48.5 | 5.6 | 107.7 | 63.8 | 4.1 |
| | 6.0 | 0.2 | 0.6 | 1550 | 46.5 | 36.7 | 2.78 | 56.0 | 16.7 | 98.7 | 4.4 | 6.0 | 0.3 | 0.6 | 1650 | 59.9 | 2.97 | 49.8 | 5.9 | 103.6 | 63.4 | 4.2 |
| | 9.0 | 1.3 | 3.1 | 1360 | 47.5 | 35.0 | 2.5 | 56.1 | 19.0 | 92.5 | 3.6 | 6.6 | 0.5 | 1.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 9.0 | 1.3 | 3.1 | 1550 | 48.5 | 37.5 | 2.55 | 57.2 | 19.0 | 92.7 | 3.7 | 6.8 | 0.5 | 1.2 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 12.0 | 2.6 | 5.9 | 1360 | 48.5 | 35.3 | 2.4 | 56.7 | 20.3 | 89.4 | 3.3 | 6.6 | 0.5 | 1.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 12.0 | 2.6 | 5.9 | 1550 | 49.5 | 37.8 | 2.44 | 57.8 | 20.3 | 89.6 | 3.4 | 6.8 | 0.5 | 1.2 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| 90 | 6.0 | 0.3 | 0.7 | 1360 | 42.4 | 33.0 | 3.1 | 53.1 | 13.6 | 107.7 | 5.5 | 4.0 | 0.2 | 0.5 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 6.0 | 0.3 | 0.7 | 1550 | 43.3 | 35.3 | 3.18 | 54.1 | 13.6 | 108.0 | 5.6 | 4.1 | 0.2 | 0.5 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 9.0 | 1.4 | 3.2 | 1360 | 44.4 | 33.8 | 2.9 | 54.2 | 15.4 | 102.0 | 4.7 | 4.0 | 0.2 | 0.5 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 9.0 | 1.4 | 3.2 | 1550 | 45.2 | 36.2 | 2.93 | 55.2 | 15.4 | 102.3 | 4.8 | 4.1 | 0.2 | 0.5 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 12.0 | 2.6 | 6.0 | 1360 | 45.4 | 34.2 | 2.8 | 54.8 | 16.4 | 99.1 | 4.4 | 4.0 | 0.2 | 0.5 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 12.0 | 2.6 | 6.0 | 1550 | 46.2 | 36.6 | 2.81 | 55.8 | 16.5 | 99.3 | 4.4 | 4.1 | 0.2 | 0.5 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| 100 | 6.0 | 0.3 | 0.8 | 1360 | 39.4 | 31.6 | 3.6 | 51.5 | 11.1 | 117.2 | 6.9 | 2.8 | 0.1 | 0.2 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 6.0 | 0.3 | 0.8 | 1550 | 40.2 | 33.9 | 3.62 | 52.5 | 11.1 | 117.5 | 7.0 | 2.9 | 0.1 | 0.2 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 9.0 | 1.4 | 3.2 | 1360 | 41.2 | 32.5 | 3.3 | 52.4 | 12.5 | 111.7 | 6.0 | 2.8 | 0.1 | 0.2 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 9.0 | 1.4 | 3.2 | 1550 | 42.0 | 34.7 | 3.36 | 53.4 | 12.5 | 111.9 | 6.1 | 2.9 | 0.1 | 0.2 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 12.0 | 2.6 | 6.0 | 1360 | 42.1 | 32.9 | 3.2 | 52.9 | 13.3 | 108.8 | 5.6 | 2.8 | 0.1 | 0.2 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 12.0 | 2.6 | 6.0 | 1550 | 43.0 | 35.2 | 3.23 | 54.0 | 13.3 | 109.0 | 5.7 | 2.9 | 0.1 | 0.2 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| 110 | 6.0 | 0.3 | 0.6 | 1360 | 36.7 | 30.2 | 4.0 | 50.4 | 9.1 | 126.8 | 8.5 | 2.2 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 6.0 | 0.3 | 0.6 | 1550 | 37.4 | 32.4 | 4.09 | 51.3 | 9.1 | 127.1 | 8.7 | 2.3 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 9.0 | 1.3 | 3.1 | 1360 | 38.2 | 31.0 | 3.7 | 51.0 | 10.2 | 121.3 | 7.5 | 2.2 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 9.0 | 1.3 | 3.1 | 1550 | 38.9 | 33.2 | 3.81 | 52.0 | 10.2 | 121.5 | 7.7 | 2.3 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 12.0 | 2.5 | 5.8 | 1360 | 39.0 | 31.4 | 3.6 | 51.4 | 10.8 | 118.6 | 7.1 | 2.2 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 12.0 | 2.5 | 5.8 | 1550 | 39.8 | 33.7 | 3.68 | 52.3 | 10.8 | 118.7 | 7.2 | 2.3 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| 120 | 6.0 | 0.0 | 0.0 | 1360 | 34.4 | 28.9 | 4.5 | 49.8 | 7.6 | 136.6 | 10.3 | 1.8 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 6.0 | 0.0 | 0.0 | 1550 | 35.1 | 31.0 | 4.59 | 50.8 | 7.6 | 136.9 | 10.5 | 1.8 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 9.0 | 1.1 | 2.6 | 1360 | 35.6 | 29.6 | 4.2 | 50.0 | 8.4 | 131.1 | 9.3 | 1.8 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 9.0 | 1.1 | 2.6 | 1550 | 36.3 | 31.7 | 4.30 | 51.0 | 8.4 | 131.3 | 9.4 | 1.8 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |
| | 12.0 | 2.3 | 5.4 | 1360 | 36.3 | 30.0 | 4.1 | 50.2 | 8.9 | 128.4 | 8.7 | 1.8 | 0.1 | 0.1 | 1450 | 60.2 | 3.11 | 49.5 | 5.7 | 108.4 | 65.0 | 4.2 |
| | 12.0 | 2.3 | 5.4 | 1550 | 37.0 | 32.2 | 4.16 | 51.2 | 8.9 | 128.5 | 8.9 | 1.8 | 0.1 | 0.1 | 1650 | 61.0 | 2.98 | 50.8 | 6.0 | 104.2 | 65.0 | 4.3 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 064 (Full Load), With vFlow®

2050 CFM Nominal (Rated) Airflow Heating, 1850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 3.3 | 0.2 | 0.4 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 15.0 | 7.3 | 16.8 | 1800 | 42.8 | 3.89 | 29.8 | 3.2 | 92.0 | 16.0 | 3.8 |
| | 3.4 | 0.2 | 0.2 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 15.0 | 7.3 | 16.8 | 2050 | 43.4 | 3.77 | 30.6 | 3.4 | 89.6 | 15.9 | 3.8 |
| 30 | 4.2 | 0.1 | 0.2 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 7.5 | 1.7 | 3.9 | 1800 | 46.9 | 3.95 | 33.6 | 3.5 | 94.1 | 21.0 | 3.9 |
| | 4.2 | 0.1 | 0.2 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 7.5 | 1.7 | 3.9 | 2050 | 47.6 | 3.82 | 34.5 | 3.6 | 91.5 | 20.8 | 4.0 |
| | 4.2 | 0.1 | 0.1 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 11.3 | 3.7 | 8.6 | 1800 | 49.1 | 3.98 | 35.8 | 3.6 | 95.3 | 23.6 | 4.0 |
| | 4.2 | 0.1 | 0.1 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 11.3 | 3.7 | 8.6 | 2050 | 49.9 | 3.86 | 36.7 | 3.8 | 92.5 | 23.5 | 4.1 |
| | 4.2 | 0.1 | 0.2 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 15.0 | 6.1 | 14.1 | 1800 | 50.4 | 4.00 | 36.9 | 3.7 | 95.9 | 25.1 | 4.0 |
| | 4.2 | 0.1 | 0.2 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 15.0 | 6.1 | 14.1 | 2050 | 51.2 | 3.88 | 37.9 | 3.9 | 93.1 | 24.9 | 4.1 |
| 40 | 5.5 | 0.3 | 0.6 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 7.5 | 1.2 | 2.7 | 1800 | 53.9 | 4.06 | 40.2 | 3.9 | 97.7 | 29.3 | 4.2 |
| | 5.7 | 0.3 | 0.2 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 7.5 | 1.2 | 2.7 | 2050 | 54.7 | 3.94 | 41.3 | 4.1 | 94.7 | 29.0 | 4.2 |
| | 5.5 | 0.3 | 0.6 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 11.3 | 3.0 | 7.0 | 1800 | 56.7 | 4.12 | 42.8 | 4.0 | 99.2 | 32.4 | 4.3 |
| | 5.7 | 0.3 | 0.8 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 11.3 | 3.0 | 7.0 | 2050 | 57.6 | 3.99 | 44.0 | 4.2 | 96.0 | 32.2 | 4.4 |
| | 5.5 | 0.3 | 0.6 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 15.0 | 5.3 | 12.2 | 1800 | 58.3 | 4.15 | 44.3 | 4.1 | 100.0 | 34.1 | 4.3 |
| | 5.7 | 0.3 | 0.8 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 15.0 | 5.3 | 12.2 | 2050 | 59.2 | 4.02 | 45.5 | 4.3 | 96.7 | 33.9 | 4.4 |
| 50 | 7.5 | 0.9 | 2.0 | 1630 | 72.4 | 47.8 | 3.1 | 82.8 | 23.5 | 72.1 | 2.8 | 7.5 | 0.9 | 2.0 | 1800 | 61.1 | 4.21 | 46.9 | 4.3 | 101.5 | 37.5 | 4.5 |
| | 7.5 | 0.9 | 2.0 | 1850 | 73.6 | 51.4 | 3.20 | 84.5 | 23.0 | 72.5 | 2.9 | 7.5 | 0.9 | 2.0 | 2050 | 62.1 | 4.08 | 48.2 | 4.5 | 98.0 | 37.2 | 4.6 |
| | 8.3 | 1.2 | 2.8 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 11.3 | 2.6 | 6.0 | 1800 | 64.5 | 4.28 | 50.0 | 4.4 | 103.2 | 41.1 | 4.6 |
| | 8.5 | 1.3 | 3.0 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 11.3 | 2.6 | 6.0 | 2050 | 65.5 | 4.15 | 51.3 | 4.6 | 99.6 | 40.9 | 4.7 |
| | 8.3 | 1.2 | 2.8 | 1630 | 73.0 | 48.1 | 3.0 | 83.2 | 24.2 | 70.0 | 2.7 | 15.0 | 4.7 | 10.8 | 1800 | 66.3 | 4.32 | 51.7 | 4.5 | 104.1 | 43.1 | 4.7 |
| | 8.5 | 1.3 | 3.0 | 1850 | 74.3 | 51.7 | 3.13 | 85.0 | 23.7 | 70.0 | 2.8 | 15.0 | 4.7 | 10.8 | 2050 | 67.3 | 4.19 | 53.0 | 4.7 | 100.4 | 42.9 | 4.8 |
| 60 | 7.5 | 0.7 | 1.7 | 1630 | 69.5 | 46.7 | 3.4 | 80.9 | 20.7 | 81.6 | 3.5 | 7.5 | 0.7 | 1.7 | 1800 | 68.5 | 4.37 | 53.6 | 4.6 | 105.2 | 45.7 | 4.9 |
| | 7.5 | 0.7 | 1.7 | 1850 | 70.7 | 50.3 | 3.47 | 82.6 | 20.4 | 82.0 | 3.6 | 7.5 | 0.7 | 1.7 | 2050 | 69.5 | 4.24 | 55.1 | 4.8 | 101.4 | 45.3 | 5.0 |
| | 11.3 | 2.4 | 5.4 | 1630 | 71.7 | 47.6 | 3.1 | 82.3 | 22.8 | 74.6 | 3.0 | 11.3 | 2.4 | 5.4 | 1800 | 72.3 | 4.46 | 57.1 | 4.7 | 107.2 | 49.8 | 5.1 |
| | 11.3 | 2.4 | 5.4 | 1850 | 73.0 | 51.1 | 3.26 | 84.1 | 22.4 | 75.0 | 3.1 | 11.3 | 2.4 | 5.4 | 2050 | 73.4 | 4.33 | 58.6 | 5.0 | 103.2 | 49.6 | 5.2 |
| | 15.0 | 4.3 | 10.0 | 1630 | 72.7 | 48.0 | 3.1 | 83.0 | 23.8 | 71.1 | 2.8 | 15.0 | 4.3 | 10.0 | 1800 | 74.4 | 4.52 | 59.0 | 4.8 | 108.3 | 52.1 | 5.2 |
| | 15.0 | 4.3 | 10.0 | 1850 | 74.0 | 51.6 | 3.16 | 84.8 | 23.4 | 71.3 | 2.8 | 15.0 | 4.3 | 10.0 | 2050 | 75.5 | 4.38 | 60.6 | 5.1 | 104.1 | 51.9 | 5.3 |
| 70 | 7.5 | 0.7 | 1.7 | 1630 | 66.1 | 45.5 | 3.7 | 78.6 | 18.0 | 91.0 | 4.4 | 7.5 | 0.7 | 1.7 | 1800 | 75.8 | 4.55 | 60.3 | 4.9 | 109.0 | 53.9 | 5.3 |
| | 7.5 | 0.7 | 1.7 | 1850 | 67.3 | 48.9 | 3.81 | 80.3 | 17.7 | 91.4 | 4.5 | 7.5 | 0.7 | 1.7 | 2050 | 77.0 | 4.41 | 61.9 | 5.1 | 104.8 | 53.5 | 5.4 |
| | 11.3 | 2.3 | 5.2 | 1630 | 68.6 | 46.4 | 3.4 | 80.3 | 20.0 | 84.2 | 3.8 | 11.3 | 2.3 | 5.2 | 1800 | 80.1 | 4.67 | 64.2 | 5.0 | 111.2 | 58.6 | 5.6 |
| | 11.3 | 2.3 | 5.2 | 1850 | 69.8 | 49.9 | 3.56 | 82.0 | 19.6 | 84.6 | 3.8 | 11.3 | 2.3 | 5.2 | 2050 | 81.3 | 4.52 | 65.9 | 5.3 | 106.7 | 58.3 | 5.7 |
| | 15.0 | 4.1 | 9.5 | 1630 | 69.9 | 46.9 | 3.3 | 81.1 | 21.0 | 80.8 | 3.5 | 15.0 | 4.1 | 9.5 | 1800 | 82.4 | 4.73 | 66.3 | 5.1 | 112.4 | 61.2 | 5.7 |
| | 15.0 | 4.1 | 9.5 | 1850 | 71.1 | 50.4 | 3.44 | 82.8 | 20.6 | 81.0 | 3.5 | 15.0 | 4.1 | 9.5 | 2050 | 83.7 | 4.59 | 68.0 | 5.3 | 107.8 | 60.9 | 5.8 |
| 80 | 7.5 | 0.8 | 1.8 | 1630 | 62.5 | 44.1 | 4.0 | 76.2 | 15.4 | 100.3 | 5.5 | 7.5 | 0.8 | 1.8 | 1800 | 83.1 | 4.75 | 66.9 | 5.1 | 112.8 | 62.2 | 5.8 |
| | 7.5 | 0.8 | 1.8 | 1850 | 63.5 | 47.5 | 4.19 | 77.8 | 15.1 | 100.8 | 5.6 | 7.5 | 0.8 | 1.8 | 2050 | 84.4 | 4.61 | 68.7 | 5.4 | 108.1 | 61.7 | 5.9 |
| | 11.3 | 2.2 | 5.2 | 1630 | 65.1 | 45.1 | 3.8 | 77.9 | 17.2 | 93.8 | 4.7 | 9.3 | 1.4 | 3.3 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 11.3 | 2.2 | 5.2 | 1850 | 66.2 | 48.5 | 3.91 | 79.6 | 16.9 | 94.1 | 4.8 | 9.5 | 1.5 | 3.6 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 15.0 | 4.1 | 9.4 | 1630 | 66.4 | 45.6 | 3.6 | 78.7 | 18.2 | 90.5 | 4.3 | 9.3 | 1.4 | 3.3 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 15.0 | 4.1 | 9.4 | 1850 | 67.5 | 49.0 | 3.78 | 80.4 | 17.9 | 90.7 | 4.4 | 9.5 | 1.5 | 3.6 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| 90 | 7.5 | 0.8 | 2.0 | 1630 | 58.7 | 42.6 | 4.5 | 74.0 | 13.1 | 109.7 | 6.7 | 5.6 | 0.2 | 0.4 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 7.5 | 0.8 | 2.0 | 1850 | 59.8 | 45.8 | 4.65 | 75.6 | 12.9 | 110.2 | 6.8 | 5.7 | 0.2 | 0.5 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 11.3 | 2.3 | 5.2 | 1630 | 61.3 | 43.7 | 4.2 | 75.5 | 14.7 | 103.4 | 5.8 | 5.6 | 0.2 | 0.4 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 11.3 | 2.3 | 5.2 | 1850 | 62.3 | 47.0 | 4.33 | 77.1 | 14.4 | 103.7 | 5.9 | 5.7 | 0.2 | 0.5 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 15.0 | 4.0 | 9.3 | 1630 | 62.6 | 44.2 | 4.0 | 76.3 | 15.5 | 100.2 | 5.4 | 5.6 | 0.2 | 0.4 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 15.0 | 4.0 | 9.3 | 1850 | 63.7 | 47.5 | 4.18 | 77.9 | 15.2 | 100.4 | 5.5 | 5.7 | 0.2 | 0.5 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| 100 | 7.5 | 0.9 | 2.0 | 1630 | 55.2 | 41.1 | 5.0 | 72.3 | 11.0 | 119.3 | 8.1 | 4.0 | 0.1 | 0.2 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 7.5 | 0.9 | 2.0 | 1850 | 56.2 | 44.2 | 5.18 | 73.9 | 10.8 | 119.7 | 8.3 | 4.1 | 0.1 | 0.2 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 11.3 | 2.3 | 5.2 | 1630 | 57.5 | 42.1 | 4.6 | 73.4 | 12.4 | 113.0 | 7.1 | 4.0 | 0.1 | 0.2 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 11.3 | 2.3 | 5.2 | 1850 | 58.5 | 45.3 | 4.82 | 75.0 | 12.1 | 113.3 | 7.3 | 4.1 | 0.1 | 0.2 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 15.0 | 4.0 | 9.3 | 1630 | 58.8 | 42.6 | 4.5 | 74.0 | 13.1 | 109.9 | 6.7 | 4.0 | 0.1 | 0.2 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 15.0 | 4.0 | 9.3 | 1850 | 59.8 | 45.9 | 4.65 | 75.6 | 12.9 | 110.1 | 6.8 | 4.1 | 0.1 | 0.2 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| 110 | 7.5 | 0.8 | 1.8 | 1630 | 52.2 | 39.6 | 5.6 | 71.4 | 9.3 | 129.0 | 9.8 | 3.1 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 7.5 | 0.8 | 1.8 | 1850 | 53.1 | 42.6 | 5.80 | 72.9 | 9.2 | 129.4 | 10.0 | 3.2 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 11.3 | 2.2 | 5.1 | 1630 | 54.1 | 40.6 | 5.2 | 71.9 | 10.4 | 122.7 | 8.7 | 3.1 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 11.3 | 2.2 | 5.1 | 1850 | 55.0 | 43.6 | 5.39 | 73.4 | 10.2 | 123.1 | 8.8 | 3.2 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 15.0 | 4.0 | 9.2 | 1630 | 55.2 | 41.1 | 5.0 | 72.3 | 11.0 | 119.6 | 8.2 | 3.1 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 15.0 | 4.0 | 9.2 | 1850 | 56.1 | 44.2 | 5.19 | 73.8 | 10.8 | 119.8 | 8.3 | 3.2 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| 120 | 7.5 | 0.6 | 1.3 | 1630 | 50.0 | 38.5 | 6.3 | 71.6 | 7.9 | 139.1 | 11.7 | 2.5 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 7.5 | 0.6 | 1.3 | 1850 | 50.8 | 41.4 | 6.53 | 73.1 | 7.8 | 139.5 | 11.9 | 2.6 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 11.3 | 2.0 | 4.7 | 1630 | 51.3 | 39.2 | 5.8 | 71.3 | 8.8 | 132.6 | 10.4 | 2.5 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 11.3 | 2.0 | 4.7 | 1850 | 52.2 | 42.1 | 6.04 | 72.8 | 8.6 | 132.9 | 10.6 | 2.6 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |
| | 15.0 | 3.8 | 8.8 | 1630 | 52.1 | 39.6 | 5.6 | 71.3 | 9.3 | 129.5 | 9.8 | 2.5 | 0.1 | 0.1 | 1800 | 86.0 | 4.84 | 69.5 | 5.2 | 114.3 | 65.0 | 6.0 |
| | 15.0 | 3.8 | 8.8 | 1850 | 53.0 | 42.6 | 5.82 | 72.9 | 9.1 | 129.7 | 10.0 | 2.6 | 0.1 | 0.1 | 2050 | 87.3 | 4.69 | 71.3 | 5.5 | 109.4 | 65.0 | 6.1 |

Interpolation is permissible, extrapolation is not. All performance data is based on the lower voltage of dual voltage units.
Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **climatemaster.com**.

## Performance Data – TE H/V/D 072 (Part Load), With vFlow®

1650 CFM Nominal (Rated) Airflow Heating, 1550 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | GPM | WPD | | COOLING - EAT 80/67 °F | | | | | | | | GPM | WPD | | HEATING - 70°F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSI | FT | CFM | TC | SC | kW | HR | EER | LWT | HWC | | PSI | FT | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| 20 | 2.8 | 0.1 | 0.2 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 14.0 | 6.5 | 15.1 | 1450 | 32.9 | 3.66 | 20.9 | 2.6 | 91.0 | 17.0 | 4.1 |
| | 2.8 | 0.1 | 0.2 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 14.0 | 6.5 | 15.1 | 1650 | 33.4 | 3.51 | 21.4 | 2.8 | 88.7 | 16.9 | 4.1 |
| 30 | 3.5 | 0.1 | 0.2 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 7.0 | 1.4 | 3.3 | 1450 | 37.2 | 3.72 | 24.8 | 2.9 | 93.7 | 22.9 | 4.2 |
| | 3.5 | 0.1 | 0.2 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 7.0 | 1.4 | 3.3 | 1650 | 37.7 | 3.57 | 25.5 | 3.1 | 91.1 | 22.7 | 4.3 |
| | 3.5 | 0.1 | 0.2 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 10.5 | 3.3 | 7.6 | 1450 | 38.7 | 3.75 | 26.3 | 3.0 | 94.7 | 25.0 | 4.2 |
| | 3.5 | 0.1 | 0.2 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 10.5 | 3.3 | 7.6 | 1650 | 39.3 | 3.59 | 27.0 | 3.2 | 92.0 | 24.9 | 4.3 |
| | 3.5 | 0.1 | 0.2 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 14.0 | 5.4 | 12.5 | 1450 | 39.6 | 3.76 | 27.1 | 3.1 | 95.3 | 26.1 | 4.2 |
| | 3.5 | 0.1 | 0.2 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 14.0 | 5.4 | 12.5 | 1650 | 40.1 | 3.60 | 27.8 | 3.3 | 92.5 | 26.0 | 4.3 |
| 40 | 4.6 | 0.1 | 0.2 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 7.0 | 0.9 | 2.2 | 1450 | 43.3 | 3.81 | 30.6 | 3.3 | 97.6 | 31.3 | 4.4 |
| | 4.7 | 0.2 | 0.4 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 7.0 | 0.9 | 2.2 | 1650 | 43.9 | 3.65 | 31.4 | 3.5 | 94.6 | 31.0 | 4.5 |
| | 4.6 | 0.2 | 0.4 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 10.5 | 2.6 | 6.1 | 1450 | 45.2 | 3.84 | 32.4 | 3.5 | 98.9 | 33.8 | 4.4 |
| | 4.7 | 0.2 | 0.4 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 10.5 | 2.6 | 6.1 | 1650 | 45.8 | 3.68 | 33.3 | 3.7 | 95.7 | 33.7 | 4.5 |
| | 4.6 | 0.2 | 0.4 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 14.0 | 4.6 | 10.7 | 1450 | 46.3 | 3.85 | 33.4 | 3.5 | 99.5 | 35.2 | 4.4 |
| | 4.7 | 0.2 | 0.4 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 14.0 | 4.6 | 10.7 | 1650 | 46.9 | 3.69 | 34.3 | 3.7 | 96.3 | 35.1 | 4.5 |
| 50 | 7.0 | 0.7 | 1.5 | 1360 | 61.7 | 39.2 | 2.3 | 69.5 | 27.1 | 69.9 | 2.6 | 7.0 | 0.7 | 1.5 | 1450 | 49.4 | 3.90 | 36.3 | 3.7 | 101.5 | 39.6 | 4.7 |
| | 7.0 | 0.7 | 1.5 | 1550 | 62.9 | 41.9 | 2.32 | 70.8 | 27.1 | 70.2 | 2.7 | 7.0 | 0.7 | 1.5 | 1650 | 50.1 | 3.74 | 37.4 | 3.9 | 98.1 | 39.3 | 4.8 |
| | 7.0 | 0.6 | 1.5 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 10.5 | 2.2 | 5.1 | 1450 | 51.7 | 3.93 | 38.5 | 3.9 | 103.0 | 42.7 | 4.8 |
| | 7.1 | 0.7 | 1.6 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 10.5 | 2.2 | 5.1 | 1650 | 52.5 | 3.77 | 39.6 | 4.1 | 99.4 | 42.5 | 4.9 |
| | 7.0 | 0.6 | 1.5 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.2 | 70.0 | 2.6 | 14.0 | 4.1 | 9.4 | 1450 | 53.0 | 3.95 | 39.7 | 3.9 | 103.8 | 44.3 | 4.8 |
| | 7.1 | 0.7 | 1.6 | 1550 | 63.0 | 42.0 | 2.31 | 70.9 | 27.2 | 70.0 | 2.7 | 14.0 | 4.1 | 9.4 | 1650 | 53.8 | 3.78 | 40.8 | 4.2 | 100.2 | 44.2 | 4.9 |
| 60 | 7.0 | 0.5 | 1.3 | 1360 | 59.1 | 38.1 | 2.6 | 68.0 | 22.7 | 79.4 | 3.2 | 7.0 | 0.5 | 1.3 | 1450 | 55.6 | 3.98 | 42.2 | 4.1 | 105.5 | 48.0 | 5.1 |
| | 7.0 | 0.5 | 1.3 | 1550 | 60.2 | 40.8 | 2.65 | 69.3 | 22.7 | 79.8 | 3.2 | 7.0 | 0.5 | 1.3 | 1650 | 56.4 | 3.82 | 43.3 | 4.3 | 101.6 | 47.6 | 5.2 |
| | 10.5 | 2.0 | 4.6 | 1360 | 60.9 | 38.8 | 2.4 | 69.0 | 25.6 | 73.1 | 2.8 | 10.5 | 2.0 | 4.6 | 1450 | 58.3 | 4.02 | 44.7 | 4.2 | 107.2 | 51.5 | 5.2 |
| | 10.5 | 2.0 | 4.6 | 1550 | 62.1 | 41.6 | 2.42 | 70.4 | 25.6 | 73.4 | 2.9 | 10.5 | 2.0 | 4.6 | 1650 | 59.1 | 3.86 | 46.0 | 4.5 | 103.2 | 51.2 | 5.3 |
| | 14.0 | 3.8 | 8.7 | 1360 | 61.8 | 39.2 | 2.3 | 69.5 | 27.1 | 69.9 | 2.7 | 14.0 | 3.8 | 8.7 | 1450 | 59.8 | 4.04 | 46.1 | 4.3 | 108.2 | 53.4 | 5.3 |
| | 14.0 | 3.8 | 8.7 | 1550 | 63.0 | 42.0 | 2.32 | 70.9 | 27.2 | 70.1 | 2.7 | 14.0 | 3.8 | 8.7 | 1650 | 60.6 | 3.88 | 47.4 | 4.6 | 104.0 | 53.2 | 5.4 |
| 70 | 7.0 | 0.5 | 1.3 | 1360 | 56.0 | 36.9 | 3.0 | 66.2 | 18.8 | 88.9 | 4.2 | 7.0 | 0.5 | 1.3 | 1450 | 61.8 | 4.07 | 48.0 | 4.4 | 109.4 | 56.3 | 5.5 |
| | 7.0 | 0.5 | 1.3 | 1550 | 57.1 | 39.5 | 3.04 | 67.5 | 18.8 | 89.3 | 4.3 | 7.0 | 0.5 | 1.3 | 1650 | 62.6 | 3.90 | 49.3 | 4.7 | 105.1 | 55.9 | 5.6 |
| | 10.5 | 1.9 | 4.5 | 1360 | 58.1 | 37.7 | 2.7 | 67.4 | 21.3 | 82.8 | 3.6 | 10.5 | 1.9 | 4.5 | 1450 | 64.8 | 4.12 | 50.9 | 4.6 | 111.4 | 60.3 | 5.7 |
| | 10.5 | 1.9 | 4.5 | 1550 | 59.2 | 40.3 | 2.78 | 68.7 | 21.3 | 83.1 | 3.7 | 10.5 | 1.9 | 4.5 | 1650 | 65.8 | 3.95 | 52.3 | 4.9 | 106.9 | 60.0 | 5.8 |
| | 14.0 | 3.6 | 8.3 | 1360 | 59.1 | 38.1 | 2.6 | 67.9 | 22.7 | 79.7 | 3.4 | 14.0 | 3.6 | 8.3 | 1450 | 66.5 | 4.14 | 52.5 | 4.7 | 112.5 | 62.5 | 5.8 |
| | 14.0 | 3.6 | 8.3 | 1550 | 60.2 | 40.7 | 2.65 | 69.3 | 22.7 | 79.9 | 3.5 | 14.0 | 3.6 | 8.3 | 1650 | 67.5 | 3.97 | 53.9 | 5.0 | 107.9 | 62.3 | 5.9 |
| 80 | 7.0 | 0.6 | 1.4 | 1360 | 52.7 | 35.6 | 3.4 | 64.3 | 15.4 | 98.4 | 5.7 | 7.0 | 0.6 | 1.4 | 1450 | 68.0 | 4.17 | 53.8 | 4.8 | 113.4 | 64.6 | 6.0 |
| | 7.0 | 0.6 | 1.4 | 1550 | 53.7 | 38.1 | 3.48 | 65.6 | 15.4 | 98.7 | 5.8 | 7.0 | 0.6 | 1.4 | 1650 | 68.9 | 3.99 | 55.3 | 5.1 | 108.7 | 64.2 | 6.1 |
| | 10.5 | 1.9 | 4.5 | 1360 | 54.8 | 36.4 | 3.1 | 65.5 | 17.5 | 92.5 | 4.9 | 7.2 | 0.7 | 1.6 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 10.5 | 1.9 | 4.5 | 1550 | 55.9 | 39.0 | 3.19 | 66.8 | 17.5 | 92.7 | 5.0 | 7.4 | 0.8 | 1.8 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 14.0 | 3.5 | 8.1 | 1360 | 55.9 | 36.8 | 3.0 | 66.1 | 18.7 | 89.4 | 4.5 | 7.2 | 0.7 | 1.6 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 14.0 | 3.5 | 8.1 | 1550 | 57.0 | 39.4 | 3.05 | 67.4 | 18.7 | 89.6 | 4.6 | 7.4 | 0.8 | 1.8 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| 90 | 7.0 | 0.7 | 1.5 | 1360 | 49.1 | 34.2 | 3.9 | 62.5 | 12.6 | 107.8 | 7.5 | 4.3 | 0.3 | 0.6 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 7.0 | 0.7 | 1.5 | 1550 | 50.1 | 36.6 | 3.98 | 63.7 | 12.6 | 108.2 | 7.6 | 4.5 | 0.3 | 0.6 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 10.5 | 2.0 | 4.5 | 1360 | 51.3 | 35.0 | 3.6 | 63.6 | 14.3 | 102.1 | 6.5 | 4.3 | 0.3 | 0.6 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 10.5 | 2.0 | 4.5 | 1550 | 52.3 | 37.5 | 3.67 | 64.8 | 14.3 | 102.3 | 6.7 | 4.5 | 0.3 | 0.6 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 14.0 | 3.5 | 8.1 | 1360 | 52.4 | 35.5 | 3.4 | 64.2 | 15.2 | 99.2 | 6.1 | 4.3 | 0.3 | 0.6 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 14.0 | 3.5 | 8.1 | 1550 | 53.5 | 38.0 | 3.51 | 65.4 | 15.2 | 99.3 | 6.2 | 4.5 | 0.3 | 0.6 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| 100 | 7.0 | 0.7 | 1.6 | 1360 | 45.5 | 32.9 | 4.5 | 60.7 | 10.2 | 117.4 | 9.7 | 3.1 | 0.2 | 0.4 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 7.0 | 0.7 | 1.6 | 1550 | 46.4 | 35.2 | 4.54 | 61.9 | 10.2 | 117.7 | 9.9 | 3.2 | 0.2 | 0.4 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 10.5 | 2.0 | 4.5 | 1360 | 47.7 | 33.7 | 4.1 | 61.7 | 11.6 | 111.8 | 8.6 | 3.1 | 0.2 | 0.4 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 10.5 | 2.0 | 4.5 | 1550 | 48.6 | 36.0 | 4.20 | 62.9 | 11.6 | 112.0 | 8.8 | 3.2 | 0.2 | 0.4 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 14.0 | 3.5 | 8.1 | 1360 | 48.8 | 34.1 | 4.0 | 62.3 | 12.3 | 108.9 | 8.1 | 3.1 | 0.2 | 0.4 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 14.0 | 3.5 | 8.1 | 1550 | 49.7 | 36.5 | 4.03 | 63.5 | 12.3 | 109.1 | 8.2 | 3.2 | 0.2 | 0.4 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| 110 | 7.0 | 0.6 | 1.4 | 1360 | 42.0 | 31.5 | 5.1 | 59.3 | 8.3 | 126.9 | 12.4 | 2.4 | 0.1 | 0.2 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 7.0 | 0.6 | 1.4 | 1550 | 42.9 | 33.8 | 5.15 | 60.4 | 8.3 | 127.3 | 12.6 | 2.5 | 0.1 | 0.2 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 10.5 | 1.9 | 4.4 | 1360 | 44.1 | 32.3 | 4.7 | 60.1 | 9.4 | 121.4 | 11.1 | 2.4 | 0.1 | 0.2 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 10.5 | 1.9 | 4.4 | 1550 | 44.9 | 34.6 | 4.78 | 61.2 | 9.4 | 121.7 | 11.3 | 2.5 | 0.1 | 0.2 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 14.0 | 3.5 | 8.0 | 1360 | 45.1 | 32.7 | 4.5 | 60.5 | 10.0 | 118.6 | 10.5 | 2.4 | 0.1 | 0.2 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 14.0 | 3.5 | 8.0 | 1550 | 46.0 | 35.0 | 4.61 | 61.7 | 10.0 | 118.8 | 10.7 | 2.5 | 0.1 | 0.2 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| 120 | 7.0 | 0.4 | 0.9 | 1360 | 38.7 | 30.3 | 5.7 | 58.2 | 6.8 | 136.6 | 15.4 | 2.0 | 0.1 | 0.1 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 7.0 | 0.4 | 0.9 | 1550 | 39.5 | 32.5 | 5.82 | 59.4 | 6.8 | 137.0 | 15.7 | 2.0 | 0.1 | 0.1 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 10.5 | 1.7 | 3.9 | 1360 | 40.6 | 31.0 | 5.3 | 58.8 | 7.6 | 131.2 | 14.0 | 2.0 | 0.1 | 0.1 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 10.5 | 1.7 | 3.9 | 1550 | 41.4 | 33.2 | 5.43 | 59.9 | 7.6 | 131.4 | 14.3 | 2.0 | 0.1 | 0.1 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |
| | 14.0 | 3.3 | 7.6 | 1360 | 41.6 | 31.3 | 5.1 | 59.1 | 8.1 | 128.4 | 13.3 | 2.0 | 0.1 | 0.1 | 1450 | 68.5 | 4.17 | 54.3 | 4.8 | 113.8 | 65.0 | 6.0 |
| | 14.0 | 3.3 | 7.6 | 1550 | 42.4 | 33.6 | 5.24 | 60.2 | 8.1 | 128.6 | 13.6 | 2.0 | 0.1 | 0.1 | 1650 | 69.5 | 4.00 | 55.8 | 5.1 | 109.0 | 65.0 | 6.1 |

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Performance stated is at the rated power supply, performance may vary as the power supply varies from the rated.
Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
AHRI/ISO certified conditions are 80.6°F DB and 66.2°F WB in cooling and 68°F DB in heating.
Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Performance Data – TE H/V/D 072 (Full Load), With vFlow®

2050 CFM Nominal (Rated) Airflow Heating, 1850 CFM Nominal (Rated) Airflow Cooling

Performance capacities shown in thousands of Btuh

| EWT °F | COOLING - EAT 80/67 °F | | | | | | | | | | HEATING - 70°F | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GPM | WPD | | CFM | TC | SC | kW | HR | EER | LWT | HWC | GPM | WPD | | CFM | HC | kW | HE | COP | LAT | LWT | HWC |
| | | PSI | FT | | | | | | | | | | PSI | FT | | | | | | | | |
| 20 | 3.7 | 0.3 | 0.6 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 17.0 | 8.9 | 20.6 | 1800 | 46.6 | 4.66 | 31.1 | 2.9 | 94.0 | 16.3 | 4.9 |
| | 3.7 | 0.3 | 0.6 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 17.0 | 8.9 | 20.6 | 2050 | 47.3 | 4.52 | 31.9 | 3.1 | 91.4 | 16.2 | 5.0 |
| 30 | 4.6 | 0.2 | 0.5 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 8.5 | 2.2 | 5.1 | 1800 | 51.6 | 4.77 | 35.6 | 3.2 | 96.5 | 21.6 | 5.1 |
| | 4.7 | 0.3 | 0.6 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 8.5 | 2.2 | 5.1 | 2050 | 52.4 | 4.63 | 36.6 | 3.3 | 93.7 | 21.4 | 5.2 |
| | 4.6 | 0.2 | 0.5 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 12.8 | 4.6 | 10.6 | 1800 | 54.0 | 4.83 | 37.8 | 3.3 | 97.8 | 24.1 | 5.3 |
| | 4.7 | 0.3 | 0.6 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 12.8 | 4.6 | 10.6 | 2050 | 54.8 | 4.68 | 38.8 | 3.4 | 94.8 | 23.9 | 5.4 |
| | 4.6 | 0.3 | 0.5 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 17.0 | 7.6 | 17.6 | 1800 | 55.3 | 4.86 | 39.0 | 3.3 | 98.4 | 25.4 | 5.3 |
| | 4.7 | 0.3 | 0.6 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 17.0 | 7.6 | 17.6 | 2050 | 56.1 | 4.71 | 40.1 | 3.5 | 95.3 | 25.3 | 5.5 |
| 40 | 6.1 | 0.5 | 1.2 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 8.5 | 1.6 | 3.8 | 1800 | 59.4 | 4.96 | 42.7 | 3.5 | 100.5 | 29.9 | 5.6 |
| | 6.2 | 0.6 | 1.3 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 8.5 | 1.6 | 3.8 | 2050 | 60.3 | 4.80 | 43.9 | 3.7 | 97.2 | 29.7 | 5.7 |
| | 6.1 | 0.5 | 1.2 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 12.8 | 3.9 | 8.9 | 1800 | 62.1 | 5.02 | 45.3 | 3.6 | 102.0 | 32.9 | 5.8 |
| | 6.2 | 0.6 | 1.3 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 12.8 | 3.9 | 8.9 | 2050 | 63.1 | 4.87 | 46.5 | 3.8 | 98.5 | 32.7 | 5.9 |
| | 6.1 | 0.5 | 1.2 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 17.0 | 6.7 | 15.5 | 1800 | 63.6 | 5.06 | 46.6 | 3.7 | 102.7 | 34.5 | 5.9 |
| | 6.2 | 0.6 | 1.3 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 17.0 | 6.7 | 15.5 | 2050 | 64.6 | 4.90 | 47.9 | 3.9 | 99.2 | 34.4 | 6.1 |
| 50 | 8.5 | 1.3 | 3.0 | 1630 | 79.1 | 49.0 | 3.5 | 91.0 | 22.3 | 71.4 | 4.5 | 8.5 | 1.3 | 3.0 | 1800 | 66.9 | 5.14 | 49.6 | 3.8 | 104.4 | 38.3 | 6.2 |
| | 8.5 | 1.3 | 3.0 | 1850 | 80.5 | 52.6 | 3.67 | 93.0 | 21.9 | 71.9 | 4.6 | 8.5 | 1.3 | 3.0 | 2050 | 67.9 | 4.99 | 50.9 | 4.0 | 100.7 | 38.0 | 6.3 |
| | 9.1 | 1.6 | 3.7 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 12.8 | 3.4 | 7.8 | 1800 | 70.1 | 5.23 | 52.5 | 3.9 | 106.1 | 41.8 | 6.5 |
| | 9.3 | 1.7 | 3.9 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 12.8 | 3.4 | 7.8 | 2050 | 71.2 | 5.07 | 53.9 | 4.1 | 102.1 | 41.5 | 6.6 |
| | 9.1 | 1.6 | 3.7 | 1630 | 79.6 | 49.1 | 3.5 | 91.3 | 22.8 | 70.0 | 4.4 | 17.0 | 6.0 | 13.9 | 1800 | 71.8 | 5.27 | 54.0 | 4.0 | 106.9 | 43.6 | 6.6 |
| | 9.3 | 1.7 | 3.9 | 1850 | 81.0 | 52.8 | 3.61 | 93.3 | 22.4 | 70.0 | 4.5 | 17.0 | 6.0 | 13.9 | 2050 | 72.9 | 5.11 | 55.5 | 4.2 | 102.9 | 43.5 | 6.8 |
| 60 | 8.5 | 1.2 | 2.7 | 1630 | 76.1 | 47.8 | 3.9 | 89.2 | 19.6 | 81.0 | 5.4 | 8.5 | 1.2 | 2.7 | 1800 | 74.4 | 5.34 | 56.4 | 4.1 | 108.3 | 46.7 | 6.9 |
| | 8.5 | 1.2 | 2.7 | 1850 | 77.4 | 51.4 | 4.01 | 91.1 | 19.3 | 81.4 | 5.6 | 8.5 | 1.2 | 2.7 | 2050 | 75.5 | 5.18 | 57.9 | 4.3 | 104.1 | 46.4 | 7.1 |
| | 12.8 | 3.1 | 7.1 | 1630 | 78.3 | 48.7 | 3.6 | 90.6 | 21.6 | 74.2 | 4.7 | 12.8 | 3.1 | 7.1 | 1800 | 78.0 | 5.44 | 59.6 | 4.2 | 110.1 | 50.7 | 7.3 |
| | 12.8 | 3.1 | 7.1 | 1850 | 79.7 | 52.3 | 3.76 | 92.5 | 21.2 | 74.5 | 4.8 | 12.8 | 3.1 | 7.1 | 2050 | 79.2 | 5.28 | 61.2 | 4.4 | 105.8 | 50.4 | 7.4 |
| | 17.0 | 5.6 | 13.0 | 1630 | 79.3 | 49.1 | 3.5 | 91.2 | 22.6 | 70.7 | 4.4 | 17.0 | 5.6 | 13.0 | 1800 | 80.0 | 5.50 | 61.4 | 4.3 | 111.1 | 52.8 | 7.5 |
| | 17.0 | 5.6 | 13.0 | 1850 | 80.7 | 52.7 | 3.64 | 93.1 | 22.2 | 71.0 | 4.5 | 17.0 | 5.6 | 13.0 | 2050 | 81.2 | 5.33 | 63.0 | 4.5 | 106.7 | 52.6 | 7.7 |
| 70 | 8.5 | 1.1 | 2.6 | 1630 | 72.4 | 46.3 | 4.3 | 86.9 | 17.0 | 90.4 | 6.7 | 8.5 | 1.1 | 2.6 | 1800 | 81.9 | 5.56 | 63.1 | 4.3 | 112.1 | 55.2 | 7.7 |
| | 8.5 | 1.1 | 2.6 | 1850 | 73.7 | 49.8 | 4.42 | 88.7 | 16.7 | 90.9 | 6.8 | 8.5 | 1.1 | 2.6 | 2050 | 83.2 | 5.38 | 64.8 | 4.5 | 107.6 | 54.8 | 7.9 |
| | 12.8 | 3.0 | 6.8 | 1630 | 75.0 | 47.4 | 4.0 | 88.5 | 18.9 | 83.8 | 5.8 | 12.8 | 3.0 | 6.8 | 1800 | 86.0 | 5.68 | 66.7 | 4.4 | 114.2 | 59.5 | 8.2 |
| | 12.8 | 3.0 | 6.8 | 1850 | 76.3 | 50.9 | 4.12 | 90.4 | 18.5 | 84.2 | 5.9 | 12.8 | 3.0 | 6.8 | 2050 | 87.3 | 5.50 | 68.5 | 4.6 | 109.4 | 59.3 | 8.4 |
| | 17.0 | 5.4 | 12.4 | 1630 | 76.3 | 47.9 | 3.8 | 89.3 | 19.8 | 80.5 | 5.4 | 17.0 | 5.4 | 12.4 | 1800 | 88.2 | 5.75 | 68.7 | 4.5 | 115.4 | 61.9 | 8.5 |
| | 17.0 | 5.4 | 12.4 | 1850 | 77.6 | 51.5 | 3.99 | 91.2 | 19.5 | 80.7 | 5.5 | 17.0 | 5.4 | 12.4 | 2050 | 89.5 | 5.57 | 70.5 | 4.7 | 110.4 | 61.7 | 8.7 |
| 80 | 8.5 | 1.2 | 2.7 | 1630 | 68.4 | 44.7 | 4.7 | 84.4 | 14.5 | 99.9 | 8.2 | 8.5 | 1.2 | 2.7 | 1800 | 89.5 | 5.79 | 69.9 | 4.5 | 116.0 | 63.6 | 8.7 |
| | 8.5 | 1.2 | 2.7 | 1850 | 69.5 | 48.1 | 4.89 | 86.2 | 14.2 | 100.3 | 8.4 | 8.5 | 1.2 | 2.7 | 2050 | 90.9 | 5.61 | 71.7 | 4.7 | 111.0 | 63.1 | 8.8 |
| | 12.8 | 2.9 | 6.7 | 1630 | 71.2 | 45.8 | 4.4 | 86.1 | 16.2 | 93.5 | 7.1 | 9.5 | 1.5 | 3.6 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 12.8 | 2.9 | 6.7 | 1850 | 72.4 | 49.3 | 4.56 | 88.0 | 15.9 | 93.8 | 7.3 | 9.8 | 1.6 | 3.8 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 17.0 | 5.2 | 12.1 | 1630 | 72.6 | 46.4 | 4.2 | 87.0 | 17.1 | 90.2 | 6.6 | 9.5 | 1.5 | 3.6 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 17.0 | 5.2 | 12.1 | 1850 | 73.8 | 49.9 | 4.40 | 88.8 | 16.8 | 90.5 | 6.7 | 9.8 | 1.6 | 3.8 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| 90 | 8.5 | 1.2 | 2.8 | 1630 | 64.1 | 43.0 | 5.3 | 82.0 | 12.2 | 109.3 | 10.0 | 5.7 | 0.2 | 0.5 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 8.5 | 1.2 | 2.8 | 1850 | 65.2 | 46.2 | 5.45 | 83.8 | 12.0 | 109.7 | 10.3 | 5.9 | 0.3 | 0.6 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 12.8 | 2.9 | 6.7 | 1630 | 67.0 | 44.1 | 4.9 | 83.6 | 13.7 | 103.1 | 8.8 | 5.7 | 0.2 | 0.5 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 12.8 | 2.9 | 6.7 | 1850 | 68.1 | 47.4 | 5.07 | 85.4 | 13.4 | 103.4 | 9.0 | 5.9 | 0.3 | 0.6 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 17.0 | 5.2 | 12.0 | 1630 | 68.4 | 44.7 | 4.7 | 84.5 | 14.5 | 99.9 | 8.2 | 5.7 | 0.2 | 0.5 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 17.0 | 5.2 | 12.0 | 1850 | 69.6 | 48.1 | 4.88 | 86.3 | 14.2 | 100.1 | 8.4 | 5.9 | 0.3 | 0.6 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| 100 | 8.5 | 1.2 | 2.8 | 1630 | 59.8 | 41.2 | 5.9 | 79.9 | 10.2 | 118.8 | 12.2 | 4.1 | 0.1 | 0.2 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 8.5 | 1.2 | 2.8 | 1850 | 60.9 | 44.3 | 6.09 | 81.6 | 10.0 | 119.2 | 12.5 | 4.2 | 0.1 | 0.2 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 12.8 | 2.9 | 6.7 | 1630 | 62.6 | 42.3 | 5.5 | 81.3 | 11.5 | 112.7 | 10.8 | 4.1 | 0.1 | 0.2 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 12.8 | 2.9 | 6.7 | 1850 | 63.7 | 45.5 | 5.66 | 83.0 | 11.2 | 113.0 | 11.0 | 4.2 | 0.1 | 0.2 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 17.0 | 5.2 | 12.0 | 1630 | 64.0 | 42.9 | 5.3 | 82.0 | 12.2 | 109.6 | 10.1 | 4.1 | 0.1 | 0.2 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 17.0 | 5.2 | 12.0 | 1850 | 65.1 | 46.2 | 5.46 | 83.8 | 11.9 | 109.9 | 10.3 | 4.2 | 0.1 | 0.2 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| 110 | 8.5 | 1.1 | 2.6 | 1630 | 55.7 | 39.5 | 6.6 | 78.3 | 8.4 | 128.4 | 14.7 | 3.2 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 8.5 | 1.1 | 2.6 | 1850 | 56.7 | 42.5 | 6.85 | 80.0 | 8.3 | 128.8 | 15.0 | 3.3 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 12.8 | 2.9 | 6.6 | 1630 | 58.3 | 40.6 | 6.1 | 79.3 | 9.5 | 122.4 | 13.1 | 3.2 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 12.8 | 2.9 | 6.6 | 1850 | 59.3 | 43.6 | 6.36 | 81.0 | 9.3 | 122.7 | 13.4 | 3.3 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 17.0 | 5.1 | 11.8 | 1630 | 59.6 | 41.1 | 5.9 | 79.9 | 10.1 | 119.4 | 12.3 | 3.2 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 17.0 | 5.1 | 11.8 | 1850 | 60.7 | 44.2 | 6.12 | 81.6 | 9.9 | 119.6 | 12.6 | 3.3 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| 120 | 8.5 | 0.9 | 2.1 | 1630 | 52.0 | 38.1 | 7.5 | 77.6 | 7.0 | 138.3 | 17.6 | 2.6 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 8.5 | 0.9 | 2.1 | 1850 | 52.9 | 41.0 | 7.72 | 79.2 | 6.8 | 138.6 | 18.0 | 2.7 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 12.8 | 2.7 | 6.2 | 1630 | 54.2 | 39.0 | 6.9 | 77.9 | 7.8 | 132.2 | 15.8 | 2.6 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 12.8 | 2.7 | 6.2 | 1850 | 55.2 | 41.9 | 7.16 | 79.6 | 7.7 | 132.5 | 16.1 | 2.7 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |
| | 17.0 | 5.0 | 11.5 | 1630 | 55.5 | 39.4 | 6.7 | 78.3 | 8.3 | 129.2 | 14.9 | 2.6 | 0.1 | 0.1 | 1800 | 91.2 | 5.84 | 71.4 | 4.6 | 116.9 | 65.0 | 9.0 |
| | 17.0 | 5.0 | 11.5 | 1850 | 56.4 | 42.4 | 6.90 | 80.0 | 8.2 | 129.4 | 15.2 | 2.7 | 0.1 | 0.1 | 2050 | 92.6 | 5.66 | 73.3 | 4.8 | 111.8 | 65.0 | 9.2 |

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Table is with entering air of 80°F DB and 67°F WB in cooling, and 70°F DB in heating.
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Table does not reflect fan or pump power corrections for AHRI/ISO conditions.
See performance correction tables for operating conditions other than those listed above. See performance data selection notes for operation in the shaded areas.
Operation below 40°F EWT is based on a 15% methanol antifreeze solution.
Operation below 60°F EWT requires optional extended range insulated water and refrigerant circuits to avoid condensation within the unit cabinet.

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## Part Load Performance Data – Correction Tables

### Air Flow Correction Table

| Airflow | Cooling | | | | Heating | | |
|---|---|---|---|---|---|---|---|
| % of Rated | Total Capacity | Sensible Capacity | Power | Heat of Rejection | Heating Capacity | Power | Heat of Extraction |
| 60% | 0.920 | 0.781 | 0.959 | 0.927 | 0.946 | 1.241 | 0.881 |
| 69% | 0.942 | 0.832 | 0.964 | 0.946 | 0.960 | 1.163 | 0.915 |
| 75% | 0.956 | 0.867 | 0.696 | 0.959 | 0.969 | 1.115 | 0.937 |
| 81% | 0.969 | 0.901 | 0.975 | 0.970 | 0.978 | 1.076 | 0.956 |
| 88% | 0.981 | 0.934 | 0.982 | 0.981 | 0.986 | 1.043 | 0.973 |
| 94% | 0.991 | 0.967 | 0.990 | 0.991 | 0.993 | 1.018 | 0.988 |
| 100% | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 106% | 1.007 | 1.033 | 1.011 | 1.008 | 1.006 | 0.990 | 1.010 |
| 113% | 1.013 | 1.065 | 1.023 | 1.015 | 1.012 | 0.986 | 1.017 |
| 119% | 1.018 | 1.098 | 1.036 | 1.021 | 1.017 | 0.983 | 1.024 |
| 125% | 1.021 | 1.131 | 1.051 | 1.026 | 1.021 | 0.981 | 1.030 |
| 130% | 1.023 | 1.159 | 1.063 | 1.030 | 1.024 | 0.979 | 1.034 |

### Entering Air Correction Table

| Heating | | | |
|---|---|---|---|
| Entering Air DB°F | Heating Capacity | Power | Heat of Extraction |
| 40 | 1.084 | 0.732 | 1.161 |
| 45 | 1.073 | 0.764 | 1.140 |
| 50 | 1.060 | 0.802 | 1.117 |
| 55 | 1.046 | 0.846 | 1.090 |
| 60 | 1.031 | 0.893 | 1.061 |
| 65 | 1.016 | 0.945 | 1.031 |
| 68 | 1.006 | 0.978 | 1.013 |
| 70 | 1.000 | 1.000 | 1.000 |
| 75 | 0.984 | 1.058 | 0.968 |
| 80 | 0.968 | 1.117 | 0.936 |

* = Sensible capacity equals total capacity
AHRI/ISO/ASHRAE 13256-1 uses entering air conditions of Cooling - 80.6°F DB/66.2°F WB, 1 and Heating - 68°F DB/59°F WB entering air temperature

| Cooling | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entering Air WB°F | Total Capacity | Sensible Cooling Capacity Multiplier - Entering DB °F | | | | | | | | | | Power | Heat of Rejection |
| | | 60 | 65 | 70 | 75 | 80 | 80.6 | 85 | 90 | 95 | 100 | | |
| 45 | 0.876 | 1.286 | 1.302 | 1.389 | * | * | * | * | * | * | * | 0.981 | 0.895 |
| 50 | 0.883 | 1.002 | 1.099 | 1.241 | * | * | * | * | * | * | * | 0.985 | 0.901 |
| 55 | 0.903 | 0.706 | 0.871 | 1.060 | 1.271 | * | * | * | * | * | * | 0.989 | 0.918 |
| 60 | 0.935 | | 0.617 | 0.844 | 1.079 | 1.319 | 1.349 | * | * | * | * | 0.993 | 0.945 |
| 65 | 0.979 | | | 0.595 | 0.849 | 1.096 | 1.128 | 1.342 | * | * | * | 0.998 | 0.982 |
| 66.2 | 0.991 | | | 0.531 | 0.789 | 1.040 | 1.070 | 1.284 | 1.522 | * | * | 0.999 | 0.993 |
| 67 | 1.000 | | | 0.486 | 0.747 | 1.000 | 1.030 | 1.245 | 1.481 | * | * | 1.000 | 1.000 |
| 70 | 1.035 | | | | 0.583 | 0.842 | 0.873 | 1.090 | 1.327 | 1.552 | * | 1.003 | 1.030 |
| 75 | 1.105 | | | | | 0.552 | 0.584 | 0.811 | 1.057 | 1.290 | 1.510 | 1.008 | 1.088 |

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## Full Load Performance Data – Correction Tables

### Air Flow Correction Table

| Airflow | Cooling | | | | Heating | | |
|---|---|---|---|---|---|---|---|
| % of Rated | Total Capacity | Sensible Capacity | Power | Heat of Rejection | Heating Capacity | Power | Heat of Extraction |
| 60% | 0.925 | 0.788 | 0.913 | 0.922 | 0.946 | 1.153 | 0.896 |
| 69% | 0.946 | 0.829 | 0.926 | 0.942 | 0.959 | 1.107 | 0.924 |
| 75% | 0.960 | 0.861 | 0.937 | 0.955 | 0.969 | 1.078 | 0.942 |
| 81% | 0.972 | 0.895 | 0.950 | 0.968 | 0.977 | 1.053 | 0.959 |
| 88% | 0.983 | 0.930 | 0.965 | 0.979 | 0.985 | 1.032 | 0.974 |
| 94% | 0.992 | 0.965 | 0.982 | 0.990 | 0.993 | 1.014 | 0.988 |
| 100% | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 106% | 1.007 | 1.033 | 1.020 | 1.009 | 1.006 | 0.989 | 1.011 |
| 113% | 1.012 | 1.064 | 1.042 | 1.018 | 1.012 | 0.982 | 1.019 |
| 119% | 1.016 | 1.092 | 1.066 | 1.025 | 1.018 | 0.979 | 1.027 |
| 125% | 1.018 | 1.116 | 1.091 | 1.032 | 1.022 | 0.977 | 1.033 |
| 130% | 1.019 | 1.132 | 1.112 | 1.037 | 1.026 | 0.975 | 1.038 |

### Entering Air Correction Table

| Heating | | | |
|---|---|---|---|
| Entering Air DB°F | Heating Capacity | Power | Heat of Extraction |
| 40 | 1.052 | 0.779 | 1.120 |
| 45 | 1.043 | 0.808 | 1.102 |
| 50 | 1.035 | 0.841 | 1.084 |
| 55 | 1.027 | 0.877 | 1.065 |
| 60 | 1.019 | 0.915 | 1.045 |
| 65 | 1.010 | 0.957 | 1.023 |
| 68 | 1.004 | 0.982 | 1.010 |
| 70 | 1.000 | 1.000 | 1.000 |
| 75 | 0.989 | 1.045 | 0.974 |
| 80 | 0.976 | 1.093 | 0.946 |

* = Sensible capacity equals total capacity
AHRI/ISO/ASHRAE 13256-1 uses entering air conditions of Cooling - 80.6°F DB/66.2°F WB, 1 and Heating - 68°F DB/59°F WB entering air temperature

| Cooling | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entering Air WB°F | Total Capacity | Sensible Cooling Capacity Multiplier - Entering DB °F | | | | | | | | | | Power | Heat of Rejection |
| | | 60 | 65 | 70 | 75 | 80 | 80.6 | 85 | 90 | 95 | 100 | | |
| 45 | 0.832 | * | * | * | * | * | * | * | * | * | * | 0.946 | 0.853 |
| 50 | 0.850 | 1.004 | 1.174 | * | * | * | * | * | * | * | * | 0.953 | 0.870 |
| 55 | 0.880 | 0.694 | 0.902 | 1.115 | * | * | * | * | * | * | * | 0.964 | 0.896 |
| 60 | 0.922 | | 0.646 | 0.875 | 1.103 | 1.329 | * | * | * | * | * | 0.977 | 0.932 |
| 65 | 0.975 | | | 0.639 | 0.869 | 1.096 | 1.123 | 1.320 | * | * | * | 0.993 | 0.979 |
| 66.2 | 0.990 | | | 0.582 | 0.812 | 1.039 | 1.066 | 1.262 | * | * | * | 0.997 | 0.991 |
| 67 | 1.000 | | | 0.545 | 0.774 | 1.000 | 1.027 | 1.223 | 1.444 | * | * | 1.000 | 1.000 |
| 70 | 1.040 | | | | 0.630 | 0.853 | 0.880 | 1.075 | 1.297 | * | * | 1.011 | 1.035 |
| 75 | 1.117 | | | | | 0.601 | 0.627 | 0.821 | 1.046 | 1.275 | 1.510 | 1.033 | 1.101 |

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## Antifreeze & Water Pressure Drop Adder for Options – Correction Tables

### Antifreeze Correction Table

| Antifreeze Type | Antifreeze % | Cooling EWT 90°F | | | Heating EWT 30°F | | WPD Corr. Fct. EWT 30°F |
|---|---|---|---|---|---|---|---|
| | | Total Cap | Sens Cap | Power | Htg Cap | Power | |
| Water | 0 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Propylene Glycol | 5 | 0.995 | 0.995 | 1.003 | 0.989 | 0.997 | 1.070 |
| | 15 | 0.986 | 0.986 | 1.009 | 0.968 | 0.990 | 1.210 |
| | 25 | 0.978 | 0.978 | 1.014 | 0.947 | 0.983 | 1.360 |
| Methanol | 5 | 0.997 | 0.997 | 1.002 | 0.989 | 0.997 | 1.070 |
| | 15 | 0.990 | 0.990 | 1.007 | 0.968 | 0.990 | 1.160 |
| | 25 | 0.982 | 0.982 | 1.012 | 0.949 | 0.984 | 1.220 |
| Ethanol | 5 | 0.998 | 0.998 | 1.002 | 0.981 | 0.994 | 1.140 |
| | 15 | 0.994 | 0.994 | 1.005 | 0.944 | 0.983 | 1.300 |
| | 25 | 0.986 | 0.986 | 1.009 | 0.917 | 0.974 | 1.360 |
| Ethylene Glycol | 5 | 0.998 | 0.998 | 1.002 | 0.993 | 0.998 | 1.040 |
| | 15 | 0.994 | 0.994 | 1.004 | 0.980 | 0.994 | 1.120 |
| | 25 | 0.988 | 0.988 | 1.008 | 0.966 | 0.990 | 1.200 |

### Modulating Valves for Closed Loop Applications, Low System Pressure Drop

| Model | CV | MOPD | WPD Adders | | |
|---|---|---|---|---|---|
| | | | GPM | PSI | FT |
| 026 | 4.7 | 200 | 3 | 0.41 | 0.94 |
| | 4.7 | 200 | 4.5 | 0.92 | 2.12 |
| | 4.7 | 200 | 6 | 1.63 | 3.76 |
| 038 | 7.4 | 200 | 4.5 | 0.37 | 0.85 |
| | 7.4 | 200 | 6.8 | 0.84 | 1.95 |
| | 7.4 | 200 | 9 | 1.48 | 3.42 |
| 049 | 10 | 200 | 6 | 0.36 | 0.83 |
| | 10 | 200 | 9 | 0.81 | 1.87 |
| | 10 | 200 | 12 | 1.44 | 3.33 |
| 064 | 19 | 200 | 7.5 | 0.16 | 0.36 |
| | 19 | 200 | 11.3 | 0.35 | 0.82 |
| | 19 | 200 | 15 | 0.62 | 1.44 |
| 072 | 19 | 200 | 8.5 | 0.20 | 0.46 |
| | 19 | 200 | 12.8 | 0.45 | 1.05 |
| | 19 | 200 | 17 | 0.80 | 1.85 |

### Modulating Valves for Open Loop Applications, High System Pressure Drop

| Model | CV | MOPD | WPD Adders | | |
|---|---|---|---|---|---|
| | | | GPM | PSI | FT |
| 026 | 4.7 | 200 | 3 | 0.41 | 0.94 |
| | 4.7 | 200 | 4.5 | 0.92 | 2.12 |
| | 4.7 | 200 | 6 | 1.63 | 3.76 |
| 038 | 4.7 | 200 | 4.5 | 0.92 | 2.12 |
| | 4.7 | 200 | 6.8 | 2.09 | 4.84 |
| | 4.7 | 200 | 9 | 3.67 | 8.47 |
| 049 | 4.7 | 200 | 6 | 1.63 | 3.76 |
| | 4.7 | 200 | 9 | 3.67 | 8.47 |
| | 4.7 | 200 | 12 | 6.52 | 15.06 |
| 064 | 7.4 | 200 | 7.5 | 1.03 | 2.37 |
| | 7.4 | 200 | 11.3 | 2.33 | 5.39 |
| | 7.4 | 200 | 15 | 4.11 | 9.49 |
| 072 | 7.4 | 200 | 8.5 | 1.32 | 3.05 |
| | 7.4 | 200 | 12.8 | 2.99 | 6.91 |
| | 7.4 | 200 | 17 | 5.28 | 12.19 |

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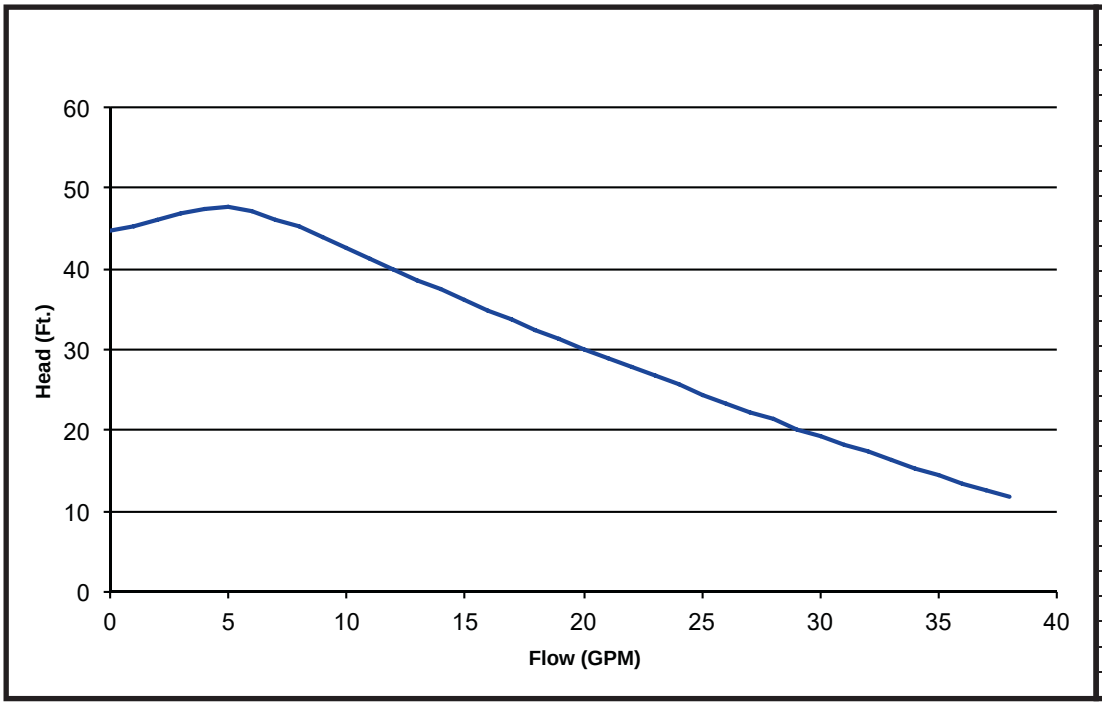
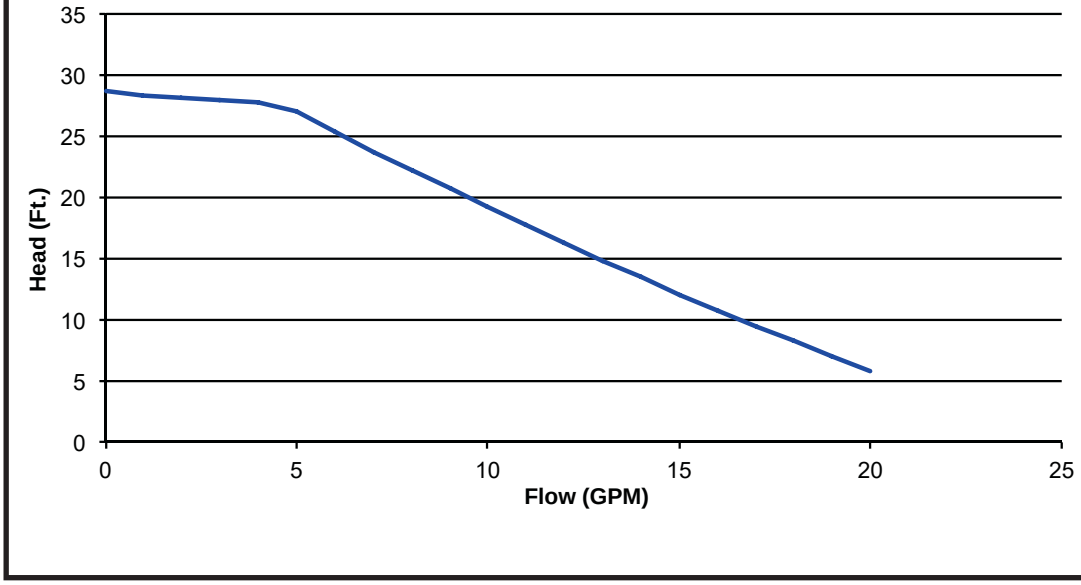
## Variable Pump Performance

### Magna Geo 25-140 High Head Variable Pump Performance




| GPM | Head (ft) |
|---|---|
| 0.0 | 44.7 |
| 1.0 | 45.4 |
| 2.0 | 46.1 |
| 3.0 | 46.8 |
| 4.0 | 47.5 |
| 5.0 | 47.7 |
| 6.0 | 47.1 |
| 7.0 | 46.1 |
| 8.0 | 45.3 |
| 9.0 | 43.9 |
| 10.0 | 42.6 |
| 11.0 | 41.2 |
| 12.0 | 39.9 |
| 13.0 | 38.7 |
| 14.0 | 37.4 |
| 15.0 | 36.1 |
| 16.0 | 34.9 |
| 17.0 | 33.7 |
| 18.0 | 32.5 |
| 19.0 | 31.3 |
| 20.0 | 30.1 |
| 21.0 | 28.9 |
| 22.0 | 27.8 |
| 23.0 | 26.7 |
| 24.0 | 25.6 |
| 25.0 | 24.5 |

### UPM Geo 25-85 Standard Head Variable Pump Performance




| GPM | Head (ft) |
|---|---|
| 0.00 | 28.7 |
| 1.00 | 28.4 |
| 2.00 | 28.1 |
| 3.00 | 27.9 |
| 4.00 | 27.7 |
| 5.00 | 27.0 |
| 6.00 | 25.3 |
| 7.00 | 23.7 |
| 8.00 | 22.2 |
| 9.00 | 20.6 |
| 10.00 | 19.1 |
| 11.00 | 17.7 |
| 12.00 | 16.2 |
| 13.00 | 14.8 |
| 14.00 | 13.4 |
| 15.00 | 12.1 |
| 16.00 | 10.8 |
| 17.00 | 9.5 |
| 18.00 | 8.2 |
| 19.00 | 7.0 |
| 20.00 | 5.8 |

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## ECM Blower Control

The ECM fan is controlled directly by the DXM2 control board that converts thermostat inputs and CFM settings to signals used by the ECM motor controller. To take full advantage of the ECM motor features, a communicating multi-stage thermostat should be used (ATC32U**).

The DXM2 control maintains a selectable operating airflow [CFM] for each heat pump operating mode. For each operating mode there are maximum and minimum airflow limits. See the ECM Blower Performance tables for the maximum, minimum, and default operating airflows.

Airflow levels are selected using the configuration menus of a communicating thermostat (ATC32U**) or diagnostic tool (ACDU**). The configuration menus allow the installer to independently select and adjust the operating airflow for each of the operating modes. Air flow can be selected in 25 CFM increments within the minimum and maximum limits shown in the ECM Blower Performance Table. The blower operating modes include:

- First Stage Cooling (Y1 & O)
- Second Stage Cooling (Y1, Y2, & O)
- First Stage Cooling in Dehumidification Mode (Y1, O, & Dehumid)
- Second Stage Cooling in Dehumidification Mode (Y1, Y2, O, & Dehumid)
- First Stage Heating (Y1)
- Second Stage Heating (Y1 & Y2)
- Third Stage (Auxiliary) Heating (Y1, Y2, & W)
- Emergency Heating (W with no Y1 or Y2)
- Fan (G with no Y1, Y2, or W)

It is highly recommended that ATC32U** or ACDU** be used to set dehumidification mode electronically. Dehumidification can NOT be selected when using a non-communicating thermostat with a vFlow® unit with Internal Flow Controller (pump). For dehumidification settings on other units using the non-communicating stat, refer to DXM2 AOM (part #97B0003N15).

The ECM motor includes "soft start" and "ramp down" features. The soft start feature is a gentle increase of motor rpm at blower start up. This creates a much quieter blower start cycle.

The ramp down feature allows the blower to slowly decrease rpm to a full stop at the end of each blower cycle. This creates a much quieter end to each blower cycle and adds overall unit efficiency.

The ramp down feature is eliminated during an ESD (Emergency Shut Down) situation. When the DXM2 ESD input is activated, the blower and all other control outputs are immediately de-activated.

The ramp down feature (also known as the heating or cooling "Off Delay") is field selectable by the installer. The allowable range is 0 to 255 seconds.

### Airflow Configuration Screen on Communicating Thermostat

| AIRFLOW SELECTION | CFM |
|---|---|
| HEAT STAGE 1 | 600 |
| HEAT STAGE 2 | 750 |
| AUXILIARY HEAT | 850 |
| EMERGENCY HEAT | 850 |
| COOL STAGE 1 | 525 |
| COOL STAGE 2 | 700 |
| COOL DEHUMID 1 | 425 |
| COOL DEHUMID 2 | 550 |
| CONTINUOUS FAN | 350 |
| HEAT OFF DELAY | 60 |
| COOL OFF DELAY | 30 |
| ◀ PREVIOUS | NEXT ▶ |

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## Blower Performance Data

### Standard Unit

Airflow in CFM with wet coil and clean air filter

| Model | Max ESP (in wg) | Fan Motor (hp) | Range | Cooling Mode | | Dehumid Mode | | Heating Mode | | Fan Only Mode | Aux Emerg Mode |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Stg 2 | Stg 1 | Stg 2 | Stg 1 | Stg 2 | Stg 1 | | |
| **026** | 1.0 | 1/2 | Default | 700 | 525 | 550 | 425 | 750 | 600 | 350 | 850 |
| | | | Maximum | 1000 | 800 | 800 | 600 | 1000 | 850 | 1000 | 1000 |
| | | | Minimum | 600 | 450 | 550 | 400 | 600 | 450 | 300 | 700 |
| **038** | 0.9 | 1/2 | Default | 1050 | 800 | 850 | 650 | 1100 | 850 | 550 | 1350 |
| | | | Maximum | 1500 | 1100 | 1200 | 900 | 1500 | 1100 | 1500 | 1500 |
| | | | Minimum | 900 | 600 | 825 | 550 | 900 | 600 | 450 | 1350 |
| **049** | 1.0 | 1 | Default | 1400 | 1050 | 1100 | 850 | 1500 | 1150 | 700 | 1500 |
| | | | Maximum | 2000 | 1500 | 1600 | 1200 | 2000 | 1500 | 2000 | 2000 |
| | | | Minimum | 1200 | 900 | 1100 | 825 | 1200 | 900 | 600 | 1350 |
| **064** | 0.7 | 1 | Default | 1750 | 1300 | 1400 | 1050 | 1875 | 1450 | 875 | 1875 |
| | | | Maximum | 2300 | 1900 | 2000 | 1500 | 2300 | 1900 | 2300 | 2300 |
| | | | Minimum | 1500 | 1100 | 1375 | 1000 | 1500 | 1100 | 750 | 1500 |
| **072** | 0.7 | 1 | Default | 1900 | 1450 | 1650 | 1250 | 2000 | 1650 | 950 | 2000 |
| | | | Maximum | 2300 | 2200 | 2000 | 1800 | 2300 | 2200 | 2300 | 2300 |
| | | | Minimum | 1800 | 1350 | 1650 | 1250 | 1800 | 1350 | 900 | 1800 |

Airflow is controlled within +/- 5% up to Max ESP shown with wet coil and standard 1" fiberglass filter.

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## Physical Data

| Model | 026 | 038 | 049 | 064 | 072 |
|---|---|---|---|---|---|
| Compressor (1 Each) | Two-Stage Scroll | | | | |
| Factory Charge (HFC-410A) (oz) [kg] | 44 [1.25] | 52 [1.47] | 69 [1.96] | 142 [4.03] | 140 [3.97] |
| **ECM Fan Motor & Blower** | | | | | |
| Fan Motor (hp) [W] | 1/2 [373] | 1/2 [373] | 1 [746] | 1 [746] | 1 [746] |
| Blower Wheel Size (dia x w) - (in) [mm] | 9 x 7 [229 x 178] | 11 x 10 [279 x 254] | 11 x 10 [279 x 254] | 11 x 10 [279 x 254] | 11 x 10 [279 x 254] |
| **Water Connection Size** | | | | | |
| FPT (in) | 3/4 | 3/4 | 1 | 1 | 1 |
| **HWG Connection Size** | | | | | |
| FPT (in) | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 |
| **Coax Volume** | | | | | |
| Volume (US Gallons) [liters] | 0.76 [2.88] | 0.92 [3.48] | 1.24 [4.69] | 1.56 [5.91] | 1.56 [5.91] |
| **Vertical Upflow/Downflow** | | | | | |
| Air Coil Dimensions (h x w) - (in) [mm] | 28 x 20 [711 x 508] | 28 x 25 [711 x 635] | 32 x 25 [813 x 635] | 36 x 25 [914 x 635] | 36 x 25 [914 x 635] |
| Standard Filter - 1" [25.4mm] Throwaway, qty (in) [mm] | 28 x 24 [711 x 610] | 28 x 29.5 [712 x 749] | 32 x 29.5 [813 x 749] | 36 x 29.5 [914 x 749] | 36 x 29.5 [914 x 749] |
| Weight - Operating, (lbs) [kg] | 298 [135] | 359 [163] | 448 [203] | 475 [215] | 475 [215] |
| Weight - Packaged, (lbs) [kg] | 308 [140] | 369 [167] | 458 [208] | 485 [220] | 485 [220] |
| **Horizontal** | | | | | |
| Air Coil Dimensions (h x w) - (in) [mm] | 18 x 31 [457 x 787] | 20 x 35 [508 x 889] | 20 x 40 [508 x 1016] | 20 x 45 [508 x 1143] | 20 x 45 [508 x 1143] |
| Standard Filter - 1" [25.4mm] Throwaway, qty (in) [mm] | 2 - 18 x 18 [457 x 457] | 1 - 12 x 20 [305 x 508]<br>1 - 20 x 25 [508 x 635] | 1 - 18 x 20 [457 x 508]<br>1 - 20 x 24 [508 x 610] | 2 - 20 x 24 [508 x 610] | 2 - 20 x 24 [508 x 610] |
| Weight - Operating, (lbs) [kg] | 298 [135] | 359 [163] | 448 [203] | 475 [215] | 475 [215] |
| Weight - Packaged, (lbs) [kg] | 308 [140] | 369 [167] | 458 [208] | 485 [220] | 485 [220] |

Notes:
All units have TXV expansion device and 1/2" & 3/4" electrical knockouts.

| Unit Maximum Water Working Pressure | |
|---|---|
| Options | Max Pressure PSIG [kPa] |
| Base Unit | 500 [3447] |
| Unit with Internal Modulation Water Valve Option | 300 [2,068] |
| Unit with Internal Water Pump Option | 145 [999] |

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## TE - Horizontal Dimensional Data

| Horizontal Model | | Overall Cabinet | | |
|---|---|---|---|---|
| | | *A Width | B Length | C Height |
| 026 | in | 22.4 | 62.2 | 19.3 |
| | cm | 56.8 | 158.0 | 48.9 |
| 038 | in | 25.4 | 71.2 | 21.3 |
| | cm | 64.5 | 180.8 | 54.0 |
| 049 | in | 25.4 | 76.2 | 21.3 |
| | cm | 64.5 | 193.5 | 54.0 |
| 064 & 072 | in | 25.4 | 81.2 | 21.3 |
| | cm | 64.5 | 206.2 | 54.0 |

*Does not include air filter supports. Add 2" (5.1cm) when a 1" (25.4mm) filter is used, add 3" (7.6cm) when a 2" (50.8mm) filter is used.

| Horizontal Model | | Water Connections | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| | | Loop In D | Loop Out E | HWG In F | HWG Out G | Cond. H | Water Loop FPT | HWG FPT |
| 026 | in | 3.9 | 8.4 | 13.9 | 16.9 | 3.5 | 3/4" | 1/2" |
| | cm | 9.9 | 21.3 | 35.2 | 42.9 | 8.9 | | |
| 038 | in | 3.9 | 8.4 | 15.6 | 18.9 | 3.4 | 3/4" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 8.6 | | |
| 049 | in | 3.9 | 8.4 | 15.6 | 18.9 | 3.4 | 1" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 8.6 | | |
| 064 & 072 | in | 3.9 | 8.4 | 15.6 | 18.9 | 3.4 | 1" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 8.6 | | |

| Horizontal Model | | Electrical Knockouts | | |
|---|---|---|---|---|
| | | J 1/2" | K 1/2" | L 3/4" |
| | | Low Voltage | External Pump | Power Supply |
| 026 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 038 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 049 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 064 & 072 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |

Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. Horizontal units shipped with filter bracket only. This bracket should be removed for return duct connection
3. Discharge flange and hanger brackets are factory installed.
4. Condensate is 3/4" FPT.
5. CCP and BSP requires 2' service access.
6. Blower service access is through back panel on straight discharge units or through panel opposite air coil on back discharge units.

Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = (Optional) Additional Service Panel

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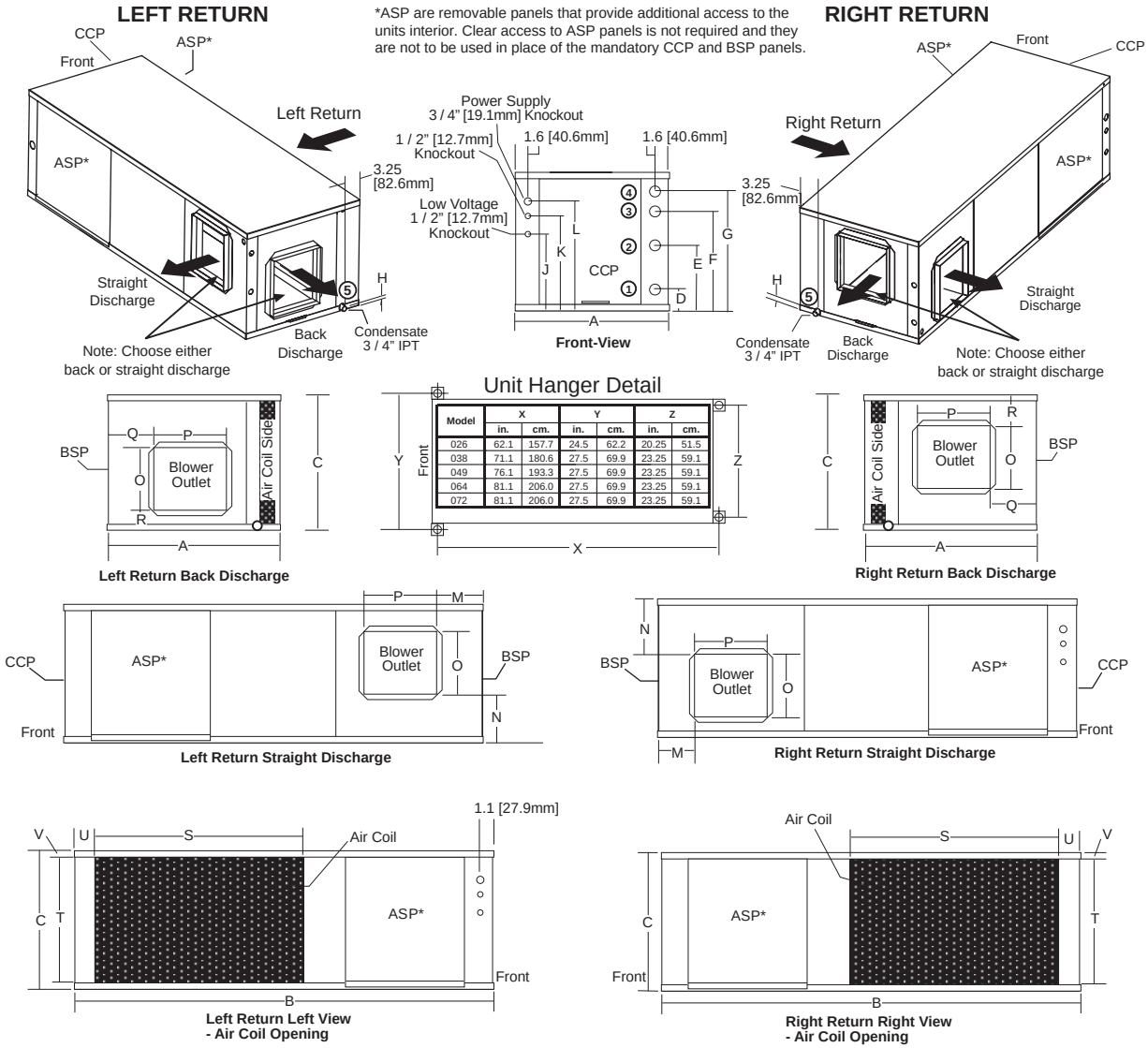
## TE - Horizontal Dimensional Data

| Horizontal Model | | Discharge Connection Duct Flange Installed | | | | | | Return Connection Using Return Air Opening | | | | Return Connection Using Optional Air Filter Frame | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | N | O Supply Height | P Supply Width | Q | R | S Return Width | T Return Height | U | V | S Return Width | T Return Height | U | V |
| 026 | in | 3.6 | 2.0 | 15.5 | 12.5 | 3.6 | 2.0 | 32.1 | 17.3 | 2.3 | 1.0 | 33.8 | 16.2 | 2.3 | 1.7 |
| | cm | 9.3 | 5.1 | 39.4 | 31.8 | 9.2 | 5.2 | 81.5 | 43.9 | 5.8 | 2.5 | 85.8 | 41.0 | 5.8 | 4.3 |
| 038 | in | 3.1 | 1.2 | 19.0 | 17.5 | 3.1 | 1.0 | 36.1 | 19.3 | 2.3 | 1.0 | 34.8 | 18.2 | 3.1 | 1.7 |
| | cm | 7.9 | 3.1 | 48.3 | 44.5 | 7.9 | 2.6 | 91.7 | 49.0 | 5.7 | 2.5 | 88.3 | 46.1 | 7.8 | 4.3 |
| 049 | in | 3.1 | 1.2 | 19.0 | 17.5 | 3.1 | 1.0 | 41.1 | 19.3 | 2.3 | 1.0 | 39.8 | 18.2 | 3.1 | 1.7 |
| | cm | 7.9 | 3.1 | 48.3 | 44.5 | 7.9 | 2.6 | 104.4 | 49.0 | 5.7 | 2.5 | 101.0 | 46.1 | 7.8 | 4.3 |
| 064 & 072 | in | 3.1 | 1.2 | 19.0 | 17.5 | 3.1 | 1.0 | 46.1 | 19.3 | 2.3 | 1.0 | 44.8 | 18.2 | 3.1 | 1.7 |
| | cm | 7.9 | 3.1 | 48.3 | 44.5 | 7.9 | 2.6 | 117.1 | 49.0 | 5.7 | 2.5 | 113.7 | 46.1 | 7.8 | 4.3 |

All dimensions are +/- 0.20 in, (+/-5.1 mm).




| Model | X in. | X cm. | Y in. | Y cm. | Z in. | Z cm. |
|---|---|---|---|---|---|---|
| 026 | 62.1 | 157.7 | 24.5 | 62.2 | 20.25 | 51.5 |
| 038 | 71.1 | 180.6 | 27.5 | 69.9 | 23.25 | 59.1 |
| 049 | 76.1 | 193.3 | 27.5 | 69.9 | 23.25 | 59.1 |
| 064 | 81.1 | 206.0 | 27.5 | 69.9 | 23.25 | 59.1 |
| 072 | 81.1 | 206.0 | 27.5 | 69.9 | 23.25 | 59.1 |

Filter Rails Removed

See Aff ---- for accessory air filter frame with duct collar

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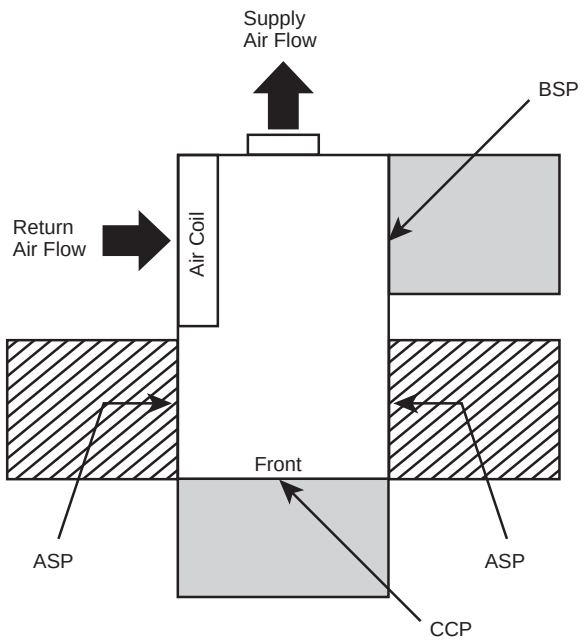
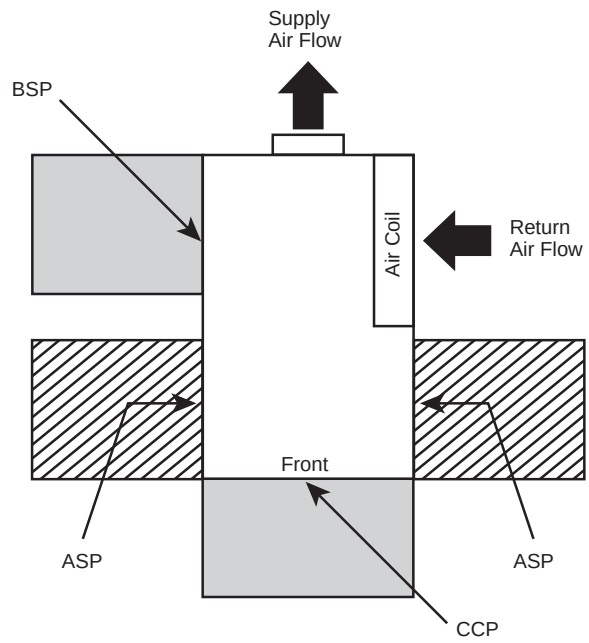
## TE - Horizontal Service Access

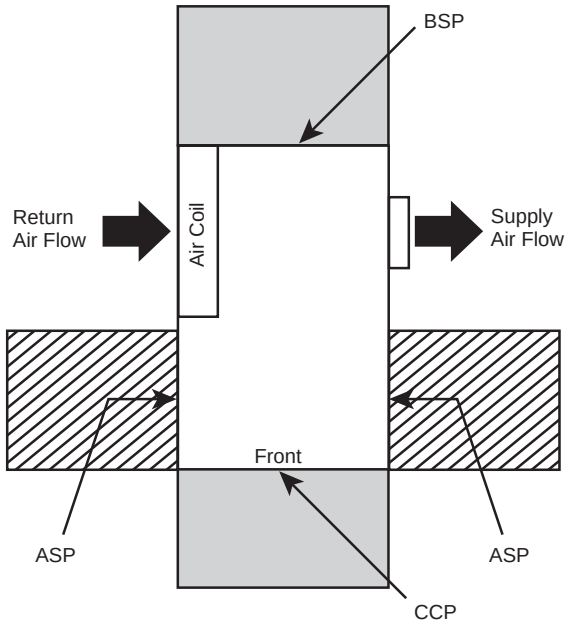
**Left Return Back Discharge**



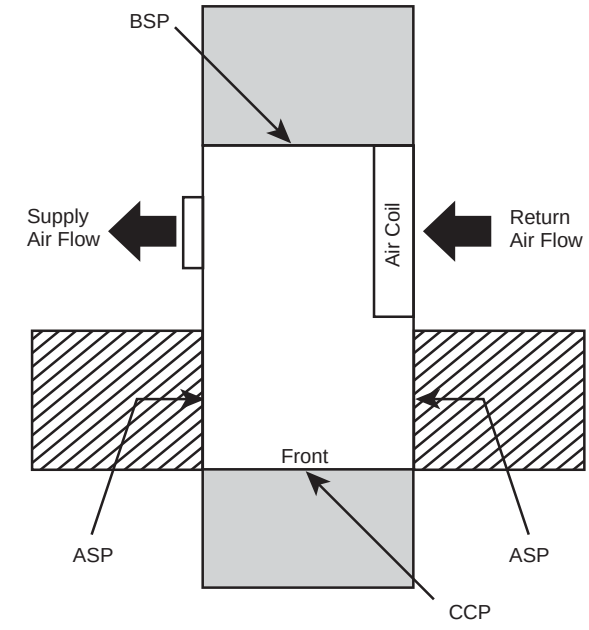

**Right Return Back Discharge**




**Left Return Straight Discharge**




**Right Return Straight Discharge**




Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. CCP and BSP requires 2′ service access.
3. Blower service access is through back panel on straight discharge units or through panel opposite air coil on back discharge units.
4. ASP are removable panels that provide additional access to the units interior. Clear access to ASP panels is not required and they are not to be used in place of the mandatory CCP and BSP panels.

**= mandatory 2′ service access**

**= (optional) additional 2′ service access**

Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = (Optional) Additional Service Panel

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## TE - Vertical Upflow Dimensional Data

| Vertical Upflow Model | | Overall Cabinet | | |
|---|---|---|---|---|
| | | *A Width | B Depth | C Height |
| 026 | in | 22.4 | 25.6 | 48.5 |
| | cm | 56.8 | 65.1 | 123.2 |
| 038 | in | 25.4 | 30.6 | 50.5 |
| | cm | 64.5 | 77.8 | 128.3 |
| 049 | in | 25.4 | 30.6 | 54.5 |
| | cm | 64.5 | 77.8 | 138.4 |
| 064 & 072 | in | 25.4 | 30.6 | 58.5 |
| | cm | 64.5 | 77.8 | 148.6 |

*Does not include air filter supports. Add 2" (5.1cm) when a 1" (25.4mm) filter is used, add 3" (7.6cm) when a 2" (50.8mm) filter is used.

| Vertical Upflow Model | | Water Connections | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| | | Loop In D | Loop Out E | HWG In F | HWG Out G | Cond. H | Water Loop FPT | HWG FPT |
| 026 | in | 3.9 | 8.4 | 13.9 | 16.9 | 17.0 | 3/4" | 1/2" |
| | cm | 9.9 | 21.3 | 35.2 | 42.9 | 43.2 | | |
| 038 | in | 3.9 | 8.4 | 15.6 | 18.9 | 18.7 | 3/4" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 47.5 | | |
| 049 | in | 3.9 | 8.4 | 15.6 | 18.9 | 18.7 | 1" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 47.5 | | |
| 064 & 072 | in | 3.9 | 8.4 | 15.6 | 18.9 | 18.7 | 1" | 1/2" |
| | cm | 9.9 | 21.3 | 39.7 | 47.9 | 47.5 | | |

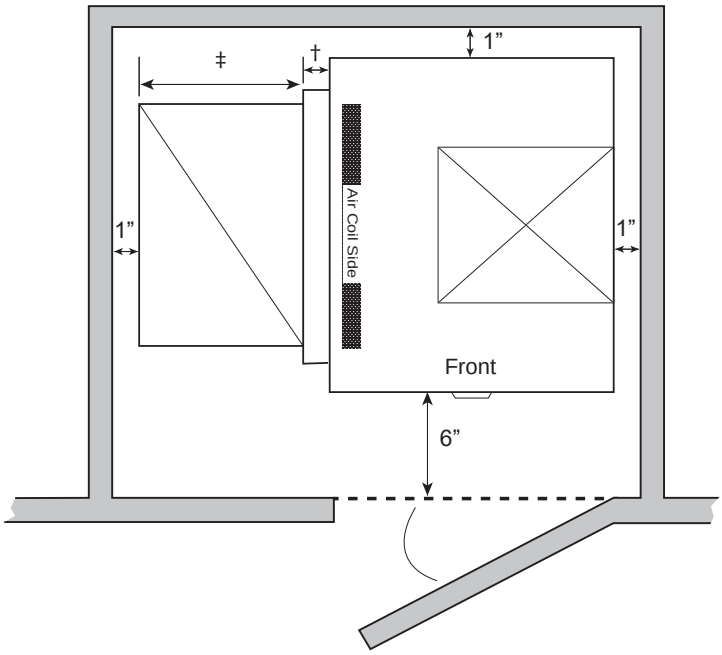
| Vertical Upflow Model | | Electrical Knockouts | | |
|---|---|---|---|---|
| | | J 1/2" | K 1/2" | L 3/4" |
| | | Low Voltage | External Pump | Power Supply |
| 026 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 038 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 049 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 064 & 072 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |

Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. Front & Side access is preferred for service access. However, all components may be serviced from the front access panel if side access is not available.
3. Discharge flange is field installed.
4. Condensate is 3/4" FPT PVC and is switchable from front to side.

Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = (optional) Additional Service Panel

| Recommended Minimum Installation Clearances for Vertical Units* | |
|---|---|
| 1" | Back of unit |
| | Side opposite return air |
| 6" | Front if hard piped |
| Return Air Side | |
| 1" | Ducted return<br>- ‡ Add for duct width<br>- † Add 2" for 1" filter frame/rail or 3" for 2" filter frame/rail |
| | Free (open) return - calculate required dimension for a maximum velocity of 600 fpm |

*Field installed accessories (hoses, air cleaners, etc.) may require additional space. Top supply air is shown, the same clearances apply to bottom supply air units.

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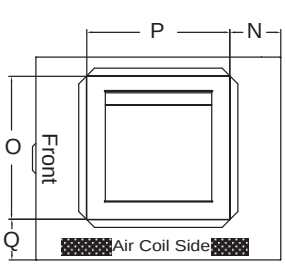
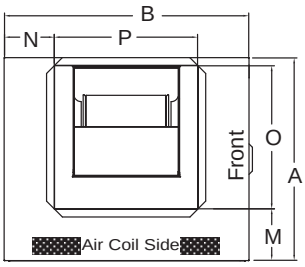
## TE - Vertical Upflow Dimensional Data

| Vertical Upflow Model | | Discharge Connection Duct Flange Installed | | | | | Return Connection Using Return Air Opening | | | | Return Connection Using Optional Air Filter Frame | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | N | O Supply Width | P Supply Depth | Q | R | S Return Depth | T Return Height | U | R | S Return Depth | T Return Height | U |
| 026 | in | 7.2 | 5.8 | 14.0 | 14.0 | 4.9 | 2.3 | 21.1 | 27.7 | 1.0 | 1.7 | 22.2 | 26.2 | 1.7 |
| | cm | 18.3 | 14.8 | 35.6 | 35.6 | 12.4 | 5.8 | 53.6 | 70.4 | 2.5 | 4.3 | 56.4 | 66.5 | 4.3 |
| 038 | in | 6.4 | 6.3 | 18.0 | 18.0 | 5.3 | 2.3 | 26.1 | 27.7 | 1.0 | 1.7 | 27.2 | 26.2 | 1.7 |
| | cm | 16.1 | 16.0 | 45.7 | 45.7 | 13.5 | 5.8 | 66.3 | 70.4 | 2.5 | 4.3 | 69.1 | 66.5 | 4.3 |
| 049 | in | 6.4 | 6.3 | 18.0 | 18.0 | 5.3 | 2.3 | 26.1 | 31.7 | 1.0 | 1.7 | 27.2 | 30.2 | 1.7 |
| | cm | 16.1 | 16.0 | 45.7 | 45.7 | 13.5 | 5.8 | 66.3 | 80.5 | 2.5 | 4.3 | 69.1 | 76.7 | 4.3 |
| 064 & 072 | in | 6.4 | 6.3 | 18.0 | 18.0 | 5.3 | 2.3 | 26.1 | 35.7 | 1.0 | 1.7 | 27.2 | 34.2 | 1.7 |
| | cm | 16.1 | 16.0 | 45.7 | 45.7 | 13.5 | 5.8 | 66.3 | 90.7 | 2.5 | 4.3 | 69.1 | 86.9 | 4.3 |

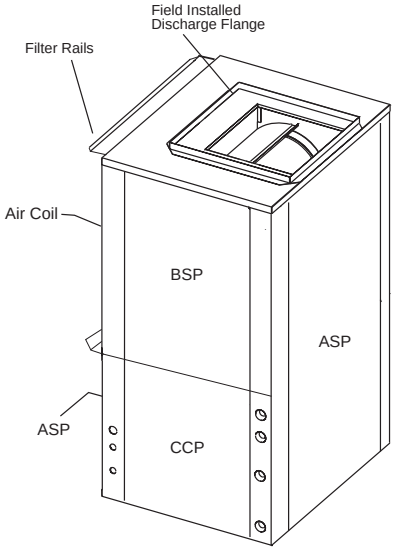
All dimensions are +/- 0.20 in, (+/-5.1 mm).



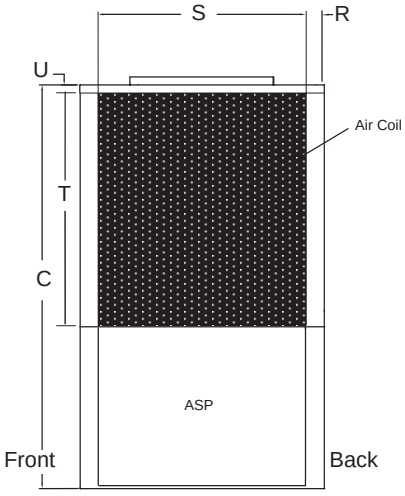

**Top View-Right Return**



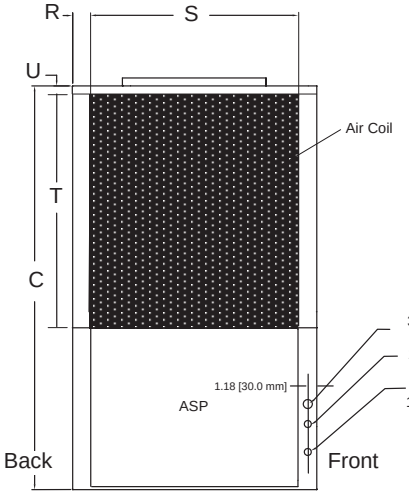

**Top View-Left Return**



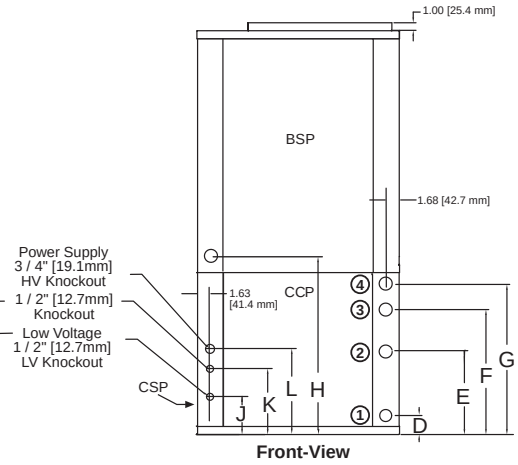

**Isometric (Left Return) View**




**Right Return Right View - Air Coil Opening**




**Left Return Left View - Air Coil Opening**




**Front-View**

Filter Rails Removed

See Aff ---- for accessory air filter frame with duct collar

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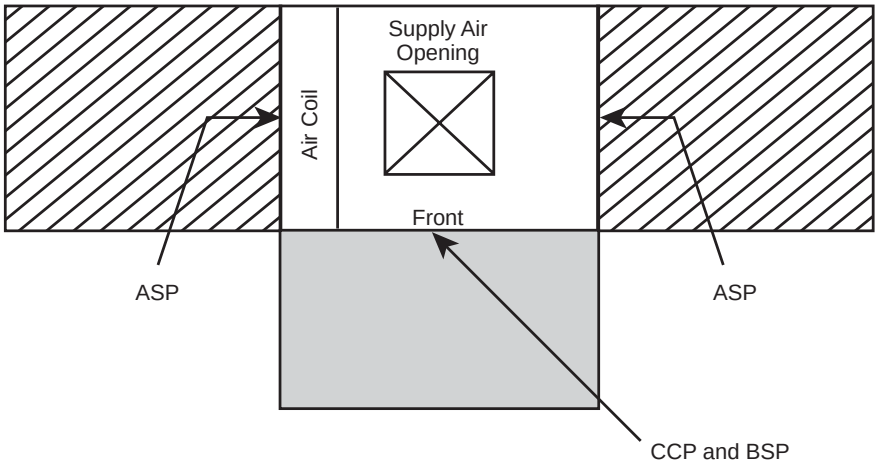
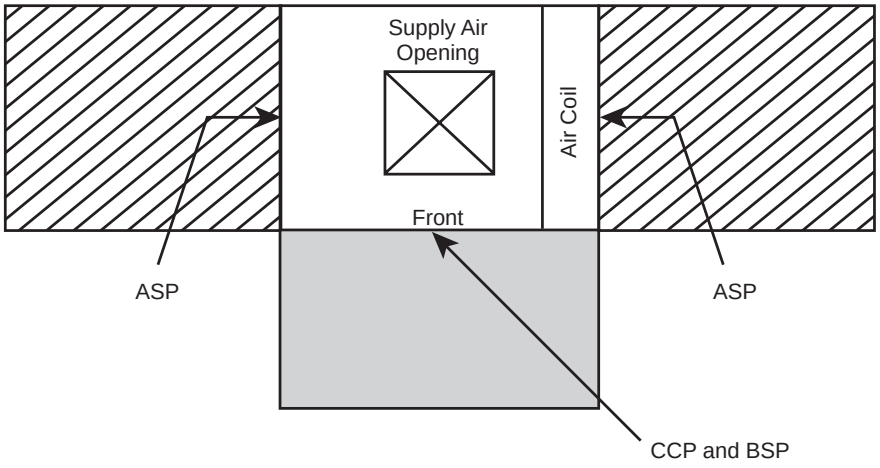
## TE - Vertical Service Access

### Vertical Units

**Left Return**




**Right Return**




Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. Front & Side access is preferred for service access. However, all components may be serviced from the front access panel if side access is not available.
3. ASP are removable panels that provide additional access to the units interior. Clear access to ASP panels is not required and they are not to be used in place of the mandatory CCP and BSP panels.
4. Top supply air is shown, the same clearances apply to bottom supply air units.

**= mandatory 2′ service access**

**= (optional) additional 2′ service access**

Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = (optional) Additional Service Panel

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## TE - Vertical Downflow Dimensional Data

| Vertical Downflow Model | | Overall Cabinet | | |
|---|---|---|---|---|
| | | *A Width | B Depth | C Height |
| 026 | in | 22.4 | 25.6 | 52.5 |
| | cm | 56.8 | 65.1 | 133.4 |
| 038 | in | 25.4 | 30.6 | 54.5 |
| | cm | 64.5 | 77.8 | 138.4 |
| 049 | in | 25.4 | 30.6 | 58.5 |
| | cm | 64.5 | 77.8 | 148.6 |
| 064 & 072 | in | 25.4 | 30.6 | 62.5 |
| | cm | 64.5 | 77.8 | 158.8 |

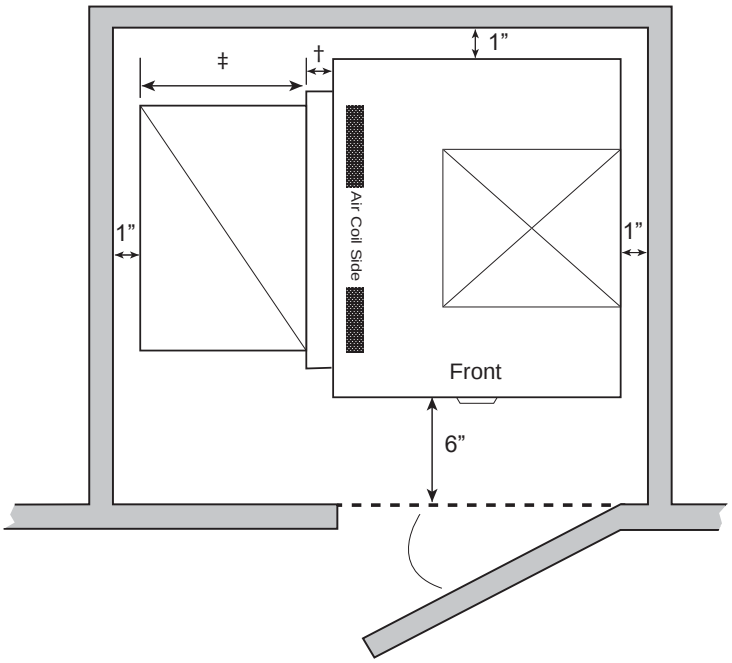
*Does not include air filter supports. Add 2" (5.1cm) when a 1" (25.4mm) filter is used, add 3" (7.6cm) when a 2" (50.8mm) filter is used.

| Vertical Downflow Model | | Electrical Knockouts | | |
|---|---|---|---|---|
| | | J 1/2" | K 1/2" | L 3/4" |
| | | Low Voltage | External Pump | Power Supply |
| 026 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 038 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 049 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |
| 064 & 072 | in | 3.6 | 6.1 | 8.6 |
| | cm | 9.2 | 15.6 | 21.9 |

| Vertical Downflow Model | | Water Connections | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| | | Loop In D | Loop Out E | HWG In F | HWG Out G | Cond. H | Water Loop FPT | HWG FPT |
| 026 | in | 15.4 | 10.9 | 5.4 | 2.4 | 4.7 | 3/4" | 1/2" |
| | cm | 39.1 | 27.7 | 13.7 | 6.1 | 11.9 | | |
| 038 | in | 17.4 | 12.9 | 5.7 | 2.4 | 4.7 | 3/4" | 1/2" |
| | cm | 44.2 | 32.8 | 14.5 | 6.1 | 11.9 | | |
| 049 | in | 17.4 | 12.9 | 5.7 | 2.4 | 4.7 | 1" | 1/2" |
| | cm | 44.2 | 32.8 | 14.5 | 6.1 | 11.9 | | |
| 064 & 072 | in | 17.4 | 12.9 | 5.7 | 2.4 | 4.7 | 1" | 1/2" |
| | cm | 44.2 | 32.8 | 14.5 | 6.1 | 11.9 | | |

| Recommended Minimum Installation Clearances for Vertical Units* | |
|---|---|
| 1" | Back of unit |
| | Side opposite return air |
| 6" | Front if hard piped |
| Return Air Side | |
| 1" | Ducted return<br>- ‡ Add for duct width<br>- † Add 2" for 1" filter frame/rail or 3" for 2" filter frame/rail |
| | Free (open) return - calculate required dimension for a maximum velocity of 600 fpm |

*Field installed accessories (hoses, air cleaners, etc.) may require additional space.
Top supply air is shown, the same clearances apply to bottom supply air units.




Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. Front & Side access is preferred for service access. However, all components may be serviced from the front access panel of a standard unit if side access is not available.
3. Condensate is 3/4" FPT PVC and is switchable from front to side.
4. Top supply air is shown, the same clearances apply to bottom supply air units.

Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = (optional) Additional Service Panel

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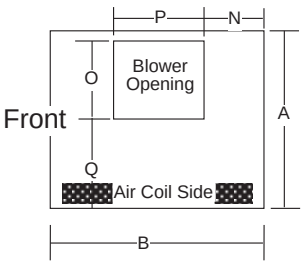
## TE - Vertical Downflow Dimensional Data

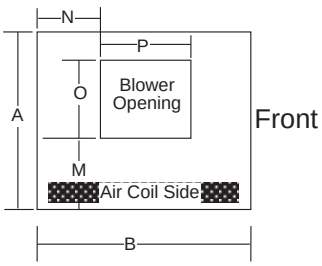
| Vertical Downflow Model | | Discharge Connection Duct Flange Installed | | | | | Return Connection Using Return Air Opening | | | | Return Connection Using Optional Air Filter Frame | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | N | O Supply Width | P Supply Depth | Q | R | S Return Depth | T Return Height | U | R | S Return Depth | T Return Height | U |
| 026 | in | 6.7 | 8.4 | 10.1 | 9.1 | 10.8 | 2.2 | 21.1 | 27.7 | 21.2 | 1.7 | 22.2 | 26.2 | 21.9 |
| | cm | 17.1 | 21.4 | 25.7 | 23.0 | 27.4 | 5.6 | 53.6 | 70.4 | 53.8 | 4.3 | 56.4 | 66.5 | 55.6 |
| 038 | in | 7.2 | 9.0 | 13.4 | 12.9 | 10.4 | 2.2 | 26.1 | 27.7 | 23.2 | 1.7 | 27.2 | 26.2 | 23.9 |
| | cm | 18.3 | 22.9 | 34.0 | 32.7 | 26.5 | 5.6 | 66.3 | 70.4 | 58.9 | 4.3 | 69.1 | 66.5 | 60.7 |
| 049 | in | 7.2 | 9.0 | 13.4 | 12.9 | 10.4 | 2.2 | 26.1 | 31.7 | 23.2 | 1.7 | 27.2 | 30.2 | 23.9 |
| | cm | 18.3 | 22.9 | 34.0 | 32.7 | 26.5 | 5.6 | 66.3 | 80.5 | 58.9 | 4.3 | 69.1 | 76.7 | 60.7 |
| 064 & 072 | in | 7.2 | 9.0 | 13.4 | 12.9 | 10.4 | 2.2 | 26.1 | 35.7 | 23.2 | 1.7 | 27.2 | 34.2 | 23.9 |
| | cm | 18.3 | 22.9 | 34.0 | 32.7 | 26.5 | 5.6 | 66.3 | 90.7 | 58.9 | 4.3 | 69.1 | 86.9 | 60.7 |

All dimensions are +/- 0.20 in, (+/-5.1 mm).

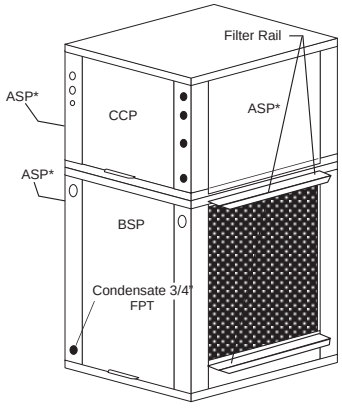
Legend:
CCP = Control/Compressor Access Panel
BSP = Blower Service Panel
ASP = Additional Service Panel (not required)



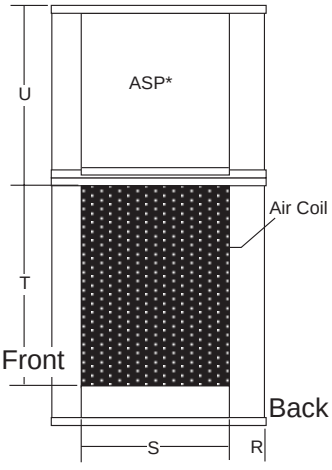

**Right Return Discharge Floor Foot Print**



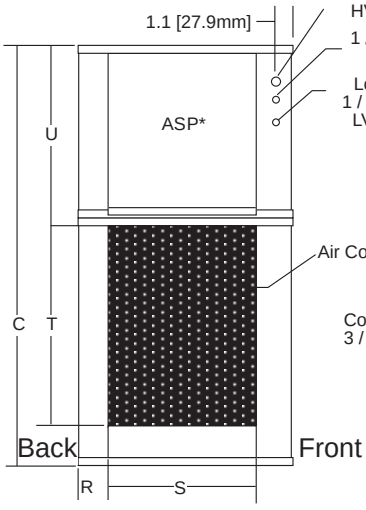

**Left Return Discharge Floor Foot Print**



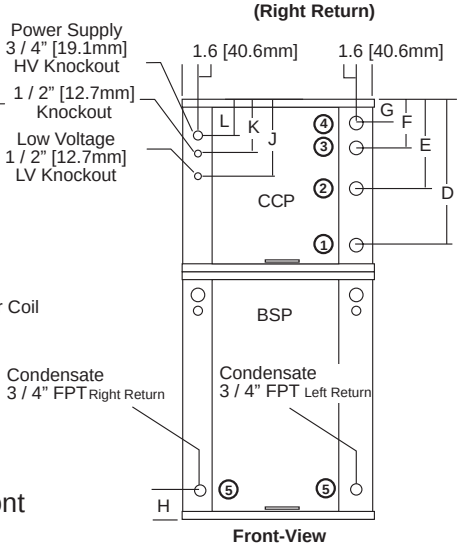

**Isometric View (Right Return)**




**Right Return Right View - Air Coil Opening**




**Left Return Left View - Air Coil Opening**




**Front-View**

Filter Rails Removed
See Aff ---- for accessory air filter frame with duct collar

Notes:
1. While clear access to all removable panels is not required, installer should take care to comply with all building codes and allow adequate clearance for future field service.
2. Front & Side access is preferred for service access. However, all components may be serviced from the front access panel if side access is not available.
3. Condensate is 3/4" FPT PVC.
4. ASP are removable panels that provide additional access to the units interior. Clear access to ASP panels is not required and they are not to be used in place of the mandatory CCP and BSP panels.

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## Corner Weights

### Corner Weights for TE Series Horizontal Units

| Model | | Total | Left-Front* | Right-Front* | Left-Back*+ | Right-Back*+ |
|---|---|---|---|---|---|---|
| 026 | Lbs | 298 | 88 | 75 | 78 | 57 |
| | kg | 135 | 40 | 34 | 35 | 26 |
| 038 | Lbs | 359 | 115 | 82 | 92 | 70 |
| | kg | 163 | 52 | 37 | 42 | 32 |
| 049 | Lbs | 448 | 156 | 100 | 106 | 86 |
| | kg | 203 | 71 | 45 | 48 | 39 |
| 064 | Lbs | 475 | 196 | 78 | 85 | 116 |
| | kg | 215 | 89 | 35 | 39 | 53 |
| 072 | Lbs | 475 | 196 | 78 | 85 | 116 |
| | kg | 215 | 89 | 35 | 39 | 53 |

*Front is control box end.
+ Weights shown are for units with left hand return air. Reverse these for a right hand return air unit.

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## Electrical Data

### Standard Units

| Model | Voltage Code | Voltage | Min/Max Voltage | Compressor | | | Fan Motor FLA | Total Unit FLA | Min Circ Amp | Max Fuse/ HACR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RLA | LRA | Qty | | | | |
| 026 | G | 208/230/60/1 | 197/252 | 11.7 | 58.3 | 1 | 3.9 | 15.6 | 18.5 | 30 |
| | E | 265/60/1 | 239/292 | 9.1 | 54.0 | 1 | 3.2 | 12.3 | 14.6 | 20 |
| | H | 208/230/60/3 | 197/252 | 6.5 | 55.4 | 1 | 3.9 | 10.4 | 12.0 | 15 |
| | *F | *460/60/3 | 414/506 | 3.5 | 28.0 | 1 | 3.2 | 6.7 | 7.6 | 15 |
| 038 | G | 208/230/60/1 | 197/252 | 15.3 | 83.0 | 1 | 3.9 | 19.2 | 23.0 | 35 |
| | E | 265/60/1 | 239/292 | 13.0 | 72.0 | 1 | 3.2 | 16.2 | 19.5 | 30 |
| | H | 208/230/60/3 | 197/252 | 11.6 | 73.0 | 1 | 3.9 | 15.5 | 18.4 | 30 |
| | *F | *460/60/3 | 414/506 | 5.7 | 38.0 | 1 | 3.2 | 8.9 | 10.3 | 15 |
| 049 | G | 208/230/60/1 | 197/252 | 21.2 | 104.0 | 1 | 6.9 | 28.1 | 33.4 | 50 |
| | E | 265/60/1 | 239/292 | 16.0 | 109.7 | 1 | 6.0 | 22.0 | 26.0 | 40 |
| | H | 208/230/60/3 | 197/252 | 14.0 | 83.1 | 1 | 6.9 | 20.9 | 24.4 | 35 |
| | *F | *460/60/3 | 414/506 | 6.4 | 41.0 | 1 | 6.0 | 12.4 | 14.0 | 20 |
| 064 | G | 208/230/60/1 | 197/252 | 27.1 | 152.9 | 1 | 6.9 | 34.0 | 40.8 | 60 |
| | E | 265/60/1 | 239/292 | 22.4 | 130.0 | 1 | 6.0 | 28.4 | 34.0 | 50 |
| | H | 208/230/60/3 | 197/252 | 16.5 | 110.0 | 1 | 6.9 | 23.4 | 27.5 | 40 |
| | *F | *460/60/3 | 414/506 | 7.2 | 52.0 | 1 | 6.0 | 13.2 | 15.0 | 20 |
| 072 | G | 208/230/60/1 | 197/252 | 29.7 | 179.2 | 1 | 6.9 | 36.6 | 44.0 | 70 |
| | H | 208/230/60/3 | 197/252 | 17.6 | 136.0 | 1 | 6.9 | 24.5 | 28.9 | 45 |
| | *F | *460/60/3 | 414/506 | 8.5 | 66.1 | 1 | 6.0 | 14.5 | 16.6 | 25 |

Wire length based on one way measurement with 2% voltage drop
Wire size based on 60°C copper conductor
All fuses Class RK-5

*** NEUTRAL CONNECTION REQUIRED! All F Voltage (460 vac) units with ECM motors require a four wire power supply with neutral. ECM motor is rated 265 vac and is wired between one hot leg and neutral.**

### Units with Secondary Pump

| Model | Voltage Code | Voltage | Min/Max Voltage | Compressor | | | Internal Pump FLA | Fan Motor FLA | Total Unit FLA | Min Circ Amp | Max Fuse/ HACR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RLA | LRA | Qty | | | | | |
| 026 | G | 208/230/60/1 | 197/252 | 11.7 | 58.3 | 1 | 0.8 | 3.9 | 16.4 | 19.3 | 30 |
| | E | 265/60/1 | 239/292 | 9.1 | 54.0 | 1 | 0.7 | 3.2 | 13.0 | 15.3 | 20 |
| | H | 208/230/60/3 | 197/252 | 6.5 | 55.4 | 1 | 0.8 | 3.9 | 11.2 | 12.8 | 15 |
| | *F | *460/60/3 | 414/506 | 3.5 | 28.0 | 1 | 0.7 | 3.2 | 7.4 | 8.3 | 15 |
| 038 | G | 208/230/60/1 | 197/252 | 15.3 | 83.0 | 1 | 0.8 | 3.9 | 20.0 | 23.8 | 35 |
| | E | 265/60/1 | 239/292 | 13.0 | 72.0 | 1 | 0.7 | 3.2 | 16.9 | 20.2 | 30 |
| | H | 208/230/60/3 | 197/252 | 11.6 | 73.0 | 1 | 0.8 | 3.9 | 16.3 | 19.2 | 30 |
| | *F | *460/60/3 | 414/506 | 5.7 | 38.0 | 1 | 0.7 | 3.2 | 9.6 | 11.0 | 15 |
| 049 | G | 208/230/60/1 | 197/252 | 21.2 | 104.0 | 1 | 0.8 | 6.9 | 28.9 | 34.2 | 50 |
| | E | 265/60/1 | 239/292 | 16.0 | 109.7 | 1 | 0.7 | 6.0 | 22.7 | 26.7 | 40 |
| | H | 208/230/60/3 | 197/252 | 14.0 | 83.1 | 1 | 0.8 | 6.9 | 21.7 | 25.2 | 35 |
| | *F | *460/60/3 | 414/506 | 6.4 | 41.0 | 1 | 0.7 | 6.0 | 13.1 | 14.7 | 20 |
| 064 | G | 208/230/60/1 | 197/252 | 27.1 | 152.9 | 1 | 1.1 | 6.9 | 35.1 | 41.8 | 60 |
| | E | 265/60/1 | 239/292 | 22.4 | 130.0 | 1 | 1.1 | 6.0 | 29.5 | 35.1 | 50 |
| | H | 208/230/60/3 | 197/252 | 16.5 | 110.0 | 1 | 1.1 | 6.9 | 24.5 | 28.6 | 45 |
| | *F | *460/60/3 | 414/506 | 7.2 | 52.0 | 1 | 1.1 | 6.0 | 14.3 | 16.1 | 20 |
| 072 | G | 208/230/60/1 | 197/252 | 29.7 | 179.2 | 1 | 1.1 | 6.9 | 37.7 | 45.1 | 70 |
| | H | 208/230/60/3 | 197/252 | 17.6 | 136.0 | 1 | 1.1 | 6.9 | 25.6 | 30.0 | 45 |
| | *F | *460/60/3 | 414/506 | 8.5 | 66.1 | 1 | 1.1 | 6.0 | 15.6 | 17.7 | 25 |

Wire length based on one way measurement with 2% voltage drop
Wire size based on 60°C copper conductor
All fuses Class RK-5

*** NEUTRAL CONNECTION REQUIRED! All F Voltage (460 vac) units with ECM motors/internal secondary circulators require a four wire power supply with neutral. ECM motors/reheat pumps/internal secondary circulators are rated 265 vac and are wired between one hot leg and neutral.**

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## Electrical Data

### Units with Variable Pump High Head

| Model | Voltage Code | Voltage | Min/Max Voltage | Compressor | | | Pump FLA | Fan Motor FLA | Total Unit FLA | Min Circ Amp | Max Fuse/ HACR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RLA | LRA | Qty | | | | | |
| 026 | G | 208/230/60/1 | 197/252 | 11.7 | 58.3 | 1 | 1.7 | 3.9 | 17.3 | 20.2 | 30 |
| | E | 265/60/1 | 239/292 | 9.1 | 54.0 | 1 | 1.5 | 3.2 | 13.8 | 16.0 | 25 |
| | H | 208/230/60/3 | 197/252 | 6.5 | 55.4 | 1 | 1.7 | 3.9 | 12.1 | 13.7 | 20 |
| | *F | *460/60/3 | 414/506 | 3.5 | 28.0 | 1 | 1.5 | 3.2 | 8.2 | 9.0 | 15 |
| 038 | G | 208/230/60/1 | 197/252 | 15.3 | 83.0 | 1 | 1.7 | 3.9 | 20.9 | 24.7 | 40 |
| | E | 265/60/1 | 239/292 | 13.0 | 72.0 | 1 | 1.5 | 3.2 | 17.7 | 20.9 | 30 |
| | H | 208/230/60/3 | 197/252 | 11.6 | 73.0 | 1 | 1.7 | 3.9 | 17.2 | 20.1 | 30 |
| | *F | *460/60/3 | 414/506 | 5.7 | 38.0 | 1 | 1.5 | 3.2 | 10.4 | 11.8 | 15 |
| 049 | G | 208/230/60/1 | 197/252 | 21.2 | 104.0 | 1 | 1.7 | 6.9 | 29.8 | 35.1 | 50 |
| | E | 265/60/1 | 239/292 | 16.0 | 109.7 | 1 | 1.5 | 6.0 | 23.5 | 27.5 | 40 |
| | H | 208/230/60/3 | 197/252 | 14.0 | 83.1 | 1 | 1.7 | 6.9 | 22.6 | 26.1 | 40 |
| | *F | *460/60/3 | 414/506 | 6.4 | 41.0 | 1 | 1.5 | 6.0 | 13.9 | 15.5 | 20 |
| 064 | G | 208/230/60/1 | 197/252 | 27.1 | 152.9 | 1 | 1.7 | 6.9 | 35.7 | 42.5 | 60 |
| | E | 265/60/1 | 239/292 | 22.4 | 130.0 | 1 | 1.5 | 6.0 | 29.9 | 35.5 | 50 |
| | H | 208/230/60/3 | 197/252 | 16.5 | 110.0 | 1 | 1.7 | 6.9 | 25.1 | 29.2 | 45 |
| | *F | *460/60/3 | 414/506 | 7.2 | 52.0 | 1 | 1.5 | 6.0 | 14.7 | 16.5 | 20 |
| 072 | G | 208/230/60/1 | 197/252 | 29.7 | 179.2 | 1 | 1.7 | 6.9 | 38.3 | 45.7 | 70 |
| | H | 208/230/60/3 | 197/252 | 17.6 | 136.0 | 1 | 1.7 | 6.9 | 26.2 | 30.6 | 45 |
| | *F | *460/60/3 | 414/506 | 8.5 | 66.1 | 1 | 1.5 | 6.0 | 16.0 | 18.1 | 25 |

Wire length based on one way measurement with 2% voltage drop
Wire size based on 60°C copper conductor
All fuses Class RK-5

* **NEUTRAL CONNECTION REQUIRED! All F Voltage (460 vac) units with ECM motors/internal pumps require a four wire power supply with neutral. ECM motors/internal pumps are rated 265 vac and are wired between one hot leg and neutral.**

### Units with Variable Pump Standard Head

| Model | Voltage Code | Voltage | Min/Max Voltage | Compressor | | | Pump FLA | Fan Motor FLA | Total Unit FLA | Min Circ Amp | Max Fuse/ HACR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RLA | LRA | Qty | | | | | |
| 026 | G | 208/230/60/1 | 197/252 | 11.7 | 58.3 | 1 | 0.7 | 3.9 | 16.3 | 19.2 | 30 |
| | E | 265/60/1 | 239/292 | 9.1 | 54.0 | 1 | 0.6 | 3.2 | 12.9 | 15.2 | 20 |
| | H | 208/230/60/3 | 197/252 | 6.5 | 55.4 | 1 | 0.7 | 3.9 | 11.1 | 12.7 | 15 |
| | *F | *460/60/3 | 414/506 | 3.5 | 28.0 | 1 | 0.6 | 3.2 | 7.3 | 8.2 | 15 |
| 038 | G | 208/230/60/1 | 197/252 | 15.3 | 83.0 | 1 | 0.7 | 3.9 | 19.9 | 23.7 | 35 |
| | E | 265/60/1 | 239/292 | 13.0 | 72.0 | 1 | 0.6 | 3.2 | 16.8 | 20.1 | 30 |
| | H | 208/230/60/3 | 197/252 | 11.6 | 73.0 | 1 | 0.7 | 3.9 | 16.2 | 19.1 | 30 |
| | *F | *460/60/3 | 414/506 | 5.7 | 38.0 | 1 | 0.6 | 3.2 | 9.5 | 10.9 | 15 |
| 049 | G | 208/230/60/1 | 197/252 | 21.2 | 104.0 | 1 | 0.7 | 6.9 | 28.8 | 34.1 | 50 |
| | E | 265/60/1 | 239/292 | 16.0 | 109.7 | 1 | 0.6 | 6.0 | 22.6 | 26.6 | 40 |
| | H | 208/230/60/3 | 197/252 | 14.0 | 83.1 | 1 | 0.7 | 6.9 | 21.6 | 25.1 | 35 |
| | *F | *460/60/3 | 414/506 | 6.4 | 41.0 | 1 | 0.6 | 6.0 | 13.0 | 14.6 | 20 |
| 064 | G | 208/230/60/1 | 197/252 | 27.1 | 152.9 | 1 | 0.7 | 6.9 | 34.7 | 41.5 | 60 |
| | E | 265/60/1 | 239/292 | 22.4 | 130.0 | 1 | 0.6 | 6.0 | 29.0 | 34.6 | 50 |
| | H | 208/230/60/3 | 197/252 | 16.5 | 110.0 | 1 | 0.7 | 6.9 | 24.1 | 28.2 | 40 |
| | *F | *460/60/3 | 414/506 | 7.2 | 52.0 | 1 | 0.6 | 6.0 | 13.8 | 15.6 | 20 |
| 072 | G | 208/230/60/1 | 197/252 | 29.7 | 179.2 | 1 | 0.7 | 6.9 | 37.3 | 44.7 | 70 |
| | H | 208/230/60/3 | 197/252 | 17.6 | 136.0 | 1 | 0.7 | 6.9 | 25.2 | 29.6 | 45 |
| | *F | *460/60/3 | 414/506 | 8.5 | 66.1 | 1 | 0.6 | 6.0 | 15.1 | 17.2 | 25 |

Wire length based on one way measurement with 2% voltage drop
Wire size based on 60°C copper conductor
All fuses Class RK-5

* **NEUTRAL CONNECTION REQUIRED! All F Voltage (460 vac) units with ECM motors/internal pumps require a four wire power supply with neutral. ECM motors/internal pumps are rated 265 vac and are wired between one hot leg and neutral.**

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## TE Series Wiring Diagram Matrix

Only DXM2 diagrams, with a representative diagram of LON and MPC Options are presented in this submittal.
Other diagrams can be located online at climatemaster.com using the part numbers presented below.

| Voltage | Description | Diagram Part Number |
|---|---|---|
| 208-230/60/1<br>265/60/1 | W/ MOD VALVE | 96B0242N01 |
| | W/ LON / MOD VALVE | 96B0242N02 |
| | W/ MPC / MOD VALVE | 96B0242N03 |
| | W/ ISP / NO PUMP OR VALVE OPTION | 96B0242N05 |
| | W/ LON / ISP / NO PUMP OR VALVE OPTION | 96B0242N06 |
| | W/ MPC / ISP / NO PUMP OR VALVE OPTION | 96B0242N07 |
| | W/ VARIABLE PUMP – 265 VOLTAGE | 96B0242N09 |
| | W/ VARIABLE PUMP – 208-230 VOLTAGE | 96B0242N12 |
| 208-230/60/3 | W/ MOD VALVE | 96B0243N01 |
| | W/ LON / MOD VALVE | 96B0243N02 |
| | W/ MPC / MOD VALVE | 96B0243N03 |
| | W/ ISP / NO PUMP OR VALVE OPTION | 96B0243N05 |
| | W/ LON / ISP / NO PUMP OR VALVE OPTION | 96B0243N06 |
| | W/ MPC / ISP / NO PUMP OR VALVE OPTION | 96B0243N07 |
| | W/ VARIABLE PUMP | 96B0243N09 |
| 460/60/3 | W/ MOD VALVE | 96B0244N01 |
| | W/ LON / MOD VALVE | 96B0244N02 |
| | W/ MPC / MOD VALVE | 96B0244N03 |
| | W/ ISP / NO PUMP OR VALVE OPTION | 96B0244N05 |
| | W/ LON / ISP / NO PUMP OR VALVE OPTION | 96B0244N06 |
| | W/ MPC / ISP / NO PUMP OR VALVE OPTION | 96B0244N07 |
| | W/ VARIABLE PUMP | 96B0244N09 |

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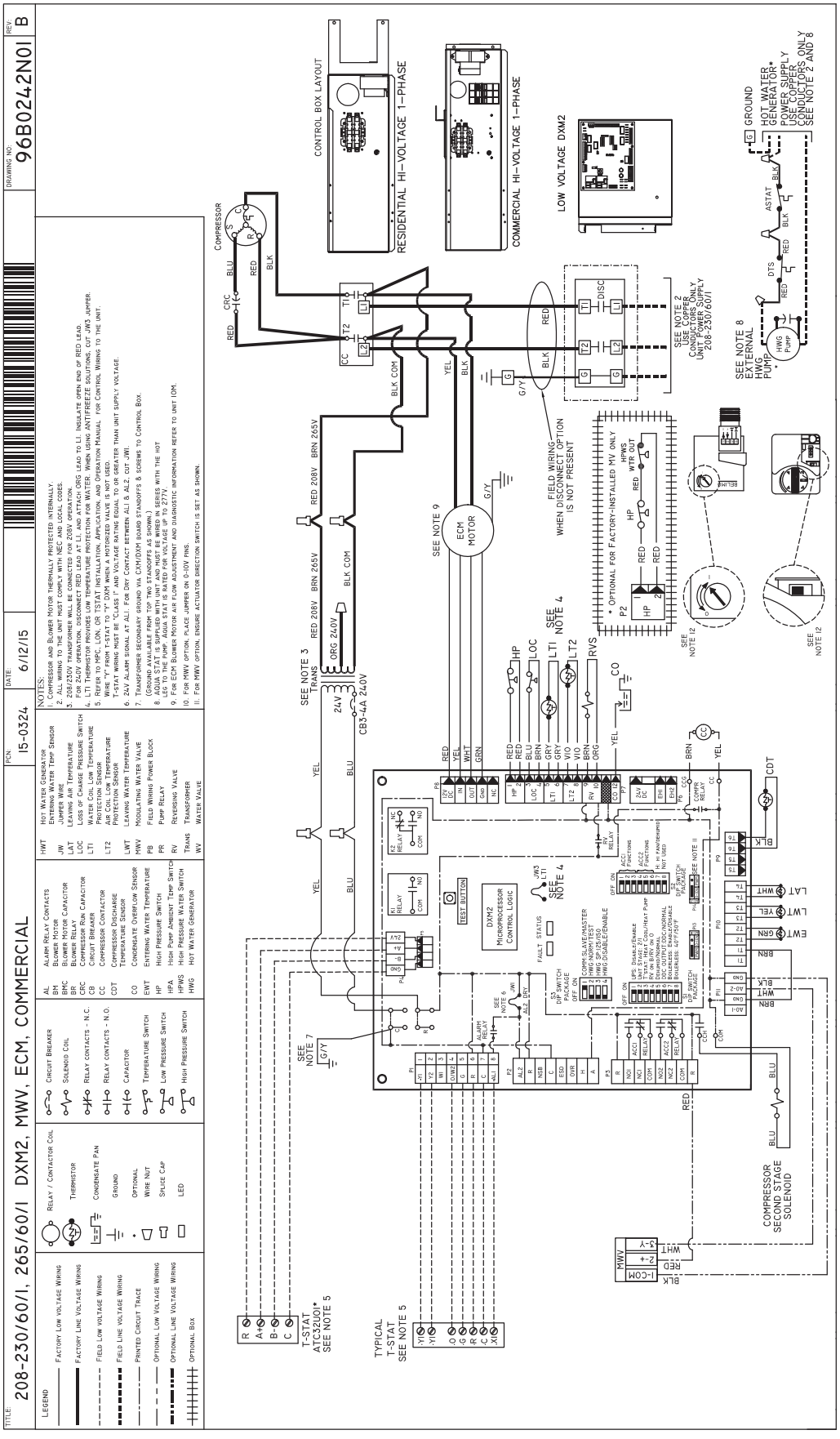
## Typical Wiring Diagram – Single Phase TE Units with Modulating Water Valve

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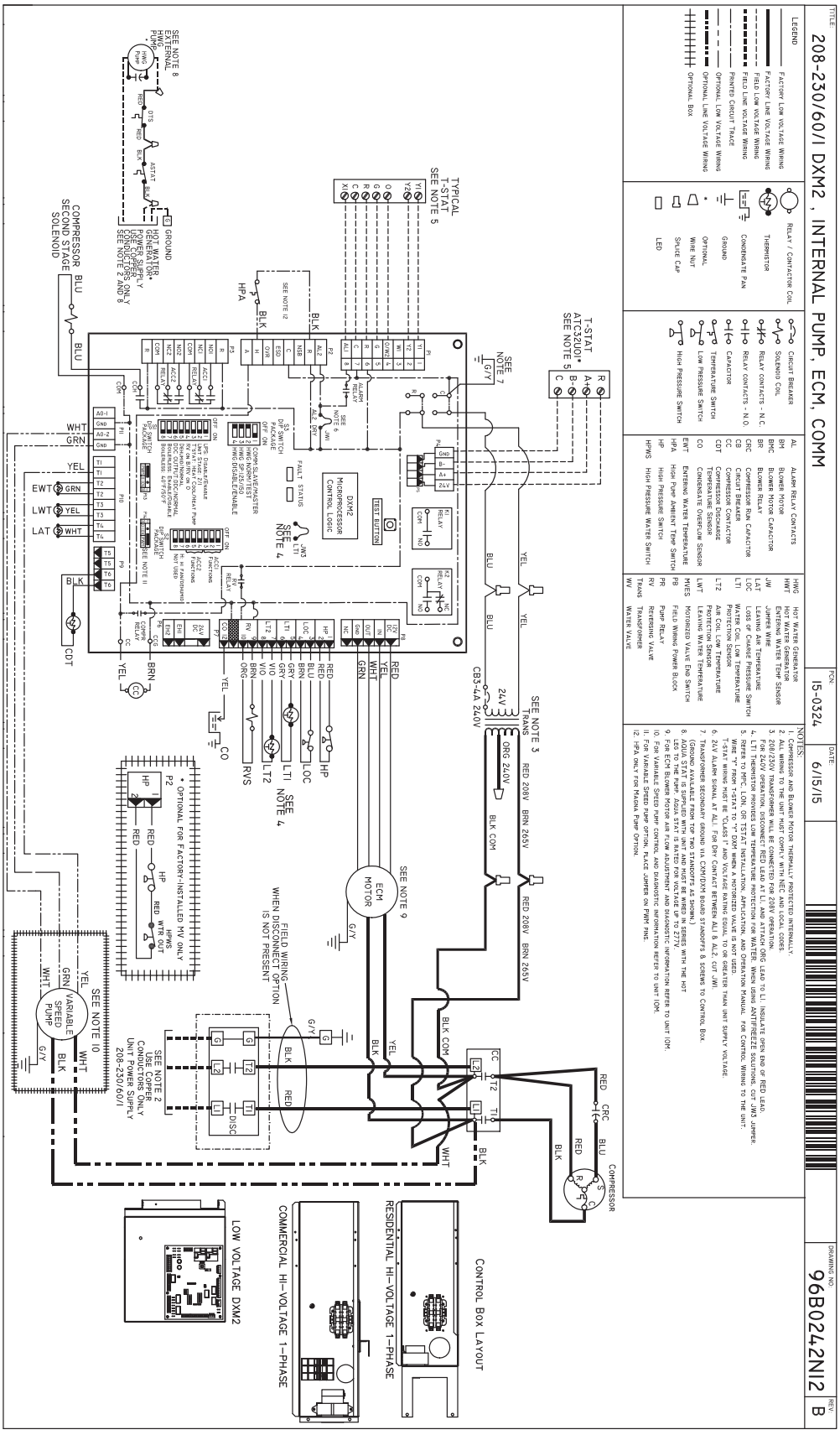
## Typical Wiring Diagram – Single Phase 208/230V TE Units with Variable Pump

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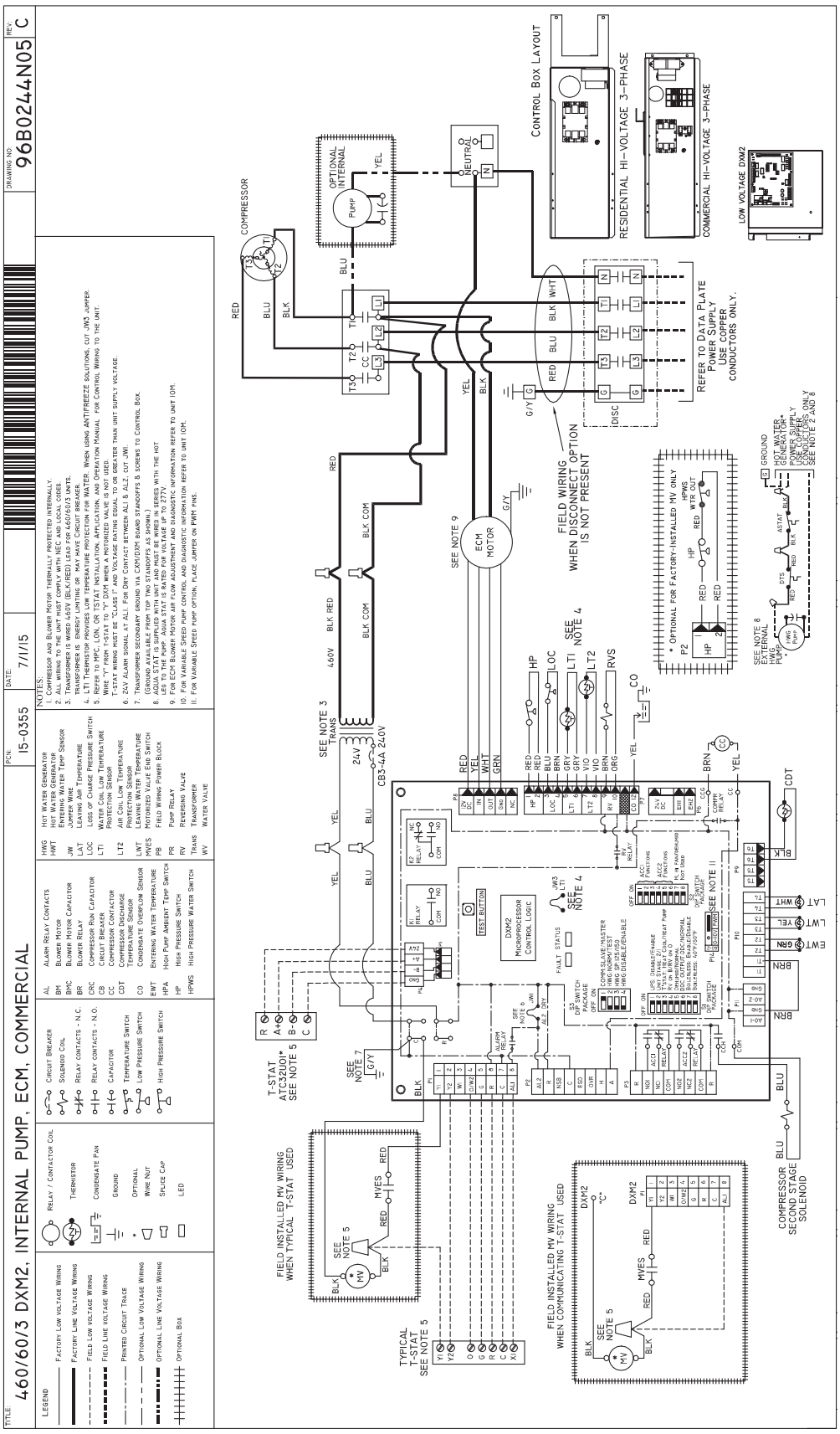
## Typical Wiring Diagram – Three Phase 460V TE Units with DXM2 Controller

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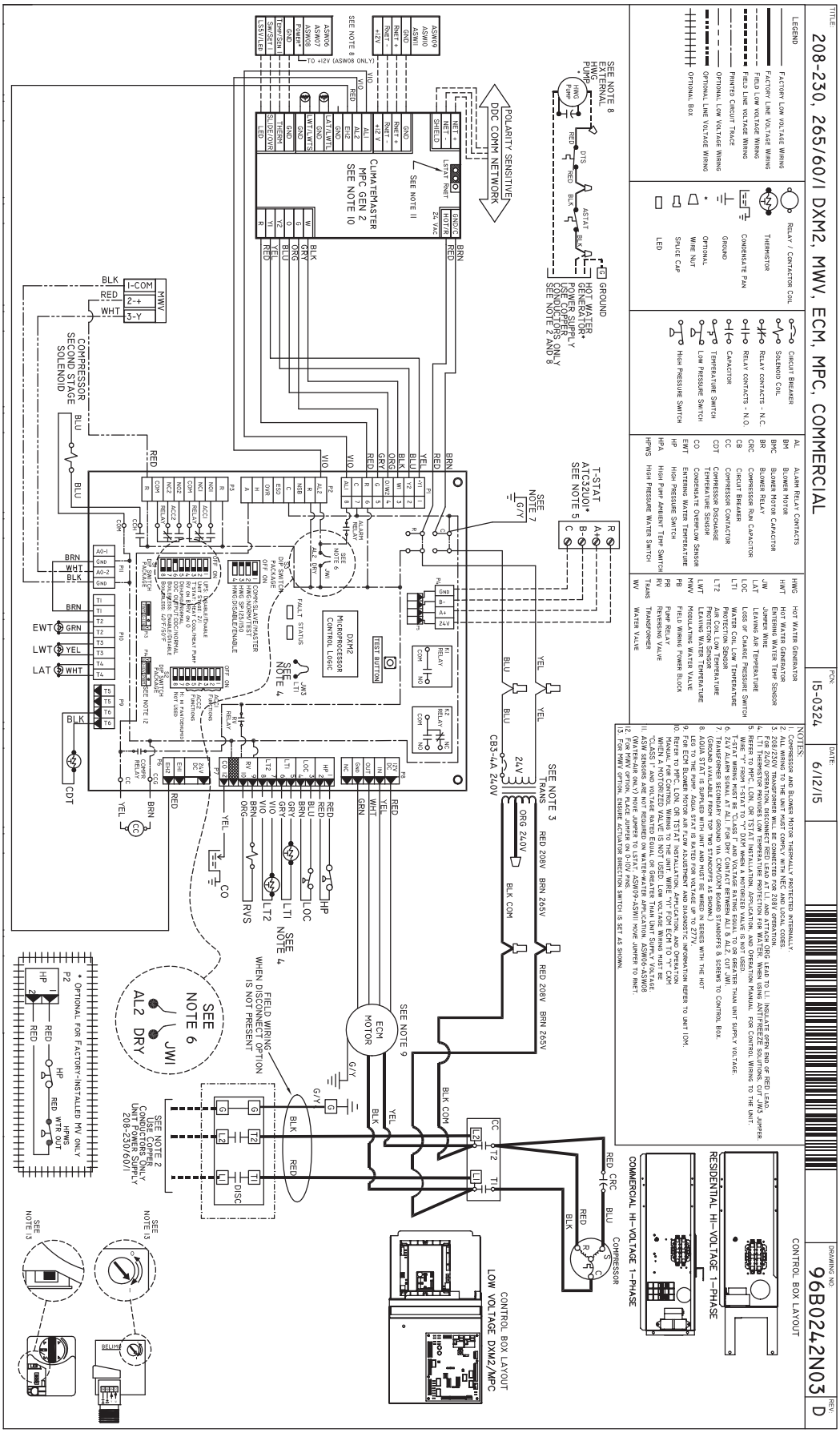
## Typical Wiring Diagram – Single Phase TE Units with MWV and MPC Controller

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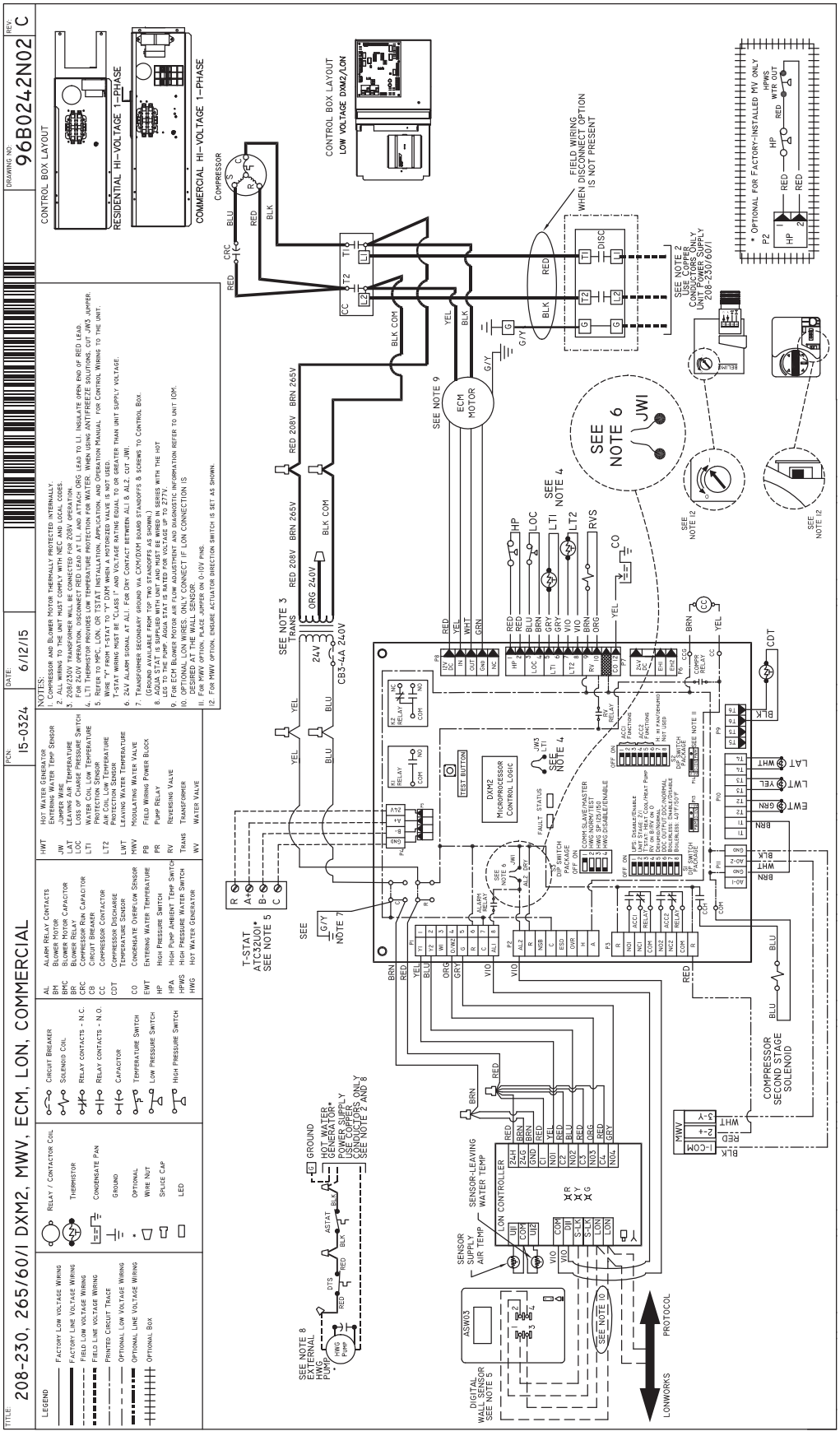
## Typical Wiring Diagram – Single Phase TE Units with MWV and LON Controller

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## Tranquility® 30 (TE) Series 60Hz Engineering Specifications – Page 1

**General:**
Furnish and install ClimateMaster Tranquility® "TE" Water Source Heat Pumps, as indicated on the plans. Equipment shall be completely assembled, piped, and internally wired. Capacities and characteristics as listed in the schedule and the specifications that follow.

Units shall be supplied completely factory built capable of operating over an entering water temperature range from 20° to 120°F (-6.7° to 48.9°C) as standard. Equivalent units from other manufacturers may be proposed provided approval to bid is given 10 days prior to bid closing. All equipment listed in this section must be rated and certified in accordance with Air-Conditioning, Heating and Refrigeration Institute/International Standards Organization (AHRI/ISO 13256-1). All equipment must be tested, investigated, and determined to comply with the requirements of the standards for Heating and Cooling Equipment UL-1995 for the United States and CAN/CSA-C22.2 NO.236 for Canada, by Intertek Testing Laboratories (ETL). The units shall have AHRI/ISO and ETL-US-C labels.

All units shall be fully quality tested by factory run testing under normal operating conditions as described herein. Quality control system shall automatically perform via computer: triple leak check, pressure tests, evacuation and accurately charge system, perform detailed heating and cooling mode tests, and quality cross check all operational and test conditions to pass/fail criteria. Detailed report card will ship with each unit displaying status for critical tests and components. **Note: If unit fails on any cross check, it shall not be allowed to ship. Serial numbers will be recorded by factory and furnished to contractor on report card for ease of unit warranty status. Units tested without water flow are not acceptable.**

**Basic Construction:**
Horizontal units shall have one of the following air flow arrangements: Left Inlet/Straight (Right) Discharge; Right Inlet/Straight (Left) Discharge; Left Inlet/Back Discharge; or Right Inlet/Back Discharge as shown on the plans. Units must have the ability to be field convertible from straight to back or back to straight discharge with no additional parts or unit structure modification. Horizontal units will have factory installed hanger brackets with rubber isolation grommets packaged separately.

Vertical Units shall have one of the following air flow arrangements: Left Return/Top Discharge, Right Return/Top Discharge, Left Return/Bottom Discharge, Right Return/Bottom Discharge as shown on the plans.

If units with these arrangements are not used, the contractor is responsible for any extra costs incurred by other trades. All units (horizontal and vertical) must have a minimum of three access panels for serviceability of compressor compartment. Units having only one access panel to compressor/heat exchangers/expansion device/refrigerant piping shall not be acceptable.

Compressor section interior surfaces shall be lined with 1/2 inch (12.7mm) thick, 1-1/2 lb/ft3 (24 kg/m3) acoustic type glass fiber insulation. Air handling section interior surfaces shall be lined with 1/2 in (12.7mm) thick, 1-1/2 lb/ft3 (24 kg/m3**) foil-faced** fiber insulation for ease of cleaning. Insulation placement shall be designed in a manner that will eliminate any exposed edges to prevent the introduction of glass fibers into the air stream. **Units without foil-faced insulation in the air handling section will not be accepted.**

The heat pumps shall be fabricated from heavy gauge galvanized steel with powder coat paint finish. Both sides of the steel shall be painted for added protection.

Standard cabinet panel insulation must meet NFPA 90A requirements, air erosion and mold growth limits of UL-181, stringent fungal resistance test per ASTM-C1071 and ASTM G21, and shall meet zero level bacteria growth per ASTM G22. **Unit insulation must meet these stringent requirements or unit(s) will not be accepted.**

All horizontal units to have factory installed 1"(25.4mm) discharge air duct collars, 1"(25.4mm) filter rails with 1"(25.4mm) filters factory installed, and factory installed unit-mounting brackets. Vertical units to have field installed discharge air duct collar, shipped loose and 1"(25.4mm) filter rails with 1"(25.4mm) filters factory installed. **If units with these factory-installed provisions are not used, the contractor is responsible for any extra costs to field install these provisions, and/or the extra costs for his sub-contractor to install these provisions.**

All units must have an insulated panel separating the fan compartment from the compressor compartment. Units with the compressor in the air stream are not acceptable. Units shall have a factory installed 1 inch (25.4mm) wide filter bracket for filter removal from either side. Units shall have a 1 inch (25.4mm) thick throwaway type glass fiber filter. The contractor shall purchase one spare set of filters and replace factory shipped filters on completion of start-up. Filters shall be standard sizes. If units utilize non-standard filter sizes then the contractor shall provide 12 spare filters for each unit.

Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. All factory-installed wiring passing through factory knockouts and openings shall be protected from sheet metal edges at openings by plastic ferrules. Supply and return water connections shall be copper FPT fittings, and shall be securely mounted flush to the cabinet corner post

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allowing for connection to a flexible hose without the use of a back-up wrench. Water connections that protrude through the cabinet or require the use of a backup wrench shall not be allowed. All water connections and electrical knockouts must be in the compressor compartment corner post as to not interfere with the serviceability of unit. Contractor shall be responsible for any extra costs involved in the installation of units that do not have this feature. Contractor must ensure that units can be easily removed for servicing and coordinate locations of electrical conduit and lights with the electrical contractor.

*Option: The unit will be supplied with optional field or factory installed 2" air filter rails (typically used for free return installation) or 1" or 2" air filter frames with filter access door and return air duct flanges (typically used for ducted return installation). A corresponding 1" or 2" throwaway type glass fiber filter will ship with the factory installed filter rails or frame.*

*Option: The contractor shall install 1 inch MERV 8, 2 inch MERV 11, or 2 inch MERV 13 rated pleated media disposable air filters on all units.*

*Option: UltraQuiet package shall consist of high technology sound attenuating material that is strategically applied to the compressor and air handling compartment casings and fan scroll in addition to the standard ClimaQuiet system design, to further dampen and attenuate sound transmissions. Compressor is mounted on specially engineered sound-tested spring isolators.*

*Option: The unit will be supplied with internally factory mounted modulating water valve for variable speed pumping requirements.*

*Option: The unit will be supplied with internally factory mounted variable speed water circulating pump.*

*Option: The unit will be supplied with internally mounted secondary pump for primary/secondary applications, including one-pipe systems.*

*Option: The unit shall be supplied with extended range insulation option, which adds closed cell insulation to internal water lines, and provides insulation on suction side refrigeration tubing including refrigerant to water heat exchanger.*

**Fan and Motor Assembly:**
Blower shall have inlet rings to allow removal of wheel and motor from one side without removing housing. Units shall have a direct-drive centrifugal fan. The fan motor shall be an ECM variable speed ball bearing type motor. The ECM fan motor shall provide soft starting, maintain constant CFM over its static operating range and provide airflow adjustment in 25 CFM increments via its control board. The fan motor shall be isolated from the housing by rubber grommets. The motor shall be permanently lubricated and have thermal overload protection. A special dehumidification mode shall be provided to allow lower airflows in cooling for better dehumidification. The dehumidification mode may be constant or automatic (humidistat controlled). Airflow/Static pressure rating of the unit shall be based on a wet coil and a clean filter in place. **Ratings based on a dry coil, and/or no air filter, shall NOT be acceptable.**

**Refrigerant Circuit:**
All units shall contain an EarthPure®(HFC-410A) sealed refrigerant circuit including a high efficiency two-stage scroll compressor designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, an enhanced corrugated aluminum lanced fin and rifled copper tube or all aluminum micro channel refrigerant to air heat exchanger, reversing valve, coaxial (tube in tube) refrigerant to water heat exchanger, and safety controls including a high pressure switch, low pressure switch (loss of charge), water coil low temperature sensor, and air coil low temperature sensor. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit. The lockout circuit shall be reset at the thermostat or at the contractor supplied disconnect switch. **Units that cannot be reset at the thermostat shall not be acceptable.**

Hermetic compressors shall be internally sprung. The compressor shall have a dual level vibration isolation system. The compressor will be mounted on specially engineered sound-tested EPDM vibration isolation grommets to a large heavy gauge compressor mounting plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration attenuation. All units shall include a discharge muffler to further enhance sound attenuation. Compressor shall have thermal overload protection. Compressor shall be located in an insulated compartment away from air stream to minimize sound transmission.

Refrigerant to air heat exchangers shall utilize enhanced corrugated lanced aluminum fins and rifled copper tube or all aluminum microchannel construction rated to withstand 625 PSIG (4309 kPa) refrigerant working pressure. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 625 PSIG (4309 kPa) working refrigerant pressure and 500 PSIG (3445 kPa) working water pressure. The refrigerant to water heat exchanger shall be "electro-coated" with a low cure cathodic epoxy material a minimum of 0.4 mils thick (0.4 – 1.5 mils range) on all surfaces. The black colored coating shall provide a minimum of 1000 hours salt spray protection per ASTM B117-97 on all external steel and copper tubing. The material shall

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be formulated without the inclusion of any heavy metals and shall exhibit a pencil hardness of 2H (ASTM D3363-92A), crosshatch adhesion of 4B-5B (ASTM D3359-95), and impact resistance of 160 in-lbs (184 kg-cm) direct (ASTM D2794-93).

Refrigerant metering shall be accomplished by thermostatic expansion valve only. Expansion valves shall be dual port balanced types with external equalizer for optimum refrigerant metering. Units shall be designed and tested for operating ranges of entering water temperatures from 20° to 120°F (-6.7° to 48.9°C). Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function. If the reversing valve solenoid defaults to cooling mode, an additional low temperature thermostat must be provided to prevent over-cooling an already cold room.

*Option: The unit will be supplied with a cupro-nickel coaxial water to refrigerant heat exchanger.*

*Option: The unit shall be supplied with a hot water generator (desuperheater).*

**Drain Pan:**
The drain pan shall be constructed of Stainless Steel to inhibit corrosion. This corrosion protection system shall meet the stringent 1000 hour salt spray test per ASTM B117. If plastic type material is used, it must be HDPE (High Density Polyethylene) to avoid thermal cycling shock stress failure over the lifetime of the unit. Drain pan shall be fully insulated. Drain outlet shall be located at pan as to allow unobstructed drainage of condensate. Drain outlet for horizontal units shall be connected from pan directly to MPT fitting. **No hidden internal tubing extensions from pan outlet extending to unit casing (that can create drainage problems) will be accepted.** The unit as standard will be supplied with solid-state electronic condensate overflow protection. **Mechanical float switches will NOT be accepted.**

Vertical units shall be furnished with a PVC FPT condensate drain connection and an internal factory installed condensate trap. If units without an internal trap are used, the contractor is responsible for any extra costs to field install these provisions, and/or the extra costs for his sub-contractor to install these provisions.

**Electrical:**
A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Reversing valve and fan motor wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote thermostat/sensor.

*Option: Units shall be supplied with factory installed non-fused electrical service disconnect switch.*

**Solid State Control System (DXM2):**
Units shall have a solid-state control system. Units utilizing electro-mechanical control shall not be acceptable. The control system microprocessor board shall be specifically designed to protect against building electrical system noise contamination, EMI, and RFI interference. The control system shall have the following features:

- Anti-short cycle time delay on compressor operation.
- Random start on power up mode.
- Low voltage protection.
- High voltage protection.
- Unit shutdown on high or low refrigerant pressures (loss of charge).
- Unit shutdown on low water temperature.
- Condensate overflow electronic protection.
- Option to reset unit at thermostat or disconnect.
- Automatic intelligent reset. Unit shall automatically reset the unit 5 minutes after trip if the fault has cleared. If a fault occurs 3 times sequentially without thermostat meeting temperature, then lockout requiring manual reset will occur.
- Ability to defeat time delays for servicing.
- Light emitting diode (LED) on circuit board to indicate high pressure, low pressure (loss of charge), low voltage, high voltage, low water/air temperature cut-out, condensate overflow, and control voltage status.
- The low-pressure (loss of charge) switch shall not be monitored for the first 120 seconds after a compressor start command to prevent nuisance safety trips.
- 24V output to cycle a motorized water valve or other device with compressor contactor.
- Unit Performance Sentinel (UPS). The UPS warns when the heat pump is running inefficiently.
- Water coil low temperature sensing (selectable for water or antifreeze).
- Air coil low temperature sensing.
- Removable thermostat connector.
- Night setback control.

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- Random start on return from night setback.
- Minimized reversing valve operation (Unit control logic shall only switch the reversing valve when cooling is demanded for the first time. The reversing valve shall be held in this position until the first call for heating, ensuring quiet operation and increased valve life.).
- Override temperature control with 2-hour timer for room occupant to override setback temperature at the thermostat.
- Dry contact night setback output for digital night setback thermostats.
- Ability to work with heat pump (Y, O) or heat/cool (Y, W) type thermostats.
- Ability to work with heat pump thermostats using O or B reversing valve control.
- Emergency shutdown contacts.
- Boilerless system heat control at low loop water temperature.
- Ability to allow up to 3 units to be controlled by one thermostat.
- Relay to operate an external damper.
- Ability to automatically change fan speed from multistage thermostat.
- Relay to start system pump.
- 75 VA control transformer. Control transformer shall have load side short circuit and overload protection via a built in circuit breaker.

**NOTE: Units not providing the 8 safety protections of anti-short cycle, low voltage, high voltage, high refrigerant pressure, low pressure (loss of charge), air coil low temperature cut-out, water coil low temperature cut-out, and condensate overflow protections will not be accepted.**

**Note: To achieve full benefit of the two-stage compressor and ECM fan, a 2 Heat/2 Cool thermostat (or a 3 Heat/2 Cool thermostat when electric backup heat is required) should be employed.**

**Digital Night Setback with Pump Restart (with ATP32U03, ATP32U04, ATC32U02C)**
The unit will be provided with a Digital Night Setback feature using an accessory relay on the DXM2 controller and an external, field-provided time clock. The external time clock will initiate and terminate the night setback period. The thermostat will have a night setback override feature with a programmable override time period.
An additional accessory relay on the unit DXM2 controller will energize the building loop pump control for the duration of the override period. **(Note: this feature requires additional low voltage wiring. Consult Application Drawings for details.)**

**Remote Service Sentinel:**
Solid state control system shall communicate with thermostat to display (at the thermostat) the unit status, fault status, and specific fault condition, as well as retrieve previously stored fault that caused unit shutdown. The Remote Service Sentinel allows building maintenance personnel or service personnel to diagnose unit from the wall thermostat. The control board shall provide a signal to the thermostat fault light, indicating a lockout. Upon cycling the G (fan) input 3 times within a 60 second time period, the fault light shall display the specific code as indicated by a sequence of flashes. A detailed flashing code shall be provided at the thermostat LED to display unit status and specific fault status such as over/under voltage fault, high pressure fault, low pressure fault, low water temperature fault, condensate overflow fault, etc. **Units that do not provide this remote service sentinel shall not be acceptable.**

**Option: Lonworks interface system**
Units shall have all the features listed above and the control board will be supplied with a LONWORKS interface board, which is LONMark certified. This will permit all units to be daisy chained via a 2-wire twisted pair shielded cable. The following points must be available at a central or remote computer location:

a. space temperature
b. leaving water temperature
c. discharge air temperature
d. command of space temperature setpoint
e. cooling status
f. heating status
g. low temperature sensor alarm
h. low pressure sensor alarm
i. high pressure switch alarm
j. condensate sensor alarm
k. hi/low voltage alarm
l. fan "ON/AUTO" position of space thermostat as specified above
m. unoccupied/occupied command
n. cooling command
o. heating command
p. fan "ON/AUTO" command

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q. fault reset command
r. itemized fault code revealing reason for specific shutdown fault (any one of 7)

**Option: MPC (Multiple Protocol Control) interface system**
Units shall have all the features listed above and the control board will be supplied with a Multiple Protocol interface board. Available protocols are BACnet MS/TP, Modbus, or Johnson Controls N2. The choice of protocol shall be field selectable/changeable via the use of a simple selector switch. **Protocol selection shall not require any additional programming or special external hardware or software tools.** This will permit all units to be daisy chain connected by a 2-wire twisted pair shielded cable. The following points must be available at a central or remote computer location:

a. space temperature
b. leaving water temperature
c. discharge air temperature
d. command of space temperature setpoint
e. cooling status
f. heating status
g. low temperature sensor alarm
h. low pressure sensor alarm
i. high pressure switch alarm
j. condensate overflow alarm
k. hi/low voltage alarm
l. fan "ON/AUTO" position of space thermostat as specified above
m. unoccupied/occupied command
n. cooling command
o. heating command
p. fan "ON/AUTO" command
q. fault reset command
r. itemized fault code revealing reason for specific shutdown fault (any one of 7)

**Warranty:**
Climate Master shall warranty equipment for a period of 12 months from start up or 18 months from shipping (which ever occurs first).

*Option: Extended 4-year compressor warranty covers compressor for a total of 5 years.*

*Option: Extended 4-year refrigeration circuit warranty covers coils, reversing valve, expansion valve and compressor for a total of 5 years.*

*Option: Extended 4-year control board warranty covers the CXM/DXM control board for a total of 5 years.*

**FIELD INSTALLED OPTIONS**

**Hose Kits:**
All units shall be connected with hoses. The hoses shall be 2 feet (61cm) long, braided stainless steel; fire rated hoses complete with adapters. Only fire rated hoses will be accepted.

**Valves:**
The following valves are available and will be shipped loose:
a. Ball valve; bronze material, standard port full flow design, FPT connections.
b. Ball valve with memory stop and PT port.
c. "Y" strainer with blowdown valve; bronze material, FPT connections.
d. Motorized water valve; slow acting, 24v, FPT connections.

**Hose Kit Assemblies:**
The following assemblies ship with the valves already assembled to the hose described:
a. Supply and return hoses having ball valve with PT port.
b. Supply hose having ball valve with PT port; return hose having automatic flow regulator valve with PT ports, and ball valve.
c. Supply hose having "Y" strainer with blowdown valve, and ball valve with PT port; return hose having automatic flow regulator with PT ports, and ball valve.

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d. Supply hose having "Y" strainer with blowdown valve, and ball valve with PT port; return hose having ball valve with PT port.

**Thermostats:**
The thermostat shall be a ClimateMaster mechanical or electronic type thermostat as selected below with the described features:

a. Thermostat (communicating) (ATC32U02C)
An electronic communicating LCD thermostat shall be provided. The thermostat shall offer three stages of heating and two stages of cooling with precise temperature control and have a four-wire connection to the unit. The thermostat shall be capable of manual or automatic change-over operation and shall operate in standard or programmable mode. An integrated humidity control feature shall be included to control a humidifier and/or a dehumidifier. The thermostat shall include a utility demand reduction feature to be initiated by an independent time program or an external input.

The thermostat shall have a comprehensive installation setup menu to include configuration of the unit CFM for each mode of operation and configuration of the water flow rate through the unit, including variation of the water flow rate based on the stage of unit operation.

The thermostat shall display system faults with probable cause and troubleshooting guidance. Comprehensive service diagnostics menus shall display, system inputs, system outputs, configuration settings, Geo source inlet and outlet temperatures, compressor discharge line temperature, liquid line temperature, leaving air temperature, and entering potable water temperature (on units equipped with a Hot Water Generator). The thermostat shall allow for immediate manual control of all DXM2 outputs at the thermostat for rapid troubleshooting.

b. Multistage Digital Automatic Changeover (ATA22U01)
Thermostat shall be multi-stage (2H/2C), manual or automatic changeover with HEAT-OFF-COOL-AUTO-EM HEAT system settings and fan ON-AUTO settings. Thermostat shall have an LCD display with temperature, setpoint(s), mode, and status indication. The temperature indication shall be selectable for °F or °C. The thermostat shall provide permanent memory of setpoint(s) without batteries. A fault LED shall be provided to indicate specific fault condition(s). Thermostat shall provide temperature display offset for custom applications. Thermostat shall allow unit to provide better dehumidification by automatically using lower fan speed on stage 1 cooling (higher latent cooling) as main cooling mode, and automatically shifting to high speed fan on stage 2 cooling.

c. Multistage Automatic or Manual Changeover Programmable 7 Day (ATP32U03)
Thermostat shall be 7 day programmable (with up to 4 setpoints per day), multi-stage (3H/2C), automatic or manual changeover with HEAT-OFF-COOL-AUTO-EM HEAT system settings and fan ON-AUTO settings. Thermostat shall have a blue backlit dot matrix LCD display with temperature, setpoints, mode, and status indication. The temperature indication shall be selectable for °F or °C. Time display shall be selectable for 12 or 24 hour clock. Fault identification shall be provided to simplify troubleshooting by providing specific unit fault at the thermostat with red backlit LCD during unit lockout. The thermostat shall provide permanent memory of setpoints without batteries. Thermostat shall provide heating setpoint range limit, cooling setpoint range limit, temperature display offset, keypad lockout, dead-band range setting, and inter-stage differential settings. Thermostat shall provide progressive recovery to anticipate time required to bring space temperature to the next programmed event. Thermostat shall provide an installer setup for configuring options and for setup of servicing contractor name and contact information. Thermostat shall allow the use of an accessory remote and/or outdoor temperature sensor (AST008). Thermostat navigation shall be accomplished via five buttons (up/down/right/left/select) with menu-driven selections for ease of use and programming.

d. Multistage Automatic or Manual Changeover Programmable 7 Day with Humidity Control (ATP32U04)
Thermostat shall be 7 day programmable (with up to 4 setpoints per day), multi-stage (3H/2C), automatic or manual changeover with HEAT-OFF-COOL-AUTO-EM HEAT system settings and fan ON-AUTO settings. Separate dehumidification and humidification setpoints shall be configurable for discreet outputs to a dehumidification option and/or an external humidifier. Installer configuration mode shall allow thermostat to operate with ECM fan dehumidification mode via settings changes. Thermostat shall have a blue backlit dot matrix LCD display with temperature, relative humidity, setpoints, mode, and status indication. The temperature indication shall be selectable for °F or °C. Time display shall be selectable for 12 or 24 hour clock. Fault identification shall be provided to simplify troubleshooting by providing specific unit fault at the thermostat with red backlit LCD during unit lockout. The thermostat shall provide permanent memory of setpoints without batteries. Thermostat shall provide heating setpoint range limit, cooling setpoint range limit, temperature display offset, keypad lockout, dead-band range setting, and inter-stage differential settings. Thermostat shall provide progressive recovery to anticipate time required to bring space temperature to the next programmed event. Thermostat shall provide an installer setup for configuring options and for setup of servicing contractor name and contact information. Thermostat shall allow the use of an accessory remote and/or outdoor temperature sensor (AST008). Thermostat navigation shall be accomplished via five buttons (up/down/right/left/select) with menu-driven selections for ease of use and programming.

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**DDC Sensors:**
ClimateMaster wall mounted DDC sensor to monitor room temperature and interfaces with optional interface system described above. Several types as described below:

a. Sensor only with no display (LON and MPC).
b. Sensor with override (LON only).
c. Sensor with setpoint adjustment and override (MPC only).
d. Sensor with setpoint adjustment and override, LCD display, status/fault indication (LON and MPC).

**Accessory:**
Hand Held Communication/Diagnostic Service Tool ACDU02C
Allows installation and service personnel to access the configuration and service modes of the DXM2 control board without installing the ATC32U02C communicating thermostat.
Configure the airflow, pump, or modulating valve operation etc.
Diagnose by viewing fault history and operating conditions at the time of fault and manually operating the unit.

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## Revision History

| Date: | Item: | Action: |
|---|---|---|
| 07/09/15 | WPD - Page 16, 17, 18 | Updated |
| 01/30/15 | Table edit - Page 39 | Updated |
| 11/21/14 | Text edit - Page 7 | Updated |
| 10/20/14 | TE026 Full Load Data | Updated |
| 09/30/14 | Decoder - Page 10; Text Edit - Page 59 | Updated |
| 09/10/14 | Added Performance Data Selection Notes - Page 12<br>Updated Performance Data Notes - Pages 13-32 | Added/Updated |
| 07/28/14 | Created | |

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**Goulds Pumps:**

Goulds Pumps, a Division of Xylem, is a manufacturer of many types of pumps, but well known for their high quality, all stainless steel submersible pumps, which are suitable for potable water and feature a robust construction. When Goulds learned of the opportunity to participate in the unique energy saving design of an ATES project, they committed to provide all four submersible pumps (45 GPM) and provided high level of technical support to insure a successful deployment. A technical brochure of their submersible pump utilized for this demonstration follow and more information can be found at http://goulds.com/.




**TECHNICAL BROCHURE**
B35-85GS

## FEATURES

**Powered for Continuous Operation:** All ratings are within the working limits of the motor as recommended by the motor manufacturer. Pump can be operated continuously without damage to the motor.

**Field Serviceable:** Units have left hand threads and are field serviceable with common tools and readily available repair parts.

**Sand Handling Design:** Our face clearance, floating impeller stack has proven itself for over 50 years as a superior sand handling, durable pump design.

**FDA Compliant Non-Metallic Parts:** Impellers, diffusers and bearing spiders are constructed of glass filled engineered composites. They are corrosion resistant and non-toxic.

**Discharge Head/Check Valve:** Cast 303 stainless steel for strength and durability. Two cast-in safety line loops for installer convenience. The built-in check valve is constructed of stainless steel and FDA compliant BUNA rubber for abrasion resistance and quiet operation.

**Motor Adapter:** Cast 303 stainless steel for rigid, accurate alignment of pump and motor. Easy access to motor mounting nuts using standard open end wrench.

**Stainless Steel Casing:** Polished stainless steel is strong and corrosion resistant.

**Hex Shaft Design:** Six sided shafts for positive impeller drive.

**Engineered Polymer Bearings:** The proprietary, engineered polymer bearing material is strong and resistant to abrasion and wear. The enclosed upper bearing is mounted in a durable Noryl® bearing spider for excellent abrasion resistance.

# e-GS

# 35GS, 45GS, 65GS & 85GS

35-85 GPM 1-10HP, 60 HZ, SUBMERSIBLE PUMPS

BUILT IN THE USA
ENGINEERED, ASSEMBLED & TESTED

GOULDS WATER TECHNOLOGY
a xylem brand

## WATER END DATA

| Series | Model | Required HP | Stages | Water End | |
|---|---|---|---|---|---|
| | | | | Length (in) | Weight (lbs) |
| 35GS | 35GS10 | 1 | 6 | 14.2 | 8 |
| | 35GS15 | 1.5 | 8 | 16.6 | 9 |
| | 35GS20 | 2 | 10 | 19.1 | 10 |
| | 35GS30 | 3 | 14 | 24.0 | 13 |
| | 35GS50 | 5 | 23 | 36.4 | 20 |
| | 35GS75 | 7.5 | 36 | 53.0 | 28 |
| | 35GS100 | 10 | 46 | 65.2 | 34 |
| 45GS | 45GS15 | 1.5 | 5 | 12.9 | 8 |
| | 45GS20 | 2 | 7 | 15.4 | 9 |
| | 45GS30 | 3 | 10 | 19.0 | 10 |
| | 45GS50 | 5 | 17 | 27.7 | 15 |
| | 45GS75 | 7.5 | 25 | 38.9 | 21 |
| | 45GS100 | 10 | 34 | 50.6 | 27 |
| 65GS | 65GS15 | 1.5 | 6 | 19.1 | 10 |
| | 65GS20 | 2 | 7 | 21.2 | 11 |
| | 65GS30 | 3 | 10 | 27.4 | 12 |
| | 65GS50 | 5 | 16 | 41.2 | 18 |
| | 65GS75 | 7.5 | 26 | 62.3 | 35 |
| | 65GS100 | 10 | 33 | 76.8 | 42 |
| 85GS | 85GS30 | 3 | 8 | 29.4 | 13 |
| | 85GS50 | 5 | 14 | 42.8 | 18 |
| | 85GS75 | 7.5 | 21 | 63.8 | 35 |
| | 85GS100 | 10 | 27 | 79.9 | 41 |

## NOMENCLATURE – SOLD AS WATER ENDS ONLY

35 GS 20

GPM at — 35, 45, 65, 85
Best Efficiency

GS Pump Series

Horsepower Code

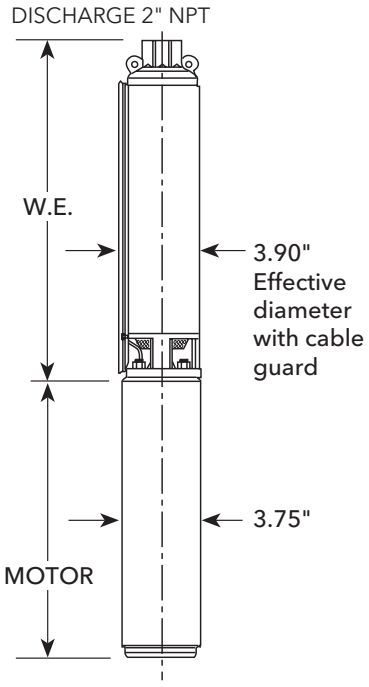
10 = 1
15 = 1 1/2
20 = 2
30 = 3
50 = 5
75 = 7 1/2
100 = 10

## SPECIFICATIONS

| Model | Flow Range GPM | Horse-Power Range | Best Efficiency GPM | Discharge Connection | Minimum Well Size | Rotation |
|---|---|---|---|---|---|---|
| 35GS | 10-50 | 1.0 - 10 | 35 | 2" | 4" | CCW |
| 45GS | 20 - 65 | 1.5 - 10 | 45 | 2" | 4" | CCW |
| 65GS | 30 - 80 | 1.5 - 10 | 65 | 2" | 4" | CCW |
| 85GS | 40 - 120 | 3.0 - 10 | 85 | 2" | 4" | CCW |

## "GS" SERIES MATERIALS OF CONSTRUCTION

| Part Name | Material |
|---|---|
| Discharge Head | AISI 303 SS |
| Check Valve Poppet | AISI 303 SS |
| Check Valve Seal | BUNA, FDA Compliant |
| Check Valve Seat | AISI 304 SS |
| Check Valve Retaining Ring | AISI 302 SS |
| Bearing Spider - Upper | Noryl |
| Bearing | Proprietary Engineered Polymer |
| Klipring | AISI 301 SS |
| Diffuser | Noryl |
| Impeller | Noryl |
| Bowl | AISI 304 SS |
| Intermediate Sleeve* | AISI 304 SS, Powder Metal |
| Intermediate Shaft Coupling* | AISI 304 SS, Powder Metal |
| Intermediate Bearing Spider* | Noryl |
| Intermediate Bearing Spider* | AISI 303 SS |
| Shim | AISI 304 SS |
| Screws - Cable Guard | AISI 304 SS |
| Motor Adapter | AISI 303 SS |
| Casing | AISI 304 SS |
| Shaft | 17-4 PH Stainless Steel |
| Coupling | AISI 304 SS, Powder Metal |
| Cable Guard | AISI 304 SS |
| Suction Screen | AISI 304 SS |



## CENTRIPRO 4" SINGLE-PHASE MOTORS

| Order No. | Type | HP | Volts | Length in. (mm) | Weight lb. (kg.) |
|---|---|---|---|---|---|
| M10422 | 2-wire PSC | 1 | 230 | 13.3 (337) | 24.5 (11.1) |
| M15422 | | 1.5 | | 14.9 (378) | 28.9 (13.1) |
| M10412 | 3-wire | 1 | 230 | 11.7 (297) | 23.1 (10.5) |
| M15412 | | 1.5 | | 13.6 (345) | 27.4 (12.4) |
| M20412 | | 2 | | 15.1 (383) | 31.0 (14.1) |
| M30412 | | 3 | | 18.3 (466) | 40.0 (18.1) |
| M50412 | | 5 | | 27.7 (703) | 70.0 (31.8) |

## CENTRIPRO 4" THREE-PHASE MOTORS

| Order No. | HP | Volts | Length in. (mm) | Weight lb. (kg.) |
|---|---|---|---|---|
| M10430 | 1 | 200 | 11.7 (297) | 22 (10.4) |
| M15430 | 1.5 | | 11.7 (297) | 22 (10.4) |
| M20430 | 2 | | 13.8 (351) | 28 (12.7) |
| M30430 | 3 | | 15.3 (389) | 32 (14.5) |
| M50430 | 5 | | 21.7 (550) | 55 (24.9) |
| M75430 | 7.5 | | 27.7 (703) | 70 (31.8) |
| M10432 | 1 | 230 | 11.7 (297) | 23 (10.4) |
| M15432 | 1.5 | | 11.7 (297) | 23 (10.4) |
| M20432 | 2 | | 13.8 (351) | 28 (12.7) |
| M30432 | 3 | | 15.3 (389) | 32 (14.5) |
| M50432 | 5 | | 21.7 (550) | 55 (24.9) |
| M75432 | 7.5 | | 27.7 (703) | 70 (31.8) |
| M10434 | 1 | 460 | 11.7 (297) | 23 (10.4) |
| M15434 | 1.5 | | 11.7 (297) | 23 (10.4) |
| M20434 | 2 | | 13.8 (351) | 28 (12.7) |
| M30434 | 3 | | 15.3 (389) | 32 (14.5) |
| M50434 | 5 | | 21.7 (550) | 55 (24.9) |
| M75434 | 7.5 | | 27.7 (703) | 70 (31.8) |
| M100434 | 10 | | – | – |
| M15437 | 1.5 | 575 | 11.7 (297) | 23 (10.4) |
| M20437 | 2 | | 15.3 (389) | 32 (14.5) |
| M30437 | 3 | | 15.3 (389) | 32 (14.5) |
| M50437 | 5 | | 27.7 (703) | 70 (31.8) |
| M75437 | 7.5 | | 27.7 (703) | 70 (31.8) |

## NEMA MOTOR

- Corrosion resistant stainless steel construction.
- Built-in surge arrestor is provided on single phase motors through 5 HP.
- Stainless steel splined shaft.
- Hermetically sealed windings.
- Replaceable motor lead assembly.
- NEMA mounting dimensions.
- Control box is required with 3 wire single phase units.
- Three phase units require a magnetic starter with three leg Class 10 overload protection.

## AGENCY LISTINGS

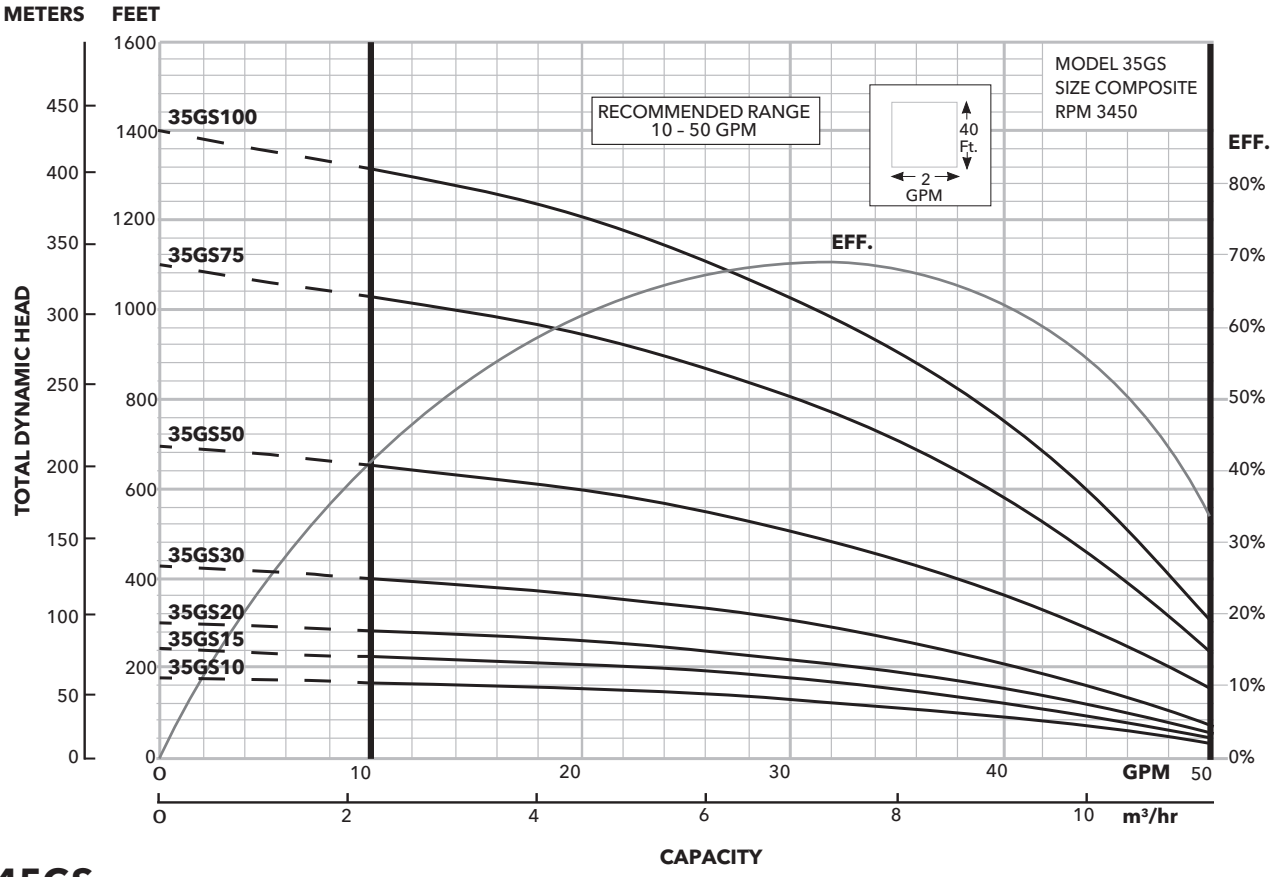
CentriPro Motor - tested to UL778 and CAN 22.2 by CSA International (Canadian Standards Association)

CentriPro Motor - Certified to NSF/ANSI 61, Annex G, Drinking Water System Components 4P49

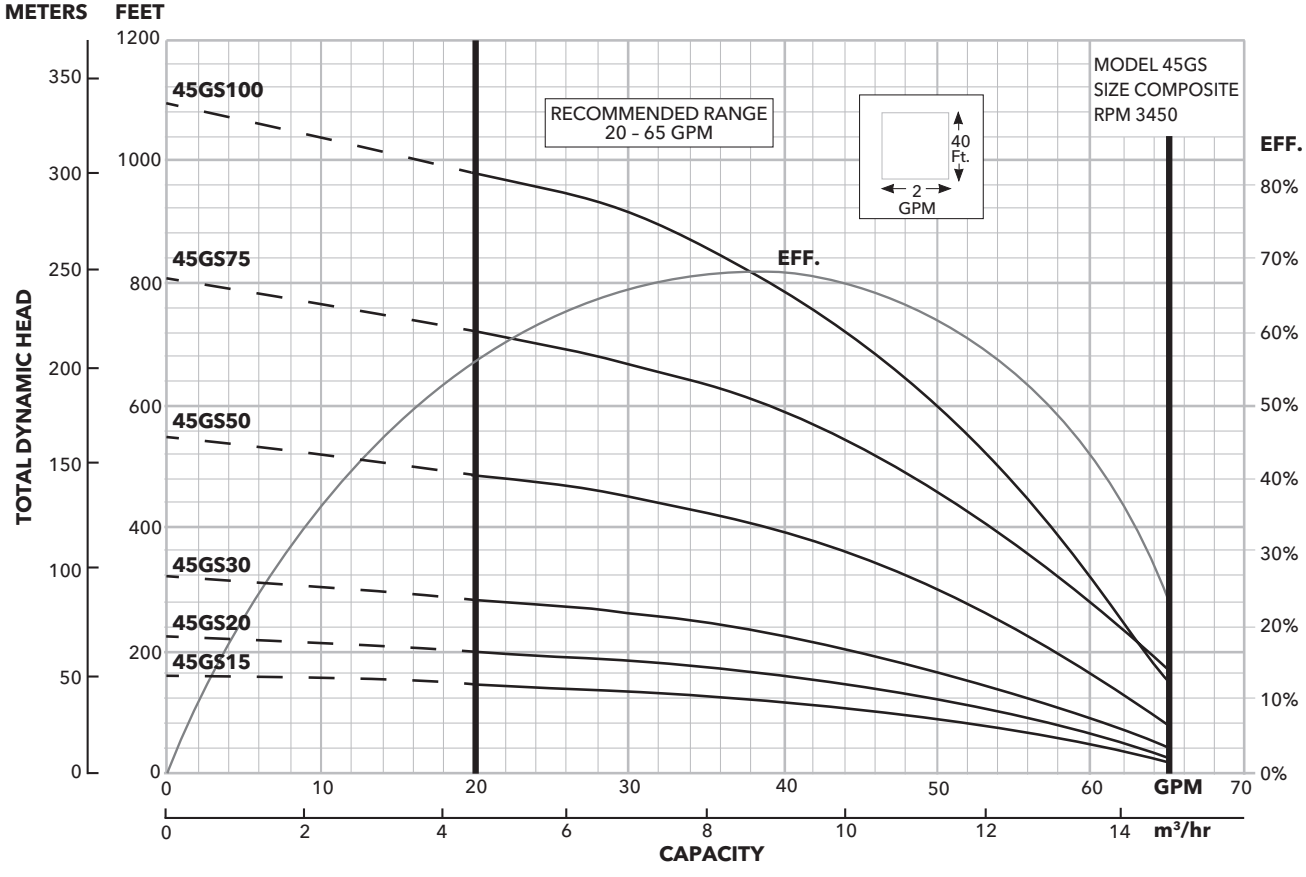
NSF/ANSI 372 – Drinking Water System Components – Lead Content

**CLASS 6853 01** - Low Lead Content Certification Program - - Plumbing Products

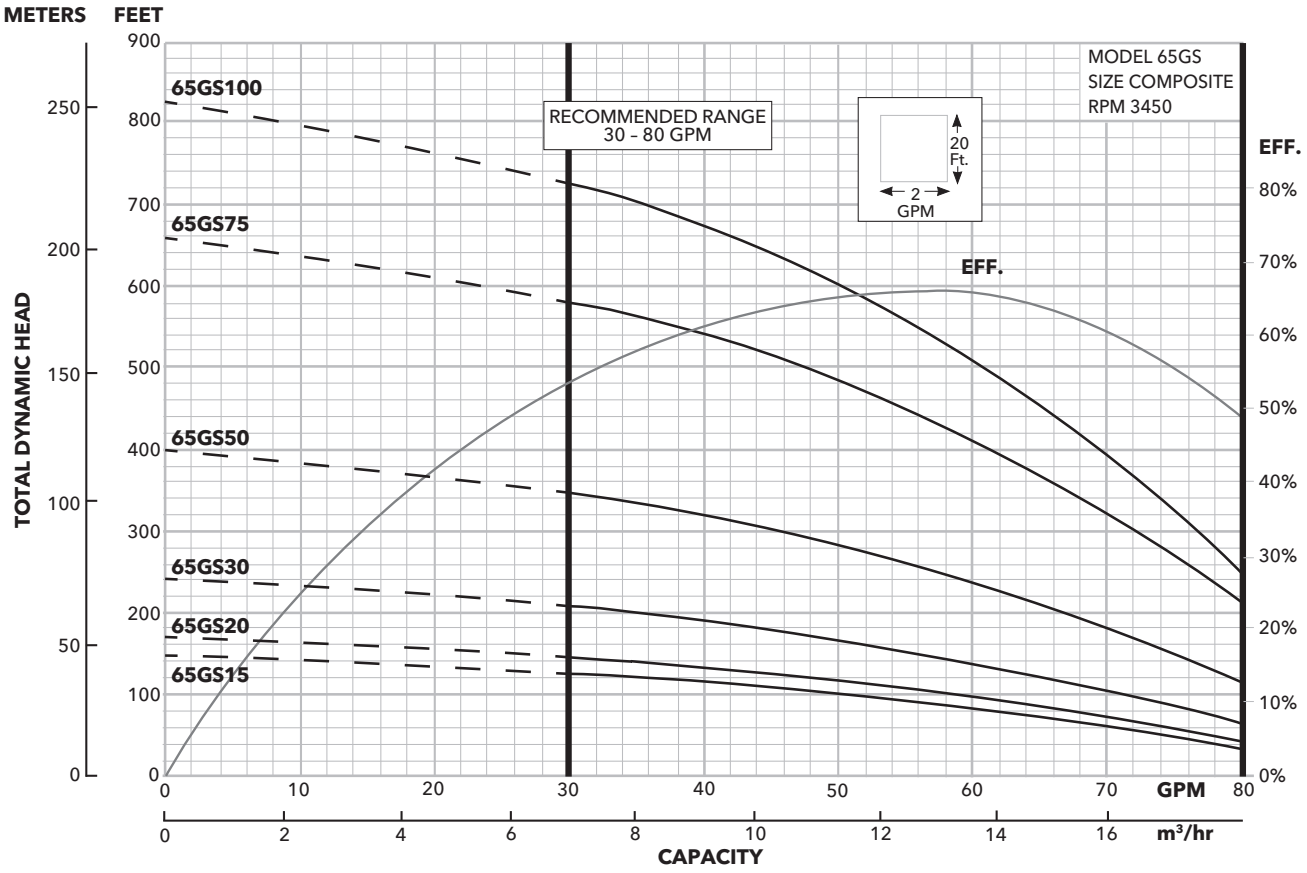
## Model 35GS



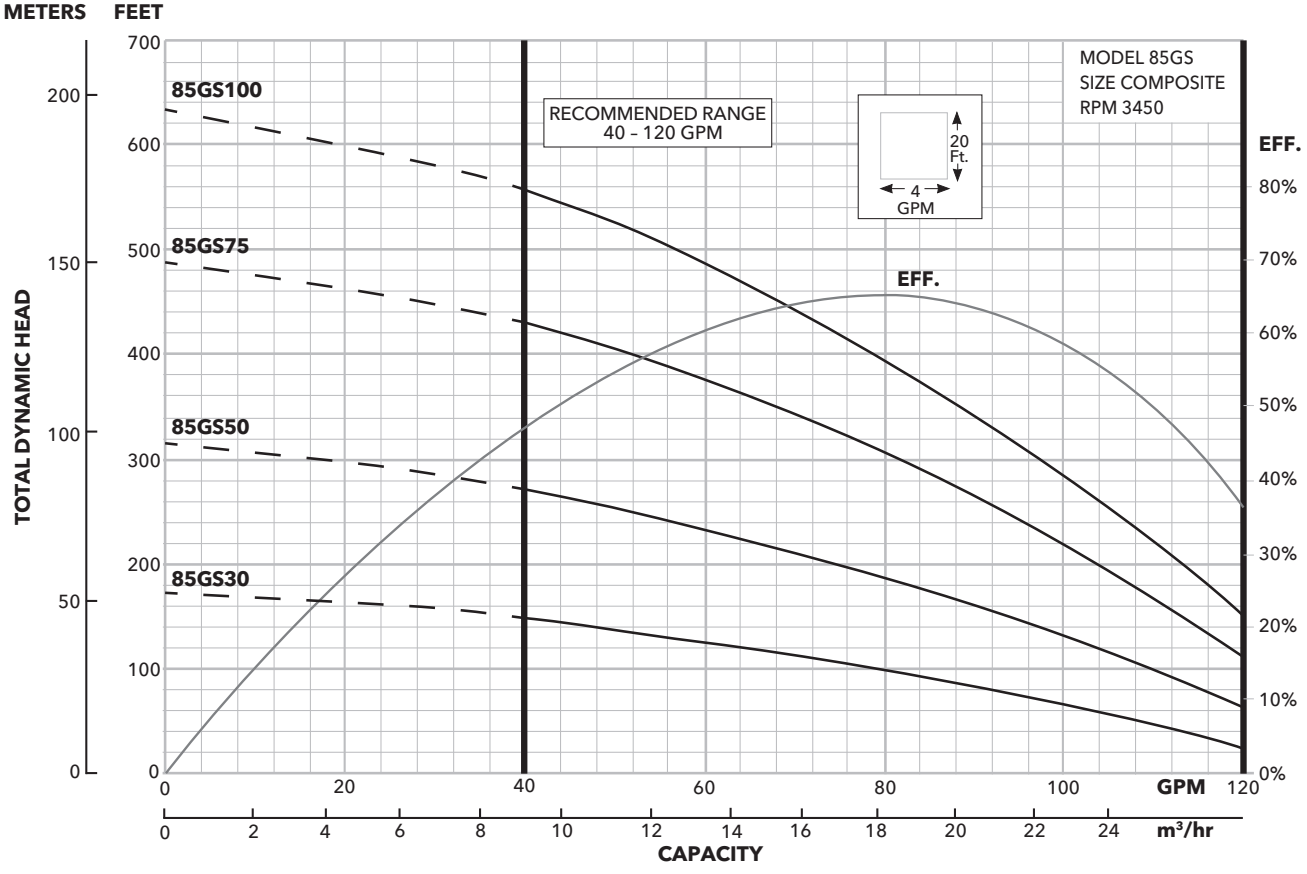

## Model 45GS



## Model 65GS




## Model 85GS



# MODEL 35GS

## SELECTION CHART

Horsepower Range 1 – 3, Recommended Range 10 – 50 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 420 | 440 | 460 | 480 | 520 | 560 | 600 |
| 35GS10 | 1 | 0 | | 49 | 46 | 42 | 38 | 33 | 26 | 15 | | | | | | | | | | | | | | | | | | | |
| | | 20 | 44 | 40 | 36 | 31 | 23 | 11 | | | | | | | | | | | | | | | | | | | | | |
| | | 30 | 40 | 36 | 30 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| | | 40 | 35 | 29 | 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 28 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | 16 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 69 | 60 | 52 | 43 | 34 | 26 | 17 | 8 | | | | | | | | | | | | | | | | | | | |
| 35GS15 | 1½ | 0 | | | 48 | 46 | 43 | 40 | 37 | 33 | 29 | 23 | 14 | | | | | | | | | | | | | | | | |
| | | 20 | 47 | 45 | 43 | 39 | 36 | 32 | 28 | 21 | 10 | | | | | | | | | | | | | | | | | | |
| | | 30 | 45 | 42 | 39 | 35 | 32 | 27 | 19 | | | | | | | | | | | | | | | | | | | | |
| | | 40 | 42 | 38 | 35 | 31 | 26 | 18 | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 38 | 34 | 30 | 25 | 16 | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | 34 | 29 | 24 | 15 | | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 97 | 88 | 79 | 71 | 62 | 53 | 45 | 36 | 27 | 19 | 10 | | | | | | | | | | | | | | | | |
| 35GS20 | 2 | 0 | | | 50 | 48 | 46 | 44 | 42 | 39 | 37 | 34 | 30 | 26 | 20 | 12 | | | | | | | | | | | | | |
| | | 20 | 49 | 47 | 45 | 43 | 41 | 38 | 36 | 33 | 29 | 24 | 17 | | | | | | | | | | | | | | | | |
| | | 30 | 47 | 45 | 43 | 40 | 38 | 35 | 32 | 28 | 23 | 16 | | | | | | | | | | | | | | | | | |
| | | 40 | 44 | 42 | 40 | 38 | 35 | 32 | 27 | 22 | 15 | | | | | | | | | | | | | | | | | | |
| | | 50 | 42 | 40 | 37 | 34 | 31 | 27 | 21 | 14 | | | | | | | | | | | | | | | | | | | |
| | | 60 | 39 | 37 | 34 | 30 | 26 | 20 | 12 | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 123 | 114 | 105 | 97 | 88 | 79 | 71 | 62 | 53 | 45 | 36 | 27 | 19 | 10 | | | | | | | | | | | | | |
| 35GS30 | 3 | 0 | | | | 50 | 48 | 47 | 45 | 44 | 42 | 41 | 39 | 38 | 36 | 34 | 31 | 28 | 25 | 21 | 16 | 10 | | | | | | | |
| | | 20 | | 49 | 48 | 46 | 45 | 43 | 42 | 40 | 39 | 37 | 35 | 33 | 30 | 27 | 24 | 19 | 14 | | | | | | | | | | |
| | | 30 | 49 | 47 | 46 | 45 | 43 | 42 | 40 | 39 | 37 | 35 | 33 | 30 | 27 | 23 | 18 | 13 | | | | | | | | | | | |
| | | 40 | 47 | 46 | 44 | 43 | 41 | 40 | 38 | 37 | 35 | 32 | 30 | 26 | 22 | 18 | 12 | | | | | | | | | | | | |
| | | 50 | 46 | 44 | 43 | 41 | 40 | 38 | 36 | 34 | 32 | 29 | 26 | 22 | 17 | 11 | | | | | | | | | | | | | |
| | | 60 | 44 | 42 | 41 | 39 | 38 | 36 | 34 | 31 | 29 | 25 | 21 | 16 | 10 | | | | | | | | | | | | | | |
| Shut-off PSI | | | 176 | 168 | 159 | 150 | 142 | 133 | 124 | 116 | 107 | 98 | 90 | 81 | 72 | 64 | 55 | 46 | 38 | 29 | 20 | 12 | | | | | | | |

Horsepower Range 5-10, Recommended Range 10 – 50 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 | 1050 | 1100 | 1150 | 1200 | 1250 | 1300 | 1350 |
| 35GS50 | 5 | 0 | | | 50 | 48 | 46 | 43 | 41 | 38 | 35 | 31 | 26 | 19 | 11 | | | | | | | | | | | | | | |
| | | 20 | | 50 | 48 | 46 | 44 | 41 | 38 | 35 | 31 | 26 | 20 | 12 | | | | | | | | | | | | | | | |
| | | 30 | | 49 | 47 | 45 | 42 | 40 | 37 | 33 | 29 | 24 | 16 | | | | | | | | | | | | | | | | |
| | | 40 | 50 | 48 | 46 | 44 | 41 | 38 | 35 | 31 | 27 | 20 | 12 | | | | | | | | | | | | | | | | |
| | | 50 | 49 | 47 | 45 | 43 | 40 | 37 | 34 | 29 | 24 | 17 | | | | | | | | | | | | | | | | | |
| | | | 48 | 46 | 44 | 41 | 39 | 35 | 32 | 27 | 21 | 13 | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 280 | 259 | 237 | 215 | 194 | 172 | 150 | 129 | 107 | 85 | 64 | 42 | | | | | | | | | | | | | | | |
| 35GS75 | 7½ | 0 | | | | | 50 | 48 | 47 | 46 | 44 | 43 | 41 | 39 | 37 | 35 | 33 | 30 | 27 | 24 | 19 | 14 | | | | | | | |
| | | 20 | | | | 50 | 49 | 47 | 46 | 44 | 43 | 41 | 39 | 37 | 35 | 33 | 31 | 28 | 24 | 20 | 14 | | | | | | | | |
| | | 30 | | | 50 | 49 | 48 | 47 | 45 | 44 | 42 | 40 | 38 | 37 | 34 | 32 | 29 | 26 | 22 | 17 | 12 | | | | | | | | |
| | | 40 | | | 50 | 49 | 47 | 46 | 44 | 43 | 41 | 39 | 38 | 36 | 33 | 31 | 28 | 24 | 20 | 15 | | | | | | | | | |
| | | 50 | | 50 | 49 | 48 | 47 | 45 | 44 | 42 | 40 | 39 | 37 | 35 | 32 | 30 | 26 | 22 | 18 | 12 | | | | | | | | | |
| | | | | 50 | 49 | 47 | 46 | 45 | 43 | 41 | 40 | 38 | 36 | 34 | 31 | 28 | 25 | 20 | 15 | | | | | | | | | | |
| Shut-off PSI | | | 453 | 431 | 410 | 388 | 366 | 345 | 323 | 301 | 280 | 258 | 236 | 215 | 193 | 171 | 150 | 128 | 106 | 85 | 63 | 42 | | | | | | | |
| 35GS100 | 10 | 0 | | | | | | | 49 | 48 | 47 | 46 | 45 | 44 | 42 | 41 | 40 | 38 | 37 | 35 | 33 | 31 | 29 | 26 | 24 | 20 | 16 | 11 | |
| | | 20 | | | | | | 49 | 48 | 47 | 46 | 45 | 44 | 42 | 41 | 40 | 38 | 37 | 35 | 33 | 31 | 29 | 27 | 24 | 20 | 16 | 12 | | |
| | | 30 | | | | | | 49 | 48 | 47 | 45 | 44 | 43 | 42 | 40 | 39 | 38 | 36 | 34 | 32 | 30 | 28 | 25 | 22 | 19 | 14 | | | |
| | | 40 | | | | | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 40 | 38 | 37 | 35 | 34 | 32 | 29 | 27 | 24 | 21 | 17 | 12 | | | |
| | | 50 | | | | | 49 | 48 | 47 | 46 | 44 | 43 | 42 | 41 | 39 | 38 | 36 | 34 | 33 | 31 | 28 | 26 | 23 | 19 | 15 | 10 | | | |
| | | | | | | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 40 | 39 | 37 | 35 | 34 | 32 | 30 | 27 | 24 | 21 | 17 | 13 | | | | |
| Shut-off PSI | | | 583 | 561 | 540 | 518 | 496 | 475 | 453 | 431 | 410 | 388 | 366 | 345 | 323 | 302 | 280 | 258 | 237 | 215 | 193 | 172 | 150 | 128 | 107 | 85 | 63 | 42 | |

# MODEL 45GS

## SELECTION CHART

Horsepower Range 1½ – 5, Recommended Range 20 – 65 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 440 | 480 | 520 | 560 | 600 | 640 | |
| 45GS15 | 1½ | 0 | 64 | 61 | 57 | 52 | 46 | 37 | 23 | | | | | | | | | | | | | | | | | | | | |
| | | 20 | 55 | 50 | 44 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| | | 30 | 49 | 43 | 32 | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 40 | 41 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 27 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 61 | 52 | 44 | 35 | 26 | 18 | 9 | | | | | | | | | | | | | | | | | | | | |
| 45GS20 | 2 | 0 | | 62 | 60 | 57 | 53 | 49 | 45 | 40 | 32 | | | | | | | | | | | | | | | | | | |
| | | 20 | 59 | 56 | 52 | 48 | 43 | 38 | 28 | | | | | | | | | | | | | | | | | | | | |
| | | 30 | 55 | 51 | 47 | 43 | 36 | 26 | | | | | | | | | | | | | | | | | | | | | |
| | | 40 | 51 | 47 | 42 | 35 | 25 | | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 46 | 41 | 34 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | 40 | 46 | 37 | 38 | 28 | 29 | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 88 | 80 | 71 | 63 | 54 | 45 | 37 | 28 | 19 | | | | | | | | | | | | | | | | | | |
| 45GS30 | 3 | 0 | | 65 | 62 | 60 | 59 | 56 | 53 | 50 | 47 | 45 | 41 | 37 | 30 | 21 | | | | | | | | | | | | | |
| | | 20 | 62 | 60 | 58 | 55 | 52 | 49 | 47 | 44 | 40 | 35 | 28 | | | | | | | | | | | | | | | | |
| | | 30 | 60 | 58 | 55 | 52 | 49 | 46 | 43 | 39 | 34 | 26 | | | | | | | | | | | | | | | | | |
| | | 40 | 57 | 54 | 51 | 49 | 46 | 42 | 38 | 33 | 25 | | | | | | | | | | | | | | | | | | |
| | | 50 | 54 | 51 | 48 | 45 | 42 | 38 | 32 | 23 | | | | | | | | | | | | | | | | | | | |
| | | 60 | 51 | 48 | 45 | 41 | 37 | 31 | 22 | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 130 | 121 | 113 | 104 | 95 | 87 | 78 | 69 | 61 | 52 | 43 | 35 | 26 | 17 | | | | | | | | | | | | | |
| 45GS50 | 5 | 0 | | | | 65 | 63 | 62 | 61 | 60 | 59 | 58 | 56 | 55 | 53 | 51 | 50 | 48 | 46 | 44 | 42 | 39 | 32 | 22 | | | | | |
| | | 20 | | 64 | 63 | 61 | 60 | 59 | 58 | 57 | 56 | 54 | 53 | 51 | 49 | 47 | 46 | 43 | 41 | 38 | 35 | 31 | 20 | | | | | | |
| | | 30 | 64 | 62 | 61 | 60 | 59 | 58 | 57 | 55 | 54 | 52 | 51 | 49 | 47 | 45 | 43 | 41 | 38 | 34 | 30 | 25 | | | | | | | |
| | | 40 | 62 | 61 | 60 | 59 | 58 | 57 | 55 | 54 | 52 | 50 | 49 | 47 | 45 | 43 | 40 | 37 | 33 | 29 | 24 | | | | | | | | |
| | | 50 | 61 | 60 | 59 | 58 | 56 | 55 | 53 | 52 | 50 | 48 | 47 | 45 | 42 | 40 | 37 | 33 | 28 | 23 | | | | | | | | | |
| | | 60 | 60 | 59 | 58 | 56 | 55 | 53 | 52 | 50 | 48 | 46 | 44 | 42 | 39 | 36 | 32 | 28 | 22 | | | | | | | | | | |
| Shut-off PSI | | | 228 | 220 | 211 | 202 | 194 | 185 | 176 | 168 | 159 | 150 | 142 | 133 | 124 | 116 | 107 | 98 | 90 | 81 | 72 | 64 | 46 | 29 | | | | | |

Horsepower Range 7½ – 10, Recommended Range 20-65 GPM, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 40 | 80 | 120 | 160 | 200 | 240 | 280 | 320 | 360 | 400 | 440 | 480 | 520 | 560 | 600 | 640 | 680 | 720 | 760 | 800 | 840 | 880 | 920 | 960 | 1000 | 1040 | |
| 45GS75 | 7½ | 0 | | | | | 63 | 62 | 60 | 58 | 56 | 53 | 51 | 48 | 46 | 43 | 39 | 34 | 28 | 21 | | | | | | | | | |
| | | 20 | | | | 63 | 61 | 60 | 57 | 55 | 53 | 50 | 48 | 45 | 42 | 38 | 33 | 27 | 19 | | | | | | | | | | |
| | | 30 | | | 64 | 62 | 60 | 58 | 56 | 54 | 51 | 49 | 46 | 43 | 40 | 35 | 30 | 23 | | | | | | | | | | | |
| | | 40 | | 65 | 63 | 61 | 59 | 57 | 55 | 52 | 50 | 47 | 45 | 41 | 37 | 32 | 26 | | | | | | | | | | | | |
| | | 50 | | 64 | 62 | 60 | 58 | 56 | 54 | 51 | 49 | 46 | 43 | 39 | 35 | 29 | 21 | | | | | | | | | | | | |
| | | 60 | 65 | 63 | 61 | 59 | 57 | 55 | 52 | 50 | 47 | 44 | 41 | 37 | 31 | 25 | | | | | | | | | | | | | |
| Shut-off PSI | | | 332 | 315 | 298 | 280 | 263 | 246 | 228 | 211 | 194 | 177 | 159 | 142 | 125 | 107 | 90 | 73 | 55 | 38 | | | | | | | | | |
| 45GS100 | 10 | 0 | | | | 65 | 64 | 63 | 61 | 60 | 58 | 57 | 55 | 54 | 53 | 51 | 50 | 48 | 46 | 44 | 42 | 39 | 36 | 32 | 28 | 23 | | | |
| | | 20 | | | 65 | 64 | 63 | 61 | 60 | 58 | 57 | 55 | 54 | 52 | 51 | 49 | 48 | 46 | 44 | 42 | 39 | 36 | 32 | 27 | 22 | | | | |
| | | 30 | | 65 | 64 | 63 | 62 | 60 | 59 | 57 | 56 | 54 | 53 | 52 | 50 | 49 | 47 | 45 | 43 | 40 | 37 | 33 | 29 | 24 | | | | | |
| | | 40 | | 65 | 64 | 62 | 61 | 60 | 58 | 56 | 55 | 54 | 52 | 51 | 49 | 48 | 46 | 44 | 41 | 38 | 35 | 31 | 26 | 21 | | | | | |
| | | 50 | 65 | 64 | 63 | 62 | 60 | 59 | 57 | 56 | 54 | 53 | 51 | 50 | 48 | 47 | 45 | 42 | 40 | 36 | 33 | 28 | 23 | | | | | | |
| | | 60 | 65 | 64 | 62 | 61 | 59 | 58 | 56 | 55 | 53 | 52 | 50 | 49 | 47 | 45 | 43 | 41 | 38 | 34 | 30 | 26 | 20 | | | | | | |
| Shut-off PSI | | | 456 | 439 | 422 | 404 | 387 | 370 | 353 | 335 | 318 | 301 | 283 | 266 | 249 | 231 | 214 | 197 | 179 | 162 | 145 | 127 | 110 | 93 | 75 | 58 | | | |

# MODEL 65GS

## SELECTION CHART

Horsepower Range 1½ – 5, Recommended Range 30 – 80 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 440 | 480 |
| 65GS15 | 1½ | 0 | | 78 | 70 | 61 | 51 | 36 | | | | | | | | | | | | | | | | |
| | | 20 | 68 | 58 | 47 | 30 | | | | | | | | | | | | | | | | | | |
| | | 30 | 57 | 45 | | | | | | | | | | | | | | | | | | | | |
| | | 40 | 42 | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 55 | 46 | 38 | 29 | 20 | 12 | | | | | | | | | | | | | | | | |
| 65GS20 | 2 | 0 | | 81 | 74 | 67 | 59 | 48 | 35 | | | | | | | | | | | | | | | |
| | | 20 | 72 | 64 | 56 | 45 | 30 | | | | | | | | | | | | | | | | | |
| | | 30 | 63 | 54 | 43 | | | | | | | | | | | | | | | | | | | |
| | | 40 | 53 | 41 | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 39 | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 65 | 56 | 48 | 39 | 30 | 22 | 13 | | | | | | | | | | | | | | | |
| 65GS30 | 3 | 0 | | | 81 | 76 | 71 | 66 | 59 | 53 | 45 | 35 | | | | | | | | | | | | |
| | | 20 | 80 | 75 | 69 | 64 | 57 | 51 | 42 | 32 | | | | | | | | | | | | | | |
| | | 30 | 74 | 69 | 63 | 56 | 49 | 41 | 30 | | | | | | | | | | | | | | | |
| | | 40 | 68 | 62 | 55 | 48 | 39 | | | | | | | | | | | | | | | | | |
| | | 50 | 61 | 54 | 47 | 38 | | | | | | | | | | | | | | | | | | |
| | | 60 | 53 | 46 | 36 | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 96 | 87 | 79 | 70 | 61 | 53 | 44 | 35 | 27 | 18 | | | | | | | | | | | | |
| 65GS50 | 5 | 0 | | | | | | 80 | 77 | 73 | 70 | 67 | 63 | 59 | 55 | 50 | 45 | 39 | 32 | | | | | |
| | | 20 | | | | 79 | 76 | 72 | 69 | 66 | 62 | 58 | 54 | 49 | 44 | 37 | 30 | | | | | | | |
| | | 30 | | | 78 | 75 | 72 | 69 | 65 | 61 | 57 | 53 | 48 | 43 | 36 | | | | | | | | | |
| | | 40 | | 78 | 75 | 71 | 68 | 64 | 61 | 57 | 52 | 47 | 42 | 35 | | | | | | | | | | |
| | | 50 | 77 | 74 | 71 | 67 | 64 | 60 | 56 | 52 | 47 | 41 | 34 | | | | | | | | | | | |
| | | 60 | 74 | 70 | 67 | 63 | 59 | 55 | 51 | 46 | 40 | 33 | | | | | | | | | | | | |
| Shut-off PSI | | | 164 | 155 | 147 | 138 | 129 | 121 | 112 | 103 | 95 | 86 | 77 | 69 | 60 | 51 | 43 | 34 | 26 | | | | | |

Horsepower Range 7½ – 10, Recommended Range 30 – 80 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 40 | 80 | 120 | 160 | 200 | 240 | 280 | 320 | 360 | 400 | 440 | 480 | 520 | 560 | 600 | 640 | 680 | 720 | 760 | 800 | 840 | 880 |
| 65GS75 | 7½ | 0 | | | | | | 78 | 74 | 70 | 66 | 61 | 56 | 50 | 44 | 35 | | | | | | | | |
| | | 20 | | | | 80 | 77 | 73 | 69 | 65 | 60 | 55 | 50 | 42 | 33 | | | | | | | | | |
| | | 30 | | | | 79 | 75 | 71 | 67 | 62 | 57 | 52 | 46 | 38 | | | | | | | | | | |
| | | 40 | | | 80 | 77 | 73 | 69 | 64 | 60 | 54 | 49 | 41 | 32 | | | | | | | | | | |
| | | 50 | | | 78 | 75 | 70 | 66 | 62 | 57 | 51 | 45 | 36 | | | | | | | | | | | |
| | | 60 | | 79 | 76 | 72 | 68 | 64 | 59 | 54 | 48 | 40 | 30 | | | | | | | | | | | |
| Shut-off PSI | | | 268 | 251 | 233 | 216 | 199 | 181 | 164 | 147 | 129 | 112 | 95 | 77 | 60 | 43 | | | | | | | | |
| 65GS100 | 10 | 0 | | | | | | 80 | 78 | 75 | 72 | 69 | 66 | 62 | 58 | 54 | 50 | 45 | 39 | 31 | | | | |
| | | 20 | | | | | 80 | 78 | 75 | 72 | 69 | 65 | 62 | 58 | 54 | 49 | 44 | 37 | 30 | | | | | |
| | | 30 | | | | | 79 | 76 | 73 | 70 | 67 | 63 | 59 | 55 | 51 | 46 | 40 | 33 | | | | | | |
| | | 40 | | | | 80 | 77 | 74 | 71 | 68 | 65 | 61 | 57 | 53 | 48 | 43 | 36 | | | | | | | |
| | | 50 | | | | 78 | 76 | 73 | 69 | 66 | 63 | 59 | 55 | 50 | 45 | 39 | 32 | | | | | | | |
| | | 60 | | | 79 | 77 | 74 | 71 | 68 | 64 | 60 | 57 | 52 | 48 | 42 | 35 | | | | | | | | |
| Shut-off PSI | | | 339 | 322 | 305 | 288 | 270 | 253 | 236 | 218 | 201 | 184 | 166 | 149 | 132 | 114 | 97 | 80 | 62 | 45 | | | | |

# MODEL 85GS

## SELECTION CHART

Horsepower Range 3 – 10, Recommended Range 40 – 120 GPM, 60 Hz, 3450 RPM

| Pump Model | HP | PSI | Depth to Water in Feet/Ratings in GPM (Gallons per Minute) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 440 | 480 | 520 |
| 85GS30 | 3 | 0 | | 112 | 103 | 92 | 79 | 64 | 48 | | | | | | | | | | | | | | | | |
| | | 20 | 100 | 88 | 74 | 59 | 42 | | | | | | | | | | | | | | | | | | |
| | | 30 | 86 | 72 | 57 | 39 | | | | | | | | | | | | | | | | | | | |
| | | 40 | 70 | 54 | | | | | | | | | | | | | | | | | | | | | |
| | | 50 | 52 | | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | | | | | | | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 66 | 58 | 49 | 40 | 32 | | | | | | | | | | | | | | | | | | |
| 85GS50 | 5 | 0 | | | | 114 | 109 | 103 | 97 | 90 | 83 | 74 | 66 | 57 | 47 | | | | | | | | | | |
| | | 20 | 119 | 113 | 107 | 101 | 95 | 88 | 80 | 72 | 63 | 54 | 43 | | | | | | | | | | | | |
| | | 30 | 112 | 106 | 101 | 94 | 87 | 79 | 70 | 62 | 52 | 41 | | | | | | | | | | | | | |
| | | 40 | 105 | 100 | 93 | 85 | 77 | 69 | 60 | 51 | 40 | | | | | | | | | | | | | | |
| | | 50 | 99 | 92 | 84 | 76 | 68 | 59 | 49 | | | | | | | | | | | | | | | | |
| | | 60 | 91 | 83 | 75 | 66 | 58 | 48 | | | | | | | | | | | | | | | | | |
| Shut-off PSI | | | 128 | 119 | 111 | 102 | 93 | 85 | 76 | 67 | 59 | 50 | 41 | 33 | 24 | | | | | | | | | | |
| 85GS75 | 7½ | 0 | | | | | | 119 | 115 | 111 | 108 | 104 | 100 | 95 | 91 | 86 | 81 | 76 | 71 | 65 | 59 | 52 | | | |
| | | 20 | | | | 118 | 114 | 110 | 106 | 102 | 98 | 94 | 89 | 84 | 80 | 74 | 69 | 63 | 57 | 50 | 41 | | | | |
| | | 30 | | | 117 | 113 | 110 | 106 | 102 | 98 | 93 | 88 | 84 | 79 | 74 | 68 | 62 | 56 | 48 | 40 | | | | | |
| | | 40 | 120 | 116 | 113 | 109 | 105 | 101 | 97 | 92 | 88 | 83 | 78 | 73 | 67 | 61 | 55 | 47 | | | | | | | |
| | | 50 | 116 | 112 | 109 | 105 | 101 | 96 | 92 | 87 | 82 | 77 | 72 | 66 | 60 | 54 | 46 | | | | | | | | |
| | | 60 | 112 | 108 | 104 | 100 | 95 | 91 | 86 | 81 | 76 | 71 | 66 | 59 | 53 | 45 | | | | | | | | | |
| Shut-off PSI | | | 203 | 194 | 185 | 177 | 168 | 159 | 151 | 142 | 133 | 125 | 116 | 107 | 99 | 90 | 81 | 73 | 64 | 55 | 47 | 38 | | | |
| 85GS100 | 10 | 0 | | | | | | | | 119 | 116 | 114 | 111 | 108 | 104 | 101 | 97 | 94 | 90 | 87 | 83 | 79 | 71 | 62 | 52 |
| | | 20 | | | | | | 118 | 116 | 113 | 110 | 107 | 103 | 100 | 96 | 93 | 89 | 85 | 82 | 78 | 74 | 70 | 61 | 50 | |
| | | 30 | | | | 120 | 118 | 115 | 112 | 109 | 106 | 103 | 99 | 96 | 92 | 89 | 85 | 81 | 77 | 73 | 69 | 65 | 55 | 42 | |
| | | 40 | | | 120 | 117 | 115 | 112 | 109 | 106 | 102 | 99 | 95 | 92 | 88 | 84 | 81 | 77 | 73 | 68 | 64 | 59 | 48 | | |
| | | 50 | | 120 | 117 | 114 | 111 | 108 | 105 | 102 | 98 | 95 | 91 | 87 | 84 | 80 | 76 | 72 | 68 | 63 | 58 | 53 | 40 | | |
| | | 60 | 119 | 117 | 114 | 111 | 108 | 105 | 101 | 98 | 94 | 91 | 87 | 83 | 79 | 75 | 71 | 67 | 63 | 58 | 52 | 46 | | | |
| Shut-off PSI | | | 265 | 257 | 248 | 239 | 231 | 222 | 213 | 205 | 196 | 188 | 179 | 170 | 162 | 153 | 144 | 136 | 127 | 118 | 110 | 101 | 84 | 66 | 49 |

## PART NUMBER CROSS REFERENCE

| Old GS Hi Cap Part Number | NEW eGS Hi Cap Part Number |
|---|---|
| 33GS10 | 35GS10 |
| 33GS15 | 35GS15 |
| 33GS20 | 35GS20 |
| 33GS30 | 35GS30 |
| 33GS50 | 35GS50 |
| 33GS75 | 35GS75 |
| 33GS100 | 35GS100 |
| 40GS15 | 45GS15 |
| 40GS20 | 45GS20 |
| 40GS30 | 45GS30 |
| 40GS50 | 45GS50 |
| 40GS75 | 45GS75 |
| - | 45GS100 |
| 55GS15 | 65GS15 |
| 55GS20 | 65GS20 |
| 55GS30 | 65GS30 |
| 55GS50 | 65GS50 |
| 55GS75 | 65GS75 |
| 55GS100 | 65GS100 |
| 60GS15 | 65GS15 |
| 60GS20 | 65GS20 |
| 60GS30 | 65GS30 |
| 60GS50 | 65GS50 |
| 60GS75 | 65GS75 |
| 75GS30 | 85GS30 |
| 75GS50 | 85GS50 |
| 75GS75 | 85GS75 |
| 75GS100 | 85GS100 |
| 80GS30 | 85GS30 |
| 80GS50 | 85GS50 |
| 80GS75 | 85GS75 |

* Determined using best efficiency point, see curves for more detail

**NOTES**

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- > Fittings
- > Fusion Equipment
- > ISCO Circuit Maker Vault
- > Custom Fabrication
- > Grout









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Welcome to the latest edition of the ISCO Geothermal Product Catalog. We have designed this tool to be your go-to resource for all your Geothermal HDPE piping needs. It contains detailed information about HDPE pipe and specifications, HDPE molded and fabricated fittings, Geothermal Socket Fusion molded fittings, McElroy fusion machines, vaults, headers, grout and much more – all in an easy-to-read indexed format.

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We regularly work with engineers, installers and contractors in the development of reliable, efficient geothermal systems for commercial and residential applications. We assure you that no company will work harder to earn your Geothermal business.

As our slogan says, ISCO "Comes through" with the HDPE product you need, when you need it, backed by experts on-hand to help make your project run smoothly – and profitably.

As always, thank you for your business and continued interest in our company. We look forward to serving you.

**Jimmy Kirchdorfer**
**PRESIDENT**

**Mark Kirchdorfer**
**V.P., OPERATIONS**

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**Make ISCO your single source for high-density polyethylene pipe (HDPE) and associated products and services.**








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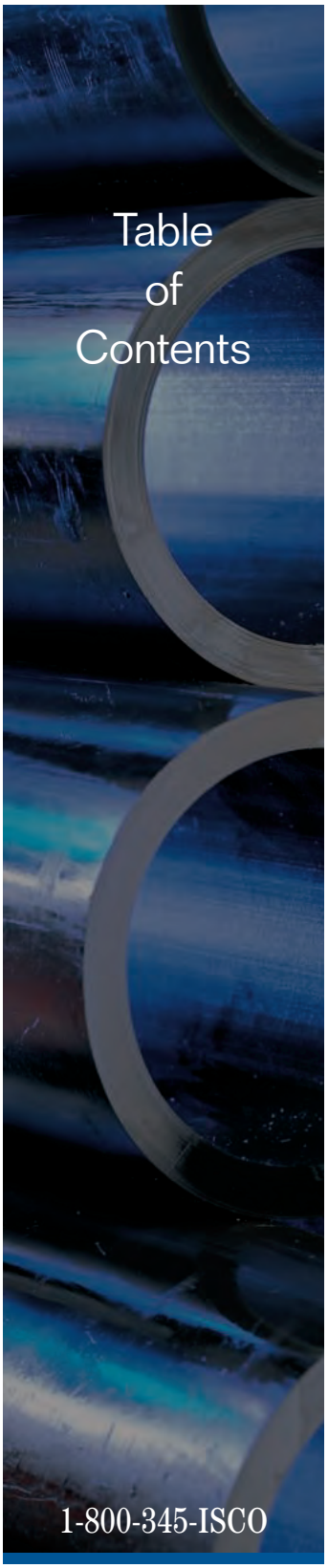


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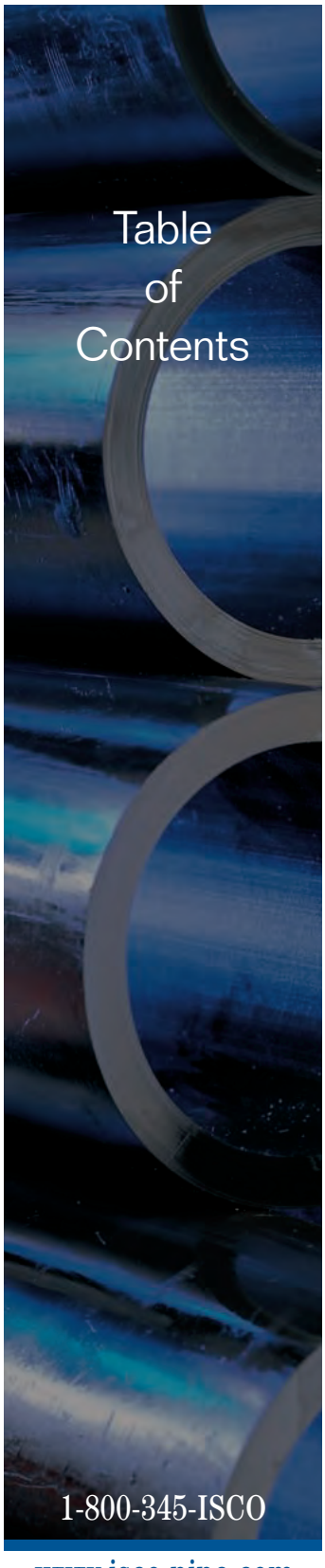


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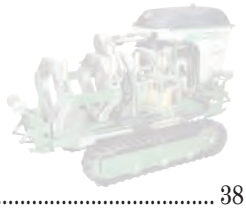

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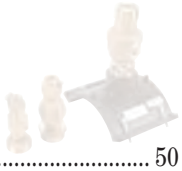

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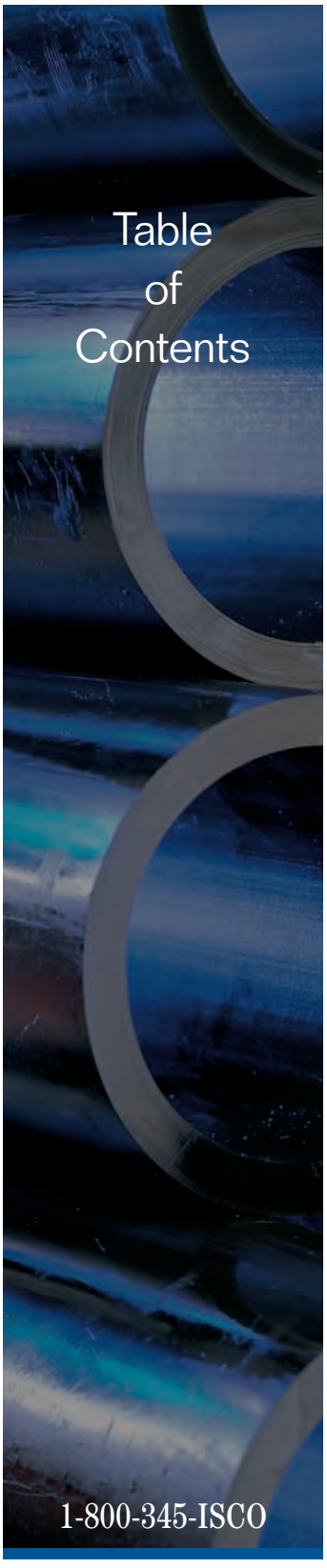




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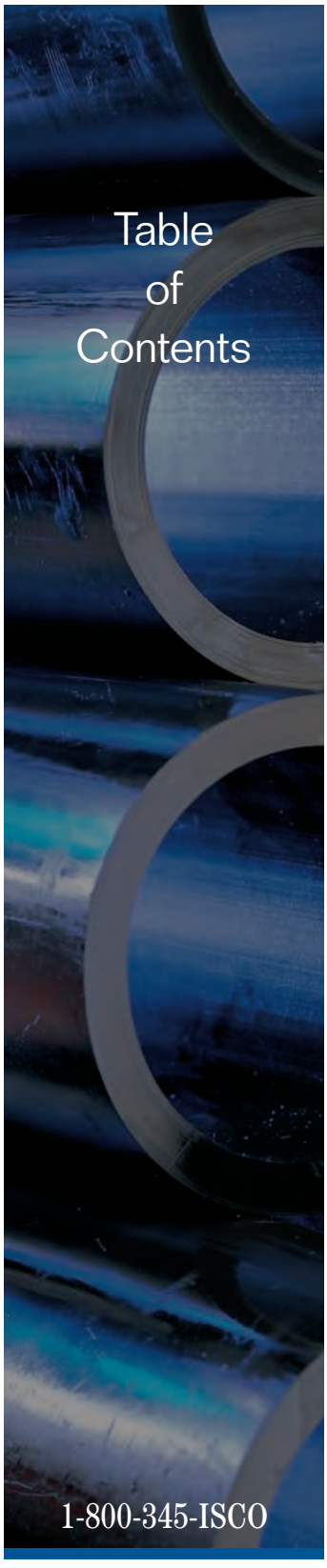


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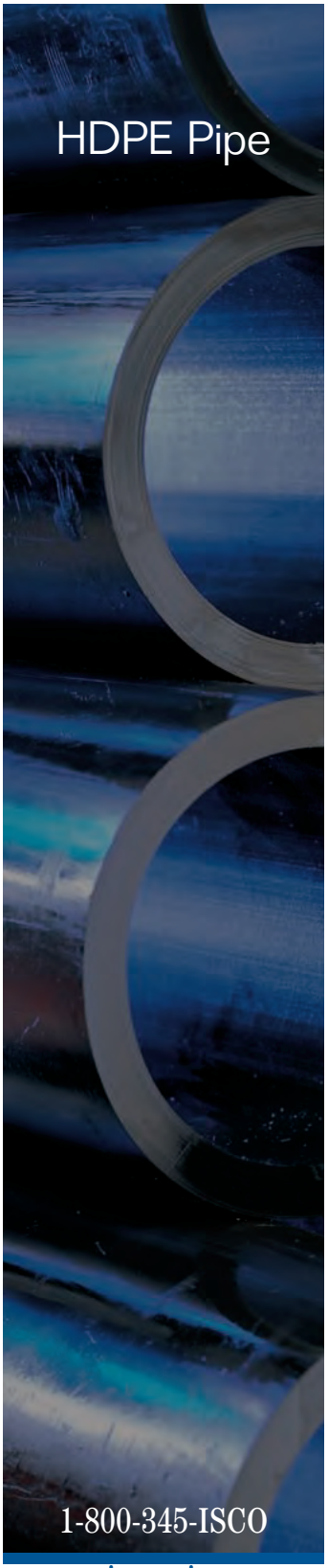


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# High-Density Polyethylene Pipe

**Introduction**

ISCO Industries, LLC is the largest high-density polyethylene pipe distributor in North America. ISCO can serve your needs anywhere in the USA and internationally. ISCO offers a complete package of HDPE piping products. Butt fusion machines are offered for sale or rental. Fusion technicians are available to provide on-site training or assistance to your project. Please call 1-800-345-ISCO for all your HDPE piping needs.

**Some of The Characteristics of HDPE Pipe are:**

- Economical
- Corrosion Resistant
- Zero Leak-Rate
- Hydraulically Smooth
- Fatigue and Surge Resistant
- Long Design Life
- Tappable
- Chemically Resistant
- Easily Installed
- Small to Large Diameters
- Non-Toxic, Non-Tasting
- Lightweight
- Reliable
- Flexible and Coilable
- Heat Fused
- Mechanically Joined (As Needed)
- Strong and Ductile
- Weather Resistant
- Impact Resistant
- Freeze Resistant
- Durable
- Abrasion Resistant
- Inert
- Self Restrained Pipe (Monolithic)
- Listed and Approved

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## Important Standards for High Density Polyethylene (HDPE) Pipe

Standards important for HDPE pipe relate to the resin the pipe is made from and the standards related to manufacturing sizes and tolerances. The American Society of Testing Materials (ASTM) standard for resin from which the pipe is made is ASTM D 3350-05, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials. This standard defines the physical properties of the resin that the pipe is made from.

**Pipe dimensions and manufacturing requirements:**

**ASTM F 714-05** Standard Specification for Polyethylene (PE) Pipe (SDR-PR) Based on Outside Diameter. This standard is used for most large diameter HDPE pipe (4" to 63") applications other than gas pipe.

**ASTM D 2513-05** Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings. Polyethylene pipe and other plastic for natural gas distribution are described in great detail in this standard.

**ASTM D 3035-03a** Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Most HDPE water tubing (½ inch to 3") is made to the dimensions in this standard. While pipe sizes up to 24" are provided, very little large diameter pipe is made to this standard.

**Installation Standards:**

**ASTM D 2321-05** Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications

**ASTM D 2774-04** Standard Practice for Underground Installation of Thermoplastic Pressure Piping

**ASTM F 1962** Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings

**ASTM F 585-94** Standard Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers

**American Water Works Association Standards**

**ANSI/AWWA C 901-2005** Polyethylene Pressure Pipe and Tubing, .5 in (13 mm) Through 3 in. (76 mm) for Water Services

**ANSI/AWWA C 906-2006** Polyethylene Pipe and Fittings, 4 in (100 mm) Through 63 In (1,575 mm) for Water Distribution

**Pipe Joining Standards:**

**ASTM F 2620** – Standard Practice for Heat Fusion of Polyethylene Pipe and Fittings

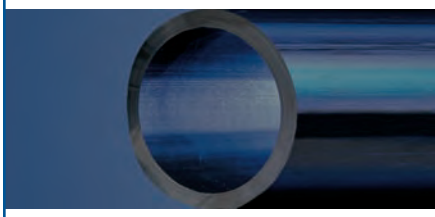
**ASTM D 2657** – Standard Practice of Heat Fusion Joining of Polyolefin Pipe and Fittings

**ASTM F 1290** – Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings

**Fitting Standards**

**ASTM D 3261** Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

**ASTM F 1055** Standard Specification for Electrofusion Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing





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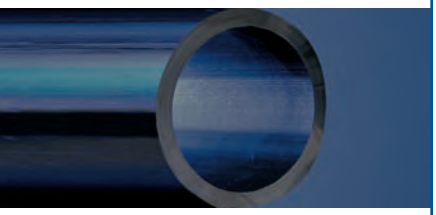

HDPE Pipe

### Specifications for HDPE Pipe

The physical properties of high-density polyethylene pipe are described using ASTM D 3350-05, "Standard Specification for Polyethylene Plastic Pipe and Fittings Materials". Recently this standard was changed. The two key areas changed are, density and slow crack growth. In the 05 version, the cell classifications for density were increased from four cells to seven cells defining the density ranges for various resins.

New high performance bimodal resins, PE 4710 resins, have higher PENT test values. Slow crack grow properties can now be defined using eight cells.

Currently, most HDPE pipe is made from resin with a cell classification of PE 345464C. The pipe is labeled as PE3408/3608. The physical properties for PE 345464C are:

| PROPERTY VALUE | | SPECIFICATION | UNIT | NOMINAL VALUE |
|---|---|---|---|---|
| Material Designation | | PPI / ASTM | | PE 3408/3608 |
| Cell Classification | | ASTM D 3350 | | 345464C |
| Density | (3) | ASTM D 1505 | g/cm3 | 0.941-943 |
| Melt Index | (4) | ASTM D 1238 | gm/ 10 min | 0.05 -.11 |
| Flexural Modulus | (5) | ASTM D 790 | psi | 110,000 to 140,000 |
| Tensile Strength | (4) | ASTM D 638 | psi | 3,200 |
| Slow Crack Growth | | | | |
| ESCR | | ASTM D 1693 | hours in 100% igepal | >5,000 |
| PENT | (6) | ASTM F 1473 | hours | >100 |
| HDB @ 73 deg F | (4) | ASTM D 2837 | psi | 1,600 |
| UV Stabilizer | (C) | ASTM D 1603 | %C | 2 to 2.5% |

The density provided is without carbon black. Typical HDPE pipe has a density of .955 to .957 with carbon black.

### Types of Polyethylene Pipe

All polyethylene (PE) is not the same. In ASTM D 3350-05, low density PE is defined as having a density range of 0.919 to 0.925 g/cc; medium density has a range of 0.926 to 0.940 g/cc and high density is defined with a range from 0.941 to 0.955. All densities are without carbon black.

Density influences key properties in polyethylene materials. As the density increases, the tensile strength increases; also chemical resistance increases.

Medium density PE resins have been used for gas distribution. This original selection was made based on superior slow crack growth properties of medium density resins. Medium density pipe is designated as PE 2406 and PE 2708.

Today new bimodal resins are being used in gas distribution because of higher pressure ratings plus superior slow crack growth. These resins are designated PE 3408, PE 3608, PE 3708, PE 3710 and PE 4710.



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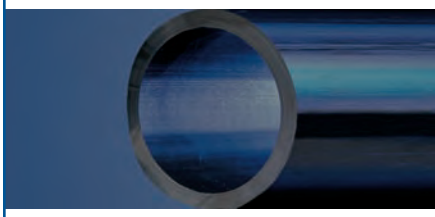



### Slow Crack Growth

The Pent test is used to determine stress crack resistance for PE resins. The PENT test is conducted in accordance with ASTM F 1473, "Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins". This test uses a solid sample of material which is notched and tested.

The PENT test is a good test of slow crack growth. Scratches and gouges can cause crack propagation. Materials with high PENT numbers are less likely to fail because of slow crack growth.

Traditional PE 3408/3608 resins have PENT test values of about 100 hours. New bimodal resins used to make PE 3710 and PE 4710 pipes have values ranging from 600 hours to several thousand hours.

### Physical Properties of PE 4710

HDPE pipe with a designation of PE 4710 is made from resin with a cell classification of PE 445474C or PE 445574C. We suggest using a specification calling for a minimum cell classification of PE 445474 C or higher. Both cell classifications can be used if specified in this way. The pipe is labeled as PE 4710. The physical properties for PE 445474C are provided below:

| PROPERTY VALUE | | SPECIFICATION | UNIT | NOMINAL VALUE |
|---|---|---|---|---|
| Material Designation | | PPI / ASTM | | PE 4710 |
| Cell Classification | | ASTM D 3350 | | 445474 C |
| Density | (4) | ASTM D 1505 | g/cm3 | 0.947-955 |
| Melt Index | (4) | ASTM D 1238 | gm/ 10 min | <.15 |
| Flexural Modulus | (5) | ASTM D 790 | psi | 110,000 to 160,000 |
| Tensile Strength | (5) | ASTM D 638 | psi | 3500-4000 |
| Slow Crack Growth | | | | |
| ESCR | | ASTM D 1693 | hours in 100% igepal | >5,000 |
| PENT | (7) | ASTM F 1473 | hours | >500 |
| HDB @ 73 deg F | (4) | ASTM D 2837 | psi | 1,600 |
| UV Stabilizer | (C) | ASTM D 1603 | %C | 2 to 2.5 % |

The density provided is without carbon black. Typical PE 4710 HDPE pipe has a density of 0.956 to 0.964 with carbon black.

To be called a PE 4710, the pipe and resin has substantiation at 50 years.

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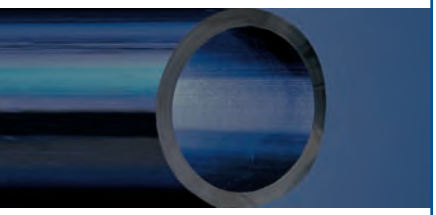

# HDPE Pipe

- **Items highlighted in Blue indicates standard stocking items that are more readily available.**
- **Pressures are based on using water at 23°C (73°F).**
- **Average inside diameter calculated using nominal OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.**
- **Service factors should be utilized to compensate for the effect of liquids other than water, and for other temperatures**
- **Other piping sizes or DR's may be available upon request.**
- **Standard Lengths: 40' for 2"-24"/ 50' for 26" and larger/ Coils available for 3/4"-6"(8" by special order).**

## PE 3608/3408 IPS HDPE Pipe Sizes

| Pressure Rating | Nominal Size | 3/4" | 1" | 1 1/4" | 1 1/2" | 2" | 3" | 4" | 5" | 5" | 6" | 7" | 8" | 10" | 12" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Actual O.D. | 1.05" | 1.315" | 1.66" | 1.90" | 2.375" | 3.50" | 4.50" | 5.375" | 5.563" | 6.625" | 7.125" | 8.625" | 10.75" | 12.75" |
| DR 7 ( 267psi ) | Min. wall | 0.150" | 0.188" | 0.237" | 0.271" | 0.339" | 0.500" | 0.643" | 0.768" | 0.795" | 0.946" | 1.018" | 1.232" | 1.536" | 1.821" |
| | Average I.D. | 0.732" | 0.917" | 1.157" | 1.325" | 1.656" | 2.440" | 3.137" | 3.747" | 3.878" | 4.619" | 4.967" | 6.013" | 7.494" | 8.889" |
| | Weight lb/ft | 0.190 | 0.290 | 0.460 | 0.603 | 0.950 | 2.060 | 3.400 | 4.850 | 5.200 | 7.360 | 8.490 | 12.480 | 19.400 | 27.280 |
| DR 7.3 ( 254psi ) | Min. wall | 0.144" | 0.180" | 0.227" | 0.260" | 0.325" | 0.479" | 0.616" | 0.736" | 0.762" | 0.908" | 0.976" | 1.182" | 1.473" | 1.747" |
| | Average I.D. | 0.745" | 0.933" | 1.178" | 1.348" | 1.685" | 2.484" | 3.193" | 3.814" | 3.947" | 4.701" | 5.056" | 6.120" | 7.628" | 9.047" |
| | Weight lb/ft | 0.180 | 0.280 | 0.445 | 0.583 | 0.911 | 1.980 | 3.280 | 4.680 | 5.020 | 7.120 | 8.230 | 12.060 | 18.740 | 26.360 |
| DR 9 ( 200psi ) | Min. wall | 0.117" | 0.146" | 0.184" | 0.211" | 0.264" | 0.389" | 0.500" | 0.597" | 0.618" | 0.736" | 0.792" | 0.958" | 1.194" | 1.417" |
| | Average I.D. | 0.803" | 1.005" | 1.269" | 1.452" | 1.816" | 2.676" | 3.440" | 4.109" | 4.253" | 5.064" | 5.447" | 6.593" | 8.218" | 9.747" |
| | Weight lb/ft | 0.150 | 0.234 | 0.372 | 0.490 | 0.770 | 1.660 | 2.750 | 3.920 | 4.200 | 5.932 | 6.890 | 10.054 | 15.680 | 22.070 |
| DR 11 ( 160psi ) | Min. wall | 0.095" | 0.120" | 0.151" | 0.173" | 0.216" | 0.318" | 0.409" | 0.489" | 0.506" | 0.602" | 0.648" | 0.784" | 0.977" | 1.159" |
| | Average I.D. | 0.848" | 1.062" | 1.340" | 1.534" | 1.917" | 2.825" | 3.633" | 4.339" | 4.491" | 5.348" | 5.752" | 6.963" | 8.678" | 10.293" |
| | Weight lb/ft | 0.130 | 0.200 | 0.312 | 0.410 | 0.640 | 1.387 | 2.300 | 3.290 | 3.520 | 4.990 | 5.780 | 8.460 | 13.140 | 18.490 |
| DR 13.5 ( 128psi ) | Min. wall | --- | --- | --- | --- | 0.176" | 0.259" | 0.333" | 0.398" | 0.412" | 0.491" | 0.528" | 0.639" | 0.796" | 0.944" |
| | Average I.D. | --- | --- | --- | --- | 2.002" | 2.950" | 3.793" | 4.531" | 4.689" | 5.585" | 6.006" | 7.271" | 9.062" | 10.748" |
| | Weight lb/ft | --- | --- | --- | --- | 0.531 | 1.160 | 1.910 | 2.730 | 2.920 | 4.150 | 4.800 | 7.030 | 10.920 | 15.360 |
| DR 15.5 ( 110psi ) | Min. wall | --- | --- | --- | --- | 0.153" | 0.226" | 0.290" | 0.347" | 0.359" | 0.427" | 0.460" | 0.556" | 0.694" | 0.823" |
| | Average I.D. | --- | --- | --- | --- | 2.050" | 3.021" | 3.885" | 4.640" | 4.802" | 5.719" | 6.150" | 7.445" | 9.280" | 11.006" |
| | Weight lb/ft | --- | --- | --- | --- | 0.470 | 1.020 | 1.680 | 2.400 | 2.570 | 3.637 | 4.210 | 6.164 | 9.580 | 13.480 |
| DR 17 ( 100psi ) | Min. wall | --- | --- | --- | --- | 0.140" | 0.206" | 0.265" | 0.316" | 0.327" | 0.390" | 0.419" | 0.507" | 0.632" | 0.750" |
| | Average I.D. | --- | --- | --- | --- | 2.079" | 3.064" | 3.939" | 4.705" | 4.869" | 5.799" | 6.236" | 7.549" | 9.409" | 11.160" |
| | Weight lb/ft | --- | --- | --- | --- | 0.430 | 0.932 | 1.540 | 2.200 | 2.353 | 3.340 | 3.860 | 5.660 | 8.880 | 12.362 |
| DR 19 ( 89psi ) | Min. wall | --- | --- | --- | --- | --- | --- | 0.237" | 0.283" | 0.293" | 0.349" | 0.375" | 0.454" | 0.566" | 0.671" |
| | Average I.D. | --- | --- | --- | --- | --- | --- | 3.998" | 4.775" | 4.942" | 5.886" | 6.330" | 7.663" | 9.551" | 11.327" |
| | Weight lb/ft | --- | --- | --- | --- | --- | --- | 1.390 | 1.980 | 2.120 | 3.010 | 3.480 | 5.100 | 7.920 | 11.140 |
| DR 21 ( 80psi ) | Min. wall | --- | --- | --- | --- | --- | --- | 0.214" | 0.256" | 0.265" | 0.315" | 0.339" | 0.411" | 0.512" | 0.607" |
| | Average I.D. | --- | --- | --- | --- | --- | --- | 4.046" | 4.832" | 5.001" | 5.956" | 6.406" | 7.754" | 9.665" | 11.463" |
| | Weight lb/ft | --- | --- | --- | --- | --- | --- | 1.262 | 1.801 | 1.930 | 2.740 | 3.170 | 4.640 | 7..21 | 10.134 |
| DR 26 ( 64 psi ) | Min. wall | --- | --- | --- | --- | --- | --- | 0.173" | 0.207" | 0.214" | 0.255" | 0.274" | 0.332" | 0.413" | 0.490" |
| | Average I.D. | --- | --- | --- | --- | --- | --- | 4.133" | 4.937" | 5.109" | 6.085" | 6.544" | 7.922" | 9.873" | 11.710" |
| | Weight lb/ft | --- | --- | --- | --- | --- | --- | 1.030 | 1.470 | 1.574 | 2.233 | 2.582 | 3.790 | 5.880 | 8.270 |
| DR 32.5 ( 51 psi ) | Min. wall | --- | --- | --- | --- | --- | --- | 0.138" | 0.165" | 0.171" | 0.204" | 0.219" | 0.265" | 0.331" | 0.392" |
| | Average I.D. | --- | --- | --- | --- | --- | --- | 4.206" | 5.024" | 5.200" | 6.193" | 6.660" | 8.062" | 10.049" | 11.918" |
| | Weight lb/ft | --- | --- | --- | --- | --- | --- | 0.831 | 1.190 | 1.270 | 1.801 | 2.083 | 3.053 | 4.750 | 6.671 |

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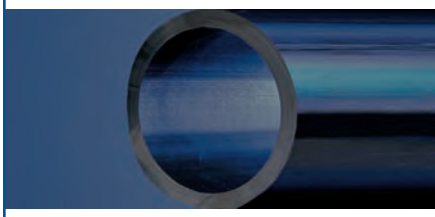
## PE 4710 IPS HDPE Pipe Sizes

| Pressure Rating | Nominal Size | 1" | 1 1/4" | 1 1/2" | 2" | 3" | 4" | 5" | 6" | 8" | 10" | 12" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Actual O.D. | 1.32" | 1.660" | 1.90" | 2.38" | 3.500" | 4.50" | 5.563" | 6.625" | 8.625" | 10.750" | 12.75" |
| DR 7 ( 336psi ) | Min. wall | 0.188" | 0.237" | 0.271" | 0.339" | 0.500" | 0.643" | 0.795" | 0.946" | 1.232" | 1.536" | 1.821" |
| | Average I.D. | 0.917" | 1.157" | 1.325" | 1.656" | 2.440" | 3.137" | 3.878" | 4.619" | 6.013" | 7.494" | 8.889" |
| | Weight lb/lf | 0.291 | 0.463 | 0.607 | 0.950 | 2.060 | 3.402 | 5.200 | 7.374 | 12.498 | 19.416 | 27.312 |
| DR 7.3 ( 320psi ) | Min. wall | 0.180" | 0.227" | 0.260" | 0.325" | 0.479" | 0.616" | 0.762" | 0.908" | 1.182" | 1.473" | 1.747" |
| | Average I.D. | 0.933" | 1.178" | 1.348" | 1.685" | 2.484" | 3.193" | 3.947" | 4.701" | 6.120" | 7.628" | 9.047" |
| | Weight lb/lf | 0.281 | 0.450 | 0.590 | 0.920 | 1.990 | 3.290 | 5.022 | 7.130 | 12.070 | 18.750 | 26.380 |
| DR 9 ( 252psi ) | Min. wall | 0.146" | 0.184" | 0.211" | 0.264" | 0.389" | 0.500" | 0.618" | 0.736" | 0.958" | 1.194" | 1.417" |
| | Average I.D. | 1.005" | 1.269" | 1.452" | 1.816" | 2.676" | 3.440" | 4.253" | 5.064" | 6.593" | 8.218" | 9.747" |
| | Weight lb/lf | 0.235 | 0.374 | 0.490 | 0.770 | 1.664 | 2.751 | 4.204 | 5.963 | 10.110 | 15.700 | 22.085 |
| DR 11 ( 202psi ) | Min. wall | 0.120" | 0.151" | 0.173" | 0.216" | 0.318" | 0.409" | 0.506" | 0.602" | 0.784" | 0.977" | 1.159" |
| | Average I.D. | 1.062" | 1.340" | 1.534" | 1.917" | 2.825" | 3.633" | 4.491" | 5.348" | 6.963" | 8.678" | 10.293" |
| | Weight lb/lf | 0.200 | 0.314 | 0.411 | 0.642 | 1.395 | 2.310 | 3.523 | 5.000 | 8.470 | 13.160 | 18.510 |
| DR 13.5 ( 161psi ) | Min. wall | --- | --- | --- | 0.176" | 0.259" | 0.333" | 0.412" | 0.491" | 0.639" | 0.796" | 0.944" |
| | Average I.D. | --- | --- | --- | 2.002" | 2.950" | 3.793" | 4.689" | 5.585" | 7.271" | 9.062" | 10.748" |
| | Weight lb/lf | --- | --- | --- | 0.534 | 1.160 | 1.920 | 2.928 | 4.152 | 7.040 | 10.932 | 15.380 |
| DR 15.5 ( 139psi ) | Min. wall | --- | --- | --- | 0.153" | 0.226" | 0.290" | 0.359" | 0.427" | 0.556" | 0.694" | 0.823" |
| | Average I.D. | --- | --- | --- | 2.050" | 3.021" | 3.885" | 4.802" | 5.719" | 7.445" | 9.280" | 11.006" |
| | Weight lb/lf | --- | --- | --- | 0.470 | 1.020 | 1.687 | 2.580 | 3.656 | 6.197 | 9.626 | 13.530 |
| DR 17 ( 126psi ) | Min. wall | --- | --- | --- | 0.140" | 0.206" | 0.265" | 0.327" | 0.390" | 0.507" | 0.632" | 0.750" |
| | Average I.D. | --- | --- | --- | 2.079" | 3.064" | 3.939" | 4.869" | 5.799" | 7.549" | 9.409" | 11.160" |
| | Weight lb/lf | --- | --- | --- | 0.431 | 0.940 | 1.550 | 2.360 | 3.360 | 5.690 | 8.834 | 12.430 |
| DR 21 ( 101psi ) | Min. wall | --- | --- | --- | --- | --- | 0.214" | 0.265" | 0.315" | 0.411" | 0.512" | 0.607" |
| | Average I.D. | --- | --- | --- | --- | --- | 4.046" | 5.001" | 5.956" | 7.754" | 9.665" | 11.463" |
| | Weight lb/lf | --- | --- | --- | --- | --- | 1.270 | 1.940 | 2.750 | 4.662 | 7.242 | 10.190 |
| DR 26 ( 81 psi ) | Min. wall | --- | --- | --- | --- | --- | 0.173" | 0.214" | 0.255" | 0.332" | 0.413" | 0.490" |
| | Average I.D. | --- | --- | --- | --- | --- | 4.133" | 5.109" | 6.085" | 7.922" | 9.873" | 11.710" |
| | Weight lb/lf | --- | --- | --- | --- | --- | 1.035 | 1.582 | 2.250 | 3.800 | 5.910 | 8.312 |
| DR 32.5 ( 64 psi ) | Min. wall | --- | --- | --- | --- | --- | 0.138" | 0.171" | 0.204" | 0.265" | 0.331" | 0.392" |
| | Average I.D. | --- | --- | --- | --- | --- | 4.206" | 5.200" | 6.193" | 8.062" | 10.049" | 11.918" |
| | Weight lb/lf | --- | --- | --- | --- | --- | 0.835 | 1.280 | 1.811 | 3.070 | 4.770 | 6.710 |



HDPE Pipe

- **Items highlighted in Blue indicates standard stocking items that are more readily available.**
- **Pressures are based on using water at 23°C (73°F).**
- **Average inside diameter calculated using nominal OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.**
- **Service factors should be utilized to compensate for the effect of liquids other than water, and for other temperaturs**
- **Other piping sizes or DR's may be available upon request.**
- **Standard Lengths: 40' for 2"-24"/ 50' for 26" and larger/ Coils available for 3/4"-6"(8" by special order).**

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# IPS HDPE Coil Pipe

- **Items highlighted in Blue indicates standard stocking items that are more readily available.**

* **Non-stock items**

## PE 3408 IPS HDPE Coil Pipe



| Nominal Size (in) | DR | Pressure Rating | Part # | Coil Length (ft.) |
|---|---|---|---|---|
| 3/4" | 11 | 160 | 10001114 | 300' |
| 3/4" | 11 | 160 | 10001124 | 400' |
| 3/4" | 11 | 160 | 10001113 | 500' |
| 3/4" | 11 | 160 | 10001126 | 600' |
| 3/4" | 11 | 160 | 10001130 | 800' |
| 1" | 11 | 160 | 10011118 | 300' |
| 1" | 11 | 160 | 10011119 | 500' |
| 1 1/4" | 11 | 160 | 10011129 | 150' |
| 1 1/2" | 11 | 160 | * | 150' |
| 1 1/2" | 11 | 160 | * | 300' |
| 1 1/2" | 11 | 160 | 10011151 | 500' |
| 2" | 11 | 160 | 10021113 | 150' |
| 2" | 11 | 160 | 10021112 | 300' |
| 2" | 11 | 160 | 10021111 | 500' |
| 2" | 11 | 160 | * | 1000' |
| 3" | 11 | 160 | * | 300' |
| 3" | 11 | 160 | * | 500' |
| 3" | 11 | 160 | * | 1000' |
| 4" | 11 | 160 | * | 500' |
| 4" | 11 | 160 | * | 1000' |



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## PE 3408 lPS HDPE Unicoil Pipe





| Nominal Size (in) | DR | Pressure Rating | Part # | Coil Length (ft.) |
|---|---|---|---|---|
| 3/4" | 11 | 160 | 10001127 | 310' |
| 3/4" | 11 | 160 | 10001128 | 410' |
| 3/4" | 11 | 160 | 10001129 | 510' |
| 1" | 11 | 160 | 10011116 | 410' |
| 1" | 11 | 160 | 10011120 | 510' |
| 1" | 11 | 160 | 10011121 | 610' |
| 1 1/4" | 11 | 160 | 10011147 | 710' |
| 1 1/4" | 11 | 160 | 10011148 | 810' |

Custom sizes are available. Call for price and availability.



IPS HDPE Uncoil Pipe

- **Items highlighted in Blue indicates standard stocking items that are more readily available.**

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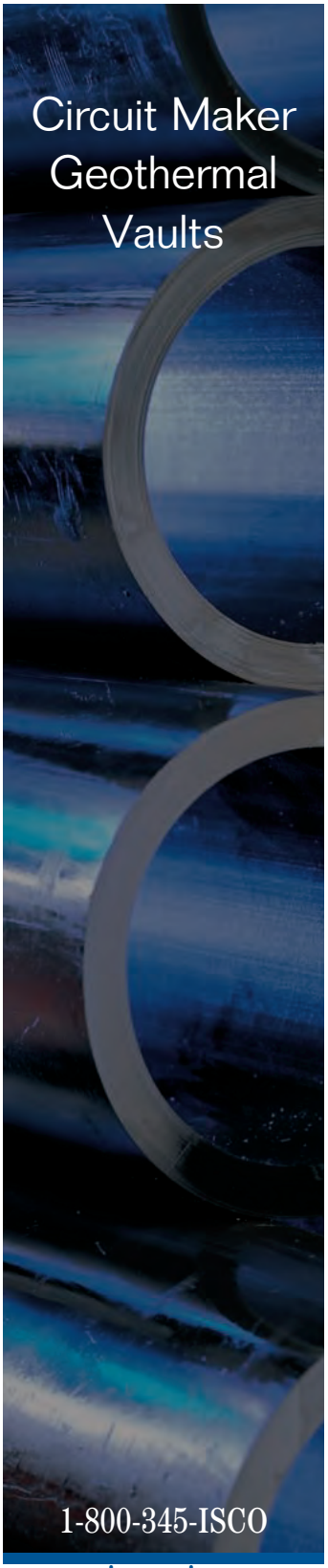


## Circuit Maker Geothermal Vaults





ISCO fabricates custom HDPE vaults for your specific geothermal needs. HDPE vaults are strong, leak-free structures that keep your valve system and other equipment clean and safe for years to come.

ISCO Circuit Maker Geothermal Vaults feature:

- Butt-fused Circuitry
- 100% Leak-Free Polyethlene Structure
- H-20 (Highway Traffic) Load Rating Available
- OSHA-Approved Access Ladder
- Custom Fabrication to your specifications
- Extrusion Welding
- Pressure Temperature (P/T) Ports on all outlets
- Choice of Metal or Polyethylene Valves
- Quick Pressure test of individual circuits
- Easy purging and isolation of circuits
- Plastic Cap Retainers

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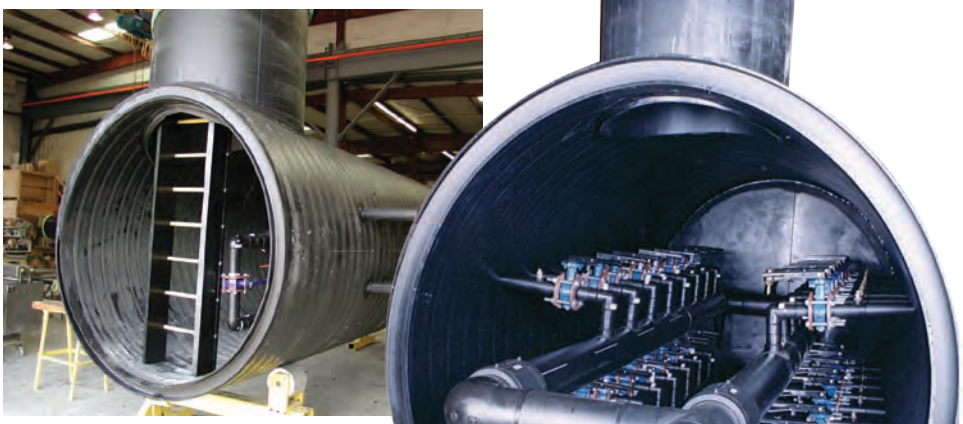

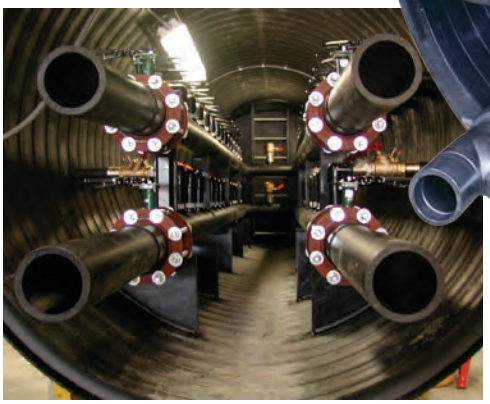







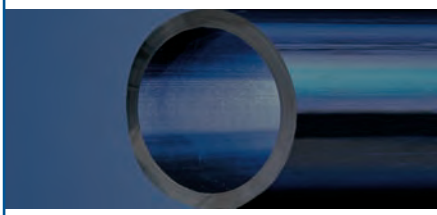

Circuit Maker Gerothermal Vaults

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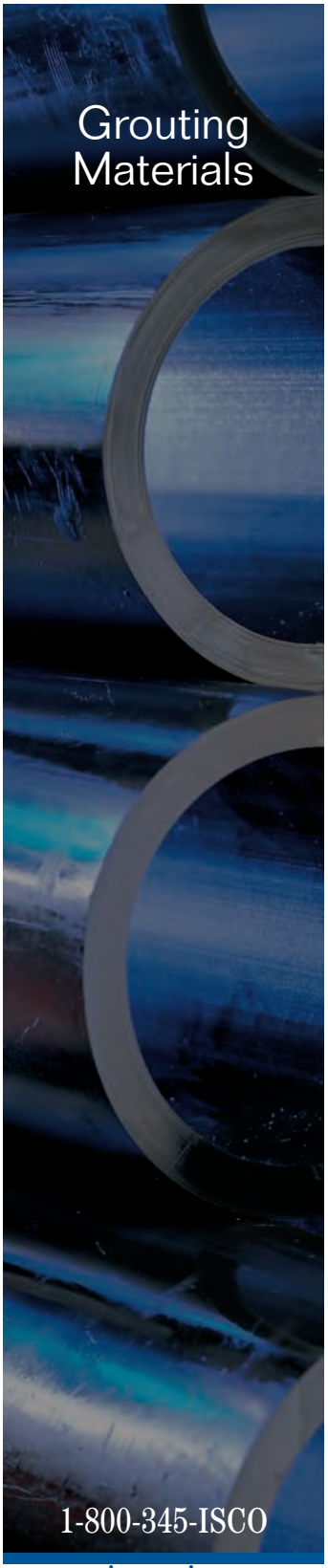


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## Grouting Materials
## GeoPro Bentonite Based Grout




Geo-Pro grout is a thermally enhanced two-part grout engineered for closed loop vertical loop systems. Grouting your borehole increases your thermal conductivity and insures protection for your local potable water source as well as increase your hydraulic performance. Geo-Pro grout is certified by the National Sanitation Foundation International to ANSI/NSF Standard 60, Drinking Water Treatment Chemicals - Health Effects. Geo-Pro grout contains no harmful chemical polymers or organic matter to decay to insure environmental compliance with state regulations.

Our grout is packaged in 50 lbs. multi-wall polylined paper bags and is shipped, shrink-wrapped on wooden pallets. Each full pallet contains 54 bags.

| | | |
|---|---|---|
| Thermal Grout Select: | | |
| Thermal Conductivity (TC) Range | 1.00 - 1.20 | BTU/hr ft F |
| Permeability | $< 6.9 \times 10^{8}$ | cm/sec |
| Unit Yield Range (based on TC) | 32.0 - 42.2 | gal/unit |
| Thermal Grout Lite: | | |
| Thermal Conductivity (TC) Range | 0.45 - 1.00 | BTU/hr ft F |
| Permeability | $< 6.9 \times 10^{8}$ | cm/sec |
| Unit Yield Range (based on TC) | 17.0 - 32.6 | gal/unit |
| BH 20 Grout: | | |
| Thermal Conductivity (TC) Range | 0.40 | BTU/hr ft F |
| Permeability | $< 1 \times 10^{1}$ | cm/sec |
| Unit Yield Range (based on TC) | 26.8 | gal/unit |

For information regarding thermal performance testing per engineered specifications, please contact ISCO's Geothermal Division at 800-345-ISCO (4726).

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## Custom Fabrication



ISCO Industries custom fabricates commercial headers for vaults, mechanical rooms and interior take-offs. Headers can be made with mains and circuits of nearly any size and configuration for various applications. Reducers, flange connections, butterfly valves, ball valves, purge ports, p/t ports, and p/t gauges are just a few of the components that can be designed into a custom header system. Let our expert designers and fabricators create a header system to meet your specific needs. Call for a header quote toll free (800) 345-ISCO, or for more information.



Custom Fabrication

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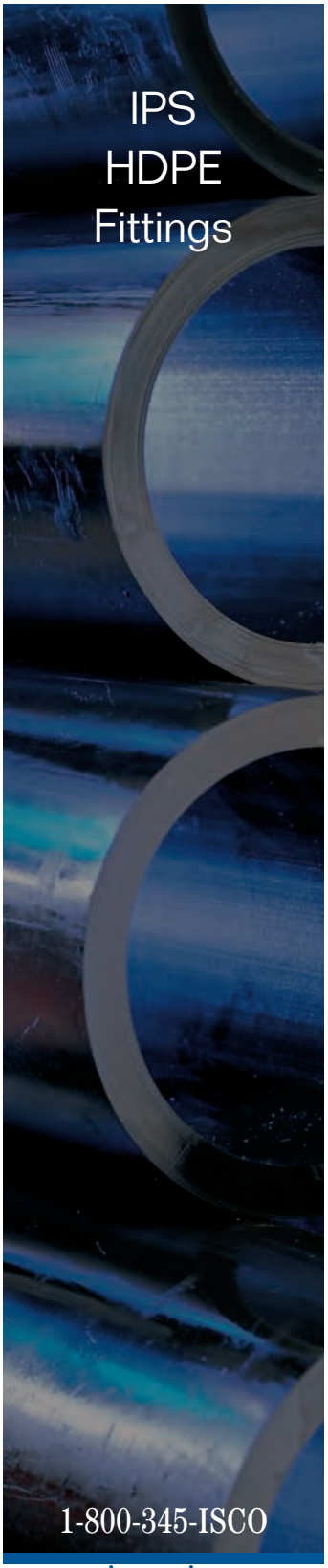
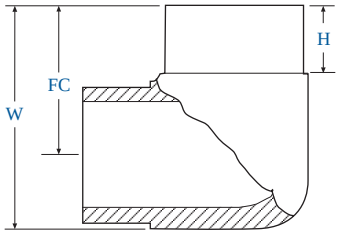



## IPS Fittings Molded 90° Ell – Butt Fusion






IPS Fittings Molded 90° Ell

| Nominal Size(in) | Pipe OD(in) | DR | Pressure Rating | Part # | Dimensions H (in) | FC (in) | W (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|
| 3/4 | 1.05 | 11 | 160 | 50001110 | 2.05 | 2.68 | 3.2 | 0.05 | FedEx |
| 1 | 1.315 | 11 | 160 | 50011126 | 2.17 | 2.91 | 3.57 | 0.1 | FedEx |
| 1-1/4 | 1.66 | 11 | 160 | 50011120 | 2.44 | 3.35 | 4.18 | 0.15 | FedEx |
| 1-1/2 | 1.9 | 11 | 160 | 50011114 | 2.64 | 3.7 | 4.65 | 0.22 | FedEx |
| 2 | 2.375 | 09 | 200 | 50020916 | 2.5 | 4.25 | 5.815 | 0.5 | FedEx |
| | | 11 | 160 | 50021117 | " | " | " | 0.43 | " |
| 3 | 3.5 | 09 | 200 | 50030915 | 3 | 5.25 | 7.4 | 1.5 | FedEx |
| | | 11 | 160 | 50031114 | " | " | " | 1.2 | " |
| 4 | 4.5 | 09 | 200 | 50040915 | 3 | 5.875 | 8.25 | 3 | FedEx |
| | | 11 | 160 | 50041121 | " | " | " | 2.4 | " |
| 6 | 6.625 | 09 | 200 | 50060916 | 4.125 | 8 | 12.5 | 7 | FedEx |
| | | 11 | 160 | 50061124 | " | " | " | 6.7 | " |
| 8 | 8.625 | 11 | 160 | 50081123 | 6 | 12 | 16.5 | 15 | FedEx |
| 10 | 10.75 | 11 | 160 | 50101113 | 6 | 13.25 | 18.875 | 27 | FedEx |
| 12 | 12.75 | 11 | 160 | 50121114 | 7.5 | 15.88 | 22.555 | 41 | FedEx |

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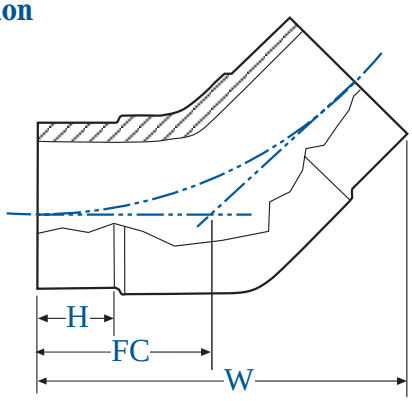
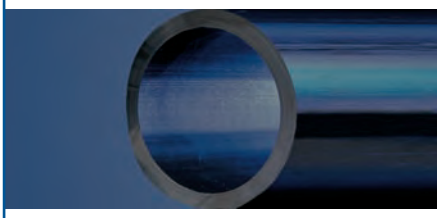
## IPS Fittings Molded 45°Ell – Butt Fusion






IPS Fittings Molded 45°Ell

| Nominal Pipe Size(in) | OD(in) | DR | Pressure Rating | Part # | Dimensions H (in) | FC (in) | W (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.315 | 11 | 160 | 50011125 | 2.17 | 2.48 | 4.69 | 0.08 | FedEx |
| 1-1/4 | 1.66 | 11 | 160 | 50011131 | 2.44 | 2.83 | 5.31 | 0.14 | FedEx |
| 1-1/2 | 1.9 | 11 | 160 | 50011132 | 2.64 | 3.07 | 5.91 | 0.21 | FedEx |
| 2 | 2.375 | 11 | 160 | 50021116 | 2.64 | 3.23 | 6.38 | 0.35 | FedEx |
| 3 | 3.5 | 09 | 200 | 50030914 | 3.125 | 5.25 | 10.20 | 2.5 | FedEx |
| | | 11 | 160 | 50031113 | " | " | " | 1.5 | " |
| 4 | 4.5 | 09 | 200 | 50040914 | 3.125 | 5 | 10.13 | 3 | FedEx |
| | | 11 | 160 | 50041120 | " | " | " | 2 | " |
| 6 | 6.625 | 09 | 200 | 50060915 | 4.125 | 9 | 17.70 | 6 | FedEx |
| | | 11 | 160 | 50061123 | " | " | " | 5.5 | " |
| 8 | 8.625 | 11 | 160 | 50081122 | 6 | 11 | 21.8 | 12 | FedEx |
| 10 | 10.75 | 11 | 160 | 50101112 | 6 | 13.25 | 26.42 | 22 | FedEx |
| 12 | 12.75 | 11 | 160 | 50121113 | 7.5 | 15.75 | 31.39 | 32 | FedEx |



IPS Fittings
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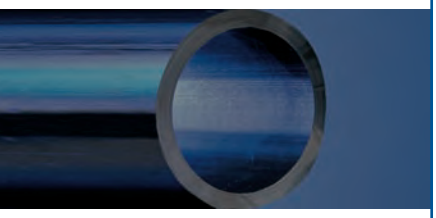
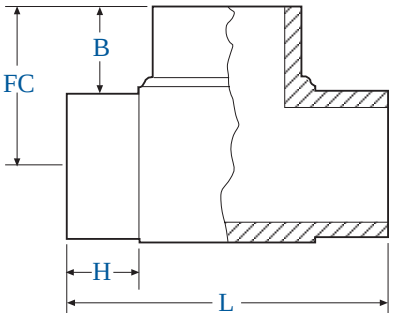


IPS Fittings
Butt Fusion

## IPS Fittings Molded Tees – Butt Fusion






IPS Fittings Molded Tees

| Nominal Pipe Size(in) | OD(in) | DR | Pressure Rating | Part # | Dimensions L (in) | H (in) | FC (in) | B (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.315 | 11 | 160 | 50011128 | 5.67 | 1.77 | 2.83 | 2.17 | 0.17 | FedEx |
| 1-1/4 | 1.66 | 11 | 160 | 50011122 | 6.61 | 2.01 | 3.31 | 2.48 | 0.3 | FedEx |
| 1-1/2 | 1.9 | 11 | 160 | 50011116 | 7.99 | 2.52 | 4 | 3.05 | 0.47 | FedEx |
| 2 | 2.375 | 09 | 200 | 50020919 | 8.5 | 2.5 | 4.26 | 3.07 | 1 | FedEx |
| | | 11 | 160 | 50021119 | " | " | " | " | 0.82 | " |
| 3 | 3.5 | 09 | 200 | 50030917 | 11.375 | 3 | 5.75 | 4 | 2.3 | FedEx |
| | | 11 | 160 | 50031116 | " | " | " | " | 2.15 | " |
| 4 | 4.5 | 09 | 200 | 50040918 | 12.25 | 3 | 6.25 | 4 | 4 | FedEx |
| | | 11 | 160 | 50041123 | " | " | " | " | 3.8 | " |
| 6 | 6.625 | 09 | 200 | 50060918 | 16.25 | 4 | 8.25 | 4.94 | 11 | FedEx |
| | | 11 | 160 | 50061126 | 18 | 4.5 | 9 | 5.69 | 10 | " |
| 8 | 8.625 | 11 | 160 | 50081125 | 23.75 | 5.85 | 11.9 | 7.59 | 25 | FedEx |
| 10 | 10.75 | 11 | 160 | 50101118 | 27 | 6.15 | 13.5 | 8.13 | 43 | FedEx |
| 12 | 12.75 | 11 | 160 | 50121118 | 31.6 | 7.5 | 15.9 | 9.53 | 67 | FedEx |



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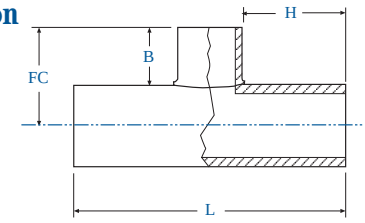
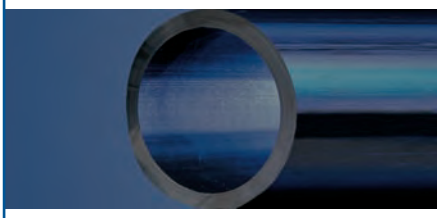
## IPS Fittings Reducing Tee – Butt Fusion






IPS Fittings Reducing Tee

| Nominal Size(in) | Pipe OD(in) | DR | Pressure Rating | Part # | Dimensions L (in) | H (in) | FC (in) | B (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 x 2 | 3.5 x 2.375 | 11 | 160 | 40031117 | 6.125 | 7.25 | 5.5 | 5 | FedEx |
| 4 x 2 | 4.5 x 2.375 | 11 | 160 | 40041126 | 6.125 | 7.75 | 5.5 | 6 | FedEx |
| 4 x 3 | 4.5 x 3.5 | 11 | 160 | 40041127 | 9.5 | 6.5 | 4.25 | 10 | FedEx |
| 6 x 2 | 6.625 x 2.375 | 11 | 160 | 40061123 | 6.125 | 8.75 | 5.4375 | 10 | FedEx |
| 6 x 3 | 6.625 x 3.5 | 11 | 160 | 40061125 | 9.5 | 7.5 | 4.1875 | 16 | FedEx |
| 6 x 4 | 6.625 x 4.5 | 11 | 160 | 40061126 | 9 | 9.25 | 5.9375 | 19 | FedEx |
| 8 x 2 | 8.625 x 2.375 | 11 | 160 | 40081131 | 6.125 | 9.75 | 5.4375 | 16 | FedEx |
| 8 x 3 | 8.625 x 3.5 | 11 | 160 | 40081132 | 9.5 | 8.625 | 4.3125 | 25 | FedEx |
| 8 x 4 | 8.625 x 4.5 | 11 | 160 | 40081134 | 9 | 10.25 | 5.9375 | 28 | FedEx |
| 8 x 6 | 8.625 x 6.625 | 11 | 160 | 40081137 | 9.8125 | 12.25 | 7.9375 | 38 | FedEx |
| 10 x 2 | 10.75 x 2.375 | 11 | 160 | 40101133 | 6.125 | 10.875 | 5.5 | 23 | FedEx |
| 10 x 3 | 10.75 x 3.5 | 11 | 160 | 40101134 | 9.5 | 9.625 | 4.25 | 36 | FedEx |
| 10 x 4 | 10.75 x 4.5 | 11 | 160 | 40101135 | 9 | 11.375 | 6 | 39 | FedEx |
| 10 x 6 | 10.75 x 6.625 | 11 | 160 | 40101138 | 9.8125 | 13.375 | 8 | 51 | FedEx |
| 10 x 8 | 10.75 x 8.625 | 11 | 160 | 40101141 | 9.875 | 13.625 | 8.25 | 60 | FedEx |
| 12 x 2 | 12.75 x 2.375 | 11 | 160 | 40121142 | 6.125 | 11.875 | 5.5 | 32 | FedEx |
| 12 x 3 | 12.75 x 3.5 | 11 | 160 | 40121143 | 9.5 | 10.625 | 4.25 | 48 | FedEx |
| 12 x 4 | 12.75 x 4.5 | 11 | 160 | 40121144 | 9 | 12.375 | 6 | 51 | FedEx |
| 12 x 6 | 12.75 x 6.625 | 11 | 160 | 40121146 | 9.8125 | 14.375 | 8 | 66 | LTL |
| 12 x 8 | 12.75 x 8.625 | 11 | 160 | 40121151 | 9.875 | 14.625 | 8.25 | 75 | LTL |
| 12 x 10 | 12.75 x 10.75 | 11 | 160 | 40121141 | 8.75 | 12.875 | 6.5 | 85 | LTL |



IPS Fittings
Butt Fusion

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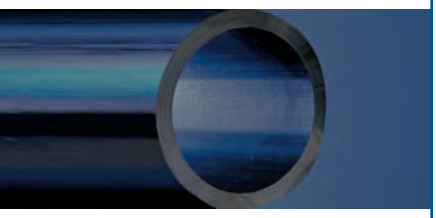

IPS Fittings
Butt Fusion

## Reducing Tees
## ButtXButtXPipe Thread Adapter – Butt Fusion



| Size |
|---|
| 1.25" x 1.25" x 0.50" FPT |
| 1.25" x 1.25" x 0.75" MTP |
| 1.25" x 1.25" x 1.00" MPT |
| 1.50" x 1.50" 0.50" FPT |
| 1.50" x 1.50" 0.75" MPT |
| 1.50" x 1.50" 1.00" MPT |
| 2.00" x 2.00" x 0.50" FPT |
| 2.00" x 2.00" x 0.75" MPT |
| 2.00" x 2.00" x 1.00" MPT |
| 2.00" x 2.00" x 1.25" MPT |
| 3.00" x 3.00" x 0.50" FPT |
| 3.00" x 3.00" x 0.75" MPT |
| 3.00" x 3.00" x 1.00" MPT |
| 3.00" x 3.00" x 1.25" MPT |
| 3.00" x 3.00" x 1.50" MPT |
| 3.00" x 3.00" x 2.00" MPT |
| 4.00" x 4.00" x 0.50" FPT |

| Size |
|---|
| 4.00" x 4.00" x 0.75" MPT |
| 4.00" x 4.00" x 1.00" MPT |
| 4.00" x 4.00" x 1.25" MPT |
| 4.00" x 4.00" x 1.50" MPT |
| 4.00" x 4.00" x 2.00" MPT |
| 6.00" x 6.00" x 0.50" FPT |
| 6.00" x 6.00" x 0.75" MPT |
| 6.00" x 6.00" x 1.00" MPT |
| 6.00" x 6.00" x 1.25" MPT |
| 6.00" x 6.00" x 1.50" MPT |
| 6.00" x 6.00" x 2.00" MPT |
| 8.00" x 8.00" x 0.50" FPT |
| 8.00" x 8.00" x 0.75" MPT |
| 8.00" x 8.00" x 1.00" MPT |
| 8.00" x 8.00" x 1.25" MPT |
| 8.00" x 8.00" x 1.50" MPT |
| 8.00" x 8.00" x 2.00" MPT |



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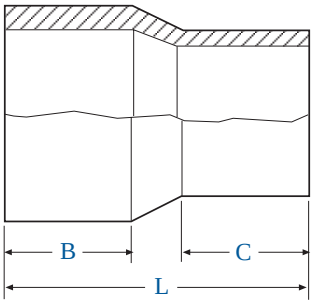
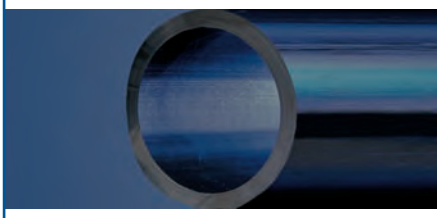
## IPS Fittings Concentric Reducer – Butt Fusion






IPS Fittings Concentric Reducer

| Nominal Size(in) | Pipe OD(in) | DR | Pressure Rating | Part # | Dimensions L (in) | B (in) | C (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|
| 1 x 3/4 | 1.315 x 1.05 | 09 | 200 | 50010917 | 4.5 | 1.5 | 2.5 | 0.1 | FedEx |
| | | 11 | 160 | 50011130 | " | " | " | " | " |
| 1-1/4 x 1 | 1.66 x 1.315 | 11 | 160 | 50011110 | 4.3 | 1.8 | 1.25 | 0.1 | FedEx |
| 1-1/2 x 3/4 | 1.9 x 1.05 | 09 | 200 | 50010912 | 5.688 | 2.5 | 2.5 | 0.2 | FedEx |
| | | 11 | 160 | 50011118 | " | " | " | " | " |
| 1-1/2 x 1 | 1.9 x 1.315 | 09 | 200 | 50010911 | 6 | 3.25 | 1.25 | 0.2 | FedEx |
| | | 11 | 160 | 50011117 | " | " | " | " | " |
| 1-1/2 x 1-1/4 | 1.9 x 1.66 | 11 | 160 | 50011133 | 4 | 1.88 | 2 | 0.2 | FedEx |
| 2 x 3/4 | 2.375 x 1.05 | 11 | 160 | 50021129 | 6.25 | 3.25 | 1.25 | 0.3 | FedEx |
| 2 x 1 | 2.375 x 1.315 | 11 | 160 | 50021125 | 6.25 | 3.25 | 1.25 | 0.3 | FedEx |
| 2 x 1-1/4 | 2.375 x 1.66 | 11 | 160 | 50021123 | 6.25 | 3.25 | 2.25 | 0.3 | FedEx |
| 2 x 1-1/2 | 2.375 x 1.9 | 09 | 200 | 50020921 | 7 | 3 | 2.5 | 0.3 | FedEx |
| | | 11 | 160 | 50021122 | " | " | " | " | " |
| 3 x 2 | 3.5 x 2.375 | 09 | 200 | 50030717 | 6.75 | 3 | 2.5 | 0.7 | FedEx |
| | | 11 | 160 | 50031122 | " | " | " | " | " |
| 4 x 2 | 4.5 x 2.375 | 11 | 160 | 50041129 | 7.5 | 3 | 2.5 | 1.2 | FedEx |
| 4 x 3 | 4.5 x 3.5 | 09 | 200 | 50040923 | 7.25 | 2.75 | 2.75 | 4 | FedEx |
| | | 11 | 160 | 50041132 | " | " | " | 3 | " |
| 5 x 4 | 5.563 x 4.5 | 11 | 160 | 50051111 | 3.75 | 1.75 | 1.25 | 2.5 | FedEx |
| 6 x 3 | 6.625 x 3.5 | 11 | 160 | 50061132 | 11.42 | 5.12 | 3.94 | 3 | FedEx |
| 6 x 4 | 6.625 x 4.5 | 09 | 200 | 50060923 | 11 | 4.5 | 3.5 | 4 | FedEx |
| | | 11 | 160 | 50061136 | " | " | " | 3.5 | " |
| 6 x 5 | 6.625 x 5.563 | 11 | 160 | 50061137 | 3.75 | 1.75 | 1.25 | 2.5 | FedEx |
| 8 x 6 | 8.625 x 6.625 | 09 | 200 | 50080918 | 12 | 4.5 | 4 | 9 | FedEx |
| | | 11 | 160 | 50081138 | " | " | " | 7.3 | " |
| 10 x 8 | 10.75 x 8.625 | 09 | 200 | 40100911 | 16 | 6 | 6 | 16 | FedEx |
| | | 11 | 160 | 40101139 | " | " | " | 13 | " |
| 12 x 8 | 12.75 x 8.625 | 11 | 160 | 40121149 | 16 | 6 | 6 | 19 | FedEx |
| 12 x 10 | 12.75 x 10.75 | 09 | 200 | 40120910 | 16 | 6 | 6 | 25 | FedEx |
| | | 11 | 160 | 40121140 | " | " | " | 21 | " |



IPS Fittings
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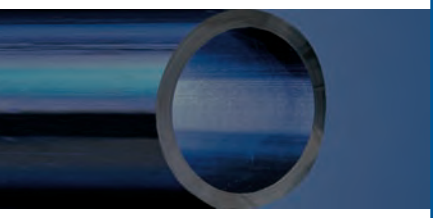
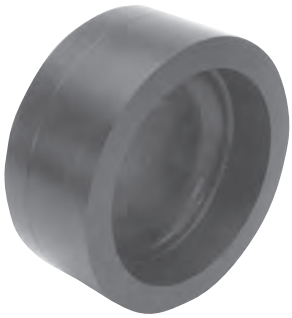
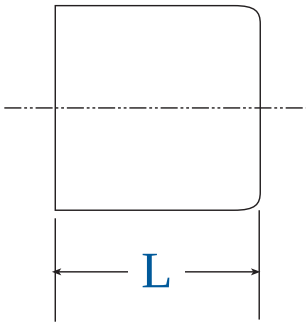


IPS Fittings
Butt Fusion

## IPS Fittings Cap – Butt Fusion






IPS Fittings Cap

| Nominal Pipe Size(in) | OD(in) | DR | Pressure Rating | Part # | Dimensions L (in) | Weight Lbs | Shipping Method |
|---|---|---|---|---|---|---|---|
| 3/4 | 1.05 | 11 | 160 | 50001111 | 2.375 | 0.05 | FedEx |
| 1 | 1.315 | 11 | 160 | 50001127 | 2.375 | 0.1 | FedEx |
| 1 1/4 | 1.66 | 11 | 160 | 50011121 | 2.25 | 0.1 | FedEx |
| 1 1/2 | 1.9 | 11 | 160 | 50011115 | 2.83 | 0.25 | FedEx |
| 2 | 2.375 | 09 | 200 | 50020917 | 3.25 | 0.3 | FedEx |
| | | 11 | 160 | 50021118 | " | " | " |
| 3 | 3.5 | 09 | 200 | 50030913 | 3.25 | 0.8 | FedEx |
| | | 11 | 160 | 50031115 | " | " | " |
| 4 | 4.5 | 09 | 200 | 50040916 | 5.5 | 2 | FedEx |
| | | 11 | 160 | 50041122 | " | " | " |
| 6 | 6.625 | 09 | 200 | 50060932 | 4.5 | 3 | FedEx |
| | | 11 | 160 | 50061125 | " | " | " |
| 8 | 8.625 | 11 | 160 | 50081124 | 4.75 | 4.4 | FedEx |
| 10 | 10.75 | 11 | 160 | 50101118 | 4 | 13 | FedEx |
| 12 | 12.75 | 11 | 160 | 50121115 | 4 | 18 | FedEx |



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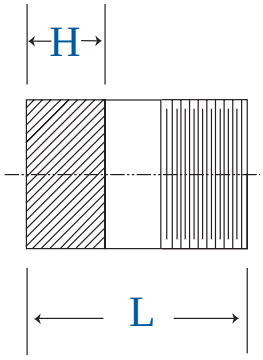
## IPS Male Threaded Transition Fitting



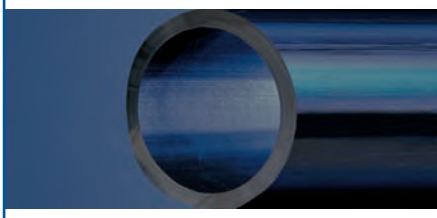



IPS Male Threaded Transition Fitting

| Nominal Size (in) | Pipe OD (in) | Material | Part # | Dimensions L (in) | Dimensions H (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|
| 3/4 | 1.05 | Steel | 53001115 | 4 | 2.4 | .17 | FedEx |
| | | Stainless Steel | 53001117 | " | " | " | " |
| | | Brass | 53001113 | " | " | " | " |
| 1 | 1.315 | Steel | 53001120 | 5 | 3 | .27 | FedEx |
| | | Stainless Steel | 53001119 | " | " | " | " |
| | | Brass | 53001117 | " | " | " | " |
| 1 1/4 | 1.66 | Steel | 53001122 | 5 | 3.4 | .27 | FedEx |
| | | Stainless Steel | 53001137 | " | " | " | " |
| | | Brass | 53001124 | " | " | " | " |
| 1 1/2 | 1.9 | Steel | 53001114 | 6 | 3.4 | .55 | FedEx |
| | | Stainless Steel | 53001136 | " | " | " | " |
| | | Brass | 53011128 | " | " | " | " |
| 2 | 2.375 | Steel | 53021122 | 8 | 4.5 | 1 | FedEx |
| | | Stainless Steel | 53021123 | " | " | " | " |
| | | Brass | 53021126 | " | " | " | " |
| 3 | 3.5 | Steel | 53031117 | 8 | 4 | 2.4 | FedEx |
| | | Stainless Steel | 53031121 | " | " | " | " |
| | | Brass | 53031120 | " | " | " | " |
| 4 | 4.5 | Steel | 53041127 | 8 | 4 | 4.3 | FedEx |
| | | Stainless Steel | 53041126 | " | " | " | " |
| 6 | 6.625 | Steel | 53061123 | 12 | 7.5 | 12 | FedEx |
| | | Stainless Steel | 53061124 | " | " | " | " |
| 8 | 8.625 | Steel | 53081121 | 13 | 6 | 20.7 | FedEx |
| | | Stainless Steel | 53081127 | " | " | " | " |
| 10 | 10.75 | Steel | 53101121 | 15 | 7 | 38.1 | FedEx |
| | | Stainless Steel | 53101138 | " | " | " | " |
| 12 | 12.75 | Steel | 53121137 | 16 | 7 | 57.1 | FedEx |
| | | Stainless Steel | 53121139 | " | " | " | " |

****Female Transitions available through 8" in same materials as male counterparts.**







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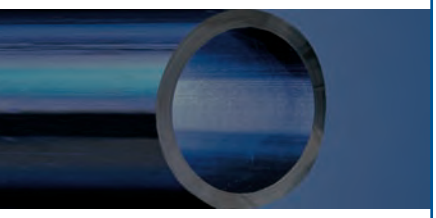
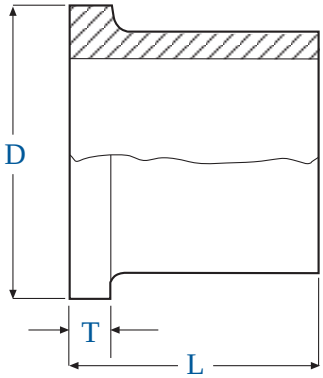


IPS Fittings
Butt Fusion

## IPS Fittings Flange Adapter – Butt Fusion






IPS Fittings Flange Adapter

| Nominal Size(in) | Pipe OD(in) | DR | Dimensions D(in) | T(in) | L(in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|
| 3/4" | 1.05 | 11 | 2 | 0.2 | 4 | 0.1 | FedEx |
| 1" | 1.315 | 11 | 2.375 | 0.21 - 0.24 | 4 | 0.1 | FedEx |
| 1-1/4" | 1.66 | 11 | 2.75 | 0.25 | 4 - 6 | 0.2 | FedEx |
| 1-1/2" | 1.9 | 11 | 3.125 | 0.29 - 0.3 | 4 - 6 | 0.2 | FedEx |
| 2" | 2.375 | 7 | 3.75 - 4.0 | 0.39 - 0.44 | 5.5 - 6 | 1 | FedEx |
| | | 9 | " | 0.39 - 0.44 | 5.5 - 6 | 1 | " |
| | | 11 | " | 0.3 - 0.55 | 5.5 - 6.125 | 1 | " |
| | | 17 | " | 0.3 - 0.55 | 5.5 - 6.125 | 1 | " |
| 3" | 3.5 | 7 | 4.625 - 5 | 0.6 - 0.63 | 6 | 2 | FedEx |
| | | 9 | " | 0.6 - 0.63 | 6 | 2 | " |
| | | 11 | " | 0.4 - 0.67 | 6 - 6.125 | 2 | " |
| | | 17 | " | 0.4 - 0.67 | 6 - 6.125 | 2 | " |
| 4" | 4.5 | 7 | 6.0 - 6.625 | 0.54 - 0.8 | 6 | 3 | FedEx |
| | | 9 | " | 0.54 - 0.8 | 6 | 3 | " |
| | | 11 | " | 0.5 - 0.8 | 6 - 7.125 | 3 | " |
| | | 17 | " | 0.5 - 0.8 | 6 - 7.125 | 3 | " |
| | | 21 | " | 0.75 | 6 | 3 | " |
| 6" | 6.625 | 7 | 8.125 - 8.625 | 1.1 - 1.14 | 8 - 8.125 | 8 | FedEx |
| | | 9 | " | 1.1 - 1.14 | 8 - 8.125 | 8 | " |
| | | 11 | " | 0.7 - 1.02 | 8 - 8.07 | 4.07 - 7 | " |
| | | 17 | " | 0.7 - 1.02 | 8 - 8.07 | 3.02 - 7 | " |
| | | 21 | " | 0.7 - 1 | 8 | 7 | " |
| | | 26 | " | 1 | 8 | 7 | " |
| | | 32.5 | " | 1 | 8 | 7 | " |
| 8" | 8.625 | 7 | 10.6 - 10.75 | 1.4 - 1.5 | 8.625 - 9 | 11 | FedEx |
| | | 9 | " | 1.13 - 1.47 | 8.625 - 9 | 10.0 - 11 | " |
| | | 11 | " | 0.8 - 1.26 | 9.02 - 11 | 7.0 - 10 | " |
| | | 17 | " | 0.9 - 1.02 | 9.02 - 11 | 5.0 - 10 | " |
| | | 21 | " | 0.9 - 1 | 11 | 5.0 - 10 | " |
| | | 26 | " | 0.9 - 1 | 11 | 3.0 - 10 | " |
| | | 32.5 | " | 1 | 11 | 10.0 - | " |
| 10" | 10.75 | 7 | 12.75 - 13 | 1.28 - 2 | 8.75 - 12 | 19 | FedEx |
| | | 9 | " | 1.28 - 2 | 8.75 - 12 | 19 | " |
| | | 11 | " | 1.1 - 1.38 | 9.02 - 12 | 18 | " |
| | | 17 | " | 0.9 - 1.28 | 9.02 - 12 | 18 | " |
| | | 21 | " | 1.1 - 1.28 | 11.0 - 12 | 18 | " |
| | | 26 | " | 1.25 - 1.28 | 11.0 - 12 | 18 | " |
| | | 32.5 | " | 1.25 - 1.28 | 11.0 - 12 | 18 | " |
| 12" | 12.75 | 7 | 15 - 15.75 | 1.54 - 2.3 | 9.125 - 12 | 25 | FedEx |
| | | 9 | " | 1.54 - 2.3 | 9.125 - 12 | 25 | " |
| | | 11 | " | 1.3 - 1.54 | 10.79 - 12 | 24 | " |
| | | 17 | " | 1 - 1.54 | 10.79 - 12 | 24 | " |
| | | 21 | " | 1.3 - 1.5 | 11.0 - 12 | 24 | " |
| | | 26 | " | 1.3 - 1.5 | 11.0 - 12 | 24 | " |
| | | 32.5 | " | 1.5 | 11 | 24 | " |



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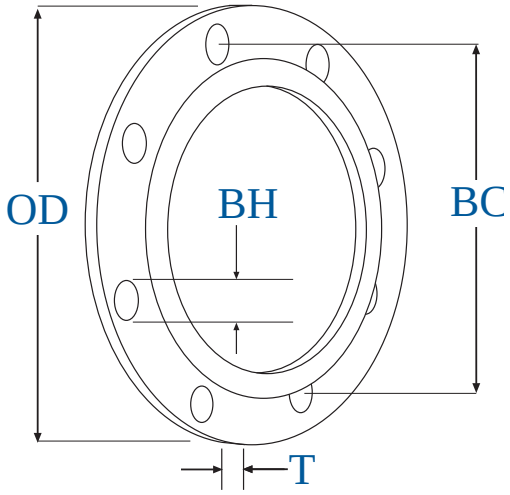
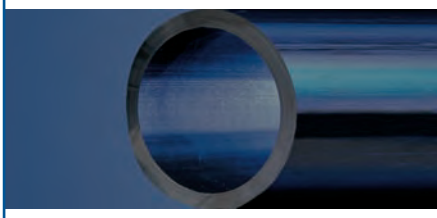
## IPS Fittings Back Up Rings (For use with the Flange Adapter)






**IPS Fittings Back Up Ring**

| Nominal Size(in) | Pipe OD(in) | Material | Part # | Dimensions OD (in) | T(in) | Bolts (#) | BH(in) | BC(in) | Pressure Rating | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/4" | 1.05" | Ductile Iron | 53000016 | 3.875 | 0.5 - 0.53 | 4 | 0.625 | 2.75 | 267 | 1 | FedEx |
| 1" | 1.315 | Ductile Iron | 53010025 | 4.25 | 0.53 - 0.56 | 4 | 0.625 | 3.125 | 267 | 1 | FedEx |
| | | Stainless Steel | 53010028 | | 0.56 | | | | 267 | 2 | |
| 1 1/4" | 1.66 | Ductile Iron | 53010015 | 4.625 | 0.63 | 4 | 0.625 | 3.5 | 267 | 2 | FedEx |
| 1 1/2" | 1.9 | Ductile Iron | 53010011 | 5 | 0.69 | 4 | 0.625 | 3.875 | 267 | 2 | FedEx |
| | | Stainless Steel | 53010012 | | 0.69 | | | | 267 | 2 | |
| 2" | 2.375 | Ductile Iron | 53020022 | 6 | 0.5, 0.75 | 4 | 0.75 | 4.75 | 160, 267 | 1.5, 3 | FedEx |
| | | PP Coated DI | 53020024 | 6.5 | 0.71 | | | | 128, 275 | 1.8 | |
| | | Stainless Steel | 53020012 | 6 | 0.4, 0.75 | | | | 160, 267 | 2, 2.6 | |
| 3" | 3.5 | Ductile Iron | 53030022 | 7.5 | 0.53, 0.94 | 4 | 0.75 | 6 | 160, 267 | 2.5, 4.5 | FedEx |
| | | PP Coated DI | 53030027 | 7.8 | 0.71, 0.73 | | | | 128, 275 | 2.4 | |
| | | Stainless Steel | 53030014 | 7.5 | 0.4, 0.94 | | | | 128, 267 | 3, 5 | |
| 4" | 4.5 | Ductile Iron | 53040024 | 9 | 0.55, 0.94 | 8 | 0.75 | 7.5 | 160, 267 | 3.5, 5.5 | FedEx |
| | | PP Coated DI | 53040025 | 9.21 | 0.71, 0.98 | | | | 128, 275 | 2.5, 4.2 | |
| | | Stainless Steel | 53040014 | 9 | 0.5 - 0.94 | | | | 128, 267 | 5, 6 | |
| 6" | 6.625 | Ductile Iron | 53060031 | 11 | 0.63, 1 | 8 | 0.875 | 9.5 | 160, 267 | 4.5, 7.5 | FedEx |
| | | PP Coated DI | 53060058 | 11.57 | 0.79, 1.18 | | | | 128, 275 | 4.0, 7.1 | |
| | | Stainless Steel | 53060019 | 11 | 0.6, 1 | | | | 128, 267 | 6, 9 | |
| 8" | 8.625 | Ductile Iron | 53080032 | 13.5 | 0.85, 1.125 | 8 | 0.875 | 11.75 | 160, 267 | 8, 12 | FedEx |
| | | PP Coated DI | 53080034 | 13.86 | 1.1, 1.34 | | | | 128, 275 | 7.5, 11.6 | |
| | | Stainless Steel | 53080018 | 13.5 | 0.7 - 1.13 | | | | 128, 267 | 9, 13 | |
| 10" | 10.75 | Ductile Iron | 53100028 | 16 | 0.98, 1.19 | 12 | 1 | 14.25 | 160, 267 | 12, 16 | FedEx |
| | | PP Coated DI | 53100036 | 16.61 | 1.22, 1.52 | | | | 128, 275 | 10.5, 16 | |
| | | Stainless Steel | 53100037 | 16 | 0.9, 1.19 | | | | 128, 267 | 12, 18 | |
| 12" | 12.75 | Ductile Iron | 53100030 | 19 | 1.25 - 1.5 | 12 | 1 | 17 | 160 - 267 | 20, 25 | FedEx |
| | | PP Coated DI | 53100031 | 19.37 | 1.61, 2.01 | | | | 128, 275 | 17.5, 28.2 | |
| | | Stainless Steel | 53100018 | 19 | 1.05 - 1.77 | | | | 128 - 267 | 21 - 37 | |





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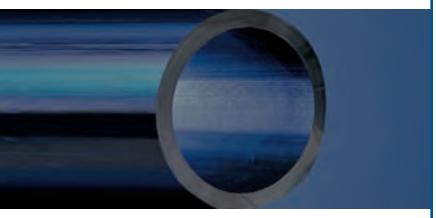
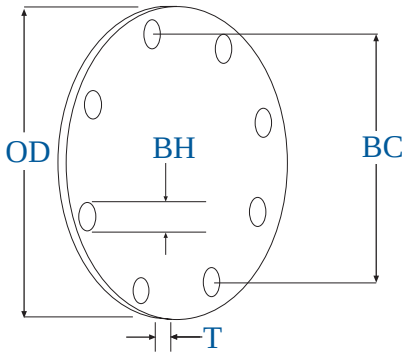


IPS Fittings

## Blind Flange






**Blind Flange**

| Nominal Size(in) | Material | Part # | Dimensions OD (in) | T(in) | Bolts(#) | BH(in) | BC(in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|---|
| 3/4 | HDPE | 49000010 | 3.875 | 1 | 4 | 0.625 | 2.75 | 0.2 | FedEx |
| | PVC | 49000022 | " | " | " | " | " | 0.3 | " |
| 1 | HDPE | 49010010 | 4.25 | 1 | 4 | 0.625 | 3.125 | 0.3 | FedEx |
| | PVC | 49010013 | " | " | " | " | " | 0.5 | " |
| 1 1/4 | HDPE | 49010011 | 4.625 | 1 | 4 | 0.625 | 3.5 | 0.5 | FedEx |
| | PVC | 49010014 | " | " | " | " | " | 1 | " |
| 1 1/2 | HDPE | 49010012 | 5 | 1 | 4 | 0.625 | 3.875 | 0.5 | FedEx |
| | PVC | 49010015 | " | " | " | " | " | 1 | " |
| | STEEL | 53010075 | " | 0.625 | " | " | " | 3.6 | " |
| 2 | HDPE | 49020013 | 6 | 1 | 4 | 0.75 | 4.75 | 1 | FedEx |
| | PVC | 49020017 | " | " | " | " | " | 1.5 | " |
| | STEEL | 53020029 | " | 0.625 | " | " | " | 5.1 | " |
| 3 | HDPE | 49030012 | 7.5 | 1 | 4 | 0.75 | 6 | 1 | FedEx |
| | PVC | 49030013 | " | " | " | " | " | 2 | " |
| | STEEL | 53030025 | " | 0.625 | " | " | " | 8.2 | " |
| 4 | HDPE | 49040012 | 9 | 1 | 8 | 0.75 | 7.5 | 2 | FedEx |
| | PVC | 49040013 | " | " | " | " | " | 3 | " |
| | STEEL | 53040030 | " | 0.625 | " | " | " | 11.7 | " |
| 6 | HDPE | 49060012 | 11 | 1 | 8 | 0.875 | 9.5 | 3 | FedEx |
| | PVC | 49060013 | " | " | " | " | " | 4 | " |
| | STEEL | 53060044 | " | 0.688 | " | " | " | 17.8 | " |
| 8 | HDPE | 49080012 | 13.5 | 1 | 8 | 0.875 | 11.75 | 5 | FedEx |
| | PVC | 49080014 | " | " | " | " | " | 7 | " |
| | STEEL | 53080053 | " | 0.688 | " | " | " | 27.2 | " |
| 10 | HDPE | 49100010 | 16 | 1 | 12 | 1 | 14.25 | 6 | FedEx |
| | PVC | 49110011 | " | " | " | " | " | 9 | " |
| | STEEL | 53100035 | " | 0.688 | " | " | " | 38.1 | " |
| 12 | HDPE | 49120011 | 19 | 1 | 12 | 1 | 17 | 9 | FedEx |
| | PVC | 49120012 | " | " | " | " | " | 13 | " |
| | STEEL | 53120033 | " | 0.812 | " | " | " | 63.1 | " |

* HDPE and PVC Blinds are not rated for full pressure above 6".
* Steel Blinds may not be fully pressure rated above 10" depending on pipe (system) DR.
* MPT outlet available on request.



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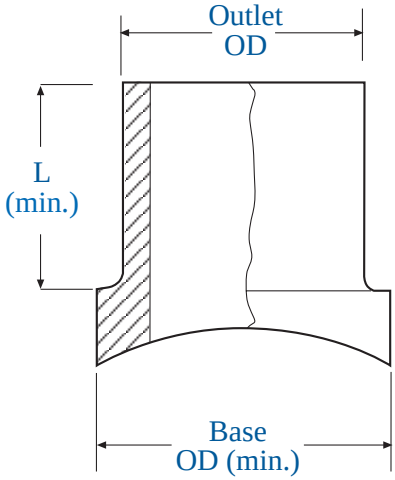
## IPS Branch Saddle



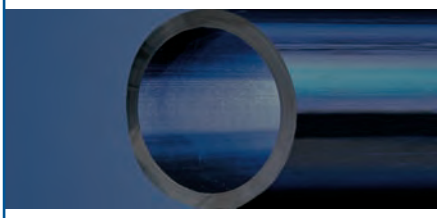



IPS Branch Saddle

| Nominal Outlet Size(in) | Outlet OD(in) | DR | Pressure Rating | Part # | Dimensions L (in) | Base OD (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|
| 2 | 2.375 | 11 | 160 | Varies* | 2.5 | 2.6 | 1 | FedEx |
| 3 | 3.5 | 11 | 160 | Varies* | 3.13 | 3.88 | 1 | FedEx |
| 4 | 4.5 | 11 | 160 | Varies* | 3.13 | 4.8 | 2 | FedEx |
| 6 | 6.625 | 11 | 160 | Varies* | 4.38 | 6.81 | 4 | FedEx |
| 8 | 8.625 | 11 | 160 | Varies* | 5.5 | 9 | 8 | FedEx |
| 10 | 10.75 | 11 | 160 | Varies* | 6 | 11.5 | 16 | FedEx |
| 12 | 12.75 | 11 | 160 | Varies* | 7.5 | 13.35 | 32 | FedEx |

* Any size main available, but must be larger than outlet size. Consideration must be given that heater plate and fusion unit are available for rent.

** Hole saws for field cutting coupons are available for purchase. See Page 49 in the fusion equipment accessory tooling section.





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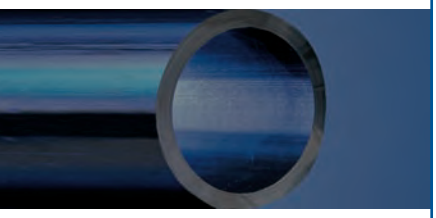
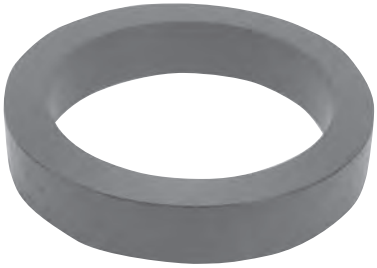
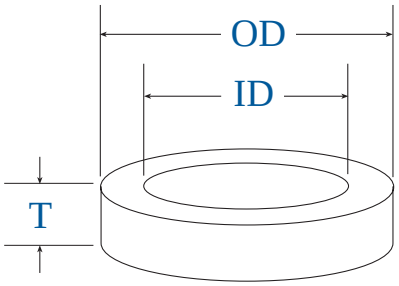


IPS Fittings

## Valve Spacers






Valve Spacers

| Nominal Size(in) | Pressure Rating | Part # | Dimensions OD (in) | ID (in) | T (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|
| 2 | 160 | 49021110 | 3.5 | 2.8 | 2 | 0.25 | FedEx |
| 3 | 160 | 49031112 | 4.8 | 3.6 | 2 | 0.5 | FedEx |
| 4 | 160 | 49041112 | 6.625 | 5.15 | 2 | 1 | FedEx |
| 6 | 160 | 49061112 | 8.625 | 6.625 | 2 | 2 | FedEx |
| 8 | 160 | 49081112 | 10.75 | 8.625 | 2 | 2.5 | FedEx |
| 10 | 160 | 49101111 | 13.0 | 10.75 | 2 | 4 | FedEx |
| 12 | 160 | 49121111 | 15.25 | 12.45 | 2 | 5 | FedEx |



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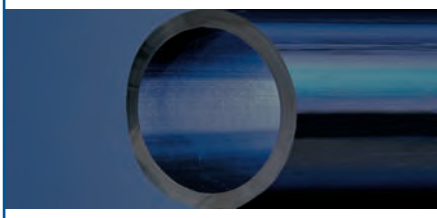

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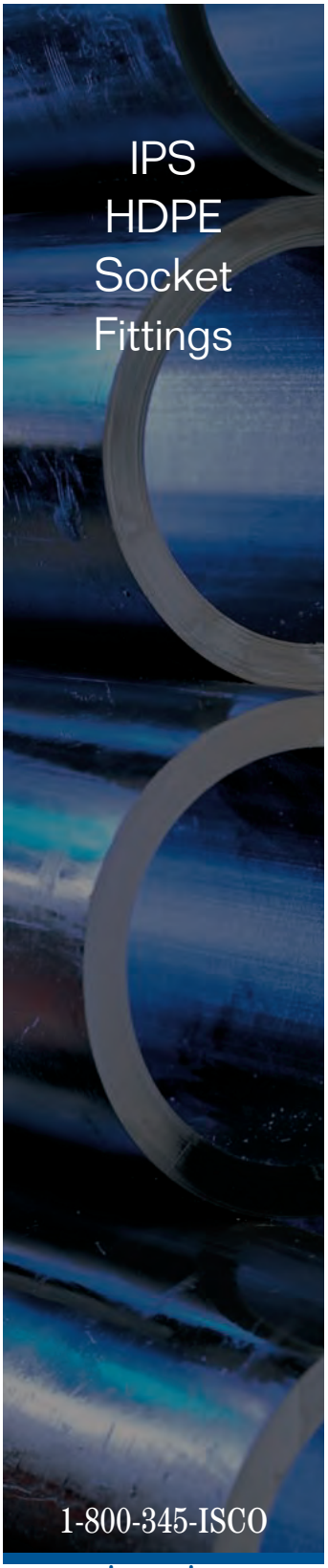
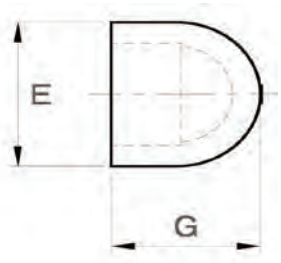



## Socket Cap

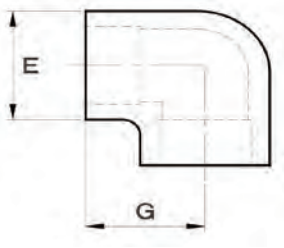





| Nominal Size (in) | Pressure Rating | Part # | Dimensions G (in) | Dimensions E (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|
| 3/4" | 160 | 52000013 | 1.42 | 1.44 | 0.04 | FedEx |
| 1" | 160 | 52010014 | 1.60 | 1.80 | 0.06 | FedEx |
| 1 1/4" | 160 | 52010028 | 2.06 | 2.28 | 0.13 | FedEx |
| 1 1/2" | 160 | 52010044 | 2.40 | 2.67 | 0.23 | FedEx |
| 2" | 160 | 52020014 | 2.58 | 3.32 | 0.37 | FedEx |

## 90 Degree Socket Elbow






| Nominal Size (in) | Pressure Rating | Part # | Dimensions G (in) | Dimensions E (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|
| 3/4" | 160 | 52000011 | 1.66 | 1.46 | 0.1 | FedEx |
| 1" | 160 | 52010010 | 1.64 | 1.78 | 0.14 | FedEx |
| 1 1/4" | 160 | 52010024 | 2.09 | 2.36 | 0.35 | FedEx |
| 1 1/2" | 160 | 52010043 | 2.41 | 2.65 | 0.46 | FedEx |
| 2" | 160 | 52020011 | 3.00 | 3.33 | 0.9 | FedEx |

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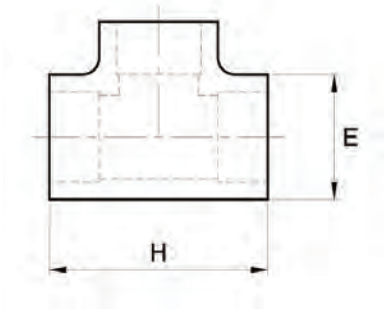
## Socket Tees



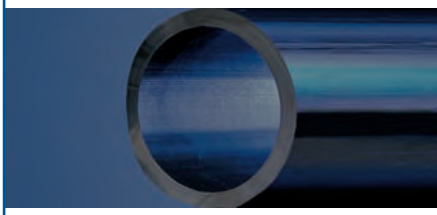



| Nominal Size (in) | Pressure Rating | Part # | Dimensions H (in) | E (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|
| 3/4" | 160 | 52000015 | 3.38 | 1.46 | .13 | FedEx |
| 1" | 160 | 52010020 | 3.75 | 1.80 | .25 | FedEx |
| 1 1/4" | 160 | 52010034 | 4.25 | 2.30 | .43 | FedEx |
| 1 1/2" | 160 | 52010042 | 4.75 | 2.65 | .67 | FedEx |
| 2" | 160 | 52020031 | 6.00 | 3.30 | 1.15 | FedEx |

## 90 Degree Reducing Socket Elbow



| Nominal Size (in) | Pressure Rating | Part # | Shipping Method |
|---|---|---|---|
| 1" x 3/4" | 160 | 52010019 | FedEx |
| 1 1/4" x 3/4" | 160 | 52010061 | FedEx |
| 1 1/4" x 1" | 160 | 52010062 | FedEx |
| 2" x 1 1/4" | 160 | 52020020 | FedEx |



IPS HDPE Socket Fittings

1-800-345-ISCO

www.isco-pipe.com

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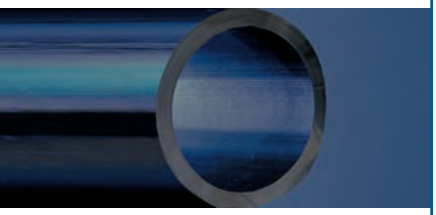

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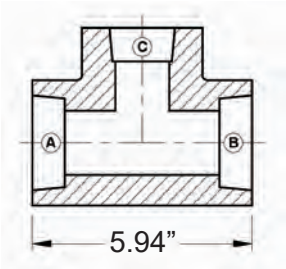
## Socket Reducing Tees






| Nominal Size (in) A-B-C | Pressure Rating | Part # | Dimensions L (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|
| 1" x 1" x 3/4" | 160 | 52010022 | 5.94 | 0.2 | FedEx |
| 1 1/4" x 3/4" x 3/4" | 160 | 52010038 | 5.94 | 0.2 | FedEx |
| 1 1/4" x 1" x 1" | 160 | 52010032 | 5.94 | .45 | FedEx |
| 1 1/4" x 1 1/4" x 3/4" | 160 | 52010039 | 5.94 | 0.2 | FedEx |
| 1 1/4" x 1 1/4" x 1" | 160 | 52010035 | 5.94 | .43 | FedEx |
| 1 1/2" x 3/4" x 3/4" | 160 | 52010090 | 5.94 | .72 | FedEx |
| 1 1/2" x 1" x 1" | 160 | 52010047 | 5.94 | .70 | FedEx |
| 1 1/2" x 1 1/4" x 3/4" | 160 | 52010048 | 5.94 | .70 | FedEx |
| 1 1/2" x 1 1/4" x 1" | 160 | 52010049 | 5.94 | .70 | FedEx |
| 1 1/2" x 1 1/4" x 1 1/4" | 160 | 52010050 | 5.94 | .70 | FedEx |
| 1 1/2" x 1 1/2" x 3/4" | 160 | 52010051 | 5.94 | .68 | FedEx |
| 1 1/2" x 1 1/2" x 1" | 160 | 52010052 | 5.94 | .68 | FedEx |
| 1 1/2" x 1 1/2" x 1 1/4" | 160 | 52010053 | 5.94 | .67 | FedEx |
| 2" x 1" x 1" | 160 | 52020019 | 5.94 | 1.14 | FedEx |
| 2" x 1 1/4" x 3/4" | 160 | 52020039 | 5.94 | 1.14 | FedEx |
| 2" x 1 1/4" x 1" | 160 | 52020022 | 5.94 | 1.14 | FedEx |
| 2" x 1 1/4" x 1 1/4" | 160 | 52020023 | 5.94 | 1.13 | FedEx |
| 2” x 1 1/2” x 3/4” | 160 | 52020026 | 5.94 | 1.2 | FedEx |
| 2” x 1 1/2” x 1” | 160 | 52020027 | 5.94 | 1.2 | FedEx |
| 2” x 2” x 3/4” | 160 | 52020032 | 5.94 | .55 | FedEx |
| 2” x 2” x 1” | 160 | 52020028 | 5.94 | 1.18 | FedEx |
| 2” x 2” x 1 1/4” | 160 | 52020029 | 5.94 | 1.15 | FedEx |
| 2” x 2” x 1 1/2” | 160 | 52020033 | 5.94 | 1.15 | FedEx |



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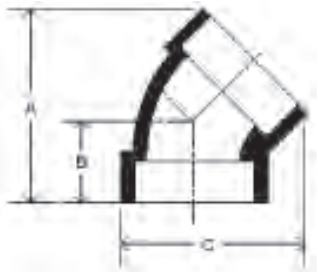
## Socket Male Pipe Thread Adaptor



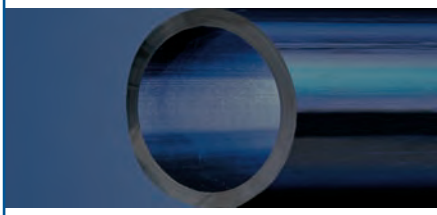
| Nominal Size (in) | Pressure Rating | Part # | Shipping Method |
|---|---|---|---|
| 3/4" x 3/4" MPT | 160 | 52000012 | FedEx |
| 3/4" x 1" MPT | 160 | 52010011 | FedEx |
| 1" x 1" MPT | 160 | 52010021 | FedEx |
| 1 1/4" x 1" MPT | 160 | 52010012 | FedEx |
| 1 1/4" x 1 1/4" MPT | 160 | 52010026 | FedEx |
| 1 1/4" x 2" MPT | 160 | 52020036 | FedEx |
| 1 1/2" x 1 1/4" MPT | 160 | 52010059 | FedEx |
| 1 1/2" x 1 1/2" MPT | 160 | 52010040 | FedEx |
| 2" x 1" MPT | 160 | 52020035 | FedEx |
| 2" x 1 1/4" MPT | 160 | 52020036 | FedEx |
| 2" x 2" MPT | 160 | 52020013 | FedEx |

## 45 Degree Socket Elbow






| Nominal Size (in) | Pressure Rating | Part # | Dimensions A (in) | B (in) | C (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|
| 3/4” | 160 | 52000018 | 2.30 | 1.10 | 2.00 | .10 | FedEx |
| 1” | 160 | 52010056 | 2.60 | 1.18 | 2.38 | .10 | FedEx |
| 1 1/4" | 160 | 52010023 | 2.90 | 1.25 | 2.75 | .32 | FedEx |
| 1 1/2" | 160 | 52010055 | 3.25 | 1.35 | 3.00 | .46 | FedEx |
| 2" | 160 | 52020010 | 3.90 | 1.70 | 3.70 | .83 | FedEx |



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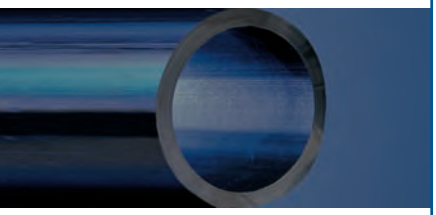

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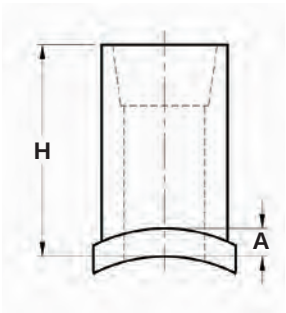
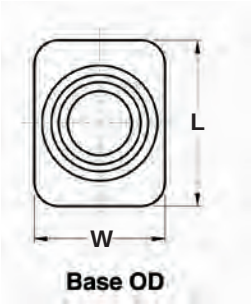
## Socket Saddle Rectangular Base






| Nominal Outlet Size (in) | Pressure Rating | Part # | Dimensions H (in) | A (in) | L (in) | W (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|---|
| 1 1/4" x 3/4" | 160 | 52010063 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 1 1/4" x 1" | 160 | 52010064 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 1 1/2" x 3/4" | 160 | 52010065 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 1 1/2" x 1" | 160 | 52010066 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 2" x 3/4" | 160 | 52010068 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 2" x 1" | 160 | 52010069 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 2" x 1 1/4" | 160 | 52010070 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 3" x 3/4" | 160 | 52010071 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 3" x 1" | 160 | 52010072 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 3" x 1 1/4" | 160 | 52010073 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 4" x 3/4" | 160 | 52010074 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 4" x 1" | 160 | 52010075 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 4" x 1 1/4" | 160 | 52010076 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 6" x 3/4" | 160 | 52010077 | 3.25 | 0.58 | 2.33 | 1.82 | 0.19 | FedEx |
| 6" x 1" | 160 | 52010078 | 3.00 | 0.37 | 2.58 | 2.05 | 0.24 | FedEx |
| 6" x 1 1/4" | 160 | 52010079 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 8" x 3/4" | 160 | 52010080 | 3.25 | 0.58 | 2.33 | 1.82 | 0.24 | FedEx |
| 8" x 1" | 160 | 52010081 | 3.00 | 0.37 | 2.58 | 2.05 | 0.29 | FedEx |
| 8" x 1 1/4" | 160 | 52010082 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 10" x 3/4" | 160 | 52010083 | 3.25 | 0.58 | 2.33 | 1.82 | 0.24 | FedEx |
| 10" x 1" | 160 | 52010084 | 3.00 | 0.37 | 2.58 | 2.05 | 0.29 | FedEx |
| 10" x 1 1/4" | 160 | 52010085 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |
| 12" x 1" | 160 | 52010086 | 3.00 | 0.37 | 2.58 | 2.05 | 0.29 | FedEx |
| 12" x 1 1/4" | 160 | 52020038 | 2.98 | 0.51 | 2.68 | 2.35 | 0.25 | FedEx |



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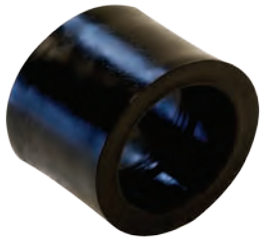
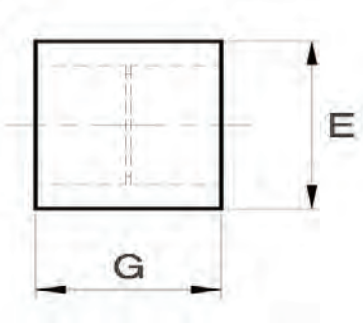
## Socket Coupling

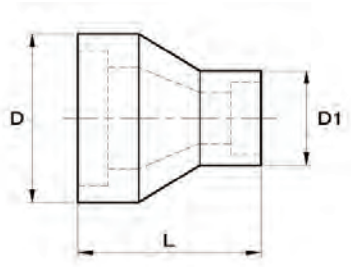




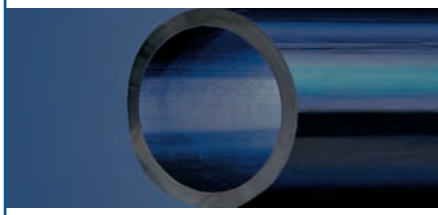

| Nominal Size (in) | Pressure Rating | Part # | Dimensions G (in) | E (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|
| 3/4" | 160 | 52000014 | 1.95 | 1.46 | 0.10 | FedEx |
| 1" | 160 | 52010015 | 1.54 | 1.80 | 0.07 | FedEx |
| 1 1/4" | 160 | 52010029 | 2.08 | 2.32 | 0.16 | FedEx |
| 1 1/2" | 160 | 52010045 | 2.33 | 2.65 | 0.22 | FedEx |
| 2" | 160 | 52020015 | 2.36 | 3.31 | 0.36 | FedEx |

## Socket Reducing Coupling






| Nominal Size (in) | Pressure Rating | Part # | Dimensions L (in) | D (in) | Dl (in) | Weight Lbs. | Shipping Method |
|---|---|---|---|---|---|---|---|
| 1" x 3/4" | 160 | 52010017 | 2.65 | 1.81 | 1.46 | 0.10 | FedEx |
| 1 1/4" x 3/4" | 160 | 52010037 | 2.95 | 2.32 | 1.46 | 0.16 | FedEx |
| 1 1/4" x 1" | 160 | 52010036 | 2.95 | 2.32 | 1.80 | 0.18 | FedEx |
| 1 1/2" x 3/4" | 160 | 52010046 | 2.31 | 2.66 | 1.46 | 0.20 | FedEx |
| 1 1/2" x 1" | 160 | 52010041 | 2.31 | 2.66 | 1.80 | 0.22 | FedEx |
| 1 1/2" x 1 1/4" | 160 | 52010054 | 2.31 | 2.66 | 2.31 | 0.24 | FedEx |
| 2" x 3/4" | 160 | 52020017 | 2.75 | 3.32 | 1.96 | 0.29 | FedEx |
| 2" x 1" | 160 | 52020018 | 3.03 | 3.32 | 1.86 | 0.29 | FedEx |
| 2" x 1 1/4" | 160 | 52020021 | 2.94 | 3.32 | 2.31 | 0.37 | FedEx |
| 2" x 1 1/2" | 160 | 52020025 | 3.75 | 3.32 | 2.66 | 0.50 | FedEx |



IPS HDPE Socket Fittings

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# APPENDIX I CX & TAB REPORT

Artesian Contracting Company, Inc.

# Marine Corps Logistics Base Albany

## Geothermal Heat Pumps with USTES Buidling 3700

Albany, GA

**Addison Energy Technologies, LLC**
45 Cannon Road
Toccoa, GA
(706) 886-5719

**November 5, 2015**

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## CERTIFICATION

### TEST, ADJUST, AND BALANCE REPORT

**Project:** **MCLB Albany Geothermal Heat Pumps with USTES Buidling 3700**

**Declaration:**

THE DATA PRESENTED IN THIS REPORT IS A RECORD OF SYSTEM MEASUREMENTS AND FINAL ADJUSTMENTS THAT HAVE BEEN OBTAINED IN ACCORDANCE WITH THE CURRENT EDITION OF THE AABC NATIONAL STANDARDS FOR TOTAL SYSTEM BALANCE. ANY VARIANCES FROM DESIGN QUANTITIES, WHICH EXCEED AABC TOLERANCES, ARE NOTED IN THE TEST-ADJUST-BALANCE REPORT PROJECT SUMMARY.

**Contractor:** **Artesian Contracting Company, Inc.**
**Engineer:** **Andrews, Hammock & Powell, Inc.**
**Architect:** **-**

**AABC Certified TAB Firm Name:** **Addison Energy Technologies, LLC**
**45 Cannon Road**
**Toccoa, GA 30577**
**Phone:** **(706) 244-3950**
**Fax:** **(706) 297-0156**

**Certification No.** **14-05-91**

**Certification Expiration Date:** **12/31/2015**

**Report Date:** **November 5, 2015**

**AABC Qualified TAB Supervisor Name:** **Eddie M. Addison**

**AABC Qualified TAB Supervisor Signature:**




Report prepared by: Annie Lawson

# AABC National Performance Guaranty

Pursuant to the agreement between

Addison Energy Technologies, LLC

AABC Certified Testing & Balancing Agency

and Artesian Contracting Company, Inc.

Client

All systems shall be tested and balanced in accordance with the project plans and specifications and to the optimum performance capabilities of the equipment. Testing and balancing shall be done in accordance with the standards published by the Associated Air Balance Council.

If the Agency listed above fails to comply with the specifications for any reason other than termination of business by the AABC agency or equipment malfunction or inadequacy which prevents proper balancing of the systems, AABC will investigate and, if warranted, will provide supervisory personnel to assist the member Agency to perform work in accordance with AABC Standards. This supervision will be provided at no additional cost to the building owner.

This Guaranty is valid for one year from the date of submission of a test and balance report, provided the Agency is a current member of AABC, and may only be invoked in writing by the building owner, architect, or engineer of record. The Guaranty is limited to the terms and conditions as stated herein.

Project Name MCLB Albany Geothermal Heat Pumps with USTES Buidling 3700

Address 814 Radford Boulevard

Albany, GA 31704

Name of Engineer Charles W. Hammock Jr.

Engineering Firm Andrews, Hammock & Powell, Inc.

Email Address chammock@ahpengr.com

Address 250 Charter Lane, Suite 100

Macon, GA 31210

Date 11/5/2015

TBE # 14-05-91

By Eddie M. Addison

AABC Certified TBE

AABC

Associated Air Balance Council

1518 K Street, N.W.
Washington, D.C. 20005
202-737-0202 • Fax 202-638-4833
info@aabc.com • www.aabc.com

## INSTRUMENT CALIBRATION REPORT

| INSTRUMENT | APPLICATION | SERIAL NO. | CALIBRATION TEST DATE |
|---|---|---|---|
| Cooper SH66A-E Temperature Meter; w/ Probes | Water / Temperature Meter | 061011054-SH66A-E | 6/5/2015 |
| Amprobe / Digital Psychrometer | Dry Bulb / Wet Bulb & Relative Humidity Dew Point | 100202417 | 6/5/2015 |
| Dwyer Digital Water Meter | Water | N/A | 3/12/2015 |
| Digital Thermometer | Temperature | N/A | 3/11/2015 |
| PLT-200 Laser Tachometer | RPM | 1847198 | 6/4/2015 |
| Amprobe AC75B | Volts-Amps | 09070083 | 6/5/2015 |
| Fluke 30 V/A/O | Volts-Amps-Ohms | N/A | 3/26/2015 |
| ADM-860C Airdata Multimeter | Air Volume | M09665 | 2/4/2015 |
| ADM-870C Airdata Multimeter | Air Volume | M10529 | 1/19/2015 |
| Shortridge HDM-250 Hydrodata Multimeter | Hydronics | W13014 | 1/26/2015 |
| Shortridge HDM-250 Hydrodata Multimeter | Hydronics | W13043 | 2/25/2015 |
| Digital Sound Level Meter | Sound Volume | M:407768 S/N:H175576 | 2/1/2015 |
| Rotating Vane Anemometer RVA801 | Air Volume | A01624 | 1/7/2015 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## ABBREVIATIONS

| | |
|---|---|
| # | Number |
| % | Percentage |
| Δ | Delta or Difference |
| ˚F | Degrees Fahrenheit |
| APD | Air Pressure Drop |
| BHP | Brake Horsepower |
| CFH | Cubic Feet per Hour |
| CFM | Cubic Feet per Minute |
| Cv | Coefficient of Velocity |
| DB | Dry Bulb |
| DIA | Diameter |
| DIFF | Differential |
| EFF | Efficiency |
| ENT | Entering |
| FL | Full Load |
| FPM | Feet per Minute |
| FT | Feet |
| GPM | Gallons per Minute |
| HP | Horsepower |
| HZ | Hertz |
| IMP | Impeller |
| IN | Inches |
| KW | Kilowatts |
| LVG | Leaving |
| MANUF | Manufacturer |
| MAX | Maximum |
| MIN | Minimum |
| N/A | Not Applicable |
| NA | Not Accessible |
| NPSH | Net Positive Suction Head |
| O/A / OSA | Outside Air |
| P | Pressure |
| PF | Power Factor |
| PSI | Pounds per Square Inch |
| QTY | Quantity |
| R.L.A. | Running Load Amps |
| REQ | Required |
| RPM | Revolutions Per Minute |
| SEC | Section |
| SF | Service Factor |
| SQFT | Square Feet |
| SZ | Size |
| TEMP | Temperature |
| W.G. / WG | Water Gauge |
| WB | Wet Bulb |
| WC | Water Column |

## PROJECT SUMMARY

**JOB NAME:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

THE DATA PRESENTED IN THIS REPORT IS A RECORD OF SYSTEM MEASUREMENTS AND FINAL ADJUSTMENTS THAT HAVE BEEN OBTAINED IN ACCORDANCE WITH THE CURRENT EDITION OF AABC'S **NATIONAL STANDARDS FOR TOTAL SYSTEM BALANCE.** ANY VARIANCES FROM DESIGN QUANTITIES, WHICH EXCEED AABC'S TOLERANCES, ARE NOTED ON THIS PROJECT SUMMARY.

AHUs: ALL RETURN AIR DAMPERS ARE LOCKED 10% OPEN AND THE OSA DAMPER IN THE UNIT ONLY HAS A TWO POSITION ACTUATOR. THERE ARE NO MANUAL DAMPERS IN THE OSA INTAKE.

PUMP TESTING WAS DONE WITH CONTROLS CONTRACTOR PRESENT. THE SYSTEM HAD TO BE MANIPULATED TO OBTAIN FLOW INFORMATION. THERE WAS NO MEANS OF OVERRIDING THE CHILLERS / PUMPS TO OBTAIN DESIGN FLOW FOR MORE THAN A FEW MINUTES. CHILLED WATER AND HEATING WATER VALVES WERE OPENED 100% DURING TESTING. THE CHILLER WAS ON AND OPERATIONAL, CONTROLLING TO A PSI DELTA P DETERMINED BY THE MANUFACTURER. CHILLER MODULES COULD NOT BE MANUALLY OVERRIDDEN.

CHILLERS AND DC START UP SHEETS ARE INCLUDED IN THE REPORT.

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-1A

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | FIRST FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | XTI-069X105 |
| SERIAL NUMBER | CMSMXT0136 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 19963 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 15700 | 18016 |
| OSA CFM | 4300 | 1947 |
| TOTAL STATIC PRESSURE | 4.50 | 3.35 |
| EXTERNAL STATIC P | 3.00 | 1.97 |
| EYE OF FAN | - | -1.70 |
| SUCTION PRESSURE | - | -0.32 |
| DISCHARGE PRESSURE | - | 1.65 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 458 / 458 / 458 |
| AMPS | 31.00 | 25.0 / 25.0 / 25.0 |
| MOTOR RPM | 1760 | 1763 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2B5V64 x 1 7/8 | |
| FAN SHEAVE SZ / BORE | 2B5V70 x 2 | |
| # BELTS / SIZE | 2 x 5VX560 | |
| FAN RPM | - | 1601 |
| CENTER DISTANCE | 17 1/2 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 73.00 | 61.00 |
| COOL LVG TEMP DB/WB | - | - | 56.00 | 53.70 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 51.60 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.10.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-1A SUPPLY
**DUCT SIZE:** 65 x 18 OVAL
**DUCT AREA:** 7.64

**DESIGN FPM:** 2618
**DESIGN CFM:** 20000
**ACTUAL CFM:** 19963

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3370 | 3061 | 2299 | 2113 | 2076 | 2315 | 2620 | 2473 | 2773 | | | |
| 3268 | 3040 | 2732 | 2178 | 1751 | 1804 | 2212 | 2369 | 2604 | | | |
| 3073 | 3029 | 2801 | 2634 | 1992 | 1727 | 1941 | 2240 | 2732 | | | |
| 3087 | 3048 | 2754 | 2693 | 2842 | 2871 | 2935 | 3237 | 3370 | | | |
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**ACTUAL FPM:** 2613

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** - @ 19963 CFM

**REMARKS:** COMP TOTALS: 17972.

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-1A RETURN
**DUCT SIZE:** 58 x 34
**DUCT AREA:** 13.69

**DESIGN FPM:** 1147
**DESIGN CFM:** 15700
**ACTUAL CFM:** 18016

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1482 | 1504 | 1177 | 1453 | 1310 | | | | | | | |
| 1196 | 1159 | 1161 | 1398 | 1262 | | | | | | | |
| 1303 | 1281 | 1328 | 1430 | 1300 | | | | | | | |
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**ACTUAL FPM:** 1316

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.32 @ 18016 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-1B

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | FIRST FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | XTI-069X105 |
| SERIAL NUMBER | CMSMXT0137 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 19575 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 16900 | 17537 |
| OSA CFM | 3100 | 2038 |
| TOTAL STATIC PRESSURE | 4.50 | 3.22 |
| EXTERNAL STATIC P | 3.00 | 1.83 |
| EYE OF FAN | - | -1.77 |
| SUCTION PRESSURE | - | -0.38 |
| DISCHARGE PRESSURE | - | 1.45 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 456 / 456 / 456 |
| AMPS | 31.00 | 24.7 / 24.7 / 24.7 |
| MOTOR RPM | 1760 | 1744 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2B5V64 x 1 7/8 | |
| FAN SHEAVE SZ / BORE | 2B5V70 x 2 | |
| # BELTS / SIZE | 2 x 5VX560 | |
| FAN RPM | - | 1594 |
| CENTER DISTANCE | 17 1/2 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 74.00 | 62.00 |
| COOL LVG TEMP DB/WB | - | - | 57.00 | 54.40 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 52.00 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.25.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-1B SUPPLY
**DUCT SIZE:** 64 x 18 OVAL
**DUCT AREA:** 7.52

**DESIGN FPM:** 2660
**DESIGN CFM:** 20000
**ACTUAL CFM:** 19575

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2814 | 2384 | 2252 | 2273 | 2831 | 2631 | 2646 | | | | | |
| 2228 | 3167 | 2982 | 2934 | 2340 | 3140 | 3171 | | | | | |
| 2859 | 2654 | 3121 | 2998 | 2610 | 2115 | 2842 | | | | | |
| 2630 | 2262 | 1909 | 2756 | 2419 | 1881 | 2022 | | | | | |
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**ACTUAL FPM:** 2603

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** 1.45 @ 19575 CFM

**REMARKS:** COMP TOTALS: 18829.

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-1B RETURN
**DUCT SIZE:** 58 x 34
**DUCT AREA:** 13.69

**DESIGN FPM:** 1234
**DESIGN CFM:** 16900
**ACTUAL CFM:** 17537

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1319 | 1336 | 1343 | 1168 | 1345 | | | | | | | |
| 1291 | 1271 | 1317 | 1380 | 1147 | | | | | | | |
| 1276 | 1328 | 1224 | 1217 | 1260 | | | | | | | |
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**ACTUAL FPM:** 1281

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.38 @ 17537 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB

**TEST DATE:** 7/1/2015 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-101

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 132 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010706 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3369 | |
| APD | 0.99 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1880 | 1840 |
| PRIMARY COOL MIN CFM | 625 | 640 |
| PRIMARY HEAT MIN CFM | 625 | 640 |
| PRIMARY HEAT MAX CFM | 940 | 960 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 940 | 960 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.30 |
| LVG WATER TEMP ˚F | 91.21 | 82.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.61 | 87.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 132 | 1 | CD | 12 | 1.00 | 470 | 411 | 411 | 87% | 447 | 447 | 95% |
| 132 | 2 | CD | 12 | 1.00 | 470 | 779 | 779 | 166% | 460 | 460 | 98% |
| 132 | 3 | CD | 12 | 1.00 | 470 | 58 | 58 | 12% | 456 | 456 | 97% |
| 132 | 4 | CD | 12 | 1.00 | 470 | 576 | 576 | 123% | 477 | 477 | 101% |
| TOTALS | | | | | 1880 | | 1824 | 97% | | 1840 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-102

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 132, 144 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010767 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2422 | |
| APD | 0.80 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2045 | 2015 |
| PRIMARY COOL MIN CFM | 685 | 710 |
| PRIMARY HEAT MIN CFM | 685 | 710 |
| PRIMARY HEAT MAX CFM | 1055 | 1107 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1055 | 1107 |
| GPM | 3.50 | 3.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.00 | 86.50 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.79 | 80.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 132 | 1 | CD | 12 | 1.00 | 470 | 464 | 464 | 99% | 446 | 446 | 95% |
| 132 | 2 | CD | 12 | 1.00 | 470 | 242 | 242 | 51% | 438 | 438 | 93% |
| 132 | 3 | CD | 12 | 1.00 | 470 | 457 | 457 | 97% | 475 | 475 | 101% |
| 132 | 4 | CD | 12 | 1.00 | 470 | 384 | 384 | 82% | 483 | 483 | 103% |
| 144 | 5 | CD | 8 | 1.00 | 165 | 94 | 94 | 57% | 173 | 173 | 105% |
| TOTALS | | | | | 2045 | | 1641 | 80% | | 2015 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-103

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010764 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3876 | |
| APD | 0.78 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1880 | 1886 |
| PRIMARY COOL MIN CFM | 625 | 638 |
| PRIMARY HEAT MIN CFM | 625 | 638 |
| PRIMARY HEAT MAX CFM | 940 | 964 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 940 | 964 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.21 | 80.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.61 | 89.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 12 | 1.00 | 470 | 492 | 492 | 105% | 448 | 448 | 95% |
| 159 | 2 | CD | 12 | 1.00 | 470 | 550 | 550 | 117% | 484 | 484 | 103% |
| 159 | 3 | CD | 12 | 1.00 | 470 | 563 | 563 | 120% | 493 | 493 | 105% |
| 159 | 4 | CD | 12 | 1.00 | 470 | 520 | 520 | 111% | 461 | 461 | 98% |
| TOTALS | | | | | 1880 | | 2125 | 113% | | 1886 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-104

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010762 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3854 | |
| APD | 0.87 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2225 | 2206 |
| PRIMARY COOL MIN CFM | 745 | 763 |
| PRIMARY HEAT MIN CFM | 745 | 763 |
| PRIMARY HEAT MAX CFM | 1105 | 1138 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1105 | 1138 |
| GPM | 3.50 | 3.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.58 | 83.93 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 87.32 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 12 | 1.00 | 445 | 470 | 470 | 106% | 467 | 467 | 105% |
| 159 | 2 | CD | 12 | 1.00 | 445 | 465 | 465 | 104% | 445 | 445 | 100% |
| 159 | 3 | CD | 12 | 1.00 | 445 | 362 | 362 | 81% | 424 | 424 | 95% |
| 159 | 4 | CD | 12 | 1.00 | 445 | 469 | 469 | 105% | 438 | 438 | 98% |
| 159 | 5 | CD | 12 | 1.00 | 445 | 451 | 451 | 101% | 432 | 432 | 97% |
| TOTALS | | | | | 2225 | | 2217 | 100% | | 2206 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-105

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010775 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1419 | |
| APD | 0.93 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 680 | 679 |
| PRIMARY COOL MIN CFM | 230 | 241 |
| PRIMARY HEAT MIN CFM | 230 | 241 |
| PRIMARY HEAT MAX CFM | 320 | 336 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 320 | 336 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.39 | 83.95 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 87.64 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 8 | 1.00 | 170 | 239 | 239 | 141% | 172 | 172 | 101% |
| 159 | 2 | CD | 8 | 1.00 | 170 | 251 | 251 | 148% | 178 | 178 | 105% |
| 159 | 3 | CD | 8 | 1.00 | 170 | 223 | 223 | 131% | 162 | 162 | 95% |
| 159 | 4 | CD | 8 | 1.00 | 170 | 233 | 233 | 137% | 167 | 167 | 98% |
| TOTALS | | | | | 680 | | 946 | 139% | | 679 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-106

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 131-135 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010780 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2695 | |
| APD | 1.19 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1130 | 1120 |
| PRIMARY COOL MIN CFM | 377 | 385 |
| PRIMARY HEAT MIN CFM | 377 | 385 |
| PRIMARY HEAT MAX CFM | 560 | 569 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 560 | 569 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.54 | 85.94 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 97.09 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 133 | 1 | CD | 6 | 1.00 | 90 | 78 | 78 | 87% | 94 | 94 | 104% |
| 132 | 2 | CD | 8 | 1.00 | 190 | 201 | 201 | 106% | 181 | 181 | 95% |
| 132 | 3 | CD | 8 | 1.00 | 190 | 210 | 210 | 111% | 185 | 185 | 97% |
| 131 | 4 | CD | 8 | 1.00 | 120 | 105 | 105 | 88% | 121 | 121 | 101% |
| 134 | 5 | CD | 6 | 1.00 | 70 | 86 | 86 | 123% | 73 | 73 | 104% |
| 135 | 6 | CD | 6 | 1.00 | 90 | 53 | 53 | 59% | 86 | 86 | 96% |
| 132 | 7 | CD | 8 | 1.00 | 190 | 230 | 230 | 121% | 198 | 198 | 104% |
| 132 | 8 | CD | 8 | 1.00 | 190 | 151 | 151 | 79% | 182 | 182 | 96% |
| TOTALS | | | | | 1130 | | 1114 | 99% | | 1120 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-107

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 132, 136-143 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010781 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 2143 | |
| APD | 1.10 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 840 | 848 |
| PRIMARY COOL MIN CFM | 335 | 346 |
| PRIMARY HEAT MIN CFM | 335 | 346 |
| PRIMARY HEAT MAX CFM | 425 | 439 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 425 | 439 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 94.79 | 88.87 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 97.35 | 87.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 142 | 1 | CD | 6 | 1.00 | 95 | 95 | 95 | 100% | 97 | 97 | 102% |
| 141 | 2 | CD | 6 | 1.00 | 85 | 89 | 89 | 105% | 89 | 89 | 105% |
| 132 | 3 | CD | 6 | 1.00 | 80 | 74 | 74 | 93% | 77 | 77 | 96% |
| 143 | 4 | CD | 6 | 1.00 | 60 | 73 | 73 | 122% | 57 | 57 | 95% |
| 140 | 5 | CD | 6 | 1.00 | 65 | 104 | 104 | 160% | 67 | 67 | 103% |
| 139 | 6 | CD | 6 | 1.00 | 55 | 85 | 85 | 155% | 60 | 60 | 109% |
| 132 | 7 | CD | 6 | 1.00 | 80 | 83 | 83 | 104% | 80 | 80 | 100% |
| 137 | 8 | CD | 6 | 1.00 | 65 | 93 | 93 | 143% | 64 | 64 | 98% |
| 132 | 9 | CD | 6 | 1.00 | 80 | 61 | 61 | 76% | 76 | 76 | 95% |
| 138 | 10 | CD | 6 | 1.00 | 110 | 109 | 109 | 99% | 115 | 115 | 105% |
| 136 | 11 | CD | 6 | 1.00 | 65 | 64 | 64 | 98% | 66 | 66 | 102% |
| TOTALS | | | | | 840 | | 930 | 111% | | 848 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-109

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 153 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010763 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3653 | |
| APD | 1.21 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2420 | 2344 |
| PRIMARY COOL MIN CFM | 810 | 826 |
| PRIMARY HEAT MIN CFM | 810 | 826 |
| PRIMARY HEAT MAX CFM | 1210 | 1235 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1210 | 1235 |
| GPM | 5.00 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 95.33 | 89.52 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.08 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 153 | 1 | CD | 12 | 1.00 | 360 | 359 | 359 | 100% | 343 | 343 | 95% |
| 153 | 2 | CD | 10 | 1.00 | 260 | 288 | 288 | 111% | 263 | 263 | 101% |
| 153 | 3 | CD | 12 | 1.00 | 360 | 322 | 322 | 89% | 345 | 345 | 96% |
| 153 | 4 | CD | 12 | 1.00 | 360 | 309 | 309 | 86% | 342 | 342 | 95% |
| 153 | 5 | CD | 12 | 1.00 | 360 | 353 | 353 | 98% | 349 | 349 | 97% |
| 153 | 6 | CD | 12 | 1.00 | 360 | 303 | 303 | 84% | 342 | 342 | 95% |
| 153 | 7 | CD | 12 | 1.00 | 360 | 364 | 364 | 101% | 360 | 360 | 100% |
| TOTALS | | | | | 2420 | | 2298 | 95% | | 2344 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-110

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 123, 152-153 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010777 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2741 | |
| APD | 0.88 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1280 | 1270 |
| PRIMARY COOL MIN CFM | 427 | 440 |
| PRIMARY HEAT MIN CFM | 427 | 440 |
| PRIMARY HEAT MAX CFM | 800 | 839 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 800 | 839 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.91 | 83.85 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 95.19 | 88.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 123 | 1 | CD | 6 | 1.00 | 100 | 148 | 148 | 148% | 101 | 101 | 101% |
| 152 | 2 | CD | 6 | 1.00 | 100 | 114 | 114 | 114% | 95 | 95 | 95% |
| 153 | 3 | CD | 12 | 1.00 | 360 | 384 | 384 | 107% | 378 | 378 | 105% |
| 153 | 4 | CD | 12 | 1.00 | 360 | 347 | 347 | 96% | 354 | 354 | 98% |
| 153 | 5 | CD | 12 | 1.00 | 360 | 303 | 303 | 84% | 342 | 342 | 95% |
| TOTALS | | | | | 1280 | | 1296 | 101% | | 1270 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-111

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010773 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1340 | |
| APD | 0.81 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 655 | 646 |
| PRIMARY COOL MIN CFM | 218 | 221 |
| PRIMARY HEAT MIN CFM | 218 | 221 |
| PRIMARY HEAT MAX CFM | 330 | 344 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 330 | 344 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.12 | 82.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 86.99 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 8 | 1.00 | 190 | 179 | 179 | 94% | 185 | 185 | 97% |
| 159 | 2 | CD | 8 | 1.00 | 190 | 203 | 203 | 107% | 198 | 198 | 104% |
| 159 | 3 | CD | 6 | 1.00 | 85 | 74 | 74 | 87% | 81 | 81 | 95% |
| 159 | 4 | CD | 8 | 1.00 | 190 | 172 | 172 | 91% | 182 | 182 | 96% |
| TOTALS | | | | | 655 | | 628 | 96% | | 646 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-112

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010776 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1454 | |
| APD | 0.90 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 720 | 716 |
| PRIMARY COOL MIN CFM | 240 | 236 |
| PRIMARY HEAT MIN CFM | 240 | 236 |
| PRIMARY HEAT MAX CFM | 360 | 358 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 360 | 358 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 95.18 | 88.50 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.64 | 84.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 8 | 1.00 | 170 | 184 | 184 | 108% | 171 | 171 | 101% |
| 159 | 2 | CD | 8 | 1.00 | 170 | 187 | 187 | 110% | 176 | 176 | 104% |
| 159 | 3 | CD | 8 | 1.00 | 190 | 196 | 196 | 103% | 188 | 188 | 99% |
| 159 | 4 | CD | 8 | 1.00 | 190 | 182 | 182 | 96% | 181 | 181 | 95% |
| TOTALS | | | | | 720 | | 749 | 104% | | 716 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-113

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010772 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1 | |
| APD | | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 720 | 740 |
| PRIMARY COOL MIN CFM | 240 | 252 |
| PRIMARY HEAT MIN CFM | 240 | 252 |
| PRIMARY HEAT MAX CFM | 360 | 373 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 360 | 373 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 95.18 | 87.81 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.64 | 85.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 159 | 1 | CD | 8 | 1.00 | 190 | 182 | 182 | 96% | 188 | 188 | 99% |
| 159 | 2 | CD | 8 | 1.00 | 170 | 204 | 204 | 120% | 175 | 175 | 103% |
| 159 | 3 | CD | 8 | 1.00 | 190 | 204 | 204 | 107% | 199 | 199 | 105% |
| 159 | 4 | CD | 8 | 1.00 | 170 | 181 | 181 | 106% | 178 | 178 | 105% |
| TOTALS | | | | | 720 | | 771 | 107% | | 740 | 103% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-114

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159, 161-165 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010792 | |
| TYPE / SIZE | VAV | 8 |
| ADDRESS | - | |
| K-FACTOR | 818 | |
| APD | 0.90 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 555 | 550 |
| PRIMARY COOL MIN CFM | 185 | 180 |
| PRIMARY HEAT MIN CFM | 185 | 180 |
| PRIMARY HEAT MAX CFM | 280 | 278 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 280 | 278 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 99.83 | 92.19 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.04 | 85.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 161 | 1 | CD | 6 | 1.00 | 80 | 77 | 77 | 96% | 78 | 78 | 98% |
| 162 | 2 | CD | 6 | 1.00 | 95 | 82 | 82 | 86% | 91 | 91 | 96% |
| 159 | 3 | CD | 8 | 1.00 | 160 | 164 | 164 | 103% | 165 | 165 | 103% |
| 163 | 4 | CD | 6 | 1.00 | 80 | 72 | 72 | 90% | 76 | 76 | 95% |
| 164 | 5 | CD | 6 | 1.00 | 70 | 85 | 85 | 121% | 69 | 69 | 99% |
| 165 | 6 | CD | 6 | 1.00 | 70 | 70 | 70 | 100% | 71 | 71 | 101% |
| TOTALS | | | | | 555 | | 550 | 99% | | 550 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-115

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 159, 166, 168 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010793 | |
| TYPE / SIZE | VAV | 6 |
| ADDRESS | - | |
| K-FACTOR | 465 | |
| APD | 0.86 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 200 | 201 |
| PRIMARY COOL MIN CFM | 67 | 70 |
| PRIMARY HEAT MIN CFM | 67 | 70 |
| PRIMARY HEAT MAX CFM | 100 | 104 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 100 | 104 |
| GPM | 0.50 | 0.55 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 95.01 | 89.80 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 99.56 | 86.80 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 166 | 1 | CD | 6 | 1.00 | 70 | 76 | 76 | 109% | 73 | 73 | 104% |
| 168 | 2 | CD | 6 | 1.00 | 40 | 69 | 69 | 173% | 42 | 42 | 105% |
| 159 | 3 | CD | 6 | 1.00 | 90 | 91 | 91 | 101% | 86 | 86 | 96% |
| TOTALS | | | | | 200 | | 236 | 118% | | 201 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-116

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 171 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010782 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1780 | |
| APD | 1.26 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 780 | 790 |
| PRIMARY COOL MIN CFM | 267 | 273 |
| PRIMARY HEAT MIN CFM | 267 | 273 |
| PRIMARY HEAT MAX CFM | 390 | 391 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 390 | 391 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.85 | 85.80 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 94.59 | 87.10 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 171 | 1 | CD | 8 | 1.00 | 195 | 180 | 180 | 92% | 196 | 196 | 101% |
| 171 | 2 | CD | 8 | 1.00 | 195 | 185 | 185 | 95% | 204 | 204 | 105% |
| 171 | 3 | CD | 8 | 1.00 | 195 | 191 | 191 | 98% | 197 | 197 | 101% |
| 171 | 4 | CD | 8 | 1.00 | 195 | 193 | 193 | 99% | 193 | 193 | 99% |
| TOTALS | | | | | 780 | | 749 | 96% | | 790 | 101% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/15/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-117

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 177 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010790 | |
| TYPE / SIZE | VAV | 19 |
| ADDRESS | - | |
| K-FACTOR | 6452 | |
| APD | 1.08 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2820 | 2816 |
| PRIMARY COOL MIN CFM | 940 | 953 |
| PRIMARY HEAT MIN CFM | 940 | 953 |
| PRIMARY HEAT MAX CFM | 1410 | 1440 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1410 | 1440 |
| GPM | 4.50 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.50 | 86.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 89.65 | 80.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 177 | 1 | CD | 12 | 1.00 | 470 | 402 | 402 | 86% | 460 | 460 | 98% |
| 177 | 2 | CD | 12 | 1.00 | 470 | 416 | 416 | 89% | 480 | 480 | 102% |
| 177 | 3 | CD | 12 | 1.00 | 470 | 367 | 368 | 78% | 490 | 490 | 104% |
| 177 | 4 | CD | 12 | 1.00 | 470 | 338 | 338 | 72% | 468 | 468 | 100% |
| 177 | 5 | CD | 12 | 1.00 | 470 | 391 | 391 | 83% | 471 | 471 | 100% |
| 177 | 6 | CD | 12 | 1.00 | 470 | 299 | 299 | 64% | 447 | 447 | 95% |
| TOTALS | | | | | 2820 | | 2214 | 79% | | 2816 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-119

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 114, 116 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM0010768 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1272 | |
| APD | 1.21 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 600 | 590 |
| PRIMARY COOL MIN CFM | 200 | 204 |
| PRIMARY HEAT MIN CFM | 200 | 204 |
| PRIMARY HEAT MAX CFM | 300 | 301 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 300 | 301 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 98.99 | 90.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 90.49 | 87.50 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 114 | 1 | CD | 8 | 1.00 | 140 | 132 | 132 | 94% | 133 | 133 | 95% |
| 114 | 2 | CD | 8 | 1.00 | 140 | 119 | 119 | 85% | 141 | 141 | 101% |
| 116 | 3 | CD | 6 | 1.00 | 40 | 66 | 66 | 165% | 38 | 38 | 95% |
| 114 | 4 | CD | 8 | 1.00 | 140 | 108 | 108 | 77% | 135 | 135 | 96% |
| 114 | 5 | CD | 8 | 1.00 | 140 | 123 | 123 | 88% | 143 | 143 | 102% |
| TOTALS | | | | | 600 | | 548 | 91% | | 590 | 98% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/15/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-120

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103, 105-107 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010791 | |
| TYPE / SIZE | VAV | 8 |
| ADDRESS | - | |
| K-FACTOR | 781 | |
| APD | 1.30 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 395 | 387 |
| PRIMARY COOL MIN CFM | 135 | 138 |
| PRIMARY HEAT MIN CFM | 135 | 138 |
| PRIMARY HEAT MAX CFM | 205 | 203 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 205 | 203 |
| GPM | 0.75 | 0.75 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.44 | 88.98 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 89.96 | 80.40 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 105 | 1 | CD | 6 | 1.00 | 80 | 73 | 73 | 91% | 76 | 76 | 95% |
| 106 | 2 | CD | 6 | 1.00 | 70 | 75 | 75 | 107% | 73 | 73 | 104% |
| 107 | 3 | CD | 6 | 1.00 | 70 | 67 | 67 | 96% | 71 | 71 | 101% |
| 103 | 4 | CD | 8 | 1.00 | 175 | 161 | 161 | 92% | 167 | 167 | 95% |
| TOTALS | | | | | 395 | | 376 | 95% | | 387 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-121

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010765 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2956 | |
| APD | 0.85 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2560 | 2581 |
| PRIMARY COOL MIN CFM | 853 | 890 |
| PRIMARY HEAT MIN CFM | 853 | 890 |
| PRIMARY HEAT MAX CFM | 1280 | 1342 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1280 | 1342 |
| GPM | 4.50 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.47 | 84.38 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.51 | 85.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 12 | 1.00 | 480 | 215 | 215 | 45% | 490 | 490 | 102% |
| 103 | 2 | CD | 12 | 1.00 | 480 | 480 | 480 | 100% | 486 | 486 | 101% |
| 103 | 3 | CD | 12 | 1.00 | 480 | 419 | 419 | 87% | 501 | 501 | 104% |
| 103 | 4 | CD | 12 | 1.00 | 480 | 319 | 319 | 66% | 461 | 461 | 96% |
| 103 | 5 | CD | 10 | 1.00 | 320 | 352 | 352 | 110% | 335 | 335 | 105% |
| 103 | 6 | CD | 10 | 1.00 | 320 | 409 | 409 | 128% | 308 | 308 | 96% |
| TOTALS | | | | | 2560 | | 2194 | 86% | | 2581 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-122

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010779 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2483 | |
| APD | 0.37 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 950 | 971 |
| PRIMARY COOL MIN CFM | 367 | 350 |
| PRIMARY HEAT MIN CFM | 367 | 350 |
| PRIMARY HEAT MAX CFM | 525 | 504 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 525 | 504 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 87.17 | 83.84 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 96.30 | 87.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 8 | 1.00 | 190 | 186 | 186 | 98% | 198 | 198 | 104% |
| 103 | 2 | CD | 8 | 1.00 | 190 | 246 | 246 | 129% | 195 | 195 | 103% |
| 103 | 3 | CD | 8 | 1.00 | 190 | 257 | 257 | 135% | 199 | 199 | 105% |
| 103 | 4 | CD | 8 | 1.00 | 190 | 61 | 61 | 32% | 198 | 198 | 104% |
| 103 | 5 | CD | 8 | 1.00 | 190 | 263 | 263 | 138% | 181 | 181 | 95% |
| TOTALS | | | | | 950 | | 1013 | 107% | | 971 | 102% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-123

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010770 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1418 | |
| APD | 1.01 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 640 | 646 |
| PRIMARY COOL MIN CFM | 250 | 241 |
| PRIMARY HEAT MIN CFM | 250 | 241 |
| PRIMARY HEAT MAX CFM | 320 | 312 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 320 | 312 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.39 | 85.46 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 87.84 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 103 | 1 | CD | 8 | 1.00 | 160 | 220 | 220 | 138% | 163 | 163 | 102% |
| 103 | 2 | CD | 8 | 1.00 | 160 | 148 | 148 | 93% | 153 | 153 | 96% |
| 103 | 3 | CD | 8 | 1.00 | 160 | 39 | 39 | 24% | 162 | 162 | 101% |
| 103 | 4 | CD | 8 | 1.00 | 160 | 68 | 68 | 43% | 168 | 168 | 105% |
| TOTALS | | | | | 640 | | 475 | 74% | | 646 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/12/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-124

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 102-103, 108-109 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010771 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1635 | |
| APD | 0.98 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 455 | 438 |
| PRIMARY COOL MIN CFM | 165 | 172 |
| PRIMARY HEAT MIN CFM | 165 | 172 |
| PRIMARY HEAT MAX CFM | 230 | 241 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 230 | 241 |
| GPM | 0.75 | 0.75 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.04 | 83.48 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 92.59 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 6 | 1.00 | 70 | 94 | 94 | 134% | 69 | 69 | 99% |
| 108 | 2 | CD | 6 | 1.00 | 70 | 95 | 95 | 136% | 69 | 69 | 99% |
| 109 | 3 | CD | 6 | 1.00 | 95 | 91 | 91 | 96% | 91 | 91 | 96% |
| 103 | 4 | CD | 8 | 1.00 | 145 | 154 | 154 | 106% | 138 | 138 | 95% |
| 102 | 5 | CD | 6 | 1.00 | 75 | 84 | 84 | 112% | 71 | 71 | 95% |
| TOTALS | | | | | 455 | | 518 | 114% | | 438 | 96% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-125

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 101, 103-104 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010786 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1992 | |
| APD | 1.81 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 825 | 856 |
| PRIMARY COOL MIN CFM | 335 | 346 |
| PRIMARY HEAT MIN CFM | 335 | 346 |
| PRIMARY HEAT MAX CFM | 415 | 434 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 415 | 434 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 95.05 | 87.79 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 97.84 | 89.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 10 | 1.00 | 295 | 316 | 316 | 107% | 309 | 309 | 105% |
| 101 | 2 | CD | 6 | 1.00 | 80 | 82 | 82 | 103% | 84 | 84 | 105% |
| 103 | 3 | CD | 6 | 1.00 | 100 | 88 | 88 | 88% | 99 | 99 | 99% |
| 104 | 4 | CD | 6 | 1.00 | 80 | 113 | 113 | 141% | 81 | 81 | 101% |
| 103 | 5 | CD | 8 | 1.00 | 130 | 84 | 84 | 65% | 136 | 136 | 105% |
| 103 | 6 | CD | 8 | 1.00 | 140 | 142 | 142 | 101% | 147 | 147 | 105% |
| TOTALS | | | | | 825 | | 825 | 100% | | 856 | 104% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-126

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 100, 176-177, 181-186 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010778 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 3055 | |
| APD | 1.81 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1485 | 1466 |
| PRIMARY COOL MIN CFM | 477 | 493 |
| PRIMARY HEAT MIN CFM | 477 | 493 |
| PRIMARY HEAT MAX CFM | 715 | 748 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 715 | 748 |
| GPM | 2.25 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 87.41 | 83.45 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 93.59 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 100 | 1 | LD | 6 | 1.00 | 100 | 137 | 137 | 137% | 95 | 95 | 95% |
| 186 | 2 | CD | 6 | 1.00 | 95 | 88 | 88 | 93% | 91 | 91 | 96% |
| 177 | 3 | CD | 8 | 1.00 | 170 | 178 | 178 | 105% | 175 | 175 | 103% |
| 176 | 4 | CD | 6 | 1.00 | 55 | 79 | 79 | 144% | 57 | 57 | 104% |
| 185 | 5 | CD | 6 | 1.00 | 95 | 86 | 86 | 91% | 91 | 91 | 96% |
| 177 | 6 | CD | 8 | 1.00 | 170 | 141 | 141 | 83% | 171 | 171 | 101% |
| 184 | 7 | CD | 6 | 1.00 | 70 | 73 | 73 | 104% | 73 | 73 | 104% |
| 183 | 8 | CD | 6 | 1.00 | 70 | 111 | 111 | 159% | 67 | 67 | 96% |
| 182 | 9 | CD | 6 | 1.00 | 70 | 76 | 76 | 109% | 73 | 73 | 104% |
| 177 | 10 | CD | 8 | 1.00 | 170 | 218 | 218 | 128% | 166 | 166 | 98% |
| 177 | 11 | CD | 8 | 1.00 | 170 | 164 | 164 | 96% | 164 | 164 | 96% |
| 177 | 12 | CD | 8 | 1.00 | 170 | 167 | 167 | 98% | 162 | 162 | 95% |
| 181 | 13 | CD | 6 | 1.00 | 80 | 76 | 76 | 95% | 81 | 81 | 101% |
| TOTALS | | | | | 1485 | | 1594 | 107% | | 1466 | 99% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-127

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 177 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010785 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 2104 | |
| APD | 1.34 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1020 | 1019 |
| PRIMARY COOL MIN CFM | 340 | 350 |
| PRIMARY HEAT MIN CFM | 340 | 350 |
| PRIMARY HEAT MAX CFM | 510 | 526 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 510 | 526 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.06 | 86.17 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.45 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 177 | 1 | CD | 8 | 1.00 | 170 | 170 | 170 | 100% | 163 | 163 | 96% |
| 177 | 2 | CD | 8 | 1.00 | 170 | 208 | 208 | 122% | 178 | 178 | 105% |
| 177 | 3 | CD | 8 | 1.00 | 170 | 173 | 173 | 102% | 165 | 165 | 97% |
| 177 | 4 | CD | 8 | 1.00 | 170 | 200 | 200 | 118% | 176 | 176 | 104% |
| 177 | 5 | CD | 8 | 1.00 | 170 | 198 | 198 | 116% | 175 | 175 | 103% |
| 177 | 6 | CD | 8 | 1.00 | 170 | 169 | 169 | 99% | 162 | 162 | 95% |
| TOTALS | | | | | 1020 | | 1118 | 110% | | 1019 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-128

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 167, 177-179 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010789 | |
| TYPE / SIZE | VAV | 19 |
| ADDRESS | - | |
| K-FACTOR | 6771 | |
| APD | 1.25 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2785 | 2695 |
| PRIMARY COOL MIN CFM | 928 | 969 |
| PRIMARY HEAT MIN CFM | 928 | 969 |
| PRIMARY HEAT MAX CFM | 1395 | 1461 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1395 | 1461 |
| GPM | 4.50 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.60 | 83.26 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 89.88 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 177 | 1 | CD | 12 | 1.00 | 500 | 390 | 390 | 78% | 476 | 476 | 95% |
| 177 | 2 | CD | 12 | 1.00 | 500 | 375 | 375 | 75% | 475 | 475 | 95% |
| 177 | 3 | CD | 12 | 1.00 | 500 | 412 | 412 | 82% | 481 | 481 | 96% |
| 177 | 4 | CD | 12 | 1.00 | 500 | 428 | 428 | 86% | 508 | 508 | 102% |
| 178 | 5 | CD | 6 | 1.00 | 90 | 99 | 99 | 110% | 86 | 86 | 96% |
| 167 | 6 | CD | 6 | 1.00 | 100 | 75 | 75 | 75% | 96 | 96 | 96% |
| 177 | 7 | CD | 12 | 1.00 | 500 | 475 | 475 | 95% | 476 | 476 | 95% |
| 179 | 8 | CD | 6 | 1.00 | 95 | 100 | 100 | 105% | 97 | 97 | 102% |
| TOTALS | | | | | 2785 | | 2354 | 85% | | 2695 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/14/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-129

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 100, 177 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010784 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1950 | |
| APD | 1.10 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 940 | 953 |
| PRIMARY COOL MIN CFM | 315 | 300 |
| PRIMARY HEAT MIN CFM | 315 | 300 |
| PRIMARY HEAT MAX CFM | 470 | 450 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 470 | 450 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.89 | 86.85 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 90.53 | 81.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 100 | 1 | LD | 10 | 1.00 | 260 | 228 | 228 | 88% | 247 | 247 | 95% |
| 177 | 2 | CD | 8 | 1.00 | 170 | 175 | 175 | 103% | 178 | 178 | 105% |
| 177 | 3 | CD | 8 | 1.00 | 170 | 203 | 203 | 119% | 175 | 175 | 103% |
| 177 | 4 | CD | 8 | 1.00 | 170 | 174 | 174 | 102% | 176 | 176 | 104% |
| 177 | 5 | CD | 8 | 1.00 | 170 | 175 | 175 | 103% | 177 | 177 | 104% |
| TOTALS | | | | | 940 | | 955 | 102% | | 953 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-130

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010774 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1045 | |
| APD | 1.32 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 680 | 666 |
| PRIMARY COOL MIN CFM | 230 | 241 |
| PRIMARY HEAT MIN CFM | 230 | 241 |
| PRIMARY HEAT MAX CFM | 340 | 357 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 340 | 357 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.88 | 83.41 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 86.37 | 81.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 8 | 1.00 | 170 | 215 | 215 | 126% | 168 | 168 | 99% |
| 103 | 2 | CD | 8 | 1.00 | 170 | 197 | 197 | 116% | 162 | 162 | 95% |
| 103 | 3 | CD | 8 | 1.00 | 170 | 233 | 233 | 137% | 169 | 169 | 99% |
| 103 | 4 | CD | 8 | 1.00 | 170 | 36 | 36 | 21% | 167 | 167 | 98% |
| TOTALS | | | | | 680 | | 681 | 100% | | 666 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-131

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103, 110 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010783 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1980 | |
| APD | 1.08 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 880 | 896 |
| PRIMARY COOL MIN CFM | 293 | 284 |
| PRIMARY HEAT MIN CFM | 293 | 284 |
| PRIMARY HEAT MAX CFM | 440 | 420 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 440 | 420 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.57 | 85.10 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 91.97 | 85.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 8 | 1.00 | 170 | 255 | 255 | 150% | 174 | 174 | 102% |
| 103 | 2 | CD | 8 | 1.00 | 170 | 33 | 33 | 19% | 178 | 178 | 105% |
| 103 | 3 | CD | 8 | 1.00 | 170 | 212 | 212 | 125% | 167 | 167 | 98% |
| 103 | 4 | CD | 8 | 1.00 | 170 | 222 | 222 | 131% | 173 | 173 | 102% |
| 110 | 5 | CD | 8 | 1.00 | 100 | 296 | 296 | 296% | 99 | 99 | 99% |
| 110 | 6 | CD | 8 | 1.00 | 100 | 336 | 336 | 336% | 105 | 105 | 105% |
| TOTALS | | | | | 880 | | 1354 | 154% | | 896 | 102% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-132

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010788 | |
| TYPE / SIZE | VAV | 19 |
| ADDRESS | - | |
| K-FACTOR | 6775 | |
| APD | 1.14 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2850 | 2778 |
| PRIMARY COOL MIN CFM | 950 | 986 |
| PRIMARY HEAT MIN CFM | 950 | 986 |
| PRIMARY HEAT MAX CFM | 1425 | 1493 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1425 | 1493 |
| GPM | 4.50 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.39 | 85.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 89.43 | 80.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 12 | 1.00 | 475 | 512 | 512 | 108% | 477 | 477 | 100% |
| 103 | 2 | CD | 12 | 1.00 | 475 | 66 | 66 | 14% | 486 | 486 | 102% |
| 103 | 3 | CD | 12 | 1.00 | 475 | 433 | 433 | 91% | 452 | 452 | 95% |
| 103 | 4 | CD | 12 | 1.00 | 475 | 415 | 415 | 87% | 454 | 454 | 96% |
| 103 | 5 | CD | 12 | 1.00 | 475 | 450 | 450 | 95% | 456 | 456 | 96% |
| 103 | 6 | CD | 12 | 1.00 | 475 | 428 | 428 | 90% | 453 | 453 | 95% |
| TOTALS | | | | | 2850 | | 2304 | 81% | | 2778 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-133

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 103 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010769 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1398 | |
| APD | 0.81 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 615 | 605 |
| PRIMARY COOL MIN CFM | 205 | 196 |
| PRIMARY HEAT MIN CFM | 205 | 196 |
| PRIMARY HEAT MAX CFM | 310 | 295 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 310 | 295 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.67 | 84.23 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.30 | 85.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 103 | 1 | CD | 8 | 1.00 | 205 | 195 | 195 | 95% | 200 | 200 | 98% |
| 103 | 2 | CD | 8 | 1.00 | 205 | 187 | 187 | 91% | 195 | 195 | 95% |
| 103 | 3 | CD | 8 | 1.00 | 205 | 225 | 225 | 110% | 210 | 210 | 102% |
| TOTALS | | | | | 615 | | 607 | 99% | | 605 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-134

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-1A / 1B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 177 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM00781 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1750 | |
| APD | 1.19 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 615 | 617 |
| PRIMARY COOL MIN CFM | 205 | 215 |
| PRIMARY HEAT MIN CFM | 205 | 215 |
| PRIMARY HEAT MAX CFM | 310 | 325 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 310 | 325 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.67 | 84.65 |
| ENT AIR TEMP ˚F | 54.00 | 53.00 |
| LVG AIR TEMP ˚F | 88.30 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 177 | 1 | CD | 8 | 1.00 | 205 | 258 | 258 | 126% | 215 | 215 | 105% |
| 177 | 2 | CD | 8 | 1.00 | 205 | 304 | 304 | 148% | 200 | 200 | 98% |
| 177 | 3 | CD | 8 | 1.00 | 205 | 234 | 234 | 114% | 202 | 202 | 99% |
| TOTALS | | | | | 615 | | 796 | 129% | | 617 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/13/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-2A

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | SECOND FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | XTI-069X105 |
| SERIAL NUMBER | CBVMXT0209 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 19085 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 15900 | 14516 |
| OSA CFM | 4100 | 4569 |
| TOTAL STATIC PRESSURE | 4.50 | 3.62 |
| EXTERNAL STATIC P | 3.00 | 2.15 |
| EYE OF FAN | - | -1.62 |
| SUCTION PRESSURE | - | -0.15 |
| DISCHARGE PRESSURE | - | 2.00 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 467 / 467 / 467 |
| AMPS | 31.00 | 26.0 / 26.0 / 26.0 |
| MOTOR RPM | 1760 | 1766 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2B5V86 x 1 7/8 | |
| FAN SHEAVE SZ / BORE | 2B5V94 x 2 | |
| # BELTS / SIZE | 2 x BX62 | |
| FAN RPM | - | 1620 |
| CENTER DISTANCE | 18 1/2 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 73.00 | 62.00 |
| COOL LVG TEMP DB/WB | - | - | 54.00 | 53.00 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 51.80 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.60.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-2A SUPPLY
**DUCT SIZE:** 65 x 18 OVAL
**DUCT AREA:** 7.64

**DESIGN FPM:** 2618
**DESIGN CFM:** 20000
**ACTUAL CFM:** 19085

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2723 | 2796 | 2713 | 2600 | 2564 | 2523 | 2414 | 2362 | 2462 | | | |
| 2794 | 2743 | 2685 | 2574 | 2495 | 2463 | 2290 | 2306 | 2252 | | | |
| 2657 | 2676 | 2683 | 2603 | 2527 | 2323 | 2267 | 2358 | 2397 | | | |
| 2472 | 2483 | 2407 | 2655 | 2348 | 2266 | 2219 | 2357 | 2453 | | | |
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**ACTUAL FPM:** 2498

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** 2.00 @ 19085 CFM

**REMARKS:** COMP TOTALS: 17843.

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-2A RETURN
**DUCT SIZE:** 78 x 26
**DUCT AREA:** 14.08

**DESIGN FPM:** 1129
**DESIGN CFM:** 15900
**ACTUAL CFM:** 14516

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 894 | 1018 | 1067 | 1002 | 1207 | 1082 | | | | | | |
| 1064 | 1013 | 1086 | 933 | 1013 | 997 | | | | | | |
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**ACTUAL FPM:** 1031

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.15 @ 14516 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-2B

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | SECOND FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | XTI-069X105 |
| SERIAL NUMBER | CBVMXT0210 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 19725 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 15800 | 15770 |
| OSA CFM | 4200 | 3955 |
| TOTAL STATIC PRESSURE | 4.50 | 4.33 |
| EXTERNAL STATIC P | 3.00 | 2.84 |
| EYE OF FAN | - | -1.68 |
| SUCTION PRESSURE | - | -0.19 |
| DISCHARGE PRESSURE | - | 2.65 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 462 / 462 / 462 |
| AMPS | 31.00 | 26.4 / 26.4 / 26.4 |
| MOTOR RPM | 1760 | 1765 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2B5V86 x 1 7/8 | |
| FAN SHEAVE SZ / BORE | 2B5V94 x 2 | |
| # BELTS / SIZE | 2 x BX62 | |
| FAN RPM | - | 1618 |
| CENTER DISTANCE | 18 1/2 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 73.00 | 62.00 |
| COOL LVG TEMP DB/WB | - | - | 55.00 | 53.90 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 50.90 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.50.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-2B SUPPLY
**DUCT SIZE:** 64 x 18 OVAL
**DUCT AREA:** 7.52

**DESIGN FPM:** 2660
**DESIGN CFM:** 20000
**ACTUAL CFM:** 19725

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2734 | 2762 | 2522 | 2704 | 2564 | 2635 | 2600 | 2670 | 2590 | | | |
| 2722 | 2663 | 2695 | 2653 | 2674 | 2655 | 2630 | 2769 | 2684 | | | |
| 2566 | 2433 | 2520 | 2625 | 2687 | 2656 | 2552 | 2724 | 2712 | | | |
| 2682 | 2459 | 2437 | 2528 | 2668 | 2599 | 2585 | 2500 | 2585 | | | |
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**ACTUAL FPM:** 2623

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** 2.65 @ 19725 CFM

**REMARKS:** COMP TOTALS: 18535.

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-2B RETURN
**DUCT SIZE:** 78 x 26
**DUCT AREA:** 14.08

**DESIGN FPM:** 1122
**DESIGN CFM:** 15800
**ACTUAL CFM:** 15770

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1285 | 1209 | 1130 | 1091 | 956 | 1102 | | | | | | |
| 1153 | 1272 | 985 | 1087 | 1109 | 1064 | | | | | | |
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**ACTUAL FPM:** 1120

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.19 @ 15770 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-201

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212, 216 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010808 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 1788 | |
| APD | 1.04 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1315 | 1276 |
| PRIMARY COOL MIN CFM | 438 | 449 |
| PRIMARY HEAT MIN CFM | 438 | 449 |
| PRIMARY HEAT MAX CFM | 660 | 691 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 660 | 691 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.43 | 81.79 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 93.47 | 85.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 10 | 1.00 | 250 | 164 | 164 | 66% | 244 | 244 | 98% |
| 212 | 2 | CD | 10 | 1.00 | 250 | 173 | 173 | 69% | 253 | 253 | 101% |
| 212 | 3 | CD | 10 | 1.00 | 250 | 229 | 229 | 92% | 240 | 240 | 96% |
| 216 | 4 | CD | 10 | 1.00 | 65 | 49 | 49 | 75% | 61 | 61 | 94% |
| 212 | 5 | CD | 10 | 1.00 | 250 | 95 | 95 | 38% | 237 | 237 | 95% |
| 212 | 6 | CD | 10 | 1.00 | 250 | 143 | 143 | 57% | 241 | 241 | 96% |
| TOTALS | | | | | 1315 | | 853 | 65% | | 1276 | 97% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/17/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-202

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 218 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010806 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1945 | |
| APD | 0.98 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1000 | 1013 |
| PRIMARY COOL MIN CFM | 333 | 337 |
| PRIMARY HEAT MIN CFM | 333 | 337 |
| PRIMARY HEAT MAX CFM | 500 | 516 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 500 | 516 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.27 | 79.66 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.19 | 86.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 218 | 1 | CD | 10 | 1.00 | 250 | 263 | 263 | 105% | 258 | 258 | 103% |
| 218 | 2 | CD | 10 | 1.00 | 250 | 237 | 237 | 95% | 241 | 241 | 96% |
| 218 | 3 | CD | 10 | 1.00 | 250 | 266 | 266 | 106% | 261 | 261 | 104% |
| 218 | 4 | CD | 10 | 1.00 | 250 | 258 | 258 | 103% | 253 | 253 | 101% |
| TOTALS | | | | | 1000 | | 1024 | 102% | | 1013 | 101% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/17/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-203

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010822 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2775 | |
| APD | 0.98 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1600 | 1608 |
| PRIMARY COOL MIN CFM | 533 | 556 |
| PRIMARY HEAT MIN CFM | 533 | 556 |
| PRIMARY HEAT MAX CFM | 800 | 821 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 800 | 821 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.71 | 84.35 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 88.61 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 400 | 314 | 314 | 79% | 414 | 414 | 104% |
| 229 | 2 | CD | 10 | 1.00 | 400 | 323 | 323 | 81% | 405 | 405 | 101% |
| 229 | 3 | CD | 10 | 1.00 | 400 | 339 | 339 | 85% | 384 | 384 | 96% |
| 229 | 4 | CD | 10 | 1.00 | 400 | 300 | 300 | 75% | 405 | 405 | 101% |
| TOTALS | | | | | 1600 | | 1276 | 80% | | 1608 | 101% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/15/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-204

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010815 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1665 | |
| APD | 1.35 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 870 |
| PRIMARY COOL MIN CFM | 290 | 285 |
| PRIMARY HEAT MIN CFM | 290 | 285 |
| PRIMARY HEAT MAX CFM | 435 | 433 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 433 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 85.29 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 85.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 290 | 257 | 257 | 89% | 289 | 289 | 100% |
| 229 | 2 | CD | 10 | 1.00 | 290 | 258 | 258 | 89% | 285 | 285 | 98% |
| 229 | 3 | CD | 10 | 1.00 | 290 | 252 | 252 | 87% | 296 | 296 | 102% |
| TOTALS | | | | | 870 | | 767 | 88% | | 870 | 100% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-205

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | * | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2348 | |
| APD | 1.70 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1250 | 1260 |
| PRIMARY COOL MIN CFM | 417 | 423 |
| PRIMARY HEAT MIN CFM | 417 | 423 |
| PRIMARY HEAT MAX CFM | 625 | 635 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 625 | 635 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 87.12 | 81.75 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 94.68 | 87.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 250 | 291 | 291 | 116% | 250 | 250 | 100% |
| 229 | 2 | CD | 10 | 1.00 | 250 | 294 | 294 | 118% | 242 | 242 | 97% |
| 229 | 3 | CD | 10 | 1.00 | 250 | 314 | 314 | 126% | 256 | 256 | 102% |
| 229 | 4 | CD | 10 | 1.00 | 250 | 311 | 311 | 124% | 263 | 263 | 105% |
| 229 | 5 | CD | 10 | 1.00 | 250 | 326 | 326 | 130% | 249 | 249 | 100% |
| TOTALS | | | | | 1250 | | 1536 | 123% | | 1260 | 101% |
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**REMARKS:** * UNABLE TO ACCESS.

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-206

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010816 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1668 | |
| APD | 1.67 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 868 |
| PRIMARY COOL MIN CFM | 290 | 281 |
| PRIMARY HEAT MIN CFM | 290 | 281 |
| PRIMARY HEAT MAX CFM | 435 | 416 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 416 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 87.56 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 290 | 264 | 264 | 91% | 279 | 279 | 96% |
| 229 | 2 | CD | 10 | 1.00 | 290 | 271 | 271 | 93% | 298 | 298 | 103% |
| 229 | 3 | CD | 10 | 1.00 | 290 | 225 | 225 | 78% | 291 | 291 | 100% |
| TOTALS | | | | | 870 | | 760 | 87% | | 868 | 100% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-207

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 200, 218 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010813 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 2016 | |
| APD | 1.37 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 873 |
| PRIMARY COOL MIN CFM | 290 | 299 |
| PRIMARY HEAT MIN CFM | 290 | 299 |
| PRIMARY HEAT MAX CFM | 435 | 438 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 438 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 86.64 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 218 | 1 | CD | 10 | 1.00 | 290 | 303 | 303 | 104% | 298 | 298 | 103% |
| 200 | 2 | CD | 10 | 1.00 | 290 | 298 | 298 | 103% | 289 | 289 | 100% |
| 218 | 3 | CD | 10 | 1.00 | 290 | 294 | 294 | 101% | 286 | 286 | 99% |
| TOTALS | | | | | 870 | | 895 | 103% | | 873 | 100% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/17/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-208

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 218 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010806 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1752 | |
| APD | 1.90 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 869 |
| PRIMARY COOL MIN CFM | 290 | 299 |
| PRIMARY HEAT MIN CFM | 290 | 299 |
| PRIMARY HEAT MAX CFM | 435 | 441 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 441 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 83.70 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 86.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 218 | 1 | CD | 10 | 1.00 | 290 | 248 | 248 | 86% | 278 | 278 | 96% |
| 218 | 2 | CD | 10 | 1.00 | 290 | 277 | 277 | 96% | 295 | 295 | 102% |
| 218 | 3 | CD | 10 | 1.00 | 290 | 273 | 273 | 94% | 296 | 296 | 102% |
| TOTALS | | | | | 870 | | 798 | 92% | | 869 | 100% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/17/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-209

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008555 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1735 | |
| APD | 1.71 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 859 |
| PRIMARY COOL MIN CFM | 290 | 296 |
| PRIMARY HEAT MIN CFM | 290 | 296 |
| PRIMARY HEAT MAX CFM | 435 | 444 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 444 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 85.17 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 84.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 10 | 1.00 | 290 | 265 | 265 | 91% | 285 | 285 | 98% |
| 212 | 2 | CD | 10 | 1.00 | 290 | 253 | 253 | 87% | 276 | 276 | 95% |
| 212 | 3 | CD | 10 | 1.00 | 290 | 285 | 285 | 98% | 298 | 298 | 103% |
| TOTALS | | | | | 870 | | 803 | 92% | | 859 | 99% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-210

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | * | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2867 | |
| APD | 0.92 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2080 | 2066 |
| PRIMARY COOL MIN CFM | 693 | 721 |
| PRIMARY HEAT MIN CFM | 693 | 721 |
| PRIMARY HEAT MAX CFM | 1040 | 1092 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1040 | 1092 |
| GPM | 3.50 | 3.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.19 | 83.90 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.09 | 85.20 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 14 | 1.00 | 520 | 432 | 432 | 83% | 520 | 520 | 100% |
| 212 | 2 | CD | 14 | 1.00 | 520 | 506 | 506 | 97% | 525 | 525 | 101% |
| 212 | 3 | CD | 14 | 1.00 | 520 | 438 | 438 | 84% | 527 | 527 | 101% |
| 212 | 4 | CD | 14 | 1.00 | 520 | 350 | 350 | 67% | 494 | 494 | 95% |
| TOTALS | | | | | 2080 | | 1726 | 83% | | 2066 | 99% |
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**REMARKS:** * UNABLE TO ACCESS.

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-211

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010823 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1214 | |
| APD | 1.91 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 690 | 690 |
| PRIMARY COOL MIN CFM | 230 | 240 |
| PRIMARY HEAT MIN CFM | 230 | 240 |
| PRIMARY HEAT MAX CFM | 345 | 359 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 345 | 359 |
| GPM | 1.25 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.71 | 85.14 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.16 | 85.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 8 | 1.00 | 230 | 182 | 182 | 79% | 220 | 220 | 96% |
| 212 | 2 | CD | 8 | 1.00 | 230 | 242 | 242 | 105% | 232 | 232 | 101% |
| 212 | 3 | CD | 8 | 1.00 | 230 | 192 | 192 | 83% | 238 | 238 | 103% |
| TOTALS | | | | | 690 | | 616 | 89% | | 690 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-212

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 218-223, 246 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010814 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1895 | |
| APD | 1.24 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 825 | 815 |
| PRIMARY COOL MIN CFM | 275 | 281 |
| PRIMARY HEAT MIN CFM | 275 | 281 |
| PRIMARY HEAT MAX CFM | 415 | 422 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 415 | 422 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.18 | 85.12 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 93.24 | 86.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 218 | 1 | CD | 8 | 1.00 | 170 | 188 | 188 | 111% | 177 | 177 | 104% |
| 246 | 2 | CD | 6 | 1.00 | 85 | 83 | 83 | 98% | 84 | 84 | 99% |
| 218 | 3 | CD | 8 | 1.00 | 120 | 108 | 108 | 90% | 114 | 114 | 95% |
| 219 | 4 | CD | 6 | 1.00 | 75 | 86 | 86 | 115% | 72 | 72 | 96% |
| 220 | 5 | CD | 6 | 1.00 | 65 | 84 | 84 | 129% | 62 | 62 | 95% |
| 221 | 6 | CD | 6 | 1.00 | 65 | 90 | 90 | 138% | 67 | 67 | 103% |
| 222 | 7 | CD | 6 | 1.00 | 65 | 80 | 80 | 123% | 62 | 62 | 95% |
| 223 | 8 | CD | 6 | 1.00 | 95 | 70 | 70 | 74% | 91 | 91 | 96% |
| 246 | 9 | CD | 6 | 1.00 | 85 | 75 | 75 | 88% | 86 | 86 | 101% |
| TOTALS | | | | | 825 | | 864 | 105% | | 815 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/22/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-213

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 224-229, 232 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010798 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1388 | |
| APD | 1.11 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 570 | 574 |
| PRIMARY COOL MIN CFM | 200 | 206 |
| PRIMARY HEAT MIN CFM | 200 | 206 |
| PRIMARY HEAT MAX CFM | 285 | 289 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 285 | 289 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.44 | 86.90 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 90.09 | 82.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 8 | 1.00 | 120 | 129 | 129 | 108% | 126 | 126 | 105% |
| 228 | 2 | CD | 6 | 1.00 | 75 | 72 | 72 | 96% | 75 | 75 | 100% |
| 227 | 3 | CD | 6 | 1.00 | 65 | 63 | 63 | 97% | 68 | 68 | 105% |
| 232 | 4 | CD | 6 | 1.00 | 85 | 65 | 65 | 76% | 81 | 81 | 95% |
| 226 | 5 | CD | 6 | 1.00 | 65 | 75 | 75 | 115% | 65 | 65 | 100% |
| 225 | 6 | CD | 6 | 1.00 | 65 | 65 | 65 | 100% | 68 | 68 | 105% |
| 224 | 7 | CD | 6 | 1.00 | 95 | 80 | 80 | 84% | 91 | 91 | 96% |
| TOTALS | | | | | 570 | | 549 | 96% | | 574 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-214

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229-230 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010818 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2447 | |
| APD | 1.20 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1400 | 1410 |
| PRIMARY COOL MIN CFM | 475 | 488 |
| PRIMARY HEAT MIN CFM | 475 | 488 |
| PRIMARY HEAT MAX CFM | 710 | 739 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 710 | 739 |
| GPM | 2.25 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 87.49 | 82.15 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 93.74 | 86.10 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 220 | 191 | 191 | 87% | 224 | 224 | 102% |
| 229 | 2 | CD | 10 | 1.00 | 230 | 181 | 181 | 79% | 218 | 218 | 95% |
| 229 | 3 | CD | 10 | 1.00 | 230 | 201 | 201 | 87% | 228 | 228 | 99% |
| 229 | 4 | CD | 10 | 1.00 | 230 | 210 | 210 | 91% | 227 | 227 | 99% |
| 230 | 5 | CD | 6 | 1.00 | 40 | 52 | 52 | 130% | 41 | 41 | 103% |
| 229 | 6 | CD | 10 | 1.00 | 220 | 202 | 202 | 92% | 231 | 231 | 105% |
| 229 | 7 | CD | 10 | 1.00 | 230 | 229 | 229 | 100% | 241 | 241 | 105% |
| TOTALS | | | | | 1400 | | 1266 | 90% | | 1410 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-215

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010802 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1839 | |
| APD | 1.04 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 750 | 718 |
| PRIMARY COOL MIN CFM | 335 | 340 |
| PRIMARY HEAT MIN CFM | 335 | 340 |
| PRIMARY HEAT MAX CFM | 375 | 380 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 375 | 380 |
| GPM | 1.25 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.03 | 85.80 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 91.95 | 82.10 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 250 | 274 | 274 | 110% | 238 | 238 | 95% |
| 229 | 2 | CD | 10 | 1.00 | 250 | 214 | 214 | 86% | 239 | 239 | 96% |
| 229 | 3 | CD | 10 | 1.00 | 250 | 220 | 220 | 88% | 241 | 241 | 96% |
| TOTALS | | | | | 750 | | 708 | 94% | | 718 | 96% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-216

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010807 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1734 | |
| APD | 1.27 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1110 | 1078 |
| PRIMARY COOL MIN CFM | 370 | 366 |
| PRIMARY HEAT MIN CFM | 370 | 366 |
| PRIMARY HEAT MAX CFM | 555 | 559 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 555 | 559 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.21 | 84.99 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.63 | 82.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 370 | 335 | 335 | 91% | 363 | 363 | 98% |
| 229 | 2 | CD | 10 | 1.00 | 370 | 345 | 345 | 93% | 358 | 358 | 97% |
| 229 | 3 | CD | 10 | 1.00 | 370 | 326 | 326 | 88% | 357 | 357 | 96% |
| TOTALS | | | | | 1110 | | 1006 | 91% | | 1078 | 97% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-217

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 233 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010796 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1351 | |
| APD | 1.18 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 640 | 642 |
| PRIMARY COOL MIN CFM | 215 | 224 |
| PRIMARY HEAT MIN CFM | 215 | 224 |
| PRIMARY HEAT MAX CFM | 320 | 336 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 320 | 336 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 97.92 | 90.89 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 96.59 | 89.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 233 | 1 | CD | 8 | 1.00 | 160 | 169 | 169 | 106% | 168 | 168 | 105% |
| 233 | 2 | CD | 8 | 1.00 | 160 | 156 | 156 | 98% | 162 | 162 | 101% |
| 233 | 3 | CD | 8 | 1.00 | 160 | 157 | 157 | 98% | 160 | 160 | 100% |
| 233 | 4 | CD | 8 | 1.00 | 160 | 144 | 144 | 90% | 152 | 152 | 95% |
| TOTALS | | | | | 640 | | 626 | 98% | | 642 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-220

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 214, 242 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010809 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 2008 | |
| APD | 1.08 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 900 | 906 |
| PRIMARY COOL MIN CFM | 300 | 294 |
| PRIMARY HEAT MIN CFM | 300 | 294 |
| PRIMARY HEAT MAX CFM | 450 | 439 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 450 | 439 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 97.21 | 92.14 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 99.06 | 87.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 214 | 1 | CD | 8 | 1.00 | 215 | 222 | 222 | 103% | 221 | 221 | 103% |
| 214 | 2 | CD | 8 | 1.00 | 215 | 210 | 210 | 98% | 214 | 214 | 100% |
| 214 | 3 | CD | 8 | 1.00 | 215 | 210 | 210 | 98% | 216 | 216 | 100% |
| 214 | 4 | CD | 8 | 1.00 | 215 | 208 | 208 | 97% | 213 | 213 | 99% |
| 242 | 5 | CD | 6 | 1.00 | 40 | 73 | 73 | 183% | 42 | 42 | 105% |
| TOTALS | | | | | 900 | | 923 | 103% | | 906 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-221

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010810 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1823 | |
| APD | 1.99 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1110 | 1061 |
| PRIMARY COOL MIN CFM | 370 | 359 |
| PRIMARY HEAT MIN CFM | 370 | 359 |
| PRIMARY HEAT MAX CFM | 555 | 546 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 555 | 546 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.21 | 83.43 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.63 | 85.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 10 | 1.00 | 370 | 286 | 286 | 77% | 353 | 353 | 95% |
| 212 | 2 | CD | 10 | 1.00 | 370 | 225 | 225 | 61% | 355 | 355 | 96% |
| 212 | 3 | CD | 10 | 1.00 | 370 | 260 | 260 | 70% | 353 | 353 | 95% |
| TOTALS | | | | | 1110 | | 771 | 69% | | 1061 | 96% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-222

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010799 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1371 | |
| APD | 1.96 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 690 | 673 |
| PRIMARY COOL MIN CFM | 230 | 236 |
| PRIMARY HEAT MIN CFM | 230 | 236 |
| PRIMARY HEAT MAX CFM | 345 | 361 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 345 | 361 |
| GPM | 1.25 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.71 | 84.35 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.16 | 87.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 8 | 1.00 | 115 | 110 | 110 | 96% | 120 | 120 | 104% |
| 212 | 2 | CD | 8 | 1.00 | 115 | 140 | 140 | 122% | 110 | 110 | 96% |
| 212 | 3 | CD | 8 | 1.00 | 230 | 213 | 213 | 93% | 224 | 224 | 97% |
| 212 | 4 | CD | 8 | 1.00 | 230 | 194 | 194 | 84% | 219 | 219 | 95% |
| TOTALS | | | | | 690 | | 657 | 95% | | 673 | 98% |
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**REMARKS:** APD: 1.96

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-223

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 201, 207-211, 238 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | | |
| TYPE / SIZE | 6HBM010804 | 12 |
| ADDRESS | - | |
| K-FACTOR | 1925 | |
| APD | 1.53 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 860 | 861 |
| PRIMARY COOL MIN CFM | 287 | 296 |
| PRIMARY HEAT MIN CFM | 287 | 296 |
| PRIMARY HEAT MAX CFM | 435 | 451 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 451 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 83.50 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 87.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 201 | 1 | CD | 8 | 1.00 | 170 | 161 | 161 | 95% | 178 | 178 | 105% |
| 238 | 2 | CD | 6 | 1.00 | 85 | 73 | 73 | 86% | 81 | 81 | 95% |
| 201 | 3 | CD | 8 | 1.00 | 120 | 161 | 161 | 134% | 126 | 126 | 105% |
| 211 | 4 | CD | 6 | 1.00 | 75 | 68 | 68 | 91% | 78 | 78 | 104% |
| 210 | 5 | CD | 6 | 1.00 | 65 | 48 | 48 | 74% | 62 | 62 | 95% |
| 209 | 6 | CD | 6 | 1.00 | 65 | 61 | 61 | 94% | 67 | 67 | 103% |
| 238 | 7 | CD | 6 | 1.00 | 85 | 68 | 68 | 80% | 81 | 81 | 95% |
| 208 | 8 | CD | 6 | 1.00 | 65 | 81 | 81 | 125% | 63 | 63 | 97% |
| STORAGE | 9 | CD | 6 | 1.00 | 35 | 68 | 68 | 194% | 34 | 34 | 97% |
| 207 | 10 | CD | 6 | 1.00 | 95 | 83 | 83 | 87% | 91 | 91 | 96% |
| TOTALS | | | | | 860 | | 872 | 101% | | 861 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/22/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-224

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 202-206, 229, 234, 236 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSWC | |
| SERIAL NUMBER | 6HBM010795 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1389 | |
| APD | 1.81 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 615 | 607 |
| PRIMARY COOL MIN CFM | 200 | 208 |
| PRIMARY HEAT MIN CFM | 200 | 208 |
| PRIMARY HEAT MAX CFM | 285 | 286 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 285 | 286 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.44 | 85.00 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 90.09 | 86.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 8 | 1.00 | 120 | 129 | 129 | 108% | 126 | 126 | 105% |
| 202 | 2 | CD | 6 | 1.00 | 75 | 72 | 72 | 96% | 72 | 72 | 96% |
| 234 | 3 | CD | 6 | 1.00 | 85 | 55 | 55 | 65% | 81 | 81 | 95% |
| 203 | 4 | CD | 6 | 1.00 | 65 | 64 | 64 | 98% | 63 | 63 | 97% |
| 204 | 5 | CD | 6 | 1.00 | 65 | 67 | 67 | 103% | 64 | 64 | 98% |
| 236 | 6 | CD | 6 | 1.00 | 45 | 52 | 52 | 116% | 47 | 47 | 104% |
| 205 | 7 | CD | 6 | 1.00 | 65 | 65 | 65 | 100% | 63 | 63 | 97% |
| 206 | 8 | CD | 6 | 1.00 | 95 | 92 | 92 | 97% | 91 | 91 | 96% |
| TOTALS | | | | | 615 | | 596 | 97% | | 607 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-225

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010821 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3529 | |
| APD | 1.74 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2250 | 2297 |
| PRIMARY COOL MIN CFM | 750 | 784 |
| PRIMARY HEAT MIN CFM | 750 | 784 |
| PRIMARY HEAT MAX CFM | 1125 | 1179 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1125 | 1179 |
| GPM | 3.70 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.11 | 86.41 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 88.32 | 80.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 12 | 1.00 | 450 | 516 | 516 | 115% | 471 | 471 | 105% |
| 229 | 2 | CD | 12 | 1.00 | 450 | 438 | 438 | 97% | 447 | 447 | 99% |
| 229 | 3 | CD | 12 | 1.00 | 450 | 418 | 418 | 93% | 457 | 457 | 102% |
| 229 | 4 | CD | 12 | 1.00 | 450 | 515 | 515 | 114% | 452 | 452 | 100% |
| 229 | 5 | CD | 12 | 1.00 | 450 | 433 | 433 | 96% | 470 | 470 | 104% |
| TOTALS | | | | | 2250 | | 2320 | 103% | | 2297 | 102% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-226

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010820 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3243 | |
| APD | 1.24 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1720 | 1744 |
| PRIMARY COOL MIN CFM | 570 | 589 |
| PRIMARY HEAT MIN CFM | 570 | 589 |
| PRIMARY HEAT MAX CFM | 855 | 890 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 855 | 890 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.09 | 87.05 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 90.65 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 12 | 1.00 | 430 | 408 | 408 | 95% | 428 | 428 | 100% |
| 229 | 2 | CD | 12 | 1.00 | 430 | 411 | 411 | 96% | 439 | 439 | 102% |
| 229 | 3 | CD | 12 | 1.00 | 430 | 415 | 415 | 97% | 446 | 446 | 104% |
| 229 | 4 | CD | 12 | 1.00 | 430 | 405 | 405 | 94% | 431 | 431 | 100% |
| TOTALS | | | | | 1720 | | 1639 | 95% | | 1744 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-227

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010801 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1910 | |
| APD | 0.89 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 889 |
| PRIMARY COOL MIN CFM | 290 | 293 |
| PRIMARY HEAT MIN CFM | 290 | 293 |
| PRIMARY HEAT MAX CFM | 435 | 446 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 446 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 85.66 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229 | 1 | CD | 10 | 1.00 | 290 | 303 | 303 | 104% | 300 | 300 | 103% |
| 229 | 2 | CD | 10 | 1.00 | 290 | 290 | 290 | 100% | 296 | 296 | 102% |
| 229 | 3 | CD | 10 | 1.00 | 290 | 291 | 291 | 100% | 293 | 293 | 101% |
| TOTALS | | | | | 870 | | 884 | 102% | | 889 | 102% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-228

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 229 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010811 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1715 | |
| APD | 1.57 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 839 |
| PRIMARY COOL MIN CFM | 290 | 278 |
| PRIMARY HEAT MIN CFM | 290 | 278 |
| PRIMARY HEAT MAX CFM | 435 | 417 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 417 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 86.50 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 84.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 229 | 1 | CD | 10 | 1.00 | 290 | 257 | 257 | 89% | 278 | 278 | 96% |
| 229 | 2 | CD | 10 | 1.00 | 290 | 268 | 268 | 92% | 284 | 284 | 98% |
| 229 | 3 | CD | 10 | 1.00 | 290 | 256 | 256 | 88% | 277 | 277 | 96% |
| TOTALS | | | | | 870 | | 781 | 90% | | 839 | 96% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-229

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 201 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010797 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1409 | |
| APD | 1.46 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 580 | 591 |
| PRIMARY COOL MIN CFM | 200 | 216 |
| PRIMARY HEAT MIN CFM | 200 | 216 |
| PRIMARY HEAT MAX CFM | 290 | 301 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 290 | 301 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.28 | 86.09 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 89.72 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 201 | 1 | CD | 10 | 1.00 | 290 | 359 | 359 | 124% | 298 | 298 | 103% |
| 201 | 2 | CD | 10 | 1.00 | 290 | 373 | 373 | 129% | 293 | 293 | 101% |
| TOTALS | | | | | 580 | | 732 | 126% | | 591 | 102% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-230

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 201 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010812 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1890 | |
| APD | 2.05 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 874 |
| PRIMARY COOL MIN CFM | 290 | 295 |
| PRIMARY HEAT MIN CFM | 290 | 295 |
| PRIMARY HEAT MAX CFM | 435 | 437 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 437 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 86.05 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 201 | 1 | CD | 10 | 1.00 | 290 | 305 | 305 | 105% | 290 | 290 | 100% |
| 201 | 2 | CD | 10 | 1.00 | 290 | 330 | 330 | 114% | 297 | 297 | 102% |
| 201 | 3 | CD | 10 | 1.00 | 290 | 238 | 238 | 82% | 287 | 287 | 99% |
| TOTALS | | | | | 870 | | 873 | 100% | | 874 | 100% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-231

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010803 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1993 | |
| APD | 2.30 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 870 | 896 |
| PRIMARY COOL MIN CFM | 290 | 299 |
| PRIMARY HEAT MIN CFM | 290 | 299 |
| PRIMARY HEAT MAX CFM | 435 | 455 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 435 | 455 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.69 | 82.85 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 92.22 | 87.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 10 | 1.00 | 290 | 291 | 291 | 100% | 291 | 291 | 100% |
| 212 | 2 | CD | 10 | 1.00 | 290 | 308 | 308 | 106% | 301 | 301 | 104% |
| 212 | 3 | CD | 10 | 1.00 | 290 | 293 | 293 | 101% | 304 | 304 | 105% |
| TOTALS | | | | | 870 | | 892 | 103% | | 896 | 103% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-232

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010817 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2445 | |
| APD | 2.44 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1720 | 1708 |
| PRIMARY COOL MIN CFM | 575 | 583 |
| PRIMARY HEAT MIN CFM | 575 | 583 |
| PRIMARY HEAT MAX CFM | 860 | 872 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 860 | 872 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.04 | 85.53 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 90.52 | 84.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 12 | 1.00 | 430 | 391 | 391 | 91% | 428 | 428 | 100% |
| 212 | 2 | CD | 12 | 1.00 | 430 | 355 | 355 | 83% | 431 | 431 | 100% |
| 212 | 3 | CD | 12 | 1.00 | 430 | 394 | 394 | 92% | 423 | 423 | 98% |
| 212 | 4 | CD | 12 | 1.00 | 430 | 378 | 378 | 88% | 426 | 426 | 99% |
| TOTALS | | | | | 1720 | | 1518 | 88% | | 1708 | 99% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-233

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 201, 212 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010825 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3066 | |
| APD | 1.87 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2250 | 2254 |
| PRIMARY COOL MIN CFM | 750 | 786 |
| PRIMARY HEAT MIN CFM | 750 | 786 |
| PRIMARY HEAT MAX CFM | 1125 | 1184 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1125 | 1184 |
| GPM | 3.50 | 3.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.42 | 80.96 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 87.44 | 86.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 212 | 1 | CD | 12 | 1.00 | 450 | 364 | 364 | 81% | 472 | 472 | 105% |
| 212 | 2 | CD | 12 | 1.00 | 450 | 499 | 499 | 111% | 448 | 448 | 100% |
| 212 | 3 | CD | 12 | 1.00 | 450 | 388 | 388 | 86% | 440 | 440 | 98% |
| 201 | 4 | CD | 12 | 1.00 | 450 | 474 | 474 | 105% | 464 | 464 | 103% |
| 201 | 5 | CD | 12 | 1.00 | 450 | 352 | 352 | 78% | 430 | 430 | 96% |
| TOTALS | | | | | 2250 | | 2077 | 92% | | 2254 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/19/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-234

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-2A / 2B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 201 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010824 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3443 | |
| APD | 1.55 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1800 | 1712 |
| PRIMARY COOL MIN CFM | 600 | 619 |
| PRIMARY HEAT MIN CFM | 600 | 619 |
| PRIMARY HEAT MAX CFM | 900 | 938 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 900 | 938 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 84.58 | 81.41 |
| ENT AIR TEMP ˚F | 54.00 | 53.90 |
| LVG AIR TEMP ˚F | 95.52 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 201 | 1 | CD | 12 | 1.00 | 450 | 431 | 431 | 96% | 429 | 429 | 95% |
| 201 | 2 | CD | 12 | 1.00 | 450 | 466 | 466 | 104% | 427 | 427 | 95% |
| 201 | 3 | CD | 12 | 1.00 | 450 | 406 | 406 | 90% | 430 | 430 | 96% |
| 201 | 4 | CD | 12 | 1.00 | 450 | 463 | 463 | 103% | 426 | 426 | 95% |
| TOTALS | | | | | 1800 | | 1766 | 98% | | 1712 | 95% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/16/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-3A

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | THIRD FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | ETI-069X105 |
| SERIAL NUMBER | CAWMXT0153 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 22052 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 15900 | 16437 |
| OSA CFM | 4100 | 5615 |
| TOTAL STATIC PRESSURE | 4.50 | 3.25 |
| EXTERNAL STATIC P | 3.00 | 1.64 |
| EYE OF FAN | - | -1.84 |
| SUCTION PRESSURE | - | -0.23 |
| DISCHARGE PRESSURE | - | 1.41 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 460 / 460 / 460 |
| AMPS | 31.00 | 27.0 / 27.0 / 27.0 |
| MOTOR RPM | 1760 | 1767 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2TB86 x 1 7/8 | |
| FAN SHEAVE SZ / BORE | 2TB94 x 2 | |
| # BELTS / SIZE | 2 x BX62 | |
| FAN RPM | - | 1612 |
| CENTER DISTANCE | 18 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 74.00 | 63.00 |
| COOL LVG TEMP DB/WB | - | - | 55.00 | 54.00 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 52.70 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.10.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-3A SUPPLY
**DUCT SIZE:** 63 x 18 OVAL
**DUCT AREA:** 7.39

**DESIGN FPM:** 2706
**DESIGN CFM:** 20000
**ACTUAL CFM:** 22052

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2658 | 3038 | 2820 | 2492 | 3297 | 3579 | 3816 | 4105 | | | | |
| 2830 | 2890 | 3143 | 3218 | 3301 | 3582 | 3598 | 4063 | | | | |
| 2720 | 2529 | 2826 | 2638 | 2998 | 2867 | 2858 | 3196 | | | | |
| 2612 | 2436 | 2330 | 2568 | 2522 | 2547 | 2501 | 2900 | | | | |
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**ACTUAL FPM:** 2984

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** 1.41 @ 22052 CFM

**REMARKS:** COMP TOTALS: 23154.

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-3A RETURN
**DUCT SIZE:** 86 x 24
**DUCT AREA:** 14.33

**DESIGN FPM:** 1110
**DESIGN CFM:** 15900
**ACTUAL CFM:** 16437

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1225 | 1286 | 1001 | 860 | 1294 | 903 | 1175 | | | | | |
| 1002 | 1011 | 1207 | 1281 | 1240 | 1222 | 1346 | | | | | |
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**ACTUAL FPM:** 1147

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.23 @ 16437 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AIR MOVING EQUIPMENT TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** AHU-3B

| UNIT DATA | |
|---|---|
| LOCATION | MECHANICAL ROOM |
| SERVICE | THIRD FLOOR |
| MANUFACTURER | YORK |
| MODEL NUMBER | ETI-069X105 |
| SERIAL NUMBER | CAWMXT0154 |
| FILTERS | 32) 12x24x2 |
| | |

| PERFORMANCE | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| TOTAL FAN CFM | 20000 | 20500 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | 16400 | 19133 |
| OSA CFM | 3600 | 1367 |
| TOTAL STATIC PRESSURE | 4.50 | 3.41 |
| EXTERNAL STATIC P | 3.00 | 1.79 |
| EYE OF FAN | - | -1.97 |
| SUCTION PRESSURE | - | -0.35 |
| DISCHARGE PRESSURE | - | 1.44 |
| | | |

| MOTOR DATA | DESIGN | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 25.00 / - | 25.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 460 / 460 / 460 |
| AMPS | 31.00 | 28.0 / 28.0 / 28.0 |
| MOTOR RPM | 1760 | 1766 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | VFD | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 3B5V52 x 1 | |
| FAN SHEAVE SZ / BORE | 3B5V56 x - | |
| # BELTS / SIZE | 3 x 5BX530 | |
| FAN RPM | - | 1639 |
| CENTER DISTANCE | 18 1/2 | |
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| ELECTRIC HEAT | | |
|---|---|---|
| DATA | DESIGN | ACTUAL |
| MODEL NUMBER | - | |
| SERIAL NUMBER | - | |
| KW | - | - |
| PHASE / HZ | - | - |
| VOLTAGE | - | - |
| AMPS | - | - |

| TEMPERATURES ˚F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT TEMP DB/WB | - | - | 73.00 | 62.00 |
| COOL LVG TEMP DB/WB | - | - | 53.00 | 52.00 |
| HEAT ENT TEMP DB | - | | - | |
| HEAT LVG TEMP DB | - | | - | |
| ENTERING WATER TEMP | - | | 43.00 | |
| LEAVING WATER TEMP | - | | 53.00 | |
| | | | | |

**REMARKS:** OSA & RETURN DAMPERS NOT INTERLOCKED. OSA HAS A TWO POSITION DAMPER. RETURN DAMPER IS LOCKED OPEN. STATIC PRESSURE SET POINT: 1.00.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-3B SUPPLY
**DUCT SIZE:** 58 x 18 OVAL
**DUCT AREA:** 6.77

**DESIGN FPM:** 2954
**DESIGN CFM:** 20000
**ACTUAL CFM:** 20500

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2934 | 2976 | 3260 | 3218 | 3185 | 3089 | 3272 | 3230 | | | | |
| 3148 | 3014 | 3158 | 3262 | 3179 | 3114 | 3029 | 3198 | | | | |
| 2870 | 2768 | 3138 | 3288 | 3230 | 3027 | 2811 | 2836 | | | | |
| 2505 | 2622 | 2768 | 3066 | 3081 | 2751 | 2848 | 3018 | | | | |
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**ACTUAL FPM:** 3028

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** 1.44 @ 20500 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** AHU-3B RETURN
**DUCT SIZE:** 86 x 26
**DUCT AREA:** 15.53

**DESIGN FPM:** 1056
**DESIGN CFM:** 16400
**ACTUAL CFM:** 19133

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1289 | 1501 | 1300 | 1126 | 1215 | 1043 | 1320 | 844 | | | | |
| 1076 | 1532 | 1309 | 1307 | 1179 | 1242 | 1279 | 1155 | | | | |
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**ACTUAL FPM:** 1232

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** -0.35 @ 19133 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-301

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 328 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM010826 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2329 | |
| APD | 0.26 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2050 | 2039 |
| PRIMARY COOL MIN CFM | 685 | 693 |
| PRIMARY HEAT MIN CFM | 685 | 693 |
| PRIMARY HEAT MAX CFM | 1025 | 1042 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1025 | 1042 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.43 | 83.37 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 86.78 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 328 | 1 | CD | 12 | 1.00 | 410 | 303 | 303 | 74% | 400 | 400 | 98% |
| 328 | 2 | CD | 12 | 1.00 | 410 | 318 | 318 | 78% | 415 | 415 | 101% |
| 328 | 3 | CD | 12 | 1.00 | 410 | 320 | 320 | 78% | 417 | 417 | 102% |
| 328 | 4 | CD | 12 | 1.00 | 410 | 272 | 272 | 66% | 390 | 390 | 95% |
| 328 | 5 | CD | 12 | 1.00 | 410 | 320 | 320 | 78% | 417 | 417 | 102% |
| TOTALS | | | | | 2050 | | 1533 | 75% | | 2039 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-302

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 337-338 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008566 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 1951 | |
| APD | 1.09 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1120 | 1126 |
| PRIMARY COOL MIN CFM | 375 | 391 |
| PRIMARY HEAT MIN CFM | 375 | 391 |
| PRIMARY HEAT MAX CFM | 560 | 587 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 560 | 587 |
| GPM | 1.80 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.78 | 81.19 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 95.35 | 88.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 337 | 1 | CD | 10 | 1.00 | 230 | 163 | 163 | 71% | 242 | 242 | 105% |
| 338 | 2 | CD | 8 | 1.00 | 100 | 80 | 80 | 80% | 99 | 99 | 99% |
| 337 | 3 | CD | 10 | 1.00 | 230 | 159 | 159 | 69% | 223 | 223 | 97% |
| 337 | 4 | CD | 10 | 1.00 | 280 | 212 | 212 | 76% | 284 | 284 | 101% |
| 337 | 5 | CD | 10 | 1.00 | 280 | 233 | 233 | 83% | 278 | 278 | 99% |
| TOTALS | | | | | 1120 | | 847 | 76% | | 1126 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-303

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 340 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008563 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2990 | |
| APD | 1.26 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1120 | 1100 |
| PRIMARY COOL MIN CFM | 375 | 361 |
| PRIMARY HEAT MIN CFM | 375 | 361 |
| PRIMARY HEAT MAX CFM | 560 | 536 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 560 | 536 |
| GPM | 1.80 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 86.78 | 83.13 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 95.35 | 88.20 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 340 | 1 | CD | 10 | 1.00 | 280 | 313 | 313 | 112% | 282 | 282 | 101% |
| 340 | 2 | CD | 10 | 1.00 | 280 | 311 | 311 | 111% | 278 | 278 | 99% |
| 340 | 3 | CD | 10 | 1.00 | 280 | 285 | 285 | 102% | 274 | 274 | 98% |
| 340 | 4 | CD | 10 | 1.00 | 280 | 262 | 262 | 94% | 266 | 266 | 95% |
| TOTALS | | | | | 1120 | | 1171 | 105% | | 1100 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-304

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 350 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008575 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 3609 | |
| APD | 0.71 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2050 | 2052 |
| PRIMARY COOL MIN CFM | 685 | 690 |
| PRIMARY HEAT MIN CFM | 685 | 690 |
| PRIMARY HEAT MAX CFM | 1025 | 1036 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1025 | 1036 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.43 | 83.89 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 88.78 | 82.50 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 350 | 1 | CD | 12 | 1.00 | 410 | 400 | 400 | 98% | 390 | 390 | 95% |
| 350 | 2 | CD | 12 | 1.00 | 410 | 490 | 490 | 120% | 412 | 412 | 100% |
| 350 | 3 | CD | 12 | 1.00 | 410 | 417 | 417 | 102% | 400 | 400 | 98% |
| 350 | 4 | CD | 12 | 1.00 | 410 | 477 | 477 | 116% | 430 | 430 | 105% |
| 350 | 5 | CD | 12 | 1.00 | 410 | 450 | 450 | 110% | 420 | 420 | 102% |
| TOTALS | | | | | 2050 | | 2234 | 109% | | 2052 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-305

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 350 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008565 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2309 | |
| APD | 0.96 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1440 | 1457 |
| PRIMARY COOL MIN CFM | 380 | 384 |
| PRIMARY HEAT MIN CFM | 380 | 384 |
| PRIMARY HEAT MAX CFM | 720 | 732 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 720 | 732 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.10 | 84.50 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.99 | 86.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 350 | 1 | CD | 8 | 1.00 | 130 | 116 | 116 | 89% | 130 | 130 | 100% |
| 350 | 2 | CD | 12 | 1.00 | 350 | 239 | 239 | 68% | 365 | 365 | 104% |
| 350 | 3 | CD | 8 | 1.00 | 130 | 126 | 126 | 97% | 136 | 136 | 105% |
| 350 | 4 | CD | 12 | 1.00 | 350 | 323 | 323 | 92% | 353 | 353 | 101% |
| 350 | 5 | CD | 8 | 1.00 | 130 | 102 | 102 | 78% | 135 | 135 | 104% |
| 350 | 6 | CD | 12 | 1.00 | 350 | 303 | 303 | 87% | 338 | 338 | 97% |
| TOTALS | | | | | 1440 | | 1209 | 84% | | 1457 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-306

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 350 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008562 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2471 | |
| APD | 1.11 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1400 | 1361 |
| PRIMARY COOL MIN CFM | 470 | 447 |
| PRIMARY HEAT MIN CFM | 470 | 447 |
| PRIMARY HEAT MAX CFM | 700 | 665 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 700 | 665 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.45 | 87.87 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 95.60 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 350 | 1 | CD | 10 | 1.00 | 280 | 277 | 277 | 99% | 273 | 273 | 98% |
| 350 | 2 | CD | 10 | 1.00 | 280 | 283 | 283 | 101% | 279 | 279 | 100% |
| 350 | 3 | CD | 10 | 1.00 | 280 | 211 | 211 | 75% | 266 | 266 | 95% |
| 350 | 4 | CD | 10 | 1.00 | 280 | 263 | 263 | 94% | 275 | 275 | 98% |
| 350 | 5 | CD | 10 | 1.00 | 280 | 214 | 214 | 76% | 268 | 268 | 96% |
| TOTALS | | | | | 1400 | | 1248 | 89% | | 1361 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-307

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 350 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008558 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1930 | |
| APD | 1.09 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1050 | 1065 |
| PRIMARY COOL MIN CFM | 350 | 366 |
| PRIMARY HEAT MIN CFM | 350 | 366 |
| PRIMARY HEAT MAX CFM | 525 | 551 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 525 | 551 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.77 | 85.41 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 90.83 | 83.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 350 | 1 | CD | 12 | 1.00 | 350 | 371 | 371 | 106% | 366 | 366 | 105% |
| 350 | 2 | CD | 12 | 1.00 | 350 | 336 | 336 | 96% | 335 | 335 | 96% |
| 350 | 3 | CD | 12 | 1.00 | 350 | 365 | 365 | 104% | 364 | 364 | 104% |
| TOTALS | | | | | 1050 | | 1072 | 102% | | 1065 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-308

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 300, 340 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008559 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1617 | |
| APD | 1.25 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 880 | 887 |
| PRIMARY COOL MIN CFM | 295 | 286 |
| PRIMARY HEAT MIN CFM | 295 | 286 |
| PRIMARY HEAT MAX CFM | 440 | 421 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 440 | 421 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.57 | 84.69 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 91.97 | 87.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 340 | 1 | CD | 10 | 1.00 | 220 | 194 | 194 | 88% | 226 | 226 | 103% |
| 340 | 2 | CD | 10 | 1.00 | 220 | 199 | 199 | 90% | 231 | 231 | 105% |
| 300 | 3 | CD | 10 | 1.00 | 220 | 196 | 196 | 89% | 221 | 221 | 100% |
| 340 | 4 | CD | 10 | 1.00 | 220 | 169 | 169 | 77% | 209 | 209 | 95% |
| TOTALS | | | | | 880 | | 758 | 86% | | 887 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-309

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 340-342 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008564 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 1987 | |
| APD | 0.99 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1260 | 1245 |
| PRIMARY COOL MIN CFM | 420 | 438 |
| PRIMARY HEAT MIN CFM | 420 | 438 |
| PRIMARY HEAT MAX CFM | 630 | 660 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 630 | 660 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 87.01 | 80.97 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.50 | 87.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 340 | 1 | CD | 10 | 1.00 | 350 | 261 | 261 | 75% | 337 | 337 | 96% |
| 340 | 2 | CD | 10 | 1.00 | 350 | 246 | 246 | 70% | 341 | 341 | 97% |
| 340 | 3 | CD | 10 | 1.00 | 350 | 256 | 256 | 73% | 364 | 364 | 104% |
| 341 | 4 | CD | 8 | 1.00 | 100 | 88 | 88 | 88% | 98 | 98 | 98% |
| 342 | 5 | CD | 8 | 1.00 | 110 | 68 | 68 | 62% | 105 | 105 | 95% |
| TOTALS | | | | | 1260 | | 919 | 73% | | 1245 | 99% |
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**REMARKS:**

**TECHNICIAN:** TB **TEST DATE:** 5/18/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-310

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 329-330, 332-337 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008571 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2253 | |
| APD | 1.14 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1265 | 1267 |
| PRIMARY COOL MIN CFM | 422 | 437 |
| PRIMARY HEAT MIN CFM | 422 | 437 |
| PRIMARY HEAT MAX CFM | 640 | 687 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 640 | 687 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 85.82 | 79.47 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.15 | 88.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 337 | 1 | CD | 8 | 1.00 | 175 | 115 | 115 | 66% | 168 | 168 | 96% |
| 333 | 2 | CD | 6 | 1.00 | 80 | 76 | 76 | 95% | 84 | 84 | 105% |
| 336 | 3 | CD | 6 | 1.00 | 100 | 78 | 78 | 78% | 104 | 104 | 104% |
| 332 | 4 | CD | 6 | 1.00 | 80 | 69 | 69 | 86% | 79 | 79 | 99% |
| 335 | 5 | CD | 6 | 1.00 | 80 | 65 | 65 | 81% | 84 | 84 | 105% |
| 329 | 6 | CD | 8 | 1.00 | 215 | 178 | 178 | 83% | 195 | 195 | 91% |
| 329 | 7 | CD | 8 | 1.00 | 215 | 150 | 150 | 70% | 225 | 225 | 105% |
| 330 | 8 | CD | 8 | 1.00 | 160 | 145 | 145 | 91% | 160 | 160 | 100% |
| 330 | 9 | CD | 8 | 1.00 | 160 | 163 | 163 | 102% | 168 | 168 | 105% |
| TOTALS | | | | | 1265 | | 1039 | 82% | | 1267 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-311

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 323, 328 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008570 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2011 | |
| APD | 0.96 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1330 | 1366 |
| PRIMARY COOL MIN CFM | 470 | 451 |
| PRIMARY HEAT MIN CFM | 470 | 451 |
| PRIMARY HEAT MAX CFM | 700 | 666 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 700 | 666 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 85.70 | 84.42 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 92.16 | 82.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 328 | 1 | CD | 8 | 1.00 | 200 | 131 | 131 | 66% | 209 | 209 | 105% |
| 328 | 2 | CD | 8 | 1.00 | 200 | 124 | 124 | 62% | 210 | 210 | 105% |
| 328 | 3 | CD | 8 | 1.00 | 200 | 178 | 178 | 89% | 210 | 210 | 105% |
| 328 | 4 | CD | 8 | 1.00 | 200 | 162 | 162 | 81% | 204 | 204 | 102% |
| 328 | 5 | CD | 8 | 1.00 | 200 | 153 | 153 | 77% | 207 | 207 | 104% |
| 328 | 6 | CD | 8 | 1.00 | 200 | 203 | 203 | 102% | 200 | 200 | 100% |
| 323 | 7 | CD | 8 | 1.00 | 130 | 80 | 80 | 62% | 126 | 126 | 97% |
| TOTALS | | | | | 1330 | | 1031 | 78% | | 1366 | 103% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-312

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 340, 343-346, 352 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008557 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 1610 | |
| APD | 1.29 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 930 | 945 |
| PRIMARY COOL MIN CFM | 310 | 298 |
| PRIMARY HEAT MIN CFM | 310 | 298 |
| PRIMARY HEAT MAX CFM | 465 | 441 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 465 | 441 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.00 | 87.21 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 90.76 | 82.10 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 340 | 1 | CD | 8 | 1.00 | 210 | 109 | 109 | 52% | 210 | 210 | 100% |
| 346 | 2 | CD | 6 | 1.00 | 75 | 61 | 61 | 81% | 77 | 77 | 103% |
| 340 | 3 | CD | 8 | 1.00 | 210 | 103 | 103 | 49% | 206 | 206 | 98% |
| 345 | 4 | CD | 6 | 1.00 | 80 | 53 | 53 | 66% | 84 | 84 | 105% |
| 344 | 5 | CD | 8 | 1.00 | 100 | 70 | 70 | 70% | 104 | 104 | 104% |
| 343 | 6 | CD | 8 | 1.00 | 100 | 62 | 62 | 62% | 102 | 102 | 102% |
| 352 | 7 | CD | 6 | 1.00 | 80 | 56 | 56 | 70% | 84 | 84 | 105% |
| 346 | 8 | CD | 6 | 1.00 | 75 | 59 | 59 | 79% | 78 | 78 | 104% |
| TOTALS | | | | | 930 | | 573 | 62% | | 945 | 102% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-313

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 350, 353-357 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008550 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1413 | |
| APD | 1.03 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 600 | 599 |
| PRIMARY COOL MIN CFM | 200 | 209 |
| PRIMARY HEAT MIN CFM | 200 | 209 |
| PRIMARY HEAT MAX CFM | 300 | 306 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 300 | 306 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.97 | 86.62 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 89.00 | 82.10 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 353 | 1 | CD | 6 | 1.00 | 80 | 80 | 80 | 100% | 83 | 83 | 104% |
| 354 | 2 | CD | 8 | 1.00 | 100 | 97 | 97 | 97% | 101 | 101 | 101% |
| 357 | 3 | CD | 8 | 1.00 | 150 | 149 | 149 | 99% | 151 | 151 | 101% |
| 355 | 4 | CD | 6 | 1.00 | 80 | 97 | 97 | 121% | 78 | 78 | 98% |
| 356 | 5 | CD | 8 | 1.00 | 110 | 91 | 91 | 83% | 105 | 105 | 95% |
| 350 | 6 | CD | 6 | 1.00 | 80 | 87 | 87 | 109% | 81 | 81 | 101% |
| TOTALS | | | | | 600 | | 601 | 100% | | 599 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-314

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 361-365 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSWC | |
| SERIAL NUMBER | 6HBM008554 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1881 | |
| APD | 1.10 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 985 | 965 |
| PRIMARY COOL MIN CFM | 330 | 315 |
| PRIMARY HEAT MIN CFM | 330 | 315 |
| PRIMARY HEAT MAX CFM | 495 | 471 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 495 | 471 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.37 | 83.43 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 89.40 | 86.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 362 | 1 | CD | 6 | 1.00 | 100 | 82 | 82 | 82% | 95 | 95 | 95% |
| 365 | 2 | CD | 8 | 1.00 | 130 | 132 | 132 | 102% | 134 | 134 | 103% |
| 361 | 3 | CD | 6 | 1.00 | 75 | 84 | 84 | 112% | 75 | 75 | 100% |
| 365 | 4 | CD | 8 | 1.00 | 250 | 249 | 249 | 100% | 251 | 251 | 100% |
| 365 | 5 | CD | 8 | 1.00 | 250 | 236 | 236 | 94% | 238 | 238 | 95% |
| 363 | 6 | CD | 6 | 1.00 | 80 | 87 | 87 | 109% | 76 | 76 | 95% |
| 364 | 7 | CD | 6 | 1.00 | 100 | 83 | 83 | 83% | 96 | 96 | 96% |
| TOTALS | | | | | 985 | | 953 | 97% | | 965 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-315

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 365, 369 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008552 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1908 | |
| APD | 0.72 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1080 | 1066 |
| PRIMARY COOL MIN CFM | 360 | 374 |
| PRIMARY HEAT MIN CFM | 360 | 374 |
| PRIMARY HEAT MAX CFM | 540 | 565 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 540 | 565 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.29 | 86.32 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 92.34 | 84.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 369 | 1 | CD | 10 | 1.00 | 270 | 261 | 261 | 97% | 265 | 265 | 98% |
| 369 | 2 | CD | 10 | 1.00 | 270 | 267 | 267 | 99% | 271 | 271 | 100% |
| 365 | 3 | CD | 10 | 1.00 | 270 | 298 | 298 | 110% | 264 | 264 | 98% |
| 365 | 4 | CD | 10 | 1.00 | 270 | 262 | 262 | 97% | 266 | 266 | 99% |
| TOTALS | | | | | 1080 | | 1088 | 101% | | 1066 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-316

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 365-369 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008553 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1895 | |
| APD | 0.85 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 900 | 876 |
| PRIMARY COOL MIN CFM | 300 | 309 |
| PRIMARY HEAT MIN CFM | 300 | 309 |
| PRIMARY HEAT MAX CFM | 450 | 462 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 450 | 462 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.34 | 77.90 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 91.48 | 92.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 369 | 1 | CD | 10 | 1.00 | 320 | 281 | 281 | 88% | 305 | 305 | 95% |
| 368 | 2 | CD | 6 | 1.00 | 80 | 92 | 92 | 115% | 83 | 83 | 104% |
| 367 | 3 | CD | 6 | 1.00 | 80 | 97 | 97 | 121% | 78 | 78 | 98% |
| 365 | 4 | CD | 10 | 1.00 | 320 | 284 | 284 | 89% | 313 | 313 | 98% |
| 366 | 5 | CD | 8 | 1.00 | 100 | 111 | 111 | 111% | 97 | 97 | 97% |
| TOTALS | | | | | 900 | | 865 | 96% | | 876 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-317

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 359, 370 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008569 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2721 | |
| APD | 0.76 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1070 | 1104 |
| PRIMARY COOL MIN CFM | 360 | 374 |
| PRIMARY HEAT MIN CFM | 360 | 374 |
| PRIMARY HEAT MAX CFM | 730 | 764 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 730 | 764 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.93 | 82.75 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.70 | 87.90 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 370 | 1 | CD | 8 | 1.00 | 190 | 196 | 196 | 103% | 196 | 196 | 103% |
| 359 | 2 | CD | 8 | 1.00 | 220 | 224 | 224 | 102% | 224 | 224 | 102% |
| 359 | 3 | CD | 8 | 1.00 | 220 | 231 | 231 | 105% | 231 | 231 | 105% |
| 359 | 4 | CD | 8 | 1.00 | 220 | 231 | 231 | 105% | 231 | 231 | 105% |
| 359 | 5 | CD | 8 | 1.00 | 220 | 222 | 222 | 101% | 222 | 222 | 101% |
| TOTALS | | | | | 1070 | | 1104 | 103% | | 1104 | 103% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-319

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 373-374, 379-380 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008546 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1327 | |
| APD | 0.83 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 720 | 718 |
| PRIMARY COOL MIN CFM | 210 | 201 |
| PRIMARY HEAT MIN CFM | 210 | 201 |
| PRIMARY HEAT MAX CFM | 310 | 296 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 310 | 296 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.67 | 85.82 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 88.30 | 84.20 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 373 | 1 | CD | 6 | 1.00 | 80 | 66 | 66 | 83% | 76 | 76 | 95% |
| OFFICE | 2 | CD | 8 | 1.00 | 160 | 129 | 129 | 81% | 162 | 162 | 101% |
| 380 | 3 | CD | 6 | 1.00 | 50 | 68 | 68 | 136% | 48 | 48 | 96% |
| 379 | 4 | CD | 6 | 1.00 | 50 | 77 | 77 | 154% | 49 | 49 | 98% |
| ENTRY | 5 | CD | 6 | 1.00 | 100 | 114 | 114 | 114% | 105 | 105 | 105% |
| 374 | 6 | CD | 6 | 1.00 | 80 | 71 | 71 | 89% | 83 | 83 | 104% |
| FRONT DOOR | 7 | CD | 8 | 1.00 | 200 | 181 | 181 | 91% | 195 | 195 | 98% |
| TOTALS | | | | | 720 | | 706 | 98% | | 718 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/22/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-321

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 326-327 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | * | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1916 | |
| APD | 1.26 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1105 | 1102 |
| PRIMARY COOL MIN CFM | 370 | 383 |
| PRIMARY HEAT MIN CFM | 370 | 383 |
| PRIMARY HEAT MAX CFM | 555 | 576 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 555 | 576 |
| GPM | 1.75 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.21 | 83.38 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 89.63 | 84.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 326 | 1 | CD | 10 | 1.00 | 240 | 243 | 243 | 101% | 238 | 238 | 99% |
| 326 | 2 | CD | 10 | 1.00 | 240 | 248 | 248 | 103% | 246 | 246 | 103% |
| 326 | 3 | CD | 10 | 1.00 | 240 | 252 | 252 | 105% | 249 | 249 | 104% |
| 327 | 4 | CD | 8 | 1.00 | 145 | 139 | 139 | 96% | 141 | 141 | 97% |
| 326 | 5 | CD | 10 | 1.00 | 240 | 215 | 215 | 90% | 228 | 228 | 95% |
| TOTALS | | | | | 1105 | | 1097 | 99% | | 1102 | 100% |
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**REMARKS:** * UNABLE TO ACCESS.

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-322

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 328 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008568 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2282 | |
| APD | 1.09 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1300 | 1253 |
| PRIMARY COOL MIN CFM | 435 | 439 |
| PRIMARY HEAT MIN CFM | 435 | 439 |
| PRIMARY HEAT MAX CFM | 650 | 651 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 650 | 651 |
| GPM | 2.25 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.60 | 85.81 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 95.66 | 84.90 |
| | | |

### UNIT AIR OUTLETS

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 328 | 1 | CD | 10 | 1.00 | 325 | 246 | 246 | 76% | 309 | 309 | 95% |
| 328 | 2 | CD | 10 | 1.00 | 325 | 260 | 260 | 80% | 316 | 316 | 97% |
| 328 | 3 | CD | 10 | 1.00 | 325 | 248 | 248 | 76% | 310 | 310 | 95% |
| 328 | 4 | CD | 10 | 1.00 | 325 | 333 | 333 | 102% | 318 | 318 | 98% |
| TOTALS | | | | | 1300 | | 1087 | 84% | | 1253 | 96% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-323

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 319 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008544 | |
| TYPE / SIZE | VAV | 8 |
| ADDRESS | - | |
| K-FACTOR | 859 | |
| APD | 1.49 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 500 | 513 |
| PRIMARY COOL MIN CFM | 170 | 172 |
| PRIMARY HEAT MIN CFM | 170 | 172 |
| PRIMARY HEAT MAX CFM | 270 | 270 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 270 | 270 |
| GPM | 1.25 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 98.83 | 90.53 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 88.55 | 85.20 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 319 | 1 | CD | 10 | 1.00 | 250 | 269 | 269 | 108% | 262 | 262 | 105% |
| 319 | 2 | CD | 10 | 1.00 | 250 | 256 | 256 | 102% | 251 | 251 | 100% |
| TOTALS | | | | | 500 | | 525 | 105% | | 513 | 103% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-324

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 303-306, 311, 314-316 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008561 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2043 | |
| APD | 0.79 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1400 | 1383 |
| PRIMARY COOL MIN CFM | 445 | 461 |
| PRIMARY HEAT MIN CFM | 445 | 461 |
| PRIMARY HEAT MAX CFM | 665 | 694 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 665 | 694 |
| GPM | 2.25 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 88.31 | 84.21 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 95.17 | 85.40 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 303 | 1 | CD | 8 | 1.00 | 150 | 136 | 136 | 91% | 145 | 145 | 97% |
| 304 | 2 | CD | 8 | 1.00 | 150 | 95 | 95 | 63% | 157 | 157 | 105% |
| 305 | 3 | CD | 6 | 1.00 | 60 | 83 | 83 | 138% | 58 | 58 | 97% |
| 306 | 4 | CD | 8 | 1.00 | 140 | 117 | 117 | 84% | 133 | 133 | 95% |
| 311 | 5 | CD | 8 | 1.00 | 140 | 93 | 93 | 66% | 141 | 141 | 101% |
| 316 | 6 | CD | 6 | 1.00 | 90 | 54 | 54 | 60% | 87 | 87 | 97% |
| 306 | 7 | CD | 10 | 1.00 | 200 | 122 | 122 | 61% | 195 | 195 | 98% |
| 315 | 8 | CD | 6 | 1.00 | 90 | 48 | 48 | 53% | 86 | 86 | 96% |
| 314 | 9 | CD | 8 | 1.00 | 110 | 71 | 71 | 65% | 115 | 115 | 105% |
| 306 | 10 | CD | 10 | 1.00 | 200 | 141 | 141 | 71% | 198 | 198 | 99% |
| STORAGE | 11 | CD | 6 | 1.00 | 70 | 45 | 45 | 64% | 68 | 68 | 97% |
| TOTALS | | | | | 1400 | | 1005 | 72% | | 1383 | 99% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-325

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 377-378 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008549 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1181 | |
| APD | 0.77 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 690 | 697 |
| PRIMARY COOL MIN CFM | 230 | 235 |
| PRIMARY HEAT MIN CFM | 230 | 235 |
| PRIMARY HEAT MAX CFM | 340 | 346 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 340 | 346 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.86 | 83.25 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 86.37 | 83.30 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 377 | 1 | CD | 10 | 1.00 | 300 | 242 | 242 | 81% | 288 | 288 | 96% |
| 377 | 2 | CD | 10 | 1.00 | 300 | 267 | 267 | 89% | 315 | 315 | 105% |
| 378 | 3 | CD | 6 | 1.00 | 90 | 78 | 78 | 87% | 94 | 94 | 104% |
| TOTALS | | | | | 690 | | 587 | 85% | | 697 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/15/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-326

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 376 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008545 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1131 | |
| APD | 0.82 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 590 | 601 |
| PRIMARY COOL MIN CFM | 200 | 205 |
| PRIMARY HEAT MIN CFM | 200 | 205 |
| PRIMARY HEAT MAX CFM | 300 | 311 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 300 | 311 |
| GPM | 1.00 | 1.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.97 | 86.33 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 89.00 | 82.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 376 | 1 | CD | 10 | 1.00 | 270 | 218 | 218 | 81% | 279 | 279 | 103% |
| 376 | 2 | CD | 10 | 1.00 | 270 | 216 | 216 | 80% | 270 | 270 | 100% |
| STORAGE | 3 | CD | 6 | 1.00 | 50 | 58 | 58 | 116% | 52 | 52 | 104% |
| TOTALS | | | | | 590 | | 492 | 83% | | 601 | 102% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-327

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 377 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008547 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1363 | |
| APD | 0.78 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 600 | 585 |
| PRIMARY COOL MIN CFM | 200 | 205 |
| PRIMARY HEAT MIN CFM | 200 | 205 |
| PRIMARY HEAT MAX CFM | 370 | 376 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 370 | 376 |
| GPM | 1.25 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.14 | 84.33 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 87.66 | 86.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 377 | 1 | CD | 10 | 1.00 | 300 | 285 | 285 | 95% | 285 | 285 | 95% |
| 377 | 2 | CD | 10 | 1.00 | 300 | 300 | 300 | 100% | 300 | 300 | 100% |
| TOTALS | | | | | 600 | | 585 | 98% | | 585 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-328

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 371-372, OFFICE | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008548 | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1328 | |
| APD | 0.76 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 590 | 578 |
| PRIMARY COOL MIN CFM | 200 | 204 |
| PRIMARY HEAT MIN CFM | 200 | 204 |
| PRIMARY HEAT MAX CFM | 370 | 375 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 370 | 375 |
| GPM | 1.25 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.14 | 86.59 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 87.66 | 82.60 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 372 | 1 | CD | 10 | 1.00 | 270 | 228 | 228 | 84% | 257 | 257 | 95% |
| 372 | 2 | CD | 8 | 1.00 | 160 | 162 | 162 | 101% | 168 | 168 | 105% |
| OFFICE | 3 | CD | 6 | 1.00 | 80 | 84 | 84 | 105% | 77 | 77 | 96% |
| 371 | 4 | CD | 6 | 1.00 | 80 | 91 | 91 | 114% | 76 | 76 | 95% |
| TOTALS | | | | | 590 | | 565 | 96% | | 578 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-329

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 372 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008574 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2988 | |
| APD | 0.84 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2550 | 2469 |
| PRIMARY COOL MIN CFM | 855 | 859 |
| PRIMARY HEAT MIN CFM | 855 | 859 |
| PRIMARY HEAT MAX CFM | 1280 | 1286 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1280 | 1286 |
| GPM | 4.50 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 93.47 | 89.00 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 88.51 | 80.00 |
| | | |

**UNIT AIR OUTLETS**

| AREA SERVED | OUTLET # | TYPE | SIZE | FACTOR | DESIGN CFM | PRELIMINARY FPM | PRELIMINARY CFM | PRELIMINARY % | FINAL FPM | FINAL CFM | FINAL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 372 | 1 | CD | 12 | 1.00 | 510 | 509 | 509 | 100% | 502 | 502 | 98% |
| 372 | 2 | CD | 12 | 1.00 | 510 | 418 | 418 | 82% | 503 | 503 | 99% |
| 372 | 3 | CD | 12 | 1.00 | 510 | 403 | 403 | 79% | 490 | 490 | 96% |
| 372 | 4 | CD | 12 | 1.00 | 510 | 381 | 381 | 75% | 485 | 485 | 95% |
| 372 | 5 | CD | 12 | 1.00 | 510 | 407 | 407 | 80% | 489 | 489 | 96% |
| TOTALS | | | | | 2550 | | 2118 | 83% | | 2469 | 97% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-330

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 369 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008572 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2745 | |
| APD | 0.64 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2450 | 2506 |
| PRIMARY COOL MIN CFM | 820 | 783 |
| PRIMARY HEAT MIN CFM | 820 | 783 |
| PRIMARY HEAT MAX CFM | 1225 | 1171 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1225 | 1171 |
| GPM | 4.00 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 92.33 | 86.34 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 87.74 | 83.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 369 | 1 | CD | 12 | 1.00 | 490 | 342 | 342 | 70% | 514 | 514 | 105% |
| 369 | 2 | CD | 12 | 1.00 | 490 | 314 | 314 | 64% | 489 | 489 | 100% |
| 369 | 3 | CD | 12 | 1.00 | 490 | 306 | 306 | 62% | 482 | 482 | 98% |
| 369 | 4 | CD | 12 | 1.00 | 490 | 348 | 348 | 71% | 513 | 513 | 105% |
| 369 | 5 | CD | 12 | 1.00 | 490 | 319 | 319 | 65% | 508 | 508 | 104% |
| TOTALS | | | | | 2450 | | 1629 | 66% | | 2506 | 102% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-331

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 313 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008543 | |
| TYPE / SIZE | VAV | 6 |
| ADDRESS | - | |
| K-FACTOR | 453 | |
| APD | 0.96 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 340 | 334 |
| PRIMARY COOL MIN CFM | 115 | 119 |
| PRIMARY HEAT MIN CFM | 115 | 119 |
| PRIMARY HEAT MAX CFM | 170 | 178 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 170 | 178 |
| GPM | 0.50 | 0.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.62 | 80.00 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 88.03 | 86.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 313 | 1 | CD | 8 | 1.00 | 170 | 169 | 169 | 99% | 163 | 163 | 96% |
| 313 | 2 | CD | 8 | 1.00 | 170 | 176 | 176 | 104% | 171 | 171 | 101% |
| TOTALS | | | | | 340 | | 345 | 101% | | 334 | 98% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-332

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 301, 320-321, 321A | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008573 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 2806 | |
| APD | 0.90 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1150 | 1161 |
| PRIMARY COOL MIN CFM | 285 | 291 |
| PRIMARY HEAT MIN CFM | 285 | 291 |
| PRIMARY HEAT MAX CFM | 575 | 586 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 575 | 586 |
| GPM | 2.50 | 2.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 94.75 | 89.05 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.13 | 85.70 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 321A | 1 | CD | 6 | 1.00 | 60 | 62 | 62 | 103% | 57 | 57 | 95% |
| 320 | 2 | CD | 8 | 1.00 | 130 | 96 | 96 | 74% | 129 | 129 | 99% |
| 320 | 3 | CD | 10 | 1.00 | 370 | 320 | 320 | 86% | 388 | 388 | 105% |
| 301 | 4 | CD | 8 | 1.00 | 120 | 87 | 87 | 73% | 120 | 120 | 100% |
| 321 | 5 | CD | 8 | 1.00 | 370 | 70 | 70 | 19% | 95 | 95 | 26% |
| 320 | 6 | CD | 10 | 1.00 | 100 | 290 | 290 | 290% | 372 | 372 | 372% |
| TOTALS | | | | | 1150 | | 925 | 80% | | 1161 | 101% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-333

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 320, 322, 322A | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008567 | |
| TYPE / SIZE | VAV | 14 |
| ADDRESS | - | |
| K-FACTOR | 2364 | |
| APD | 1.05 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1280 | 1239 |
| PRIMARY COOL MIN CFM | 425 | 416 |
| PRIMARY HEAT MIN CFM | 425 | 416 |
| PRIMARY HEAT MAX CFM | 640 | 611 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 640 | 611 |
| GPM | 2.00 | 2.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 86.82 | 86.45 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 94.15 | 82.30 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 320 | 1 | CD | 10 | 1.00 | 370 | 308 | 308 | 83% | 352 | 352 | 95% |
| 322 | 2 | CD | 6 | 1.00 | 85 | 106 | 106 | 125% | 88 | 88 | 104% |
| 320 | 3 | CD | 10 | 1.00 | 370 | 275 | 275 | 74% | 355 | 355 | 96% |
| 322A | 4 | CD | 6 | 1.00 | 85 | 97 | 97 | 114% | 84 | 84 | 99% |
| 320 | 5 | CD | 10 | 1.00 | 370 | 297 | 297 | 80% | 360 | 360 | 97% |
| TOTALS | | | | | 1280 | | 1083 | 85% | | 1239 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-334

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 320 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008576 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2620 | |
| APD | 1.11 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 1960 | 1958 |
| PRIMARY COOL MIN CFM | 655 | 678 |
| PRIMARY HEAT MIN CFM | 655 | 678 |
| PRIMARY HEAT MAX CFM | 980 | 1021 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 980 | 1021 |
| GPM | 3.00 | 3.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 90.83 | 84.12 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 87.73 | 82.60 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 320 | 1 | CD | 12 | 1.00 | 490 | 441 | 441 | 90% | 476 | 476 | 97% |
| 320 | 2 | CD | 12 | 1.00 | 490 | 369 | 369 | 75% | 514 | 514 | 105% |
| 320 | 3 | CD | 12 | 1.00 | 490 | 325 | 325 | 66% | 495 | 495 | 101% |
| 320 | 4 | CD | 12 | 1.00 | 490 | 336 | 336 | 69% | 473 | 473 | 97% |
| TOTALS | | | | | 1960 | | 1471 | 75% | | 1958 | 100% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-335

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 320 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008577 | |
| TYPE / SIZE | VAV | 16 |
| ADDRESS | - | |
| K-FACTOR | 2862 | |
| APD | 1.21 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 2550 | 2469 |
| PRIMARY COOL MIN CFM | 855 | 891 |
| PRIMARY HEAT MIN CFM | 855 | 891 |
| PRIMARY HEAT MAX CFM | 1275 | 1331 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 1275 | 1331 |
| GPM | 4.00 | 5.00 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 91.99 | 81.85 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 86.92 | 86.40 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 320 | 1 | CD | 12 | 1.00 | 510 | 456 | 456 | 89% | 485 | 485 | 95% |
| 320 | 2 | CD | 12 | 1.00 | 510 | 439 | 439 | 86% | 491 | 491 | 96% |
| 320 | 3 | CD | 12 | 1.00 | 510 | 439 | 439 | 86% | 495 | 495 | 97% |
| 320 | 4 | CD | 12 | 1.00 | 510 | 389 | 389 | 76% | 507 | 507 | 99% |
| 320 | 5 | CD | 12 | 1.00 | 510 | 366 | 366 | 72% | 491 | 491 | 96% |
| TOTALS | | | | | 2550 | | 2089 | 82% | | 2469 | 97% |
| | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/21/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-336

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 312 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | 6HBM008556 | |
| TYPE / SIZE | VAV | 12 |
| ADDRESS | - | |
| K-FACTOR | 1764 | |
| APD | 0.91 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 940 | 909 |
| PRIMARY COOL MIN CFM | 315 | 307 |
| PRIMARY HEAT MIN CFM | 315 | 307 |
| PRIMARY HEAT MAX CFM | 470 | 449 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 470 | 449 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 89.89 | 85.73 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 90.53 | 84.00 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 312 | 1 | CD | 10 | 1.00 | 315 | 305 | 305 | 97% | 309 | 309 | 98% |
| 312 | 2 | CD | 10 | 1.00 | 315 | 297 | 297 | 94% | 305 | 305 | 97% |
| 312 | 3 | CD | 10 | 1.00 | 310 | 276 | 276 | 89% | 295 | 295 | 95% |
| TOTALS | | | | | 940 | | 878 | 93% | | 909 | 97% |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## VARIABLE AIR VOLUME WITH HOT WATER TEST SHEET

**PROJECT:** MCLB ALBANY GHPs WITH USTES BUILDING 3700 **UNIT NUMBER:** VAV-337

**LOCATION:** ALBANY, GA **SERVED BY:** AHU-3A / 3B

| UNIT DATA | | |
|---|---|---|
| LOCATION | CEILING | |
| SERVICE | 308 | |
| MANUFACTURER | JOHNSON CONTROLS | |
| MODEL NUMBER | TSSWC | |
| SERIAL NUMBER | * | |
| TYPE / SIZE | VAV | 10 |
| ADDRESS | - | |
| K-FACTOR | 1395 | |
| APD | 0.86 | |
| **CALIBRATION** | **DESIGN** | **ACTUAL** |
| CFM | - | - |
| K-FACTOR | - | - |
| | | |

| PERFORMANCE DATA | | |
|---|---|---|
| **AIRFLOW** | **DESIGN** | **ACTUAL** |
| PRIMARY COOL MAX CFM | 750 | 726 |
| PRIMARY COOL MIN CFM | 250 | 255 |
| PRIMARY HEAT MIN CFM | 250 | 255 |
| PRIMARY HEAT MAX CFM | 375 | 383 |
| **REHEAT COIL** | **DESIGN** | **ACTUAL** |
| CFM | 375 | 383 |
| GPM | 1.50 | 1.50 |
| ENT WATER TEMP ˚F | 115.00 | 105.00 |
| LVG WATER TEMP ˚F | 94.84 | 88.12 |
| ENT AIR TEMP ˚F | 54.00 | 54.20 |
| LVG AIR TEMP ˚F | 90.77 | 84.80 |
| | | |

**UNIT AIR OUTLETS**

| | OUTLET | | | | DESIGN | PRELIMINARY | | | FINAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA SERVED | # | TYPE | SIZE | FACTOR | CFM | FPM | CFM | % | FPM | CFM | % |
| 308 | 1 | CD | 10 | 1.00 | 250 | 246 | 246 | 98% | 245 | 245 | 98% |
| 308 | 2 | CD | 10 | 1.00 | 250 | 262 | 262 | 105% | 241 | 241 | 96% |
| 308 | 3 | CD | 10 | 1.00 | 250 | 216 | 216 | 86% | 240 | 240 | 96% |
| TOTALS | | | | | 750 | | 724 | 97% | | 726 | 97% |
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**REMARKS:** LABELED VAV-327 ON DRAWINGS. * UNABLE TO ACCESS.

**TECHNICIAN:** MD/TB **TEST DATE:** 5/20/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## ENERGY RECOVERY UNIT (SUPPLY) TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** ERU-1

| UNIT DATA | |
|---|---|
| LOCATION | ROOF |
| SERVICE | AHU OSA |
| MANUFACTURER | DES CHAMPS |
| MODEL NUMBER | PV24 |
| SERIAL NUMBER | 940572 |
| FILTERS | - |
| | |

| PERFORMANCE | | |
|---|---|---|
| AIRFLOW | DESIGN | ACTUAL |
| TOTAL FAN CFM | 23400 | 24432 |
| TOTAL OUTLET CFM | 23400 | 19491 |
| RETURN CFM | - | - |
| OSA CFM | 23400 | 24432 |
| RELIEF | - | - |
| | | |

| MOTOR DATA | NAMEPLATE | ACTUAL |
|---|---|---|
| MANUFACTURER | BALDOR | |
| HP / BHP | 30.00 / - | 30.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 471 / 470 / 468 |
| AMPS | 36.00 | 25.1 / 26.0 / 26.0 |
| MOTOR RPM | 1760 | 1779 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | ADJUSTABLE (29 - 44.1) | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 7 1/2" O.D. x BX 7/8 | |
| FAN SHEAVE SZ / BORE | 9 1/2" O.D. x 2 1/8 | |
| # BELTS / SIZE | 2 x 5BX1000 | |
| FAN RPM | - | 1383 |
| CENTER DISTANCE | 37 | |

| STATIC | DESIGN | ACTUAL |
|---|---|---|
| TOTAL STATIC PRESSURE | - | 2.54 |
| EXTERNAL STATIC P | - | 1.09 |
| EYE OF FAN | - | -2.31 |
| SUCTION PRESSURE | - | -0.86 |
| DISCHARGE PRESSURE | - | 0.23 |
| | | |
| | | |

| TEMPERATURES °F | DESIGN | | ACTUAL | |
|---|---|---|---|---|
| COOL ENT AIR TEMP DB/WB | - | - | - | - |
| COOL LVG AIR TEMP DB/WB | - | - | - | - |
| HEAT ENT AIR TEMP DB | - | | - | |
| HEAT LVG AIR TEMP DB | - | | - | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** ERU-1 SUPPLY
**DUCT SIZE:** 16 @ 24 x 18
**DUCT AREA:** 48.00

**DESIGN FPM:** 488
**DESIGN CFM:** 23400
**ACTUAL CFM:** 24432

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 281 | 583 | 651 | 568 | | | | | | | | |
| 376 | 552 | 400 | 599 | | | | | | | | |
| 591 | 561 | 496 | 482 | | | | | | | | |
| 496 | 520 | 473 | 511 | | | | | | | | |
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**ACTUAL FPM:** 509

**INITIAL STATIC PRESSURE:** - @ - CFM
**FINAL STATIC PRESSURE:** - @ 24432 CFM

**REMARKS:** ERU-1 SUPPLY = AHU OSAs: 1947 + 2038 + 4569 + 3955 + 5615 + 1367 = 19491 CFM.

**TECHNICIAN:** MD/TB

**TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## ENERGY RECOVERY UNIT (EXHAUST) TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** ERU-1

| UNIT DATA | |
|---|---|
| LOCATION | ROOF |
| SERVICE | EXHAUST |
| MANUFACTURER | DES CHAMPS |
| MODEL NUMBER | PV24 |
| SERIAL NUMBER | 940572 |
| FILTERS | - |
| | |

| PERFORMANCE | | |
|---|---|---|
| AIRFLOW | DESIGN | ACTUAL |
| TOTAL FAN CFM | 12820 | 16675 |
| TOTAL OUTLET CFM | - | - |
| RETURN CFM | - | - |
| OSA CFM | - | - |
| RELIEF | - | - |
| | | |

| MOTOR DATA | NAMEPLATE | ACTUAL |
|---|---|---|
| MANUFACTURER | MARATHON | |
| HP / BHP | 15.00 / - | 15.00 / - |
| PHASE / HZ | 3/60 | 3/60 |
| VOLTAGE | 460 | 471 / 471 / 468 |
| AMPS | 16.60 | 12.0 / 11.1 / 12.4 |
| MOTOR RPM | 1740 | 1776 |
| SF / EFF / PF | 1.15 / - / - | |
| STARTER HEATER ELEMENTS | ADJUSTABLE (14 - 22) | |
| FRAME | - | |
| MOTOR SHEAVE SZ / BORE | 2VP71A x 1 5/8 | |
| FAN SHEAVE SZ / BORE | 11 1/4" O.D. x 2 3/16 | |
| # BELTS / SIZE | 1 x 5VX1120 | |
| FAN RPM | - | 1006 |
| CENTER DISTANCE | 42 | |

| STATIC | DESIGN | ACTUAL |
|---|---|---|
| TOTAL STATIC PRESSURE | - | 3.06 |
| EXTERNAL STATIC P | - | 2.74 |
| EYE OF FAN | - | -2.46 |
| SUCTION PRESSURE | - | -2.14 |
| DISCHARGE PRESSURE | - | 0.60 |
| | | |
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| WHEEL DATA | DESIGN | ACTUAL |
|---|---|---|
| ΔP ACROSS WHEEL | - | - |
| RPM | - | - |
| BELT SIZE | - | |
| | | |
| | | |

**REMARKS:** RUNNING AT 130%; UNABLE TO ADJUST SHEAVES DUE TO RUST BUILD UP.

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DUCT TRAVERSE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA

**SYSTEM:** ERU-1 EXHAUST
**DUCT SIZE:** 30 x 39
**DUCT AREA:** 8.13

**DESIGN FPM:** 1577
**DESIGN CFM:** 12820
**ACTUAL CFM:** 16675

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1968 | 2285 | 1957 | | | | | | | | | |
| 2078 | 1670 | 2349 | | | | | | | | | |
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**ACTUAL FPM:** 2051

**INITIAL STATIC PRESSURE:** - @ 16675 CFM
**FINAL STATIC PRESSURE:** - @ 16675 CFM

**REMARKS:**

**TECHNICIAN:** MD/TB
**TEST DATE:** 7/1/2015

## STATIC PRESSURE PROFILE

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** AHU-1A

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.32 | |
| MIXING BOX | 2 | -0.64 | |
| AFTER FILTERS | 3 | -0.76 | |
| EYE OF FAN | 4 | -1.70 | |
| DISCHARGE | 5 | 1.65 | |
| | | | |
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**SYSTEM:** AHU-1B

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.38 | |
| MIXING BOX | 2 | -0.73 | |
| AFTER FILTERS | 3 | -0.98 | |
| EYE OF FAN | 4 | -1.77 | |
| DISCHARGE | 5 | 1.45 | |
| | | | |
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**SYSTEM:** AHU-2A

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.15 | |
| MIXING BOX | 2 | -0.69 | |
| AFTER FILTERS | 3 | -0.91 | |
| EYE OF FAN | 4 | -1.62 | |
| DISCHARGE | 5 | 2.00 | |
| | | | |
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**TECHNICIAN:** MD/TB **TEST DATE:** 7/1/2015

## STATIC PRESSURE PROFILE

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** AHU-2B

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.19 | |
| MIXING BOX | 2 | -0.63 | |
| AFTER FILTERS | 3 | -0.86 | |
| EYE OF FAN | 4 | -1.68 | |
| DISCHARGE | 5 | 2.65 | |
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**SYSTEM:** AHU-3A

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.23 | |
| MIXING BOX | 2 | -0.68 | |
| AFTER FILTERS | 3 | -0.96 | |
| EYE OF FAN | 4 | -1.84 | |
| DISCHARGE | 5 | 1.41 | |
| | | | |
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**SYSTEM:** AHU-3B

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| RETURN | 1 | -0.35 | |
| MIXING BOX | 2 | -0.71 | |
| AFTER FILTERS | 3 | -1.01 | |
| EYE OF FAN | 4 | -1.97 | |
| DISCHARGE | 5 | 1.44 | |
| | | | |
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**TECHNICIAN:** MD/TB **TEST DATE:** 7/1/2015 7/29/2015

## STATIC PRESSURE PROFILE

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** ERU-1 SUPPLY

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| SUCTION | 1 | -0.86 | |
| EYE OF FAN | 2 | -2.31 | |
| DISCHARGE | 3 | 0.23 | |
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**SYSTEM:** ERU-1 EXHAUST

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
| SUCTION | 1 | -2.14 | |
| EYE OF FAN | 2 | -2.46 | |
| DISCHARGE | 3 | 0.60 | |
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**SYSTEM:**

| AREA | # | STATIC in WG | REMARKS |
|---|---|---|---|
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**TECHNICIAN:** MD/TB **TEST DATE:** 7/1/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC HEATER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| UNIT DATA | |
|---|---|
| UNIT NUMBER | UH-1 |
| LOCATION | PUMP ROOM |
| SERVICE | 154 |
| MANUFACTURER | STERLING |
| MODEL NUMBER | HS-054 |
| SERIAL NUMBER | D1501374344-001001 |
| | |
| | |
| | |

| PERFORMANCE | DESIGN | ACTUAL |
|---|---|---|
| CFM | 1400 | 1413 |
| GPM | 2.30 | 2.30 |
| HP | 0.08 | 0.08 |
| PHASE | 1 | 1 |
| VOLTAGE | 115 | 121 |
| AMPS | 2.20 | 1.50 |
| RPM | 1080 | DIRECT DRIVE |
| ENT WATER TEMP ˚F | - | 82.00 |
| LVG WATER TEMP ˚F | - | 97.60 |

| UNIT DATA | |
|---|---|
| UNIT NUMBER | |
| LOCATION | |
| SERVICE | |
| MANUFACTURER | |
| MODEL NUMBER | |
| SERIAL NUMBER | |
| | |
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| | |

| PERFORMANCE | DESIGN | ACTUAL |
|---|---|---|
| CFM | | |
| GPM | | |
| HP | | |
| PHASE | | |
| VOLTAGE | | |
| AMPS | | |
| RPM | | |
| ENT WATER TEMP ˚F | | |
| LVG WATER TEMP ˚F | | |

| UNIT DATA | |
|---|---|
| UNIT NUMBER | |
| LOCATION | |
| SERVICE | |
| MANUFACTURER | |
| MODEL NUMBER | |
| SERIAL NUMBER | |
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| PERFORMANCE | DESIGN | ACTUAL |
|---|---|---|
| CFM | | |
| GPM | | |
| HP | | |
| PHASE | | |
| VOLTAGE | | |
| AMPS | | |
| RPM | | |
| ENT WATER TEMP ˚F | | |
| LVG WATER TEMP ˚F | | |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-1

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | BTES LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x6x11.5 4030 |
| SERIAL NUMBER | 757889 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 30.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 35.40 / 1.15 |
| DESIGN GPM | 845.00 |
| DESIGN FT HEAD | 88.20 |
| DESIGN IMPELLER (IN) | 11.50 |
| REQ. NPSH | - |
| EFF / PF | 94.1 / 83 |
| FRAME | 286TC |
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| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 46.30 |
| SHUT OFF DISCHARGE PSI | 88.30 |
| SHUT OFF DIFF PSI | 41.90 |
| SHUT OFF FT HEAD | 96.80 |
| WIDE OPEN SUCTION PSI | 26.00 |
| WIDE OPEN DISCHARGE PSI | 54.30 |
| WIDE OPEN DIFF PSI | 28.30 |
| WIDE OPEN FT HEAD | 65.20 |
| WIDE OPEN GPM | 1150.00 |
| FINAL SUCTION PSI | 39.00 |
| FINAL DISCHARGE PSI | 74.30 |
| DIFFERENTIAL PSI | 35.30 |
| FINAL FT HEAD | 81.50 |
| FINAL GPM | 820.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 471 / 474 / 473 |
| AMPS | 30.6 / 31.0 / 29.8 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 10.00 |
| HP / BHP | 30.00 / 26.11 |
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**REMARKS:**

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-2

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | BTES LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x6x11.5 4030 |
| SERIAL NUMBER | 757890 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 30.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 35.40 / 1.15 |
| DESIGN GPM | 845.00 |
| DESIGN FT HEAD | 88.20 |
| DESIGN IMPELLER (IN) | 11.50 |
| REQ. NPSH | - |
| EFF / PF | 94.1 / 83 |
| FRAME | 286TC |
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| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 43.80 |
| SHUT OFF DISCHARGE PSI | 85.90 |
| SHUT OFF DIFF PSI | 42.10 |
| SHUT OFF FT HEAD | 97.20 |
| WIDE OPEN SUCTION PSI | 25.90 |
| WIDE OPEN DISCHARGE PSI | 53.30 |
| WIDE OPEN DIFF PSI | 27.40 |
| WIDE OPEN FT HEAD | 63.30 |
| WIDE OPEN GPM | 1170.00 |
| FINAL SUCTION PSI | 37.40 |
| FINAL DISCHARGE PSI | 75.50 |
| DIFFERENTIAL PSI | 38.10 |
| FINAL FT HEAD | 88.01 |
| FINAL GPM | 830.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 476 / 471 / 473 |
| AMPS | 29.3 / 28.7 / 29.0 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 10.00 |
| HP / BHP | 30.00 / 24.90 |
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**REMARKS:**

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-3

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | CHILLED SOURCE LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x5x10 4030 |
| SERIAL NUMBER | 757843 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 20.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 25.00 / 1.15 |
| DESIGN GPM | 845.00 |
| DESIGN FT HEAD | 55.00 |
| DESIGN IMPELLER (IN) | 10.00 |
| REQ. NPSH | - |
| EFF / PF | 93 / 81 |
| FRAME | 254/6TC |
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| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 53.60 |
| SHUT OFF DISCHARGE PSI | 80.50 |
| SHUT OFF DIFF PSI | 26.80 |
| SHUT OFF FT HEAD | 62.00 |
| WIDE OPEN SUCTION PSI | 42.70 |
| WIDE OPEN DISCHARGE PSI | 64.10 |
| WIDE OPEN DIFF PSI | 21.30 |
| WIDE OPEN FT HEAD | 49.30 |
| WIDE OPEN GPM | 900.00 |
| FINAL SUCTION PSI | 42.70 |
| FINAL DISCHARGE PSI | 64.10 |
| DIFFERENTIAL PSI | 21.30 |
| FINAL FT HEAD | 49.30 |
| FINAL GPM | 900.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 473 / 471 / 472 |
| AMPS | 23.3 / 24.0 / 23.6 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 8.500 |
| HP / BHP | 20.00 / 19.51 |
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**REMARKS:** DELTA P CONTROLLING SETPOINT IS 4.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/25/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-4

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | CHILLED SOURCE LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x5x10 4030 |
| SERIAL NUMBER | 757844 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 20.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 25.00 / 1.15 |
| DESIGN GPM | 845.00 |
| DESIGN FT HEAD | 55.00 |
| DESIGN IMPELLER (IN) | 10.00 |
| REQ. NPSH | - |
| EFF / PF | 93 / 81 |
| FRAME | 254/6TC |
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| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 53.80 |
| SHUT OFF DISCHARGE PSI | 80.80 |
| SHUT OFF DIFF PSI | 27.00 |
| SHUT OFF FT HEAD | 62.40 |
| WIDE OPEN SUCTION PSI | 42.20 |
| WIDE OPEN DISCHARGE PSI | 64.30 |
| WIDE OPEN DIFF PSI | 22.00 |
| WIDE OPEN FT HEAD | 50.90 |
| WIDE OPEN GPM | 900.00 |
| FINAL SUCTION PSI | 42.20 |
| FINAL DISCHARGE PSI | 64.30 |
| DIFFERENTIAL PSI | 22.00 |
| FINAL FT HEAD | 50.90 |
| FINAL GPM | 900.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 473 / 474 / 472 |
| AMPS | 23.6 / 23.0 / 24.0 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 8.50 |
| HP / BHP | 20.00 / 19.47 |
| | |
| | |
| | |
| | |
| | |

**REMARKS:** DELTA P CONTROLLING SETPOINT IS 4.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-5

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x4x13 4030 |
| SERIAL NUMBER | 757891 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 40.00 |
| NAME PLATE MOTOR RPM | 1775 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 48.20 / 1.15 |
| DESIGN GPM | 912.00 |
| DESIGN FT HEAD | 128.70 |
| DESIGN IMPELLER (IN) | 13.00 |
| REQ. NPSH | - |
| EFF / PF | 94.1 / 83 |
| FRAME | 324TC |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 43.00 |
| SHUT OFF DISCHARGE PSI | 112.90 |
| SHUT OFF DIFF PSI | 69.80 |
| SHUT OFF FT HEAD | 161.10 |
| WIDE OPEN SUCTION PSI | 38.00 |
| WIDE OPEN DISCHARGE PSI | 92.00 |
| WIDE OPEN DIFF PSI | 54.60 |
| WIDE OPEN FT HEAD | 124.50 |
| WIDE OPEN GPM | 950.00 |
| FINAL SUCTION PSI | 38.00 |
| FINAL DISCHARGE PSI | 92.00 |
| DIFFERENTIAL PSI | 54.60 |
| FINAL FT HEAD | 124.50 |
| FINAL GPM | 950.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 473 / 475 / 472 |
| AMPS | 41.7 / 43.6 / 44.0 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 12.50 |
| HP / BHP | 40.00 / 37.00 |
| | |
| | |
| | |
| | |
| | |

**REMARKS:** DELTA P CONTROLLING SETPOINT IS 5.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-6

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 6x4x13 4030 |
| SERIAL NUMBER | 757892 |
| MOTOR MANUFACTURER | WEG |
| NAME PLATE HP | 40.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 48.20 / 1.15 |
| DESIGN GPM | 912.00 |
| DESIGN FT HEAD | 128.00 |
| DESIGN IMPELLER (IN) | 13.00 |
| REQ. NPSH | - |
| EFF / PF | 94.1 / 83 |
| FRAME | 324TC |
| | |
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| | |
| | |
| | |

| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 43.40 |
| SHUT OFF DISCHARGE PSI | 113.70 |
| SHUT OFF DIFF PSI | 70.20 |
| SHUT OFF FT HEAD | 162.00 |
| WIDE OPEN SUCTION PSI | 37.70 |
| WIDE OPEN DISCHARGE PSI | 91.20 |
| WIDE OPEN DIFF PSI | 53.50 |
| WIDE OPEN FT HEAD | 123.50 |
| WIDE OPEN GPM | 960.00 |
| FINAL SUCTION PSI | 37.70 |
| FINAL DISCHARGE PSI | 91.20 |
| DIFFERENTIAL PSI | 53.50 |
| FINAL FT HEAD | 123.50 |
| FINAL GPM | 960.00 |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 472 / 471 / 474 |
| AMPS | 42.0 / 43.6 / 44.0 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 12.50 |
| HP / BHP | 40.00 / 37.08 |
| | |
| | |
| | |
| | |
| | |

**REMARKS:** DELTA P CONTROLLING SETPOINT IS 5.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-7

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | HOT WATER LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 3x2x13 4030 |
| SERIAL NUMBER | 757845 |
| MOTOR MANUFACTURER | ARMSTRONG |
| NAME PLATE HP | 15.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 18.20 / 1.00 |
| DESIGN GPM | 200.00 |
| DESIGN FT HEAD | 109.00 |
| DESIGN IMPELLER (IN) | 13.00 |
| REQ. NPSH | - |
| EFF / PF | 92.4 / 81 |
| FRAME | 254TC |
| | |
| | |
| | |
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| | |
| | |
| | |

| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 35.20 |
| SHUT OFF DISCHARGE PSI | 86.60 |
| SHUT OFF DIFF PSI | 51.30 |
| SHUT OFF FT HEAD | 118.50 |
| WIDE OPEN SUCTION PSI | 31.90 |
| WIDE OPEN DISCHARGE PSI | 66.40 |
| WIDE OPEN DIFF PSI | 35.00 |
| WIDE OPEN FT HEAD | 80.80 |
| WIDE OPEN GPM | 300.00 |
| FINAL SUCTION PSI | - |
| FINAL DISCHARGE PSI | - |
| DIFFERENTIAL PSI | - |
| FINAL FT HEAD | - |
| FINAL GPM | - |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 473 / 472 / 473 |
| AMPS | 16.9 / 16.3 / 16.5 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 10.50 |
| HP / BHP | 15.00 / 13.61 |
| | |
| | |
| | |
| | |
| | |

**REMARKS:** DELTA P CONTROLLING SETPOINT IS 2.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HYDRONIC PUMP TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA **UNIT NUMBER:** P-8

| PUMP DATA | |
|---|---|
| LOCATION | MECH ROOM |
| SERVICE | HOT WATER LOOP |
| MANUFACTURER | ARMSTRONG |
| MODEL NUMBER | 3x2x13 4030 |
| SERIAL NUMBER | 757846 |
| MOTOR MANUFACTURER | ARMSTRONG |
| NAME PLATE HP | 15.00 |
| NAME PLATE MOTOR RPM | 1770 |
| VOLTAGE / PHASE | 460 / 3 |
| FL AMPS / SF | 18.20 / 1.00 |
| DESIGN GPM | 200.00 |
| DESIGN FT HEAD | 109.00 |
| DESIGN IMPELLER (IN) | 13.00 |
| REQ. NPSH | - |
| EFF / PF | 92.4 / 81 |
| FRAME | 254TC |
| | |
| | |
| | |
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| | |
| | |
| | |
| | |
| | |

| TEST DATA | READING |
|---|---|
| SHUT OFF SUCTION PSI | 46.40 |
| SHUT OFF DISCHARGE PSI | 97.70 |
| SHUT OFF DIFF PSI | 57.20 |
| SHUT OFF FT HEAD | 118.20 |
| WIDE OPEN SUCTION PSI | 32.00 |
| WIDE OPEN DISCHARGE PSI | 67.90 |
| WIDE OPEN DIFF PSI | 35.90 |
| WIDE OPEN FT HEAD | 82.80 |
| WIDE OPEN GPM | 290.00 |
| FINAL SUCTION PSI | - |
| FINAL DISCHARGE PSI | - |
| DIFFERENTIAL PSI | - |
| FINAL FT HEAD | - |
| FINAL GPM | - |
| PUMP OFF PRESSURE PSI | - |
| VOLTAGE | 473 / 471 / 472 |
| AMPS | 17.0 / 16.8 / 16.7 |
| HERTZ | 60.00 |
| ACTUAL IMP DIA | 10.50 |
| HP / BHP | 15.00 / 13.81 |
| | |
| | |
| | |
| | |
| | |

**REMARKS:** DELTA P CONTROLLING SETPOINT IS 2.50 PSI.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## WATER COOLED CHILLER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | CHILLER-1 |
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER |
| MANUFACTURER | CLIMACOOL |
| MODEL NUMBER | UCH085AFASAWB0S |
| SERIAL NUMBER | C1413210188 |
| TONS | * |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | 460 | * |
| R.L.A. | 143.40 | * |
| % LOADED | - | * |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | 197.30 | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 54.00 | * |
| LVG WATER TEMP °F | 44.00 | * |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | - | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 85.00 | * |
| LVG WATER TEMP °F | 97.00 | * |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB °F | - | * |
| OUTSIDE AIR WB °F | - | * |

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | CHILLER-2 |
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER |
| MANUFACTURER | CLIMACOOL |
| MODEL NUMBER | UCH085AFASAWB0S |
| SERIAL NUMBER | C1413210189 |
| TONS | * |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | 460 | * |
| R.L.A. | 143.40 | * |
| % LOADED | - | * |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | 197.30 | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 54.00 | * |
| LVG WATER TEMP °F | 44.00 | * |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | - | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 85.00 | * |
| LVG WATER TEMP °F | 97.00 | * |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB °F | - | * |
| OUTSIDE AIR WB °F | - | * |

**REMARKS:** * SEE MANUFACTURER'S START UP SHEET.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

CLIMACOOL
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 79 Page 1 of 1

| | | | |
|---|---|---|---|
| **Project Name:** | NAVFAC Building 3700 | **Contractor Name:** | SafeAire Heating & Cooling |
| **Address:** | 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE | **Address:** | 3199 Palmyra Road |
| **City/State/Zip:** | Albany, GA 31704 | **City/State/Zip:** | Albany, GA 31707 |
| **Startup Date:** | 3/27/15 | **Phone No.:** | 229-789-0124 |

## Module

| | |
|---|---|
| **Model No.:** | UCH085AFASAWBOS |
| **Serial No.:** | C1413210188 |
| **Chiller No.:** | 1 **Bank No.:** 1 |

## Compressor

| | |
|---|---|
| **Model No.:** | GSD80485VAB421 |
| **Serial No. 1:** | 2786200052 |
| **Serial No. 2:** | 2786300444 |

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 51.6/ 47.5 | 4.1 | Δ P |
| **Condenser:** | 53.2/ 50.9 | 2.1 | Δ P |
| **Source:** | 53 / 43 | 10 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► All wiring terminations in module panel, safeties and compressors tightened: ☑ Yes ☐ No

► Rotation of scroll compressor is correct: ☑ Yes ☐ No

## Voltage / Ground

**L1** 273 **L2** 272 **L3** 274

**Low Voltage (24V):** 24.3

## Phase / Phase

**L1/L2** 471 **L2/L3** 472 **L1/L3** 473

## Compressor Circuit #1

**Amperage:** **L1** 37 **L2** 41 **L3** 38

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 140 | 103 |
| **Suction Temperature:** | | 66.4 | 50.4 |
| **Compressor Superheat:** | | 17.6 | 17.5 |
| **Discharge Pressure:** | | 394 | 277 |
| **Discharge Line Temperature (F):** | 220° max | 165 | 142 |
| **Discharge Gas Superheat (F):** | 50° min | 50 | 52 |
| **Liquid Line Temperature:** | | 96 | 74 |
| **Liquid Subcooling:** | | 20 | 16 |
| **Evaporator Entering Water Temperature:** | | 75 | 50.2 |
| **Evaporator Leaving Water Temperature:** | | 56.6 | 43.4 |
| **Condenser Entering Water Temperature:** | | 98 | 75.1 |
| **Condenser Leaving Water Temperature:** | | 113 | 88.5 |
| **Evaporator Pressure Differential:** | | 2 | 4 |
| **Condenser Pressure Differential:** | | 2 | 2 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** **L1** 38 **L2** 41 **L3** 39

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 140 | 101 |
| **Suction Temperature:** | | 62.5 | 50.5 |
| **Compressor Superheat:** | | 13.3 | 18.4 |
| **Discharge Pressure:** | | 403 | 280 |
| **Discharge Line Temperature (F):** | 220° max | 160 | 141 |
| **Discharge Gas Superheat (F):** | 50° min | 53S | 50 |
| **Liquid Line Temperature:** | | 98 | 75 |
| **Liquid Subcooling:** | | 18 | 17 |
| **Evaporator Entering Water Temperature:** | | 75 | 50.2 |
| **Evaporator Leaving Water Temperature:** | | 56.6 | 43.4 |
| **Condenser Entering Water Temperature:** | | 99 | 75.1 |
| **Condenser Leaving Water Temperature:** | | 114 | 88.5 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:** Enrique Bordallo **Print Name:** Enrique Bordallo

**E-Signature:** ☑ Check Box **(Authorized Signature)**

CLIMACOOL
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 92 Page 1 of 1

| | | | |
|---|---|---|---|
| Project Name: | NAVFAC Building 3700 | Contractor Name: | SafeAire Heating & Cooling |
| Address: | 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE | Address: | 3199 Palmyra Road |
| City/State/Zip: | Albany, GA 31704 | City/State/Zip: | Albany, GA 31707 |
| Startup Date: | 3/27/15 | Phone No.: | 229-789-0124 |

## Module

| | |
|---|---|
| Model No.: | UCH085AFASAWBOS |
| Serial No.: | C1413210189 |
| Chiller No.: | 2 |
| Bank No.: | 1 |

## Compressor

| | |
|---|---|
| Model No.: | GSD80485VAB421 |
| Serial No. 1: | 2786300436 |
| Serial No. 2: | 2786200056 |

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| Evaporator: | 49 / 43 | 6 | Δ P |
| Condenser: | 50.5/ 45.5 | 5 | Δ P |
| Source: | 55 / 47 | 8 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| Evaporator: | ☑ Yes | ☐ N/A |
| Condenser: | ☑ Yes | ☐ N/A |
| Source: | ☑ Yes | ☐ N/A |

"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop: ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► All wiring terminations in module panel, safeties and compressors tightened: ☑ Yes ☐ No

► Rotation of scroll compressor is correct: ☑ Yes ☐ No

## Voltage / Ground

L1 275 L2 274 L3 275

Low Voltage (24V): 24.5

## Phase / Phase

L1/L2 475 L2/L3 475 L1/L3 477

## Compressor Circuit #1

Amperage: L1 39.3 L2 41.5 L3 39.8

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 3/4 | 3/4 |
| Suction Pressure: | | 137 | 104 |
| Suction Temperature: | | 71.6 | 51.3 |
| Compressor Superheat: | | 23.2 | 17.8 |
| Discharge Pressure: | | 399 | 290 |
| Discharge Line Temperature (F): | 220° max | 171 | 146 |
| Discharge Gas Superheat (F): | 50° min | 52 | 52 |
| Liquid Line Temperature: | | 95 | 80 |
| Liquid Subcooling: | | 21 | 14 |
| Evaporator Entering Water Temperature: | | 78 | 51 |
| Evaporator Leaving Water Temperature: | | 55.6 | 44 |
| Condenser Entering Water Temperature: | | 101 | 80 |
| Condenser Leaving Water Temperature: | | 118 | 90.6 |
| Evaporator Pressure Differential: | | 2 | 4 |
| Condenser Pressure Differential: | | 2 | 3 |

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

Amperage: L1 39.8 L2 41.8 L3 40.2

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/3 | 1/3 |
| Suction Pressure: | | 133 | 96 |
| Suction Temperature: | | 72.1 | 51.5 |
| Compressor Superheat: | | 25.6 | 22 |
| Discharge Pressure: | | 418 | 298 |
| Discharge Line Temperature (F): | 220° max | 180 | 152 |
| Discharge Gas Superheat (F): | 50° min | 60 | 57 |
| Liquid Line Temperature: | | 99 | 80 |
| Liquid Subcooling: | | 20 | 16 |
| Evaporator Entering Water Temperature: | | 78 | 52.9 |
| Evaporator Leaving Water Temperature: | | 55.6 | 45.5 |
| Condenser Entering Water Temperature: | | 101 | 80 |
| Condenser Leaving Water Temperature: | | 118 | 92 |

Software Version: UCH-SHC-HR.LON.06A.14

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

Rep Signature: Enrique Bordallo Print Name: Enrique Bordallo

E-Signature: ☑ Check Box (Authorized Signature)

# ADDISON ENERGY TECHNOLOGIES, LLC

## WATER COOLED CHILLER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | CHILLER-3 |
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER |
| MANUFACTURER | CLIMACOOL |
| MODEL NUMBER | UCH085AFASAWB0S |
| SERIAL NUMBER | C1413210187 |
| TONS | * |

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | CHILLER-4 |
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER |
| MANUFACTURER | CLIMACOOL |
| MODEL NUMBER | UCH085AFASAWB0S |
| SERIAL NUMBER | C1413210185 |
| TONS | * |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | 460 | * |
| R.L.A. | 143.40 | * |
| % LOADED | - | * |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | 460 | * |
| R.L.A. | 143.40 | * |
| % LOADED | - | * |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | 197.30 | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 54.00 | * |
| LVG WATER TEMP °F | 44.00 | * |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | 197.30 | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 54.00 | * |
| LVG WATER TEMP °F | 44.00 | * |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | - | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 85.00 | * |
| LVG WATER TEMP °F | 97.00 | * |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | - | * |
| ΔP FT | - | * |
| ENT WATER TEMP °F | 85.00 | * |
| LVG WATER TEMP °F | 97.00 | * |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB °F | - | * |
| OUTSIDE AIR WB °F | - | * |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB °F | - | * |
| OUTSIDE AIR WB °F | - | * |

**REMARKS:** * SEE MANUFACTURER'S START UP SHEET.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

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# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 90 Page 1 of 1

| | | | |
|---|---|---|---|
| Project Name: | NAVFAC Building 3700 | Contractor Name: | SafeAire Heating & Cooling |
| Address: | 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE | Address: | 3199 Palmyra Road |
| City/State/Zip: | Albany, GA 31704 | City/State/Zip: | Albany, GA 31707 |
| Startup Date: | 3/27/15 | Phone No.: | 229-789-0124 |

## Module

| | | | |
|---|---|---|---|
| Model No.: | UCH085AFASAWBOS | | |
| Serial No.: | C1413210187 | | |
| Chiller No.: | 3 | Bank No.: | 1 |

## Compressor

| | |
|---|---|
| Model No.: | GSD80485VAB421 |
| Serial No. 1: | 2786300441 |
| Serial No. 2: | 2786300440 |

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| Evaporator: | 51 / 49 | 2 | Δ P |
| Condenser: | 53 / 43 | 10 | Δ P |
| Source: | 53 / 50 | 3 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| Evaporator: | ☑ Yes | ☐ N/A |
| Condenser: | ☑ Yes | ☐ N/A |
| Source: | ☑ Yes | ☐ N/A |

"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop: ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► All wiring terminations in module panel, safeties and compressors tightened: ☑ Yes ☐ No

► Rotation of scroll compressor is correct: ☑ Yes ☐ No

## Voltage / Ground

L1 275 L2 273 L3 275

Low Voltage (24V): 24.5

## Phase / Phase

L1/L2 474 L2/L3 475 L1/L3 477

## Compressor Circuit #1

Amperage: L1 38 L2 40 L3 39

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/3 | 1/3 |
| Suction Pressure: | | 142 | 101 |
| Suction Temperature: | | 79.3 | 49.6 |
| Compressor Superheat: | | 28.9 | 16.9 |
| Discharge Pressure: | | 356 | 254 |
| Discharge Line Temperature (F): | 220° max | 166 | 138 |
| Discharge Gas Superheat (F): | 50° min | 54 | 54 |
| Liquid Line Temperature: | | 107 | 87 |
| Liquid Subcooling: | | 3 | 2 |
| Evaporator Entering Water Temperature: | | 81 | 50.5 |
| Evaporator Leaving Water Temperature: | | 60.3 | 44.5 |
| Condenser Entering Water Temperature: | | 98.3 | 80 |
| Condenser Leaving Water Temperature: | | 111.9 | 89.6 |
| Evaporator Pressure Differential: | | 3 | 4 |
| Condenser Pressure Differential: | | 2 | 4 |

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

Amperage: L1 39 L2 41 L3 40

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/2 | 1/2 |
| Suction Pressure: | | 154 | 103 |
| Suction Temperature: | | 70.1 | 50 |
| Compressor Superheat: | | 16 | 17.2 |
| Discharge Pressure: | | 399 | 288 |
| Discharge Line Temperature (F): | 220° max | 165 | 143 |
| Discharge Gas Superheat (F): | 50° min | 48 | 51 |
| Liquid Line Temperature: | | 103 | 82 |
| Liquid Subcooling: | | 13 | 10 |
| Evaporator Entering Water Temperature: | | 81 | 50.2 |
| Evaporator Leaving Water Temperature: | | 60.3 | 44.5 |
| Condenser Entering Water Temperature: | | 98.6 | 80.3 |
| Condenser Leaving Water Temperature: | | 11.9 | 89.5 |

Software Version: UCH-SHC-HR.LON.06A.14

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

Rep Signature: Enrique Bordallo Print Name: Enrique Bordallo

E-Signature: ☑ Check Box (Authorized Signature)

CLIMACOOL
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 87 Page 1 of 1

| | | | |
|---|---|---|---|
| Project Name: | NAVFAC Building 3700 | Contractor Name: | SafeAire Heating & Cooling |
| Address: | 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE | Address: | 3199 Palmyra Road |
| City/State/Zip: | Albany, GA 31704 | City/State/Zip: | Albany, GA 31707 |
| Startup Date: | 3/27/15 | Phone No.: | 229-789-0124 |

## Module

| | |
|---|---|
| Model No.: | UCH085AFASAWBOS |
| Serial No.: | C1413210185 |
| Chiller No.: | 4 Bank No.: 1 |

## Compressor

| | |
|---|---|
| Model No.: | GSD80485VAB421 |
| Serial No. 1: | 2786300449 |
| Serial No. 2: | 2786300447 |

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| Evaporator: | 69 / 60 | 9 | Δ P |
| Condenser: | 35.0/ 27.0 | 8 | Δ P |
| Source: | 32.6/ 28.5 | 4.1 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| Evaporator: | ☑ Yes | ☐ N/A |
| Condenser: | ☑ Yes | ☐ N/A |
| Source: | ☑ Yes | ☐ N/A |

"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop: ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► All wiring terminations in module panel, safeties and compressors tightened: ☑ Yes ☐ No

► Rotation of scroll compressor is correct: ☑ Yes ☐ No

## Voltage / Ground

L1 273 L2 272 L3 274

Low Voltage (24V): 24.4

## Phase / Phase

L1/L2 472 L2/L3 472 L1/L3 476

## Compressor Circuit #1

Amperage: L1 39 L2 41 L3 40

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/2 | 1/2 |
| Suction Pressure: | | 159 | 114 |
| Suction Temperature: | | 77.2 | 55.8 |
| Compressor Superheat: | | 20.6 | 18.8 |
| Discharge Pressure: | | 486 | 307 |
| Discharge Line Temperature (F): | 220° max | 183 | 146.6 |
| Discharge Gas Superheat (F): | 50° min | 51 | 52 |
| Liquid Line Temperature: | | 115 | 84 |
| Liquid Subcooling: | | 17 | 12 |
| Evaporator Entering Water Temperature: | | 83 | 54.8 |
| Evaporator Leaving Water Temperature: | | 63 | 47.5 |
| Condenser Entering Water Temperature: | | 113 | 81 |
| Condenser Leaving Water Temperature: | | 131 | 91.5 |
| Evaporator Pressure Differential: | | 2 | 3 |
| Condenser Pressure Differential: | | 2 | 4 |

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

Amperage: L1 40 L2 43 L3 41

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/3 | 1/3 |
| Suction Pressure: | | 158 | 107 |
| Suction Temperature: | | 77.2 | 54 |
| Compressor Superheat: | | 21.2 | 18.7 |
| Discharge Pressure: | | 484 | 296 |
| Discharge Line Temperature (F): | 220° max | 180 | 144 |
| Discharge Gas Superheat (F): | 50° min | 50 | 49 |
| Liquid Line Temperature: | | 112 | 83 |
| Liquid Subcooling: | | 20 | 13 |
| Evaporator Entering Water Temperature: | | 83 | 52.7 |
| Evaporator Leaving Water Temperature: | | 63 | 45.5 |
| Condenser Entering Water Temperature: | | 113 | 80.2 |
| Condenser Leaving Water Temperature: | | 131 | 90.3 |

Software Version: UCH-SHC-HR.LON.06A.14

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

Rep Signature: Enrique Bordallo Print Name: Enrique Bordallo

E-Signature: ☑ Check Box (Authorized Signature)

# ADDISON ENERGY TECHNOLOGIES, LLC

## WATER COOLED CHILLER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | CHILLER-5 |
| LOCATION | MECH ROOM |
| SERVICE | CHILLED WATER |
| MANUFACTURER | CLIMACOOL |
| MODEL NUMBER | UCH085AFASAWB0S |
| SERIAL NUMBER | C1413210186 |
| TONS | * |

| CHILLER DATA | |
|---|---|
| UNIT NUMBER | |
| LOCATION | |
| SERVICE | |
| MANUFACTURER | |
| MODEL NUMBER | |
| SERIAL NUMBER | |
| TONS | |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | 460 | * |
| R.L.A. | 143.40 | * |
| % LOADED | - | * |

| ELECTRICAL | NAMEPLATE | ACTUAL |
|---|---|---|
| VOLTAGE | | |
| R.L.A. | | |
| % LOADED | | |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | 197.30 | * |
| ΔP FT | - | * |
| ENT WATER TEMP ˚F | 54.00 | * |
| LVG WATER TEMP ˚F | 44.00 | * |

| PERFORMANCE DATA | | |
|---|---|---|
| EVAPORATOR | DESIGN | ACTUAL |
| GPM | | |
| ΔP FT | | |
| ENT WATER TEMP ˚F | | |
| LVG WATER TEMP ˚F | | |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | - | * |
| ΔP FT | - | * |
| ENT WATER TEMP ˚F | 85.00 | * |
| LVG WATER TEMP ˚F | 97.00 | * |

| CONDENSER | DESIGN | ACTUAL |
|---|---|---|
| GPM | | |
| ΔP FT | | |
| ENT WATER TEMP ˚F | | |
| LVG WATER TEMP ˚F | | |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB ˚F | - | * |
| OUTSIDE AIR WB ˚F | - | * |

| CONDITIONS | DESIGN | ACTUAL |
|---|---|---|
| OUTSIDE AIR DB ˚F | | |
| OUTSIDE AIR WB ˚F | | |

**REMARKS:** * SEE MANUFACTURER'S START UP SHEET.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

CLIMACOOL
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 87 Page 1 of 1

| | | | |
|---|---|---|---|
| Project Name: | 473 | Contractor Name: | SafeAire Heating & Cooling |
| Address: | 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE | Address: | 3199 Palmyra Road |
| City/State/Zip: | Albany, GA 31704 | City/State/Zip: | Albany, GA 31707 |
| Startup Date: | 3/27/15 | Phone No.: | 229-789-0124 |

## Module

| | |
|---|---|
| Model No.: | UCH085AFASAWBOS |
| Serial No.: | C1413210186 |
| Chiller No.: | 4 Bank No.: 1 |

## Compressor

| | |
|---|---|
| Model No.: | GSD80485VAB421 |
| Serial No. 1: | 2786300446 |
| Serial No. 2: | 2786300447 |

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| Evaporator: | 46.3/ 37.5 | 8.8 | Δ P |
| Condenser: | 31.2/ 27.0 | 4.2 | Δ P |
| Source: | 53.9/ 51.3 | 2.6 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| Evaporator: | ☑ Yes | ☐ N/A |
| Condenser: | ☑ Yes | ☐ N/A |
| Source: | ☑ Yes | ☐ N/A |

"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop: ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► All wiring terminations in module panel, safeties and compressors tightened: ☑ Yes ☐ No

► Rotation of scroll compressor is correct: ☑ Yes ☐ No

## Voltage / Ground

L1 273 L2 272 L3 274

Low Voltage (24V): 24.3

## Phase / Phase

L1/L2 470 L2/L3 472 L1/L3 473

## Compressor Circuit #1

Amperage: L1 44.2 L2 45.9 L3 44.3

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/3 | 1/3 |
| Suction Pressure: | | 159 | 121 |
| Suction Temperature: | | 77.3 | 60.7 |
| Compressor Superheat: | | 21.5 | 19.9 |
| Discharge Pressure: | | 487 | 352 |
| Discharge Line Temperature (F): | 220° max | 180 | 158.5 |
| Discharge Gas Superheat (F): | 50° min | 58 | 51 |
| Liquid Line Temperature: | | 112 | 93 |
| Liquid Subcooling: | | 20 | 13 |
| Evaporator Entering Water Temperature: | | 85 | 60.7 |
| Evaporator Leaving Water Temperature: | | 63 | 51.9 |
| Condenser Entering Water Temperature: | | 115 | 80 |
| Condenser Leaving Water Temperature: | | 130 | 92.5 |
| Evaporator Pressure Differential: | | 2 | 4.0 |
| Condenser Pressure Differential: | | 2 | 2.5 |

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

Amperage: L1 44 L2 45.5 L3 44.2

| | | HEAT | COOL |
|---|---|---|---|
| Sight Glass Oil Level: | | 1/2 | 1/2 |
| Suction Pressure: | | 162 | 121 |
| Suction Temperature: | | 72.6 | 60.4 |
| Compressor Superheat: | | 15.5 | 19.2 |
| Discharge Pressure: | | 493 | 304 |
| Discharge Line Temperature (F): | 220° max | 177 | 144.3 |
| Discharge Gas Superheat (F): | 50° min | 44 | 47 |
| Liquid Line Temperature: | | 113 | 82 |
| Liquid Subcooling: | | 19 | 16 |
| Evaporator Entering Water Temperature: | | 85 | 60 |
| Evaporator Leaving Water Temperature: | | 63 | 50.9 |
| Condenser Entering Water Temperature: | | 115 | 80 |
| Condenser Leaving Water Temperature: | | 130 | 92.5 |

Software Version: UCH-SHC-HR.LON.06A.14

► Verify Safety Setting Limits:

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

Rep Signature: Enrique Bordallo Print Name: Enrique Bordallo

E-Signature: ☑ Check Box (Authorized Signature)

# ADDISON ENERGY TECHNOLOGIES, LLC

## DRY COOLER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| COOLING TOWER DATA | | |
|---|---|---|
| UNIT NUMBER | DC-1 | |
| LOCATION | PAD | |
| SERVICE | CONDENSER | |
| MANUFACTURER | GUNTNER | |
| MODEL NUMBER | S-GFD090.ID/2x9-M21F/2P.M | |
| SERIAL NUMBER | 300/874444.0001 | |
| SIZE | | |
| **PERFORMANCE** | **DESIGN** | **ACTUAL** |
| ENT WATER TEMP °F | - | * |
| LVG WATER TEMP °F | - | * |
| GPM | - | * |
| | | |
| | | |
| **CONDITIONS** | **ON** | **OFF** |
| OUTSIDE AIR WB °F | * | * |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| FAN MOTOR | NAMEPLATE | ACTUAL |
|---|---|---|
| MANUFACTURER | - | |
| HP / BHP | - | * |
| PHASE / HZ | 3/60 | * |
| VOLTAGE | - | * |
| AMPS 1 | 3.15 | * |
| AMPS 2 | 3.15 | * |
| AMPS 3 | 3.15 | * |
| AMPS 4 | 3.15 | * |
| AMPS 5 | 3.15 | * |
| AMPS 6 | 3.15 | * |
| AMPS 7 | 3.15 | * |
| AMPS 8 | 3.15 | * |
| AMPS 9 | 3.15 | * |
| AMPS 10 | 3.15 | * |
| AMPS 11 | 3.15 | * |
| AMPS 12 | 3.15 | * |
| AMPS 13 | 3.15 | * |
| AMPS 14 | 3.15 | * |
| AMPS 15 | 3.15 | * |
| AMPS 16 | 3.15 | * |
| AMPS 17 | 3.15 | * |
| AMPS 18 | 3.15 | * |
| MOTOR RPM | 910 | * |
| SF / EFF / PF | - | |

**REMARKS:** * SEE MANUFACTURER'S START UP SHEET.+

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## DRY COOLER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

| COOLING TOWER DATA | | |
|---|---|---|
| UNIT NUMBER | DC-2 | |
| LOCATION | PAD | |
| SERVICE | CONDENSER | |
| MANUFACTURER | GUNTNER | |
| MODEL NUMBER | S-GFD090.ID/2x9-M21F/2P.M | |
| SERIAL NUMBER | 300/874445.0001 | |
| SIZE | | |
| **PERFORMANCE** | **DESIGN** | **ACTUAL** |
| ENT WATER TEMP °F | - | * |
| LVG WATER TEMP °F | - | * |
| GPM | - | * |
| | | |
| | | |
| **CONDITIONS** | **ON** | **OFF** |
| OUTSIDE AIR WB °F | * | * |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| FAN MOTOR | NAMEPLATE | ACTUAL |
|---|---|---|
| MANUFACTURER | - | |
| HP / BHP | - | * |
| PHASE / HZ | 3/60 | * |
| VOLTAGE | - | * |
| AMPS 1 | 3.15 | * |
| AMPS 2 | 3.15 | * |
| AMPS 3 | 3.15 | * |
| AMPS 4 | 3.15 | * |
| AMPS 5 | 3.15 | * |
| AMPS 6 | 3.15 | * |
| AMPS 7 | 3.15 | * |
| AMPS 8 | 3.15 | * |
| AMPS 9 | 3.15 | * |
| AMPS 10 | 3.15 | * |
| AMPS 11 | 3.15 | * |
| AMPS 12 | 3.15 | * |
| AMPS 13 | 3.15 | * |
| AMPS 14 | 3.15 | * |
| AMPS 15 | 3.15 | * |
| AMPS 16 | 3.15 | * |
| AMPS 17 | 3.15 | * |
| AMPS 18 | 3.15 | * |
| MOTOR RPM | 910 | * |
| SF / EFF / PF | - | |

**REMARKS:** * SEE MANUFACTURER'S START UP SHEET.

**TECHNICIAN:** JM **TEST DATE:** 6/28/2015

## CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

### I.- INFORMACION GENERAL

NOMBRE DEL PROYECTO: 510594
CLIENTE: SPEE-AIRE
CIUDAD, ESTADO, PAIS: Albany GA
MODELO DE CONDENSADOR: S-GFD 090-4D/289-421 VOLTAJE: 460
NUMERO DE SERIE: 300/874444-0001 FASES: 3
FRECUENCIA: 60

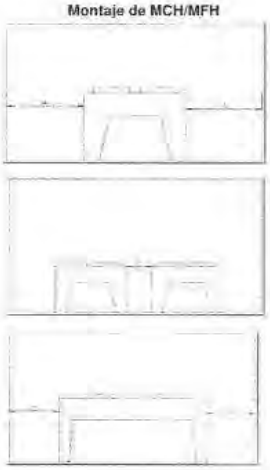
### II.- INSTALACIÓN MECÁNICA

| MODELO | | A | B | C |
|---|---|---|---|---|
| MCH | 1 hilera | 1.5 veces el ancho | 1.5 veces el ancho | Altura de las patas |
| | 2 hileras | 1.25 veces el ancho | 1.25 veces el ancho | |
| MCV | 1 hilera | 0.8 veces la altura | 0.5 veces la longitud | 0.5 veces la long. |
| | 2 hileras | 0.5 veces la altura | | |
| MCD | | 0.5 veces la long. | 0.5 veces la long. | 20 in |
| MFH | 1 hilera | 1.5 veces el ancho | 1.5 veces el ancho | Altura de las patas |
| | 2 hileras | 1.25 veces el ancho | 1.25 veces el ancho | |
| MFV | 1 hilera | 0.8 veces la altura | 0.5 veces la longitud | 0.5 veces la long. |
| | 2 hileras | 0.5 veces la altura | | |
| MFD | | 0.5 veces la long. | 0.5 veces la long. | 20 in. |

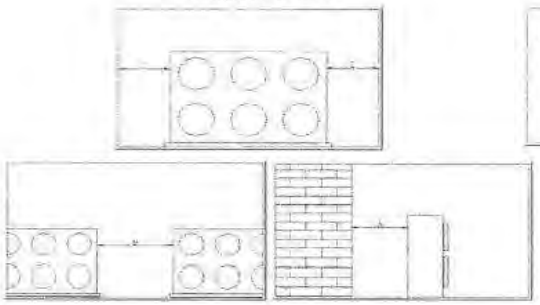
Indique las dimensiones:

A = _____ m
B = 15 ft
C = _____ m

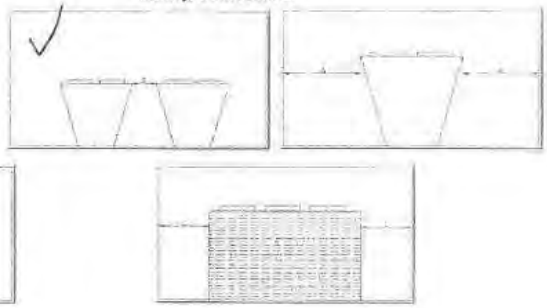
Montaje de MCH/MFH



Montaje de MCV/MFV

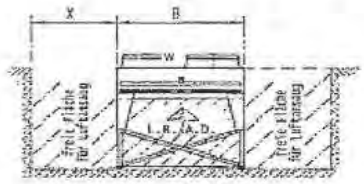


Montaje de MCD/MFD

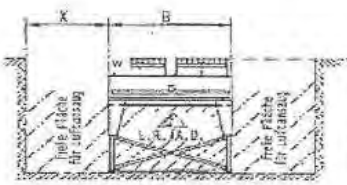




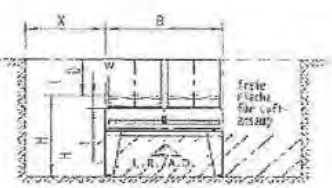





Sin accesorios




Con Streamer




Con ducto

## CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

GÜNTNER

**II.- INSTALACIÓN MECÁNICA (Continuación)**

a) ¿Hay daños de embarque? (Si o No) Sí
Si hay daño describalo e indique donde: ver fotos, Pata soporte en unidad costado derecho
Este daño, impide el arranque de la unidad? (Si o No) NO
b) ¿El condensador firmemente soportado? (Si o No) Si
c) ¿El condensador tiene instalado dampers? (Si o No) NO
d) ¿El condensador está nivelado? (Si o No) Si
e) ¿Hay tornillos o tuercas flojos? (Si o No) Si Ventilador ( ) Soporte ( ) Placa vent.( ) Block ( ) soporte de Pads
f) Accesos para sevicio de mtto y/o reemplazo:

| | | |
|---|---|---|
| Ventiladores | (Bien, Mal, NA) | B |
| Serpentín (para limpieza) | (Bien, Mal, NA) | B |
| Caja de conexiones eléctricas | (Bien, Mal, NA) | B |
| Tablero de control | (Bien, Mal, NA) | B |
| Interruptores de reparación | (Bien, Mal, NA) | NA |

g) Comentarios sobre la instalación mecánica:
Se dejaron algunas de las tablas de transporte en las placas de ventilador

**III.- INSTALACIÓN ELÉCTRICA**

a) Verificar suministro eléctrico de acuerdo a unidad — Voltaje 478
b) Verificar conexión a tierra — (Si o No) Si
c) Verificar capacidad del circuito de protección — Amperes 43.5 46.5
d) Verificar calibre de cables de alimentación principal — Calibre o MCM 2/0
e) Verificar tubería conduit no tenga filos en contacto con cables — (Si o No) NO
f) Verificar conectores glandula apretadas — (Si o No) Si
g) Verificar terminales apretadas en caja de conexiones — (Si o No) Si
h) Modelo de ventiladores instalados — V7030630
i) Cantidad de ventiladores instalados — 18
h) Verificar conexión de ventiladores de acuerdo a su voltaje — Voltaje L Conexión (Y, ▲) Motor EC
i) Verificar conexión de protección térmica de cada ventilador TK's — (Si o No) NA
j) Verificar conexión de interruptor de servicio — (Si o No) Si
k) Verificar terminales apretadas en tablero eléctrico — (Si o No) Si

l) Comentarios sobre la instalación eléctrica:
Se agregaron relevadores al tablero para señales remotas de encendido

**IV.- INSTALACIÓN DE REFRIGERACIÓN PARA CONDENSADOR**

a) Verificar tubería de descarga — Diametro ____ Tiene trampa aire (Si o No) ____ Cobre o Acero? ____ Tiene válvula de purga de aire (Si o No) ____
b) Verificar tubería de condensado — Diametro ____ Tiene sifon (Si o No) ____ Cobre o Acero? ____
c) Tiene serpentín subenfriador (Si o No) ____
d) Tiene sifon entre condensador y subenfriador (Si o No) ____
e) Tiene el recibidor entre condensador y subenfriador (Si o No) ____
f) ¿Se hizo la prueba de fuga en el condensador? (Si o No) ____
g) En la prueba de fugas se utilizó: detector de fugas ( ) Mechas de azufre ( ) Agua jabonosa ( ) Otro ____ ( )
h) Tiene sistema de espreado para enfriamiento por agua? (Si o No) ____
i) Verificar la direccion de cada espreа (Si o No) ____ ¿Cuántas espreas estan instaladas? ____
j) Se localizaron y repararon fugas en: ____

k) Comentarios sobre la instalación de refrigeración:

## CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

**V.- INSTALACION HIDRAULICA PARA AEROENFRIADORES**

a) Verificar tubería de entrada Diametro 4 1/8" Cobre o Acero? Acero
Tiene valvula de purga de liquido (Si o No) Si

b) Verificar tubería de salida Diametro 4 1/8" Cobre o Acero? Acero
Tiene valvula de linea de drenaje (Si o No) Si

c) Tiene valvula de purga de aire (Si o No) Si ¿Dónde está colocada? a la entrada del enfriador

d) Bomba: Marca — Modelo —

RPM — Potencia del motor — HP

e) Tanques ¿Cuantos tanques hay? —

Volumen del tanque — ¿Está aislado termicamente? (Si o No) —

¿Es tanque abierto? (Si o No) — ¿Es tanque cerrado a presión? (Si o No) —

f) Tiene sistema de espreado para enfriamiento por agua? (Si o No) ACS
g) Verificar la direccion de cada esprea (Si o No) NA ¿Cuántas espreas estan instaladas? NA

h) ¿Hay fugas en el sistema? (Si o No) No
i) Se localizaron y repararon fugas en: —

d) Hacer diagrama de flujo del proceso indicando Aeroenfriadores, tanques, bombas, carga, y puntos abiertos a la atmósfera

c) Comentarios sobre la instalación hidráulica:
La tubería esta en proceso de aislamiento

| Personal de Güntner: | Cliente: |
|---|---|
| Nombre | Nombre |
| Firma | Firma |

## CHECKLIST DE OPERACIÓN PARA CONDENSADOR Y AEROENFRIADOR

**I.- INFORMACION GENERAL**

NOMBRE DEL PROYECTO: MCLB Geothermal Heat Pump

CLIENTE: Safe Air Heating and Cooling

CIUDAD, ESTADO. PAIS: Albany GA

MODELO DE CONDENSADOR: S-GFÖ 090.1Ö/209-421

NUMERO DE SERIE: _____

**II.- OPERACIÓN DE VENTILADORES**

a) Voltaje 470 ~ Voltios
b) Frecuencia 60 Hertz
c) Corriente _____ Amperios
d) Sentido de giro correcto (Si, No) Si
e) El ventilador vibra? (Si, No) No
f) El ventilador tiene ruido? (Si, No) No dB _____ mt
g) Hay obstrucción externa al flujo de aire? (Si, No) No
h) ¿Hay vibración en toda la unidad? (Si o No) No

i) Comentarios sobre la operación de ventiladores

**III.- OPERACIÓN DE CONDENSADOR**

a) Refrigerante Fluido
b) Evaporación P = _____ psig T = _____ °C
c) Condensación P = _____ psig T = _____ °C
d) Temperatura del gas entrando T = _____ °C
e) Temperatura del liquido saliendo T = 90 °C °F
f) Temperatura ambiente a 10m de la unidad: T = _____ °C
g) Temperatura del aire entrando a la unidad: T = _____ °C
h) Temperatura del aire saliendo de la unidad: T = _____ °C
i) Velocidad promedio del aire en block Vel = _____ m/s
j) ¿Está obstruido el serpentin? (Si o No) No Sarro ( ) Polvo ( ) Otros: Hay fugas en el area.
k) Tiene sistema de espreado para enfriamiento por agua? (Si o No) Si ACS
l) ¿Esta ajustado para trabajar máximo 240 horas por año? (Si o No) No
m) ¿Usan tratamiento de agua? (Si o No) Si ¿Qué tipo de tratamiento? Ver tabs
n) Se tomó muestra del agua de espreado: (Si o No) No Tamaño de la muestra: ___ ml

o) Comentarios sobre la operación de condensadores
Se elimino el control ACS y se instalo se opero control desde su tablero principal

**Notas Adicionales:**

## CHECKLIST DE OPERACIÓN PARA CONDENSADOR Y AEROENFRIADOR

GÜNTNER

**IV.- OPERACIÓN DE AEROENFRIADOR**

a) Fluido: Agua ( ) Etilenglicol ( ) Propilenglicol ( ) Otro: _____
b) Concentración _____ %
c) Temperatura fluido entrando Tent = _____ ºC
d) Temperatura fluido saliendo Tsal = _____ ºC
e) Temperatura ambiente a 10m de la unidad: T = _____ ºC
f) Temperatura del aire entrando a la unidad: T = _____ ºC
g) Temperatura del aire saliendo de la unidad: T = _____ ºC
h) Presión fluido entrando Pent = _____ psig
i) Presión fluido saliendo Psal = _____ psig
j) Se tomó muestra del fluido: (Si o No) _____ Tamaño de la muestra: _____ ml
k) Se midió flujo en tubería entrada: (Si o No) _____ Flujo medido _____ LPH
l) Se midió flujo en tubería salida: (Si o No) _____ Flujo medido _____ LPH
m) Tiene sistema de espreado para enfriamiento por agua? (Si o No) _____
n) ¿Esta ajustado para trabajar máximo 240 horas por año? (Si o No) _____
o) ¿Usan tratamiento de agua? (Si o No) _____ ¿Qué tipo de tratamiento? _____
p) Se tomó muestra del agua de espreado: (Si o No) _____ Tamaño de la muestra: _____ ml
q) Comentarios sobre la operación de aeroenfriadores

_____
_____
_____

**Notas Adicionales:**

Personal de Güntner:
Nombre Jorian Carlos Izquierdo P.

Cliente:
Nombre Ray Olson

# ADDISON ENERGY TECHNOLOGIES, LLC

## CIRCUIT SETTER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** COOLING

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | SETTING | ACTUAL GPM | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| AHU-1A | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 100.34 | 41.10 |
| AHU-1B | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 105.23 | 45.20 |
| AHU-2A | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 112.65 | 51.80 |
| AHU-2B | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 114.16 | 53.20 |
| AHU-3A | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 112.65 | 51.80 |
| AHU-3B | TACO | ACUF250 | 2 1/2 | 152.00 | 0.00 | 112.98 | 52.10 |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## CIRCUIT SETTER TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** BOREFIELD

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | SETTING | ACTUAL GPM | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| NORTH | PFS | HVT-BFVF | 8 | - | VENTURI | 260.00 | 37.20 |
| MIDDLE | PFS | HVT-BFVF | 8 | - | VENTURI | 258.00 | 36.50 |
| SOUTH | PFS | HVT-BFVF | 8 | - | VENTURI | 244.00 | 32.60 |
| | | | | | | 762.00 | |
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**REMARKS:**

**TECHNICIAN:** MD **TEST DATE:** 8/31/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AUTO BALANCING VALVE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** HEATING

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | ACTUAL GPM | ΔP RANGE | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| VAV-101 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.00 | 3.00 | 2-32 | 4.30 |
| VAV-102 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.50 | 3.50 | 2-32 | 3.60 |
| VAV-103 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.00 | 3.00 | 2-32 | 5.10 |
| VAV-104 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.50 | 3.50 | 2-32 | 5.40 |
| VAV-105 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 3.70 |
| VAV-106 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 2.90 |
| VAV-107 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 6.20 |
| VAV-109 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 5.00 | 5.00 | 2-32 | 5.50 |
| VAV-110 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.00 | 3.00 | 2-32 | 4.50 |
| VAV-111 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 4.10 |
| VAV-112 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.40 |
| VAV-113 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.10 |
| VAV-114 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.50 | 1.50 | 2-32 | 3.00 |
| VAV-115 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 0.50 | 0.55 | 2-32 | 2.40 |
| VAV-116 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.70 |
| VAV-117 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.50 | 5.00 | 2-32 | 2.60 |
| VAV-119 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 4.80 |
| VAV-120 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 0.75 | 0.75 | 2-32 | 5.70 |
| VAV-121 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.50 | 5.00 | 2-32 | 6.30 |
| VAV-122 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 2.60 |
| VAV-123 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 3.20 |
| VAV-124 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 0.75 | 0.75 | 2-32 | 7.10 |
| VAV-125 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 3.80 |
| VAV-126 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.25 | 2.50 | 2-32 | 4.90 |
| VAV-127 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 5.60 |
| VAV-128 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.50 | 5.00 | 2-32 | 8.30 |
| VAV-129 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 10.10 |
| VAV-130 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 7.70 |
| VAV-131 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 8.30 |
| VAV-132 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.50 | 5.00 | 2-32 | 2.40 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AUTO BALANCING VALVE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** HEATING

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | ACTUAL GPM | ΔP RANGE | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| VAV-133 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 4.90 |
| VAV-134 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 6.60 |
| | | | | | | | |
| VAV-201 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 7.20 |
| VAV-202 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 5.90 |
| VAV-203 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 4.30 |
| VAV-204 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 4.00 |
| VAV-205 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 3.60 |
| VAV-206 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 2.80 |
| VAV-207 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.40 |
| VAV-208 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 5.30 |
| VAV-209 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 8.20 |
| VAV-210 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.50 | 3.50 | 2-32 | 9.40 |
| VAV-211 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.25 | 1.50 | 2-32 | 10.60 |
| VAV-212 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 13.10 |
| VAV-213 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 2.50 |
| VAV-214 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.25 | 2.50 | 2-32 | 3.60 |
| VAV-215 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.25 | 1.50 | 2-32 | 4.50 |
| VAV-216 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 4.10 |
| VAV-217 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 3.30 |
| VAV-220 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 6.50 |
| VAV-221 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 7.20 |
| VAV-222 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.25 | 2.00 | 2-32 | 8.30 |
| VAV-223 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 7.40 |
| VAV-224 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 4.30 |
| VAV-225 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.70 | 5.00 | 2-32 | 6.60 |
| VAV-226 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.00 | 3.00 | 2-32 | 6.20 |
| VAV-227 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 5.00 |
| VAV-228 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 4.20 |
| VAV-229 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 3.40 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AUTO BALANCING VALVE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** HEATING

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | ACTUAL GPM | ΔP RANGE | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| VAV-230 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.60 |
| VAV-231 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 4.40 |
| VAV-232 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.00 | 3.00 | 2-32 | 2.50 |
| VAV-233 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 3.50 | 3.50 | 2-32 | 2.20 |
| VAV-234 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 3.10 |
| | | | | | | | |
| VAV-301 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.00 | 3.00 | 2-32 | 3.00 |
| VAV-302 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.80 | 2.00 | 2-32 | 4.40 |
| VAV-303 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.80 | 2.00 | 2-32 | 4.50 |
| VAV-304 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.00 | 3.00 | 2-32 | 6.80 |
| VAV-305 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 6.20 |
| VAV-306 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 4.90 |
| VAV-307 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 4.10 |
| VAV-308 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.50 |
| VAV-309 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 4.20 |
| VAV-310 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 5.60 |
| VAV-311 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 7.10 |
| VAV-312 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 8.10 |
| VAV-313 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 6.50 |
| VAV-314 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 4.40 |
| VAV-315 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 3.80 |
| VAV-316 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 2.60 |
| VAV-317 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 2.70 |
| VAV-319 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.00 | 1.00 | 2-32 | 3.10 |
| | | | | | | | |
| VAV-321 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.75 | 2.00 | 2-32 | 2.80 |
| VAV-322 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.25 | 2.50 | 2-32 | 2.50 |
| VAV-323 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 1.25 | 1.50 | 2-32 | 3.30 |
| VAV-324 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.25 | 2.50 | 2-32 | 4.30 |
| VAV-325 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 4.10 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## AUTO BALANCING VALVE TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700
**LOCATION:** ALBANY, GA
**SYSTEM:** HEATING

| UNIT | MANUFACTURER | MODEL | SIZE | DESIGN GPM | ACTUAL GPM | ΔP RANGE | ACTUAL ΔP |
|---|---|---|---|---|---|---|---|
| VAV-326 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.00 | 1.00 | 2-32 | 2.30 |
| VAV-327 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.25 | 1.50 | 2-32 | 2.40 |
| VAV-328 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.25 | 1.50 | 2-32 | 3.00 |
| VAV-329 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.50 | 5.00 | 2-32 | 2.10 |
| VAV-330 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.00 | 5.00 | 2-32 | 2.00 |
| VAV-331 | GRISWOLD | CPP1IRIR1LLT | 1/2 | 0.50 | 0.50 | 2-32 | 2.90 |
| VAV-332 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.50 | 2.50 | 2-32 | 3.20 |
| VAV-333 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 2.00 | 2.00 | 2-32 | 3.00 |
| VAV-334 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 3.00 | 3.00 | 2-32 | 2.60 |
| VAV-335 | GRISWOLD | CPP1IRIR1NNT | 1/2 | 4.00 | 5.00 | 2-32 | 2.40 |
| VAV-336 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 3.60 |
| VAV-337 | GRISWOLD | CPP1IRIR1MMT | 1/2 | 1.50 | 1.50 | 2-32 | 5.10 |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/29/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** COOLING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| AHU-1A | 20000 | - | - | - | - | 19963 | 73.00 | 61.00 | 56.00 | 53.70 | - | 152.00 | - | - | - | 100.34 | 43.00 | 51.60 |
| AHU-1B | 20000 | - | - | - | - | 19575 | 74.00 | 62.00 | 57.00 | 54.40 | - | 152.00 | - | - | - | 105.23 | 43.00 | 52.00 |
| | | | | | | | | | | | | | | | | | | |
| AHU-2A | 20000 | - | - | - | - | 19085 | 73.00 | 62.00 | 54.00 | 53.00 | - | 152.00 | - | - | - | 112.65 | 43.00 | 51.80 |
| AHU-2B | 20000 | - | - | - | - | 19725 | 73.00 | 62.00 | 55.00 | 53.90 | - | 152.00 | - | - | - | 114.16 | 43.00 | 50.90 |
| | | | | | | | | | | | | | | | | | | |
| AHU-3A | 20000 | - | - | - | - | 22052 | 74.00 | 63.00 | 55.00 | 54.00 | - | 152.00 | - | - | - | 112.65 | 43.00 | 52.70 |
| AHU-3B | 20000 | - | - | - | - | 20500 | 73.00 | 62.00 | 53.00 | 52.00 | - | 152.00 | - | - | - | 112.98 | 43.00 | 53.00 |
| | | | | | | | | | | | | | | | | | | |
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**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-101 | 940 | 54.00 | - | 88.61 | - | 960 | 53.00 | - | 87.00 | - | - | 3.00 | 115.00 | 91.21 | 4.30 | 3.00 | 105.30 | 82.00 |
| VAV-102 | 1055 | 54.00 | - | 88.79 | - | 1107 | 53.00 | - | 80.00 | - | - | 3.50 | 115.00 | 92.00 | 3.60 | 3.50 | 105.00 | 86.50 |
| VAV-103 | 940 | 54.00 | - | 88.61 | - | 964 | 53.00 | - | 89.00 | - | - | 3.00 | 115.00 | 91.21 | 5.10 | 3.00 | 105.00 | 80.00 |
| VAV-104 | 1105 | 54.00 | - | 87.32 | - | 1138 | 53.00 | - | 83.00 | - | - | 3.50 | 115.00 | 91.58 | 5.40 | 3.50 | 105.00 | 83.93 |
| VAV-105 | 320 | 54.00 | - | 87.64 | - | 336 | 53.00 | - | 82.00 | - | - | 1.00 | 115.00 | 91.39 | 3.70 | 1.00 | 105.00 | 83.95 |
| VAV-106 | 560 | 54.00 | - | 97.09 | - | 569 | 53.00 | - | 84.00 | - | - | 2.00 | 115.00 | 88.54 | 2.90 | 2.00 | 105.00 | 85.94 |
| VAV-107 | 425 | 54.00 | - | 97.35 | - | 439 | 53.00 | - | 87.00 | - | - | 2.00 | 115.00 | 94.79 | 6.20 | 2.00 | 105.00 | 88.87 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VAV-109 | 1210 | 54.00 | - | 91.08 | - | 1235 | 53.00 | - | 82.00 | - | - | 5.00 | 115.00 | 95.33 | 5.50 | 5.00 | 105.00 | 89.52 |
| VAV-110 | 800 | 54.00 | - | 95.19 | - | 839 | 53.00 | - | 88.00 | - | - | 3.00 | 115.00 | 90.91 | 4.50 | 3.00 | 105.00 | 83.85 |
| VAV-111 | 330 | 54.00 | - | 86.99 | - | 344 | 53.00 | - | 84.00 | - | - | 1.00 | 115.00 | 91.12 | 4.10 | 1.00 | 105.00 | 82.00 |
| VAV-112 | 360 | 54.00 | - | 91.64 | - | 358 | 53.00 | - | 84.90 | - | - | 1.50 | 115.00 | 95.18 | 3.40 | 1.50 | 105.00 | 88.50 |
| VAV-113 | 360 | 54.00 | - | 91.64 | - | 373 | 53.00 | - | 85.00 | - | - | 1.50 | 115.00 | 95.18 | 3.10 | 1.50 | 105.00 | 87.81 |
| VAV-114 | 280 | 54.00 | - | 91.04 | - | 278 | 53.00 | - | 85.00 | - | - | 1.50 | 115.00 | 99.83 | 3.00 | 1.50 | 105.00 | 92.19 |
| VAV-115 | 100 | 54.00 | - | 99.56 | - | 104 | 53.00 | - | 86.80 | - | - | 0.50 | 115.00 | 95.01 | 2.40 | 0.55 | 105.00 | 89.80 |
| VAV-116 | 390 | 54.00 | - | 94.59 | - | 391 | 53.00 | - | 87.10 | - | - | 1.50 | 115.00 | 91.85 | 3.70 | 1.50 | 105.00 | 85.80 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-117 | 1410 | 54.00 | - | 89.65 | - | 1440 | 53.00 | - | 80.00 | - | - | 4.50 | 115.00 | 90.50 | 2.60 | 5.00 | 105.00 | 86.00 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VAV-119 | 300 | 54.00 | - | 90.49 | - | 301 | 53.00 | - | 87.50 | - | - | 1.50 | 115.00 | 98.99 | 4.80 | 1.50 | 105.00 | 90.00 |
| VAV-120 | 205 | 54.00 | - | 89.96 | - | 203 | 53.00 | - | 80.40 | - | - | 0.75 | 115.00 | 93.44 | 5.70 | 0.75 | 105.00 | 88.98 |
| VAV-121 | 1280 | 54.00 | - | 88.51 | - | 1342 | 53.00 | - | 85.00 | - | - | 4.50 | 115.00 | 93.47 | 6.30 | 5.00 | 105.00 | 84.38 |
| VAV-122 | 525 | 54.00 | - | 96.30 | - | 504 | 53.00 | - | 87.00 | - | - | 1.75 | 115.00 | 87.17 | 2.60 | 2.00 | 105.00 | 83.84 |
| VAV-123 | 320 | 54.00 | - | 87.84 | - | 312 | 53.00 | - | 82.00 | - | - | 1.00 | 115.00 | 91.39 | 3.20 | 1.00 | 105.00 | 85.46 |
| VAV-124 | 230 | 54.00 | - | 92.59 | - | 241 | 53.00 | - | 84.00 | - | | 0.75 | 115.00 | 89.04 | 7.10 | 0.75 | 105.00 | 83.48 |
| VAV-125 | 415 | 54.00 | - | 97.84 | - | 434 | 53.00 | - | 89.70 | - | - | 2.00 | 115.00 | 95.05 | 3.80 | 2.00 | 105.00 | 87.79 |
| VAV-126 | 715 | 54.00 | - | 93.59 | - | 748 | 53.00 | - | 83.00 | - | - | 2.25 | 115.00 | 87.41 | 4.90 | 2.50 | 105.00 | 83.45 |
| VAV-127 | 510 | 54.00 | - | 91.45 | - | 526 | 53.00 | - | 82.00 | - | - | 1.75 | 115.00 | 91.06 | 5.60 | 2.00 | 105.00 | 86.17 |
| VAV-128 | 1395 | 54.00 | - | 89.88 | - | 1461 | 53.00 | - | 84.00 | - | - | 4.50 | 115.00 | 90.60 | 8.30 | 5.00 | 105.00 | 83.26 |
| VAV-129 | 470 | 54.00 | - | 90.53 | - | 450 | 53.00 | - | 81.00 | - | - | 1.50 | 115.00 | 89.89 | 10.10 | 1.50 | 105.00 | 86.85 |
| VAV-130 | 340 | 54.00 | - | 86.37 | - | 357 | 53.00 | - | 81.00 | - | - | 1.00 | 115.00 | 90.88 | 7.70 | 1.00 | 105.00 | 83.41 |
| VAV-131 | 440 | 54.00 | - | 91.97 | - | 420 | 53.00 | - | 85.90 | - | - | 1.50 | 115.00 | 90.57 | 8.30 | 1.50 | 105.00 | 85.10 |
| VAV-132 | 1425 | 54.00 | - | 89.43 | - | 1493 | 53.00 | - | 80.00 | - | - | 4.50 | 115.00 | 90.39 | 2.40 | 5.00 | 105.00 | 85.00 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-133 | 310 | 54.00 | - | 88.30 | - | 295 | 53.00 | - | 85.60 | - | - | 1.00 | 115.00 | 91.67 | 4.90 | 1.00 | 105.00 | 84.23 |
| VAV-134 | 310 | 54.00 | - | 88.30 | - | 325 | 53.00 | - | 82.00 | - | - | 1.00 | 115.00 | 91.67 | 6.60 | 1.00 | 105.00 | 84.65 |
| | | | | | | | | | | | | | | | | | | |
| VAV-201 | 660 | 54.00 | - | 93.47 | - | 691 | 53.90 | - | 85.00 | - | - | 2.00 | 115.00 | 88.43 | 7.20 | 2.00 | 105.00 | 81.79 |
| VAV-202 | 500 | 54.00 | - | 89.19 | - | 516 | 53.90 | - | 86.00 | - | - | 1.50 | 115.00 | 89.27 | 5.90 | 1.50 | 105.00 | 79.66 |
| VAV-203 | 800 | 54.00 | - | 88.61 | - | 821 | 53.90 | - | 83.00 | - | - | 2.50 | 115.00 | 90.71 | 4.30 | 2.50 | 105.00 | 84.35 |
| VAV-204 | 435 | 54.00 | - | 92.22 | - | 433 | 53.90 | - | 85.00 | - | - | 1.50 | 115.00 | 90.69 | 4.00 | 1.50 | 105.00 | 85.29 |
| VAV-205 | 625 | 54.00 | - | 94.68 | - | 635 | 53.90 | - | 87.80 | - | | 2.00 | 115.00 | 87.12 | 3.60 | 2.00 | 105.00 | 81.75 |
| VAV-206 | 435 | 54.00 | - | 92.22 | - | 416 | 53.90 | - | 83.00 | - | - | 1.50 | 115.00 | 90.69 | 2.80 | 1.50 | 105.00 | 87.56 |
| VAV-207 | 435 | 54.00 | - | 92.22 | - | 438 | 53.90 | - | 83.00 | - | - | 1.50 | 115.00 | 90.69 | 3.40 | 1.50 | 105.00 | 86.64 |
| VAV-208 | 435 | 54.00 | - | 92.22 | - | 441 | 53.90 | - | 86.70 | - | - | 1.50 | 115.00 | 90.69 | 5.30 | 1.50 | 105.00 | 83.70 |
| VAV-209 | 435 | 54.00 | - | 92.22 | - | 444 | 53.90 | - | 84.90 | - | - | 1.50 | 115.00 | 90.69 | 8.20 | 1.50 | 105.00 | 85.17 |
| VAV-210 | 1040 | 54.00 | - | 89.09 | - | 1092 | 53.90 | - | 85.20 | - | - | 3.50 | 115.00 | 92.19 | 9.40 | 3.50 | 105.00 | 83.90 |
| VAV-211 | 345 | 54.00 | - | 89.16 | - | 359 | 53.90 | - | 85.60 | - | - | 1.25 | 115.00 | 93.71 | 10.60 | 1.25 | 105.00 | 85.14 |
| VAV-212 | 415 | 54.00 | - | 93.24 | - | 422 | 53.90 | - | 86.60 | - | - | 1.50 | 115.00 | 91.18 | 13.10 | 1.50 | 105.00 | 85.12 |
| VAV-213 | 285 | 54.00 | - | 90.09 | - | 289 | 53.90 | - | 82.90 | - | - | 1.00 | 115.00 | 92.44 | 2.50 | 1.00 | 105.00 | 86.90 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-214 | 710 | 54.00 | - | 93.74 | - | 739 | 53.90 | - | 86.10 | - | - | 2.25 | 115.00 | 87.49 | 3.60 | 2.50 | 105.00 | 82.15 |
| VAV-215 | 375 | 54.00 | - | 91.95 | - | 380 | 53.90 | - | 82.10 | - | - | 1.25 | 115.00 | 90.03 | 4.50 | 1.50 | 105.00 | 85.80 |
| VAV-216 | 555 | 54.00 | - | 89.63 | - | 559 | 53.90 | - | 82.90 | - | - | 1.75 | 115.00 | 90.21 | 4.10 | 2.00 | 105.00 | 84.99 |
| VAV-217 | 320 | 54.00 | - | 96.59 | - | 336 | 53.90 | - | 89.00 | - | - | 1.75 | 115.00 | 97.92 | 3.30 | 2.00 | 105.00 | 90.89 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VAV-220 | 450 | 54.00 | - | 99.06 | - | 439 | 53.90 | - | 87.80 | - | - | 2.50 | 115.00 | 97.21 | 6.50 | 2.50 | 105.00 | 92.14 |
| VAV-221 | 555 | 54.00 | - | 89.63 | - | 546 | 53.90 | - | 85.90 | - | | 1.75 | 115.00 | 90.21 | 7.20 | 2.00 | 105.00 | 83.43 |
| VAV-222 | 345 | 54.00 | - | 89.16 | - | 361 | 53.90 | - | 87.00 | - | - | 1.25 | 115.00 | 93.71 | 8.30 | 2.00 | 105.00 | 84.35 |
| VAV-223 | 435 | 54.00 | - | 92.22 | - | 451 | 53.90 | - | 87.00 | - | - | 1.50 | 115.00 | 90.69 | 7.40 | 1.50 | 105.00 | 83.50 |
| VAV-224 | 285 | 54.00 | - | 90.09 | - | 286 | 53.90 | - | 86.70 | - | - | 1.00 | 115.00 | 92.44 | 4.30 | 1.00 | 105.00 | 85.00 |
| VAV-225 | 1125 | 54.00 | - | 88.32 | - | 1179 | 53.90 | - | 80.90 | - | - | 3.70 | 115.00 | 92.11 | 6.60 | 5.00 | 105.00 | 86.41 |
| VAV-226 | 855 | 54.00 | - | 90.65 | - | 890 | 53.90 | - | 82.00 | - | - | 3.00 | 115.00 | 92.09 | 6.20 | 3.00 | 105.00 | 87.05 |
| VAV-227 | 435 | 54.00 | - | 92.22 | - | 446 | 53.90 | - | 84.00 | - | - | 1.50 | 115.00 | 90.69 | 5.00 | 1.50 | 105.00 | 85.66 |
| VAV-228 | 435 | 54.00 | - | 92.22 | - | 417 | 53.90 | - | 84.70 | - | - | 1.50 | 115.00 | 90.69 | 4.20 | 1.50 | 105.00 | 86.50 |
| VAV-229 | 290 | 54.00 | - | 89.72 | - | 301 | 53.90 | - | 83.00 | - | - | 1.00 | 115.00 | 92.28 | 3.40 | 1.00 | 105.00 | 86.09 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-230 | 435 | 54.00 | - | 92.22 | - | 437 | 53.90 | - | 84.00 | - | - | 1.50 | 115.00 | 90.69 | 3.60 | 1.50 | 105.00 | 86.05 |
| VAV-231 | 435 | 54.00 | - | 92.22 | - | 455 | 53.90 | - | 87.70 | - | - | 1.50 | 115.00 | 90.69 | 4.40 | 1.50 | 105.00 | 82.85 |
| VAV-232 | 860 | 54.00 | - | 90.52 | - | 872 | 53.90 | - | 84.90 | - | - | 3.00 | 115.00 | 92.04 | 2.50 | 3.00 | 105.00 | 85.53 |
| VAV-233 | 1125 | 54.00 | - | 87.44 | - | 1184 | 53.90 | - | 86.80 | - | - | 3.50 | 115.00 | 91.42 | 2.20 | 3.50 | 105.00 | 80.96 |
| VAV-234 | 900 | 54.00 | - | 95.52 | - | 938 | 53.90 | - | 83.00 | - | - | 2.50 | 115.00 | 84.58 | 3.10 | 2.50 | 105.00 | 81.41 |
| | | | | | | | | | | | | | | | | | | |
| VAV-301 | 1025 | 54.00 | - | 86.78 | - | 1042 | 54.20 | - | 83.00 | - | - | 3.00 | 115.00 | 90.43 | 3.00 | 3.00 | 105.00 | 83.37 |
| VAV-302 | 560 | 54.00 | - | 95.35 | - | 587 | 54.20 | - | 88.00 | - | | 1.80 | 115.00 | 88.78 | 4.40 | 2.00 | 105.00 | 81.19 |
| VAV-303 | 560 | 54.00 | - | 95.35 | - | 536 | 54.20 | - | 88.20 | - | - | 1.80 | 115.00 | 86.78 | 4.50 | 2.00 | 105.00 | 83.13 |
| VAV-304 | 1025 | 54.00 | - | 88.78 | - | 1036 | 54.20 | - | 82.50 | - | - | 3.00 | 115.00 | 90.43 | 6.80 | 3.00 | 105.00 | 83.89 |
| VAV-305 | 720 | 54.00 | - | 94.99 | - | 732 | 54.20 | - | 86.60 | - | - | 2.50 | 115.00 | 89.10 | 6.20 | 2.50 | 105.00 | 84.50 |
| VAV-306 | 700 | 54.00 | - | 95.60 | - | 655 | 54.20 | - | 84.00 | - | - | 2.50 | 115.00 | 89.45 | 4.90 | 2.50 | 105.00 | 87.87 |
| VAV-307 | 525 | 54.00 | - | 90.83 | - | 551 | 54.20 | - | 83.00 | - | - | 1.75 | 115.00 | 90.77 | 4.10 | 2.00 | 105.00 | 85.41 |
| VAV-308 | 440 | 54.00 | - | 91.97 | - | 421 | 54.20 | - | 87.70 | - | - | 1.50 | 115.00 | 90.57 | 3.50 | 1.50 | 105.00 | 84.69 |
| VAV-309 | 630 | 54.00 | - | 94.50 | - | 660 | 54.20 | - | 87.90 | - | - | 2.00 | 115.00 | 87.01 | 4.20 | 2.00 | 105.00 | 80.97 |
| VAV-310 | 640 | 54.00 | - | 94.15 | - | 687 | 54.20 | - | 88.60 | - | - | 2.00 | 115.00 | 85.82 | 5.60 | 2.00 | 105.00 | 79.47 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-311 | 700 | 54.00 | - | 92.16 | - | 666 | 54.20 | - | 82.80 | - | - | 2.00 | 115.00 | 85.70 | 7.10 | 2.00 | 105.00 | 84.42 |
| VAV-312 | 465 | 54.00 | - | 90.76 | - | 441 | 54.20 | - | 82.10 | - | - | 1.50 | 115.00 | 90.00 | 8.10 | 1.50 | 105.00 | 87.21 |
| VAV-313 | 300 | 54.00 | - | 89.00 | - | 306 | 54.20 | - | 82.10 | - | - | 1.00 | 115.00 | 91.97 | 6.50 | 1.00 | 105.00 | 86.62 |
| VAV-314 | 495 | 54.00 | - | 89.40 | - | 471 | 54.20 | - | 86.00 | - | - | 1.50 | 115.00 | 89.37 | 4.40 | 1.50 | 105.00 | 83.43 |
| VAV-315 | 540 | 54.00 | - | 92.34 | - | 565 | 54.20 | - | 84.80 | - | - | 2.00 | 115.00 | 92.29 | 3.80 | 2.00 | 105.00 | 86.32 |
| VAV-316 | 450 | 54.00 | - | 91.48 | - | 462 | 54.20 | - | 92.00 | - | - | 1.50 | 115.00 | 90.34 | 2.60 | 1.50 | 105.00 | 77.90 |
| VAV-317 | 730 | 54.00 | - | 94.70 | - | 764 | 54.20 | - | 87.90 | - | - | 2.50 | 115.00 | 88.93 | 2.70 | 2.50 | 105.00 | 82.75 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VAV-319 | 310 | 54.00 | - | 88.30 | - | 296 | 54.20 | - | 84.20 | - | - | 1.00 | 115.00 | 91.67 | 3.10 | 1.00 | 105.00 | 85.82 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VAV-321 | 555 | 54.00 | - | 89.63 | - | 576 | 54.20 | - | 84.60 | - | - | 1.75 | 115.00 | 90.21 | 2.80 | 2.00 | 105.00 | 83.38 |
| VAV-322 | 650 | 54.00 | - | 95.66 | - | 651 | 54.20 | - | 84.90 | - | - | 2.25 | 115.00 | 88.60 | 2.50 | 2.50 | 105.00 | 85.81 |
| VAV-323 | 270 | 54.00 | - | 88.55 | - | 270 | 54.20 | - | 85.20 | - | - | 1.25 | 115.00 | 98.83 | 3.30 | 1.50 | 105.00 | 90.53 |
| VAV-324 | 665 | 54.00 | - | 95.17 | - | 694 | 54.20 | - | 85.40 | - | - | 2.25 | 115.00 | 88.31 | 4.30 | 2.50 | 105.00 | 84.21 |
| VAV-325 | 340 | 54.00 | - | 86.37 | - | 346 | 54.20 | - | 83.30 | - | - | 1.00 | 115.00 | 90.86 | 4.10 | 1.00 | 105.00 | 83.25 |
| VAV-326 | 300 | 54.00 | - | 89.00 | - | 311 | 54.20 | - | 82.00 | - | - | 1.00 | 115.00 | 91.97 | 2.30 | 1.00 | 105.00 | 86.33 |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

# ADDISON ENERGY TECHNOLOGIES, LLC

## HEATING / COOLING COIL TEST SHEET

**PROJECT:** MCLB ALBANY GEOTHERMAL HEAT PUMPS WITH USTES BUILDING 3700

**LOCATION:** ALBANY, GA

**SYSTEM:** HEATING

| | DESIGN AIR | | | | | ACTUAL AIR | | | | | DESIGN WATER | | | | ACTUAL WATER | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTERING ˚F | | LEAVING ˚F | | | ENTERING ˚F | | LEAVING ˚F | | | | TEMP °F | | | | TEMP °F | |
| UNIT | CFM | DB | WB | DB | WB | CFM | DB | WB | DB | WB | ΔP | GPM | ENT | LVG | ΔP | GPM | ENT | LVG |
| VAV-327 | 370 | 54.00 | - | 87.66 | - | 376 | 54.20 | - | 86.00 | - | - | 1.25 | 115.00 | 93.14 | 2.40 | 1.50 | 105.00 | 84.33 |
| VAV-328 | 370 | 54.00 | - | 87.66 | - | 375 | 54.20 | - | 82.60 | - | - | 1.25 | 115.00 | 93.14 | 3.00 | 1.50 | 105.00 | 86.59 |
| VAV-329 | 1280 | 54.00 | - | 88.51 | - | 1286 | 54.20 | - | 80.00 | - | - | 4.50 | 115.00 | 93.47 | 2.10 | 5.00 | 105.00 | 89.00 |
| VAV-330 | 1225 | 54.00 | - | 87.74 | - | 1171 | 54.20 | - | 83.70 | - | - | 4.00 | 115.00 | 92.33 | 2.00 | 5.00 | 105.00 | 86.34 |
| VAV-331 | 170 | 54.00 | - | 88.03 | - | 178 | 54.20 | - | 86.70 | - | - | 0.50 | 115.00 | 89.62 | 0.50 | 2.90 | 105.00 | 80.00 |
| VAV-332 | 575 | 54.00 | - | 94.13 | - | 586 | 54.20 | - | 85.70 | - | - | 2.50 | 115.00 | 94.75 | 3.20 | 2.50 | 105.00 | 89.05 |
| VAV-333 | 640 | 54.00 | - | 94.15 | - | 611 | 54.20 | - | 82.30 | - | - | 2.00 | 115.00 | 86.82 | 3.00 | 2.00 | 105.00 | 86.45 |
| VAV-334 | 980 | 54.00 | - | 87.73 | - | 1021 | 54.20 | - | 82.60 | - | | 3.00 | 115.00 | 90.83 | 2.60 | 3.00 | 105.00 | 84.12 |
| VAV-335 | 1275 | 54.00 | - | 86.92 | - | 1331 | 54.20 | - | 86.40 | - | | 4.00 | 115.00 | 91.99 | 2.40 | 5.00 | 105.00 | 81.85 |
| VAV-336 | 470 | 54.00 | - | 90.53 | - | 449 | 54.20 | - | 84.00 | - | | 1.50 | 115.00 | 89.89 | 3.60 | 1.50 | 105.00 | 85.73 |
| VAV-337 | 375 | 54.00 | - | 90.77 | - | 383 | 54.20 | - | 84.80 | - | | 1.50 | 115.00 | 94.84 | 5.10 | 1.50 | 105.00 | 88.12 |
| | | | | | | | | | | | | | | | | | | |
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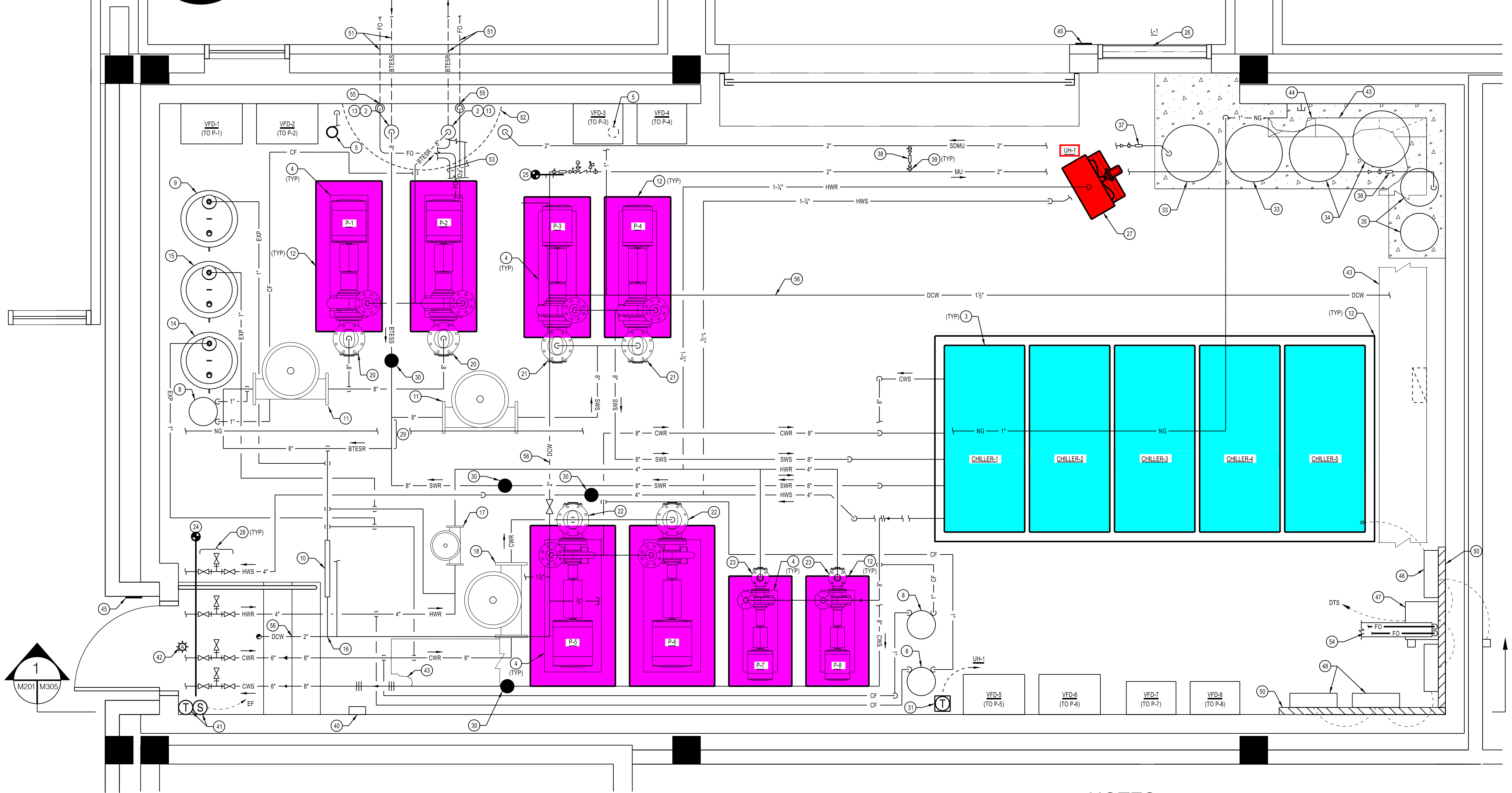
| | | | | | | | | | | | | | | | | | | |

**REMARKS:**

**TECHNICIAN:** MD/TB **TEST DATE:** 7/30/2015

IF YOU DIG GEORGIA...
CALL US FIRST!
1-800-282-7411
UTILITIES PROTECTION CENTER
IT'S THE LAW




# 1ST FLOOR MECHANICAL ROOM NEW WORK FLOOR PLAN

SCALE: ½"=1'-0"

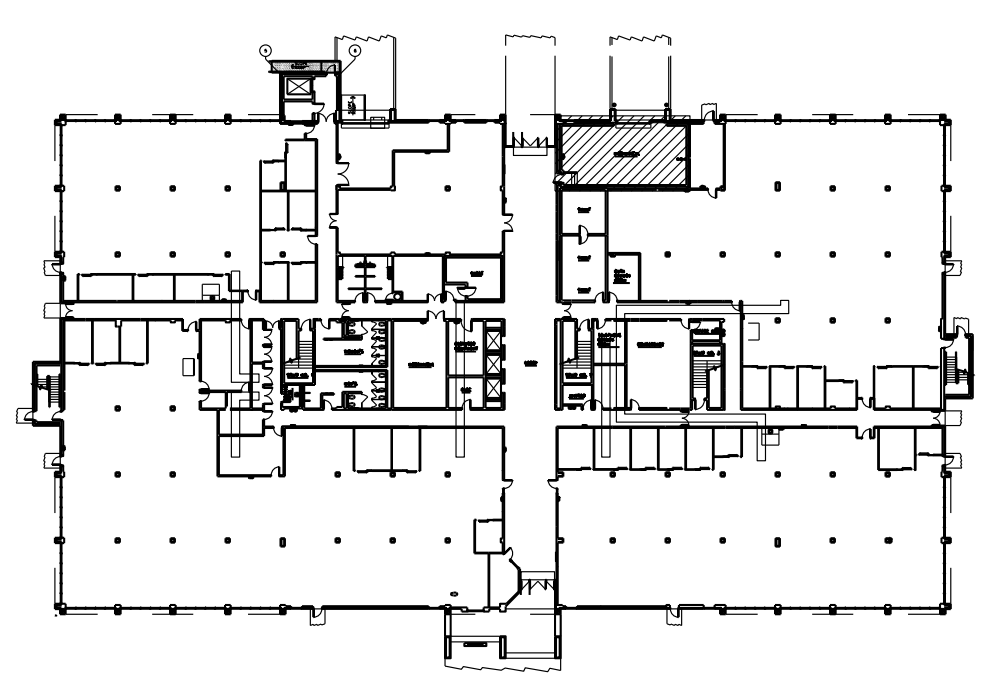
2' 1' 0' 2' 4' 6'
SCALE: ½" = 1'-0"

## NOTES: (THIS SHEET ONLY)

1. GENERAL: SEE PIPING SCHEMATICS FOR ADDITIONAL INFORMATION.
2. SEE SHEET M001 FOR GEOTHERMAL BTES LOOP PIPING CONTINUATION.
3. MODULAR CHILLER WITH HEATING HOT WATER (HW), CHILLED WATER (CW) AND SOURCE WATER (SW) CONNECTIONS. SEE MODULAR HEAT RECOVERY CHILLER PIPING CONFIGURATION SCHEMATIC ON SHEET 304.
4. END SUCTION BASE MOUNTED PUMP. SEE BASE MOUNTED END SUCTION PUMP DETAIL.
5. TERMINATE EXISTING COOLING TOWER PIPING WITH BLIND FLANGE AT NEAREST FLANGE CONNECTION ABOVE FINISHED FLOOR (APPROXIMATELY 24" A.F.F.)
6. GENERAL: CONTRACTOR SHALL SCHEDULE SITE VISIT TO EVALUATE AND VERIFY EXISTING CONDITIONS AND ELEVATIONS.
7. GENERAL: DRAWINGS SHOW GENERAL ARRANGEMENT, LAYOUT, AND LOCATION OF PIPING APPURTENANCES AND OFFSETS THAT MAY BE NECESSARY TO INSTALL PIPING AND CONNECT TO EQUIPMENT ETC. OFFSET PIPING AROUND ALL OBSTRUCTIONS. FABRICATE AND INSTALL PIPING, FITTINGS AND OFFSETS BASED ON FIELD MEASUREMENTS AND AT NO ADDITIONAL COST TO THE GOVERNMENT. PIPE ROUTING SHOWN ON DRAWINGS SHALL BE ALTERED BY MECHANICAL CONTRACTOR WHERE REQUIRED TO AVOID INTERFERENCE AND CLEARANCE DIFFICULTIES. CAREFULLY COORDINATE PIPE ROUTING WITH EXISTING ELECTRICAL TO AVOID CONFLICTS WITH ELECTRICAL CONDUIT, CABLE TRAY, LIGHTS, ETC. COORDINATE PIPE ROUTING WITH EXISTING PLUMBING PIPES (E.G. SPRINKLER VENT PIPING, STORM DRAIN, DOMESTIC WATER, ETC.) TO AVOID CONFLICTS.
8. ONE SHOT CHEMICAL FEEDER. SEE ONE SHOT CHEMICAL FEED SYSTEM DETAIL.
9. VERTICAL MOUNTED BLADDER TYPE PRESSURIZED ASME STAMPED EXPANSION TANK WITH 53.0 GALLON ACCEPTANCE VOLUME AND 53.0 GALLON TOTAL VOLUME. PRE-CHARGE TANK TO 15 PSIG.
10. MAKE-UP WATER STATION. SEE MAKE-UP WATER STATION DETAIL.
11. TANGENTIAL ASME STAMPED AIR SEPARATOR WITH INTEGRAL STRAINER, DRAIN AND FLANGED ACCESS PORT. SEE AIR SEPARATOR DETAIL. MAXIMUM PRESSURE DROP THRU AIR SEPARATOR SHALL NOT EXCEED 5.5 FT. HEAD. MOUNT AIR SEPARATOR AS HIGH AS POSSIBLE.
12. CONCRETE EQUIPMENT PAD. SEE CONCRETE EQUIPMENT PAD DETAIL.
13. GEOTHERMAL BTES LOOP SUPPLY/RETURN PIPING RISES UP THRU MECHANICAL ROOM. SEE MECHANICAL ROOM FLOOR PENETRATION/FLOW METER DETAIL.
14. VERTICAL MOUNTED BLADDER TYPE PRESSURIZED ASME STAMPED EXPANSION TANK WITH 53.0 GALLON ACCEPTANCE VOLUME AND 53.0 GALLON TOTAL VOLUME. PRE-CHARGE TANK TO 15 PSIG.
15. VERTICAL MOUNTED BLADDER TYPE PRESSURIZED ASME STAMPED EXPANSION TANK WITH 80.0 GALLON ACCEPTANCE VOLUME AND 80.0 GALLON TOTAL VOLUME. PRE-CHARGE TANK TO 15 PSIG.
16. CONNECT TO EXISTING DOMESTIC COLD WATER PLUMBING MAIN. PROVIDE ADAPTER AS REQUIRED.
17. TANGENTIAL ASME STAMPED AIR SEPARATOR WITH INTEGRAL STRAINER, DRAIN AND FLANGED ACCESS PORT. SEE AIR SEPARATOR DETAIL. MAXIMUM PRESSURE DROP THRU AIR SEPARATOR SHALL NOT EXCEED 4.5 FT. HEAD. MOUNT AIR SEPARATOR AS HIGH AS POSSIBLE.
18. TANGENTIAL ASME STAMPED AIR SEPARATOR WITH INTEGRAL STRAINER, DRAIN AND FLANGED ACCESS PORT. SEE AIR SEPARATOR DETAIL. MAXIMUM PRESSURE DROP THRU AIR SEPARATOR SHALL NOT EXCEED 6.0 FT. HEAD. MOUNT AIR SEPARATOR AS HIGH AS POSSIBLE.
19. 3-WAY SWITCHING CONTROL VALVE.
20. SUCTION DIFFUSER WITH SUPPORT FOOT, STRAINER AND MAGNET. PROVIDE TEMPORARY FINE MESH STRAINER DURING START-UP. REPLACE WITH STANDARD STRAINER MESH AFTER CLEANING AND START-UP OF PIPING SYSTEM. MAXIMUM PRESSURE DROP THRU SUCTION DIFFUSER SHALL NOT EXCEED 2.2 FT. HEAD.
21. SUCTION DIFFUSER WITH SUPPORT FOOT, STRAINER AND MAGNET. PROVIDE TEMPORARY FINE MESH STRAINER DURING START-UP. REPLACE WITH STANDARD STRAINER MESH AFTER CLEANING AND START-UP OF PIPING SYSTEM. MAXIMUM PRESSURE DROP THRU SUCTION DIFFUSER SHALL NOT EXCEED 2.2 FT. HEAD.
22. SUCTION DIFFUSER WITH SUPPORT FOOT, STRAINER AND MAGNET. PROVIDE TEMPORARY FINE MESH STRAINER DURING START-UP. REPLACE WITH STANDARD STRAINER MESH AFTER CLEANING AND START-UP OF PIPING SYSTEM. MAXIMUM PRESSURE DROP THRU SUCTION DIFFUSER SHALL NOT EXCEED 2.6 FT. HEAD.
23. SUCTION DIFFUSER WITH SUPPORT FOOT, STRAINER AND MAGNET. PROVIDE TEMPORARY FINE MESH STRAINER DURING START-UP. REPLACE WITH STANDARD STRAINER MESH AFTER CLEANING AND START-UP OF PIPING SYSTEM. MAXIMUM PRESSURE DROP THRU SUCTION DIFFUSER SHALL NOT EXCEED 2.7 FT. HEAD.
24. CONNECT NEW PIPING OF INDICATED TYPE AND SIZE TO EXISTING PIPING AT THIS APPROXIMATE LOCATION. CONTRACTOR SHALL REMOVED EXISTING FLEX CONNECTORS AND CONNECT PIPE MAIN TEE ASSEMBLY AT EXISTING FLANGE AT WHICH THE EXISTING FLEX CONNECTIONS ARE LOCATED.
25. CONNECT DOMESTIC COLD WATER PIPING OF INDICATED SIZE AT THIS APPROXIMATE LOCATION TO DRY COOLER LOCATION AS INDICATED. CONTRACTOR SHALL PROVIDE ISOLATION BALL VALVES, PRESSURE REDUCING VALVE, WATER METER, PRESSURE GAUGE, CHECK VALVE AND PRESSURE RELIEF VALVE (SET AT 50 PSIG) AS INDICATED.
26. NEW COMBINATION LOUVER INSTALLED IN EXISTING OPENING. ACTUATOR PROVIDED AND INSTALLED BY MECHANICAL, WIRED BY ELECTRICAL. SEE COMBINATION LOUVER DETAIL.
27. HOT WATER HYDRONIC UNIT HEATER WITH HORIZONTAL DISCHARGE. SEE HOT WATER UNIT HEATER DETAIL.
28. CONTRACTOR SHALL INSTALL GATE VALVE AND LINE-SIZED TEE ASSEMBLY AT THIS APPROXIMATE LOCATION. SEE PIPE MAIN TEE CONNECTION DETAIL. CONTRACTOR SHALL INSTALL THIS ASSEMBLY DURING WEEKEND WHEN TRANSITION TO TEMPORARY EQUIPMENT IS OCCURRING.
29. COMMON/BRIDGE PIPING BETWEEN PRIMARY AND SECONDARY LOOPS.
30. LOCATION OF ELECTROMAGNETIC FLOW SENSOR. SEE ELECTROMAGNECTIC FLOW SENSOR DETAIL.
31. HEAVY DUTY THERMOSTAT WITH LOCKING COVER. THERMOSTAT SHALL BE BY MANUFACTURER; INSTALLED BY MECHANICAL; WIRED BY ELECTRICAL.
32. VARIABLE FREQUENCY DRIVE. PROVIDED AND INSTALLED BY MECHANICAL. WIRED BY ELECTRICAL.
33. DUPLEX DE-ALKALIZER TANKS/SYSTEM AND CONTROLS TO TREAT MAKE-UP WATER FOR ADIABATIC DRY-COOLER. SEE DETAIL ON SHEET M407.
34. BRINE TANKS SERVING DE-ALKALIZER AND WATER SOFTENER SYSTEM. SEE DETAIL ON SHEET M407.
35. DUPLEX WATER SOFTENER AND CONTROLS TO TREAT MAKE-UP WATER FOR ADIABATIC DRY-COOLER.
36. WATER METER CONNECTED TO DDC SYSTEM TO MEASURE INLET WATER USAGE OF WATER SOFTENER/DE-ALKALIZER AND BACKFLUSH OF WATER SOFTENER/DE-ALKALIZER.
37. WATER METER CONNECTED TO DDC SYSTEM TO MEASURE NET WATER DELIVERY (OUTPUT) OF WATER SOFTENER/DE-ALKALIZER.
38. WATER METER CONNECTED TO DDC SYSTEM TO MEASURE WATER VOLUME OF BY-PASS WATER.
39. BALANCE VALVE WITH MEMORY STOP.

## NOTES: (THIS SHEET ONLY - CONTINUED)

40. EXISTING REFRIGERANT MONITOR, CONTROL AND ALARM SYSTEM TO REMAIN IF IT CAN BE REUSED AND ITS SENSOR REPLACED WITH R-410A SENSOR; OTHERWISE, IT SHALL BE REPLACED. WHEN ACTIVATED, SYSTEM SHALL START EXISTING 3,300 CFM EXHAUST FAN (NOTE 44) ON HIGH AND OPEN NEW INTAKE LOUVER (NOTE 26) AND ACTIVATE LOCAL AND REMOTE ALARM LIGHT/HORN. SEE ALSO NOTE 41 & 42. REFRIGERANT MONITOR SHALL INCLUDE AUXILIARY CONTACTS TO THE FIRE ALARM PANEL AND LOCAL DDC SYSTEM.
41. PROVIDE NEW TWO-STAGE THERMOSTAT IN PARALLEL WITH REFRIGERANT MONITOR (NOTE 40) TO START NEW LOUVER L-1 (NOTE 26) AND EXISITNG EXHAUST FAN (NOTE 44) AND LOW SPEED IF ROOM TEMPERATURE RISES ABOVE 85ºF AND ON HIGH SPEED AT 95ºF. ALSO PROVIDE MANUAL OVER RIDE SWITCH TO START FAN ON HIGH AND AN ASHRAE COMPLIANT ENGRAVED LABEL STATING "MECHANICAL ROOM EXHAUST FAN. TURN SWITCH ON WHEN ROOM IS OCCUPIED".
42. EXISTING REFRIGERANT ALARM LIGHT AND HORN TO REMAIN FOR REUSE IF OPERABLE; OTHERWISE, REPLACE.
43. EXISTING SHEET METAL EXHAUST DUCT AND GRILLES TO REMAIN FOR REUSE. SEE NOTE 44 FOR CONTINUATION.
44. EXISTING SHEET METAL EXHAUST DUCT RISES UP THRU SECOND FLOOR SLAB AND CONTINUES UP TO EXISTING 3,300 CFM EXHAUST FAN ON ROOF WHICH SHALL REMAIN FOR REUSE.
45. PROVIDE BAKE LIGHT LABEL AT 5'-0" A.F.F. STATING, "REFRIGERANT VESSELS INSIDE. SWITCH EXHAUST FAN SWITCH TO ON POSITION UPON ENTRY".
46. MODULAR CHILLER CONTROL PANEL.
47. DISTRIBUTED TEMPERATURE SENSING (DTS) CONTROL CABINET/HEAD-IN. SEE DETAIL SHEET M408.
48. DDC CONTROL PANEL.
49. PHASE MONITOR RELAY PROVIDED BY CHILLER MANUFACTURER AND INTERCONNECTED TO CHILLER CONTROLS TO SHUT DOWN ALL CHILLERS UPON PHASE LOSS.
50. PROVIDE ¾" PLYWOOD BACKBOARD FOR DDC CONTROLS, DTS CABINET, ETC.
51. BTES S/R PIPING WITH DTS FO CABLE IS ROUTED UNDERGROUND TO BTES BOREFIELD. SEE SHEET M001 FOR CONTINUATION AND SHEET M404 FOR INSTALLATION DETAILS.
52. SAW CUT AWAY FLOOR SLAB AS REQUIRED FOR INSTALLATION OF NEW PIPING AND CONDUIT AND PATCH BACK FLOOR WITH REINFORCED CONCRETE SLAB TO MATCH EXISTING.
53. DTS FO CABLE IS ROUTED IN 2" WIDE PLASTIC SLOTTED DUCT WITH HINGED COVER (PANDUCT TYPE G) SUPPORTED ON 2'-0" CENTERS OVERHEAD TO DTS HEAD-IN. SEE NOTES 47 AND 54 FOR CONTINUATION.
54. DTS FO CABLE IS ROUTED IN 2" WIDE PLASTIC SLOTTED DUCT WITH HINGED COVER (PANDUCT TYPE G) SUPPORTED ON 2'-0" CENTERS OVERHEAD FROM DTS HEAD-IN TO FLOOR PENETRATION. SEE NOTES 53 AND 55 FOR CONTINUATION.
55. DTS FO CABLE FROM HEAD-IN (NOTE 53 AND 54) DROPS ALONG WALL INSIDE OF PLASTIC SLOTTED WALL DUCT WITH HINGED COVER (PANDUCT TYPE G) SECURED TO WALL AND ENTERS 2"Ø LONG RADIUS (MIN. 12"R) PVC SWEEP ELBOW AND PENETRATES FLOOR SLAB, FOUNDATION WALL AND EXTEND 3'-0" BEYOND BUILDING WHERE IT IS DIRECT BURIED. SEE SHEET M101 AND M404 FOR CONTINUATION.
56. EXISTING PIPING TO REMAIN FOR REUSE.



KEY PLAN
SCALE: NONE


Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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AH&P CONSULTING ENGINEERS
ANDREWS, HAMMOCK & POWELL, INC.
250 Charter Lane,
Suite 100
Macon, Georgia 31210
Phone: (478) 405-8301
Fax: (478) 405-8210
www.ahpengr.com


ESTCP
DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS
REV. | DESCRIPTION | PREP BY | DATE | APPRVD.

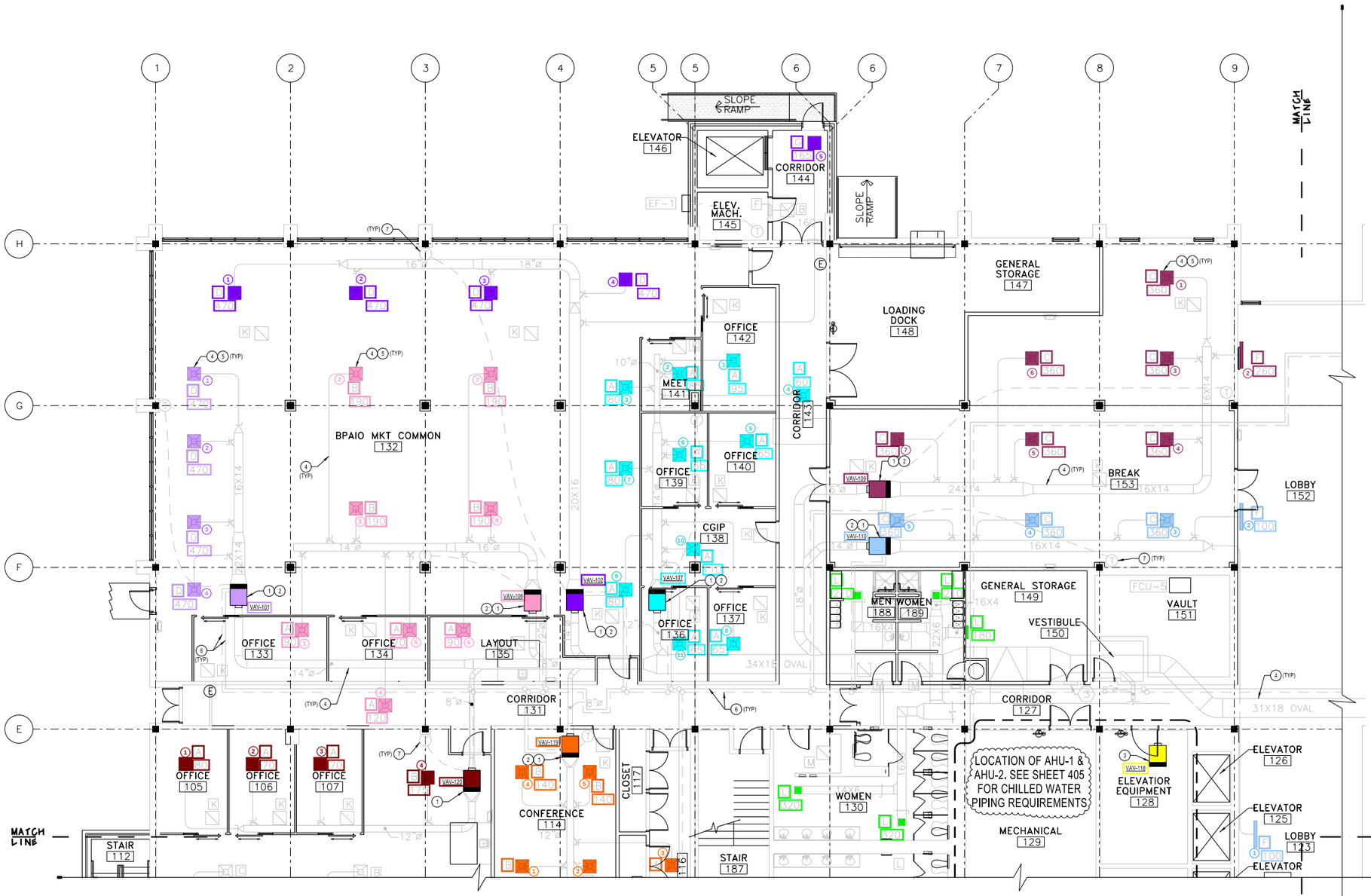
MCLB ALBANY, GEORGIA
INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700
1ST FLOOR MECHANICAL ROOM NEW WORK FLOOR PLAN

APPROVED | EFD FOR COMMANDER, NAVFAC | DATE

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. PROFESSIONAL ENGINEER CHARLES W. HAMMOCK JR.

RECORD DRAWING DATE 05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 645
SHEET 23 OF 60
M201




## NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REVMOED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
2. THE NEW VAV BOX THAT REPLACES THE EXISTING VAV BOX IS INCREASED IN SIZE. PROVIDE MEDIUM PRESSURE TRANSITION AS REQUIRED FOR CONNECTION OF EXISTING MEDIUM PRESSURE DUCT TO NEW VAV BOX INLET CONNECTION SIZE. SEE VAV SCHEDULE FOR VAV BOX SIZE. CONTRACTOR SHALL FIELD VERIFY EXISTING MEDIUM PRESSURE DUCTWORK SIZE.
3. EXISTING VAV BOX TO REMAIN.
4. EXISTING MEDIUM AND LOW PRESSURE DUCT, FLEX DUCT AND DIFFUSERS TO REMAIN FOR REUSE (TYPICAL).
5. EACH GRILLE SHALL BE REBALANCED FOR THE CFM INDICATED (TYPICAL).
6. EXISTING HOT WATER MAINS AND BRANCH RUN-OUTS UP TO THE ISOLATION VALVES AT EACH VAV BOX SHALL REMAIN FOR RESUSE (TYPICAL).
7. EXISTING THERMOSTATS AND WIRING TO REMAIN (TYPICAL).

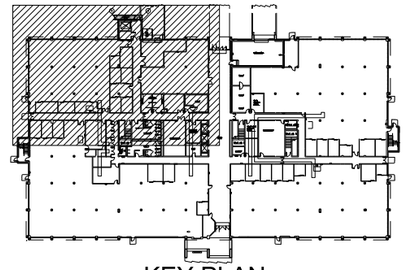
# PARTIAL FIRST FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

NOTICE: THIS FACILITY WILL BE FULLY OCCUPIED DURING THE WEEKDAYS DURING THE CONSTRUCTION PERIOD. ACCORDINGLY, ALL WORK SHOWN ON THIS SHEET, AND ANY WORK OUTSIDE THE MECHANICAL/ELECTRICAL ROOMS, MUST BE ACCOMPLISHED BETWEEN 6PM FRIDAY AND 6AM MONDAY AFTER ARRANGEMENTS ARE MADE WITH THE NAVFAC CONSTRUCTION SUPERVISOR. THE CONTRACTOR WILL BE ALLOWED WEEKEND ACCESS TO ONE HALF OF ANY FLOOR AT A TIME UNTIL WORK IN THAT AREA IS COMPLETE. DESK/COMPUTERS/ETC. SHALL PROTECTED FROM DUST/WATER/DEBRIS/ETC. DURING ALL DEMOLITION & CONSTRUCTION ACTIVITIES AND ALL CEILING SYSTEMS/SURFACES/EQUIPMENT/APPURTENANCES/ETC. RESTORED TO THEIR ORIGINAL CONDITION BY 6AM MONDAY



KEY PLAN

SCALE: NONE

Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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AH&P CONSULTING ENGINEERS
ANDREWS, HAMMOCK & POWELL, INC.
250 Charter Lane,
Suite 100
Macon, Georgia 31210
Phone: (478) 405-8301
Fax: (478) 405-8210
www.ahpengr.com


ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP BY | DATE | APPRVD. |
|---|---|---|---|---|
| | | | | |

MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700

PARTIAL FIRST FLOOR PLAN – HVAC NEW WORK PLAN

APPROVED DATE

EFD FOR COMMANDER, NAVFAC

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

| | |
|---|---|
| RECORD DRAWING DATE | 05-SEPTEMBER-2013 |
| CODE I.D. NO. | |
| DRAWING SIZE: | 24 X 36 |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 647 |
| SHEET | 25 OF 60 |

M203




# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF DEMOLISHED VAV BOX. INSTALL THE DDC CONTROLLERASSOCIATED WITH THE DEMOLISHED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPNENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
2. THE NEW VAV BOX THAT REPLACES THE EXISTING IS INCREASED IN SIZE. PROVIDE MEDIUM PRESSURE TRANSITION AS REQUIRED FOR CONNECTION OF EXISTING MEDIUM PRESSURE DUCT TO NEW VAV BOX INLET CONNECTION SIZE. SEE VAV SCHEDULE FOR VAV BOX SIZE. CONTRACTOR SHALL FIELD VERIFY EXISTING MEDIUM PRESSURE DUCTWORK SIZE.
3. EXISTING THERMOSTATS AND WIRING TO REMAIN (TYPICAL).
4. EXISTING MEDIUM AND LOW PRESSURE DUCT, FLEX DUCT AND DIFFUSERS TO REMAIN FOR REUSE (TYPICAL).
5. EACH GRILLE SHALL BE REBALANCED FOR THE CFM INDICATED (TYPICAL).
6. EXISTING HOT WATER MAINS AND BRANCH RUN-OUTS UP TO THE ISOLATION VALVES AT EACH VAV BOX SHALL REMAIN FOR REUSE (TYPICAL).

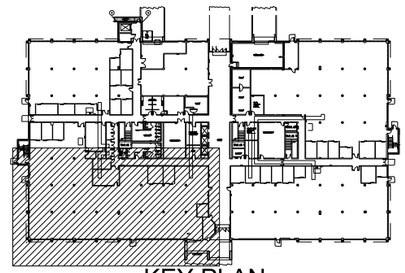
## PARTIAL FIRST FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

NOTICE: THIS FACILITY WILL BE FULLY OCCUPIED DURING THE WEEKDAYS DURING THE CONSTRUCTION PERIOD. ACCORDINGLY, ALL WORK SHOWN ON THIS SHEET, AND ANY WORK OUTSIDE THE MECHANICAL/ELECTRICAL ROOMS, MUST BE ACCOMPLISHED BETWEEN 6PM FRIDAY AND 6AM MONDAY AFTER ARRANGEMENTS ARE MADE WITH THE NAVFAC CONSTRUCTION SUPERVISOR. THE CONTRACTOR WILL BE ALLOWED WEEKEND ACCESS TO ONE HALF OF ANY FLOOR AT A TIME UNTIL WORK IN THAT AREA IS COMPLETE. DESK/COMPUTERS/ETC. SHALL PROTECTED FROM DUST/WATER/DEBRIS/ETC. DURING ALL DEMOLITION & CONSTRUCTION ACTIVITIES AND ALL CEILING SYSTEMS/SURFACES/EQUIPMENT/APPURTENANCES/ETC. RESTORED TO THEIR ORIGINAL CONDITION BY 6AM MONDAY



KEY PLAN

SCALE: NONE

Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
This drawing was modified by Addison Energy Technologies, LLC for Commissioning and T&B only. Not to be used for engineering or design purposes.


AH&P CONSULTING ENGINEERS
ANDREWS, HAMMOCK & POWELL, INC.
250 Charter Lane,
Suite 100
Macon, Georgia 31210
Phone: (478) 405-8301
Fax: (478) 405-8210
www.ahpengr.com


ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP. BY | DATE | APPRVD. |
|---|---|---|---|---|
| | | | | |

ALBANY, GEORGIA

MCLB

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL FIRST FLOOR PLAN – HVAC NEW WORK PLAN

DATE

APPROVED

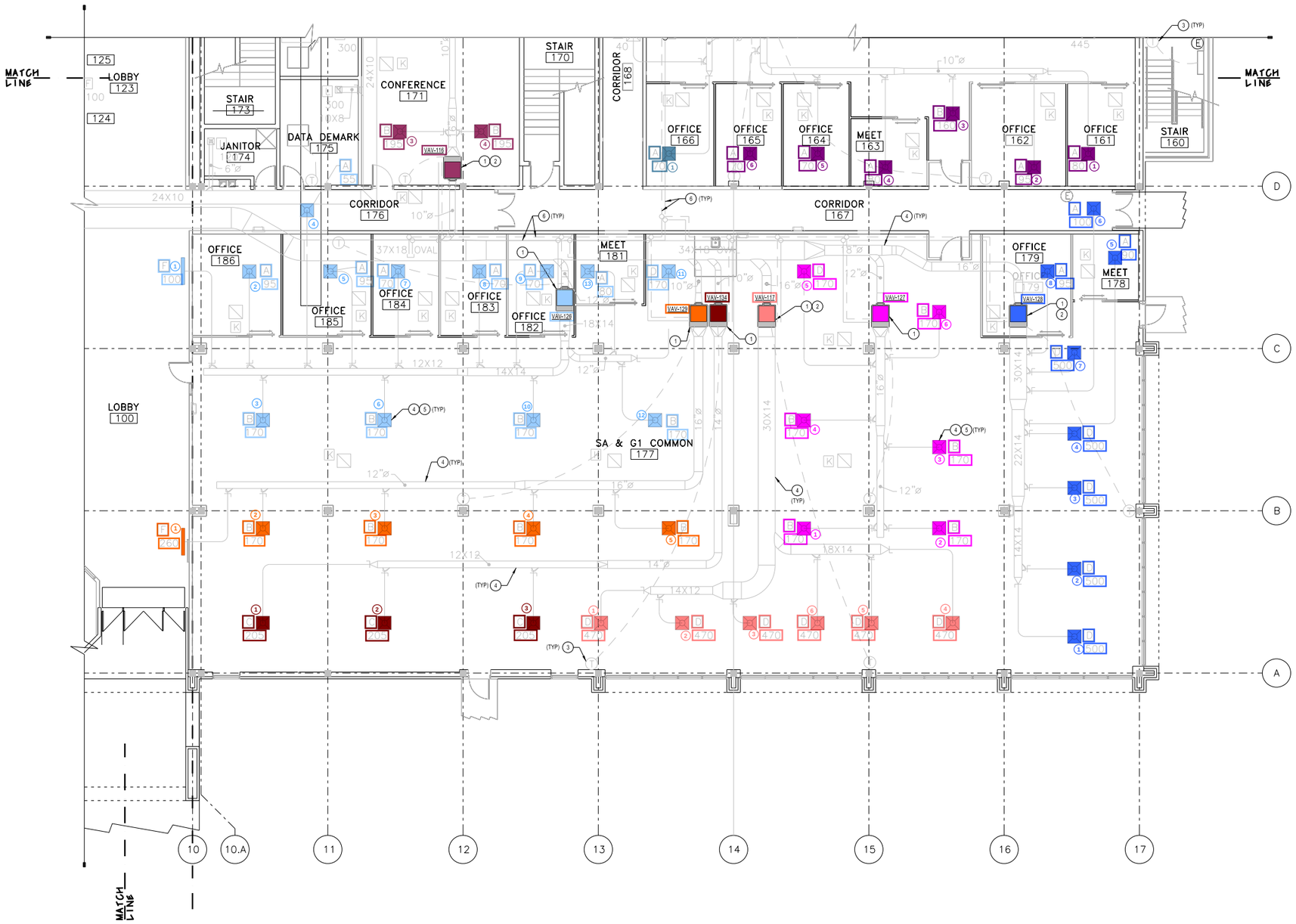
EFD FOR COMMANDER, NAVFAC

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED NO. ENGINEER CHARLES W. HAMMOCK, JR.

| | |
|---|---|
| RECORD DRAWING DATE | 05-SEPTEMBER-2013 |
| CODE I.D. NO. | |
| DRAWING SIZE: | 24 X 36 |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 648 |
| SHEET | 26 OF 60 |

M204




# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REMOVED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
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3. EXISTING THERMOSTATS AND WIRING TO REMAIN (TYPICAL).
4. EXISTING MEDIUM AND LOW PRESSURE DUCT, FLEX DUCT AND DIFFUSERS TO REMAIN FOR REUSE (TYPICAL).
5. EACH GRILLE SHALL BE REBALANCED FOR THE CFM INDICATED (TYPICAL).
6. EXISTING HOT WATER MAINS AND BRANCH RUN-OUTS UP TO THE ISOLATION VALVES AT EACH VAV BOX SHALL REMAIN FOR REUSE (TYPICAL).

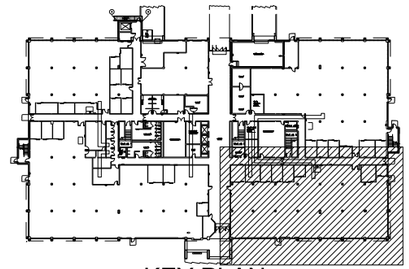
## PARTIAL FIRST FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

NOTICE: THIS FACILITY WILL BE FULLY OCCUPIED DURING THE WEEKDAYS DURING THE CONSTRUCTION PERIOD. ACCORDINGLY, ALL WORK SHOWN ON THIS SHEET, AND ANY WORK OUTSIDE THE MECHANICAL/ELECTRICAL ROOMS, MUST BE ACCOMPLISHED BETWEEN 6PM FRIDAY AND 6AM MONDAY AFTER ARRANGEMENTS ARE MADE WITH THE NAVFAC CONSTRUCTION SUPERVISOR. THE CONTRACTOR WILL BE ALLOWED WEEKEND ACCESS TO ONE HALF OF ANY FLOOR AT A TIME UNTIL WORK IN THAT AREA IS COMPLETE. DESK/COMPUTERS/ETC. SHALL PROTECTED FROM DUST/WATER/DEBRIS/ETC. DURING ALL DEMOLITION & CONSTRUCTION ACTIVITIES AND ALL CEILING SYSTEMS/SURFACES/EQUIPMENT/APPURTENANCES/ETC. RESTORED TO THEIR ORIGINAL CONDITION BY 6AM MONDAY



KEY PLAN

SCALE: NONE

Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP. BY | DATE | APPROVD. |
|---|---|---|---|---|
| | | | | |

MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL FIRST FLOOR PLAN – HVAC NEW WORK PLAN

DATE EFD FOR COMMANDER, NAVFAC

APPROVED

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED ENGINEER CHARLES W. HAMMOCK, JR.

RECORD DRAWING DATE 05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 649
SHEET 27 OF 60

M205

# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REMOVED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
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7. EXISTING THERMOSTATS AND WIRING TO REMAIN (TYPICAL).

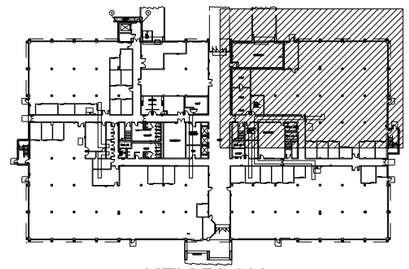



## PARTIAL FIRST FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"



KEY PLAN

SCALE: NONE

NOTICE: THIS FACILITY WILL BE FULLY OCCUPIED DURING THE WEEKDAYS DURING THE CONSTRUCTION PERIOD. ACCORDINGLY, ALL WORK SHOWN ON THIS SHEET, AND ANY WORK OUTSIDE THE MECHANICAL/ELECTRICAL ROOMS, MUST BE ACCOMPLISHED BETWEEN 6PM FRIDAY AND 6AM MONDAY AFTER ARRANGEMENTS ARE MADE WITH THE NAVFAC CONSTRUCTION SUPERVISOR. THE CONTRACTOR WILL BE ALLOWED WEEKEND ACCESS TO ONE HALF OF ANY FLOOR AT A TIME UNTIL WORK IN THAT AREA IS COMPLETE. DESK/COMPUTERS/ETC. SHALL PROTECTED FROM DUST/WATER/DEBRIS/ETC. DURING ALL DEMOLITION & CONSTRUCTION ACTIVITIES AND ALL CEILING SYSTEMS/SURFACES/EQUIPMENT/APPURTENANCES/ETC. RESTORED TO THEIR ORIGINAL CONDITION BY 6AM MONDAY

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MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP BY | DATE | APPRVD. |
|---|---|---|---|---|
| | | | | |

MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL FIRST FLOOR PLAN – HVAC NEW WORK PLAN

APPROVED DATE

EFD FOR COMMANDER, NAVFAC

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

| | |
|---|---|
| RECORD DRAWING DATE | 05-SEPTEMBER-2013 |
| CODE I.D. NO. | |
| DRAWING SIZE: 24 X 36 | |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 650 |
| SHEET | 28 OF 60 |
| | M206 |




# PARTIAL SECOND FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

## NOTES: (THIS SHEET ONLY)

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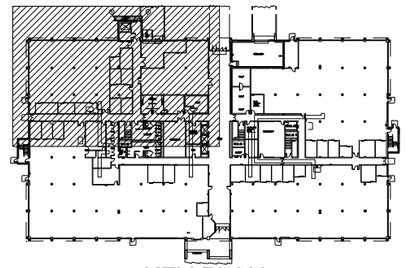

KEY PLAN

SCALE: NONE

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MCLB Albany Geothermal Heat Pumps with USTES
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ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP. BY | DATE | APPRVD. |
|---|---|---|---|---|
| | | | | |

MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL SECOND FLOOR PLAN–HVAC NEW WORK PLAN

| APPROVED | DATE |
|---|---|
| EFD FOR COMMANDER, NAVFAC | |

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

RECORD DRAWING DATE 05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 651
SHEET 29 OF 60
M207




## NOTES: (THIS SHEET ONLY)

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# PARTIAL SECOND FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

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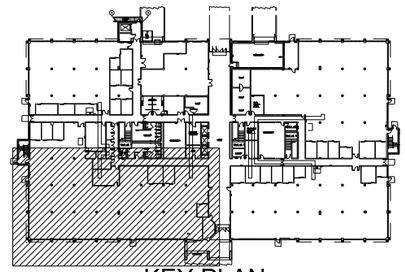

KEY PLAN

SCALE: NONE

Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP. BY | DATE | APPRVD. |
|---|---|---|---|---|
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MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL SECOND FLOOR PLAN–HVAC NEW WORK PLAN

DATE: ED FOR COMMANDER, NAVFAC APPROVED

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED NO. ENGINEER CHARLES W. HAMMOCK JR.

RECORD DRAWING DATE 05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 652
SHEET 30 OF 60

M208




# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REMOVED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
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## PARTIAL SECOND FLOOR PLAN - HVAC NEW WORK PLAN

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SCALE: 1/8" = 1'-0"

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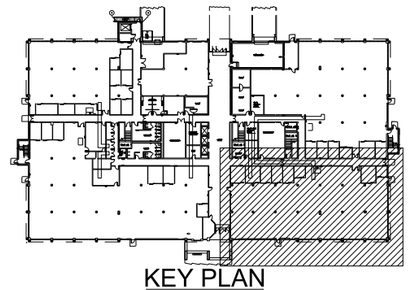

KEY PLAN

SCALE: NONE

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MCLB Albany Geothermal Heat Pumps with USTES
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ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP BY | DATE | APPRVD. |
|---|---|---|---|---|
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ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700
PARTIAL SECOND FLOOR PLAN - HVAC NEW WORK PLAN

MCLB

DATE

EFD FOR COMMANDER, NAVFAC

APPROVED

NAVFAC
Naval Facilities Engineering Command
NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

RECORD DRAWING DATE
05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO.
12 645 653
SHEET 31 OF 60
M209

# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REMOVED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
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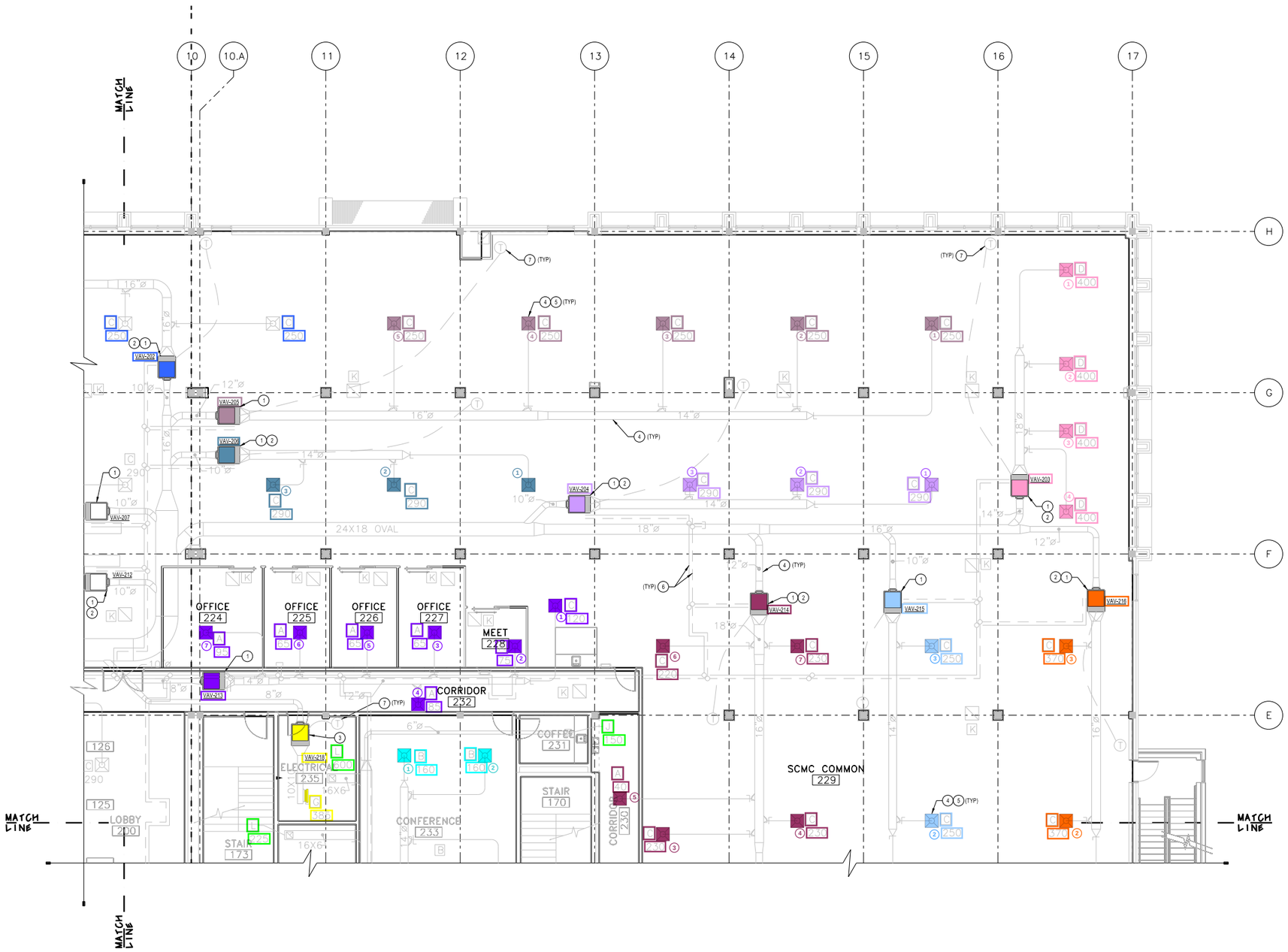


## PARTIAL SECOND FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

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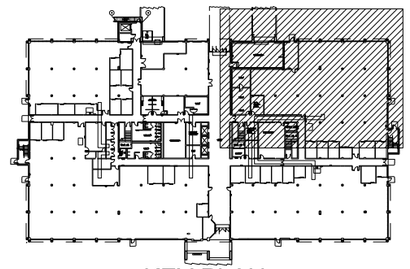

KEY PLAN

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Addison Energy Technologies, LLC
MCLB Albany Geothermal Heat Pumps with USTES
Building 3700
Albany, GA
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www.ahpengr.com


ESTCP

DESIGNER: CWH/SES DRAWN BY: SES REVIEWER: CWH
PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

DRAWING REVISIONS

| REV. | DESCRIPTION | PREP. BY | DATE | APPRVD. |
|---|---|---|---|---|

MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL SECOND FLOOR PLAN–HVAC NEW WORK PLAN

| APPROVED | DATE |
|---|---|
| EFD FOR COMMANDER, NAVFAC | |

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

RECORD DRAWING DATE 05–SEPTEMBER–2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 654
SHEET 32 OF 60

M210




# NOTES: (THIS SHEET ONLY)

1. INSTALL NEW VAV BOX IN PLACE OF REMOVED VAV BOX. INSTALL THE DDC CONTROLLER ASSOCIATED WITH THE REMOVED VAV BOX AT NEW VAV BOX TO MAINTAIN CONTROL FUNCTION. PROVIDE ALL NECESSARY ELECTRICAL COMPONENTS AS REQUIRED FOR RE-INSTALLATION OF DDC CONTROLLER. PROVIDE LOW PRESSURE SUPPLY DUCT TRANSITION AS REQUIRED TO CONNECT NEW VAV BOX TO EXISTING SUPPLY DUCT.
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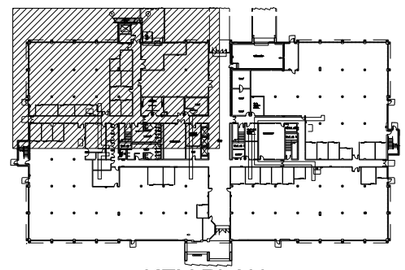
7. EXISTING THERMOSTATS AND WIRING TO REMAIN (TYPICAL).
8. EXISTING HOT WATER PIPING ENTERS 3RD FLOOR MECHANICAL ROOM AT THIS APPROXIMATE LOCATION. CONTRACTOR SHALL INSTALL PRESSURE DIFFERENTIAL TRANSMITTER ACROSS THE TWO HEADERS (HIGH PRESSURE PORT CONNECTED TO HOT WATER SUPPLY PIPING). SEE DIFFERENTIAL PRESSURE SENSOR PIPING DETAIL.

## PARTIAL THIRD FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"



KEY PLAN

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PROJECT LEADER:
SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

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MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700

PARTIAL THIRD FLOOR PLAN – HVAC NEW WORK PLAN

EFD FOR COMMANDER, NAVFAC

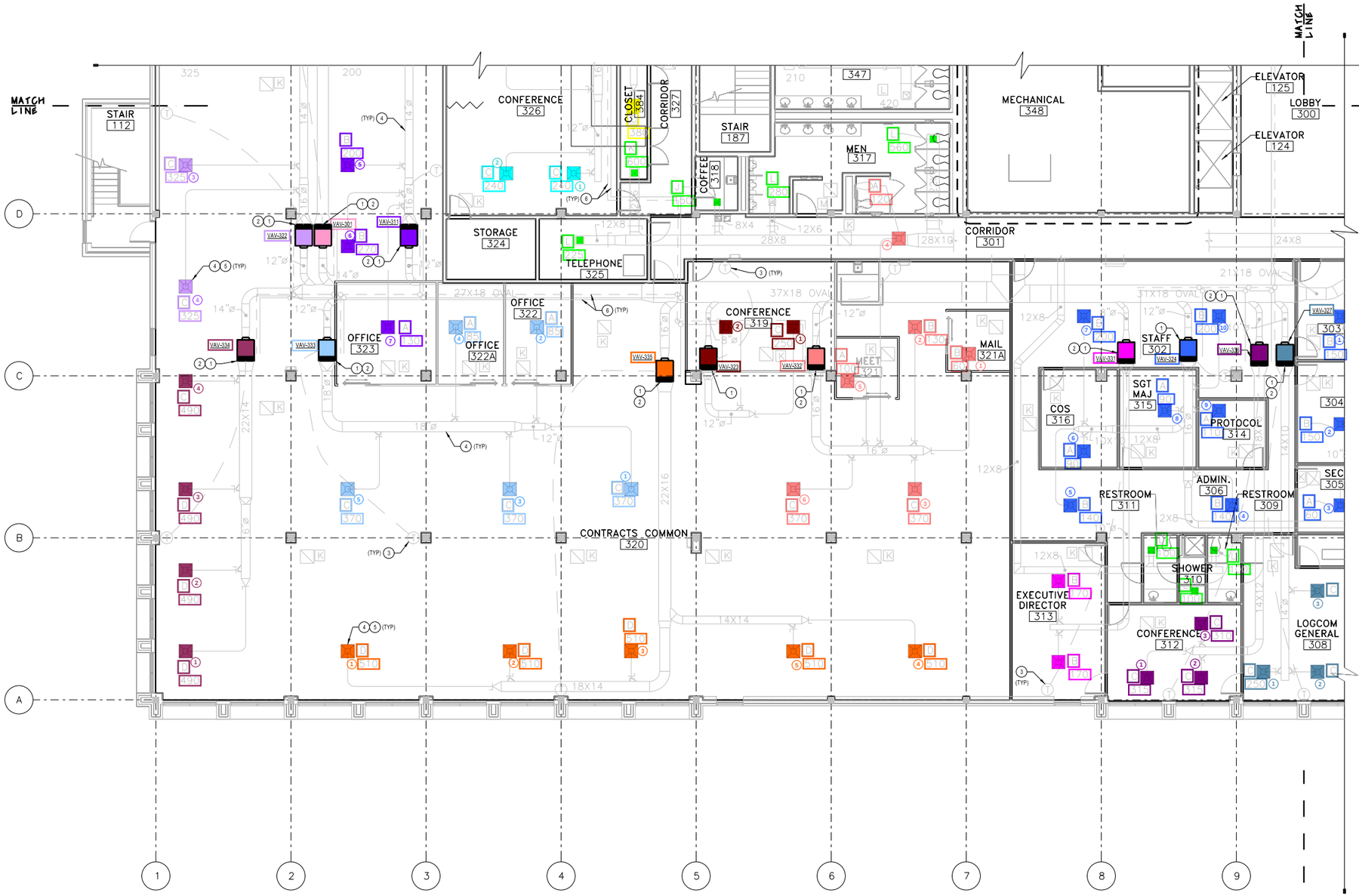
DATE
APPROVED

NAVFAC Naval Facilities Engineering Command
NAVFAC SOUTHEAST

GEORGIA REGISTERED ENGINEER CHARLES W. HAMMOCK JR.

| | |
|---|---|
| RECORD DRAWING DATE | 05-SEPTEMBER-2013 |
| CODE I.D. NO. | |
| DRAWING SIZE: | 24 X 36 |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 655 |
| SHEET | 33 OF 60 |

M211

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# PARTIAL THIRD FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

8' 4' 0' 8' 16' 24'

SCALE: 1/8" = 1'-0"

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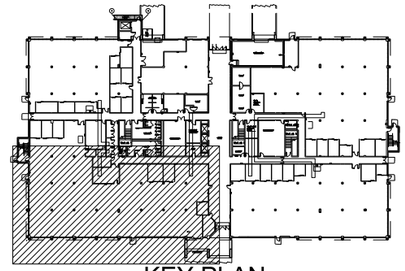

KEY PLAN

SCALE: NONE

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SUBMITTED BY:
NAVFAC TECHNICAL LEAD:
F.P.E. :

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MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700

PARTIAL THIRD FLOOR PLAN – HVAC NEW WORK PLAN

DATE EFD FOR COMMANDER, NAVFAC

APPROVED

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

| | |
|---|---|
| RECORD DRAWING DATE | 05-SEPTEMBER-2013 |
| CODE I.D. NO. | |
| DRAWING SIZE: | 24 X 36 |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 656 |
| SHEET | 34 OF 60 |

M212




# PARTIAL THIRD FLOOR PLAN - HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"

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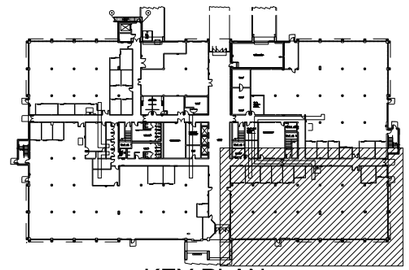

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NAVFAC TECHNICAL LEAD:
F.P.E. :

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MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES) BUILDING 3700

PARTIAL THIRD FLOOR PLAN – HVAC VAV BOX PLAN

EFD FOR COMMANDER, NAVFAC

APPROVED DATE

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED NO. ENGINEER CHARLES W. HAMMOCK, JR.

RECORD DRAWING DATE 05-SEPTEMBER-2013
CODE I.D. NO.
DRAWING SIZE: 24 X 36
CONSTRN. CONTR. NO.
NAVFAC DRAWING NO. 12 645 657
SHEET 35 OF 60
M213

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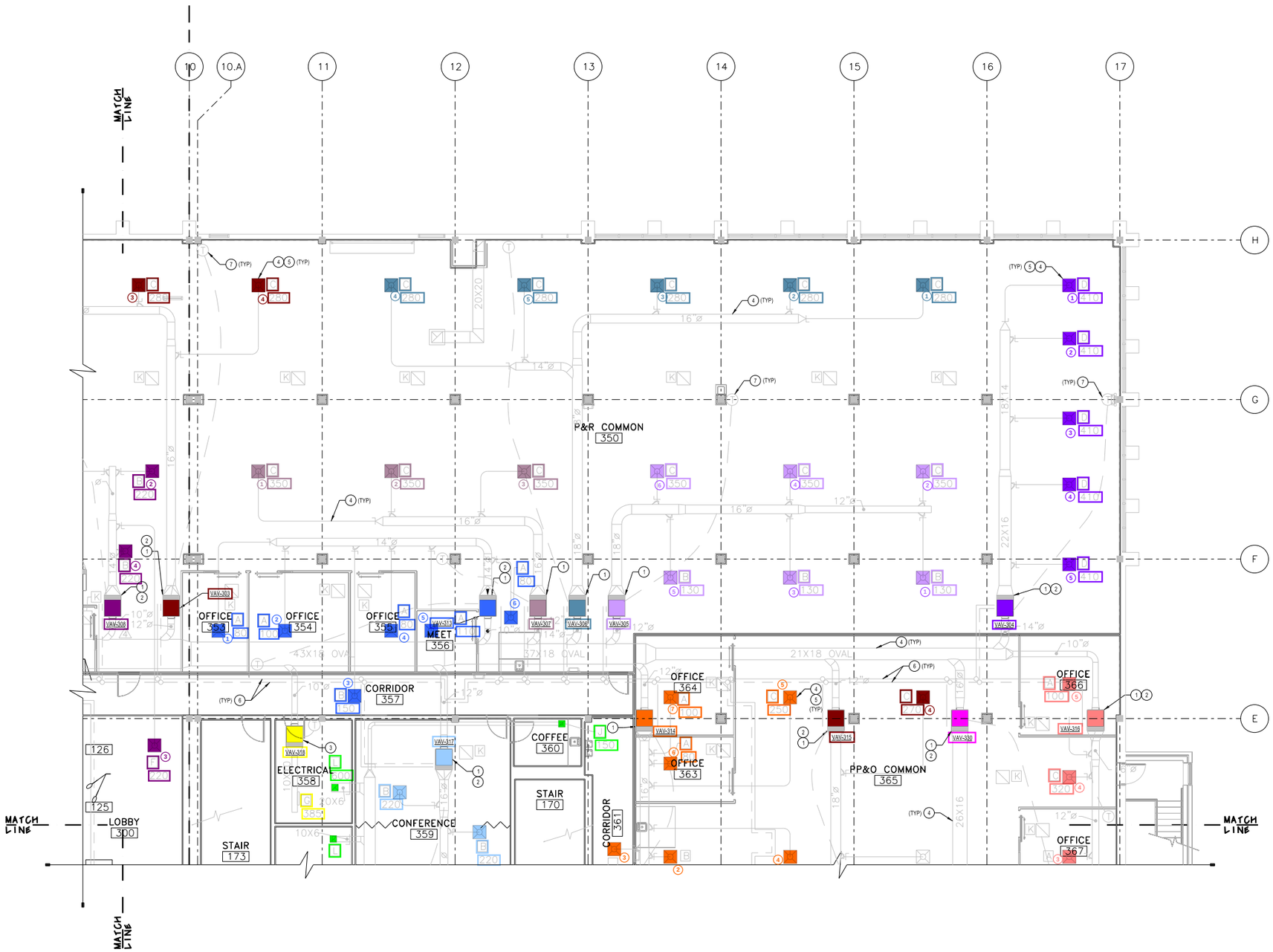


## PARTIAL THIRD FLOOR PLAN - HVAC NEW WORK PLAN

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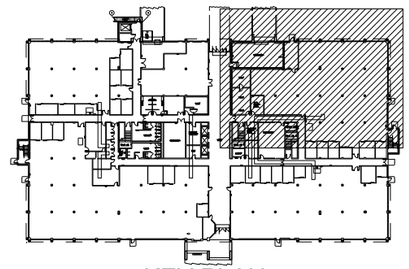

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MCLB ALBANY, GEORGIA

INSTALL GEOTHERMAL HEAT PUMPS WITH UNDERGROUND SEASONAL THERMAL ENERGY STORAGE (USTES)
BUILDING 3700
PARTIAL THIRD FLOOR PLAN - HVAC NEW WORK PLAN

APPROVED DATE

EFD FOR COMMANDER, NAVFAC

NAVFAC Naval Facilities Engineering Command NAVFAC SOUTHEAST

GEORGIA REGISTERED No. ENGINEER CHARLES W. HAMMOCK, JR.

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| DRAWING SIZE: 24 X 36 | |
| CONSTRN. CONTR. NO. | |
| NAVFAC DRAWING NO. | 12 645 658 |
| SHEET | 36 OF 60 |

M214

# Final Commissioning Report

## Marine Corps Logistics Base (MCLB) Albany

## Coupling GHPs with USTES

## Building 3700

**Addison Energy Technologies, LLC**

**December 14, 2015**

## Table of Contents

Project Summary ..... 3
New System Commissioning ..... 3
Existing System Commissioning ..... 3
Appendix A – Final Commissioning Issues Log for New Systems ..... 5
Appendix B – Final Commissioning Issues Log for Existing Systems ..... 5
Appendix C – Field Reports ..... 5
Appendix D – Start-up Reports ..... 5

## Project Summary

The Building 3700 is served by a total of six Air Handling Units arranged in sets of two serving each floor level. The set layout is with a left hand and right hand unit each having a supply air and return air distribution duct network, but sharing a common outside air supply (OAS). The OAS is provided via a rooftop installed Energy Recovery Unit (ERU).

The GHP/USTES is a stand-alone and separately controlled source water supply system. A total of 99 VAV boxes were upgraded and/or replaced within the Scope of Work for the GHP/USTES specification. Individual piping runouts for the VAV boxes remain unmodified up to the respective isolation valves at each VAV. Existing thermostats and wiring were scheduled to remain in place, and were reused.

Addison Energy Technologies (AET) was hired as an independent third party to ensure that the building's HVAC systems were installed properly and operating as intended by the design, specifications, and the Owner's operational needs. An AET employee was present on-site for six weeks during the construction phase to perform Installation Verification and Functional Performance Testing. These visits identified problems early so they could be addressed with minimal cost implications and ensure high quality building operation for the owner.

## New System Commissioning

The Final Issues Log for the newly installed systems is provided as appendix A to this final commissioning report (35 pages). A total of 53 issues were identified and only 1 item remains open.

## Existing System Commissioning

The Existing System Commissioning effort focused on the existing Air Handing Units (AHUs) and an existing Energy Recovery Unit (ERU), all of which had been previously modified, but not as a certain effort of the current GHP/USTES Project. The commissioning of six Air Handling Units (AHUs) and the Energy Recovery Unit (ERU) in Building 3700 at MCLB Albany Georgia occurred on July 29-31, 2015.

The AHU and ERU equipment was observed to be deficient in several areas for each unit. The primary area of deficiency is that "ALL" dampers were in fixed positions, which nullified any normal control capability for air flows – e.g. outside air supply, return air volume, supply air volume. The flow was intended to be manipulated by increasing or decreasing fan speed only. The SOP is not functional as result of above-mentioned fixed damper positions. Additionally, the effectiveness of the ERU could not be determined, as it too, is not functional per its normal SOP. The lack of a normal functional SOP prohibits the control of supply temperature reset conditions. It was also determined that because the equipment is essentially setup for Occupied Mode on a 24/7 schedule, all normal energy savings from unoccupied setbacks cannot be achieved.

Many sensors, such as duct static pressure, freeze stats, do not shutdown equipment – some are circumvented and others appear to have not been included in the control programming. Additionally,

the freeze stats have not been set uniformly – some are set to 45°F and others are set to 35°F (A setting of 45°F would be normal for a single stage stat.). In addition, the above-referenced sensors do not "Alarm" at the front BAS unit.

It is recommended that the deficiencies need to be corrected and followed with a formal Re-commissioning. By definition, this is "Commissioning to be performed in a building whose HVAC System was commissioned previously, either during construction or occupancy." The Re-commissioning process will develop documentation and establish operational conditions for continued cost savings performance over time in several areas:

- DDC sequences of operation will start/stop air handlers depending on respective space occupancy.
- Variable ventilation systems will be verified for correct operation.
- Hot Water systems will maintain hot water set points based on outside air temperature.
- Chiller systems will maintain chilled water supply set points based on the outside air temperature.
- Dampers that are normally controlled by the DDC system will modulate based on space occupancy or space temperature set points.
- Maximize energy savings from implementation of various control strategies in order to alleviate occupant comfort problems.

At a minimum, scope of work for Re-commissioning should include the following:

- Review of existing sequence of operation for each AHU.
- Review of occupied space conditions to identify thermal comfort problems.
- Review of design drawings and compare existing space conditions with design. Verification and recalibration of damper actuator(s) operation, or replacement of each as applicable.
- Verification of economizer operation.
- Test and balance of airflows at each AHU after all deficient components and devices have been replaced and/or calibrated.
- Identification and verification of optimum locations for different sensors.
- Recalibration of temperature, static pressure sensors, etc.
- Validate the graphics on the host front end computer (if applicable).
- Test and balance CHW and HW flows through AHU coils
- Estimate costs for all the major repairs.
- Functional test of the control loop sequence of operations.
- Check operating functional performance of AHU, exhaust fan, and chiller.
- Check correct operation and calibration of all analog and digital points (point-to-point).
- Check actuators, valves, and dampers for proper operations.
- Check for valve leak through.
- Develop a comprehensive report including field observations, test data and results.

The Final Issues Log for the existing systems is provided as appendix B to this final commissioning report (5 pages). A total of 87 issues were identified. None of the issues have been addressed to the best of our knowledge.

The following appendices have been attached to the final commissioning report.

**Appendix A – Final Commissioning Issues List for New Systems (35 pages)**

**Appendix B – Final Commissioning Issues Log for Existing Systems (5 pages)**

**Appendix C – Commissioning Field Reports (77 pages)**

**Appendix D – Start-up Reports (16 pages)**

# Appendix A

# Final Commissioning Issues List for New Systems

# Construction Issues

53 Issues sorted by **status**

Open 1 records

## FO-1-1 OPEN HIGH

Exhaust fan EF-1 is not operational per plan and duct work is in poor condition.

**Assigned To** SafeAir
**Asset** HVAC
**Discipline** Mechanical
**Drawing** M201
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:36 AM

Exhaust fan is operational. The wall stat was verified to energize the fan. The ductwork remains in poor condition and should be repaired. Currently, if a refrigerant leak were to occur the refrigerant would not properly be removed from the building. This is a safety issue.

**Mike Sabo** on **12/14/2015** at **02:22 PM**

Closed 52 records

## FO-4-4 CLOSED MODERATE

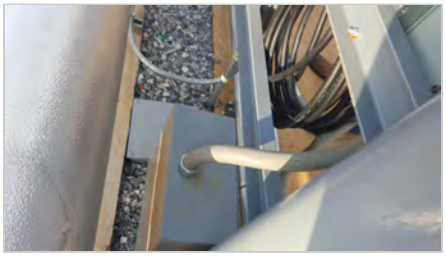
At the Dry Cooler location two junction boxes, one labeled P-9(NEMA 4x) and a PVC junction box, both located below electrical panel DP-LICC have liquid tight connectors penetrating the top side of both boxes. If the topside of the box is to be penetrated then a Myer's Hub should be used to ensure a sealed connection.

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Created By** Paul Southwell
**Identified On** 7/22/2015 1:06 PM

Contractor reported that the existing connections are equivalent to Myer's Hubs

**Mike Sabo** on **12/14/2015** at **01:45 PM**









CxAlloy

## FO-4-3 CLOSED HIGH

The electrical panel, MDP-LIC, located adjacent to the main switchgear is no longer feeding equipment that use to occupy the mechanical room. The remaining breakers need to be identified and the electrical schedule should be updated to eliminate any possibility of injury due to mislabeled breakers.

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Created By** Paul Southwell
**Identified On** 7/22/2015 12:55 PM

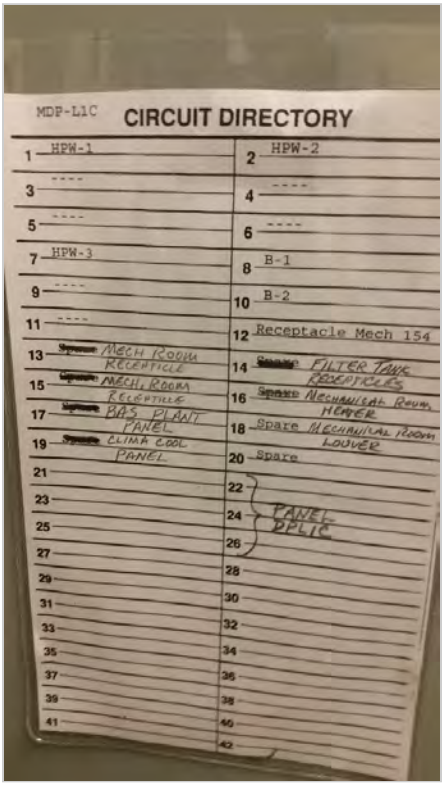
A new panel directory was created.

**Mike Sabo** on **12/14/2015** at **01:45 PM**












CxAlloy

## FO-4-2 CLOSED

Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. According to electrical drawings, the existing breakers located in the distribution section of the switchboard are to be relabeled as "SPARES" since all of the new equipment was being fed from the new distribution section of the switchgear.

**Created By** Paul Southwell
**Identified On** 7/22/2015 12:37 PM

Laminated, plastic nameplates have been added.

**Mike Sabo** on **12/14/2015** at **01:44 PM**

First verify that these breakers are not being used(remove wiring if not used) and provide the appropriate laminated nameplates indicating the breaker is a spare.

**Paul Southwell** on **07/22/2015** at **12:37 PM**







CxAlloy

## FO-4-1 CLOSED MODERATE

358.12 Uses Not Permitted. EMT shall not be used under the following conditions: Where, during installation or afterward, it will be subject to severe physical damage.(3/4" PVC was observed at the rear of both dry coolers coming out of the gravel and terminating on the back of the dry coolers)

**Assigned To** McKenney's
**Asset** Dry Cooler
**Discipline** Electrical
**Drawing** n/a
**Due Date** 8/5/2015
**Created By** Paul Southwell
**Identified On** 7/22/2015 12:28 PM

The referenced conduit is part of the temporary monitoring system installed by the design engineer, AHP. Reportedly, the government has approved the as-built condition.

**Mike Sabo** on **12/14/2015** at **01:44 PM**

Typically, these raceways would be installed using either rigid or IMC conduit, anchoring the conduits utilizing the appropriate strap, i.e., kendorf channel.

**Paul Southwell** on **07/22/2015** at **12:28 PM**





CxAlloy

## FO-3-2 CLOSED MODERATE

The piping arrangement for the BTES loop chemical feeder is not per plan. The supply is from the high pressure side of the BTES pumps. The return is to the low pressure side of the SW pumps (upstream of the BTES/SW decoupler). Because the SW and BTES loops have different pressures (by design) there could be a scenario where the return of the chemical feeder is at a higher pressure than the supply. This will cause reverse flow through the feeder and coupon rack. Per the chemical treatment vendor, this is not desired. The owner should provide approval of the installed condition or provide a corrective course of action.

**Assigned To** Owner
**Asset** Source Water Loop
**Discipline** Mechanical
**Drawing** M301
**Due Date** 7/2/2015
**Created By** Mike Sabo
**Identified On** 6/18/2015 12:50 PM

Currently, the control programming is such that the BTES loop piping will constantly be 10 GPM higher that the Source loop. This will result in proper direction of flow in the chemical treatment system.

**Mike Sabo** on **12/14/2015** at **01:48 PM**

## FO-3-1 CLOSED MODERATE

Five of the Automatic Air Vents (AAV) shown on plans M301, M302, and M303 are missing.

**Assigned To** SafeAir
**Asset** Source Water Loop
**Discipline** Mechanical
**Drawing** M301, M302, M303
**Due Date** 7/2/2015
**Created By** Mike Sabo
**Identified On** 6/18/2015 12:38 PM

The AAVs have been added in different places. This is reportedly per chiller manufacturer recommendations.

**Mike Sabo** on **12/14/2015** at **01:49 PM**

## FO-2-32 CLOSED HIGH

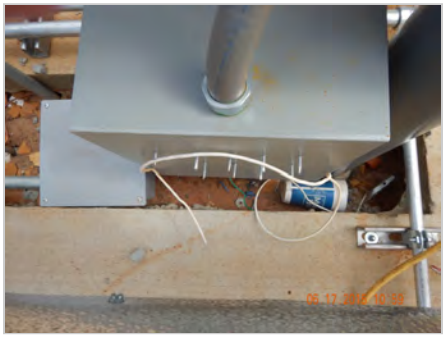
At the dry-cooler area, a NEMA 4X plastic enclosure is located below the NEMA 3R electrical panel. Instead of using a back panel for mounting terminal blocks within the enclosure, the back wall of the water-proof enclosure has been penetrated. These penetrations will allow moisture to enter the enclosure.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Due Date** 7/1/2015
**Created By** Paul Southwell
**Identified On** 6/17/2015 11:16 AM

The penetrations have been sealed.

**Mike Sabo** on **12/14/2015** at **01:50 PM**





## FO-1-15 CLOSED HIGH

The final configuration of the chilled water coils (2-way or 3-way valves has to be established before balancing pumps. Recent testing indicated the 3-way valves should remain.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 11:51 AM

The 3-way valves have been left in place and are valves off or opened less than 10% open to allow minimal flow.

**Mike Sabo** on **12/14/2015** at **01:59 PM**

## FO-2-31 CLOSED HIGH

Verification of the following: Distribution Panel Enclosure Cabinetry: Verify that ground bus is not bonded to neutral at Panel DP-L1CC. Enclosure is grounded and resistance to ground meets grounding specifications.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:38 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **01:59 PM**

MetroPower has verified the requirements of FO-2-31 have been met.

**Paul Southwell** on **06/12/2015** at **10:57 AM**

## FO-2-30 CLOSED HIGH

Verification for the following:
1. Ckt SWBD-B-1/Chiller-1 /3#2/0, #6G / 2" conduit.
2. Ckt SWBD-B-2/Chiller-2 /3#2/0, #6G / 2" conduit.
3. Ckt SWBD-B-3/Chiller-3 /3#2/0, #6G / 2" conduit.
4. Ckt SWBD-B-4/Chiller-4 /3#2/0, #6G / 2" conduit.
5. Ckt SWBD-B-5/Chiller-5 /3#2/0, #6G / 2" conduit.
6. Ckt SWBD-B-6 /P-1 / 3#6,#10G / 1" conduit
7. Ckt SWBD-B-7 /P-2 / 3#6,#10G / 1" conduit
8. Ckt SWBD-B-8 /P-3 / 3#8,#10G / 3/4" conduit
9. Ckt SWBD-B-9 /P-4 / 3#8,#10G/ 3/4" conduit
10. Ckt SWBD-B-10 /P-5 / 3#4, #8G/1 1,4"
11. Ckt SWBD-B-11 /P-6 /3#4, #8G/1 1,4"
12.Ckt SWBD-B-12 /P-7 / 3#12, #12G / 3/4" conduit
13. Ckt SWBD-B-13 /P-8 / 4#12,#12G / 3/4" conduit
14. Ckt SWBD-B-14 /DC-1 / 4#12/#12G / 3/4" conduit
15. Ckt SWBD-B-15 /DC-2 / 4#12,#12G / 3/4" conduit
16. Ckt SWBD-B-16 /Chiller Phase Loss / 4#12,#12G / 3/4" conduit

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:37 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:00 PM**

Metr0Power has verified that all circuits added meet the above specifications.

**Paul Southwell** on **06/12/2015** at **10:55 AM**

## FO-2-29 CLOSED HIGH

Verification for the following:
Ground rods shall be copper-clad steel, with minimum diameter of 3/4 inch and minimum length of 10 feet.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Specification Section 26
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:27 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:00 PM**

Metro Power has confirmed ground rod added does meet specifications

**Paul Southwell** on **06/17/2015** at **10:41 AM**

Does ground rod added meet specifications?

**Paul Southwell** on **06/12/2015** at **10:54 AM**

## FO-2-28 CLOSED LOW

Verification based upon the Grounding System Construction Checklist:
1.Requested documentation submitted:Manufacturer's cut sheets.
2.Requested documentation submitted:Installation and startup manual and plan.
3.Requested documentation submitted:O&M manuals.
4. Requested documentation submitted:Warranty Certificate
5.Installation Checks: Grounding electrodes have been installed in accordance with drawings and specifications.
6.Installation Checks: Connections to grounding electrodes have been made in accordance with manufacturer's specifications.
7.Installation Checks: Grounding conductors have been routed in accordance with the drawings and specifications.
8. Installation Checks: Grounding conductors have been properly terminated at the service equipment or separately derived source. Bonding conductors have been installed as required.
9. Installation Checks: Test wells are accessible and clearly marked..
10. Operational Checks: Specified sequences of operation and operating schedules have been provided with all variations documented.
11. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Grounding System Construc
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:25 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:01 PM**

Metro Power has agreed to verify modification to grounding system, to me complete by June 26,2015

**Paul Southwell** on **06/17/2015** at **10:39 AM**

MetroPower's position is that project did not require grounding system to be modified. In reality, they did make additions to the system.

**Paul Southwell** on **06/12/2015** at **10:53 AM**



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## FO-2-27 CLOSED LOW

Verification based upon Panel Construction Checklist:
1.Distribution Panel Enclosure/Cabinetry: Equipment installed per manufacturer's instructions and specifications.
2.Distribution Panel Enclosure/Cabinetry: Equipment installed agrees with shop drawings and specifications
3.Distribution Panel Enclosure/Cabinetry: Verify mounting, location and clearances are per plans and specifications.
4.Distribution Panel Enclosure/Cabinetry: Equipment labels permanently affixed
5.Distribution Panel Enclosure/Cabinetry: Panel is clean and clear of dust or dirt
6.Distribution Panel Enclosure/Cabinetry: Verify the application of manufacturer recommended torque values applied to bolted connections.
7. Distribution Panel Enclosure/Cabinetry: Verify correct circuit breaker sizes and types per the specifications and manufacturer's drawings.
8. Distribution Panel Enclosure/Cabinetry: Neutral bus isolated from cabinet.
9. Circuit Breakers 208/120 VAC Panels: Installed per manufacturer's instructions, plans and specifications.
10. Circuit Breakers 208/120 VAC Panels: No physical damage.
11. Circuit Breakers 208/120 VAC Panels: Verify voltage and current rating of circuit breaker are per plans and specifications.
12. Circuit Breakers 208/120 VAC Panels: Verify breakers are mounted securely and operates smoothly.
13.Circuit Breakers 208/120 VAC Panels: Verify wire is properly installed and suitable size for breaker.
14. Operational Checks: Specified sequences of operation and operating schedules have been provided with all variations documented.
15. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.
16.

**Assigned To** MetroPower
**Asset** Panelboards
Panelboards
Electrical
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:18 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:01 PM**

MetroPower is taking the position that the only panel applicable is Panel DP-L1CC. They are indicating that the panel MDP is existing even though they have modified it.

**Paul Southwell** on **06/12/2015** at **10:51 AM**



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## FO-2-26 CLOSED LOW



CxAlloy

Verification required by Low Voltage Switchgear Construction Checklist:
1. Switchgear enclosure /Cabinetry: Equipment installed per manufacturer's instructions and specifications
2. Switchgear Enclosure /Cabinetry: Equipment installed agrees with shop drawings and specifications
3.Switchgear Enclosure/Cabinetry: Verify mounting, location and clearances are per plans and specifications
4.Switchgear Enclosure /Cabinetry: Inspect for physical, electrical and mechanical condition of equipment and cabinet. No damage evident
5.Switchgear Enclosure /Cabinetry:Inspect panels and doors for proper fit and alignment
6.Switchgear Enclosure /Cabinetry: Equipment labels permanently affixed
7.Switchgear Enclosure /Cabinetry: Panel is clean and clear of dust or dirt
8. Switchgear Enclosure /Cabinetry: Verify correct circuit breaker sizes and types per the specifications and manufacturer's drawings
9. Switchgear Enclosure /Cabinetry: Seismic anchoring installed and functional where applicable (non-short circuiting)
10. Switchgear Enclosure /Cabinetry: Inspect insulators, barriers and shields for damage or contamination
11. Switchgear Enclosure /Cabinetry: Verify that ground bus is properly bonded to enclosure, enclosure is grounded and resistance to ground meets grounding specifications
12. Switchgear Enclosure /Cabinetry: Verify three or four wire configuration
13. Switchgear Enclosure /Cabinetry: Verify metering transformer nameplate matches specified and approved transformer
14. Switchgear Enclosure /Cabinetry: Transformer installed per manufacturer's instruction, plans and specifications.
15. Switchgear Enclosure /Cabinetry: Inspect metering transformer cables and connections for defects or physical damage
16. Switchgear Enclosure /Cabinetry: Verify metering transformer connections are correct per the single line
17. Switchgear Enclosure /Cabinetry: Verify all grounding and shorting connections for the metering transformer are in place
18. Switchgear Enclosure /Cabinetry: Verify correct fusing for the metering transformer primary and secondary
19. Switchgear Enclosure /Cabinetry: Verify the metering transformer taps are in accordance with the manufacturer's nameplate and specifications.
20. Switchgear Enclosure /Cabinetry: Verify the vents and air inlets are free and unobstructed. Clean air filters installed (if required).
21. Feeder Circuit Breakers: Verify all maintenance and service clearances are maintained.
22. Feeder Circuit Breakers: Verify no physical damage.
23. Feeder Circuit Breakers: Verify voltage and current rating of circuit breaker are per plans and specifications.
24. Feeder Circuit Breakers: Confirm correct application of manufacturer's recommended lubricant.
25. Feeder Circuit Breakers: Verify that primary and secondary contact wipe dimensions are correct.
26. Feeder Circuit Breakers: Verify breakers are mounted securely and

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:09 AM



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operates smoothly.
27. Feeder Circuit Breakers: Verify wire is properly installed and suitable size for breaker.
28. Operational Checks: All incoming cables are terminated and “ABC” phasing is correct. Terminations are torqued, checked, stress cones are properly grounded and exposed energized surfaces are insulated.
29. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.
30.

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:01 PM**

These requirements have been satisfied by previous requests.

**Paul Southwell** on **06/17/2015** at **10:35 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist.Same verification required.

**Paul Southwell** on **06/12/2015** at **10:07 AM**

## FO-2-25 CLOSED LOW

Verification required by Specification Section 12 23 00:
1. Compare equipment nameplate data with specifications and approved shop drawings.
2.Confirm correct application of manufacturer's recommended lubricants.
3.Verify that circuit breaker sizes and types correspond to approved shop drawings.
4.Confirm correct operation and sequencing of electrical and mechanical interlock systems.
5.Verify correct barrier installation.
6.Verify that vents are clear.
7.MANUFACTURER'S NAMEPLATE:Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a
conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

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**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:43 AM

MetroPower has verified items 1 through 7

**Paul Southwell** on **06/12/2015** at **10:46 AM**



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## FO-2-24 CLOSED LOW

Documentation required based upon Low Voltage Switchgear Construction Checklist and Panel Construction Checklist:
1. Requested documentation submitted: Manufacturer's cut sheets
2.Requested documentation submitted: Installation and startup manual and plan
3.Requested documentation submitted: O&M manuals
4.Requested documentation submitted: Sequences and control strategies
5.Requested documentation submitted: Warranty Certificate
6.Requested documentation submitted: Installation and startup manual and plan

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:33 AM

This requirement met by previous issue, FO-2-24

**Paul Southwell** on **06/17/2015** at **10:33 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist.

**Paul Southwell** on **06/12/2015** at **10:05 AM**

## FO-2-23 CLOSED LOW

Documentation required by Specification Section 12 23 00:
1.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, short-circuit current test
2.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, enclosure test
3.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, dielectric test
4.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:a. 60-hertz dielectric tests
5.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:a. mechanical operation tests
6.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include electrical operation and control wiring tests

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:22 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:01 PM**

Metro Power agrees to documentation required by Specification Section 12 23 00., to be complete by June 26, 2015.

**Paul Southwell** on **06/17/2015** at **10:31 AM**

MetroPower has requested information from manufacturer on 6/8/2015

**Paul Southwell** on **06/12/2015** at **10:41 AM**



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## FO-2-22 CLOSED HIGH

Installation Checks: Resistance of the grounding system has been measured and recorded. Provide method of measurement.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Grounding System Construc
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:11 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:02 PM**

Metro Power agrees to this installation check, to be complete by June 26, 2015

**Paul Southwell** on **06/17/2015** at **10:29 AM**

MetroPower agrees to testing on Panel DP-L1CC

**Paul Southwell** on **06/12/2015** at **10:40 AM**

## FO-2-21 CLOSED HIGH

Distribution Panel Enclosure/Cabinetry: Megger test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations.

**Assigned To** MetroPower
**Asset** Panelboards
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:10 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

MetroPower agrees to testing on Panel DP-L1CC

**Paul Southwell** on **06/12/2015** at **10:39 AM**

## FO-2-20 CLOSED HIGH

Feeder Circuit Breakers: Hi-potential test of circuit breaker – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:08 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:02 PM**

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:05 AM**

## FO-2-19 CLOSED HIGH

Feeder Circuit Breakers: Megger test of circuit breaker – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:07 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:02 PM**

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Testing requirements are the same

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-18 CLOSED HIGH

Hi-potential test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:06 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:02 PM**

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:27 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-17 CLOSED HIGH

Switchgear Enclosure/Cabinetry: Megger test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:05 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:03 PM**

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:27 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-16 CLOSED HIGH

Electrical Tests: Perform over potential tests.

**Assigned To** Owner
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:03 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:03 PM**

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:26 AM**

MetroPower questions whether MCLB will be acceptable to over potential testing?

**Paul Southwell** on **06/12/2015** at **09:31 AM**

## FO-2-15 CLOSED HIGH

Electrical Tests: Perform insulation-resistance tests on each bus section.

**Assigned To** Owner
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:02 AM

Delete this issue, buss bars are not insulated

**Paul Southwell** on **06/17/2015** at **10:25 AM**

MetroPower questions whether MCLB will be acceptable to insulation resistance testing?

**Paul Southwell** on **06/12/2015** at **09:30 AM**

## FO-2-14 CLOSED HIGH

Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:01 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:29 PM**

Metro Power agrees to switchboard verification at next power outage, currently scheduled for June 28, 2015

**Paul Southwell** on **06/17/2015** at **10:23 AM**

MetroPower agrees to comply during outage to remove temporary power

**Paul Southwell** on **06/12/2015** at **09:28 AM**

## FO-2-13 CLOSED MODERATE

Weater proof , GFI receptacles should be located adjacent DDC control panels and chiller control cabinet.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:58 AM

Contract documents did not specify weather proof and/or GFI receptacles

**Paul Southwell** on **06/17/2015** at **10:20 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:27 AM**






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## FO-2-12 CLOSED MODERATE

Hybrid Dry Cooler De-Alkalizer/Water softener receptacles-should be weather proof / GFI(Mechanical Rm)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** M407
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:57 AM

Contract documents did not specify weather proof and/or GFI receptacles

**Paul Southwell** on **06/17/2015** at **10:20 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:27 AM**





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## FO-2-11 CLOSED HIGH

In the Dry Cooler area, a mixture of enclosures ranging from Nema 3R, Nema 4x, and Nema 6P were observed. NEMA 4X and NEMA 6P are more water resistant than NEMA 3R.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC-Table 110.28
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:56 AM

Metro Power has complied with the contract documents by supplying the correct panel in a NEMA 3R enclosure

**Paul Southwell** on **06/17/2015** at **10:18 AM**

MetroPower claims contract documents call for NEMA 3R enclosure. Whereas contract documents (Drawing E400) requires NEMA 4X enclosures.

**Paul Southwell** on **06/12/2015** at **09:25 AM**





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## FO-2-10 CLOSED HIGH

In the Dry Cooler area, a mixture of rigid, EMT, and PVC conduits are utilized.

**Assigned To** McKenney's
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.4 / 358.12/312.2
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:55 AM

Only GRC and IMC in use now, deficiency issue resolved.

**Paul Southwell** on **06/17/2015** at **10:16 AM**

MetroPower claims all conduit installed by them is GRC, is the EMT and PVC McKenny's

**Paul Southwell** on **06/12/2015** at **09:18 AM**





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## FO-2-9 CLOSED MODERATE

Openings around electrical penetrations into or through fire-resistant-rated walls, partitions artitions, floors, or ceilings shall be firestopped using approved methods to maintain the fire resistance rating. (Conduits penetrating wall separating Electrical room and mechanical room.)

**Assigned To** Artesian Contracting
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.21
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:53 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:29 PM**

MetroPower claims this is Artesian responsibility

**Paul Southwell** on **06/12/2015** at **09:17 AM**






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## FO-2-8 CLOSED HIGH

Uses Not Permitted. PVC conduit shall not be used under the conditions specified in 352.12(A) through (E). Where subject to physical damage unless identified for such use. (PVC conduit is exposed at the floor level at two locations in mechanical room)

**Assigned To** McKenney's
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_352.12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:52 AM

The referenced conduit is part of the temporary monitoring system installed by the design engineer, AHP. Reportedly, the government has approved the as-built condition.

**Mike Sabo** on **12/14/2015** at **02:04 PM**

PVC should be converted to either IMC or GRC where exposed to physical damage.

**Paul Southwell** on **06/17/2015** at **09:52 AM**

MetroPower questions ownership of PVC subject to damage coming out of the slab in mechanical room, is this McKenny's

**Paul Southwell** on **06/12/2015** at **09:16 AM**







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## FO-2-7 CLOSED HIGH

312.2 Damp and Wet Locations. In damp or wet locations, surface-type enclosures within the scope of this article shall be placed or equipped so as to prevent moisture or water from entering and accumulating within the cabinet or cutout box. (Chiller disconnects have top penetrations using EMT connectors instead of water-tight hubs.)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_312.2
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:51 AM

Paul Southwell agrees with Metro Power that mechanical room is not a damp or wet area, therefore, this deficiency is deleted.

**Paul Southwell** on **06/17/2015** at **09:50 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:13 AM**






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## FO-2-6 CLOSED HIGH

358.12 Uses Not Permitted. EMT shall not be used under the following conditions: Where, during installation or afterward, it will be subject to severe physical damage.(mechanical room floor)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.4 / 358.12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:50 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:30 PM**

Exposed EMT to pumps has been replaced with GRC with the exception of Pump #4, Metro Power agrees to have last pump done by June 26, 2015

**Paul Southwell** on **06/17/2015** at **09:46 AM**

MetroPower agrees to change EMT to GRC where applicable, what about McKenny?

**Paul Southwell** on **06/12/2015** at **09:07 AM**






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## FO-2-5 CLOSED LOW

Unless otherwise provided, MC cables shall be secured at intervals not exceeding 1.8 m (6 ft). Cables containing four or fewer conductors sized no larger than 10 AWG shall be secured within 300 mm (12 in.) of every box, cabinet, fitting, or other cable termination. (Mechanical Rm ceiling)

**Assigned To** McKenney's
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC 330.30(b)
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:49 AM

Problem supporting MC cable resolved.

**Paul Southwell** on **06/17/2015** at **09:44 AM**

MetroPower is indicating that they are not using MC cable, is McKenny using MC cable in the mechanical room?

**Paul Southwell** on **06/12/2015** at **09:05 AM**



## FO-2-4 CLOSED MODERATE

Ckt MDP-L1c_2 to louver/fan not installed, including modifications to existing starter

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:27 AM

Louver has been installed.

**Mike Sabo** on **12/14/2015** at **02:30 PM**

Metro power to have power and controls by June 26, 2015.

**Paul Southwell** on **06/17/2015** at **09:34 AM**

SafeAire to have louver installed by June 19, 2015

**Paul Southwell** on **06/17/2015** at **09:33 AM**

MetroPower indicates that the louver/fan has not been installed yet. What is schedule on installation of louver /fan?

**Paul Southwell** on **06/12/2015** at **09:00 AM**



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## FO-2-3 CLOSED MODERATE

Ckt MDP-L1c_1 to hot water unit heater not installed, including motor switch Sm

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:25 AM

Unit heater has been installed.

**Mike Sabo** on **12/14/2015** at **02:31 PM**

Metro Power to have power and controls complete by June 26,2015

**Paul Southwell** on **06/17/2015** at **09:31 AM**

SafeAire agrees to have unit heater and louver installed by June 19, 2005

**Paul Southwell** on **06/17/2015** at **09:30 AM**

MetroPower indicates this has not been installed yet? What is schedule on installation of hot water unit heater?

**Paul Southwell** on **06/12/2015** at **09:00 AM**

## FO-2-2 CLOSED LOW

Mount switchboard on concrete slab. The slab thickness shall match the existing. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Current slab does not meet specification

**Assigned To** Artesian Contracting
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 8:51 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:06 PM**

Slab does not agree with specifications. MetroPower indicates this was Artesian's responsibility, Artesian response?

**Paul Southwell** on **06/12/2015** at **08:58 AM**





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## FO-1-14 CLOSED LOW

The VAVs can be configured to generate an alarm with a space temperature high limit and a space temperature low limit. Owner needs to provide these limits and needs to provide where the alarm should be viewed.

**Assigned To** Owner
**Asset** Terminal Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 8:48 AM

Owner has not provided these values. The defaults are 65 and 85.

**Mike Sabo** on **12/14/2015** at **02:07 PM**

## FO-1-13 CLOSED MODERATE

The heating water and chilled water pumps are set-up in the control system as lead/lag. This appears to be a miscommunication between the specs and controls submittal. Confirm that the CW and HW pumps are operated in duty/standby (with periodic rotation of the pump that is in duty). This will be similar to the source water and BTES pumps.

**Assigned To** Owner
**Asset** HVAC
**Discipline** Mechanical
**Drawing** Specs
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:15 AM

The design intent was Lead/Standby. The controls submittal was incorrect and the pumps currently operate as Lead/Standby.

**Mike Sabo** on **12/14/2015** at **02:08 PM**

## FO-1-12 CLOSED MODERATE

The set points and configuration for the VAV terminals have been retained from the original BAS. They are able to be accessed and actively changed by the building maintenance staff. Many of the thermal zones were in heating when the outside air temperature is over 80F. Are we intentionally allowing the zones to be in "reheat" or are the terminals in heating because the space setpoints are too high and offset too low? If the latter, recommend an equivalent deadband of 5 degrees F, a heat lockout sequence when OA temp is above 65F, and a supply air temperature reset based on the number of units in cooling/heating. This should help keep the building load under better control.

**Assigned To** Owner
**Asset** HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:07 AM

The building maintenance staff is comfortable with allowing reheat and with inconsistent set-points. If a retro-commissioning effort takes place this can be addressed.

**Mike Sabo** on **12/14/2015** at **02:09 PM**

## FO-1-11 CLOSED MODERATE

There will be no commissioning efforts for the existing ERU. The commissioning of the existing AHUs will consist of verifying occupied schedules only (currently all 6 AHUs are set to occupied 24/7). The TAB efforts for the ERU and existing AHUs will only consist of simple supply/ exhaust air measurements as appropriate for the conditions that exist at exact time of TAB. The reason for this is:
1) The existing ERUs and AHUs were not modified by the construction project and are considered to be outside the scope of work.
2) We have no authority or access rights to modify/change/manipulate the operating conditions.
3) We have no design data on the ERUs or AHUs.
4) We do not have current and accurate sequences of operation for the ERUs or AHUs.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:01 AM

## FO-1-10 CLOSED LOW

The chiller modules cannot be functionally tested individually since the on-board controls cannot be "manipulated" by anyone except the ClimaCool equipment rep. The workaround is to functionally test the entire chiller at once using the existing conditions at the time of commissioning and verifying trend logs.

**Assigned To** Owner
**Asset** Chiller
**Discipline** Mechanical
**Drawing** Cx Specs
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:28 AM

Work-around efforts were used when commissioning.

**Mike Sabo** on **12/14/2015** at **02:10 PM**

## FO-1-9 CLOSED MODERATE

The unit heater and corresponding controls are not installed yet

**Assigned To** SafeAir
**Asset** UH-1
Unit Heater
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:17 AM

Unit heater and wall mounted thermostat were installed and functionally tested to be working properly.

**Mike Sabo** on **12/14/2015** at **02:11 PM**

## FO-1-8 CLOSED HIGH

The summation of the GPM for all the 3-way HW valves is 49.5. The automatic flow control valves are installed to maintain the scheduled GPM in the HW coils given the pumps are providing enough head. Closing the flow to all of the reheat coils and closing the existing HW bypass should result in flow of 49.5 GPM. We were only flowing 27 GPM with all the VAVs in bypass, the HW bypass closed and one hot water pump at 100%. The DP in the HW loop reached 47 psi before we opened the bypass. We are very confident that there are restrictions in the HW system but cannot fully know the extent because the chiller conditions affect the flow in the HW loop. The test should be run again with two chiller modules "open" to HW loop to confirm the full extent of the restrictions on the building side. Then the blockages should be found and removed so we can achieve a flow of 49.5 GPM during the same test.

**Assigned To** Owner
**Asset** Heating Hot Water Loop
Heating Hot Water Loop
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:01 AM

The strainers have been cleaned and the maintenance staff has received training on the problems with clogged strainers and closed valves. Several VAV terminal units still appear to have blockages by analysis at the front-end BAS, however. A list will be generated and given to the maintenance staff.

**Mike Sabo** on **12/14/2015** at **02:14 PM**

This issue has been corrected (temporarily). The building maintenance staff has been closing the return leg of the reheat coil likely due when responding to a hot call. They will likely end up in a low flow condition if the maintenance staff continues to close the valves. The owner needs to address this.

**Mike Sabo** on **06/18/2015** at **01:01 PM**

## FO-1-7 CLOSED HIGH

The following are installed backwards:
1) AHU-2B coil circuit setter
2) AHU-1A bypass circuit setter
3) AHU-1B bypass circuit setter

**Assigned To** SafeAir
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:00 AM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:15 PM**

During the 6/17/15 visit, circuit setter for the coil in AHU-2B was correct. The other two are still incorrect but have been completely shut to make the coil configuration operate similar to 2-way vice 3-way. No further action needed until the 2-way vs 3-way chilled water coil is corrected. Issue to remain open for tracking purposes.

**Mike Sabo** on **06/18/2015** at **12:57 PM**



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## FO-1-6 CLOSED MODERATE

Strainer near dry coolers will be difficult to clean.

**Assigned To** Ray and Sons
**Asset** Dry Cooler
**Discipline** Mechanical
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:42 AM



## FO-1-5 CLOSED MODERATE

Existing refrigerant monitor in alarm and not interlocked with fan.

**Assigned To** McKenney's
**Asset** Chiller
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:39 AM

Alarm has been cleared and monitor and fan were reportedly interlocked.

**Mike Sabo** on **12/14/2015** at **02:17 PM**

## FO-1-4 CLOSED LOW

The ChW, HW, and SW expansion tanks do not have pressure gauges. These are shown in the piping schematics M301, M302, M303

**Assigned To** SafeAir
**Asset** HVAC
**Discipline** Mechanical
**Drawing** M301, M302, M303
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:39 AM

Pressure gauges have been installed.

**Mike Sabo** on **12/14/2015** at **02:18 PM**





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## FO-1-3 CLOSED HIGH

Existing energy recovery unit (ERU) is supplying too much direct Outdoor Air (OA). The supply fan appears to be at full speed and the ductwork has been compromised (i.e. "blown out"). The exhaust fan is operating at a much lower speed. The ERU OA dampers are in full open position with the outside air temperature above 85F (perhaps in OA economizer?). Furthermore, the OA and RA dampers for AHUs 1A and 1B are all in full open position indicating that they have not been adjusted to bring in the proper OA/RA combination even if the ERU is returned to normal operation. The OA dampers for AHUs 2A, 2B, 3A and 3B also appear much more open than expected. This building-wide operating condition will result in too much latent and sensible load on the chilled water coils in the AHUs. The ERU and AHUs should be placed back into proper operation or there will be temperature and humidity issues in the building not caused by the GHP project.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:38 AM

Administratively closed. Issues have been cited in a separate commissioning issues list.

**Mike Sabo** on **12/14/2015** at **02:20 PM**

## FO-1-2 CLOSED MODERATE

BTES pump P-2 coupling was defective as of 5/21/15. Mechanical contractor to fix.

**Assigned To** SafeAir
**Asset** P-2
Pump
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:37 AM

Pump coupling has been fixed

**Mike Sabo** on **06/18/2015** at **12:53 PM**



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## FO-2-1 CLOSED LOW

Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings

**Assigned To** MetroPower
**Discipline** Electrical
**Drawing** Elec
**Due Date** 6/17/2015
**Created By** Paul Southwell
**Identified On** 6/3/2015 6:24 PM

Administratively closed.

**Mike Sabo** on **12/14/2015** at **02:31 PM**

Metro Power committed to having breaker identification complete by 6/17/2015

**Paul Southwell** on **06/17/2015** at **09:13 AM**

Please give schedule for compliance.

**Paul Southwell** on **06/12/2015** at **08:56 AM**





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# Appendix B

# Final Commissioning Issues Log for Existing Systems

**Commissioning Issues Log - Addison Energy Technologies, LLC**

Project: MCLB Albany - Building 3700 AHUs and ERU Equipment

Date: 8/24/2015

New/Open: 87

Closed: 0

Next issue #:

| REF # | CURRENT STATUS | DATE NOTED | System / Equipment | ACTIVITY | REF DOC (Dwg/Spec) | ORIGINAL COMMENT | COMMENTER | PERSON RESPONSIBLE | PROJECT TEAM RESPONSE | RESPONDER | NOTES | OWNER REVIEW NEEDED? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 2 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 3 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 4 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and shutsdown AHU. DEVICE is not monitored and DOES NOT send alarm to "BAS". Function not in program. | L. A. Pohl | MCLB | | | | |
| 5 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 6 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Electrical flex at CHW valve to AHU has broken connection at the JB (electrical junction box) | L. A. Pohl | MCLB | | | | |
| 7 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 8 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 9 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 10 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and DOES NOT shutdown AHU. DEVICE is not monitored and DOES NOT send alarm to "BAS". Function not in program. | L. A. Pohl | MCLB | | | Questionable if unit correctly wired to VFD. | |
| 11 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 12 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | VFD not secured properly to wall. Appears unit had been replaced and only anchored at top of unit, also needs to be anchored at lower uni-strut. | L. A. Pohl | MCLB | | | | |
| 13 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 14 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 15 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 16 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | | Freeze stat set at 35F | L. A. Pohl | MCLB | | | Recommended setting is 40F. | |
| 17 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and shutsdown AHU. | L. A. Pohl | MCLB | | | Unlike other similar devices, this has the auto reset function. | |

**Commissioning Issues Log - Addison Energy Technologies, LLC**

Project: MCLB Albany - Building 3700 AHUs and ERU Equipment

Date: 8/24/2015

New/Open: 87

Closed: 0

Next issue #:

| REF # | CURRENT STATUS | DATE NOTED | System / Equipment | ACTIVITY | REF DOC (Dwg/Spec) | ORIGINAL COMMENT | COMMENTER | PERSON RESPONSIBLE | PROJECT TEAM RESPONSE | RESPONDER | NOTES | OWNER REVIEW NEEDED? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 19 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 20 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 21 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 22 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Freeze stat set at 35F | L. A. Pohl | MCLB | | | Recommended setting is 40F. | |
| 23 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and shutsdown AHU. | L. A. Pohl | MCLB | | | Unlike other similar devices, this has the auto reset function. | |
| 24 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, are not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 25 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | CHWR pressure gauge appears to be broken (not indicating) | L. A. Pohl | MCLB | | | | |
| 26 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 27 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 28 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 29 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and DOES NOT shutdown AHU. DEVICE appears to be circumvented, is not monitored and DOES NOT send alarm to "BAS". Function not in program. | L. A. Pohl | MCLB | | | | |
| 30 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, are not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 31 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | CHWR temperature gauge broken. Needs to be replaced. | L. A. Pohl | MCLB | | | | |
| 32 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Outside Air Damper (Mixed air damper) in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 33 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Return Air Damper in fixed position and inoperative. Linkage disconnected and/or drive motor not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 34 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Freeze protection installed and inoperative because of fixed dampers. | L. A. Pohl | MCLB | | | | |
| 35 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Freeze stat set at 35F | L. A. Pohl | MCLB | | | Recommended setting is 40F. | |

**Commissioning Issues Log - Addison Energy Technologies, LLC**

Project: MCLB Albany - Building 3700 AHUs and ERU Equipment

Date: 8/24/2015

New/Open: 87

Closed: 0

Next issue #:

| REF # | CURRENT STATUS | DATE NOTED | System / Equipment | ACTIVITY | REF DOC (Dwg/Spec) | ORIGINAL COMMENT | COMMENTER | PERSON RESPONSIBLE | PROJECT TEAM RESPONSE | RESPONDER | NOTES | OWNER REVIEW NEEDED? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Alarm Safety "Freeze Stat" installed and shutsdown AHU. DEVICE is not monitored and DOES NOT send alarm to "BAS". Function not in program. | L. A. Pohl | MCLB | | | | |
| 37 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Alarm Safety "High Static Pressure" and "Low Static Pressure" installed and DO NOT shutdown AHU. DEVICES appear to be circumvented, are not monitored and DO NOT send alarm signal to "BAS". Functions not in program. | L. A. Pohl | MCLB | | | Questionable if sensors are appropriate for desired function. | |
| 38 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Outside Air Dampers in fixed position and inoperative. Linkage disconnected and/or drive motors not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 39 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Return Air Dampers in fixed position and inoperative. Linkage disconnected and/or drive motors not functional. | L. A. Pohl | MCLB | | | Fixed position does not allow auto-function checks and commissioning of equipment. Status shown on "BAS" Graphics is meaningless (not real time status) | |
| 40 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | By-Pass dampers in fixed position and inoperative. Linkage disconnected and/or drive motors not functional. | L. A. Pohl | MCLB | | | | |
| 41 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Filters in variousloose positions and potential to become ineffective. | L. A. Pohl | MCLB | | | | |
| 42 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Supply Fan does not shutdown when supply air chamber access door is opened, AND fan belt/pulley are not equipped with Safety Guarding as required. | L. A. Pohl | MCLB | | | | |
| 43 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Exhaust Fan does not shutdown when exhaust air chamber access door is opened, AND fan belt/pulley are not equipped with Safety Guarding as required. | L. A. Pohl | MCLB | | | | |
| 44 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Outside Air Duct is damaged (cracked in multiple locations) and leaking. | L. A. Pohl | MCLB | | | | |
| 45 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 46 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 47 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 48 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |
| 49 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 50 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 51 | new | 7/30/15 | HVAC AHU-1A | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 52 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 53 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 54 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 55 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |
| 56 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 57 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |

**Commissioning Issues Log - Addison Energy Technologies, LLC**

Project: MCLB Albany - Building 3700 AHUs and ERU Equipment

Date: 8/24/2015

New/Open: 87

Closed: 0

Next issue #:

| REF # | CURRENT STATUS | DATE NOTED | System / Equipment | ACTIVITY | REF DOC (Dwg/Spec) | ORIGINAL COMMENT | COMMENTER | PERSON RESPONSIBLE | PROJECT TEAM RESPONSE | RESPONDER | NOTES | OWNER REVIEW NEEDED? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 | new | 7/30/15 | HVAC AHU-1B | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 59 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 60 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 61 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 62 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |
| 63 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 64 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 65 | new | 7/30/15 | HVAC AHU-2A | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 66 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 67 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 68 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 69 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |
| 70 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 71 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 72 | new | 7/30/15 | HVAC AHU-2B | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 73 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 74 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 75 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 76 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |
| 77 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 78 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 79 | new | 7/30/15 | HVAC AHU-3A | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 80 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unit scheduled "Occupied" 24/7 | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 81 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Occupied Schedule. | L. A. Pohl | MCLB | | | | |
| 82 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to verify all terminal units are indexed to AHU Unoccupied Schedule. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 83 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to verify function of air dampers with respect to duct static pressure for fan speed variations and/or air volume adjustments. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 do not allow this check. Also believe function not programmed. | |

**Commissioning Issues Log - Addison Energy Technologies, LLC**

Project: MCLB Albany - Building 3700 AHUs and ERU Equipment

Date: 8/24/2015

New/Open: 87

Closed: 0

Next issue #:

| REF # | CURRENT STATUS | DATE NOTED | System / Equipment | ACTIVITY | REF DOC (Dwg/Spec) | ORIGINAL COMMENT | COMMENTER | PERSON RESPONSIBLE | PROJECT TEAM RESPONSE | RESPONDER | NOTES | OWNER REVIEW NEEDED? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to verify certain functions -e.g. reset of static pressure setpoint, fan speed adjustments w/r static pressure fluctuations, etc. as per Sequence of Operations. | L. A. Pohl | MCLB | | | Sequence of Operations not available. | |
| 85 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to verify operational conditions - e.g. SF Off, CHW Valve 100% closed, Outside Air Damper closed, etc. for "Unoccupied" Mode. | L. A. Pohl | MCLB | | | "Unoccupied" Mode disabled. Need enabled. | |
| 86 | new | 7/30/15 | HVAC AHU-3B | Fuctional Testing | n/a | Unable to determine functionality of "Unoccupied Override" or if it exists. | L. A. Pohl | MCLB | | | Sequence of Operations not available. "Unoccupied" Mode disabled. | |
| 87 | new | 7/30/15 | HVAC ERU | Fuctional Testing | n/a | Unable to verify normal functionalities of ERU with respect to Sequence of Operations. | L. A. Pohl | MCLB | | | Fixed position dampers and "Occupied: Mode 24/7 for AHUs does not allow this check. Also believe function not programmed. "BAS" depicts Mixed Air Damper (By-Pass) "open" but this is questionable. | |

# Appendix C

# Commissioning Field Reports

# Field Observations

4 Field Observations sorted by **reference number**

# Field Observation No. 1

Mike Sabo | Install Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage Building 3700 MCLB Albany | 960 (ESTCP No. EW-200135)

Commissioning (Cx) Field Report #1, HVAC Installation Verification: HVAC Installation Verification site visits were performed by Mike Sabo on 6/1/15 through 6/4/15. The project has reached substantial completion. Several issues have been identified and will need to be addressed before functional performance testing can begin.

**Author** Mike Sabo
**Present** Bill Adams, Paul Southwell, Jamie Martin from AET; David Fugua and Jason Norris from Artesian Contracting; Ray from SafeAir; Ken Alexander from McKenneys
**Date Observed** 6/4/2015
**Weather** Sunny High of 85
**Location** Albany, GA
**Type** Commissioning

## Issues 15

### FO-1-1 OPEN MODERATE

Exhaust fan EF-1 is not operational per plan and duct work is in poor condition.

**Assigned To** SafeAir
**Asset** HVAC
**Discipline** Mechanical
**Drawing** M201
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:36 AM

### FO-1-2 CLOSED MODERATE

BTES pump P-2 coupling was defective as of 5/21/15. Mechanical contractor to fix.

**Assigned To** SafeAir
**Asset** P-2
Pump
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:37 AM

Pump coupling has been fixed

**Mike Sabo** on **06/18/2015** at **12:53 PM**



CxAlloy

## FO-1-3 OPEN HIGH

Existing energy recovery unit (ERU) is supplying too much direct Outdoor Air (OA). The supply fan appears to be at full speed and the ductwork has been compromised (i.e. "blown out"). The exhaust fan is operating at a much lower speed. The ERU OA dampers are in full open position with the outside air temperature above 85F (perhaps in OA economizer?). Furthermore, the OA and RA dampers for AHUs 1A and 1B are all in full open position indicating that they have not been adjusted to bring in the proper OA/RA combination even if the ERU is returned to normal operation. The OA dampers for AHUs 2A, 2B, 3A and 3B also appear much more open than expected. This building-wide operating condition will result in too much latent and sensible load on the chilled water coils in the AHUs. The ERU and AHUs should be placed back into proper operation or there will be temperature and humidity issues in the building not caused by the GHP project.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:38 AM

## FO-1-4 OPEN LOW

The ChW, HW, and SW expansion tanks do not have pressure gauges. These are shown in the piping schematics M301, M302, M303

**Assigned To** SafeAir
**Asset** HVAC
**Discipline** Mechanical
**Drawing** M301, M302, M303
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:39 AM

## FO-1-5 OPEN MODERATE

Existing refrigerant monitor in alarm and not interlocked with fan.

**Assigned To** McKenney's
**Asset** Chiller
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:39 AM

## FO-1-6 OPEN MODERATE

Strainer near dry coolers will be difficult to clean.

**Assigned To** Ray and Sons
**Asset** Dry Cooler
**Discipline** Mechanical
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 5:42 AM

## FO-1-7 OPEN HIGH

The following are installed backwards:
1) AHU-2B coil circuit setter
2) AHU-1A bypass circuit setter
3) AHU-1B bypass circuit setter

**Assigned To** SafeAir
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:00 AM

During the 6/17/15 visit, circuit setter for the coil in AHU-2B was correct. The other two are still incorrect but have been completely shut to make the coil configuration operate similar to 2-way vice 3-way. No further action needed until the 2-way vs 3-way chilled water coil is corrected. Issue to remain open for tracking purposes.

**Mike Sabo** on **06/18/2015** at **12:57 PM**

## FO-1-8 OPEN HIGH

The summation of the GPM for all the 3-way HW valves is 49.5. The automatic flow control valves are installed to maintain the scheduled GPM in the HW coils given the pumps are providing enough head. Closing the flow to all of the reheat coils and closing the existing HW bypass should result in flow of 49.5 GPM. We were only flowing 27 GPM with all the VAVs in bypass, the HW bypass closed and one hot water pump at 100%. The DP in the HW loop reached 47 psi before we opened the bypass. We are very confident that there are restrictions in the HW system but cannot fully know the extent because the chiller conditions affect the flow in the HW loop. The test should be run again with two chiller modules "open" to HW loop to confirm the full extent of the restrictions on the building side. Then the blockages should be found and removed so we can achieve a flow of 49.5 GPM during the same test.

**Assigned To** Owner
**Asset** Heating Hot Water Loop
Heating Hot Water Loop
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:01 AM

This issue has been corrected (temporarily). The building maintenance staff has been closing the return leg of the reheat coil likely due when responding to a hot call. They will likely end up in a low flow condition if the maintenance staff continues to close the valves. The owner needs to address this.

**Mike Sabo** on **06/18/2015** at **01:01 PM**

## FO-1-9 OPEN MODERATE

The unit heater and corresponding controls are not installed yet

**Assigned To** SafeAir
**Asset** UH-1
Unit Heater
HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:17 AM

## FO-1-10 OPEN LOW

The chiller modules cannot be functionally tested individually since the on-board controls cannot be "manipulated" by anyone except the ClimaCool equipment rep. The workaround is to functionally test the entire chiller at once using the existing conditions at the time of commissioning and verifying trend logs.

**Assigned To** Owner
**Asset** Chiller
**Discipline** Mechanical
**Drawing** Cx Specs
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 6:28 AM

## FO-1-11 OPEN MODERATE

There will be no commissioning efforts for the existing ERU. The commissioning of the existing AHUs will consist of verifying occupied schedules only (currently all 6 AHUs are set to occupied 24/7). The TAB efforts for the ERU and existing AHUs will only consist of simple supply/ exhaust air measurements as appropriate for the conditions that exist at exact time of TAB. The reason for this is:
1) The existing ERUs and AHUs were not modified by the construction project and are considered to be outside the scope of work.
2) We have no authority or access rights to modify/change/manipulate the operating conditions.
3) We have no design data on the ERUs or AHUs.
4) We do not have current and accurate sequences of operation for the ERUs or AHUs.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:01 AM

## FO-1-12 OPEN MODERATE

The set points and configuration for the VAV terminals have been retained from the original BAS. They are able to be accessed and actively changed by the building maintenance staff. Many of the thermal zones were in heating when the outside air temperature is over 80F. Are we intentionally allowing the zones to be in "reheat" or are the terminals in heating because the space setpoints are too high and offset too low? If the latter, recommend an equivalent deadband of 5 degrees F, a heat lockout sequence when OA temp is above 65F, and a supply air temperature reset based on the number of units in cooling/heating. This should help keep the building load under better control.

**Assigned To** Owner
**Asset** HVAC
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:07 AM

## FO-1-13 OPEN MODERATE

The heating water and chilled water pumps are set-up in the control system as lead/lag. This appears to be a miscommunication between the specs and controls submittal. Confirm that the CW and HW pumps are operated in duty/standby (with periodic rotation of the pump that is in duty). This will be similar to the source water and BTES pumps.

**Assigned To** Owner
**Asset** HVAC
**Discipline** Mechanical
**Drawing** Specs
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 7:15 AM

## FO-1-14 OPEN LOW

The VAVs can be configured to generate an alarm with a space temperature high limit and a space temperature low limit. Owner needs to provide these limits and needs to provide where the alarm should be viewed.

**Assigned To** Owner
**Asset** Terminal Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/18/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 8:48 AM

## FO-1-15 OPEN HIGH

The final configuration of the chilled water coils (2-way or 3-way valves has to be established before balancing pumps. Recent testing indicated the 3-way valves should remain.

**Assigned To** Owner
**Asset** Air Handling Unit
**Discipline** Mechanical
**Drawing** Mech
**Due Date** 6/11/2015
**Created By** Mike Sabo
**Identified On** 6/4/2015 11:51 AM

# Field Observation No. 2

Mike Sabo | Install Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage Building 3700 MCLB Albany | 960 (ESTCP No. EW-200135)

Commissioning (Cx) Field Report #2, Electrical Verification / Pre-functional Checklist Visit: A site visit was performed by Paul Southwell from 6/1/2015 to 6/4/2015.The electrical was roughed-in and most of the equipment was in place. The new distribution section to the existing switchgear was was onsite but not activated. Apparently the buss bars were not in alignment and additional components had to be ordered. This created a month delay in the job schedule Electrical work in the Dry Cooler area was taking place at this time. The majority of the HVAC equipment was operational and the mechanical commissioning has begun. The attached issues, documented based on the categories: plan/specification compliance, NEC Code Compliance, Documentation requirements, Testing requirements, and Verification requirements are all listed in this report organized by priority levels of Low, Moderate, and High.

| | |
|---|---|
| **Author** | Paul Southwell |
| **Present** | Jason Norris,Artesian<br>David Fuqua, Artesian<br>Mark Andrews, AH&P<br>Jaime Martin, AET<br>Ken Allen. McKenny<br>Mike Sabo, AET |
| **Date Observed** | 6/4/2015 |
| **Weather** | Sunny, 85 degrees, Humid |
| **Location** | MCLB_Albany |
| **Type** | Commissioning |

## Issues 32

### FO-2-1 PENDING APPROVAL LOW

Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings

| | |
|---|---|
| **Assigned To** | MetroPower |
| **Discipline** | Electrical |
| **Drawing** | Elec |
| **Due Date** | 6/17/2015 |
| **Created By** | Paul Southwell |
| **Identified On** | 6/3/2015 6:24 PM |

Metro Power committed to having breaker identification complete by 6/17/2015

**Paul Southwell** on **06/17/2015** at **09:13 AM**

Please give schedule for compliance.

**Paul Southwell** on **06/12/2015** at **08:56 AM**





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## FO-2-2 OPEN LOW

Mount switchboard on concrete slab. The slab thickness shall match the existing. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Current slab does not meet specification

**Assigned To** Artesian Contracting
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 8:51 AM

Slab does not agree with specifications. MetroPower indicates this was Artesian's responsibility, Artesian response?

**Paul Southwell** on **06/12/2015** at **08:58 AM**



## FO-2-3 PENDING APPROVAL MODERATE

Ckt MDP-L1c_1 to hot water unit heater not installed, including motor switch Sm

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:25 AM

Metro Power to have power and controls complete by June 26,2015

**Paul Southwell** on **06/17/2015** at **09:31 AM**

SafeAire agrees to have unit heater and louver installed by June 19, 2005

**Paul Southwell** on **06/17/2015** at **09:30 AM**

MetroPower indicates this has not been installed yet? What is schedule on installation of hot water unit heater?

**Paul Southwell** on **06/12/2015** at **09:00 AM**

## FO-2-4 PENDING APPROVAL MODERATE

Ckt MDP-L1c_2 to louver/fan not installed, including modifications to existing starter

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:27 AM

Metro power to have power and controls by June 26, 2015.

**Paul Southwell** on **06/17/2015** at **09:34 AM**

SafeAire to have louver installed by June 19, 2015

**Paul Southwell** on **06/17/2015** at **09:33 AM**

MetroPower indicates that the louver/fan has not been installed yet. What is schedule on installation of louver /fan?

**Paul Southwell** on **06/12/2015** at **09:00 AM**

## FO-2-5 CLOSED LOW

Unless otherwise provided, MC cables shall be secured at intervals not exceeding 1.8 m (6 ft). Cables containing four or fewer conductors sized no larger than 10 AWG shall be secured within 300 mm (12 in.) of every box, cabinet, fitting, or other cable termination. (Mechanical Rm ceiling)

**Assigned To** McKenney's
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC 330.30(b)
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:49 AM

Problem supporting MC cable resolved.

**Paul Southwell** on **06/17/2015** at **09:44 AM**

MetroPower is indicating that they are not using MC cable, is McKenny using MC cable in the mechanical room?

**Paul Southwell** on **06/12/2015** at **09:05 AM**





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## FO-2-6 PENDING APPROVAL HIGH

358.12 Uses Not Permitted. EMT shall not be used under the following conditions: Where, during installation or afterward, it will be subject to severe physical damage.(mechanical room floor)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.4 / 358.12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:50 AM

Exposed EMT to pumps has been replaced with GRC with the exception of Pump #4, Metro Power agrees to have last pump done by June 26, 2015

**Paul Southwell** on **06/17/2015** at **09:46 AM**

MetroPower agrees to change EMT to GRC where applicable, what about McKenny?

**Paul Southwell** on **06/12/2015** at **09:07 AM**






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## FO-2-7 CLOSED HIGH

312.2 Damp and Wet Locations. In damp or wet locations, surface-type enclosures within the scope of this article shall be placed or equipped so as to prevent moisture or water from entering and accumulating within the cabinet or cutout box. (Chiller disconnects have top penetrations using EMT connectors instead of water-tight hubs.)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_312.2
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:51 AM

Paul Southwell agrees with Metro Power that mechanical room is not a damp or wet area, therefore, this deficiency is deleted.

**Paul Southwell** on **06/17/2015** at **09:50 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:13 AM**






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## FO-2-8 OPEN HIGH

Uses Not Permitted. PVC conduit shall not be used under the conditions specified in 352.12(A) through (E). Where subject to physical damage unless identified for such use. (PVC conduit is exposed at the floor level at two locations in mechanical room)

| | |
|---|---|
| **Assigned To** | McKenney's |
| **Asset** | Wiring |
| | Wiring |
| | Electrical |
| **Discipline** | Electrical |
| **Drawing** | NEC_352.12 |
| **Due Date** | 6/18/2015 |
| **Created By** | Paul Southwell |
| **Identified On** | 6/4/2015 9:52 AM |

PVC should be converted to either IMC or GRC where exposed to physical damage.

**Paul Southwell** on **06/17/2015** at **09:52 AM**

MetroPower questions ownership of PVC subject to damage coming out of the slab in mechanical room, is this McKenny's

**Paul Southwell** on **06/12/2015** at **09:16 AM**





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## FO-2-9 PENDING APPROVAL MODERATE

Openings around electrical penetrations into or through fire-resistant-rated walls, partitions artitions, floors, or ceilings shall be firestopped using approved methods to maintain the fire resistance rating. (Conduits penetrating wall separating Electrical room and mechanical room.)

**Assigned To** Artesian Contracting
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.21
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:53 AM

MetroPower claims this is Artesian responsibility

**Paul Southwell** on **06/12/2015** at **09:17 AM**






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## FO-2-10 CLOSED HIGH

In the Dry Cooler area, a mixture of rigid, EMT, and PVC conduits are utilized.

**Assigned To** McKenney's
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC_300.4 / 358.12/312.2
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:55 AM

Only GRC and IMC in use now, deficiency issue resolved.

**Paul Southwell** on **06/17/2015** at **10:16 AM**

MetroPower claims all conduit installed by them is GRC, is the EMT and PVC McKenny's

**Paul Southwell** on **06/12/2015** at **09:18 AM**





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## FO-2-11 CLOSED HIGH

In the Dry Cooler area, a mixture of enclosures ranging from Nema 3R, Nema 4x, and Nema 6P were observed. NEMA 4X and NEMA 6P are more water resistant than NEMA 3R.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** NEC-Table 110.28
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:56 AM

Metro Power has complied with the contract documents by supplying the correct panel in a NEMA 3R enclosure

**Paul Southwell** on **06/17/2015** at **10:18 AM**

MetroPower claims contract documents call for NEMA 3R enclosure. Whereas contract documents (Drawing E400) requires NEMA 4X enclosures.

**Paul Southwell** on **06/12/2015** at **09:25 AM**





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## FO-2-12 CLOSED MODERATE

Hybrid Dry Cooler De-Alkalizer/Water softener receptacles-should be weather proof / GFI(Mechanical Rm)

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** M407
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:57 AM

Contract documents did not specify weather proof and/or GFI receptacles

**Paul Southwell** on **06/17/2015** at **10:20 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:27 AM**





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## FO-2-13 CLOSED MODERATE

Weater proof , GFI receptacles should be located adjacent DDC control panels and chiller control cabinet.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 9:58 AM

Contract documents did not specify weather proof and/or GFI receptacles

**Paul Southwell** on **06/17/2015** at **10:20 AM**

MetroPower debates the need for weather-proof enclosures. Electrical drawing E102 indicates weather-proof / GFI receptacles to be used in mechanical room.

**Paul Southwell** on **06/12/2015** at **09:27 AM**




## FO-2-14 PENDING APPROVAL HIGH

Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:01 AM

Metro Power agrees to switchboard verification at next power outage, currently scheduled for June 28, 2015

**Paul Southwell** on **06/17/2015** at **10:23 AM**

MetroPower agrees to comply during outage to remove temporary power

**Paul Southwell** on **06/12/2015** at **09:28 AM**

## FO-2-15 CLOSED HIGH

Electrical Tests: Perform insulation-resistance tests on each bus section.

**Assigned To** Owner
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:02 AM

Delete this issue, buss bars are not insulated

**Paul Southwell** on **06/17/2015** at **10:25 AM**

MetroPower questions whether MCLB will be acceptable to insulation resistance testing?

**Paul Southwell** on **06/12/2015** at **09:30 AM**

## FO-2-16 PENDING APPROVAL HIGH

Electrical Tests: Perform over potential tests.

**Assigned To** Owner
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:03 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:26 AM**

MetroPower questions whether MCLB will be acceptable to over potential testing?

**Paul Southwell** on **06/12/2015** at **09:31 AM**

## FO-2-17 PENDING APPROVAL HIGH

Switchgear Enclosure/Cabinetry: Megger test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:05 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:27 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-18 PENDING APPROVAL HIGH

Hi-potential test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:06 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:27 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-19 PENDING APPROVAL HIGH

Feeder Circuit Breakers: Megger test of circuit breaker – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:07 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Testing requirements are the same

**Paul Southwell** on **06/12/2015** at **10:04 AM**

## FO-2-20 PENDING APPROVAL HIGH

Feeder Circuit Breakers: Hi-potential test of circuit breaker – phase to phase and phase to ground. Test voltage per manufacturer's recommendations

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:08 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist. Same test apply.

**Paul Southwell** on **06/12/2015** at **10:05 AM**

## FO-2-21 PENDING APPROVAL HIGH

Distribution Panel Enclosure/Cabinetry: Megger test of bus – phase to phase and phase to ground. Test voltage per manufacturer's recommendations.

**Assigned To** MetroPower
**Asset** Panelboards
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:10 AM

Metro Power to check with owner since test requires putting stress on switchgear.

**Paul Southwell** on **06/17/2015** at **10:28 AM**

MetroPower agrees to testing on Panel DP-L1CC

**Paul Southwell** on **06/12/2015** at **10:39 AM**

## FO-2-22 PENDING APPROVAL HIGH

Installation Checks: Resistance of the grounding system has been measured and recorded. Provide method of measurement.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Grounding System Construc
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:11 AM

Metro Power agrees to this installation check, to be complete by June 26, 2015

**Paul Southwell** on **06/17/2015** at **10:29 AM**

MetroPower agrees to testing on Panel DP-L1CC

**Paul Southwell** on **06/12/2015** at **10:40 AM**

## FO-2-23 PENDING APPROVAL LOW

Documentation required by Specification Section 12 23 00:
1.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, short-circuit current test
2.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, enclosure test
3.Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification, dielectric test
4.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:a. 60-hertz dielectric tests
5.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:a. mechanical operation tests
6.Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include electrical operation and control wiring tests

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:22 AM

Metro Power agrees to documentation required by Specification Section 12 23 00., to be complete by June 26, 2015.

**Paul Southwell** on **06/17/2015** at **10:31 AM**

MetroPower has requested information from manufacturer on 6/8/2015

**Paul Southwell** on **06/12/2015** at **10:41 AM**

## FO-2-24 CLOSED LOW

Documentation required based upon Low Voltage Switchgear Construction Checklist and Panel Construction Checklist:
1. Requested documentation submitted: Manufacturer's cut sheets
2.Requested documentation submitted: Installation and startup manual and plan
3.Requested documentation submitted: O&M manuals
4.Requested documentation submitted: Sequences and control strategies
5.Requested documentation submitted: Warranty Certificate
6.Requested documentation submitted: Installation and startup manual and plan

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:33 AM

This requirement met by previous issue, FO-2-24

**Paul Southwell** on **06/17/2015** at **10:33 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist.

**Paul Southwell** on **06/12/2015** at **10:05 AM**

## FO-2-25 CLOSED LOW

Verification required by Specification Section 12 23 00:
1. Compare equipment nameplate data with specifications and approved shop drawings.
2.Confirm correct application of manufacturer's recommended lubricants.
3.Verify that circuit breaker sizes and types correspond to approved shop drawings.
4.Confirm correct operation and sequencing of electrical and mechanical interlock systems.
5.Verify correct barrier installation.
6.Verify that vents are clear.
7.MANUFACTURER'S NAMEPLATE:Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a
conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

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**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Specification Section 12
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 10:43 AM

MetroPower has verified items 1 through 7

**Paul Southwell** on **06/12/2015** at **10:46 AM**

## FO-2-26 CLOSED LOW



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Verification required by Low Voltage Switchgear Construction Checklist:
1. Switchgear enclosure /Cabinetry: Equipment installed per manufacturer's instructions and specifications
2. Switchgear Enclosure /Cabinetry: Equipment installed agrees with shop drawings and specifications
3.Switchgear Enclosure/Cabinetry: Verify mounting, location and clearances are per plans and specifications
4.Switchgear Enclosure /Cabinetry: Inspect for physical, electrical and mechanical condition of equipment and cabinet. No damage evident
5.Switchgear Enclosure /Cabinetry:Inspect panels and doors for proper fit and alignment
6.Switchgear Enclosure /Cabinetry: Equipment labels permanently affixed
7.Switchgear Enclosure /Cabinetry: Panel is clean and clear of dust or dirt
8. Switchgear Enclosure /Cabinetry: Verify correct circuit breaker sizes and types per the specifications and manufacturer's drawings
9. Switchgear Enclosure /Cabinetry: Seismic anchoring installed and functional where applicable (non-short circuiting)
10. Switchgear Enclosure /Cabinetry: Inspect insulators, barriers and shields for damage or contamination
11. Switchgear Enclosure /Cabinetry: Verify that ground bus is properly bonded to enclosure, enclosure is grounded and resistance to ground meets grounding specifications
12. Switchgear Enclosure /Cabinetry: Verify three or four wire configuration
13. Switchgear Enclosure /Cabinetry: Verify metering transformer nameplate matches specified and approved transformer
14. Switchgear Enclosure /Cabinetry: Transformer installed per manufacturer's instruction, plans and specifications.
15. Switchgear Enclosure /Cabinetry: Inspect metering transformer cables and connections for defects or physical damage
16. Switchgear Enclosure /Cabinetry: Verify metering transformer connections are correct per the single line
17. Switchgear Enclosure /Cabinetry: Verify all grounding and shorting connections for the metering transformer are in place
18. Switchgear Enclosure /Cabinetry: Verify correct fusing for the metering transformer primary and secondary
19. Switchgear Enclosure /Cabinetry: Verify the metering transformer taps are in accordance with the manufacturer's nameplate and specifications.
20. Switchgear Enclosure /Cabinetry: Verify the vents and air inlets are free and unobstructed. Clean air filters installed (if required).
21. Feeder Circuit Breakers: Verify all maintenance and service clearances are maintained.
22. Feeder Circuit Breakers: Verify no physical damage.
23. Feeder Circuit Breakers: Verify voltage and current rating of circuit breaker are per plans and specifications.
24. Feeder Circuit Breakers: Confirm correct application of manufacturer's recommended lubricant.
25. Feeder Circuit Breakers: Verify that primary and secondary contact wipe dimensions are correct.
26. Feeder Circuit Breakers: Verify breakers are mounted securely and

**Assigned To** MetroPower
**Asset** Switchboards
Switchboards
Electrical
**Discipline** Electrical
**Drawing** Low Voltage Switchgear Ch
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:09 AM



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operates smoothly.
27. Feeder Circuit Breakers: Verify wire is properly installed and suitable size for breaker.
28. Operational Checks: All incoming cables are terminated and “ABC” phasing is correct. Terminations are torqued, checked, stress cones are properly grounded and exposed energized surfaces are insulated.
29. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.
30.

These requirements have been satisfied by previous requests.

**Paul Southwell** on **06/17/2015** at **10:35 AM**

Testing procedures were inadvertently taken from the Medium Voltage Switchgear Construction Checklist as opposed to Low Voltage Switchgear Construction Checklist.Same verification required.

**Paul Southwell** on **06/12/2015** at **10:07 AM**

## FO-2-27 CLOSED LOW

Verification based upon Panel Construction Checklist:
1.Distribution Panel Enclosure/Cabinetry: Equipment installed per manufacturer's instructions and specifications.
2.Distribution Panel Enclosure/Cabinetry: Equipment installed agrees with shop drawings and specifications
3.Distribution Panel Enclosure/Cabinetry: Verify mounting, location and clearances are per plans and specifications.
4.Distribution Panel Enclosure/Cabinetry: Equipment labels permanently affixed
5.Distribution Panel Enclosure/Cabinetry: Panel is clean and clear of dust or dirt
6.Distribution Panel Enclosure/Cabinetry: Verify the application of manufacturer recommended torque values applied to bolted connections.
7. Distribution Panel Enclosure/Cabinetry: Verify correct circuit breaker sizes and types per the specifications and manufacturer's drawings.
8. Distribution Panel Enclosure/Cabinetry: Neutral bus isolated from cabinet.
9. Circuit Breakers 208/120 VAC Panels: Installed per manufacturer's instructions, plans and specifications.
10. Circuit Breakers 208/120 VAC Panels: No physical damage.
11. Circuit Breakers 208/120 VAC Panels: Verify voltage and current rating of circuit breaker are per plans and specifications.
12. Circuit Breakers 208/120 VAC Panels: Verify breakers are mounted securely and operates smoothly.
13.Circuit Breakers 208/120 VAC Panels: Verify wire is properly installed and suitable size for breaker.
14. Operational Checks: Specified sequences of operation and operating schedules have been provided with all variations documented.
15. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.
16.

**Assigned To** MetroPower
**Asset** Panelboards
Panelboards
Electrical
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:18 AM

MetroPower is taking the position that the only panel applicable is Panel DP-L1CC. They are indicating that the panel MDP is existing even though they have modified it.

**Paul Southwell** on **06/12/2015** at **10:51 AM**



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## FO-2-28 PENDING APPROVAL LOW

Verification based upon the Grounding System Construction Checklist:
1.Requested documentation submitted:Manufacturer's cut sheets.
2.Requested documentation submitted:Installation and startup manual and plan.
3.Requested documentation submitted:O&M manuals.
4. Requested documentation submitted:Warranty Certificate
5.Installation Checks: Grounding electrodes have been installed in accordance with drawings and specifications.
6.Installation Checks: Connections to grounding electrodes have been made in accordance with manufacturer's specifications.
7.Installation Checks: Grounding conductors have been routed in accordance with the drawings and specifications.
8. Installation Checks: Grounding conductors have been properly terminated at the service equipment or separately derived source. Bonding conductors have been installed as required.
9. Installation Checks: Test wells are accessible and clearly marked..
10. Operational Checks: Specified sequences of operation and operating schedules have been provided with all variations documented.
11. Operational Checks: Specified point-to-point checks have been completed and documentation record submitted for this system.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Grounding System Construc
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:25 AM

Metro Power has agreed to verify modification to grounding system, to me complete by June 26,2015

**Paul Southwell** on **06/17/2015** at **10:39 AM**

MetroPower's position is that project did not require grounding system to be modified. In reality, they did make additions to the system.

**Paul Southwell** on **06/12/2015** at **10:53 AM**

## FO-2-29 CLOSED HIGH

Verification for the following:
Ground rods shall be copper-clad steel, with minimum diameter of 3/4 inch and minimum length of 10 feet.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Specification Section 26
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:27 AM

Metro Power has confirmed ground rod added does meet specifications

**Paul Southwell** on **06/17/2015** at **10:41 AM**

Does ground rod added meet specifications?

**Paul Southwell** on **06/12/2015** at **10:54 AM**



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## FO-2-30 CLOSED HIGH

Verification for the following:
1. Ckt SWBD-B-1/Chiller-1 /3#2/0, #6G / 2" conduit.
2. Ckt SWBD-B-2/Chiller-2 /3#2/0, #6G / 2" conduit.
3. Ckt SWBD-B-3/Chiller-3 /3#2/0, #6G / 2" conduit.
4. Ckt SWBD-B-4/Chiller-4 /3#2/0, #6G / 2" conduit.
5. Ckt SWBD-B-5/Chiller-5 /3#2/0, #6G / 2" conduit.
6. Ckt SWBD-B-6 /P-1 / 3#6,#10G / 1" conduit
7. Ckt SWBD-B-7 /P-2 / 3#6,#10G / 1" conduit
8. Ckt SWBD-B-8 /P-3 / 3#8,#10G / 3/4" conduit
9. Ckt SWBD-B-9 /P-4 / 3#8,#10G/ 3/4" conduit
10. Ckt SWBD-B-10 /P-5 / 3#4, #8G/1 1,4"
11. Ckt SWBD-B-11 /P-6 /3#4, #8G/1 1,4"
12.Ckt SWBD-B-12 /P-7 / 3#12, #12G / 3/4" conduit
13. Ckt SWBD-B-13 /P-8 / 4#12,#12G / 3/4" conduit
14. Ckt SWBD-B-14 /DC-1 / 4#12/#12G / 3/4" conduit
15. Ckt SWBD-B-15 /DC-2 / 4#12,#12G / 3/4" conduit
16. Ckt SWBD-B-16 /Chiller Phase Loss / 4#12,#12G / 3/4" conduit

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** E102
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:37 AM

Metr0Power has verified that all circuits added meet the above specifications.

**Paul Southwell** on **06/12/2015** at **10:55 AM**

## FO-2-31 CLOSED HIGH

Verification of the following: Distribution Panel Enclosure Cabinetry: Verify that ground bus is not bonded to neutral at Panel DP-L1CC. Enclosure is grounded and resistance to ground meets grounding specifications.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Drawing** Panel Construction Checkl
**Due Date** 6/18/2015
**Created By** Paul Southwell
**Identified On** 6/4/2015 11:38 AM

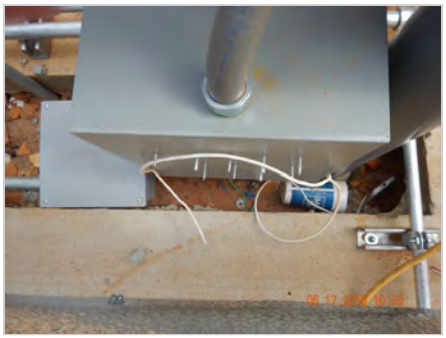
MetroPower has verified the requirements of FO-2-31 have been met.

**Paul Southwell** on **06/12/2015** at **10:57 AM**

## FO-2-32 OPEN HIGH

At the dry-cooler area, a NEMA 4X plastic enclosure is located below the NEMA 3R electrical panel. Instead of using a back panel for mounting terminal blocks within the enclosure, the back wall of the water-proof enclosure has been penetrated. These penetrations will allow moisture to enter the enclosure.

**Assigned To** MetroPower
**Asset** Wiring
Wiring
Electrical
**Discipline** Electrical
**Due Date** 7/1/2015
**Created By** Paul Southwell
**Identified On** 6/17/2015 11:16 AM



# Field Observation No. 3

Mike Sabo | Install Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage Building 3700 MCLB Albany | 960 (ESTCP No. EW-200135)

Commissioning (Cx) Field Report #3, HVAC Installation Verification Visit: An installation verification site visits was performed by Mike Sabo on 6/15/15 and 6/17/15. One of the previous commissioning issues have been fully corrected and several are partially completed or were in-progress while on site. Two new issues have been identified. The new issues are contained in this report. The next site visit is estimated to occur in July when the installed equipment is ready for functional testing (need updated sequences to finish functional testing forms).

**Author** Mike Sabo
**Present** Mike Sabo and Paul Southwell from AET; David Fugua and Jason Norris from Artesian Contracting; Ray from SafeAir; Ken Alexander from McKenneys
**Date Observed** 6/17/2015
**Weather** Sunny, High of 90 low of 70, 40-
**Location** Albany, GA
**Type** Commissioning

## Issues 2

### FO-3-1 OPEN MODERATE

Five of the Automatic Air Vents (AAV) shown on plans M301, M302, and M303 are missing.

**Assigned To** SafeAir
**Asset** Source Water Loop
**Discipline** Mechanical
**Drawing** M301, M302, M303
**Due Date** 7/2/2015
**Created By** Mike Sabo
**Identified On** 6/18/2015 12:38 PM

### FO-3-2 OPEN MODERATE

The piping arrangement for the BTES loop chemical feeder is not per plan. The supply is from the high pressure side of the BTES pumps. The return is to the low pressure side of the SW pumps (upstream of the BTES/SW decoupler). Because the SW and BTES loops have different pressures (by design) there could be a scenario where the return of the chemical feeder is at a higher pressure than the supply. This will cause reverse flow through the feeder and coupon rack. Per the chemical treatment vendor, this is not desired. The owner should provide approval of the installed condition or provide a corrective course of action.

**Assigned To** Owner
**Asset** Source Water Loop
**Discipline** Mechanical
**Drawing** M301
**Due Date** 7/2/2015
**Created By** Mike Sabo
**Identified On** 6/18/2015 12:50 PM

# Field Observation No. 4

Mike Sabo | Install Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage Building 3700 MCLB Albany | 960 (ESTCP No. EW-200135)

Commissioning (Cx) Field Report #4, Pre-final walk through w/Owner: A site visit was scheduled and performed by Paul Southwell on 7/17/2015 to coincide with the pre-final walk through with the owner scheduled for Friday morning at 10:00 AM. Paul was not only acting as representative for the AET Commissioning Group but being onsite gave him the opportunity to review the electrical work completed since his last visit on June 17th. The electrical was in the final stages of completion. The attached issues, documented based on the categories: plan/specification compliance, NEC Code Compliance, Documentation requirements, Testing requirements, and Verification requirements are all listed in this report organized by priority levels of Low, Moderate, and High.

**Author** Paul Southwell
**Present** David Fuqua, Jason Norris, Ken Alexander, Ray from SafeAire, NavFac representatives
**Date Observed** 7/17/2015
**Weather** Hot, Mid 90's
**Location** Building 3700
**Type** Commissioning

## Issues 4

### FO-4-1 OPEN MODERATE

358.12 Uses Not Permitted. EMT shall not be used under the following conditions: Where, during installation or afterward, it will be subject to severe physical damage.(3/4" PVC was observed at the rear of both dry coolers coming out of the gravel and terminating on the back of the dry coolers)

**Assigned To** McKenney's
**Asset** Dry Cooler
**Discipline** Electrical
**Drawing** n/a
**Due Date** 8/5/2015
**Created By** Paul Southwell
**Identified On** 7/22/2015 12:28 PM

Typically, these raceways would be installed using either rigid or IMC conduit, anchoring the conduits utilizing the appropriate strap, i.e., kendorf channel.

**Paul Southwell** on **07/22/2015** at **12:28 PM**



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## FO-4-2 OPEN

Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. According to electrical drawings, the existing breakers located in the distribution section of the switchboard are to be relabeled as "SPARES" since all of the new equipment was being fed from the new distribution section of the switchgear.

**Created By** Paul Southwell
**Identified On** 7/22/2015 12:37 PM

First verify that these breakers are not being used(remove wiring if not used) and provide the appropriate laminated nameplates indicating the breaker is a spare.

**Paul Southwell** on **07/22/2015** at **12:37 PM**





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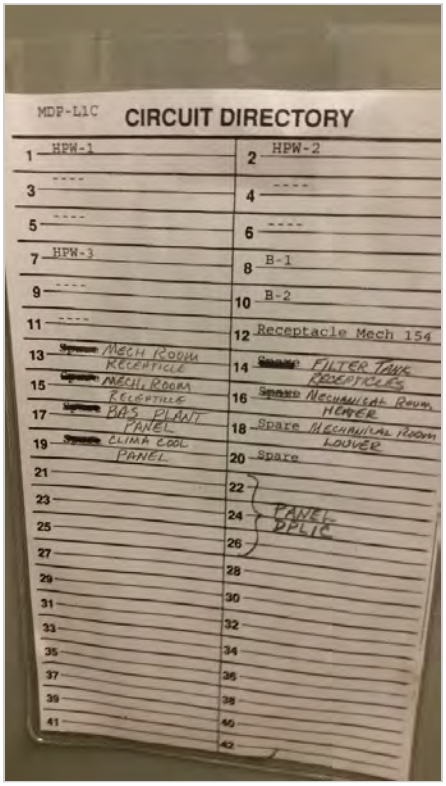
## FO-4-3 OPEN HIGH

The electrical panel, MDP-LIC, located adjacent to the main switchgear is no longer feeding equipment that use to occupy the mechanical room. The remaining breakers need to be identified and the electrical schedule should be updated to eliminate any possibility of injury due to mislabeled breakers.

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Created By** Paul Southwell
**Identified On** 7/22/2015 12:55 PM




## FO-4-4 OPEN MODERATE

At the Dry Cooler location two junction boxes, one labeled P-9(NEMA 4x) and a PVC junction box, both located below electrical panel DP-LICC have liquid tight connectors penetrating the top side of both boxes. If the topside of the box is to be penetrated then a Myer's Hub should be used to ensure a sealed connection.

**Assigned To** MetroPower
**Asset** Electrical
**Discipline** Electrical
**Created By** Paul Southwell
**Identified On** 7/22/2015 1:06 PM





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# MCLB Albany – Building 3700 Commissioning
# Site Visit Report

## EXECUTIVE SUMMARY

The Scope of Work for this site visit was to commission the existing Air Handing Units (AHUs) and an existing Energy Recovery Unit (ERU), all of which had been previously modified, but not as a certain effort of the current GHP/USTES Project. This report summarizes the results of the scheduled commissioning of the six (6) Air Handling Units (AHU) and a single Energy Recovery Unit (ERU) in Building 3700 at MCLB Albany Georgia, 29-31 July 2015.

The sections of the report are:

- Building AHU and ERU Conditions Report
- Re-Commissioning Recommendations
- Appendix A – FUNCTIONAL OBSERVATIONS AHUs and ERU
- Appendix B – CONDITIONS OBSERVATIONS AHUs and ERU
- Appendix C – "BAS" SCREEN SHOTS

## BUILDING AHU and ERU CONDITIONS REPORT

The AHU and ERU equipment was observed to be deficient in several areas for each unit. The primary area of deficiency is that "ALL" dampers were in fixed positions, which nullified any normal control capability for air flows – e.g. outside air supply, return air volume, supply air volume. The flow was intended to be manipulated by increasing or decreasing fan speed only.

The SOP is not functional as result of above-mentioned fixed damper positions. Additionally, the effectiveness of the ERU could not be determined, as it too, is not functional per its normal SOP.

The lack of a normal functional SOP prohibits the control of supply temperature reset conditions. It was also determined that because the equipment is essentially setup for Occupied Mode on a 24/7 schedule, all normal energy savings from unoccupied setbacks cannot be achieved.

Many sensors, such as duct static pressure, freeze stats, do not shutdown equipment – some are circumvented and others appear to have not been included in the control programming. Additionally, the freeze stats have not been set uniformly – some are set to 45$^{o}$F and others are set to 35$^{o}$F (A setting of 45$^{o}$F would be normal for a single stage stat.).

The above-referenced sensors do not "Alarm" at the front BAS unit.

Tabulations and comments for each AHU and the ERU have been included for reference in Appendix B of this report.

# RE-COMMISSIONING RECOMMENDATION

This recommendation for Re-Commissioning follows directly from the observations made of the equipment conditions as herein stated. It is recommended that the deficiencies need to be corrected and followed with a formal Re-commissioning. By definition, this is “Commissioning to be performed in a building whose HVAC System was commissioned previously, either during construction or occupancy.”.

The Re-commissioning process will develop documentation and establish operational conditions for continued cost savings performance over time in several areas:

- DDC sequences of operation will start/stop air handlers depending on respective space occupancy.
- Variable ventilation systems will be verified for correct operation.
- Hot Water systems will maintain hot water set points based on outside air temperature.
- Chiller systems will maintain chilled water supply set points based on the outside air temperature.
- Dampers that are normally controlled by the DDC system will modulate based on space occupancy or space temperature set points.
- Maximize energy savings from implementation of various control strategies in order to alleviate occupant comfort problems.

At a minimum, scope of work for Re-commissioning should include the following:

1. Review of existing sequence of operation for each AHU.
2. Review of occupied space conditions to identify thermal comfort problems.
3. Review of design drawings and compare existing space conditions with design. Verification and recalibration of damper actuator(s) operation, or replacement of each as applicable.
4. If applicable, verification of economizer operation.
5. Test and balance of airflows at each AHU after all deficient components and devices have been replaced and/or calibrated.
6. Identification and verification of optimum locations for different sensors.
7. Recalibration of temperature, static pressure sensors, etc.
8. Validate the graphics on the host front end computer (if applicable).
9. Test and balance CHW and HW flows through AHU coils
10. Estimate costs for all the major repairs.
11. Functional test of the control loop sequence of operations
12. Check operating functional performance of AHU, exhaust fan, and chiller
13. Check correct operation and calibration of all analog and digital points (point-to-point)
14. Check actuators, valves, and dampers for proper operations.
15. Check for valve leak through
16. Develop a comprehensive report to include field observations, test data and results.

# APPENDIX – A

# FUNCTIONAL OBSERVATIONS
# AHUs AND ERU

| EXISTING AHU-1A | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 87$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 63% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 72.9$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 72.8$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 57.9$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 48.7$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 56.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 74% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.26” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm. Not in control program | Device is functional and shutdown AHU. Device not in program and not monitored. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is installed, and circumvented. Not functional. | |

| EXISTING AHU-1B | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 92$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 67% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 73.9$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 74.0$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 58.2$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | 100% |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 50.0$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 58.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 77% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.26” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm. Not in control program | Device is inoperative (? If VFD Wiring). Device not in program and not monitored. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is installed, and circumvented. Not functional. (? Type of device) | |

| EXISTING AHU-2A | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 92$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 67% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 73.2$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 74.6$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 55.9$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | 100% |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 50.0$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 57.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 63.6% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.24” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm | Device is functional and shutdown AHU. Device did auto-reset. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is incomplete. | |

| EXISTING AHU-2B | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 92$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 67% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 73.7$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 76.2$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 56.4$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | 100% |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 50.0$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 58.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 65.5% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.28” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm | Device is functional and shutdown AHU. Device did auto-reset. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is incomplete. | |

| EXISTING AHU-3A | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 95$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 65% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 75.2$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 77.7$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 57.2$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | 100% |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 49.0$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 57.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 69.9% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.26” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm | Device is installed, and circumvented. Not functional. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is incomplete. | |

| EXISTING AHU-3B | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | Terminal Units Schedule | All “On” | VAVs not linked per AHU Occupied/Unoccupied Schedule. All VAVs shutdown with AHU. | |
| 3 | DDC - Supply Fans | “On” and “Running” | | |
| 4 | DDC – OA Dampers | Fixed Position 100% Open | Damper inoperative. Status on Graphics Meaningless. | |
| 5 | DDC – OA Temp Sensor | Reading correctly | Central single temperature sensor. Each AHU does not have individual sensor. | 95$^{o}$F |
| 6 | DDC – Outside RH Sensor | Reading correctly | Central single RH Sensor. Irrelevant because RH not a control parameter. | 64% |
| 7 | DDC – RA Dampers | Fixed Position 100% Open | Damper inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 8 | DDC – RA Temp Sensor | Indicating correctly | | 74.9$^{o}$F |
| 9 | DDC – MA Temp Sensor | Indicating correctly | Sensor in duct, not across air stream | 79.1$^{o}$F |
| 10 | DDC – SA Temp Sensor | Indicating correctly | | 57.0$^{o}$F |
| 11 | DDC – CHW Control Valve | Position indicating correctly | Graphics indicate same | 100% |
| 12 | DDC – CHW Control Valve | Responds to commands | Graphics indicate same | |
| 13 | DDC – CHW Coil Inlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 50.2$^{o}$F |
| 14 | DDC – CHW Coil Outlet Temp | Indicating correctly | Sensor is at CHW Cooler in Mech Room | 58.0$^{o}$F |
| 15 | DDC – SF Speed | Indicating correctly | Graphics and VFD indicating same | 69.0% |
| 16 | DDC – Duct Static Pressure | Indicating correctly | Static Pressure 1.26” and setpoint1.25”, generally agree | 1.25” |
| 17 | Freeze Protection | Inoperative | OA Damper is 2-Position and “fixed open”. | |
| 18 | Alarm Safety – Freeze Stat | No alarm | Device is installed, and shutdown AHU. | |
| 19 | Alarm Safety – High Static Pres | No alarm. Not in control program | Device is incomplete. | |

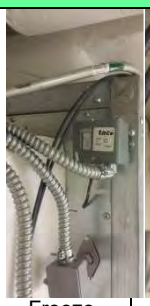
| EXISTING ERU | | | | |
|---|---|---|---|---|
| **Item No.** | **Description** | **Status** | **Comment** | **Data** |
| 1 | Existing Schedule | Occupied 24/7 | Set to 24/7 Occupied Schedule. Unoccupied Schedule not setup (disabled) | 24/7 |
| 2 | DDC – OA Dampers | Fixed Position 100% Open | Dampers inoperative. Status on Graphics Meaningless. | |
| 3 | DDC – By-Pass Dampers | Fixed Position 100% Closed | Dampers inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 4 | DDC – Face Dampers | Fixed Position 100% Open | Dampers inoperative. Missing actuators. Status on Graphics Meaningless. | |
| 5 | DDC – Supply Fan | "On" and "Running" | | |
| 6 | DDC – Exhaust Fan | "On" and "Running" | | |
| 7 | DDC – Exhaust Damper | Gravity Damper | | |
| 8 | DDC – Exhaust Temp Sensor | Not monitored | Exhaust air measured at outlet grille | 87.3°F |
| 9 | DDC – Exhaust RH Sensor | Not monitored | RH measured at outlet grille | 38.7% |
| 10 | DDC – OA Temp Sensor | Not monitored | ERU does not have individual sensor. OA Temp measured near ERU. | 96.3°F |
| 11 | DDC – OA RH Sensor | Not monitored | Irrelevant, RH not a control parameter. RH was measured near ERU to compare with RH of the exhaust air. | 48.2% |
| | | | | |
| | | | | |

# APPENDIX – B

# CONDITIONS OBSERVATIONS
## AHUs and ERU

# AHU-1A EXISTING CONDITIONS

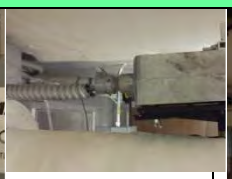


Freeze Stat



Freeze Stat <40°F



CHW Valve Actuator with open flex connection.



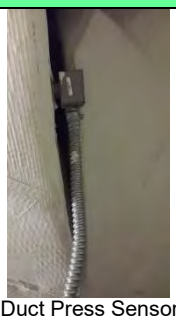
CHWS/R Piping



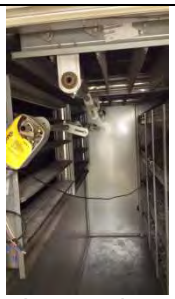
CHW Temp/Pres s



Duct Press Sensor



Duct Press Sensor



Inoperative Dampers



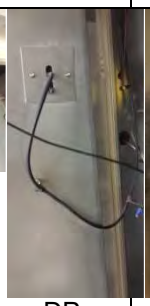
Inoperati ve Damper



Freeze Stat Routing



Freeze Stat Routing



DP Tubing



DP Gauge



DP Sensor Tubings



DP Sensor Across Coil Section



DP Sensor Across Coil Section



Condensat e Drip Pan Leakage



VFD Status



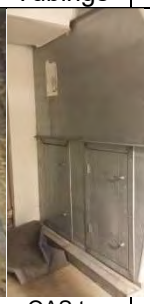
CHWS/R Piping



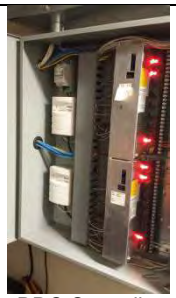
Condensat e Drain



Condensat e Drain

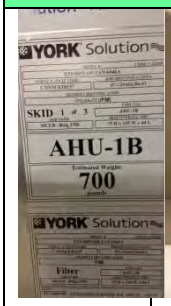


OAS to AHUs-1&2



DDC Controller

# AHU-1B EXISTING CONDITIONS






CHW Temp/Press



CHWS/R Piping



CHW Valve Actuator.



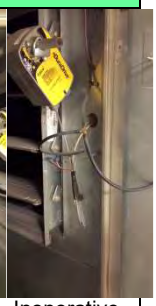
Freeze Stat



Freeze Stat <40°F



Inoperative Dampers



Inoperative Dampers



Freeze Stat Routing



Freeze Stat Routing



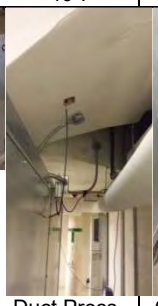
DP Gauge



Dirty Filter DP



Dirty Filter DP Sensor Tubing



Duct Press Sensor



Condensate Drip Pan Leakage



Duct Static Pressure Unit w/Reset



VFD




VFD Status



VFD Anchored at top Only. Unit is loose.



CHWS/R Piping



Condensate Drain



Condensate Drain



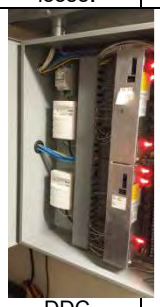
Condensate Drain



Inoperative Dampers

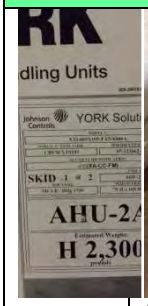
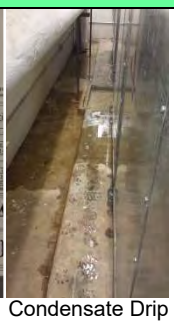
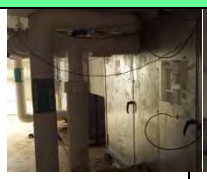
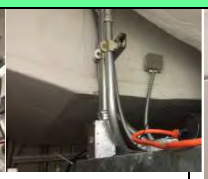
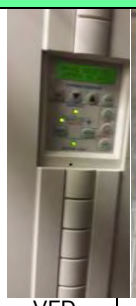
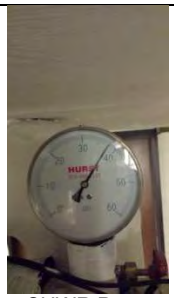
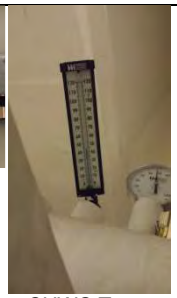
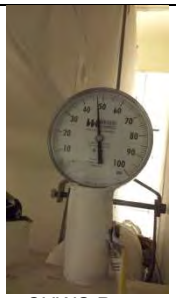
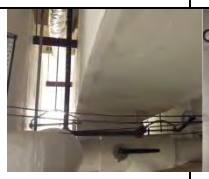
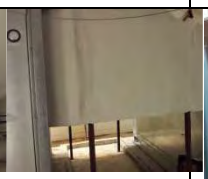
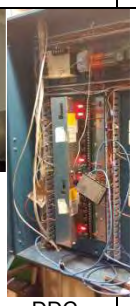


OAS to AHUs-1&2

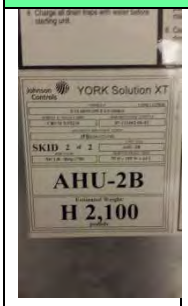
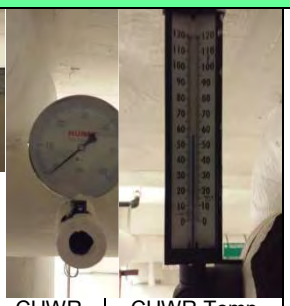
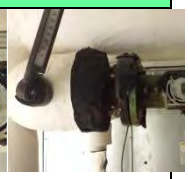
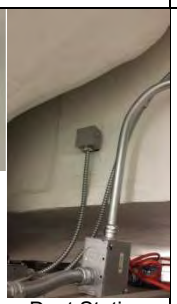
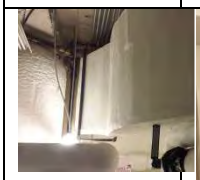


DDC Controller

# AHU-2A EXISTING CONDITIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  |  Condensate Drip Pan Leakage |  CHWS/R Piping |  Duct Static Pressure Unit w/Rese |  Duct Temp Sensor |  VFD Status |  VFD Status |  Condensate Drip Pan Leakage |
|  Dirty Filter DP |  CHWR Temp |  CHWR Press |  CHW Valve Actuator. |  CHWS Temp |  CHWS Press |  DP Gauge |  Condensate Drip Pan Leakage |
|  |  Freeze Stat |  Freeze Stat Set 35°F |  OAS to AHUs-1&2 |  OAS to AHU-2A/2B |  OAS to AHU-2A/2B |  DDC Controller | |

# AHU-2B EXISTING CONDITIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  |  CHWS/R Piping |  DP Gauge |  CHW Valve Actuator. |  CHWR Press<br>CHWR Temp |  CHW Valve |  CHW Valve | |
|  CHW Valve Actuator. |  Inoperative Dampers |  Inoperative Dampers |  Inoperative Dampers |  Inoperative Dampers<br>VFD Status |  VFD Status |  Dirty Filter DP | |
|  Dirty Filter DP Sensor Tubing |  Duct Static Pressure and Temperature Sensors |  Duct Static Pressure and Temperature Sensors |  Freeze Stat and Temp and Press Sensors |  Presssure Sensor with Reset<br>Freeze Stat |  Freeze Stat Set 35°F |  CHWR Piping | |
|  CHWS/R Pipin |  OAS to AHUs-1&2 |  OAS to AHU-2A/2B |  OAS to AHU-2A/2B |  DDC Controller | | | |

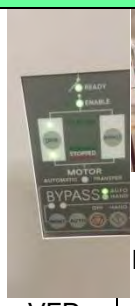
# AHU-3A EXISTING CONDITIONS



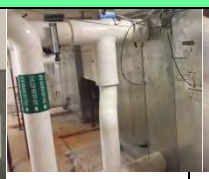




VFD Status




VFD Status



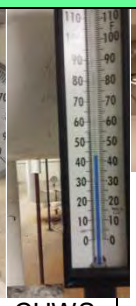
Dirty Filter DP Sensor Tubing



Freeze Stat Set 40°F



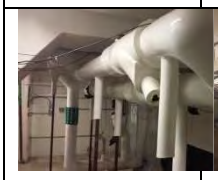
CHWS Press



CHWS Temp



CHW Valve Actuator.



CHWS/R Piping



CHWS/R Piping



CHWR Temp (Broken)



CHWR Press



CHW Valve




DP Gauge



Duct Static Pressure Sensor



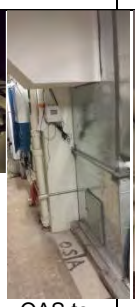
Duct Static Pressure and Temperature Sensors



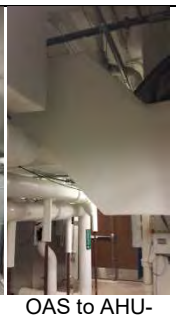
Inoperative Dampers



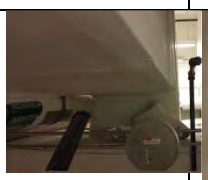
Inoperative Dampers



OAS to AHU-3A/3B



OAS to AHU-3A/3B



OAS to AHU-3A/3B



Minor Leakage from Condensate Drip Pans



Duct Static Pressure and Temperature Sensors



Duct Static Pressure and Temperature Sensors




Dirty Filter DP

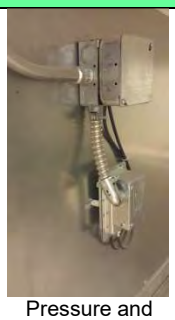
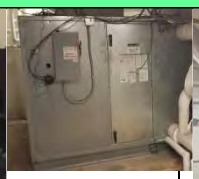
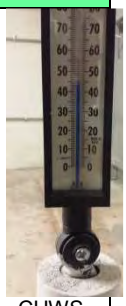
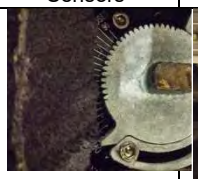
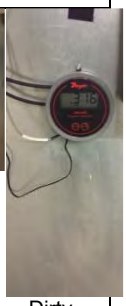
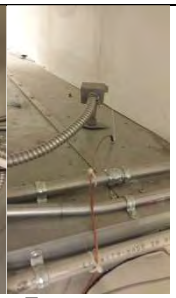
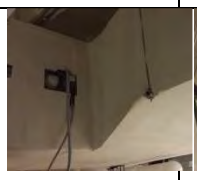


Dirty Filter DP Sensor Tubing

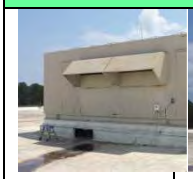
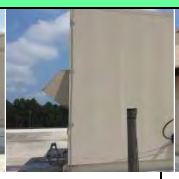
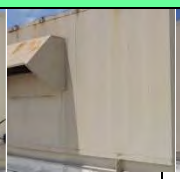
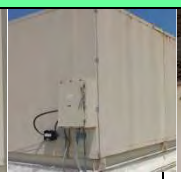
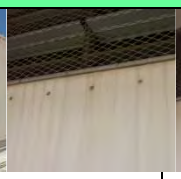
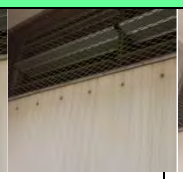
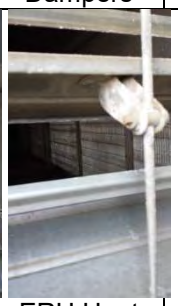
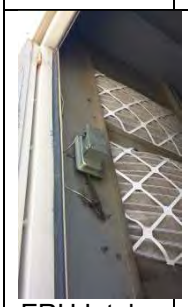
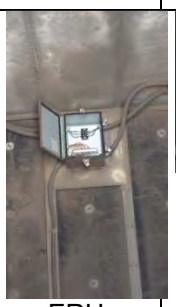
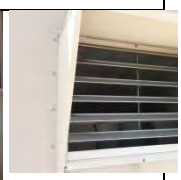


DDC Controller

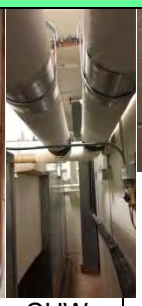
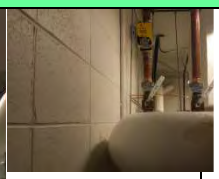
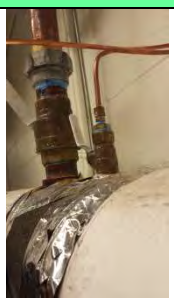
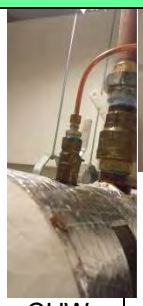
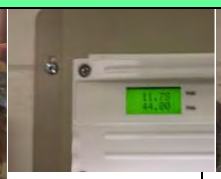
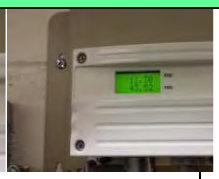
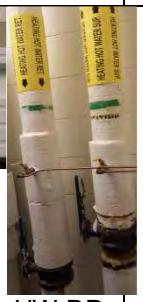
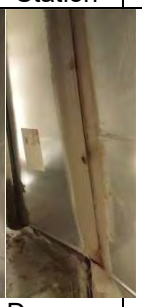
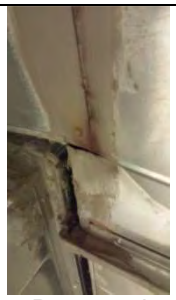
# AHU-3B EXISTING CONDITIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  |  Pressure and Temperature Sensors |  DP Gauge |  |  CHWS/R Piping |  CHWS/R Piping |  CHWS Press |  CHWS Temp |
|  CHW Valve |  CHW Valve |  Inoperative Dampers |  Inoperative Dampers |  Inoperative Dampers |  Freeze Stat Set 35°F |  Dirty Filter DP Sensor Tubing |  Dirty Filter DP |
|  CHW Valve Actuator. Loosely fitted. |  CHW Valve Actuator. Loosely fitted. |  Duct Static Pressure and Temperature Sensors. Jumbled mess of wires. |  Duct Static Pressure and Temperature Sensors. Jumbled mess of wires. |  Temperature Sensor |  Duct Static Pressure and Temperature Sensors |  Duct Static Pressure and Temperature Sensors |  VFD Status |
|  DDC Controller | | | | | | | |

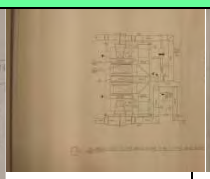
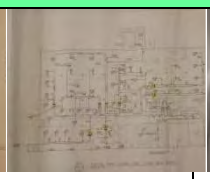
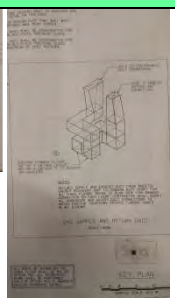
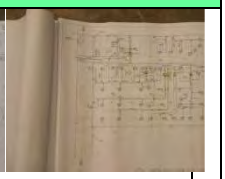
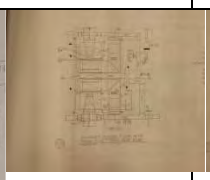
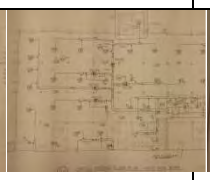
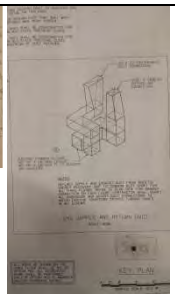
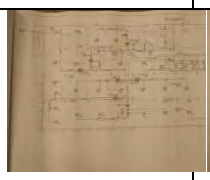
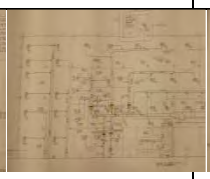
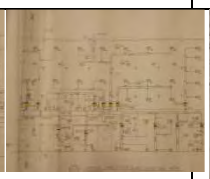
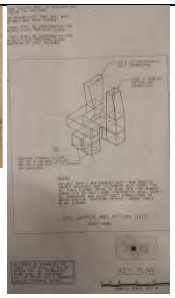
# ERU EXISTING CONDITIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |
| ERU Intake | ERU Control Panel | ERU Exhaust | ERU Intake | ERU Inoperative Intake Dampers | ERU Inoperative Intake Dampers | ERU Inoperative Intake Dampers | ERU Inoperative Intake Dampers |
|  |  |  |  |  |  |  |  |
| ERU Freeze Stat Set 40°F | ERU Heat Exchanger Chamber | ERU Inoperative Dampers | ERU Inoperative Face Dampers | ERU Inoperative By-Pass Dampers | ERU Heat Exchanger | ERU Intake Filters | ERU Intake Filters |
|  |  |  |  |  |  |  |  |
| ERU Intake Filters | ERU Damper Control Terminal Box | ERU Final Filters | ERU Final Filters | ERU Final Filters | ERU Supply Fan | ERU Exhaust Fan | ERU Exhaust and Dampers |

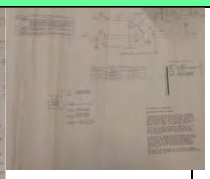
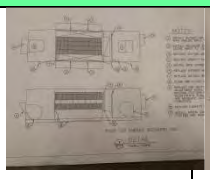
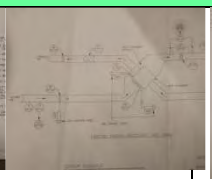
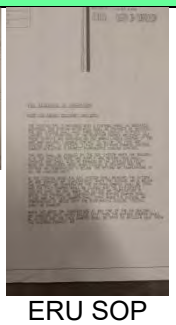
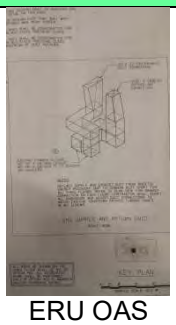
## MISCELLANEOUS EXISTING CONDITIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  CHW DP Station |  CHW DP Station |  CHW DP Station |  CHW DP Station |  CHW DP Station |  CHW DP Station |  CHW DP Station | |
|  HW DP Station |  HW DP Station |  HW DP Station |  HW DP Station |  HW DP Station | | | |
|  Damaged OAS Duct |  Damaged OAS Duct |  Damaged OAS Duct |  OAS Duct down to AHUs 1&2 |  HOBO for AHU Monitoring (Typical each AHU) |   HOBO for AHU Monitoring (Typical each AHU) |  HOBO for AHU Monitoring (Typical each AHU) |  HOBO for AHU Monitoring (Typical each AHU) |

## EXISTING DUCT DISTRIBUTION DRAWINGS AHU-1A/1B, 2A/2B, 3A/3B

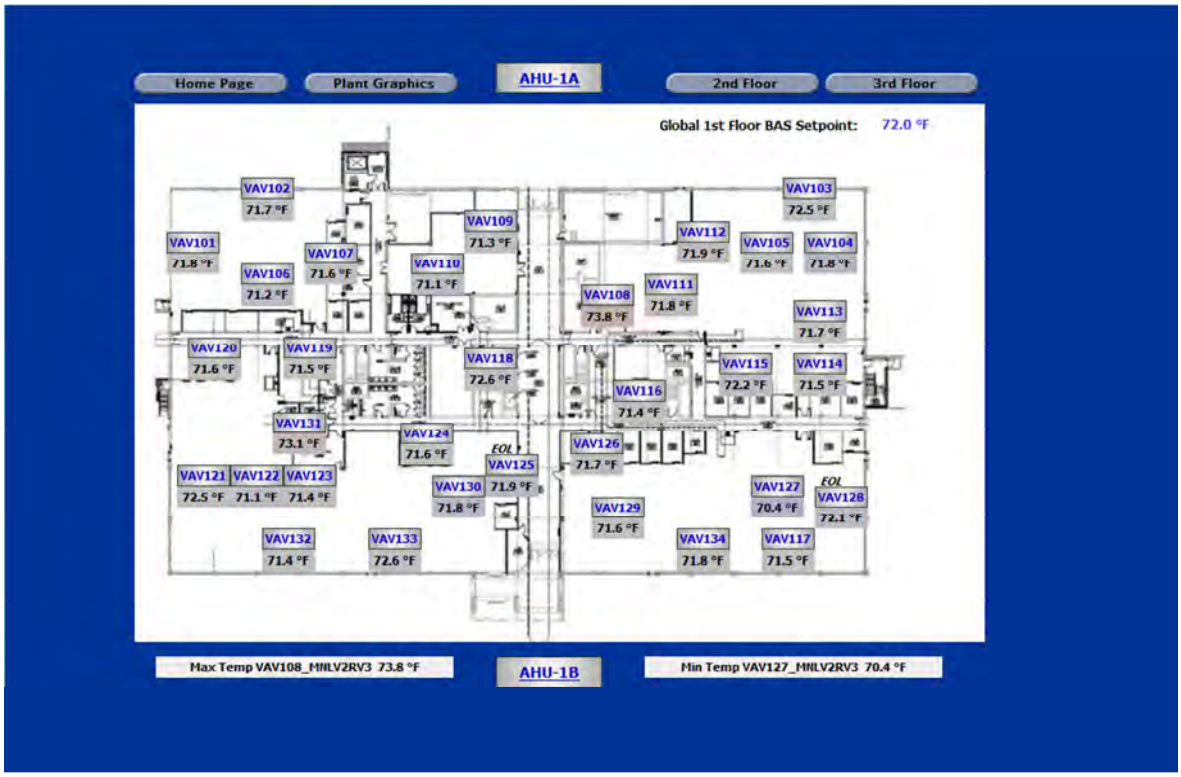
| | | | | | | |
|---|---|---|---|---|---|---|
|  OAS Duct |  Layout AHU-1A/1B |  AHU-1A Ductwork |  AHU-1A Ductwork |  OAS Duct |  AHU-1B Ductwork |  AHU-1B Ductwork |
|  OAS Duct |  Layout AHU-2A/2B |  AHU-2A Ductwork |  AHU-2A Ductwork |  OAS Duct |  AHU-2B Ductwork |  AHU-2B Ductwork |
|  OAS Duct |  Layout AHU-3A/3B |  AHU-3A Ductwork |  AHU-3A Ductwork |  OAS Duct |  AHU-3B Ductwork |  AHU-3B Ductwork |

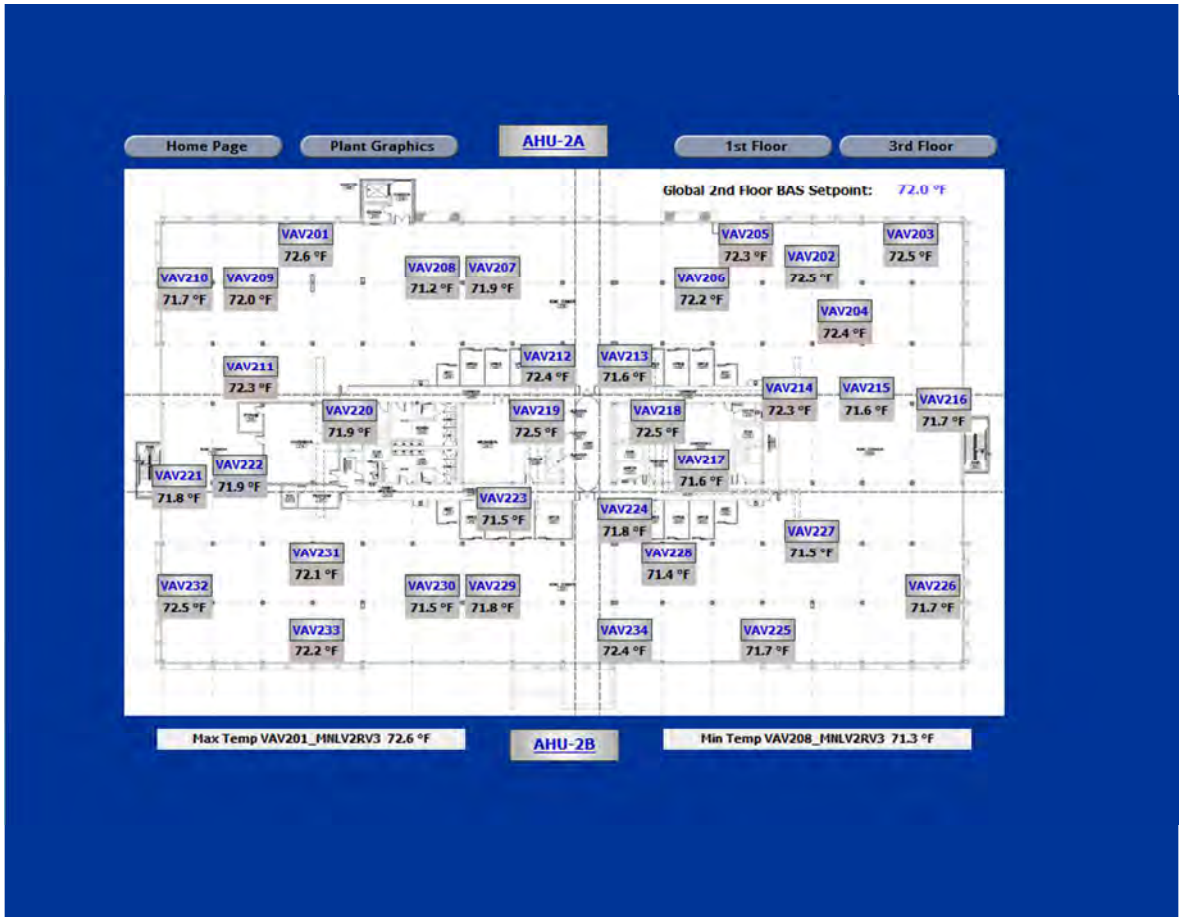
## EXISTING DRAWINGS ERU SOP

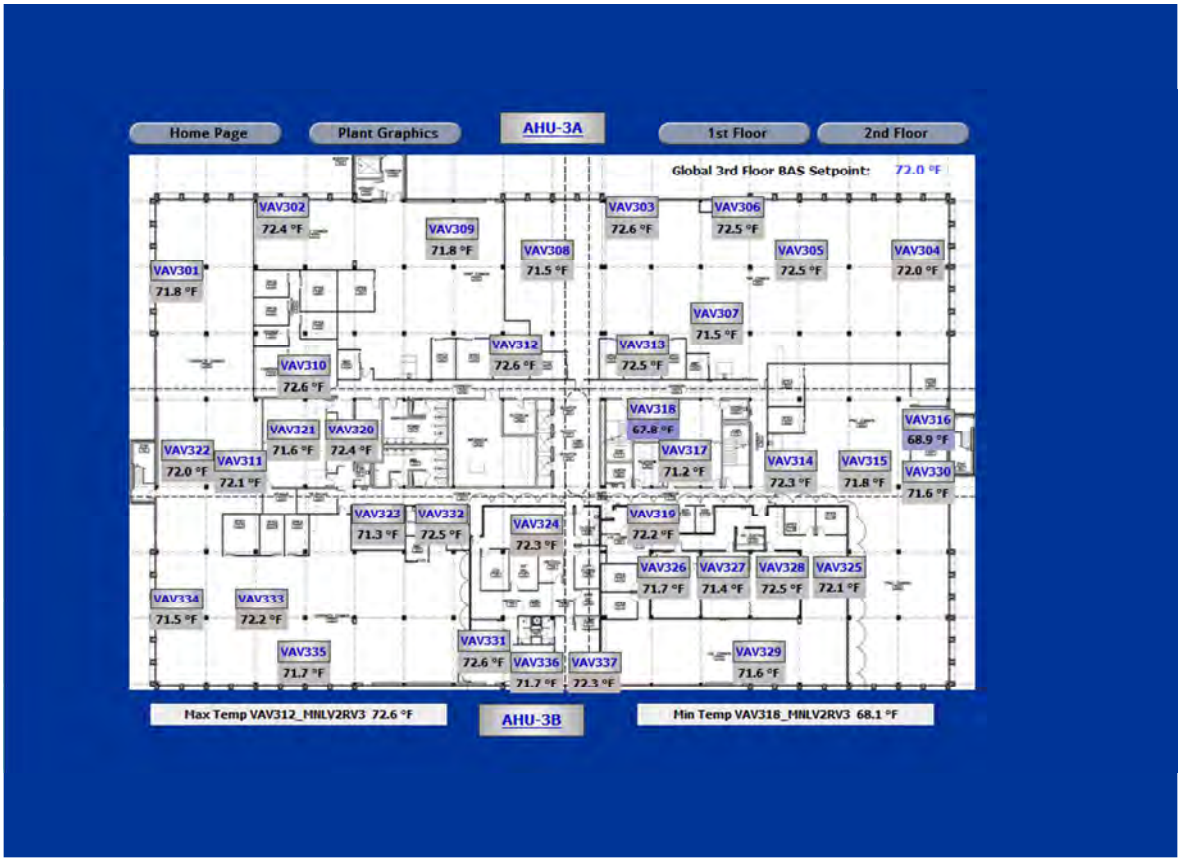
| | | | | | | |
|---|---|---|---|---|---|---|
|  ERU Control Panel |  ERU Operation Plan |  ERU 2007 Upgrades |  ERU 2007 Upgrades |  ERU Operation Diagram |  ERU SOP |  ERU OAS Duct Down to AHUs |

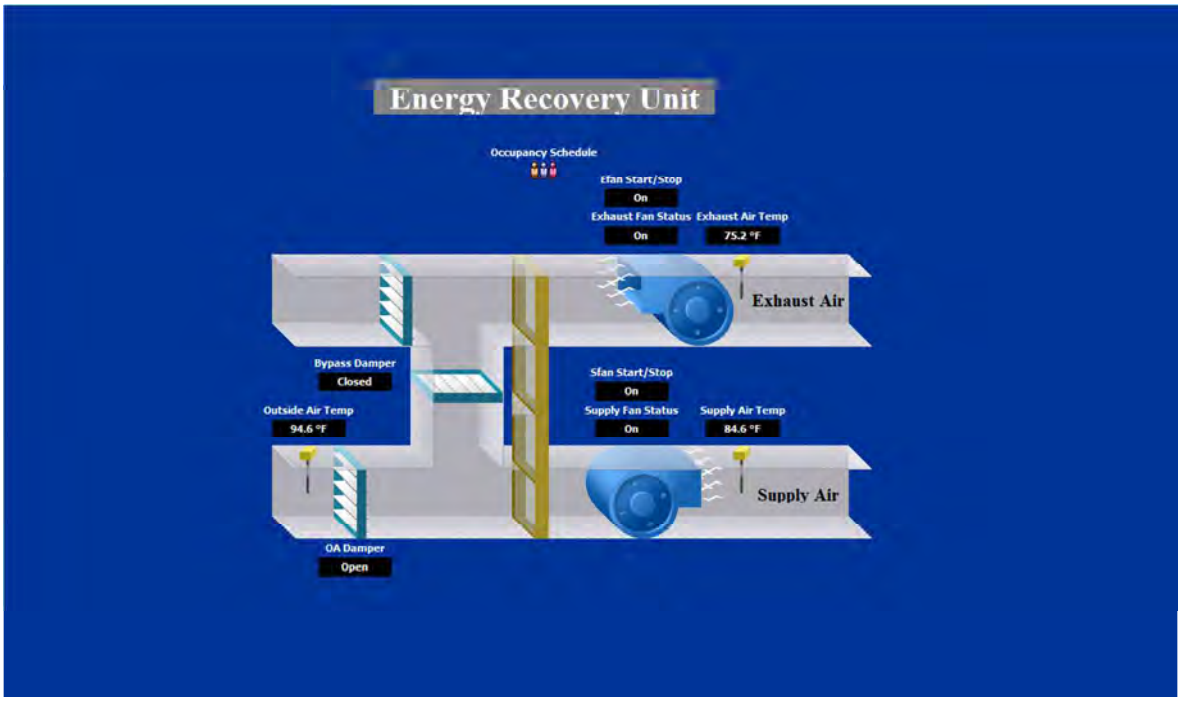
# APPENDIX - C

# “BAS” SCREEN SHOTS

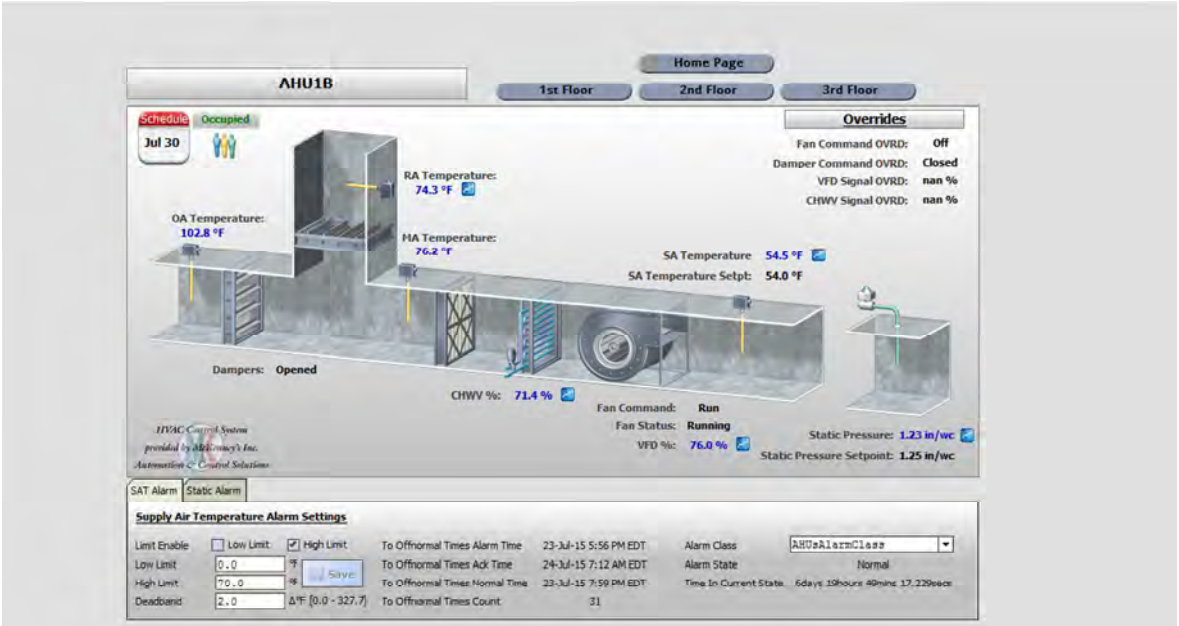

Home Page
Plant Graphics
AHU-1A
2nd Floor
3rd Floor
Global 1st Floor BAS Setpoint: 72.0 °F
VAV102 71.7 °F
VAV103 72.5 °F
VAV101 71.8 °F
VAV109 71.3 °F
VAV112 71.9 °F
VAV105 71.6 °F
VAV104 71.8 °F
VAV107 71.6 °F
VAV110 71.1 °F
VAV106 71.2 °F
VAV108 73.8 °F
VAV111 71.8 °F
VAV113 71.7 °F
VAV120 71.6 °F
VAV119 71.5 °F
VAV118 72.6 °F
VAV115 72.2 °F
VAV114 71.5 °F
VAV116 71.4 °F
VAV131 73.1 °F
VAV124 71.6 °F
EOL
VAV125 71.9 °F
VAV126 71.7 °F
VAV121 72.5 °F
VAV122 71.1 °F
VAV123 71.4 °F
VAV130 71.8 °F
VAV127 70.4 °F
EOL
VAV128 72.1 °F
VAV129 71.6 °F
VAV132 71.4 °F
VAV133 72.6 °F
VAV134 71.8 °F
VAV117 71.5 °F
Max Temp VAV108_MNLV2RV3 73.8 °F
AHU-1B
Min Temp VAV127_MNLV2RV3 70.4 °F

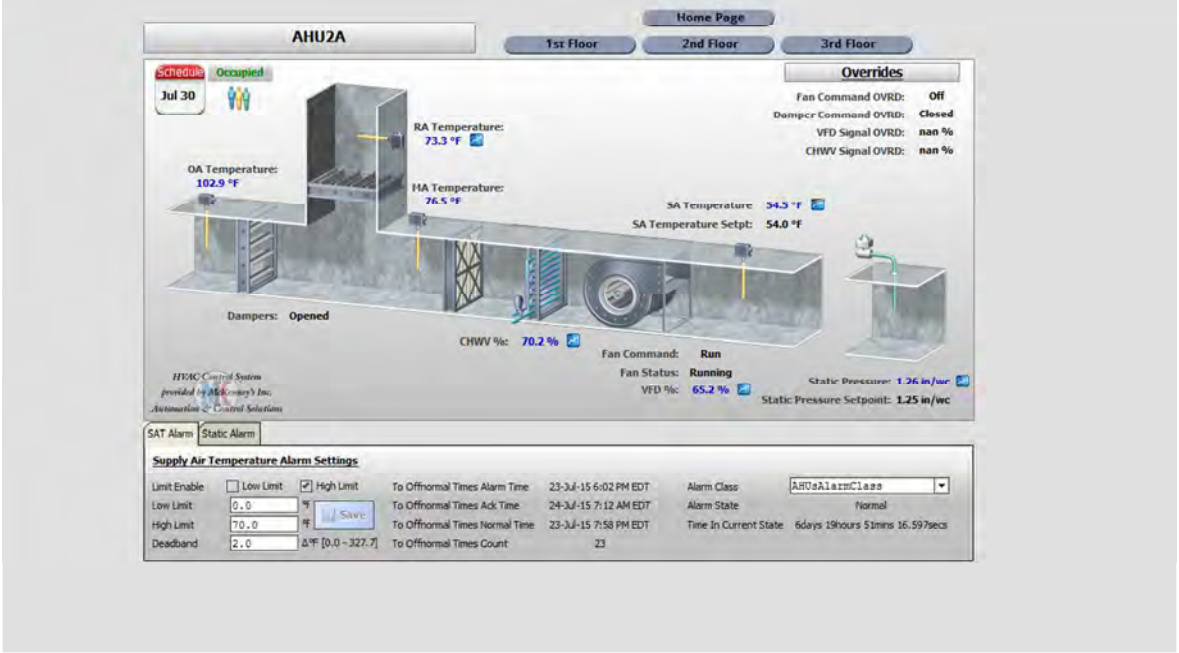

Home Page
Plant Graphics
AHU-2A
1st Floor
3rd Floor
Global 2nd Floor BAS Setpoint: 72.0 °F
VAV201 72.6 °F
VAV205 72.3 °F
VAV203 72.5 °F
VAV202 72.5 °F
VAV210 71.7 °F
VAV209 72.0 °F
VAV208 71.2 °F
VAV207 71.9 °F
VAV206 72.2 °F
VAV204 72.4 °F
VAV211 72.3 °F
VAV212 72.4 °F
VAV213 71.6 °F
VAV214 72.3 °F
VAV215 71.6 °F
VAV216 71.7 °F
VAV220 71.9 °F
VAV219 72.5 °F
VAV218 72.5 °F
VAV222 71.9 °F
VAV221 71.8 °F
VAV217 71.6 °F
VAV223 71.5 °F
VAV224 71.8 °F
VAV227 71.5 °F
VAV231 72.1 °F
VAV228 71.4 °F
VAV232 72.5 °F
VAV230 71.5 °F
VAV229 71.8 °F
VAV226 71.7 °F
VAV233 72.2 °F
VAV234 72.4 °F
VAV225 71.7 °F
Max Temp VAV201_MNLV2RV3 72.6 °F
AHU-2B
Min Temp VAV208_MNLV2RV3 71.3 °F

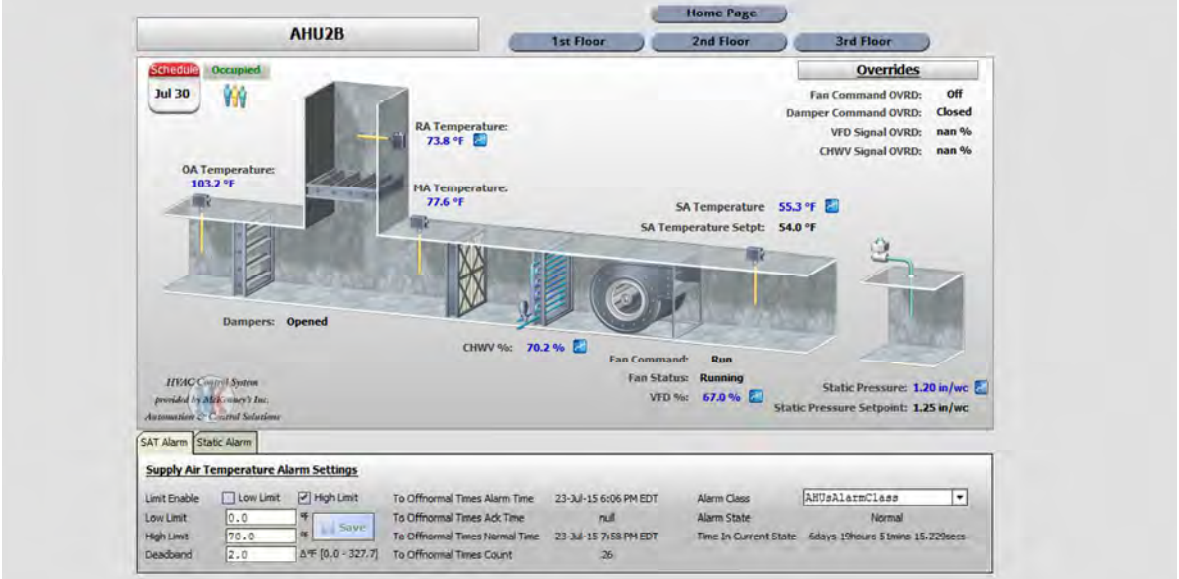

Home Page
Plant Graphics
AHU-3A
1st Floor
2nd Floor
Global 3rd Floor BAS Setpoint: 72.0 °F
VAV302 72.4 °F
VAV309 71.8 °F
VAV308 71.5 °F
VAV303 72.6 °F
VAV306 72.5 °F
VAV305 72.5 °F
VAV304 72.0 °F
VAV301 71.8 °F
VAV307 71.5 °F
VAV312 72.6 °F
VAV313 72.5 °F
VAV310 72.6 °F
VAV318 67.8 °F
VAV316 68.9 °F
VAV321 71.6 °F
VAV320 72.4 °F
VAV322 72.0 °F
VAV311 72.1 °F
VAV317 71.2 °F
VAV314 72.3 °F
VAV315 71.8 °F
VAV330 71.6 °F
VAV323 71.3 °F
VAV332 72.5 °F
VAV324 72.3 °F
VAV319 72.2 °F
VAV326 71.7 °F
VAV327 71.4 °F
VAV328 72.5 °F
VAV325 72.1 °F
VAV334 71.5 °F
VAV333 72.2 °F
VAV335 71.7 °F
VAV331 72.6 °F
VAV336 71.7 °F
VAV337 72.3 °F
VAV329 71.6 °F
Max Temp VAV312_MNLV2RV3 72.6 °F
AHU-3B
Min Temp VAV318_MNLV2RV3 68.1 °F

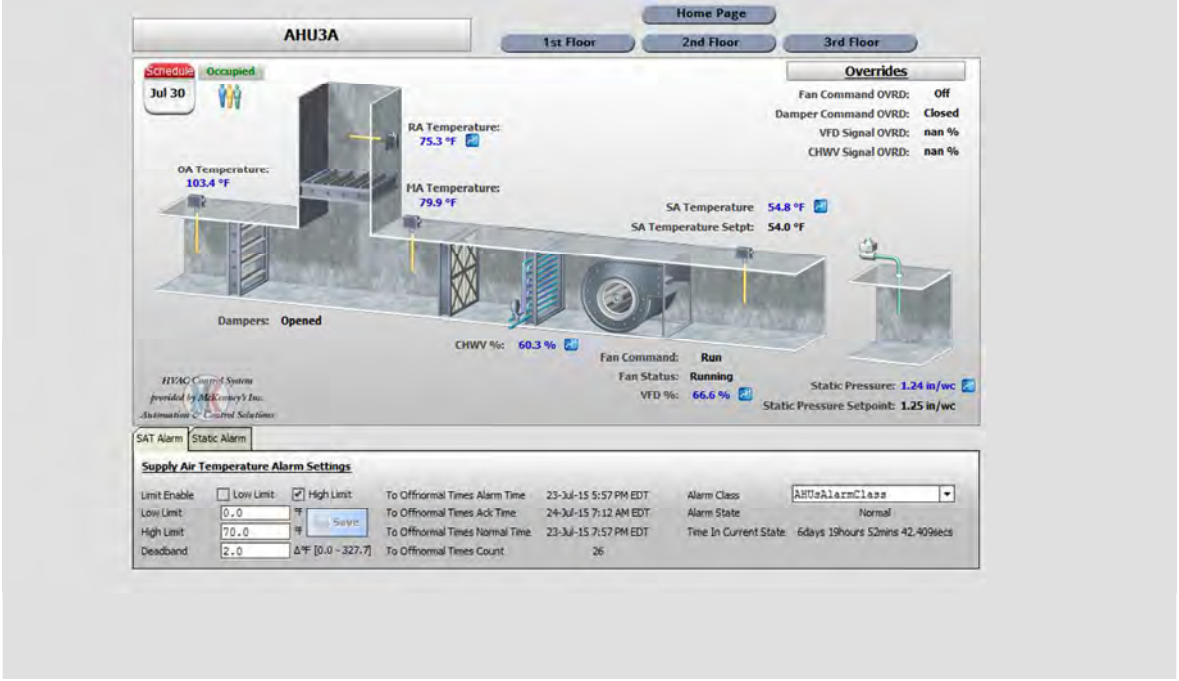

Energy Recovery Unit
Occupancy Schedule
Efan Start/Stop
On
Exhaust Fan Status
On
Exhaust Air Temp
75.2 °F
Exhaust Air
Bypass Damper
Closed
Outside Air Temp
94.6 °F
Sfan Start/Stop
On
Supply Fan Status
On
Supply Air Temp
84.6 °F
Supply Air
OA Damper
Open

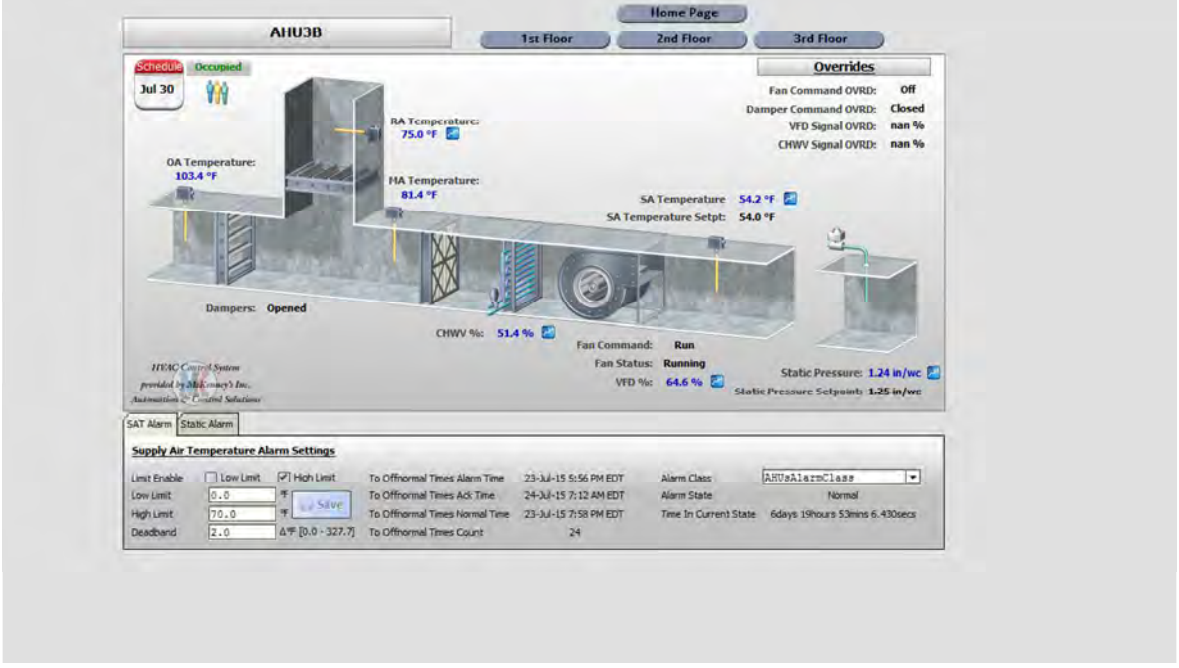

AHU1A
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 73.1 °F
OA Temperature: 102.1 °F
MA Temperature: 75.4 °F
SA Temperature 54.2 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 71.1 %
Fan Command: Run
Fan Status: Running
VFD %: 71.7 %
Static Pressure: 1.25 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System
provided by McKinney's Inc.
Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Low Limit 0.0 °F
High Limit 70.0 °F
Save
Deadband 2.0 ΔºF [0.0 - 327.7]
To Offnormal Times Alarm Time 23-Jul-15 6:00 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:58 PM EDT
To Offnormal Times Count 25
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 49mins 22.839secs


AHU1B
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 74.3 °F
OA Temperature: 102.8 °F
MA Temperature: 76.2 °F
SA Temperature 54.5 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 71.4 %
Fan Command: Run
Fan Status: Running
VFD %: 76.0 %
Static Pressure: 1.23 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System
provided by McKinney's Inc.
Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Low Limit 0.0 °F
High Limit 70.0 °F
Save
Deadband 2.0 ΔºF [0.0 - 327.7]
To Offnormal Times Alarm Time 23-Jul-15 5:56 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:59 PM EDT
To Offnormal Times Count 31
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 49mins 17.229secs


AHU2A
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 73.3 °F
OA Temperature: 102.9 °F
MA Temperature: 76.5 °F
SA Temperature: 54.5 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 70.2 %
Fan Command: Run
Fan Status: Running
VFD %: 65.2 %
Static Pressure: 1.26 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System provided by McKenney's Inc. Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Deadband
Save
To Offnormal Times Alarm Time 23-Jul-15 6:02 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:58 PM EDT
To Offnormal Times Count 23
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 51mins 16.597secs

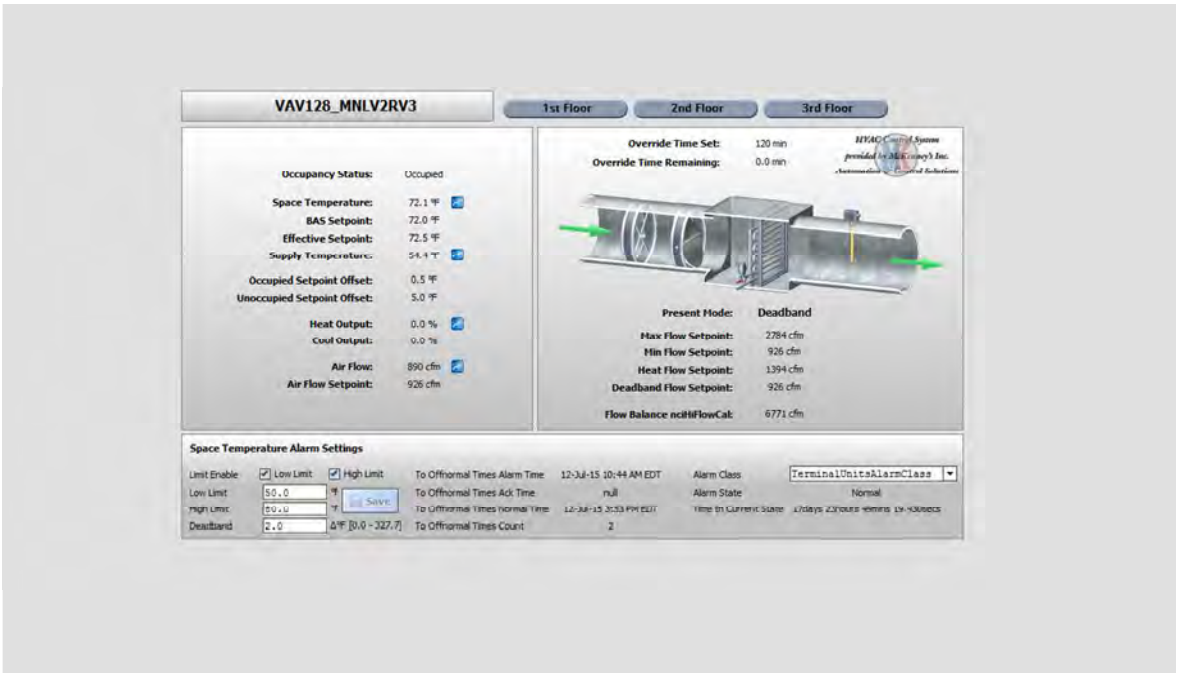

AHU2B
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 73.8 °F
OA Temperature: 103.2 °F
MA Temperature: 77.6 °F
SA Temperature: 55.3 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 70.2 %
Fan Status: Running
VFD %: 67.0 %
Static Pressure: 1.20 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System provided by McKenney's Inc. Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Deadband
Save
To Offnormal Times Alarm Time 23-Jul-15 6:06 PM EDT
To Offnormal Times Ack Time null
To Offnormal Times Normal Time 23-Jul-15 7:58 PM EDT
To Offnormal Times Count 26
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 51mins 15.229secs

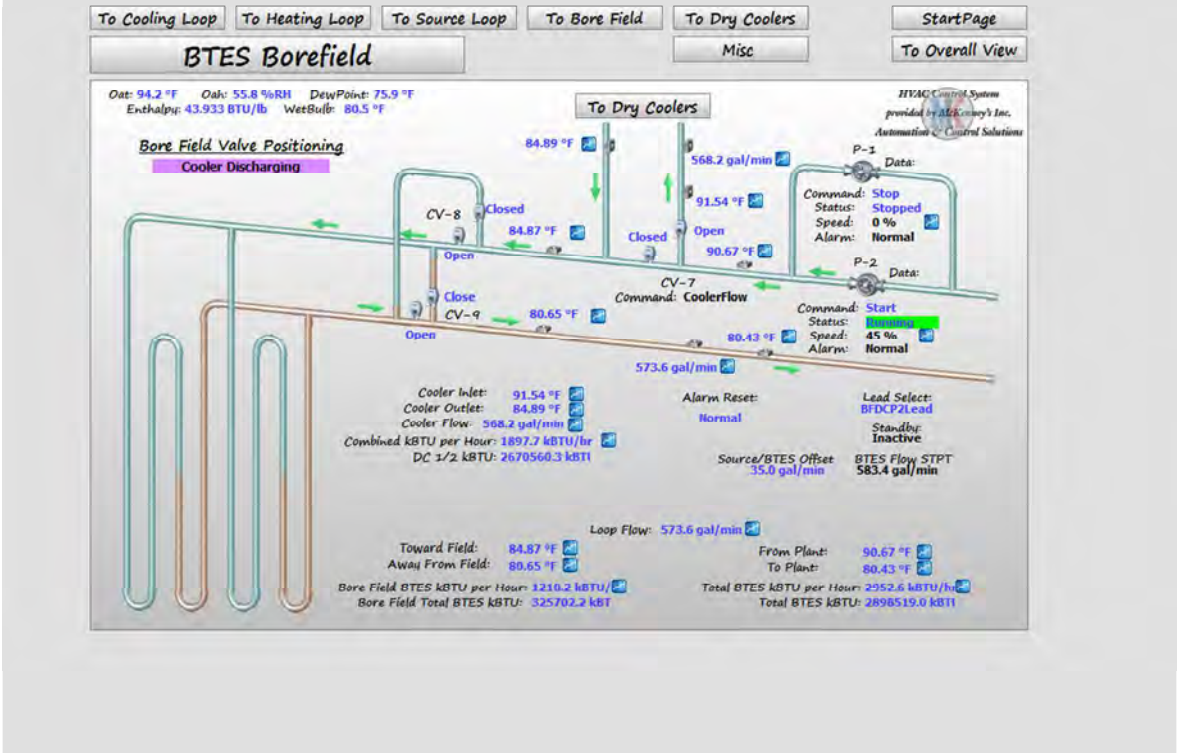

AHU3A
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 75.3 °F
OA Temperature: 103.4 °F
MA Temperature: 79.9 °F
SA Temperature 54.8 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 60.3 %
Fan Command: Run
Fan Status: Running
VFD %: 66.6 %
Static Pressure: 1.24 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System provided by McKinney's Inc. Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Deadband
0.0
70.0
2.0
Δ°F [0.0 - 327.7]
Save
To Offnormal Times Alarm Time 23-Jul-15 5:57 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:57 PM EDT
To Offnormal Times Count 26
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 52mins 42.409secs

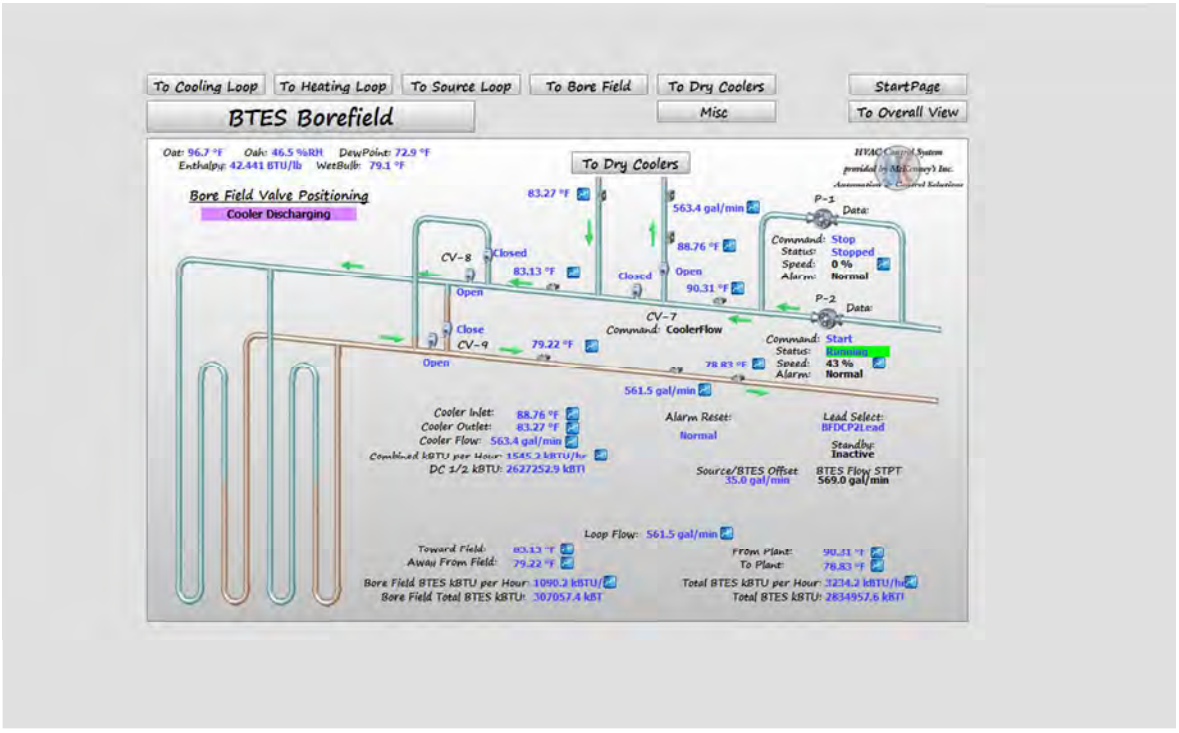

AHU3B
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 30
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 75.0 °F
OA Temperature: 103.4 °F
MA Temperature: 81.4 °F
SA Temperature 54.2 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 51.4 %
Fan Command: Run
Fan Status: Running
VFD %: 64.6 %
Static Pressure: 1.24 in/wc
Static Pressure Setpoint: 1.25 in/wc
HVAC Control System provided by McKinney's Inc. Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Deadband
0.0
70.0
2.0
Δ°F [0.0 - 327.7]
Save
To Offnormal Times Alarm Time 23-Jul-15 5:56 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:58 PM EDT
To Offnormal Times Count 24
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 6days 19hours 53mins 6.430secs

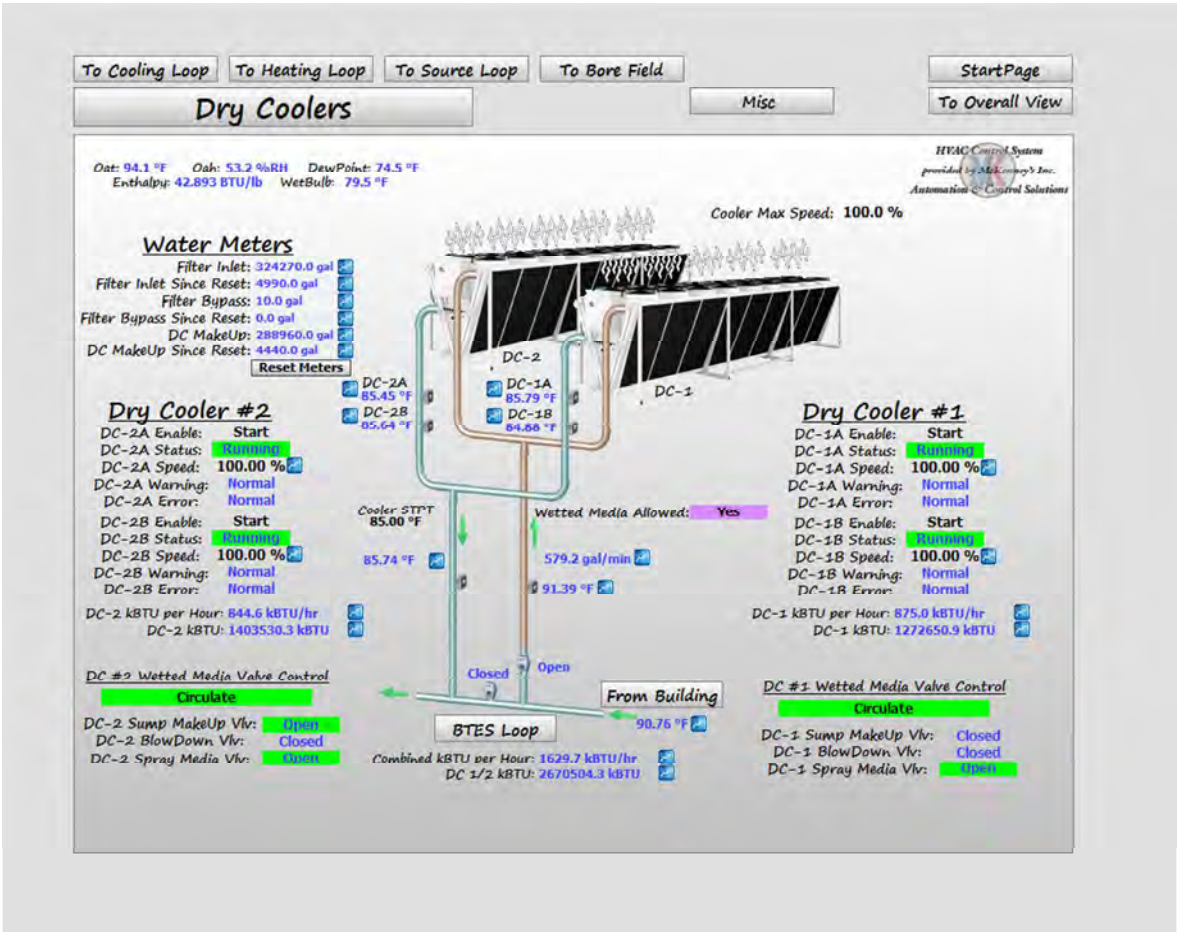

AHU3A
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 31
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 75.4 °F
OA Temperature: 104.6 °F
MA Temperature: 80.1 °F
SA Temperature 53.2 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 61.3 %
Fan Command: Run
Fan Status: Running
VFD %: 65.2 %
Static Pressure: 1.10 in/wc
Static Pressure Setpoint: 1.10 in/wc
HVAC Control System
provided by McKinney's Inc.
Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Low Limit 0.0 °F
High Limit 70.0 °F
Deadband 2.0 ΔF [0.0 - 327.7]
Save
To Offnormal Times Alarm Time 23-Jul-15 5:57 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:57 PM EDT
To Offnormal Times Count 26
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 7days 18hours 35mins 52.664secs

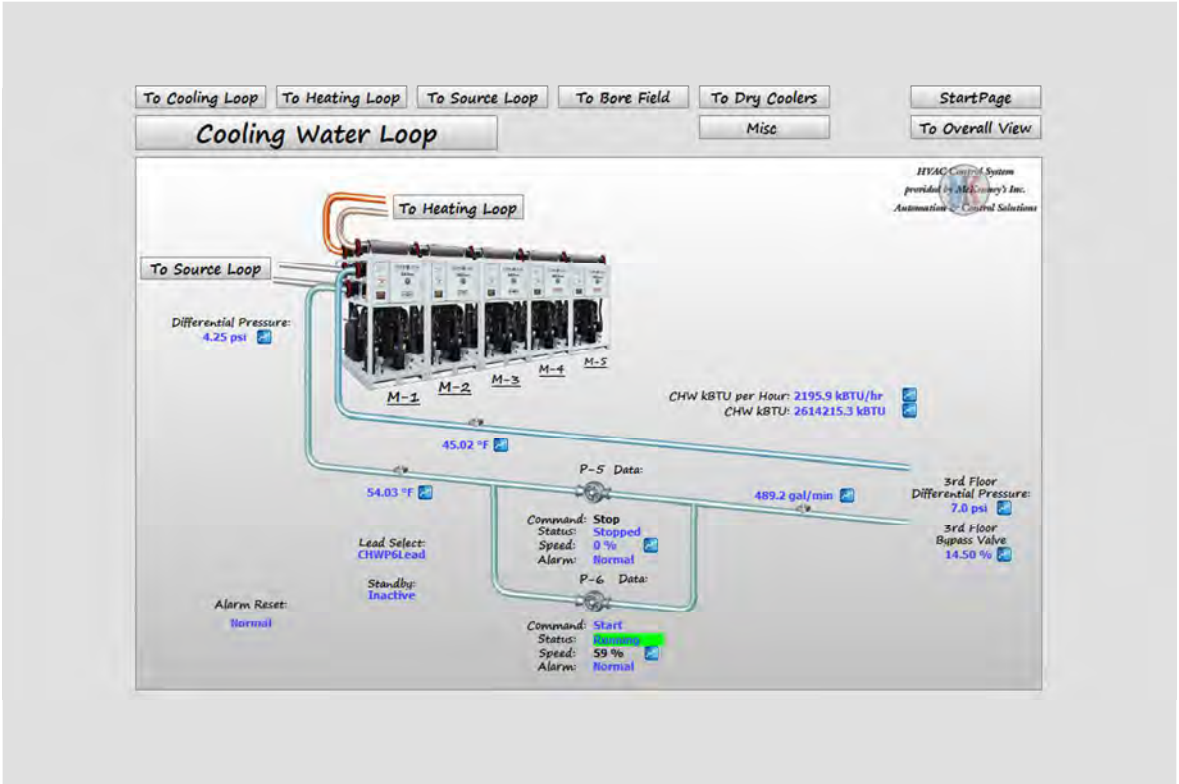

AHU3B
Home Page
1st Floor
2nd Floor
3rd Floor
Schedule
Occupied
Jul 31
Overrides
Fan Command OVRD: Off
Damper Command OVRD: Closed
VFD Signal OVRD: nan %
CHWV Signal OVRD: nan %
RA Temperature: 75.1 °F
OA Temperature: 104.5 °F
MA Temperature: 81.4 °F
SA Temperature 53.6 °F
SA Temperature Setpt: 54.0 °F
Dampers: Opened
CHWV %: 44.0 %
Fan Command: Run
Fan Status: Running
VFD %: 60.8 %
Static Pressure: 1.02 in/wc
Static Pressure Setpoint: 1.00 in/wc
HVAC Control System
provided by McKinney's Inc.
Automation & Control Solutions
SAT Alarm
Static Alarm
Supply Air Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Low Limit 0.0 °F
High Limit 70.0 °F
Deadband 2.0 ΔF [0.0 - 327.7]
Save
To Offnormal Times Alarm Time 23-Jul-15 5:56 PM EDT
To Offnormal Times Ack Time 24-Jul-15 7:12 AM EDT
To Offnormal Times Normal Time 23-Jul-15 7:58 PM EDT
To Offnormal Times Count 24
Alarm Class AHUsAlarmClass
Alarm State Normal
Time In Current State 7days 18hours 36mins 6.658secs

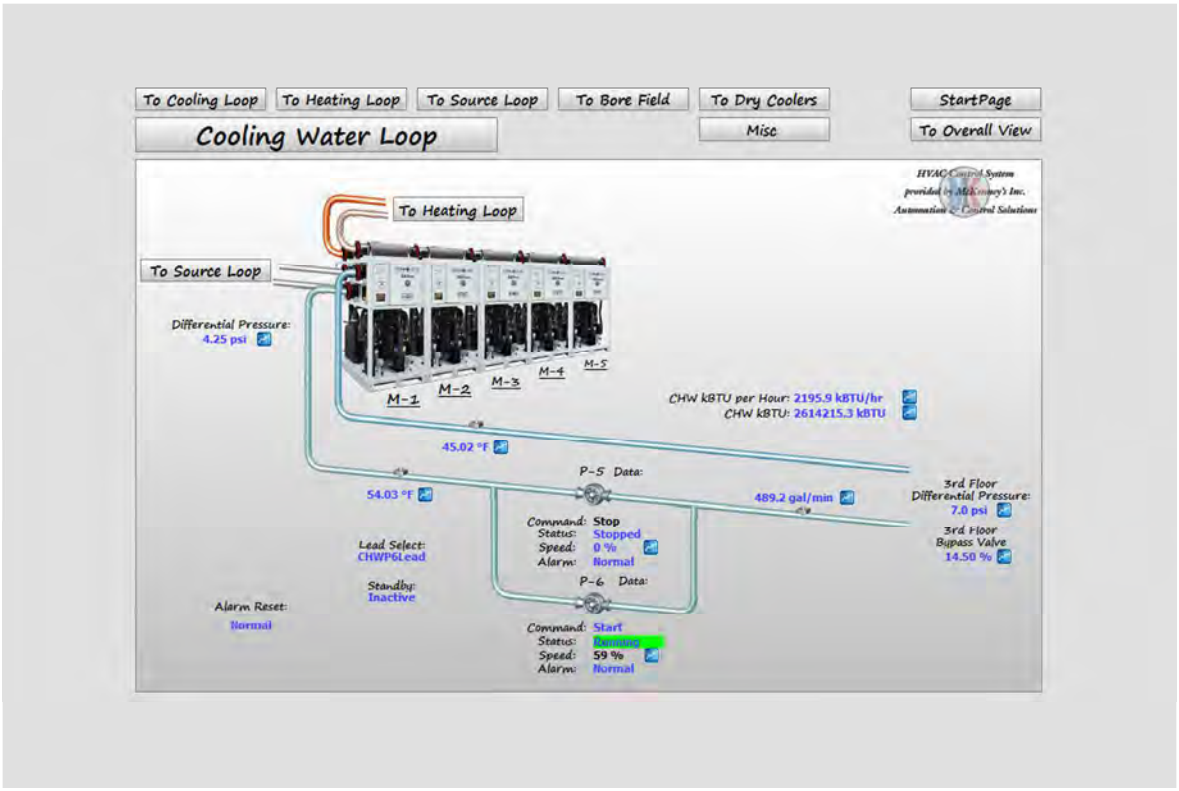

VAV128_MNLV2RV3
1st Floor
2nd Floor
3rd Floor
Occupancy Status: Occupied
Space Temperature: 72.1 °F
BAS Setpoint: 72.0 °F
Effective Setpoint: 72.5 °F
Occupied Setpoint Offset: 0.5 °F
Unoccupied Setpoint Offset: 5.0 °F
Heat Output: 0.0 %
Air Flow: 890 cfm
Air Flow Setpoint: 926 cfm
Override Time Set: 120 min
Override Time Remaining: 0.0 min
Present Mode: Deadband
Max Flow Setpoint: 2784 cfm
Min Flow Setpoint: 926 cfm
Heat Flow Setpoint: 1394 cfm
Deadband Flow Setpoint: 926 cfm
Flow Balance nciHiFlowCal: 6771 cfm
Space Temperature Alarm Settings
Limit Enable
Low Limit
High Limit
Low Limit 50.0 °F
Deadband 2.0 Δ°F [0.0 - 327.7]
Save
To Offnormal Times Alarm Time 12-Jul-15 10:44 AM EDT
To Offnormal Times Ack Time null
To Offnormal Times Count 2
Alarm Class TerminalUnitsAlarmClass
Alarm State Normal

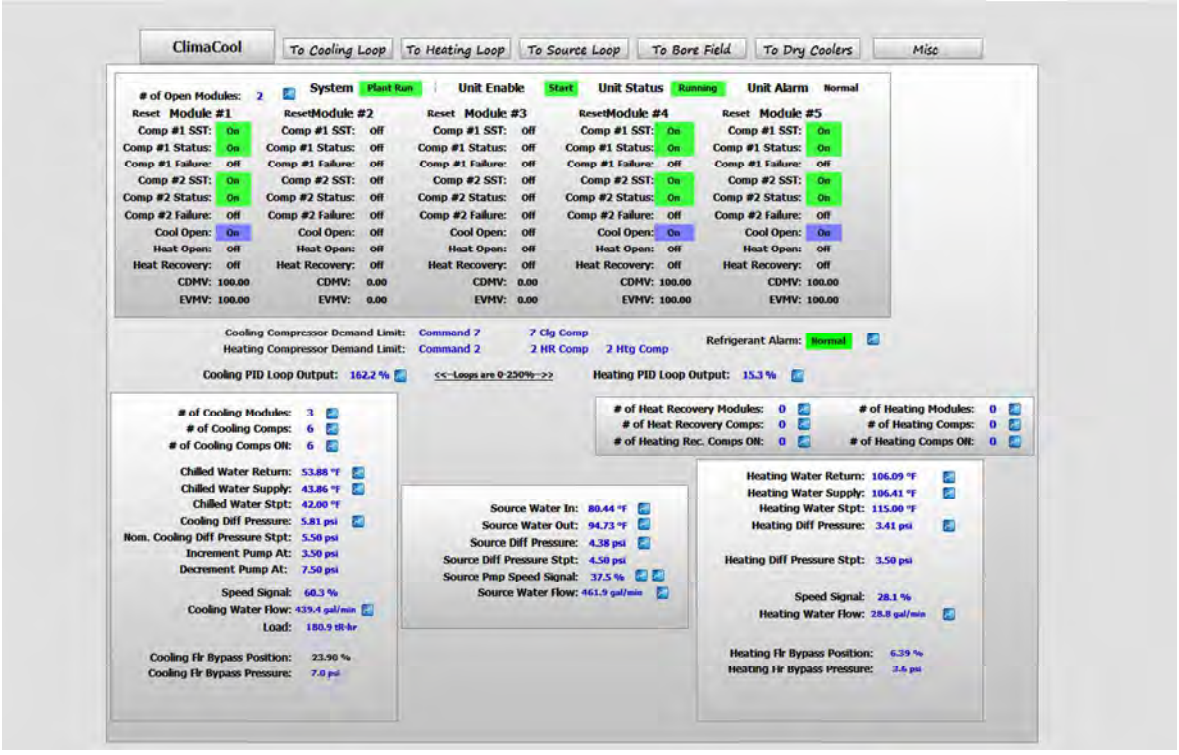

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
BTES Borefield
Misc
To Overall View
Oat: 94.2 °F Oah: 55.8 %RH DewPoint: 75.9 °F
Enthalpy: 43.933 BTU/lb WetBulb: 80.5 °F
To Dry Coolers
Bore Field Valve Positioning
Cooler Discharging
84.89 °F
568.2 gal/min
91.54 °F
P-1
Data:
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
CV-8
Closed
84.87 °F
Closed
Open
90.67 °F
P-2
Data:
Open
Close
CV-9
80.65 °F
CV-7
Command: CoolerFlow
Command: Start
Status: Running
Speed: 45 %
Alarm: Normal
Open
80.43 °F
573.6 gal/min
Cooler Inlet: 91.54 °F
Cooler Outlet: 84.89 °F
Cooler Flow: 568.2 gal/min
Combined kBTU per Hour: 1897.7 kBTU/hr
DC 1/2 kBTU: 2670560.3 kBTU
Alarm Reset:
Normal
Lead Select:
BFDCP2Lead
Standby:
Inactive
Source/BTES Offset
35.0 gal/min
BTES Flow STPT
583.4 gal/min
Loop Flow: 573.6 gal/min
Toward Field: 84.87 °F
Away From Field: 80.65 °F
From Plant: 90.67 °F
To Plant: 80.43 °F
Bore Field BTES kBTU per Hour: 1210.2 kBTU/
Bore Field Total BTES kBTU: 325702.2 kBT
Total BTES kBTU per Hour: 2952.6 kBTU/hr
Total BTES kBTU: 2898519.0 kBTU

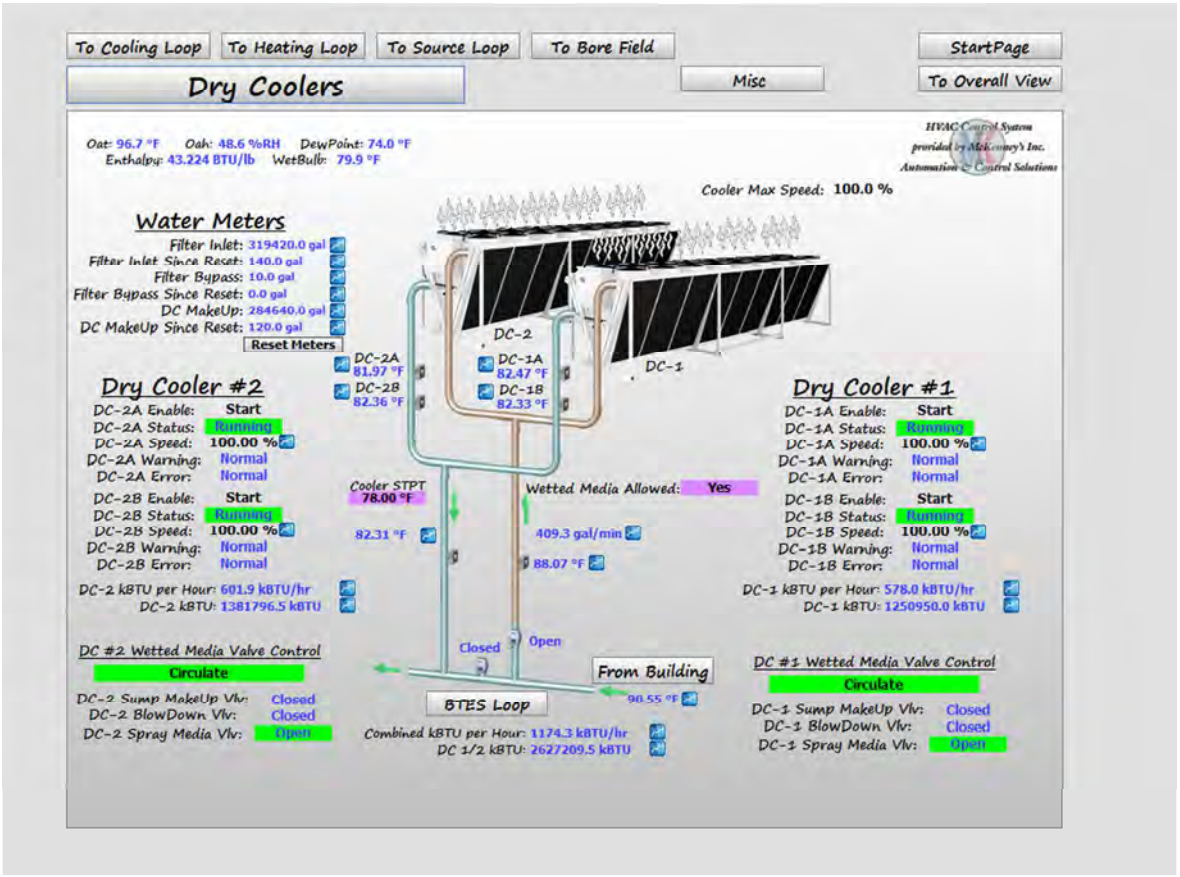

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
BTES Borefield
Misc
To Overall View
Oat: 96.7 °F Oah: 46.5 %RH DewPoint: 72.9 °F
Enthalpy: 42.441 BTU/lb WetBulb: 79.1 °F
To Dry Coolers
Bore Field Valve Positioning
Cooler Discharging
83.27 °F
563.4 gal/min
88.76 °F
P-1
Data:
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
CV-8
Closed
83.13 °F
Closed
Open
90.31 °F
P-2
Data:
Open
Close
CV-9
79.22 °F
CV-7
Command: CoolerFlow
Command: Start
Status: Running
Speed: 43 %
Alarm: Normal
Open
78.83 °F
561.5 gal/min
Cooler Inlet: 88.76 °F
Cooler Outlet: 83.27 °F
Cooler Flow: 563.4 gal/min
Combined kBTU per Hour: 1545.2 kBTU/hr
DC 1/2 kBTU: 2627252.9 kBTU
Alarm Reset:
Normal
Lead Select:
BFDCP2Lead
Standby:
Inactive
Source/BTES Offset
35.0 gal/min
BTES Flow STPT
569.0 gal/min
Loop Flow: 561.5 gal/min
Toward Field: 83.13 °F
Away From Field: 79.22 °F
From Plant: 90.31 °F
To Plant: 78.83 °F
Bore Field BTES kBTU per Hour: 1090.2 kBTU/
Bore Field Total BTES kBTU: 307057.4 kBT
Total BTES kBTU per Hour: 3234.2 kBTU/hr
Total BTES kBTU: 2834957.6 kBTU

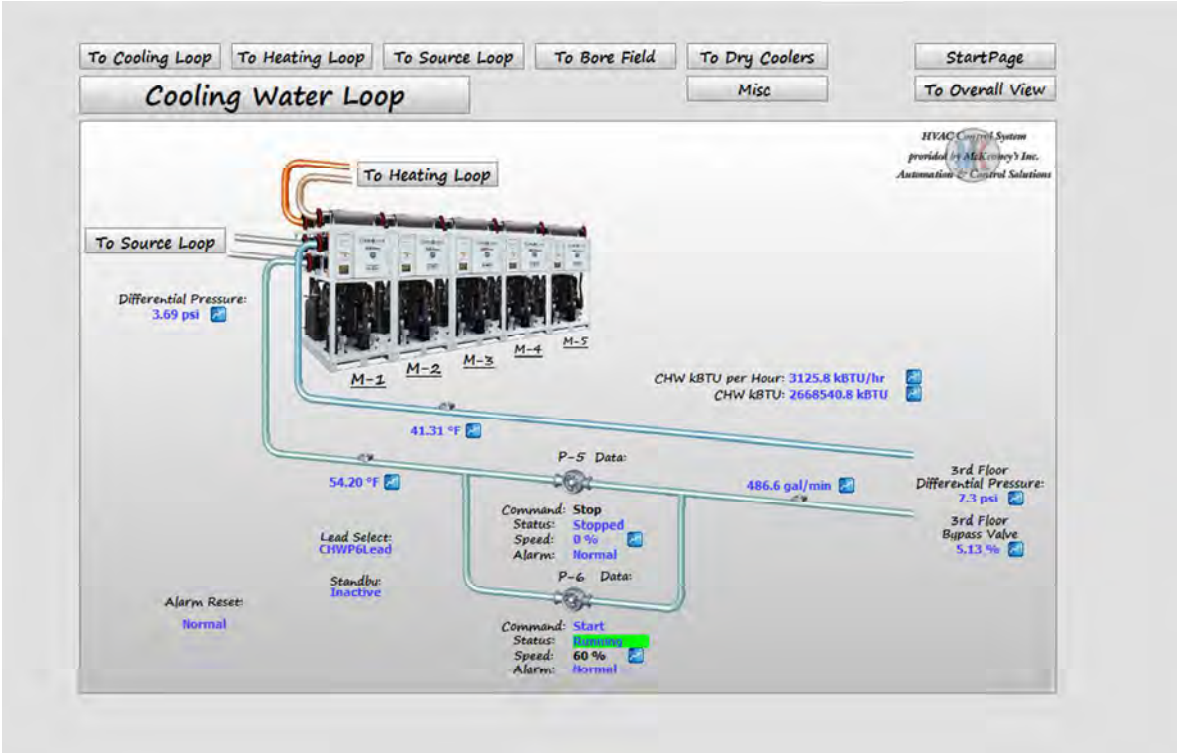

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
StartPage
Dry Coolers
Misc
To Overall View
Oat: 94.1 °F Oah: 53.2 %RH DewPoint: 74.5 °F
Enthalpy: 42.893 BTU/lb WetBulb: 79.5 °F
HVAC Control System provided by McKinney's Inc. Automation & Control Solutions
Cooler Max Speed: 100.0 %
Water Meters
Filter Inlet: 324270.0 gal
Filter Inlet Since Reset: 4990.0 gal
Filter Bypass: 10.0 gal
Filter Bypass Since Reset: 0.0 gal
DC MakeUp: 288960.0 gal
DC MakeUp Since Reset: 4440.0 gal
Reset Meters
DC-2
DC-1
DC-2A 85.45 °F
DC-2B 85.64 °F
DC-1A 85.79 °F
DC-1B 84.88 °F
Dry Cooler #2
DC-2A Enable: Start
DC-2A Status: Running
DC-2A Speed: 100.00 %
DC-2A Warning: Normal
DC-2A Error: Normal
DC-2B Enable: Start
DC-2B Status: Running
DC-2B Speed: 100.00 %
DC-2B Warning: Normal
DC-2B Error: Normal
DC-2 kBTU per Hour: 844.6 kBTU/hr
DC-2 kBTU: 1403530.3 kBTU
Dry Cooler #1
DC-1A Enable: Start
DC-1A Status: Running
DC-1A Speed: 100.00 %
DC-1A Warning: Normal
DC-1A Error: Normal
DC-1B Enable: Start
DC-1B Status: Running
DC-1B Speed: 100.00 %
DC-1B Warning: Normal
DC-1B Error: Normal
DC-1 kBTU per Hour: 875.0 kBTU/hr
DC-1 kBTU: 1272650.9 kBTU
Cooler STPT 85.00 °F
Wetted Media Allowed: Yes
85.74 °F
579.2 gal/min
91.39 °F
DC #2 Wetted Media Valve Control
Circulate
DC-2 Sump MakeUp Vlv: Open
DC-2 BlowDown Vlv: Closed
DC-2 Spray Media Vlv: Open
Closed
Open
From Building
BTES Loop
90.76 °F
Combined kBTU per Hour: 1629.7 kBTU/hr
DC 1/2 kBTU: 2670504.3 kBTU
DC #1 Wetted Media Valve Control
Circulate
DC-1 Sump MakeUp Vlv: Closed
DC-1 BlowDown Vlv: Closed
DC-1 Spray Media Vlv: Open

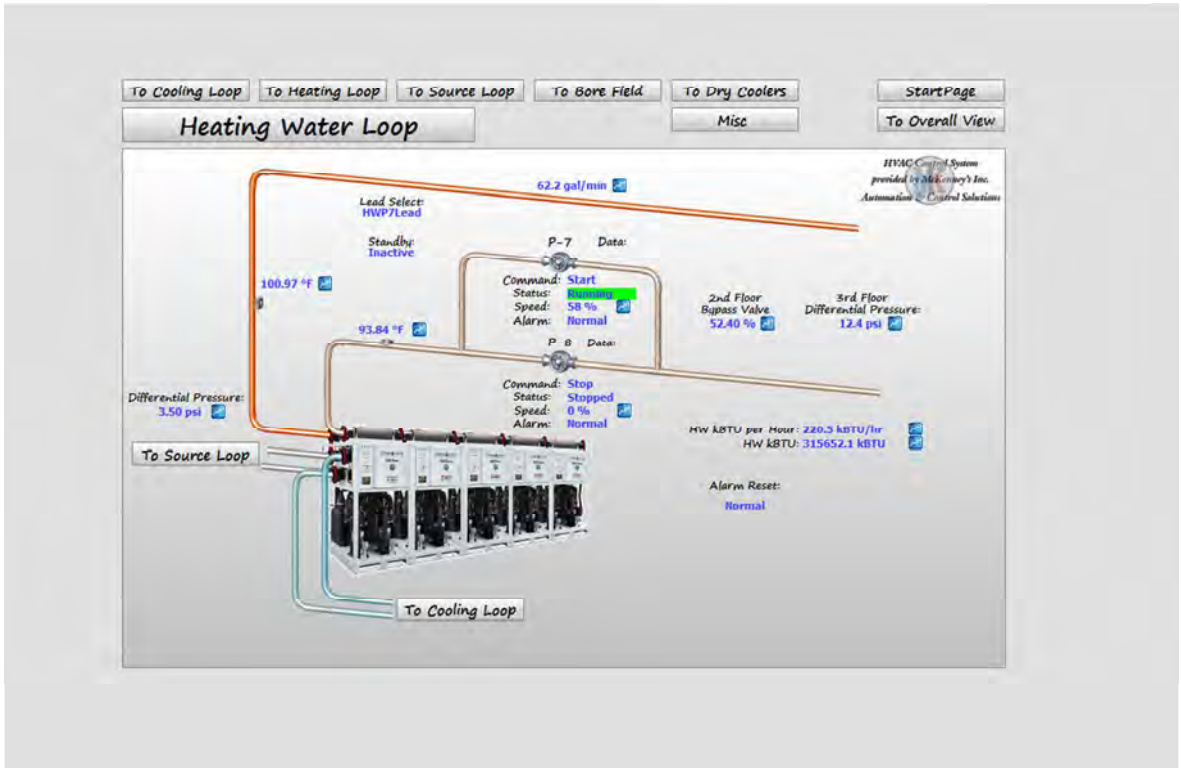

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
Cooling Water Loop
Misc
To Overall View
HVAC Control System provided by McKinney's Inc. Automation & Control Solutions
To Heating Loop
To Source Loop
Differential Pressure: 4.25 psi
M-1
M-2
M-3
M-4
M-5
CHW kBTU per Hour: 2195.9 kBTU/hr
CHW kBTU: 2614215.3 kBTU
45.02 °F
54.03 °F
P-5 Data:
489.2 gal/min
3rd Floor Differential Pressure: 7.0 psi
3rd Floor Bypass Valve 14.50 %
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
Lead Select: CHWP6Lead
Standby: Inactive
P-6 Data:
Alarm Reset: Normal
Command: Start
Status: Running
Speed: 59 %
Alarm: Normal

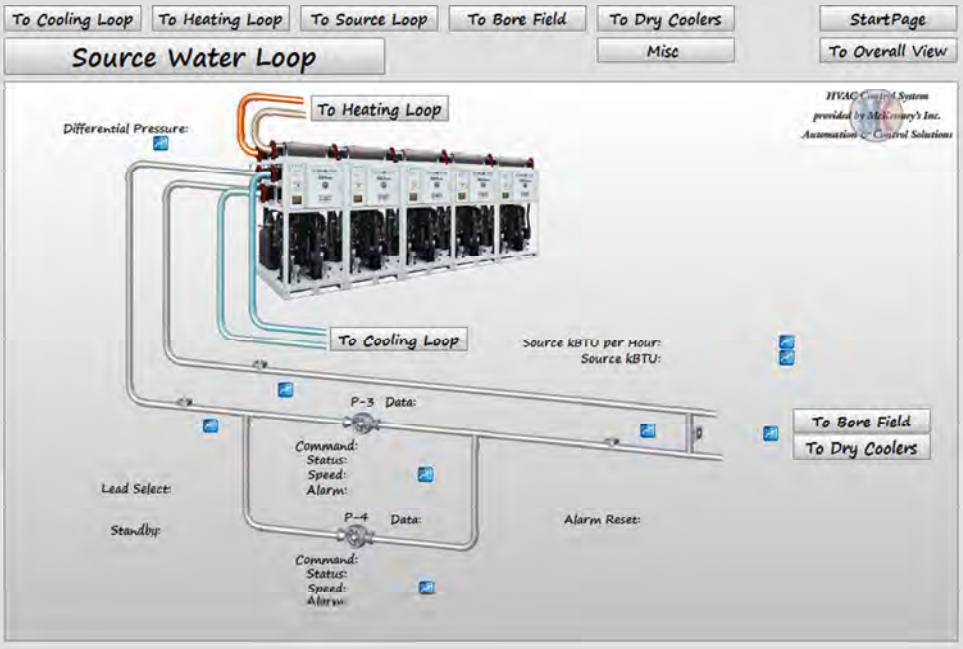

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
Misc
StartPage
To Overall View
Cooling Water Loop
HVAC Control System
provided by McKinney's Inc.
Automation & Control Solutions
To Heating Loop
To Source Loop
Differential Pressure:
4.25 psi
M-1
M-2
M-3
M-4
M-5
CHW kBTU per Hour: 2195.9 kBTU/hr
CHW kBTU: 2614215.3 kBTU
45.02 °F
54.03 °F
P-5 Data:
489.2 gal/min
3rd Floor
Differential Pressure:
7.0 psi
3rd Floor
Bypass Valve
14.50 %
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
Lead Select:
CHWP6Lead
Standby:
Inactive
P-6 Data:
Alarm Reset:
Normal
Command: Start
Status: Running
Speed: 59 %
Alarm: Normal

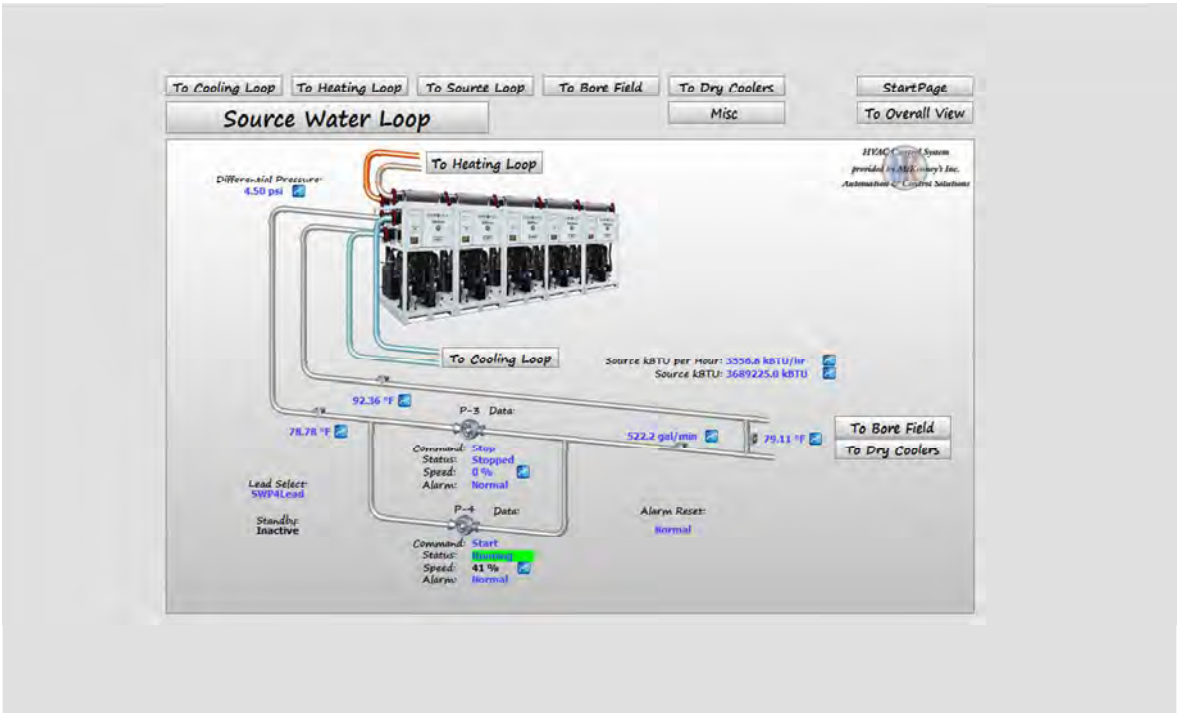

ClimaCool
To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
Misc
# of Open Modules: 2
System Plant Run
Unit Enable Start
Unit Status Running
Unit Alarm Normal
Reset Module #1
Reset Module #2
Reset Module #3
Reset Module #4
Reset Module #5
Comp #1 SST:
Comp #1 Status:
Comp #1 Failure:
Comp #2 SST:
Comp #2 Status:
Comp #2 Failure:
Cool Open:
Heat Open:
Heat Recovery:
CDMV:
EVMV:
Cooling Compressor Demand Limit: Command 7 7 Clg Comp
Heating Compressor Demand Limit: Command 2 2 HR Comp 2 Htg Comp
Refrigerant Alarm: Normal
Cooling PID Loop Output: 162.2 %
<<-Loops are 0-250%->>
Heating PID Loop Output: 15.3 %
# of Cooling Modules: 1
# of Cooling Comps: 6
# of Cooling Comps ON: 6
Chilled Water Return: 53.88 °F
Chilled Water Supply: 43.86 °F
Chilled Water Stpt: 42.00 °F
Cooling Diff Pressure: 5.81 psi
Nom. Cooling Diff Pressure Stpt: 5.50 psi
Increment Pump At: 3.50 psi
Decrement Pump At: 7.50 psi
Speed Signal: 60.3 %
Cooling Water Flow: 439.4 gal/min
Load: 180.9 tlt-hr
Cooling Flr Bypass Position: 23.90 %
Cooling Flr Bypass Pressure: 7.0 psi
# of Heat Recovery Modules: 0
# of Heat Recovery Comps: 0
# of Heating Rec. Comps ON: 0
# of Heating Modules: 0
# of Heating Comps: 0
# of Heating Comps ON: 0
Source Water In: 80.44 °F
Source Water Out: 94.73 °F
Source Diff Pressure: 4.38 psi
Source Diff Pressure Stpt: 4.50 psi
Source Pmp Speed Signal: 37.5 %
Source Water Flow: 461.9 gal/min
Heating Water Return: 106.09 °F
Heating Water Supply: 106.41 °F
Heating Water Stpt: 115.00 °F
Heating Diff Pressure: 3.41 psi
Heating Diff Pressure Stpt: 3.50 psi
Speed Signal: 28.1 %
Heating Water Flow: 28.8 gal/min
Heating Flr Bypass Position: 6.39 %
Heating Flr Bypass Pressure: 3.6 psi

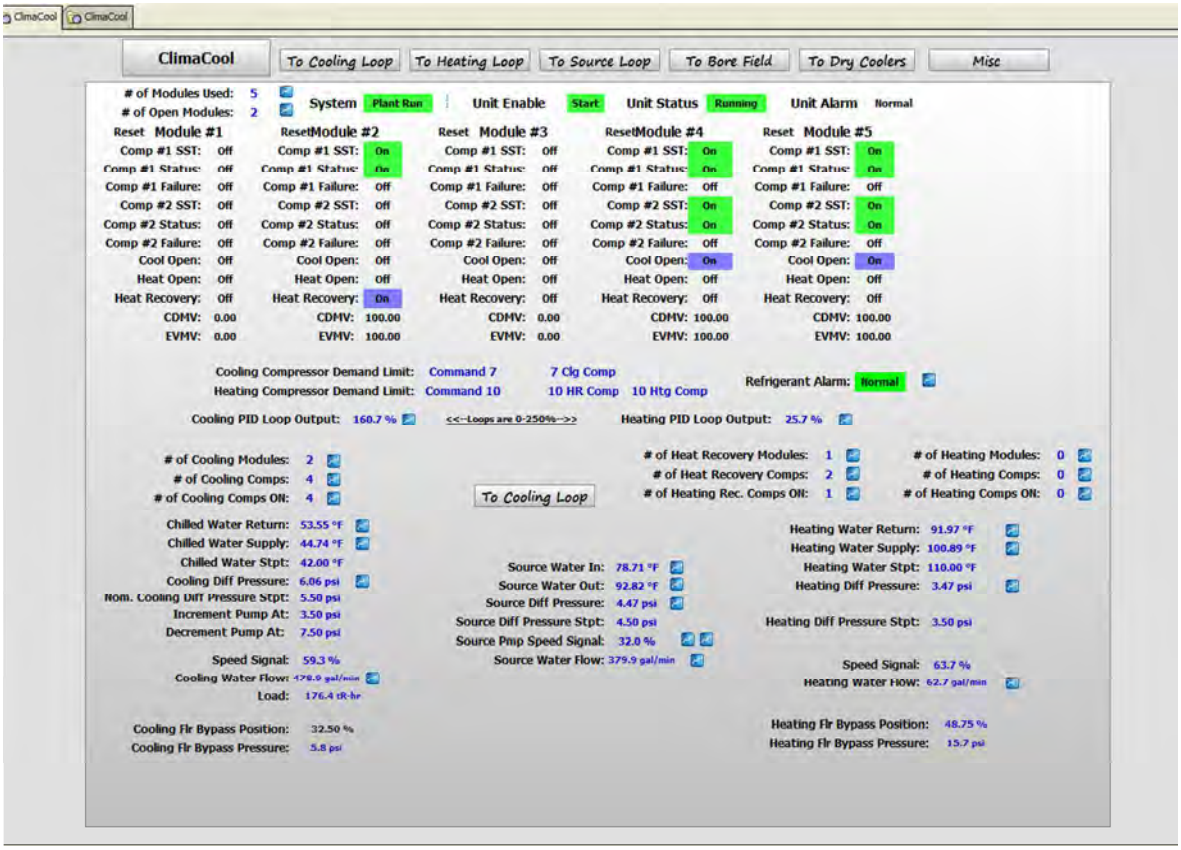

To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
StartPage
Dry Coolers
Misc
To Overall View
HVAC Control System provided by McKenney's Inc. Automation & Control Solutions
Oat: 96.7 °F Oah: 48.6 %RH DewPoint: 74.0 °F
Enthalpy: 43.224 BTU/lb WetBulb: 79.9 °F
Cooler Max Speed: 100.0 %
Water Meters
Filter Inlet: 319420.0 gal
Filter Inlet Since Reset: 140.0 gal
Filter Bypass: 10.0 gal
Filter Bypass Since Reset: 0.0 gal
DC MakeUp: 284640.0 gal
DC MakeUp Since Reset: 120.0 gal
Reset Meters
DC-2
DC-1
DC-2A 81.97 °F
DC-2B 82.36 °F
DC-1A 82.47 °F
DC-1B 82.33 °F
Dry Cooler #2
DC-2A Enable: Start
DC-2A Status: Running
DC-2A Speed: 100.00 %
DC-2A Warning: Normal
DC-2A Error: Normal
DC-2B Enable: Start
DC-2B Status: Running
DC-2B Speed: 100.00 %
DC-2B Warning: Normal
DC-2B Error: Normal
DC-2 kBTU per Hour: 601.9 kBTU/hr
DC-2 kBTU: 1381796.5 kBTU
Cooler STPT 78.00 °F
82.31 °F
Wetted Media Allowed: Yes
409.3 gal/min
88.07 °F
Dry Cooler #1
DC-1A Enable: Start
DC-1A Status: Running
DC-1A Speed: 100.00 %
DC-1A Warning: Normal
DC-1A Error: Normal
DC-1B Enable: Start
DC-1B Status: Running
DC-1B Speed: 100.00 %
DC-1B Warning: Normal
DC-1B Error: Normal
DC-1 kBTU per Hour: 578.0 kBTU/hr
DC-1 kBTU: 1250950.0 kBTU
DC #2 Wetted Media Valve Control
Circulate
DC-2 Sump MakeUp Vlv: Closed
DC-2 BlowDown Vlv: Closed
DC-2 Spray Media Vlv: Open
Closed
Open
From Building
90.55 °F
BTES Loop
Combined kBTU per Hour: 1174.3 kBTU/hr
DC 1/2 kBTU: 2627209.5 kBTU
DC #1 Wetted Media Valve Control
Circulate
DC-1 Sump MakeUp Vlv: Closed
DC-1 BlowDown Vlv: Closed
DC-1 Spray Media Vlv: Open


To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
Cooling Water Loop
Misc
To Overall View
HVAC Control System provided by McKenney's Inc. Automation & Control Solutions
To Heating Loop
To Source Loop
Differential Pressure: 3.69 psi
M-1
M-2
M-3
M-4
M-5
CHW kBTU per Hour: 3125.8 kBTU/hr
CHW kBTU: 2668540.8 kBTU
41.31 °F
P-5 Data:
54.20 °F
486.6 gal/min
3rd Floor Differential Pressure: 7.3 psi
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
3rd Floor Bypass Valve 5.13 %
Lead Select: CHWP6Lead
Standby: Inactive
P-6 Data:
Alarm Reset: Normal
Command: Start
Status: Running
Speed: 60 %
Alarm: Normal


To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
Misc
To Overall View
Heating Water Loop
62.2 gal/min
Lead Select:
HWP7Lead
Standby:
Inactive
P-7 Data:
Command: Start
Status: Running
Speed: 58 %
Alarm: Normal
100.97 °F
93.84 °F
2nd Floor
Bypass Valve
52.40 %
3rd Floor
Differential Pressure:
12.4 psi
P-8 Data:
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
Differential Pressure:
3.50 psi
HW kBTU per Hour: 220.3 kBTU/hr
HW kBTU: 315652.1 kBTU
To Source Loop
Alarm Reset:
Normal
To Cooling Loop


To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
StartPage
Misc
To Overall View
Source Water Loop
To Heating Loop
Differential Pressure:
To Cooling Loop
Source kBTU per Hour:
Source kBTU:
P-3 Data:
Command:
Status:
Speed:
Alarm:
To Bore Field
To Dry Coolers
Lead Select:
Standby:
P-4 Data:
Alarm Reset:
Command:
Status:
Speed:
Alarm:


To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
Misc
StartPage
To Overall View
Source Water Loop
To Heating Loop
Differential Pressure:
4.50 psi
To Cooling Loop
Source kBTU per Hour: 3556.8 kBTU/hr
Source kBTU: 3689225.0 kBTU
92.36 °F
78.78 °F
P-3 Data:
Command: Stop
Status: Stopped
Speed: 0 %
Alarm: Normal
522.2 gal/min
79.11 °F
To Bore Field
To Dry Coolers
Lead Select:
SWP4Lead
Standby:
Inactive
P-4 Data:
Alarm Reset:
Normal
Command: Start
Status: Running
Speed: 41 %
Alarm: Normal


ClimaCool
ClimaCool
To Cooling Loop
To Heating Loop
To Source Loop
To Bore Field
To Dry Coolers
Misc
# of Modules Used: 5
# of Open Modules: 2
System Plant Run
Unit Enable Start
Unit Status Running
Unit Alarm Normal
Reset Module #1
Reset Module #2
Reset Module #3
Reset Module #4
Reset Module #5
Comp #1 SST: Off / On
Comp #1 Status: Off / On
Comp #1 Failure: Off
Comp #2 SST: Off / On
Comp #2 Status: Off / On
Comp #2 Failure: Off
Cool Open: Off / On
Heat Open: Off
Heat Recovery: Off / On
CDMV: 0.00 / 100.00
EVMV: 0.00 / 100.00
Cooling Compressor Demand Limit: Command 7 7 Clg Comp
Heating Compressor Demand Limit: Command 10 10 HR Comp 10 Htg Comp
Refrigerant Alarm: Normal
Cooling PID Loop Output: 160.7 %
<<--Loops are 0-250%-->>
Heating PID Loop Output: 25.7 %
# of Cooling Modules: 2
# of Cooling Comps: 4
# of Cooling Comps ON: 4
# of Heat Recovery Modules: 1
# of Heat Recovery Comps: 2
# of Heat Recovery Comps ON: 1
# of Heating Modules: 0
# of Heating Comps: 0
# of Heating Comps ON: 0
To Cooling Loop
Chilled Water Return: 53.55 °F
Chilled Water Supply: 44.74 °F
Chilled Water Stpt: 42.00 °F
Cooling Diff Pressure: 6.06 psi
Nom. Cooling Diff Pressure Stpt: 5.50 psi
Increment Pump At: 3.50 psi
Decrement Pump At: 7.50 psi
Speed Signal: 59.3 %
Cooling Water Flow: 478.9 gal/min
Load: 176.4 tR-hr
Cooling Flr Bypass Position: 32.50 %
Cooling Flr Bypass Pressure: 5.8 psi
Source Water In: 78.71 °F
Source Water Out: 92.82 °F
Source Diff Pressure: 4.47 psi
Source Diff Pressure Stpt: 4.50 psi
Source Pmp Speed Signal: 32.8 %
Source Water Flow: 379.9 gal/min
Heating Water Return: 91.97 °F
Heating Water Supply: 100.89 °F
Heating Water Stpt: 110.00 °F
Heating Diff Pressure: 3.47 psi
Heating Diff Pressure Stpt: 3.50 psi
Speed Signal: 63.7 %
Heating Water Flow: 62.7 gal/min
Heating Flr Bypass Position: 48.75 %
Heating Flr Bypass Pressure: 15.7 psi

# Appendix D

# Start-up Reports

CLIMACOOL®
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# Startup and Warranty Registration Form (SHC onDEMAND®)

**Sign, date and E-mail to: technicalsupport@climacoolcorp.com or**
**Fax: 405.815.3052 Attn: Technical Support**

**Ambient Temp:** 79 **Page** 1 of 1

**Project Name:** NAVFAC Building 3700
**Address:** 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE
**City/State/Zip:** Albany, GA 31704
**Startup Date:** 3/27/15

**Contractor Name:** SafeAire Heating & Cooling
**Address:** 3199 Palmyra Road
**City/State/Zip:** Albany, GA 31707
**Phone No.:** 229-789-0124

## Module

**Model No.:** UCH085AFASAWBOS
**Serial No.:** C1413210188
**Chiller No.:** 1 **Bank No.:** 1

## Compressor

**Model No.:** GSD80485VAB421
**Serial No. 1:** 2786200052
**Serial No. 2:** 2786300444

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 51.6/ 47.5 | 4.1 | Δ P |
| **Condenser:** | 53.2/ 50.9 | 2.1 | Δ P |
| **Source:** | 53 / 43 | 10 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► **All wiring terminations in module panel, safeties and compressors tightened:** ☑ Yes ☐ No

► **Rotation of scroll compressor is correct:** ☑ Yes ☐ No

## Voltage / Ground

**L1** 273 **L2** 272 **L3** 274
**Low Voltage (24V):** 24.3

## Phase / Phase

**L1/L2** 471 **L2/L3** 472 **L1/L3** 473

## Compressor Circuit #1

**Amperage:** **L1** 37 **L2** 41 **L3** 38

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 140 | 103 |
| **Suction Temperature:** | | 66.4 | 50.4 |
| **Compressor Superheat:** | | 17.6 | 17.5 |
| **Discharge Pressure:** | | 394 | 277 |
| **Discharge Line Temperature (F):** | 220° max | 165 | 142 |
| **Discharge Gas Superheat (F):** | 50° min | 50 | 52 |
| **Liquid Line Temperature:** | | 96 | 74 |
| **Liquid Subcooling:** | | 20 | 16 |
| **Evaporator Entering Water Temperature:** | | 75 | 50.2 |
| **Evaporator Leaving Water Temperature:** | | 56.6 | 43.4 |
| **Condenser Entering Water Temperature:** | | 98 | 75.1 |
| **Condenser Leaving Water Temperature:** | | 113 | 88.5 |
| **Evaporator Pressure Differential:** | | 2 | 4 |
| **Condenser Pressure Differential:** | | 2 | 2 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** **L1** 38 **L2** 41 **L3** 39

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 140 | 101 |
| **Suction Temperature:** | | 62.5 | 50.5 |
| **Compressor Superheat:** | | 13.3 | 18.4 |
| **Discharge Pressure:** | | 403 | 280 |
| **Discharge Line Temperature (F):** | 220° max | 160 | 141 |
| **Discharge Gas Superheat (F):** | 50° min | 53S | 50 |
| **Liquid Line Temperature:** | | 98 | 75 |
| **Liquid Subcooling:** | | 18 | 17 |
| **Evaporator Entering Water Temperature:** | | 75 | 50.2 |
| **Evaporator Leaving Water Temperature:** | | 56.6 | 43.4 |
| **Condenser Entering Water Temperature:** | | 99 | 75.1 |
| **Condenser Leaving Water Temperature:** | | 114 | 88.5 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:** **Print Name:** Enrique Bordallo
**E-Signature:** ☑ Check Box **(Authorized Signature)**

CLIMACOOL®
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 92 Page 1 of 1

**Project Name:** NAVFAC Building 3700
**Address:** 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE
**City/State/Zip:** Albany, GA 31704
**Startup Date:** 3/27/15

**Contractor Name:** SafeAire Heating & Cooling
**Address:** 3199 Palmyra Road
**City/State/Zip:** Albany, GA 31707
**Phone No.:** 229-789-0124

## Module

**Model No.:** UCH085AFASAWBOS
**Serial No.:** C1413210189
**Chiller No.:** 2 **Bank No.:** 1

## Compressor

**Model No.:** GSD80485VAB421
**Serial No. 1:** 2786300436
**Serial No. 2:** 2786200056

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 49 / 43 | 6 | Δ P |
| **Condenser:** | 50.5/ 45.5 | 5 | Δ P |
| **Source:** | 55 / 47 | 8 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► **All wiring terminations in module panel, safeties and compressors tightened:** ☑ Yes ☐ No

► **Rotation of scroll compressor is correct:** ☑ Yes ☐ No

## Voltage / Ground

**L1** 275 **L2** 274 **L3** 275
**Low Voltage (24V):** 24.5

## Phase / Phase

**L1/L2** 475 **L2/L3** 475 **L1/L3** 477

## Compressor Circuit #1

**Amperage:** **L1** 39.3 **L2** 41.5 **L3** 39.8

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 3/4 | 3/4 |
| **Suction Pressure:** | | 137 | 104 |
| **Suction Temperature:** | | 71.6 | 51.3 |
| **Compressor Superheat:** | | 23.2 | 17.8 |
| **Discharge Pressure:** | | 399 | 290 |
| **Discharge Line Temperature (F):** | 220° max | 171 | 146 |
| **Discharge Gas Superheat (F):** | 50° min | 52 | 52 |
| **Liquid Line Temperature:** | | 95 | 80 |
| **Liquid Subcooling:** | | 21 | 14 |
| **Evaporator Entering Water Temperature:** | | 78 | 51 |
| **Evaporator Leaving Water Temperature:** | | 55.6 | 44 |
| **Condenser Entering Water Temperature:** | | 101 | 80 |
| **Condenser Leaving Water Temperature:** | | 118 | 90.6 |
| **Evaporator Pressure Differential:** | | 2 | 4 |
| **Condenser Pressure Differential:** | | 2 | 3 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** **L1** 39.8 **L2** 41.8 **L3** 40.2

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 133 | 96 |
| **Suction Temperature:** | | 72.1 | 51.5 |
| **Compressor Superheat:** | | 25.6 | 22 |
| **Discharge Pressure:** | | 418 | 298 |
| **Discharge Line Temperature (F):** | 220° max | 180 | 152 |
| **Discharge Gas Superheat (F):** | 50° min | 60 | 57 |
| **Liquid Line Temperature:** | | 99 | 80 |
| **Liquid Subcooling:** | | 20 | 16 |
| **Evaporator Entering Water Temperature:** | | 78 | 52.9 |
| **Evaporator Leaving Water Temperature:** | | 55.6 | 45.5 |
| **Condenser Entering Water Temperature:** | | 101 | 80 |
| **Condenser Leaving Water Temperature:** | | 118 | 92 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:**
**E-Signature:** ☑ Check Box **(Authorized Signature)**

**Print Name:** Enrique Bordallo

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# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 90 Page 1 of 1

**Project Name:** NAVFAC Building 3700
**Address:** 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE
**City/State/Zip:** Albany, GA 31704
**Startup Date:** 3/27/15

**Contractor Name:** SafeAire Heating & Cooling
**Address:** 3199 Palmyra Road
**City/State/Zip:** Albany, GA 31707
**Phone No.:** 229-789-0124

## Module

**Model No.:** UCH085AFASAWBOS
**Serial No.:** C1413210187
**Chiller No.:** 3 **Bank No.:** 1

## Compressor

**Model No.:** GSD80485VAB421
**Serial No. 1:** 2786300441
**Serial No. 2:** 2786300440

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 51 / 49 | 2 | Δ P |
| **Condenser:** | 53 / 43 | 10 | Δ P |
| **Source:** | 53 / 50 | 3 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► **All wiring terminations in module panel, safeties and compressors tightened:** ☑ Yes ☐ No

► **Rotation of scroll compressor is correct:** ☑ Yes ☐ No

## Voltage / Ground

**L1** 275 **L2** 273 **L3** 275
**Low Voltage (24V):** 24.5

## Phase / Phase

**L1/L2** 474 **L2/L3** 475 **L1/L3** 477

## Compressor Circuit #1

**Amperage:** L1 38 L2 40 L3 39

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 142 | 101 |
| **Suction Temperature:** | | 79.3 | 49.6 |
| **Compressor Superheat:** | | 28.9 | 16.9 |
| **Discharge Pressure:** | | 356 | 254 |
| **Discharge Line Temperature (F):** | 220° max | 166 | 138 |
| **Discharge Gas Superheat (F):** | 50° min | 54 | 54 |
| **Liquid Line Temperature:** | | 107 | 87 |
| **Liquid Subcooling:** | | 3 | 2 |
| **Evaporator Entering Water Temperature:** | | 81 | 50.5 |
| **Evaporator Leaving Water Temperature:** | | 60.3 | 44.5 |
| **Condenser Entering Water Temperature:** | | 98.3 | 80 |
| **Condenser Leaving Water Temperature:** | | 111.9 | 89.6 |
| **Evaporator Pressure Differential:** | | 3 | 4 |
| **Condenser Pressure Differential:** | | 2 | 4 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** L1 39 L2 41 L3 40

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/2 | 1/2 |
| **Suction Pressure:** | | 154 | 103 |
| **Suction Temperature:** | | 70.1 | 50 |
| **Compressor Superheat:** | | 16 | 17.2 |
| **Discharge Pressure:** | | 399 | 288 |
| **Discharge Line Temperature (F):** | 220° max | 165 | 143 |
| **Discharge Gas Superheat (F):** | 50° min | 48 | 51 |
| **Liquid Line Temperature:** | | 103 | 82 |
| **Liquid Subcooling:** | | 13 | 10 |
| **Evaporator Entering Water Temperature:** | | 81 | 50.2 |
| **Evaporator Leaving Water Temperature:** | | 60.3 | 44.5 |
| **Condenser Entering Water Temperature:** | | 98.6 | 80.3 |
| **Condenser Leaving Water Temperature:** | | 11.9 | 89.5 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:** **Print Name:** Enrique Bordallo
**E-Signature:** ☑ Check Box **(Authorized Signature)**

CLIMACOOL®
THE ULTIMATE CHILLER SOLUTION

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 87 Page 1 of 1

**Project Name:** NAVFAC Building 3700
**Address:** 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE
**City/State/Zip:** Albany, GA 31704
**Startup Date:** 3/27/15

**Contractor Name:** SafeAire Heating & Cooling
**Address:** 3199 Palmyra Road
**City/State/Zip:** Albany, GA 31707
**Phone No.:** 229-789-0124

## Module

**Model No.:** UCH085AFASAWBOS
**Serial No.:** C1413210185
**Chiller No.:** 4 **Bank No.:** 1

## Compressor

**Model No.:** GSD80485VAB421
**Serial No. 1:** 2786300449
**Serial No. 2:** 2786300447

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 69 / 60 | 9 | Δ P |
| **Condenser:** | 35.0/ 27.0 | 8 | Δ P |
| **Source:** | 32.6/ 28.5 | 4.1 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► **All wiring terminations in module panel, safeties and compressors tightened:** ☑ Yes ☐ No

► **Rotation of scroll compressor is correct:** ☑ Yes ☐ No

## Voltage / Ground

**L1** 273 **L2** 272 **L3** 274
**Low Voltage (24V):** 24.4

## Phase / Phase

**L1/L2** 472 **L2/L3** 472 **L1/L3** 476

## Compressor Circuit #1

**Amperage:** L1 39 L2 41 L3 40

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/2 | 1/2 |
| **Suction Pressure:** | | 159 | 114 |
| **Suction Temperature:** | | 77.2 | 55.8 |
| **Compressor Superheat:** | | 20.6 | 18.8 |
| **Discharge Pressure:** | | 486 | 307 |
| **Discharge Line Temperature (F):** | 220° max | 183 | 146.6 |
| **Discharge Gas Superheat (F):** | 50° min | 51 | 52 |
| **Liquid Line Temperature:** | | 115 | 84 |
| **Liquid Subcooling:** | | 17 | 12 |
| **Evaporator Entering Water Temperature:** | | 83 | 54.8 |
| **Evaporator Leaving Water Temperature:** | | 63 | 47.5 |
| **Condenser Entering Water Temperature:** | | 113 | 81 |
| **Condenser Leaving Water Temperature:** | | 131 | 91.5 |
| **Evaporator Pressure Differential:** | | 2 | 3 |
| **Condenser Pressure Differential:** | | 2 | 4 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** L1 40 L2 43 L3 41

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 158 | 107 |
| **Suction Temperature:** | | 77.2 | 54 |
| **Compressor Superheat:** | | 21.2 | 18.7 |
| **Discharge Pressure:** | | 484 | 296 |
| **Discharge Line Temperature (F):** | 220° max | 180 | 144 |
| **Discharge Gas Superheat (F):** | 50° min | 50 | 49 |
| **Liquid Line Temperature:** | | 112 | 83 |
| **Liquid Subcooling:** | | 20 | 13 |
| **Evaporator Entering Water Temperature:** | | 83 | 52.7 |
| **Evaporator Leaving Water Temperature:** | | 63 | 45.5 |
| **Condenser Entering Water Temperature:** | | 113 | 80.2 |
| **Condenser Leaving Water Temperature:** | | 131 | 90.3 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:** **Print Name:** Enrique Bordallo
**E-Signature:** ☑ Check Box **(Authorized Signature)**

CLIMACOOL®
THE ULTIMATE CHILLER SOLUTION®

# Startup and Warranty Registration Form (SHC onDEMAND®)

Sign, date and E-mail to: technicalsupport@climacoolcorp.com or
Fax: 405.815.3052 Attn: Technical Support

Ambient Temp: 87 Page 1 of 1

**Project Name:** 473
**Address:** 5500 WALKER AVE.MARINE CORPS LOGISITCS BASE
**City/State/Zip:** Albany, GA 31704
**Startup Date:** 3/27/15

**Contractor Name:** SafeAire Heating & Cooling
**Address:** 3199 Palmyra Road
**City/State/Zip:** Albany, GA 31707
**Phone No.:** 229-789-0124

## Module

**Model No.:** UCH085AFASAWBOS
**Serial No.:** C1413210186
**Chiller No.:** 4 **Bank No.:** 1

## Compressor

**Model No.:** GSD80485VAB421
**Serial No. 1:** 2786300446
**Serial No. 2:** 2786300447

## Bank Water Pressures Entering / Leaving

| | | | |
|---|---|---|---|
| **Evaporator:** | 46.3/ 37.5 | 8.8 | Δ P |
| **Condenser:** | 31.2/ 27.0 | 4.2 | Δ P |
| **Source:** | 53.9/ 51.3 | 2.6 | Δ P |

## Water Samples Taken (Mark "X")

| | | |
|---|---|---|
| **Evaporator:** | ☑ Yes | ☐ N/A |
| **Condenser:** | ☑ Yes | ☐ N/A |
| **Source:** | ☑ Yes | ☐ N/A |

**"Flow devices" shut off chiller below 40% of flow for Cool & Source loop and 25% for Heat loop:** ☑ Yes

**For initial MANDATORY water samples, bottles are provided.**
**Follow instructions on label and mail the same day sample is taken.**

► **All wiring terminations in module panel, safeties and compressors tightened:** ☑ Yes ☐ No

► **Rotation of scroll compressor is correct:** ☑ Yes ☐ No

## Voltage / Ground

**L1** 273 **L2** 272 **L3** 274
**Low Voltage (24V):** 24.3

## Phase / Phase

**L1/L2** 470 **L2/L3** 472 **L1/L3** 473

## Compressor Circuit #1

**Amperage:** **L1** 44.2 **L2** 45.9 **L3** 44.3

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/3 | 1/3 |
| **Suction Pressure:** | | 159 | 121 |
| **Suction Temperature:** | | 77.3 | 60.7 |
| **Compressor Superheat:** | | 21.5 | 19.9 |
| **Discharge Pressure:** | | 487 | 352 |
| **Discharge Line Temperature (F):** | 220° max | 180 | 158.5 |
| **Discharge Gas Superheat (F):** | 50° min | 58 | 51 |
| **Liquid Line Temperature:** | | 112 | 93 |
| **Liquid Subcooling:** | | 20 | 13 |
| **Evaporator Entering Water Temperature:** | | 85 | 60.7 |
| **Evaporator Leaving Water Temperature:** | | 63 | 51.9 |
| **Condenser Entering Water Temperature:** | | 115 | 80 |
| **Condenser Leaving Water Temperature:** | | 130 | 92.5 |
| **Evaporator Pressure Differential:** | | 2 | 4.0 |
| **Condenser Pressure Differential:** | | 2 | 2.5 |

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

## Compressor Circuit #2

**Amperage:** **L1** 44 **L2** 45.5 **L3** 44.2

| | | HEAT | COOL |
|---|---|---|---|
| **Sight Glass Oil Level:** | | 1/2 | 1/2 |
| **Suction Pressure:** | | 162 | 121 |
| **Suction Temperature:** | | 72.6 | 60.4 |
| **Compressor Superheat:** | | 15.5 | 19.2 |
| **Discharge Pressure:** | | 493 | 304 |
| **Discharge Line Temperature (F):** | 220° max | 177 | 144.3 |
| **Discharge Gas Superheat (F):** | 50° min | 44 | 47 |
| **Liquid Line Temperature:** | | 113 | 82 |
| **Liquid Subcooling:** | | 19 | 16 |
| **Evaporator Entering Water Temperature:** | | 85 | 60 |
| **Evaporator Leaving Water Temperature:** | | 63 | 50.9 |
| **Condenser Entering Water Temperature:** | | 115 | 80 |
| **Condenser Leaving Water Temperature:** | | 130 | 92.5 |

**Software Version:** UCH-SHC-HR.LON.06A.14

► **Verify Safety Setting Limits:**

| Low Temp: | High Pressure: | Low Pressure: |
|---|---|---|
| ☑ 32 | ☑ 575 | ☑ 92 |

**Rep Signature:** **Print Name:** Enrique Bordallo
**E-Signature:** ☑ Check Box **(Authorized Signature)**

# CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

## I.- INFORMACION GENERAL

NOMBRE DEL PROYECTO: 510594

CLIENTE: SAFE - AIRE

CIUDAD, ESTADO. PAIS: Albany GA

MODELO DE CONDENSADOR: S-GFD 090 . 48 / 289 -421 VOLTAJE: 460

FASES: 3

NUMERO DE SERIE: 300/874444 . 0001 FRECUENCIA: 60

## II.- INSTALACIÓN MECÁNICA

| MODELO | | A | B | C |
|---|---|---|---|---|
| MCH | 1 hilera | 1.5 veces el ancho | 1.5 veces el ancho | Altura de las patas |
| | 2 hileras | 1.25 veces el ancho | 1.25 veces el ancho | |
| MCV | 1 hilera | 0.8 veces la altura | 0.5 veces la longitud | 0.5 veces la long. |
| | 2 hileras | 0.5 veces la altura | | |
| MCD | | 0.5 veces la long. | 0.5 veces la long. | 20 in |
| MFH | 1 hilera | 1.5 veces el ancho | 1.5 veces el ancho | Altura de las patas |
| | 2 hileras | 1.25 veces el ancho | 1.25 veces el ancho | |
| MFV | 1 hilera | 0.8 veces la altura | 0.5 veces la longitud | 0.5 veces la long. |
| | 2 hileras | 0.5 veces la altura | | |
| MFD | | 0.5 veces la long. | 0.5 veces la long. | 20 in. |

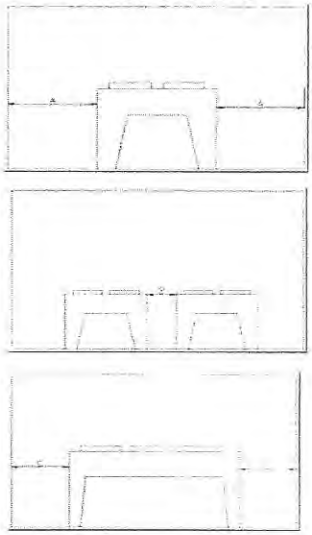
Indique las dimensiones:

A = _____ m

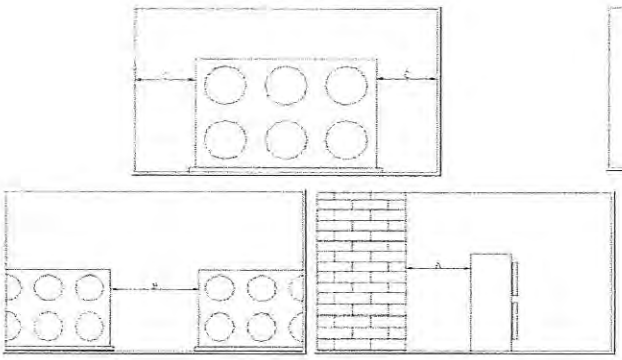
B = 15 ft

C = _____ m

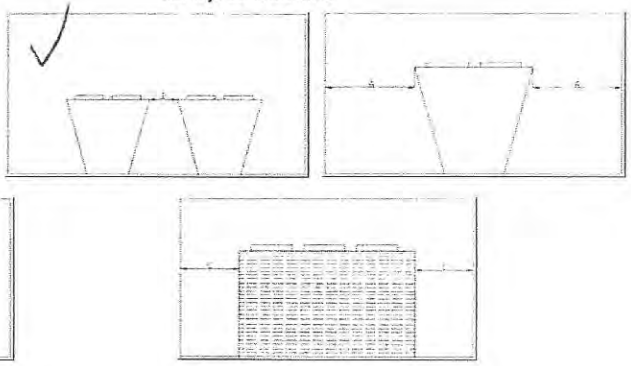
**Montaje de MCH/MFH**

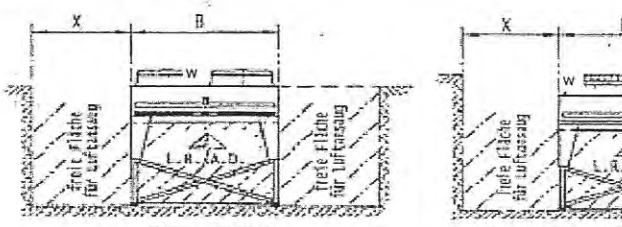


**Montaje de MCV/MFV**

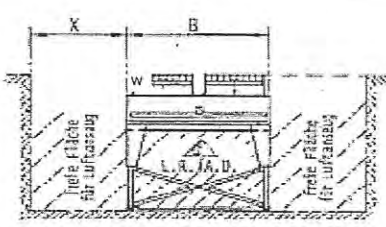


**Montaje de MCD/MFD**

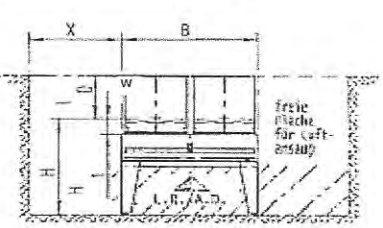





Sin accesorios




Con Streamer




Con ducto

## CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

### II.- INSTALACIÓN MECÁNICA (Continuación)

a) ¿Hay daños de embarque? (Si o No) Si
Si hay daño describalo e indique donde: ver fotos, pata soporte en unidad costado derecho
Este daño, impide el arranque de la unidad? (Si o No) NO
b) ¿El condensador firmemente soportado? (Si o No) Si
c) ¿El condensador tiene instalado dampers? (Si o No) NO
d) ¿El condensador está nivelado? (Si o No) Si
e) ¿Hay tornillos o tuercas flojos? (Si o No) Si Ventilador ( ) Soporte ( ) Placa vent.( ) Block ( ) soporte de Rodo
f) Accesos para sevicio de mtto y/o reemplazo:

| | |
|---|---|
| Ventiladores | (Bien, Mal, NA) B |
| Serpentín (para limpieza) | (Bien, Mal, NA) B |
| Caja de conexiones eléctricas | (Bien, Mal, NA) B |
| Tablero de control | (Bien, Mal, NA) B |
| Interruptores de reparación | (Bien, Mal, NA) B NA |

g) Comentarios sobre la instalación mécánica:
Se dejaron algunas de las tablas de transporte en las placas de ventilador

### III.- INSTALACIÓN ELÉCTRICA

| | |
|---|---|
| a) Verificar suministro eléctrico de acuerdo a unidad | Voltaje 478 |
| b) Verificar conexión a tierra | (Si o No) Si |
| c) Verificar capacidad del circuito de protección | Amperes 43.5 46.5 |
| d) Verificar calibre de cables de alimentación principal | Calibre o MCM 2/0 |
| e) Verificar tubería conduit no tenga filos en contacto con cables | (Si o No) No |
| f) Verificar conectores glandula apretadas | (Si o No) Si |
| g) Verificar terminales apretadas en caja de conexiones | (Si o No) Si |
| h) Modelo de ventiladores instalados | VT030630 |
| i) Cantidad de ventiladores instalados | 18 |
| h) Verificar conexión de ventiladores de acuerdo a su voltaje | Voltaje L Conexión ( Y, ▲) Motor EC |
| i) Verificar conexión de proteccion térmica de cada ventilador TK's | (Si o No) NA |
| j) Verificar conexión de interruptor de servicio | (Si o No) Si |
| k) Verificar terminales apretadas en tablero eléctrico | (Si o No) Si |

l) Comentarios sobre la instalación eléctrica:
Se agregaron relevadores al tablero para señales remotas de encendido

### IV.- INSTALACIÓN DE REFRIGERACIÓN PARA CONDENSADOR

a) Verificar tubería de descarga Diametro _____ Cobre o Acero? _____
Tiene trampa aire (Si o No) _____ Tiene valvula de purga de aire (Si o No) _____
b) Verificar tubería de condensado Diametro _____ Cobre o Acero? _____
Tiene sifon (Si o No) _____
c) Tiene serpentín subenfriador (Si o No) _____
d) Tiene sifon entre condensador y subenfriador (Si o No) _____
e) Tiene el recibidor entre condensador y subenfriador (Si o No) _____
f) ¿Se hizo la prueba de fuga en el condensador? (Si o No) _____
g) En la prueba de fugas se utilizó: detector de fugas ( ) Mechas de azufre ( ) Agua jabonosa ( ) Otro _____ ( )
h) Tiene sistema de espreado para enfriamiento por agua? (Si o No) _____
i) Verificar la direccion de cada espreа (Si o No) _____ ¿Cuántas espreas estan instaladas? _____
j) Se localizaron y repararon fugas en: _____
k) Comentarios sobre la instalación de refrigeración:

## CHECKLIST DE INSTALACIÓN PARA CONDENSADOR Y AEROENFRIADOR

**V.- INSTALACIÓN HIDRÁULICA PARA AEROENFRIADORES**

a) Verificar tubería de entrada Diametro 4 1/8" Cobre o Acero? Acero
Tiene valvula de purga de liquido (Si o No) Si

b) Verificar tubería de salida Diametro 4 1/8" Cobre o Acero? Acero
Tiene valvula de linea de drenaje (Si o No) Si

c) Tiene valvula de purga de aire (Si o No) Si ¿Dónde está colocada? a la entrada del enfriador

d) Bomba: Marca — Modelo —

RPM — Potencia del motor — HP

e) Tanques ¿Cuántos tanques hay? —

Volumen del tanque — ¿Está aislado termicamente? (Si o No) —

¿Es tanque abierto? (Si o No) — ¿Es tanque cerrado a presión? (Si o No) —

f) Tiene sistema de espreado para enfriamiento por agua? (Si o No) ACS
g) Verificar la direccion de cada esprea (Si o No) NA ¿Cuántas espreas estan instaladas? NA

h) ¿Hay fugas en el sistema? (Si o No) No
i) Se localizaron y repararon fugas en: —

d) Hacer diagrama de flujo del proceso indicando Aeroenfriadores, tanques, bombas, carga, y puntos abiertos a la atmósfera

c) Comentarios sobre la instalación hidráulica:
La tubería esta en proceso de aislamiento

Personal de Güntner:

Nombre

Firma

Cliente:

Nombre

Firma

## CHECKLIST DE OPERACIÓN PARA CONDENSADOR Y AEROENFRIADOR

**I.- INFORMACION GENERAL**

NOMBRE DEL PROYECTO: MCLB Geothermal Heat Pump

CLIENTE: Safe Air Heating and Cooling

CIUDAD, ESTADO, PAIS: Albany GA

MODELO DE CONDENSADOR: S-GFS 090.1S/209-M21

NUMERO DE SERIE: _____

**II.- OPERACIÓN DE VENTILADORES**

a) Voltaje 470 ~ Voltios
b) Frecuencia 60 Hertz
c) Corriente _____ Amperios
d) Sentido de giro correcto (Si, No) Si
e) El ventilador vibra? (Si, No) No
f) El ventilador tiene ruido? (Si, No) No dB _____ mt
g) Hay obstrucción externa al flujo de aire? (Si, No) No
h) ¿Hay vibración en toda la unidad? (Si o No) No

i) Comentarios sobre la operación de ventiladores

**III.- OPERACIÓN DE CONDENSADOR**

a) Refrigerante Fluido
b) Evaporación P = _____ psig T = _____ ºC
c) Condensación P = _____ psig T = _____ ºC
d) Temperatura del gas entrando T = _____ ºC
e) Temperatura del liquido saliendo T = 90 ~~ºC~~ ºF
f) Temperatura ambiente a 10m de la unidad: T = _____ ºC
g) Temperatura del aire entrando a la unidad: T = _____ ºC
h) Temperatura del aire saliendo de la unidad: T = _____ ºC
i) Velocidad promedio del aire en block Vel = _____ m/s
j) ¿Está obstruido el serpentin? (Si o No) No Sarro ( ) Polvo ( ) Otros: Hay hierba en el area.
k) Tiene sistema de espreado para enfriamiento por agua? (Si o No) Si ACS
l) ¿Esta ajustado para trabajar máximo 240 horas por año? (Si o No) NA
m) ¿Usan tratamiento de agua? (Si o No) Si ¿Qué tipo de tratamiento? ver datos
n) Se tomó muestra del agua de espreado: (Si o No) No Tamaño de la muestra: — ml

o) Comentarios sobre la operación de condensadores
Se elimino el control ACS y se deja lo se opera control desde su tablero principal.

**Notas Adicionales:**

## CHECKLIST DE OPERACIÓN PARA CONDENSADOR Y AEROENFRIADOR

**IV.- OPERACIÓN DE AEROENFRIADOR**

a) Fluido: Agua ( ) Etilenglicol ( ) Propilenglicol ( ) Otro: _____
b) Concentración _____%
c) Temperatura fluido entrando Tent = _____ ºC
d) Temperatura fluido saliendo Tsal = _____ ºC
e) Temperatura ambiente a 10m de la unidad: T = _____ ºC
f) Temperatura del aire entrando a la unidad: T = _____ ºC
g) Temperatura del aire saliendo de la unidad: T = _____ ºC
h) Presión fluido entrando Pent = _____ psig
i) Presión fluido saliendo Psal = _____ psig
j) Se tomó muestra del fluido: (Si o No) _____ Tamaño de la muestra: _____ml
k) Se midió flujo en tubería entrada: (Si o No) _____ Flujo medido _____ LPH
l) Se midió flujo en tubería salida: (Si o No) _____ Flujo medido _____ LPH
m) Tiene sistema de espreado para enfriamiento por agua? (Si o No) _____
n) ¿Esta ajustado para trabajar máximo 240 horas por año? (Si o No) _____
o) ¿Usan tratamiento de agua? (Si o No) _____ ¿Qué tipo de tratamiento? _____
p) Se tomó muestra del agua de espreado: (Si o No) _____ Tamaño de la muestra: _____ml
q) Comentarios sobre la operación de aeroenfriadores

_____
_____
_____

**Notas Adicionales:**

Personal de Güntner:

Nombre Juan Carlos Izquierdo R.

Cliente:

Nombre Ray Olson

McKenney's
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#1**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-101 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1880 | 625 | 940 | 16 | 3500 | na | 5-Oct |
| VAV-102 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2045 | 685 | 1055 | 16 | 3500 | na | 4-Oct |
| VAV-103 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1880 | 625 | 940 | 16 | 3500 | na | 11-Oct |
| VAV-104 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2225 | 745 | 1105 | 16 | 3500 | na | 11-Oct |
| VAV-105 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 680 | 230 | 320 | 10 | 1400 | na | 11-Oct |
| VAV-106 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1130 | 377 | 560 | 14 | 2750 | na | 4-Oct |
| VAV-107 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1100 | 335 | 425 | 12 | 1900 | na | 4-Oct |
| VAV-108 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | na |
| VAV-109 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2420 | 810 | 1210 | 16 | 3500 | na | 4-Oct |
| VAV-110 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1280 | 427 | 800 | 14 | 2750 | na | 4-Oct |
| VAV-111 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 655 | 218 | 330 | 10 | 1400 | na | 11-Oct |
| VAV-112 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 720 | 240 | 360 | 10 | 1400 | na | 11-Oct |
| VAV-113 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 720 | 240 | 360 | 10 | 1400 | na | 12-Oct |
| VAV-114 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 555 | 185 | 280 | 8 | 820 | na | 12-Oct |
| VAV-115 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 200 | 67 | 100 | 6 | 385 | na | 12-Oct |
| VAV-116 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 800 | 267 | 390 | 12 | 1900 | na | 25-Oct |
| VAV-117 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2820 | 940 | 1410 | 19 | 8300 | na | 25-Oct |
| VAV-118 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | na |
| VAV-119 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 300 | 10 | 1400 | na | 5-Oct |
| VAV-120 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 405 | 135 | 205 | 8 | 820 | na | 5-Oct |
| VAV-121 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2560 | 853 | 1280 | 16 | 3500 | na | 13-Oct |
| VAV-122 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1100 | 367 | 525 | 14 | 2750 | na | 13-Oct |
| VAV-123 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 750 | 250 | 320 | 12 | 1900 | na | 18-Oct |
| VAV-124 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 165 | 230 | 10 | 1400 | na | 18-Oct |
| VAV-125 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 825 | 335 | 415 | 12 | 1900 | na | 13-Oct |
| VAV-126 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1430 | 477 | 715 | 14 | 2750 | na | 19-Oct |

McKenney's Inc.
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#1**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-127 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1020 | 340 | 510 | 12 | 1900 | na | 25-Oct |
| VAV-128 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2785 | 928 | 1395 | 19 | 8300 | na | 25-Oct |
| VAV-129 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 940 | 315 | 470 | 12 | 1900 | na | 19-Oct |
| VAV-130 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 680 | 230 | 340 | 10 | 1400 | na | 18-Oct |
| VAV-131 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 880 | 293 | 440 | 12 | 1900 | na | 18-Oct |
| VAV-132 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2850 | 950 | 1425 | 19 | 8300 | na | 19-Oct |
| VAV-133 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 615 | 205 | 310 | 10 | 1400 | na | 18-Oct |
| VAV-134 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 615 | 205 | 310 | 10 | 1400 | na | 25-Oct |

Checked by: **Justin Boggs/Ken Alexander** Date: **10/19/2014**

HVAC Control System
provided by McKenney's Inc.
Automation & Control Solutions

Note #1: VAV-111 had no flow when HWV actuator was virified open. Safe Aire cleared clogged pipe but still low flow to coil.
Note #2: VAV-105 has no flow when HWV actuator was verified open. Safe Aire has not corrected.
Note #3: VAV-121 has low flow when HWV actuator was verified open. Safe Aire has not corrected. Set Heat CFM to match minimum
Note #4: Found multiple splices/t-taps above ceiling. Far exceeds free topology wiring limits.
Note #5: VAV-104 has no flow when HWV actuator was verified open. Safe Aire has not corrected. Set Heat CFM to match minmum.

McKenney's
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#2**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-201 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1315 | 438 | 660 | 14 | 2750 | na | 11-Jan |
| VAV-202 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1000 | 333 | 500 | 12 | 1900 | na | 15-Nov |
| VAV-203 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1600 | 533 | 800 | 16 | 3500 | na | 9-Nov |
| VAV-204 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 15-Nov |
| VAV-205 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1250 | 417 | 625 | 14 | 2750 | na | 15-Nov |
| VAV-206 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 15-Nov |
| VAV-207 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 15-Nov |
| VAV-208 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 15-Nov |
| VAV-209 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 10-Jan |
| VAV-210 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2080 | 693 | 1040 | 16 | 3500 | na | 10-Jan |
| VAV-211 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 690 | 230 | 345 | 10 | 1400 | na | 10-Jan |
| VAV-212 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 825 | 275 | 415 | 12 | 1900 | na | 15-Nov |
| VAV-213 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 285 | 10 | 1400 | na | 10-Jan |
| VAV-214 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1420 | 475 | 710 | 14 | 2750 | na | 8-Nov |
| VAV-215 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 800 | 335 | 375 | 12 | 1900 | na | 9-Nov |
| VAV-216 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1110 | 370 | 555 | 12 | 1900 | na | 9-Nov |
| VAV-217 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 640 | 215 | 320 | 10 | 1400 | na | 9-Nov |
| VAV-218 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | |
| VAV-219 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | |
| VAV-220 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 900 | 300 | 450 | 12 | 1900 | na | 11-Jan |
| VAV-221 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1110 | 370 | 555 | 12 | 1900 | na | 1-Nov |
| VAV-222 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 690 | 230 | 345 | 10 | 1400 | na | 1-Nov |
| VAV-223 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 860 | 287 | 430 | 12 | 1900 | na | 2-Nov |
| VAV-224 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 285 | 10 | 1400 | na | 2-Nov |
| VAV-225 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2250 | 750 | 1125 | 16 | 3500 | na | 8-Nov |
| VAV-226 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1710 | 570 | 855 | 16 | 3500 | na | 8-Nov |
| VAV-227 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 8-Nov |

McKenney's
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#2**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-228 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 2-Nov |
| VAV-229 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 290 | 10 | 1400 | na | 26-Oct |
| VAV-230 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 26-Oct |
| VAV-231 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 870 | 290 | 435 | 12 | 1900 | na | 26-Oct |
| VAV-232 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1720 | 575 | 860 | 14 | 2750 | na | 1-Nov |
| VAV-233 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2250 | 750 | 1125 | 16 | 3500 | na | 1-Nov |
| VAV-234 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1800 | 600 | 900 | 16 | 3500 | na | 2-Nov |

Checked by: **Justin Boggs/Ken Alexander** Date: **1/10/2015**

HVAC Control System provided by McKenney's Inc. Automation & Control Solutions

Note #1: Found that Nueron ID for VAV-229 was physically installed on VAV-230. Corrected by swapping Neurons in database.

Note #2: VAV-224 has clogged pipe and will not heat. SAT @ 59.3 DegF with control valve full open. Heat CFM matches cool min.

Note #3:

McKenney's inc.
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#3**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-301 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2050 | 685 | 1025 | 16 | 3500 | na | 25-Jan |
| VAV-302 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1120 | 375 | 560 | 14 | 2750 | na | 19-Jan |
| VAV-303 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1120 | 375 | 560 | 14 | 2750 | na | 18-Jan |
| VAV-304 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2050 | 685 | 1025 | 16 | 3500 | na | 18-Jan |
| VAV-305 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1140 | 380 | 720 | 14 | 2750 | na | 17-Jan |
| VAV-306 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1400 | 470 | 700 | 14 | 2750 | na | 17-Jan |
| VAV-307 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1050 | 350 | 525 | 12 | 1900 | na | 17-Jan |
| VAV-308 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 880 | 295 | 440 | 12 | 1900 | na | 18-Jan |
| VAV-309 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1260 | 420 | 630 | 14 | 2750 | na | 19-Jan |
| VAV-310 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1265 | 422 | 640 | 14 | 2750 | na | 19-Jan |
| VAV-311 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1400 | 470 | 700 | 14 | 2750 | na | 25-Jan |
| VAV-312 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 930 | 310 | 465 | 14 | 2750 | na | 18-Jan |
| VAV-313 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 300 | 10 | 1400 | na | 17-Jan |
| VAV-314 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 985 | 330 | 495 | 12 | 1900 | na | 13-Dec |
| VAV-315 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1080 | 360 | 540 | 12 | 1900 | na | 7-Dec |
| VAV-316 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 900 | 300 | 450 | 12 | 1900 | na | 13-Dec |
| VAV-317 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1100 | 360 | 730 | 14 | 2750 | na | 24-Jan |
| VAV-318 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | |
| VAV-319 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 620 | 210 | 310 | 10 | 1400 | na | 6-Dec |
| VAV-320 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | | | na | |
| VAV-321 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1105 | 370 | 555 | 12 | 1900 | na | 19-Jan |
| VAV-322 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1300 | 435 | 650 | 14 | 2750 | na | 25-Jan |
| VAV-323 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 500 | 170 | 270 | 8 | 820 | na | 24-Jan |
| VAV-324 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1330 | 445 | 665 | 14 | 2750 | na | 13-Dec |
| VAV-325 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 680 | 230 | 340 | 10 | 1400 | na | 6-Dec |
| VAV-326 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 300 | 10 | 1400 | na | 6-Dec |
| VAV-327 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 370 | 10 | 1400 | na | 6-Dec |

McKenney's Inc.
Building A Higher Standard

Job Name: **MCLB Building 3700**

Job Number: **1277-7536** Floor: **#3**

## Terminal Unit Checkout Sheet

| | Control Function | | | | | | Raise Setpoint | | | | | Lower Setpoint | | | | | Configuration | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | Verify Installation | Verify Zone Sensor | Verify DAT Sensor | Verify Comm | Verify Clg (heat/fan off, flow) | Verify Htg (flow, fan/heat on) | Airflow Decrease w/ AF-SP | Fan Start | Heat Stage 1 On | Heat Stage 2 On | Modulating Heat % Up | Heat Stage 1 Off | Heat Stage 2 Off | Fan Stop | Modulating Heat % Down | Airflow Increase w/ AF-SP | Clockwise/Counter Clockwise | # of Stages of Heat | Series/Parallel Fan | Modulating/Staged Heat | Max Cooling CFM | Min Cooling CFM | Heating CFM | Box Size | High Flow Calibration | Area Control Links | Date Completed |
| VAV-328 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 600 | 200 | 370 | 10 | 1400 | na | 7-Dec |
| VAV-329 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2560 | 855 | 1280 | 16 | 3500 | na | 6-Dec |
| VAV-330 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2450 | 820 | 1225 | 16 | 3500 | na | 7-Dec |
| VAV-331 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 340 | 115 | 170 | 6 | 400 | na | 14-Dec |
| VAV-332 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1150 | 285 | 575 | 12 | 1900 | na | 24-Jan |
| VAV-333 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1280 | 425 | 640 | 14 | 2750 | na | 25-Jan |
| VAV-334 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 1960 | 655 | 980 | 16 | 3500 | na | 24-Jan |
| VAV-335 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 2550 | 855 | 1275 | 16 | 3500 | na | 24-Jan |
| VAV-336 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 940 | 315 | 470 | 12 | 1900 | na | 14-Dec |
| VAV-337 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | na | na | na | Yes | na | na | na | Yes | Yes | CCW | na | na | Yes | 750 | 250 | 375 | 10 | 1400 | na | 14-Dec |

Checked by: **Justin Boggs/Ken Alexander** Date: **1/25/2015**

HVAC Control System
provided by McKenney's Inc.
Automation & Control Solutions

Note #1: VAV-337 had existing logic that had it's PB Occ enabled to start AHU-3B. Made the same logic in the retrofit programming.
Note #2: VAV-316 has low/no hot water flow. Set the maxHeatCFM setpt to match minCFM setpt. --Advised GC that this change isn't helping.
Note #3: VAV-330 has low/no hot water flow. Set the maxHeatCFM setpt to match minCFM setpt. --Advised GC that this change isn't helping.
Note #4: VAV-324 has low/no hot water flow. Set the maxHeatCFM setpt to match minCFM setpt. --Advised GC that this change isn't helping.
Note #5: VAV-331 has low/no hot water flow. Set the maxHeatCFM setpt to match minCFM setpt. --Advised GC that this change isn't helping.
Note #6: Found that the CHWV on AHU-3b was inoperable and wired incorrectly to MNL-800. Replaced Actuator and rewired in MNL-800.

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# APPENDIX J ENERGY MODELING RESULTS

MCLB - Albany,GA - B3700
Existing HVAC System

REPORT- BEPS Building Energy Performance WEATHER FILE- ALBANY DOUGHERTY GA

| | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2- ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 1102.0 | 0.0 | 3218.0 | 0.0 | 29.3 | 0.0 | 3.5 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4355.3 |
| EM1 ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 23.5 | 2957.0 | 469.1 | 1538.0 | 992.2 | 0.0 | 0.0 | 0.0 | 0.0 | 5979.9 |
| FM2- NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 545.6 | 0.0 | 545.6 |
| FM1 NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 4148.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4148.0 |
| MBTU | 1102.0 | 0.0 | 3218.0 | 4172.0 | 2987.0 | 469.1 | 1541.0 | 995.2 | 0.0 | 0.0 | 545.6 | 0.0 | 15029.0 |

TOTAL SITE ENERGY 15028.80 MBTU 89.3 KBTU/SQFT-YR GROSS-AREA 89.3 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 35699.40 MBTU 212.1 KBTU/SQFT-YR GROSS-AREA 212.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 20.91
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 1287
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 24

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

ESTCP-MCLB Albany-Bldg 3700(2012-06-12) DOE-2.2-48y 1/24/2017 13:31:43 BDL RUN 1

MCLB - Albany,GA - B3700
Existing HVAC System

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- ALBANY DOUGHERTY GA

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2- ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 103612. | 97195. | 115170. | 102748. | 111325. | 110501. | 103701. | 115237. | 102772. | 107478. | 102716. | 103650. | 1276104. |
| MAX KW | 333.6 | 333.6 | 333.8 | 333.7 | 334.1 | 334.0 | 334.0 | 333.9 | 334.0 | 333.8 | 333.8 | 333.6 | 334.1 |
| DAY/HR | 27/16 | 23/12 | 23/16 | 26/16 | 24/16 | 15/16 | 20/15 | 30/16 | 21/16 | 6/14 | 8/15 | 14/16 | 5/24 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 115983. | 107152. | 124198. | 125654. | 152753. | 181546. | 199305. | 190310. | 167646. | 152354. | 117498. | 117722. | 1752122. |
| MAX KW | 304.8 | 299.5 | 286.5 | 304.2 | 340.4 | 376.6 | 392.4 | 384.3 | 366.1 | 374.4 | 278.8 | 298.6 | 392.4 |
| DAY/HR | 6/16 | 28/16 | 27/16 | 3/16 | 16/15 | 15/16 | 21/14 | 31/14 | 1/16 | 5/16 | 24/14 | 8/16 | 7/21 |
| **FM2- NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 438. | 415. | 499. | 437. | 479. | 478. | 438. | 499. | 437. | 459. | 437. | 438. | 5456. |
| MAX THERM/HR | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| DAY/HR | 11/10 | 14/10 | 2/10 | 5/10 | 4/10 | 1/10 | 27/10 | 16/10 | 26/10 | 17/10 | 3/10 | 20/10 | 12/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 5596. | 4809. | 4505. | 2782. | 2436. | 2144. | 2319. | 2152. | 2169. | 2384. | 3683. | 6502. | 41480. |
| MAX THERM/HR | 22.1 | 18.4 | 18.1 | 14.4 | 9.1 | 8.4 | 8.2 | 8.2 | 8.1 | 12.2 | 16.7 | 19.0 | 22.1 |
| DAY/HR | 1/ 1 | 12/ 8 | 19/ 8 | 23/ 8 | 21/19 | 18/11 | 9/22 | 27/21 | 17/21 | 17/ 6 | 5/ 7 | 25/22 | 1/ 1 |

MCLB - Albany,GA - B3700
GHP HVAC System

REPORT- BEPS Building Energy Performance WEATHER FILE- ALBANY DOUGHERTY GA

| | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2- ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 1102.0 | 0.0 | 3218.0 | 0.0 | 29.2 | 0.0 | 3.5 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4355.2 |
| EM1 ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 830.2 | 3230.0 | 0.0 | 1755.0 | 979.4 | 0.0 | 0.0 | 0.0 | 0.0 | 6794.1 |
| FM2- NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 545.6 | 0.0 | 545.6 |
| FM1 NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MBTU | 1102.0 | 0.0 | 3218.0 | 830.2 | 3259.0 | 0.0 | 1758.0 | 982.4 | 0.0 | 0.0 | 545.6 | 0.0 | 11695.0 |

TOTAL SITE ENERGY 11694.90 MBTU 69.5 KBTU/SQFT-YR GROSS-AREA 69.5 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 33993.60 MBTU 202.0 KBTU/SQFT-YR GROSS-AREA 202.0 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 20.34
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 1106
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 26

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

MCLB - Albany,GA - B3700
GHP HVAC System

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- ALBANY DOUGHERTY GA

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2- ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 103610. | 97192. | 115167. | 102745. | 111322. | 110499. | 103699. | 115236. | 102770. | 107476. | 102714. | 103648. | 1276078. |
| MAX KW | 333.6 | 333.6 | 333.8 | 333.7 | 334.1 | 334.0 | 334.0 | 333.9 | 334.0 | 333.8 | 333.8 | 333.6 | 334.1 |
| DAY/HR | 27/16 | 23/12 | 23/16 | 26/16 | 24/16 | 15/16 | 20/15 | 30/16 | 21/16 | 6/14 | 8/15 | 14/16 | 5/24 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 149489. | 138207. | 152889. | 140782. | 166729. | 189159. | 206396. | 198530. | 179260. | 163140. | 141834. | 164262. | 1990676. |
| MAX KW | 311.1 | 315.8 | 306.7 | 321.3 | 355.2 | 390.6 | 399.2 | 396.6 | 388.3 | 392.0 | 317.1 | 334.8 | 399.2 |
| DAY/HR | 6/16 | 28/16 | 26/17 | 30/17 | 16/15 | 15/16 | 21/14 | 31/14 | 1/16 | 6/14 | 9/14 | 8/16 | 7/21 |
| **FM2- NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 438. | 415. | 499. | 437. | 479. | 478. | 438. | 499. | 437. | 459. | 437. | 438. | 5456. |
| MAX THERM/HR | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| DAY/HR | 11/10 | 14/10 | 2/10 | 5/10 | 4/10 | 1/10 | 27/10 | 16/10 | 26/10 | 17/10 | 3/10 | 20/10 | 12/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAX THERM/HR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DAY/HR | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

REPORT- BEPS Building Energy Performance WEATHER FILE- ALBANY DOUGHERTY GA

| | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2- ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 1102.0 | 0.0 | 3218.0 | 0.0 | 29.7 | 0.0 | 3.5 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4355.7 |
| EM1 ELECTRICITY | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 2197.0 | 5285.0 | 0.0 | 80.4 | 984.7 | 0.0 | 0.0 | 0.0 | 0.0 | 8546.9 |
| FM2- NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 545.6 | 0.0 | 545.6 |
| FM1 NATURAL-GAS | | | | | | | | | | | | | |
| MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MBTU | 1102.0 | 0.0 | 3218.0 | 2197.0 | 5315.0 | 0.0 | 83.9 | 987.7 | 0.0 | 0.0 | 545.6 | 0.0 | 13448.0 |

TOTAL SITE ENERGY 13448.20 MBTU 79.9 KBTU/SQFT-YR GROSS-AREA 79.9 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 39253.40 MBTU 233.2 KBTU/SQFT-YR GROSS-AREA 233.2 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 20.76
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 1210
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

ESTCP-MCLB Albany-Bldg 3700(2012-06-12) DOE-2.2-48y 1/27/2017 9:55:42 BDL RUN 5

MCLB - Albany,GA - B3700
ASHP HVAC System

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- ALBANY DOUGHERTY GA

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2- ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 103624. | 97205. | 115181. | 102757. | 111333. | 110509. | 103709. | 115246. | 102780. | 107487. | 102726. | 103662. | 1276218. |
| MAX KW | 333.6 | 333.6 | 333.8 | 333.7 | 334.1 | 334.0 | 334.0 | 333.9 | 334.0 | 333.9 | 333.8 | 333.6 | 334.1 |
| DAY/HR | 27/16 | 23/12 | 23/16 | 26/16 | 24/16 | 15/16 | 20/15 | 30/16 | 21/16 | 6/14 | 8/15 | 14/16 | 5/24 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 189558. | 172235. | 187259. | 167451. | 204018. | 247170. | 277353. | 257290. | 227786. | 199264. | 167008. | 207854. | 2504246. |
| MAX KW | 461.9 | 426.7 | 408.4 | 437.8 | 502.2 | 577.2 | 594.3 | 564.9 | 552.7 | 551.3 | 380.5 | 427.0 | 594.3 |
| DAY/HR | 1/ 1 | 20/14 | 26/17 | 30/17 | 16/16 | 15/16 | 21/14 | 30/17 | 13/15 | 6/14 | 11/13 | 26/ 1 | 7/21 |
| **FM2- NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 438. | 415. | 499. | 437. | 479. | 478. | 438. | 499. | 437. | 459. | 437. | 438. | 5456. |
| MAX THERM/HR | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| DAY/HR | 11/10 | 14/10 | 2/10 | 5/10 | 4/10 | 1/10 | 27/10 | 16/10 | 26/10 | 17/10 | 3/10 | 20/10 | 12/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAX THERM/HR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DAY/HR | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

Fort Benning, GA - B3215
Existing HVAC System
2-Pipe System

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/26/2017 16:03:05 BDL RUN 7

REPORT- BEPS Building Energy Performance WEATHER FILE- Columbus GA TMY2

| | | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 141.1 | 0.0 | 127.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.6 | 0.0 | 276.8 |
| EM1 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 133.8 | 17.1 | 33.5 | 253.8 | 0.0 | 0.0 | 0.0 | 0.0 | 438.2 |
| FM1 | NATURAL-GAS | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 141.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 141.7 |
| | MBTU | 141.1 | 0.0 | 127.2 | 141.7 | 133.8 | 17.1 | 33.5 | 253.8 | 0.0 | 0.0 | 8.6 | 0.0 | 856.7 |

TOTAL SITE ENERGY 856.66 MBTU 88.8 KBTU/SQFT-YR GROSS-AREA 88.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 2286.52 MBTU 237.1 KBTU/SQFT-YR GROSS-AREA 237.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

Fort Benning, GA - B3215
Existing HVAC System
2-Pipe System

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/26/2017 16:03:05 BDL RUN 7

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- Columbus GA TMY2

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 6805. | 6164. | 6815. | 7129. | 7113. | 6459. | 7087. | 7076. | 6439. | 7086. | 6130. | 6792. | 81094. |
| MAX KW | 25.6 | 25.7 | 25.7 | 25.7 | 25.6 | 25.5 | 25.5 | 25.4 | 25.4 | 25.5 | 25.5 | 25.6 | 25.7 |
| DAY/HR | 28/10 | 4/10 | 13/10 | 1/10 | 13/10 | 3/10 | 1/10 | 12/10 | 19/10 | 31/10 | 18/10 | 2/10 | 3/13 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 6489. | 5853. | 6428. | 6208. | 13317. | 15484. | 17543. | 17467. | 15524. | 11378. | 6228. | 6461. | 128379. |
| MAX KW | 8.7 | 8.7 | 8.7 | 23.8 | 30.3 | 29.5 | 30.5 | 31.0 | 28.4 | 25.5 | 8.7 | 8.7 | 31.0 |
| DAY/HR | 1/ 1 | 1/ 1 | 1/ 1 | 30/ 1 | 30/17 | 19/17 | 2/17 | 20/17 | 20/17 | 18/17 | 1/ 2 | 1/ 1 | 8/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 414. | 306. | 155. | 73. | 0. | 0. | 0. | 0. | 0. | 1. | 176. | 292. | 1417. |
| MAX THERM/HR | 1.7 | 2.2 | 0.9 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.9 | 1.3 | 2.2 |
| DAY/HR | 28/ 8 | 4/ 8 | 13/ 8 | 1/ 8 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 31/ 1 | 24/ 7 | 2/ 8 | 2/ 4 |

Fort Benning, GA - B3215
Modified Existing HVAC
System to 4-Pipe System

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/26/2017 16:13:19 BDL RUN 7

REPORT- BEPS Building Energy Performance WEATHER FILE- Columbus GA TMY2

| | | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 141.1 | 0.0 | 127.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.6 | 0.0 | 276.8 |
| EM1 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 162.5 | 18.1 | 49.5 | 253.8 | 0.0 | 0.0 | 0.0 | 0.0 | 483.9 |
| FM1 | NATURAL-GAS | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 155.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 155.3 |
| | MBTU | 141.1 | 0.0 | 127.2 | 155.3 | 162.5 | 18.1 | 49.5 | 253.8 | 0.0 | 0.0 | 8.6 | 0.0 | 915.9 |

TOTAL SITE ENERGY 915.93 MBTU 95.0 KBTU/SQFT-YR GROSS-AREA 95.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 2437.24 MBTU 252.8 KBTU/SQFT-YR GROSS-AREA 252.8 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

Fort Benning, GA - B3215
Modified Existing HVAC
System to 4-Pipe System

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/26/2017 16:13:19 BDL RUN 7

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- Columbus GA TMY2

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 6805. | 6164. | 6816. | 7130. | 7113. | 6459. | 7087. | 7076. | 6439. | 7086. | 6131. | 6792. | 81097. |
| MAX KW | 25.6 | 25.7 | 25.7 | 25.7 | 25.6 | 25.5 | 25.5 | 25.4 | 25.4 | 25.5 | 25.5 | 25.6 | 25.7 |
| DAY/HR | 28/10 | 4/10 | 12/10 | 1/10 | 13/10 | 3/10 | 1/10 | 12/10 | 19/10 | 31/10 | 18/10 | 2/10 | 3/12 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 7055. | 6607. | 9119. | 11136. | 13381. | 15596. | 17659. | 17576. | 15631. | 11518. | 8731. | 7766. | 141775. |
| MAX KW | 16.2 | 16.9 | 20.5 | 23.6 | 30.6 | 29.8 | 30.7 | 31.0 | 28.4 | 25.5 | 21.7 | 19.1 | 31.0 |
| DAY/HR | 30/17 | 15/16 | 29/17 | 9/18 | 30/17 | 19/17 | 2/17 | 20/17 | 20/17 | 18/17 | 15/17 | 30/17 | 8/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 421. | 315. | 174. | 63. | 17. | 0. | 0. | 0. | 0. | 67. | 194. | 302. | 1553. |
| MAX THERM/HR | 1.7 | 2.2 | 0.9 | 0.7 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.9 | 1.4 | 2.2 |
| DAY/HR | 28/ 8 | 4/ 8 | 13/ 8 | 21/23 | 13/ 4 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 26/21 | 24/ 7 | 2/ 8 | 2/ 4 |

Fort Benning, GA - B3215
GHP HVAC System

REPORT- BEPS Building Energy Performance WEATHER FILE- Columbus GA TMY2

| | | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 141.1 | 0.0 | 127.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.6 | 0.0 | 276.8 |
| EM1 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 8.0 | 123.2 | 0.0 | 28.9 | 156.1 | 0.0 | 0.0 | 0.0 | 0.0 | 316.3 |
| FM1 | NATURAL-GAS | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | MBTU | 141.1 | 0.0 | 127.2 | 8.0 | 123.2 | 0.0 | 28.9 | 156.1 | 0.0 | 0.0 | 8.6 | 0.0 | 593.0 |

TOTAL SITE ENERGY 593.04 MBTU 61.5 KBTU/SQFT-YR GROSS-AREA 61.5 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1779.13 MBTU 184.5 KBTU/SQFT-YR GROSS-AREA 184.5 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.87
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 76
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev Fort Benning, GA - B3215 GHP HVAC System DOE-2.2-48y 1/29/2017 9:52:03 BDL RUN 4

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- Columbus GA TMY2

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 6807. | 6165. | 6816. | 7130. | 7112. | 6458. | 7086. | 7075. | 6438. | 7085. | 6131. | 6793. | 81098. |
| MAX KW | 25.6 | 25.7 | 25.7 | 25.7 | 25.6 | 25.5 | 25.5 | 25.4 | 25.4 | 25.5 | 25.5 | 25.6 | 25.7 |
| DAY/HR | 28/10 | 5/10 | 13/10 | 1/10 | 13/10 | 3/10 | 1/10 | 12/10 | 30/10 | 7/10 | 25/10 | 18/10 | 3/13 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 5424. | 4391. | 5087. | 6626. | 8414. | 10494. | 12395. | 12272. | 10741. | 7041. | 4999. | 4780. | 92664. |
| MAX KW | 13.0 | 14.4 | 15.7 | 18.3 | 21.7 | 21.8 | 22.1 | 22.4 | 21.8 | 20.0 | 15.8 | 13.6 | 22.4 |
| DAY/HR | 27/ 8 | 4/ 8 | 28/17 | 9/17 | 30/17 | 21/17 | 3/14 | 20/14 | 20/17 | 11/17 | 15/16 | 31/16 | 8/20 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAX THERM/HR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DAY/HR | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

REPORT- BEPS Building Energy Performance WEATHER FILE- Columbus GA TMY2

| | | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 141.1 | 0.0 | 127.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.6 | 0.0 | 276.8 |
| EM1 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 27.6 | 189.4 | 0.0 | 1.2 | 156.1 | 0.0 | 2.3 | 0.0 | 0.0 | 376.8 |
| FM1 | NATURAL-GAS | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | MBTU | 141.1 | 0.0 | 127.2 | 27.6 | 189.4 | 0.0 | 1.2 | 156.1 | 0.0 | 2.3 | 8.6 | 0.0 | 653.5 |

TOTAL SITE ENERGY 653.54 MBTU 67.8 KBTU/SQFT-YR GROSS-AREA 67.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1960.62 MBTU 203.3 KBTU/SQFT-YR GROSS-AREA 203.3 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.71
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 62
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev Fort Benning, GA - B3215 ASHP HVAC System DOE-2.2-48y 1/26/2017 22:28:11 BDL RUN 3

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- Columbus GA TMY2

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EM2 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 6807. | 6165. | 6816. | 7130. | 7112. | 6458. | 7086. | 7075. | 6438. | 7085. | 6131. | 6793. | 81098. |
| MAX KW | 25.6 | 25.7 | 25.7 | 25.7 | 25.6 | 25.5 | 25.5 | 25.4 | 25.4 | 25.5 | 25.5 | 25.6 | 25.7 |
| DAY/HR | 28/10 | 5/10 | 13/10 | 1/10 | 13/10 | 3/10 | 1/10 | 12/10 | 30/10 | 7/10 | 25/10 | 18/10 | 3/13 |
| **EM1 ELECTRICITY** | | | | | | | | | | | | | |
| KWH | 7671. | 5828. | 5611. | 7356. | 9583. | 12468. | 15245. | 14908. | 12433. | 7598. | 5626. | 6062. | 110389. |
| MAX KW | 35.7 | 45.4 | 19.3 | 24.4 | 31.3 | 31.9 | 31.8 | 32.4 | 30.0 | 26.0 | 18.6 | 24.4 | 45.4 |
| DAY/HR | 27/ 8 | 4/ 8 | 28/17 | 5/17 | 30/17 | 20/17 | 9/17 | 20/17 | 20/17 | 11/17 | 15/16 | 18/ 8 | 2/ 4 |
| **FM1 NATURAL-GAS** | | | | | | | | | | | | | |
| THERM | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAX THERM/HR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DAY/HR | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

Fort Benning, GA - B3215
Conventional HVAC System
w/ local CHW and HHW

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/30/2017 12:44:45 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- Columbus GA TMY2

| | | LIGHTS | TASK LIGHTS | MISC EQUIP | SPACE HEATING | SPACE COOLING | HEAT REJECT | PUMPS & AUX | VENT FANS | REFRIG DISPLAY | HT PUMP SUPPLEM | DOMEST HOT WTR | EXT USAGE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 141.1 | 0.0 | 127.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.6 | 0.0 | 276.8 |
| EM1 | ELECTRICITY | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 0.0 | 166.3 | 0.0 | 22.6 | 253.8 | 0.0 | 0.0 | 0.0 | 0.0 | 442.7 |
| FM1 | NATURAL-GAS | | | | | | | | | | | | | |
| | MBTU | 0.0 | 0.0 | 0.0 | 141.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 141.7 |
| | MBTU | 141.1 | 0.0 | 127.2 | 141.7 | 166.3 | 0.0 | 22.6 | 253.8 | 0.0 | 0.0 | 8.6 | 0.0 | 861.2 |

TOTAL SITE ENERGY 861.16 MBTU 89.3 KBTU/SQFT-YR GROSS-AREA 89.3 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 2300.01 MBTU 238.5 KBTU/SQFT-YR GROSS-AREA 238.5 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

Fort Benning, GA - B3215
Conventional HVAC System
w/ local CHW and HHW

ESTCP-Ft Benning-Bldg 3215 (13-08-02)Rev DOE-2.2-48y 1/30/2017 12:44:45 BDL RUN 1

REPORT- PS-B Utility and Fuel Use Summary WEATHER FILE- Columbus GA TMY2

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM2 ELECTRICITY | | | | | | | | | | | | | |
| KWH | 6805. | 6164. | 6815. | 7129. | 7113. | 6459. | 7087. | 7076. | 6439. | 7086. | 6130. | 6792. | 81094. |
| MAX KW | 25.6 | 25.7 | 25.7 | 25.7 | 25.6 | 25.5 | 25.5 | 25.4 | 25.4 | 25.5 | 25.5 | 25.6 | 25.7 |
| DAY/HR | 28/10 | 4/10 | 13/10 | 1/10 | 13/10 | 3/10 | 1/10 | 12/10 | 19/10 | 31/10 | 18/10 | 2/10 | 3/13 |
| EM1 ELECTRICITY | | | | | | | | | | | | | |
| KWH | 6489. | 5853. | 6428. | 6207. | 13365. | 15721. | 18133. | 17871. | 15671. | 11271. | 6228. | 6461. | 129697. |
| MAX KW | 8.7 | 8.7 | 8.7 | 23.2 | 34.1 | 35.6 | 35.1 | 35.8 | 31.5 | 27.4 | 8.7 | 8.7 | 35.8 |
| DAY/HR | 1/ 1 | 1/ 1 | 1/ 1 | 30/ 1 | 30/17 | 20/17 | 9/17 | 20/17 | 20/17 | 11/17 | 1/ 2 | 1/ 1 | 8/20 |
| FM1 NATURAL-GAS | | | | | | | | | | | | | |
| THERM | 414. | 306. | 155. | 73. | 0. | 0. | 0. | 0. | 0. | 1. | 176. | 292. | 1417. |
| MAX THERM/HR | 1.7 | 2.2 | 0.9 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.9 | 1.3 | 2.2 |
| DAY/HR | 28/ 8 | 4/ 8 | 13/ 8 | 1/ 8 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 31/ 1 | 24/ 7 | 2/ 8 | 2/ 4 |

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# APPENDIX K COST ANALYSIS REPORTS

# NIST BLCC 5.3-16: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

## Base Case: Conventional HVAC

## Alternative: BTES

## General Information

| | |
|---|---|
| File Name: | C:\Users\ssullens\Desktop\2011184 - ESTCP Project\12-Final Report & SF-298\BLCC\ESTCP-MCLB-Demonstration.xml |
| Date of Study: | Tue Jan 31 13:02:16 EST 2017 |
| Project Name: | ESTCP-MCLB-Demonstration |
| Project Location: | Georgia |
| Analysis Type: | MILCON Analysis, Energy Project |
| Analyst: | |
| Base Date: | October 1, 2016 |
| Beneficial Occupancy Date: | October 1, 2016 |
| Study Period: | 20 years 0 months(October 1, 2016 through September 30, 2036) |
| Discount Rate: | 3% |
| Discounting Convention: | Mid-Year |

# Comparison of Present-Value Costs

## PV Life-Cycle Cost

| | Base Case | Alternative | Savings from Alternative |
|---|---|---|---|
| **Initial Investment Costs:** | | | |
| Capital Requirements as of Base Date | $3,196,912 | $5,100,000 | -$1,903,088 |
| **Future Costs:** | | | |
| Energy Consumption Costs | $3,688,241 | $2,606,399 | $1,081,842 |
| Energy Demand Charges | $0 | $0 | $0 |
| Energy Utility Rebates | $0 | $0 | $0 |
| Water Costs | $647,329 | $0 | $647,329 |
| Routine Recurring and Non-Recurring OM&R Costs | $981,465 | $0 | $981,465 |
| Major Repair and Replacements | $0 | $0 | $0 |
| Residual Value at End of Study Period | $0 | $0 | $0 |
| Subtotal (for Future Cost Items) | $5,317,035 | $2,606,399 | $2,710,636 |
| **Total PV Life-Cycle Cost** | $8,513,947 | $7,706,399 | $807,548 |

## Net Savings from Alternative Compared with Base Case

| | |
|---|---|
| PV of Non-Investment Savings | $2,710,636 |
| - Increased Total Investment | $1,903,088 |
| **Net Savings** | $807,548 |

## Savings-to-Investment Ratio (SIR)

**SIR =** 1.42

## Adjusted Internal Rate of Return

**AIRR =** 4.84%

## Payback Period

### Estimated Years to Payback (from beginning of Beneficial Occupancy Period)

Simple Payback occurs in year 11

Discounted Payback occurs in year 13

# Energy Savings Summary

## Energy Savings Summary (in stated units)

Units are not the same for each energy type; can't report energy savings.

## Energy Savings Summary (in MBtu)

| Energy Type | Average Annual Consumption Base Case | Alternative | Savings | Life-Cycle Savings |
|---|---|---|---|---|
| Electricity | 7,048.1 MBtu | 5,768.2 MBtu | 1,279.8 MBtu | 25,593.0 MBtu |
| Natural Gas | 3,944.3 MBtu | 0.0 MBtu | 3,944.3 MBtu | 78,875.5 MBtu |

# Emissions Reduction Summary

| Energy Type | Average Annual Emissions Base Case | Alternative | Reduction | Life-Cycle Reduction |
|---|---|---|---|---|
| Electricity | | | | |
| CO2 | 1,350,470.83 kg | 1,105,245.22 kg | 245,225.62 kg | 4,903,840.93 kg |
| SO2 | 6,804.97 kg | 5,569.29 kg | 1,235.68 kg | 24,710.27 kg |
| NOx | 2,015.46 kg | 1,649.48 kg | 365.98 kg | 7,318.56 kg |
| Natural Gas | | | | |
| CO2 | 208,351.88 kg | 0.00 kg | 208,351.88 kg | 4,166,467.19 kg |
| SO2 | 1,681.47 kg | 0.00 kg | 1,681.47 kg | 33,624.71 kg |
| NOx | 174.81 kg | 0.00 kg | 174.81 kg | 3,495.64 kg |
| Total: | | | | |
| CO2 | 1,558,822.71 kg | 1,105,245.22 kg | 453,577.50 kg | 9,070,308.12 kg |
| SO2 | 8,486.44 kg | 5,569.29 kg | 2,917.15 kg | 58,334.98 kg |
| NOx | 2,190.27 kg | 1,649.48 kg | 540.78 kg | 10,814.20 kg |

# NIST BLCC 5.3-16: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

## Base Case: Air Cooled CHW / Boiler HHW HVAC

## Alternative: ATES Demonstration

## General Information

| | |
|---|---|
| File Name: | C:\Users\ssullens\Desktop\2011184 - ESTCP Project\12-Final Report & SF-298\BLCC\ESTCP-Benning-Demonstration.xml |
| Date of Study: | Tue Jan 31 12:11:03 EST 2017 |
| Project Name: | ESTCP - ATES Demonstration - Fort Benning |
| Project Location: | Georgia |
| Analysis Type: | MILCON Analysis, Energy Project |
| Analyst: | |
| Base Date: | October 1, 2016 |
| Beneficial Occupancy Date: | October 1, 2016 |
| Study Period: | 20 years 0 months(October 1, 2016 through September 30, 2036) |
| Discount Rate: | 3% |
| Discounting Convention: | Mid-Year |

# Comparison of Present-Value Costs

## PV Life-Cycle Cost

| | Base Case | Alternative | Savings from Alternative |
|---|---|---|---|
| **Initial Investment Costs:** | | | |
| Capital Requirements as of Base Date | $608,375 | $648,304 | -$39,929 |
| **Future Costs:** | | | |
| Energy Consumption Costs | $144,657 | $80,330 | $64,327 |
| Energy Demand Charges | $0 | $0 | $0 |
| Energy Utility Rebates | $0 | $0 | $0 |
| Water Costs | $0 | $0 | $0 |
| Routine Recurring and Non-Recurring OM&R Costs | $0 | $0 | $0 |
| Major Repair and Replacements | $0 | $0 | $0 |
| Residual Value at End of Study Period | $0 | $0 | $0 |
| Subtotal (for Future Cost Items) | $144,657 | $80,330 | $64,327 |
| **Total PV Life-Cycle Cost** | $753,032 | $728,634 | $24,398 |

## Net Savings from Alternative Compared with Base Case

| | |
|---|---|
| PV of Non-Investment Savings | $64,327 |
| - Increased Total Investment | $39,929 |
| **Net Savings** | $24,398 |

## Savings-to-Investment Ratio (SIR)

**SIR =** 1.61

## Adjusted Internal Rate of Return

**AIRR =** 5.49%

## Payback Period

### Estimated Years to Payback (from beginning of Beneficial Occupancy Period)

| | |
|---|---|
| Simple Payback occurs in year | 10 |
| Discounted Payback occurs in year | 12 |

# Energy Savings Summary

## Energy Savings Summary (in stated units)

| Energy Type | Average Annual Consumption: Base Case | Alternative | Savings | Life-Cycle Savings |
|---|---|---|---|---|
| Electricity | 129,697.0 kWh | 79,834.0 kWh | 49,863.0 kWh | 997,123.5 kWh |
| Natural Gas | 1,413.0 Therm | 0.0 Therm | 1,413.0 Therm | 28,256.1 Therm |

## Energy Savings Summary (in MBtu)

| Energy Type | -----Average Annual Consumption----- Base Case | Alternative | Savings | Life-Cycle Savings |
|---|---|---|---|---|
| Electricity | 442.5 MBtu | 272.4 MBtu | 170.1 MBtu | 3,402.3 MBtu |
| Natural Gas | 141.3 MBtu | 0.0 MBtu | 141.3 MBtu | 2,825.6 MBtu |

## Emissions Reduction Summary

| Energy Type | -----Average Annual Emissions----- Base Case | Alternative | Reduction | Life-Cycle Reduction |
|---|---|---|---|---|
| Electricity | | | | |
| CO2 | 88,708.08 kg | 54,603.58 kg | 34,104.50 kg | 681,996.60 kg |
| SO2 | 594.92 kg | 366.20 kg | 228.72 kg | 4,573.83 kg |
| NOx | 109.27 kg | 67.26 kg | 42.01 kg | 840.09 kg |
| Natural Gas | | | | |
| CO2 | 7,463.97 kg | 0.00 kg | 7,463.97 kg | 149,258.88 kg |
| SO2 | 60.24 kg | 0.00 kg | 60.24 kg | 1,204.57 kg |
| NOx | 6.26 kg | 0.00 kg | 6.26 kg | 125.23 kg |
| Total: | | | | |
| CO2 | 96,172.05 kg | 54,603.58 kg | 41,568.46 kg | 831,255.48 kg |
| SO2 | 655.16 kg | 366.20 kg | 288.96 kg | 5,778.40 kg |
| NOx | 115.53 kg | 67.26 kg | 48.27 kg | 965.32 kg |

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# APPENDIX L BTES/ATES THERMAL STORAGE ANALYSIS

# BTES THERMAL ENERGY STORAGE ANALYSIS

**Assumed or Inherent Site Properties**

| | | |
|---|---|---|
| **$C_p$ Water** | 1.000 | ***btu/lb/°F*** |
| **$C_p$ Limestone** | 0.217 | ***btu/lb/°F*** |
| **Density Water** | 62.4 | ***lb/ft$^3$*** |
| **Density Limestone** | 150.0 | ***lb/ft$^3$*** |
| **Porosity (% $H_2O$)** | 30% | |
| **Porosity (% Limestone)** | 70% | |

| | | |
|---|---|---|
| **Composite Density** | 123.72 | ***lb/ft$^3$*** |
| **Composite $C_p$** | 0.4519 | ***btu/lb/°F*** |
| | 400 | ***ft. Dia.*** |
| **Underground BTES Geological Volume** | 210 | ***ft. Depth*** |
| | 26,389,440 | ***ft$^3$*** |
| **Underground BTES Geological Mass** | 3,264,901,517 | ***lbs*** |
| | 1,632,451 | ***tons (weight)*** |

***Heat Capacity Formula: btus = m * $C_p$ * $\Delta T$***

| | | |
|---|---|---|
| **m =** | 3,264,901,517 | ***lbs*** |
| **$C_p$ =** | 0.4519 | ***btu/lb/°F*** |
| **$\Delta$T =** | 1.0 | ***°F*** |
| **btus =** | 1,475,408,995 | |
| **kbtus =** | 1,475,409 | **per °F of rise or fall above/below its +/- 70°F** |
| **kWh =** | 432,418 | **undisturbed deep earth temperature** |
| **Wh =** | 432,417,642 | |
| **Equiv. Energy of 9V Batteries =** | 96,092,809 | Qty |
| **Equiv. Energy of 12V Batteries =** | 720,696 | Qty |

**NOTES**

| | | | | | | |
|---|---|---|---|---|---|---|
| 9V | = | 0.500 | Amp hours | = | 4.5 | ***Wh*** |
| 12V Car Battery | = | 50 | Amp hours | = | 600 | ***Wh*** |

# ATES THERMAL ENERGY STORAGE ANALYSIS

**Assumed or Inherent Site Properties**

| | | |
|---|---|---|
| **Specific Heat ($C_p$) Water** | 1.000 | ***btu/lb/°F*** |
| **Specific Heat ($C_p$) Sand** | 0.210 | ***btu/lb/°F*** |
| **Density of Water** | 62.4 | ***lb/ft$^3$*** |
| **Density of Sand** | 100.0 | ***lb/ft$^3$*** |
| **Porosity (% $H_2O$)** | 39% | |
| **Porosity (% Limestone)** | 61% | |

| | | |
|---|---|---|
| **Composite Density** | 85.2 | ***lb/ft$^3$*** |
| **Composite $C_p$** | 0.521 | ***btu/lb/°F*** |
| **Underground ATES Geological & Hydrogeological Volume** | 6,169,500 | ***Estimated Annual Injected Water Volume (gal)*** |
| | 824,799 | ***ft$^3$ Water*** |
| | 1,268,922 | ***ft$^3$ Sand*** |
| **Underground ATES Geological and Hydrogeological Mass** | 178,359,712 | ***lbs*** |
| | 89,180 | ***tons (weight)*** |

***Heat Capacity Formula: btus = m * $C_p$ * $\Delta T$***

| | | |
|---|---|---|
| **m =** | 178,359,712 | ***lbs*** |
| **$C_p$ =** | 0.521 | ***btu/lb/°F*** |
| **$\Delta$T =** | 1.0 | ***°F*** |
| **btus =** | 92,963,244 | |
| **kbtus =** | 92,963 | **per °F of rise or fall above/below its +/- 70°F** |
| **kWh =** | 27,246 | **undisturbed deep earth temperature** |
| **Wh =** | 27,245,968 | |
| **Equiv. Energy of 9V Batteries =** | 6,054,660 | Qty |
| **Equiv. Energy of 12V Car Batteries =** | 45,410 | Qty |

| **NOTES** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 9V | = | 0.500 | Amp hours | = | 4.5 | ***Wh*** |
| | 12V Car Battery | = | 50 | Amp hours | = | 600 | ***Wh*** |