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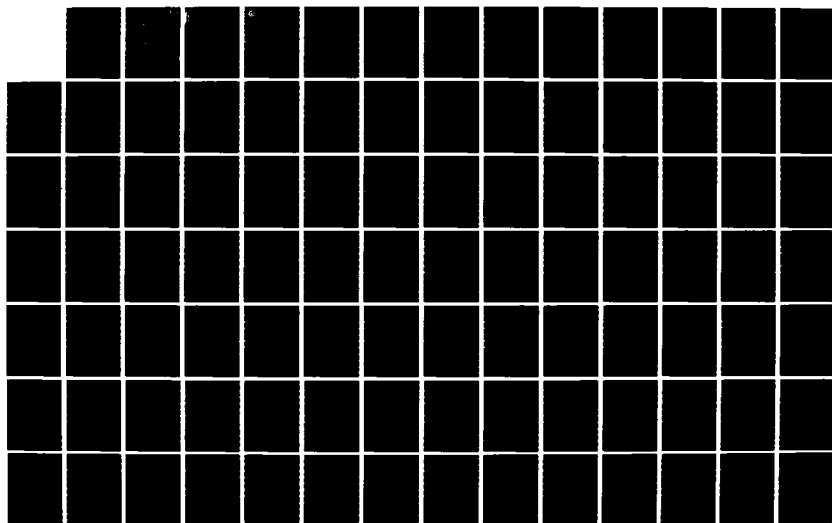
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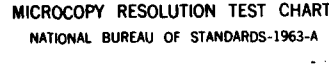
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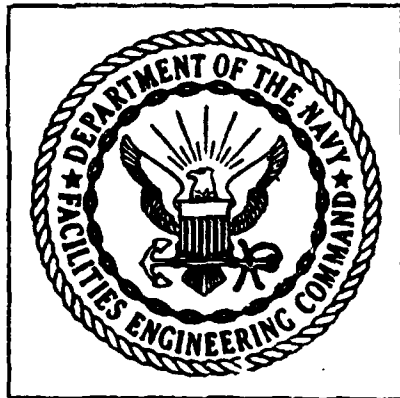
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Energy Conservation Guide For Industrial Processes

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA

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Enclosure ()

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Industrial Energy Conservation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Energy Conservation Guide for Industrial Processes has simple instructions to survey energy use areas at Navy Industrial Activities like Shipyards, Naval Air Rework Facilities and Government Owned, Contractor Operated (GOCO) plants.

This guide includes information and procedures on:

- Organizing and conducting an Industrial Energy Survey;
- Evaluating purchased energy data;
- Descriptions of Industrial Systems, and
- Evaluation of industrial processes for conservation.

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DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA 19112

Executive Order 12003 of 20 July 1977 requires a 20% reduction in energy usage in all existing federal buildings by fiscal year 1985. Fiscal year 1975 usage has been established as the baseline against which the reduction effort is to be measured.

To assist the Naval Shore Facilities to achieve their goals, the Naval Facilities Engineering Command implemented the Energy Engineering Program (EEP). Under this program, Northern Division's Energy Programs Branch, Code 111, was assigned the task of having a survey guide developed that could be used by Navy Industrial Activities in implementing an energy conservation program.

The result of this assignment is this Energy Conservation Guide for Industrial Processes which provides easy to follow instructions and procedures for systematically surveying industrial energy use areas at Navy Industrial Activities such as Naval Shipyards, Naval Air Rework Facilities and Government Owned, Contractor Operated (GOCO) plants.

Information and procedures are provided in this Guide on:

- How to organize and conduct an Industrial Energy Survey
- How to evaluate purchased energy data
- How to evaluate industrial processes for energy conservation opportunities
- How to prepare Energy Conservation Investment Program (ECIP) projects and Energy Technology Applications Program (ETAP) projects.

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ENERGY CONSERVATION
GUIDE FOR
INDUSTRIAL PROCESSES

CONTRACT NO. N62472-78-C-1059
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

BY

SYSKA & HENNESSY, ENGINEERS
11 WEST 42ND STREET
NEW YORK, NEW YORK 10036

The material contained in Energy Conservation Guide for Industrial Processes is not intended to be used in connection with a particular installation. The adaption and use should be the responsibility of a skilled professional at the site. The contractor, Syska & Hennessy is not responsible for any claims, losses, damages or expenses arising from the use of "Energy Conservation Guide for Industrial Processes."

ENERGY CONSERVATION GUIDE
FOR
INDUSTRIAL PROCESSES

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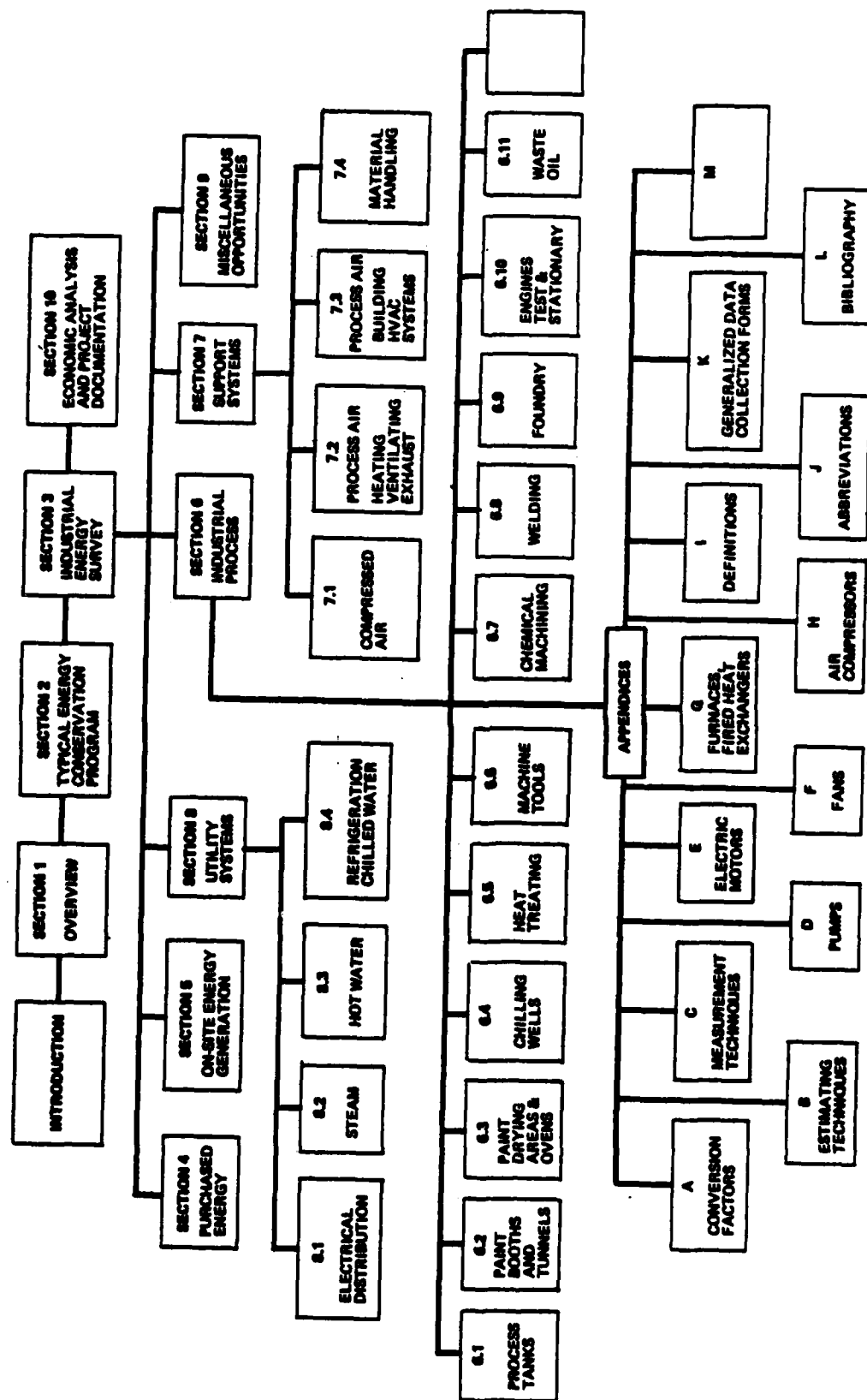
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AN INTRODUCTION TO THE GUIDE

The purpose of this Guide is to provide instructions and procedures for evaluating the energy utilization of selected industrial processing equipment.

A block diagram of the contents of the Guide is presented in Figure INTRO-1. A brief description of Figure INTRO-1 and the Guide follows.

ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES



The first five sections of the GUIDE contain:

- a. The answers to the most-often-asked-questions about energy conservation. The OVERVIEW sets the stage in SECTION ONE.
- b. A typical Energy Conservation Program is developed in SECTION TWO.
- c. How to organize and conduct an Industrial Energy Survey is the purpose of SECTION THREE.
- d. How to evaluate Purchased Energy consumption data in SECTION FOUR and On-Site Energy Generation in SECTION FIVE is discussed.

The industrial processes that appear to offer practical energy conservation opportunities are included in SECTION 6. The unique features of each of the processes are listed in their appropriate subsections while information on devices which are common to most industrial processes are contained in the appendices. For example, a paint booth has its unique design and operating characteristics developed in SECTION 6.3, while generalized information about electric motors and fans is located in the APPENDICES G & H. Likewise, the information about a heat-treat oven, SECTION 6.5 will be directed towards its unique features. Energy conservation data for the fans, motors, etc. are found in the APPENDICES.

The Guidebook format has been designed to:

- a. Allow for the uniqueness of each facility. Provide flexibility so that Data Collection, Analysis and Check-off sheets can be assembled based on the type of equipment to be surveyed and the detail required in the survey.
- b. Allow for flexibility in additions and updating. Data for processes not covered in this Guidebook can be added to SECTION 6 and the APPENDIX.
- c. Allow easy updating so that as new energy conservation information and techniques are developed, they can be added to the Guidebook.

Support systems, such as compressed air and exhaust systems are another source of energy conservation opportunities. The systems are included in SECTION 7. For example, the paint booth survey, discussed earlier, might also include data and forms from SECTION 7.1 Compressed Air, and SECTION 7.2 Process Air: Heating, Ventilating and Exhaust.

Another survey could include a number of heated wash tanks. Each tank is without lids and requires air for agitation. The following resources in the Guide would be investigated:

SECTION 6.1, Process Tanks

SECTION 7.1, Compressed Air

SECTION 7.2, Process Air: Heating, Ventilating and Exhaust.

APPENDIX D, Pumps.

APPENDIX E, Electric Motors.

APPENDIX F, Fans.

APPENDIX H, Air Compressors.

Energy conservation opportunities found in utility systems and miscellaneous systems are developed in SECTION 8 and SECTION 9.

Energy conservation and economics are inseparable. Economic analysis and project document are explained in SECTION 10 for MILCON and Special Projects.

APPENDICES A, B, C, I and J contain definitions, abbreviations, heating values, energy measurement techniques and energy cost estimating techniques.

APPENDICES D through H contain data collection and analysis forms for the equipment common to most industrial processes - namely: pumps, electric motors, fans, furnaces-fired heat exchanges and air compressors.

Each facility has its own unique role, and as a result must operate in a specialized manner. The challenge is to develop an energy conservation plan for the facility that is neither disruptive or confusing. It is reasonable to believe that no one Guide could be developed that would

be complete for every facility. The Guide, however, takes this into account and its format is designed to be flexible. A key to the success of the program will be the manner in which the personnel at a facility modify the Guide to accommodate their particular industrial processes.

SECTION 1

OVERVIEW

1.1 ITEMS TO BE CONSIDERED. Improved energy management is a worthwhile goal. Energy management is not new. Today, however, there is more emphasis on improving it. This overview of the Guide considers the following:

- 1.1.1 Why energy conservation?
- 1.1.2 What does the Guide provide?
- 1.1.3 What is industrial process equipment?
- 1.1.4 What processes typically yield potential energy savings?
- 1.1.5 Why are energy savings reported as source energy?
- 1.1.6 What are MBtu?
- 1.1.7 Why is the Guide format modular?

1.1.1 Why Energy Conservation?

Today's high energy costs and impending fuel shortages have propagated a new interest in energy conservation. The President's Executive Order No. 12003 requires that all federal departments and agencies adopt procedures which aim at reducing energy use in federal buildings. The order calls for a 20% reduction by 1985 from 1975 standards in existing buildings, and by 45% for new federal buildings. Since the start of 1977,

department and agency heads have been initiating programs which accomplish this end. Directives from the Department of Defense and the Chief of Naval Operations have initiated energy conservation programs at all major naval installations.

1.1.2 What Does the Guide Provide?

The guide provides methods to evaluate the energy utilization of selected industrial process equipment. The guide can be used to identify and analyze cost-effective energy conservation opportunities.

It accomplishes this by identifying process equipment which has the highest energy conservation potential, and specifies the data needed for thermal and electrical analysis. The Guide describes the phases of a survey including review of related documentation, data collection, estimating energy usage and savings, modifications, and payback. It is intended that this Guide and its references be sufficient to enable facilities/utilities engineering personnel, to conduct basic industrial energy surveys. Sample data sheets are included; specific data for each type process is listed. Computational methods have been reduced to a simplified format to expedite the process of estimating energy consumption. The Guide describes how to recognize the large energy users and suggests solutions

which will reduce consumption. The Guide also describes how to identify energy conservation projects and relates them to Energy Conservation Investment Program (ECIP) selection guidelines.

1.1.3 What is Industrial Process Equipment?

Industrial process equipment, as defined in this document, includes machinery, ovens, tanks, test facilities, etc., used to fabricate repair, refinish and test. Supporting laboratories are also considered to be process equipment. To complete the definition, the equipment or process should have a nameplate rating of at least 8 KW or 30,000 Btu/hr.

1.1.4 What Processes Typically Yield Potential Energy Savings?

An example of a typical plant devoted to aircraft manufacturing is Grumman Aerospace Corporation's Plant 2 in Bethpage, New York. Table A shows an apportionment of where the steam and electricity are used.

TABLE A ENERGY CONSUMPTION, TYPICAL AIRCRAFT
MFG. AND PROCESS FACILITY*

Energy User	% Plant Electric	% Plant Steam
Lights	37	-
HVAC System	15	17
Process Exhaust	13	34
Process Paint Hangar	7	33
Process Heat	3	16
Process Equipment	25	-
TOTALS	100	100

*Table A information is from the Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Virginia, Atlantic Division, NAVFAC, 1978.

The requirement for lighting and exhausting large amounts of conditioned air results in the greatest energy usage. Electric power to run exhaust and make-up fans, and steam for heating and humidification account for the bulk of energy consumed in spray finishing facilities, chemical process tanks, and vapor degreasing tanks. A considerable amount of energy is consumed in cutting, grinding, abrasive - cleaning, welding and foundry operations.

Table B shows a summary of the classification of energy savings resulting from equipment and procedural modifications. Spray finishing operations account for one-third, chemical process tanks account for one-third, and the remaining third is distributed among vapor degreasing, air compressors, cutting, grinding, foundry, and laboratories. The relative contribution to energy conservation will vary from plant to plant and by location; however, these figures indicate those areas with the greatest potential for energy reduction.

The Table B information is from the Energy Conservation Guide for Industrial Process, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978.

TABLE B POTENTIAL ENERGY SAVINGS,
TYPICAL AIRCRAFT MFG. &
PROCESS EQUIPMENT*

Processes	% Potential Savings	
	Electrical	Steam
Spray Finishing	36	54
Process Tank Lines	34	23
Heat-Treat	12	11
Vapor Degreasing	6	10
Air Compressors	8	-
Foundry	2	1
Cutting, Grinding, Welding	2	1
TOTALS	100	100

1.1.5 Why Are Energy Savings Reported as "Source" Energy?

The production of energy from various fuels and systems can be expressed in terms of the BTU (British Thermal Unit). The energy in a cubic foot of natural gas or a kilowatt-hour of electricity can be expressed in a common term of Btu's.

Since most electrical energy in the United States is produced in thermal plants, the source energy must take into account the efficiency of converting thermal energy to electrical energy as well as the electrical distribution losses. To produce and deliver 1 kw-hr of electricity to the plant a conversion factor of 11,600 Btu per kw-hr is used. Hence, every kw-hr conserved in the operation of the industrial plant represents a saving of 11,600 Btu of fuel at the electric generating station. From the point of view of physics, the amount of energy in one kw-hr is 3413 Btu. The conversion factor is often used, but it does not come to grips with the efficiency of the energy conversion equipment.

1.1.6 What are M Btu?

There is considerable confusion and sometimes errors result from the interpretation of the term M Btu. Is it one thousand Btu or one million Btu? Sometimes, the term is written as MM Btu, a sure sign

that M is a Roman numeral, and the term is for 1000 times 1000 Btu or one million Btu. In this document M is the abbreviation for mega, and M Btu will mean one million Btu's. Other documents may differ, and the reader should be certain of the definition used in the document.

1.1.7 Why is the Guide Format Modular?

If the time to do a comprehensive audit of the complete facility is not available, the Guide is arranged so that an energy management team can elect to do sections of it. Furthermore, the format allows for modifications to the manual should a facility, because of its uniqueness, need to emphasize or add sections.

SECTION 2
A TYPICAL ENERGY CONSERVATION
PROGRAM

2.1 TYPICAL PROGRAM

The Guide deals with the energy conservation survey for an industrial facility. It is important to recognize that it is but an element of a typical energy conservation plan. The following is an outline of an energy conservation program. It is general and should be modified to conform with local situations. These guidelines are as follows:

- a. Management should demonstrate their commitment and set goals.
- b. Survey industrial energy uses, analyze data, and develop savings proposals.
- c. Take action to conserve energy by defining and implementing projects.
- d. Develop a continuing effort to assure that savings opportunities are seized as they appear.

Management can demonstrate their commitment by taking the following action:

- a. Inform line supervisors of the economic reasons for energy conservation and the responsibility to take action in their areas.

- b. Establish a committee with representaton from each shop, the utility department, engineering, and others; appoint a coordinator with the responsibility to report to management.
- c. Plan and take part in energy audits.
- d. Develop and improve energy metering, accounting and reporting.
- e. Develop tough but achievable goals for energy conservation based on inputs from preliminary surveys of the departments involved.
- f. Research, develop, and promote energy conservation ideas.
- g. Enlist employee participation at all levels by appropraite communication and activity programs.

Survey industrial energy uses:

- a. Set priorities for the various areas based on knowledge of energy usage. Do the surveys in order of priority.
- b. Take readings and perform test to identify energy losses and waste.
- c. Analyze the readings to determine the losses and compare with standards to arrive at potential savings.
- d. Select a corrective action and make an economic evaluation to determine its feasibility.

- e. Make off-hours surveys to determine wasteful situations such as unnecessary lighting, ventilation, or equipment left running.
- f. Analyze major systems such as steam, water, and compressed air to improve metering; reduce leaks; and establish needs for appropriate energy recovery devices.

Take action to conserve energy by:

- a. Correcting maintenance and operational problems such as leaks and unnecessary running ventilation systems. Claim savings for these as part of the program effort.
- b. Preparing for each project either a short form or detailed economic analysis, as required by the estimated cost to implement.
- c. Listing proposed energy conservation projects in categories such as projects requiring no cost to implement, projects requiring minor cost to implement, and so on.
- d. Recommending implementation of projects according to priority based on payback times.
- e. Reviewing designs of all capital projects, such as expansion, new buildings, modernization, and revisions to assure that energy is efficiently utilized.

Establish a continuing energy management program since it:

- a. Provides a constant check that conservation steps in operation are being sustained.
- b. Will reveal if maintenance of equipment is slipping.
- c. Documents energy management savings in Btu's as well as in dollars.

The concept of developing a continuing effort to conserve energy is important. Some benefits of energy conservation are certainly achievable on a one-shot basis, but true management requires continuing vigilance to prevent operational back-sliding. The opportunities for conservation are not exhausted by a one-shot application because, with inflationary escalation of costs, new opportunities are created continuously.

SECTION 3

THE INDUSTRIAL ENERGY SURVEY

3.1 SURVEY OBJECTIVES

The survey has four distinct objectives, each necessary for a thorough understanding of energy management at the facility. They are:

- a. To document the industrial energy consumption by fuel type and amount purchased, electricity purchased, and steam purchased (if any), and also the on-site production of utilities. These data will show your total utility consumption, along with total dollars spent for utilities each month during the past year; in addition, these figures will show monthly peaks and seasonal trends in usage, and may be used in specific energy-use calculations. This information will also be the basis for the economic evaluation of energy-conservation opportunities identified as a result of the audit.
- b. To provide an analysis of the energy consumption of industrial processes, including the energy consumption for each process by type of fuel or energy. Such items as furnaces, ovens, exhaust systems, etc. will be evaluated and analyzed, both

separately and in relation to each other, for energy consumption and efficiency.

- c. To identify energy conservation opportunities and to provide alternative methods for controlling and reducing energy consumption. These will include operational changes and capital additions for such items as heat recovery and control equipment.
- d. To identify monitoring equipment and provide the procedures needed for an on-going energy monitoring and control program.

3.2 PRELIMINARY TASKS BEFORE CONDUCTING THE SURVEY

- a. Statement of Work and Schedule. When a facility is selected for an energy survey, the initial effort should include the following two steps. The first is to generate a statement of work and the second is to prepare a program schedule. When the survey is an "in-house" effort, this is usually the first scheduling task. Surveys done by outside contractors, however, must include and define those items in the agreed-to-work statement and schedule, which is an integral part of the contractual document.
- b. Security Clearance. A list of the survey team names and their respective security levels must be

submitted to the Base Security Officer to establish the required clearances and enable the issuing of badges. If the survey personnel do not have the necessary security level, an escort will have to be provided when required.

- c. Alerting Plant Supervisors. Supervisors of plants to be surveyed should be informed of the arrival date of the team and their duration of stay. Plant Supervisors will be advised of needed survey team assistance from Plant Maintenance Section and will post notices in the surveyed areas which briefly describe the reasons for the energy survey. It is important to state that the survey team is not monitoring the work productivity of the employees. This notification should be two weeks in advance of the start date.
- d. Scheduling Data Collection. The survey team will monitor energy usage during normal working and non-working hours. Therefore, it is necessary to schedule data collection during typical shifts as opposed to partial work load activity. It is a much easier task to schedule this effort for an "in-house" energy conservation team because of their ready availability.

3.3 REVIEW OF EXISTING INFORMATION

Documents relating to the energy survey will be reviewed prior to the start of the survey effort. Typical sources for this information are:

- a. Statement of work and schedule
- b. Previously completed energy conservation reports
- c. Utility operating records for previous year
- d. Purchased rate schedules
- e. Process specifications
- f. Regulations pertaining to certain processes such as OSHA and NIOSH
- g. Activity engineering service requests affecting energy conservation.

3.4 REVIEW OF EXISTING DRAWINGS AND EQUIPMENT DATA

Their existence, up-to-dateness, and storage location will be confirmed before the survey begins. Typical drawings and schedules are:

- a. Architectural drawings
- b. Mechanical drawings
 - heating
 - air conditioning and air flow schedules
 - exhaust systems and air flow schedules
 - steam distribution
 - HTW distribution

chilled water distribution

- c. Plant equipment

layout drawings

- d. Electrical drawings

distribution

- e. The in-place metering for the applicable facility or plant or process equipment.

- f. The portable on-site energy measuring meters and devices.

3.5 SELECTING A SURVEY TEAM

Selecting the proper mix of talents will have a significant bearing on the success of an energy survey. Previous experience is useful, but not essential, provided a detailed plan, and instructions are followed by the participants. A strong background in heating, air conditioning and ventilating equipment is useful. A major part of industrial energy consumption is concentrated in this area. Experienced survey teams are generally a mix of mechanical and electrical engineers who have specialized in HVAC, lighting and process equipment energy conservation. Lacking previous energy conservation experience, a survey

team should have some basic knowledge of the types of equipment involved. Generally, these people will be found in Utility or Facility Engineering groups.

Using shop personnel for some of the data collection tasks can be done successfully and has some advantages over using engineers exclusively. Many energy conservation measures require the users to implement new operational procedures. This is generally enhanced when workers have an awareness of energy conservation goals and have participated in a survey. Energy Conservation-related suggestions from shop personnel should be encouraged; experience has shown that residents of an area are more critical observers than a survey team member in a foreign area.

The size of the survey team is a function of facility size, contents, and time scheduled to complete the survey. To some extent, the experience level of the team will also be a determining factor. The data collection phase of the survey entails the review of existing documentation, collecting certain name plate ratings, energy measurements, and determining duty cycles by observation and/or interrogating users. Industrial activities having a high density of energy-using equipment require the most time for data collection. For estimating purposes, a performance factor of 30,000 sq. ft. of floor area for one man-day of

survey time can be used. Office buildings, particularly modern ones, will require less time for data collection. Mechanical drawings have performance and operations details for HVAC and lighting systems; this eliminates most of the need for inspection and enables analytical work to be done using data from drawings exclusively.

The analytical and report writing phases of an energy survey should be done by technical personnel, and not delegated to shop personnel. There are definite advantages to having the same people involved in all phases of the survey. The experienced analyst, for instance, will recognize what data is necessary to gather in order to perform each computation; this will improve the efficiency of the data collection phase. Conversely, collecting unnecessary data is also minimized.

Another option to forming a survey team is to do the data collection function with regular employees, and have the analytical functions done by an energy conservation specialty organization. The advantage in hiring out the analysis work is that specialists often have computer programs to do the analysis much more expeditiously.

3.6 WHAT TO SURVEY-ASSIGNING RESPONSIBILITIES

The Survey Coverage Form is to be used in conjunction with the Survey Team Form.

- 3.6.1 Complete the Survey Coverage Form as follows:
- a. Indicate the purpose of the program and estimate the results expected.
 - b. Designate the industrial areas, buildings, or shops that are to be audited.
 - c. Indicate the processes, systems, and other situations to be examined.
- 3.6.2 Complete the Survey Team Form as follows:
- a. List the names of the team members, their department or shop numbers, and their team responsibilities assignments or specialities.
 - b. Plan to report periodically and at major states in the program to promote interest and maintain control.
- 3.6.3 Complete the Pre-Survey Check-Off List as follows:
- a. Develop file folders for the items to be checked. In some cases copies of the data can be inserted in the folder for use by the survey team. Other times, the folder will contain the names and telephone numbers of people to contact for the data, etc. It is important to develop the pre-survey check-off sheet properly. It increases the efficiency of the survey team, and provides a record for planning future surveys.

One way to reduce the amount of effort in completing the Pre-Survey Check Off-List is to become familiar with all the sections in this Guide.

SURVEY SCOPE FORM

DATE _ _ _ _ _

Sheet 1 of 3

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: _ _ _ _ _

LOCATION: _ _ _ _ _

SURVEY COVERAGE: Buildings, Shops _ _ _ _ _

_ _ _ _ _

_ _ _ _ _

PROGRAM SCOPE:

I. Industrial Processes

	<u>Applies</u>		<u>Building</u>
	<u>Yes</u>	<u>No</u>	<u>No.</u>
Cleaning and Coating Operations (Process Tanks)			
Paint Booths			
Chilling Well.....			
Heat Treating.....			
Machine Tools.....			
Metal Working.....			
Metal Machining.....			
Wood Working.....			
.....			

SURVEY SCOPE FORM

DATE _ _ _ _ _

Sheet 2 of 3

	<u>Applies</u>		<u>Building</u>
	<u>Yes</u>	<u>No</u>	<u>No.</u>
<u>PROGRAM SCOPE:</u> (Continued)			
Chemical Machining Operations.....			_____
Welding Brazing and Flame Cutting.....			_____
Foundry.....			_____
_____.....			_____
Engines, Stationary and Test Facilities.....			_____
Waste Oil Processing.....			_____
_____.....			_____

II. Support Systems.

&
Used for
Industrial
Process

Compressed Air.....
Process Air: Heating Ventilating
and Exhaust.....
Process Building, HVAC.....
Material Handling.....

SURVEY TEAM & REPORT SCHEDULE FORM

DATE _ _ _ _ _

Sheet 3 of 3

PROGRAM SCOPE: (Continued)

III. Utility Systems

&
Used for
Industrial
Process

Electrical.....

Steam.....

Hot Water (High Temp).....

Refrigeration, Chilled Water.....

SURVEY TEAM AND REPORT SCHEDULE FORM

DATE _ _ _ _ _

Sheet 1 of 1

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: _ _ _ _ _

LOCATION: _ _ _ _ _

PROGRAM TEAM;

<u>NAME</u>	<u>DEPT.</u>	<u>RESPONSIBILITY</u>
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _	_ _ _ _ _

SCHEDULE OF REPORTS:

<u>Report</u>	<u>Due Date</u>
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _
_ _ _ _ _	_ _ _

PRE-SURVEY CHECK-OFF LIST

Sheet 1 of 8

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: _ _ _ _ _

LOCATION: _ _ _ _ _

(Develop folders for the items to be checked)

		<u>By</u>	<u>Date</u>
I.	SURVEY SCHEDULE DEVELOPED (Milestones)	_ _ _ _	' _ _ _ _
II.	SECURITY CLEARANCE OBTAINED	_ _ _ _	' _ _ _ _
III.	PLANT SUPERVISORS ALERTED FOR THE SURVEY	_ _ _ _	' _ _ _ _
IV.	PREVIOUSLY COMPLETED ENERGY CONSERVATION REPORTS.		

<u>Title</u>	<u>Date of Report</u>	<u>Title of Project</u> <u>Developed or</u> <u>Recommendation</u>
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _

V. ENGINEERING SERVICE REQUESTS AFFECTING
ENERGY CONSERVATION.

<u>Title</u>	<u>ESR #</u>	<u>Date of ESR</u>	<u>Status</u>
- - - - -	- - - - -	- - - - -	- - - - -
- - - - -	- - - - -	- - - - -	- - - - -
- - - - -	- - - - -	- - - - -	- - - - -
- - - - -	- - - - -	- - - - -	- - - - -
- - - - -	- - - - -	- - - - -	- - - - -

VI. LIST OF PROCESSES AND SYSTEMS TO BE CHECKED. List processes and systems to be checked along with whether the checks will be made during normal and/or non-working hours, when applicable include the actual hours.

Bldg #	<u>Item</u>	<u>Normal Working Hours</u>	<u>Non- Working Hours</u>

VII. OSHA & NIOSH

Regulations Affecting Subject Energy Conservation Survey

<u>Title</u>	<u>Report or Regulation Filed At:</u>
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----

VIII. DRAWINGS AND SPECIFICATIONS

Architectural

Mechanical

Process steam

Process hot water

Building HVAC

Process air, heating,
ventilating and exhaust

Chilled water

Compressed air

Electrical

Distribution

VIII. DRAWINGS AND SPECIFICATIONS (Continued)

Applicable process and system specifications

Overall Plant Layout

IX. ENERGY MEASUREMENTS

1. Listing of existing meters for:

Processes

Systems

Purchased Utilities

Utilities generated-on-site

2. Listing of portable meters and recorders used for measuring energy usage of:

Processes

Systems

Purchased Utilities

Utilities generated on site

3. List of portable instruments not available at the site that should be considered for purchase or lease.

4. Is the utility metering for the building sufficient to warrant obtaining billing data and rate schedules:

Yes _ _ _ No _ _ _

If yes, complete the following:

Utility consumption, usage and billing data available, oil _ _ _ , natural gas _ _ _ , electricity _ _ _ , steam _ _ _ , HTW _ _ _ , chilled water _ _ _ , compressed air _ _ _ , _ _ _ .

PRE-SURVEY CHECK OFF LIST (Continued)

Utilities-on-site generation, usage and billing data
 available electricity _ _ _ _ , steam _ _ _ _ , HTW _ _ _ _ ,
 chilled water _ _ _ _ , compressed air _ _ _ _
 , _ _ _ _ _ _ _ _ _ _ .

Purchased or on site rate schedules, oil _ _ _ _ , natural
 gas _ _ _ _ , electricity _ _ _ _ , steam _ _ _ _ , compressed
 air _ _ _ _ .

Checkoff Sheet Completed By

Date

SECTION 4

PURCHASED ENERGY DATA

4.1 IS THE DATA APPLICABLE TO THE SURVEY?

Purchased energy data is useful when the metering or purchase information can supply pertinent data for the buildings or processes being surveyed.

The number of buildings being surveyed coupled with the ability to separate electrical consumption and electrical demand loads on a building-by-building basis should be a consideration. Generally, metering on a per building basis at an industrial facility is seldom done. Electrical metering is usually minimized to take advantage of rate schedules. A large steam distribution system will usually have central plant metering but not have steam flow monitoring on a building-by-building basis.

For each survey, a judgement should be made during the initial planning for the survey, as to the practicality of reviewing purchased energy data.

4.2 SUPPLIER DATA (If Applicable)

Most information in this section is already at hand in the form of utility (or other supplier) contracts, billings, rate schedules, and similar data. The process is one of point-by-point familiarization with the suppliers of each energy form so that contacts can be made readily and

accurately when members of the energy audit team generate questions.

The main meters, their locations and types, and the rate schedules and riders applicable to the specific location and service should be studied to make certain there is mutual understanding as to the billings, the meter readings, and the rate structure. Each utility has a rate structure unique to itself, and contacts with the business representative may be required to help clarify the details, such as demand and power factor penalty charges as they relate to opportunities for cost savings. In the case of fuels (except natural gas), there may be transportation charges, another potential savings area.

4.3 CONSUMPTION DATA (If Applicable)

The purpose of this activity is to develop a picture of seasonal energy-consumption variations. This will help to identify large energy users that are operational only certain months of the year. The effect that changes in workload or shifts have on energy consumption will be reflected in these numbers. The effect of operating various processes or parts of processes, and of drydocks, etc. will also show up.

Select a form for the type of energy being audited. Indicate delivery point or service number. Each service should be summarized independently. Forms should be copied as needed to audit each service.

Heat-conversion factor is an indication of the heat (in Btu) contained in a unit of the energy source. Enter in this space the heat-conversion factor corresponding to the service.

Energy consumption data are obtained from monthly billings. If bills were copied while collecting supplier data, enter the monthly data in the table. Otherwise, the bills must be obtained from the accounting department or the Public Works Department.

A presentation in graphic form will make seasonal consumption variations even more noticeable.

4.4 FORMS - UTILITIES, PURCHASED

The purchased energy forms are arranged in pages 4-4 to 4-11 as follows:

<u>Utility</u>	<u>Supplier Data</u>	<u>Consumption Data</u>
	<u>Page #</u>	<u>Page #</u>
Electricity	4-4	4-5, 4-6
Fuel Oil	4-7	4-6
Natural Gas	4-8	4-6
LP Gas	4-8	4-6
Coal	4-9	4-6
Refuse Derived Fuel	4-9	4-6
Steam	4-10	4-6, 4-11

SUPPLIER DATA - ELECTRICITY

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Utility Company Name: _____

Address: _____

Business Representative: _____ Phone: _____

MAIN METERING

Service Number	Meter Location	Metering Voltage	Demand Period (15 Min/30 Min)	Check () Type of Meter		
				KWH	KW Demand	Power Factor
1						
2						
3						

BILLING

Attach rate schedule and applicable riders for each service.

PURCHASED ENERGY - ELECTRICITY

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Service: _____

VOLTAGE: _____

Heat Conversion Factor 0.0116 MBtu/KWH

CONSUMPTION DATA

Month of Fiscal Year	Actual	Demand KW or KVA Billed	Quantity KWH	Cost		Energy Consumption MBtu/Period KWH x 0.0116
				Total	Per KWH	
1st _ _ _						
2nd _ _ _						
3rd _ _ _						
1st Quarter						
4th _ _ _						
5th _ _ _						
6th _ _ _						
2nd Quarter						
7th _ _ _						
8th _ _ _						
9th _ _ _						
3rd Quarter						
10th _ _ _						
11th _ _ _						
12th _ _ _						
4th Quarter						
Total Per Fiscal Year FY _ _ _						

Plot the above data on copies of the chart on sheet 4-6

- Demand, Actual: During the 12 months
- Consumption: KWH during the 12 months

PURCHASED ENERGY		CONSUMPTION DATA	
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
21	22	23	24
25	26	27	28
29	30	31	32
33	34	35	36
37	38	39	40
41	42	43	44
45	46	47	48
49	50	51	52
53	54	55	56
57	58	59	60
61	62	63	64
65	66	67	68
69	70	71	72
73	74	75	76
77	78	79	80
81	82	83	84
85	86	87	88
89	90	91	92
93	94	95	96
97	98	99	100

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

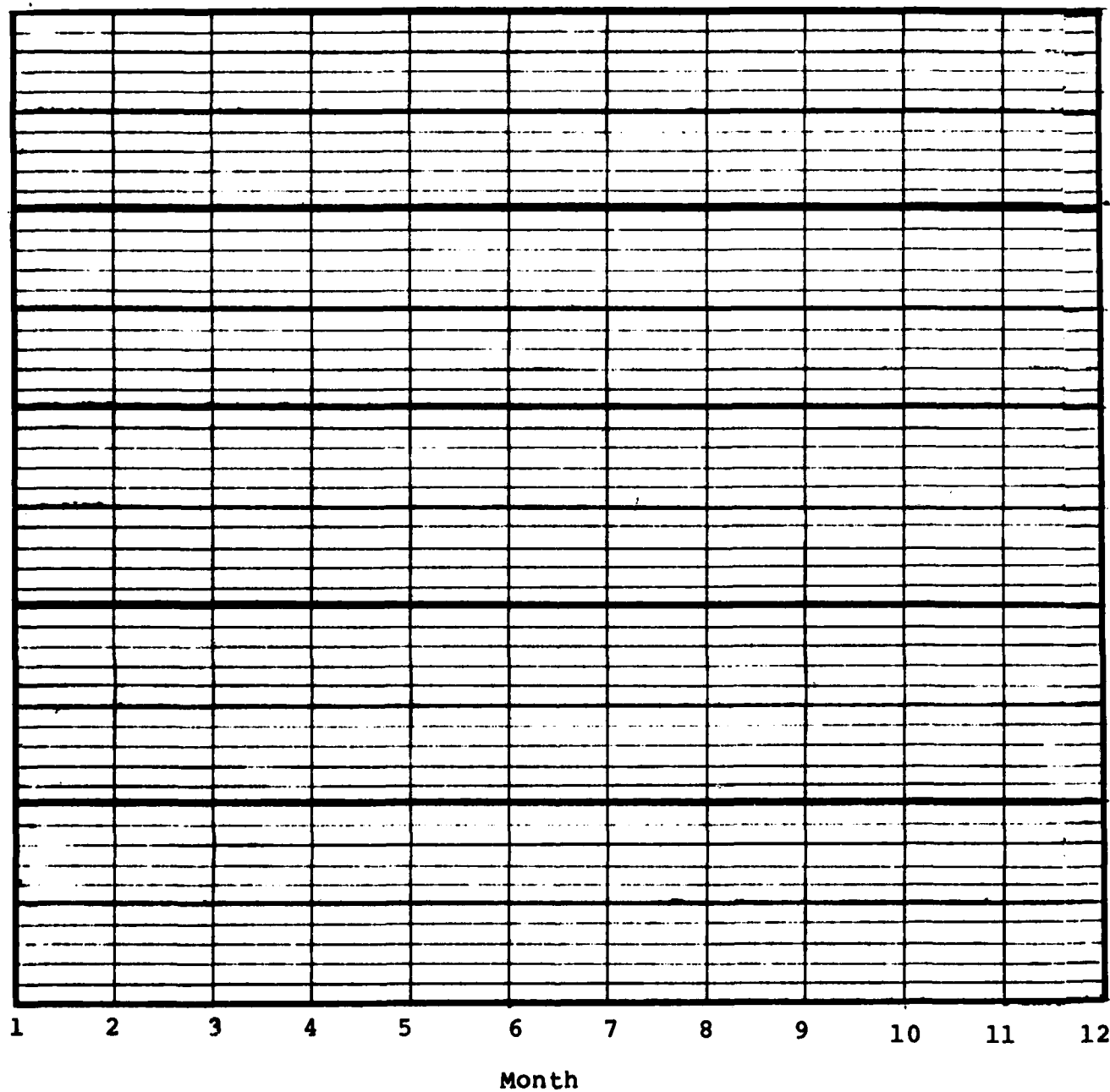
ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY

LOCATION: FL BAY

STHN



SUPPLIER DATA - FUEL OIL

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO. _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

Oil Company Name: _____

Address: _____

Business Representative: _____ Phone: _____

DELIVERY POINTS

Point No.	Tank Size	Area Served	Oil Type	Heating Value

CONSUMPTION DATA

Develop a table similar to page 4-5. Provide columns for: Month of Year, Quantity Used (gallons), Total Cost per Month; Average Cost Per Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - NATURAL OR LP GAS

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Gas Supplier: _____

Address: _____

Business Representative: _____ Phone: _____

METERING POINTS

Service	Location	Pressure	Size	Heating Value

LP Gas Delivery Point	LP Gas Tank gal.	LP Gas Area Served *	Heating Value

CONSUMPTION DATA

Develop a table similar to page 4-5. Provide columns for: Month of Year, Quantity Used (gallons), Total Cost per Month; Average Cost (Per 1000 cubic feet or per Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - COAL OR REFUSE DERIVED FUEL

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Supplier: _____

Address: _____

Business Representative: _____ Phone: _____

DELIVERY POINTS

Point No.	Area Served	Type	Heating Value Btu/ton

CONSUMPTION DATA (RDF or Coal)

Develop a table similar to page 4-5. Provide columns for: Month of Year, Quantity Used (tons or gallons), Total Cost per Month; Average Cost Per Ton or Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - COAL OR REFUSE DERIVED FUEL

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _ _

Utility Company Name: _____

Address: _____

Business Representative: _____ Phone: _____

MAIN METERING

Service Number	Meter Location	Steam Conditions		Maximum Capacity lb/hr
		Pressure, psig	Temp. °F	
1				
2				
3				

BILLING

Attach most recent rate schedule and applicable riders for each service.

PURCHASED ENERGY - STEAM

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Service: _____

Incoming Pressure: _____ psig

Heat Conversion Factor (Heat Content) = _____ Btu/lb
(from Steam Tables)

CONSUMPTION DATA

Month of Fiscal Year	lbs/hr Demand		Quantity 1000 Lbs	Cost		Energy Consumption MBtu/Period Quantity x Heating Value
	Actual	Billed		Total	Per MLBS	
1st _____						
2nd _____						
3rd _____						
1st Quarter						
4th _____						
5th _____						
6th _____						
2nd Quarter						
7th _____						
8th _____						
9th _____						
3rd Quarter						
10th _____						
11th _____						
12th _____						
4th Quarter						
Total Per Fiscal Year FY _____						

Plot the above data on copies of the chart on sheet 4-6

SECTION 5

ON - SITE ENERGY GENERATION

5.1 IS THE DATA APPLICABLE TO THE SURVEY?

On-site energy production data is applicable when the metering or estimated use can supply useful information for the buildings or process being surveyed.

5.2 EQUIPMENT DATA (If Applicable)

Using the forms accompanying this section:

- a. Enter the equipment or process identification.
Consider each piece of fired equipment separately, and identify the areas served.
- b. Record the characteristics of the working fluid or electric energy produced, such as pressure, voltage, etc.
- c. Indicate the type of fuel or motive energy consumed.

5.3 CONSUMPTION DATA (If Applicable)

Using the forms accompanying this section:

- a. Tabulate the monthly fuel consumption or fuel input for conversion data in the table, for the last fiscal year. Fuel input for conversion refers to the primary utility energy converted for an industrial process.
- b. Examine the data for large variations in monthly fuel consumption and conversion rates. Look for major energy consumers that were operational during

the periods of high energy consumption and conversion rates. Try to evaluate the proportion of the energy from this source used by various areas served. See if you can correlate monthly consumption or conversion rates to operating hours or operating rates. Look for major energy-consuming processes that were used during the periods of high activity such as drydock pumping. Note the gross seasonal variations due to heating by steam in winter and air conditioning by electricity (or steam) in summer.

- c. Data from the production data sheet should be plotted on the production plot. The graphic format will make seasonal variations in energy consumption and conversion rates more visible.

5.4 FORMS - ON SITE ENERGY GENERATION

The energy conversion forms are arranged in pages 5-3 to 5-8 as follows:

<u>Conversion Equipment</u>	<u>Equipment Data Page #</u>	<u>Production Data Page #</u>
Electricity	5-3	5-3
Steam	5-5	5-5
Hot Water	5-6	5-6
Compressed Air	5-7	5-7
Chilled Water	5-8	5-8

GENERATED ENERGY - ELECTRICITY

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____
 Generator No.: _____ Location: _____
 Area Served: _____
 Generated Voltage: _____
 Driver: (Check One) Diesel Gas Turbine Steam Turbine
 Fuel: Oil No. _____ Gas, Natural Gas, Other
 Purchased Steam: _____ psig _____ °F
 Generated Steam: _____ psig _____ °F Boiler # _____

Month of Fiscal Year	Fuel Used Units _____	Steam Used 1000 lbs	Electricity	
			Generated, KWH	Demand KW or KVA
1st _____				
2nd _____				
3rd _____				
1st Quarter				
4th _____				
5th _____				
6th _____				
2nd Quarter				
7th _____				
8th _____				
9th _____				
3rd Quarter				
10th _____				
11th _____				
12th _____				
4th Quarter				
Total FY _____				

Plot the above data on copies of the chart on Sheet 5-4

- Demand, Actual: During the 12 months
- Consumption: KWH during the 12 months

GENERATED ENERGY

DEPT. OF NAVY - NAVFAC BUILDING NO.:

ENERGY CONSERVATION AUDIT SHOP NO.: ID NO.:

ACTIVITY _____ LOCATION: FL _____ BAY _____

UNIT 5

A blank graph grid with 12 columns labeled 1 to 12 and 10 rows. The x-axis is labeled "Month".

GENERATED ENERGY - STEAM

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____
 Boiler No.: _____ Location: _____

Areas Served: _____
 Boiler No.: _____ Location: _____
 Areas Served: _____

STEAM CHARACTERISTICS:

Pressure: _____ psig
 Temperature: _____ °F
 Heat Content: _____ Btu/lb

Fuel Type (Check One)

No. _____ Fuel Oil _____ Coal _____
 Natural Gas _____ Other _____ Type _____

Month of Fiscal Year	Fuel Consumed Units _____	Steam Produced 1000 lbs
1st _____		
2nd _____		
3rd _____		
1st Quarter		
4th _____		
5th _____		
6th _____		
2nd Quarter		
7th _____		
8th _____		
9th _____		
3rd Quarter		
10th _____		
11th _____		
12th _____		
4th Quarter		
Total FY _____		

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - HOT WATER, PROCESS

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____

ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

Boiler No.: _____ Location: _____

Areas Served: _____

HOT WATER CHARACTERISTICS:

Temperature: _____ °F _____ psig

Heat Content: _____ Btu/lb

Fuel Type: (Check One)

No. _____ Fuel Oil Coal
Natural Gas Other Specify _____
Steam _____ psig _____ °F

Month of Fiscal Year	Fuel Consumed Units _____	Hot Water Produced 1000 Gals
1st _____		
2nd _____		
3rd _____		
1st Quarter		
4th _____		
5th _____		
6th _____		
2nd Quarter		
7th _____		
8th _____		
9th _____		
3rd Quarter		
10th _____		
11th _____		
12th _____		
4th Quarter		
Total FY _____		

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - COMPRESSED AIR

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____

ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

Compressor No.: _____ Location: _____

Areas Served: _____ Rate: SCFM _____

Pressure: _____ psig

Volume measured as standard cubic feet per minute, air at 60°F,
and atmospheric pressure at sea level.

Month of Fiscal Year	Electric Usage KWH	Compressed Air Produced 1000 CF
1st _____		
2nd _____		
3rd _____		
1st Quarter		
4th _____		
5th _____		
6th _____		
2nd Quarter		
7th _____		
8th _____		
9th _____		
3rd Quarter		
10th _____		
11th _____		
12th _____		
4th Quarter		

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - CHILLED WATER

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____
 Chiller No.: _____ Location: _____
 Area Served: _____
 Chilled Water Temperature: _____ °F
 Energy Source (Check One) Steam Electricity
 Other Specify
 Purchased Steam: _____ psig _____ °F
 Generated Steam: _____ psig _____ °F

Month of Fiscal Year	Electricity Consumed KWH	Steam Consumed 1000 Lbs	Chilled Water Produced 1000 Gals
1st _____			
2nd _____			
3rd _____			
1st Quarter			
4th _____			
5th _____			
6th _____			
2nd Quarter			
7th _____			
8th _____			
9th _____			
3rd Quarter			
10th _____			
11th _____			
12th _____			
4th Quarter			
Total FY _____			

Plot the above data on copies of the chart on sheet 5-4.

SECTION 6

ENERGY CONSERVATION - INDUSTRIAL PROCESSES

PROCESS TANKS

6.1.1 INTRODUCTION:

Process tanks include those used for electroplating, degreasing, etching, stripping and other cleaning and coating operations. The heat loss from process tanks can represent significant energy losses and hence process tanks are good energy conservation modification candidates with relatively short paybacks of 1 to 3 years.

Special attention should be paid to evaporation and ventilation heat losses in process tanks. If OSHA, NIOSH and environmental regulations permit tanks containing hot fluids should have lids. Use of lids can greatly reduce evaporation heat losses and this would reduce the need for forced (fan) space ventilation (where tanks are located). Additional economic advantage is that evaporation loss of expensive solvents is reduced.

An alternate to mechanically operated lids and covers are hollow plastic spheres or other plastic configurations that can be floated on the surface to form a layer and act as a lid.

Another area to be considered is tank insulation. Uninsulated process tanks have a high heat loss.

6.1.2 VAPOR DEGREASERS

A vapor degreaser generally is a steel tank with steam or electric heating coils located near the bottom and immersed in a few inches of a chlorinated liquid solvent such as Trichlorethylene or III-Trichlorethane. The tank may range in size from a few to over one hundred square feet, and may be hand-fed or conveyORIZED. Vapor from the boiling solvent fills the tank, into which the parts to be cleaned are lowered. Above the cleaning space is a condenser consisting of a water-jacket or cooling coil, where the vapor is condensed and returned to the boiling sump. The tank wall above the cooling jacket is the freeboard, and its purpose is to minimize cross drafts which will carry off vapor. Usually, the tank will have a lip exhaust along one or both long sides, above the freeboard. A liquid solvent spray lance frequently is included.

Roughly one-half the energy consumption of a typical, open-top degreaser operation is by the degreaser itself, for vapor boiling; the balance for make-up ventilation air heating and exhaust fan power. Therefore, efforts must be made to minimize exhaust ventilation. A cover must be provided which will not disturb the vapor line when opened. For this reason, a sliding cover is much preferred to a hinged one. In addition, the cover must seal the tank below the lip exhaust openings. If the degreaser is not in continuous use, the cover should be kept closed except for loading/unloading and use time. Automatic electric or hydraulically-operated covers are

most convenient and are most likely to be utilized by operating personnel. If the cooling jacket is operating properly, it may be possible to reduce or even turn-off the exhaust while the cover is closed. The limiting factor, easily measured, is the vapor concentration in the surrounding area, so that ventilation may be minimized by careful trial and measurement. Interlocking of cover and exhaust fan is desirable for maximum efficiency. Refrigerated cooling coils may allow elimination of exhaust fans altogether. However, their initial cost and operating expenses must be considered.

Reduction of energy use of the degreaser itself is straightforward. Insulation can reduce wall heat loss. The degreaser should be shut down for periods of non-use greater than a few hours. The most positive method of shutdown is use of automatic timers, which can turn off degreasers after an active shift, with a time delay to shut down exhaust fans shortly thereafter. A thorough energy conservation effort may result in reduction of energy usage of vapor degreasing operations by as much as 75%. In addition, the accompanying reduction in solvent loss may be even more rewarding, due to the high cost of chlorinated solvents.

6.1.3 CHEMICAL PROCESS LINES

Chemical process areas typically contain a number of tanks, aligned to allow parts to be dipped, either manually or

by means of an overhead hoist, in a sequential manner to perform a particular process, such as plating, anodizing, cleaning, etc. Ventilation may be individually provided, as by a lip canopy or hood exhaust, or there may be general area ventilation. Individual tanks may be heated by gas, electricity or steam, and if heated, may or may not be insulated. Covers may exist, and if so, may or may not be utilized. Tank solutions may be agitated, by bubbling of compressed air or by mechanical means. Rinse water tanks will frequently be continuously flushed.

The conditions required of the particular process must first be determined, on an individual tank basis, and steps taken to eliminate unnecessary requirements. Exhaust flow must be minimized and shut-off when possible.

Covers should be considered to reduce ventilation requirements and to minimize surface heat loss of heated liquids. It may be possible to interlock tank exhaust with tank covers, to ventilate only when the cover is open. The use of hollow plastic spheres or other plastic configurations that can be floated on the surface to act as a lid should be investigated.

Wall insulation should be considered especially if the liquid is maintained at temperatures above 120°F. Temperatures should be reduced to the minimum allowable. For heated tanks, water-to-water heat exchangers

should be considered to recover heat from continuous overflows or from the heating coil condensate. During non-active shifts, it may be possible to turn off tank heaters, reduce or eliminate ventilation, stop liquid agitation and flush flow, reduce area temperature and turn off area lights.

Maximum use of automatic controls is recommended. Covers may be electrically or pneumatically activated. Exhaust fans, heaters, agitation devices, flush flow and even area temperature and lighting can be automatically controlled by one or more timers.

6.1.4 RESOURCES FOR A SURVEY

Data Collection Forms	6.1-8
Estimating Heat Losses From Tanks.	6.1-10
Data Analysis Form	6.1-19
Checklists	6.1-21

Where Applicable:

Compressed Air	7.1

The checklist, particularly when air is used for agitation.

Process Air: Heating, Ventilating & Exhaust Systems	Section 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements and specifications provided by the facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements	Appendix B. 4

Review instrumentation, data gathering, and calculations.

Pumps and Electric Motors	Appendices D & E

Fans and Electric Motors Appendices F&E
Proper operating schedules as well as
sizing and speeds can offer energy savings.

Air Compressors Appendix H
Important to consider when dedicated
(exclusively for the tanks) air
compressors are used.

DATA COLLECTION

Sheet 1 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____ ITEM: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____
 SKETCH SHEET _____ YES _____ NO _____

DESIGN DATA

Plating Tanks, Fill in Blocks A and C

OTHER Tanks, Fill in Blocks B and C

BLOCK A

Plating Solution: _____ Plated Material _____

Electric-DC: _____ Volts _____ Amps

BLOCK B

Tank Solution: _____ Function: _____

BLOCK C

Solution Temp _____ °F

Estimated temperature of surrounding surfaces in plant _____ °F

Agitation: _____ Air, Flow Regulated with Gages _____ psig
 or Flowmeter _____ SCFMg, _____ Mechanical _____ None

Heating Source Steam Coil _____ LBS/hr

Electric _____ KW

Gas _____ BTU/hr

Hot Water _____ BTU/hr

Cooling Source Chilled Water _____ LBS/hr

Tank Dimensions Length _____ FT

Width _____

Height _____

Solution Depth _____

Conducted By _____ Date _____

DATA COLLECTION

Sheet 2 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____ ITEM: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____

AUDIT DATA

Plating Tanks, Fill in Blocks D and E

Other Tanks, Fill in Blocks E

BLOCK D

Electric-DC: _____ Volts _____ Amps

BLOCK E

Solution Temp _____ °F
 Tank Wall Temp _____ °F
 Shop (Ambient) Temp _____ °F

Wall Material _____

Painted	Yes _____	No _____
Insulated	Yes _____	No _____
Mechanical Lid	Yes _____	No _____
Floating Plastic Spheres	Yes _____	No _____

Ventilation

Lip, Hood, Open _____
 Duct Section Area _____ In²
 Air Velocity _____ ft/min

Duty Cycle

	<u>Heat</u>	<u>Ventilation</u>
Hours/Day	_____	_____
Days/Week	_____	_____

Estimated Costs:

Electricity _____

Oil _____

CONDUCTED BY _____ DATE _____

6.1.5 ESTIMATING HEAT LOSSES FROM TANKS

The tank walls and cover transfer heat to the surroundings by convection and radiation. If the tank bottom is not in contact with the floor convection losses occur. When the tank is uncovered, the heat loss from the liquid surface is by convection, radiation and evaporation.

Estimates for the heat loss from the tank walls, cover and bottom are developed in the following sections:

- 6.1.5.1 Estimated Heat Loss from Tank Walls, Cover and Bottom.
- 6.1.5.2 Estimated Heat Loss from the Fluid Surface. (No Covers).

The heat lost by the tank is the sum of the estimated heat losses in section 6.1.5.1 through 6.1.5.2.

A sample calculation is included in section 6.1.6.

6.1.5.1 Estimated Heat Loss from Tank Walls, Cover and Bottoms.

A method for estimating heat losses from tank walls, cover and bottom is by solving the following equation:

$$Q = A(U_1 \text{ or } U_2) (T_L - T_A), \text{ where}$$

$$Q = \text{Tank wall, cover and bottom convection loss} \\ \text{- Btu/hr}$$

$$U_1 = \text{Heat transfer coefficient for tank walls,} \\ \text{bottom and cover without insulation (Btu/hr} \\ \text{- sq ft - deg. F)}$$

$$U_2 = \text{Heat transfer coefficient for tank walls and} \\ \text{bottom with insulation (Btu/hr - sq ft -} \\ \text{deg. F)}$$

$$A = \text{Area - square feet}$$

$$T_L = \text{Liquid temperature - deg. F}$$

$$T_A = \text{Ambient temperature - deg. F}$$

T_L , T_A , and A are measured values, U_1 is selected from Table 6.1 and U_2 is selected from Table 6.2. Note that the tank bottom transfers heat when not in direct contact with the floor.

6.1.5.2 Estimated Heat Loss from the Fluid Surface (no covers)

Heat loss from the exposed liquid surface of an open tank is by convection and radiation from the surface and by evaporation of the liquid. Heat loss by evaporation is a rather involved phenomenon to measure and the formula for the sum of these three different phases of heat loss is extremely complex.

The accompanying Table 6.3 is a solution of the common case of various water temperatures and air velocities where the surrounding air is 80 deg. F and 70%, relative humidity. Note that air velocities are in feet per second.

The equation is as follows:

$$Q_c = AH, \text{ where}$$

$$Q_c = \text{Combined heat loss from the fluid surface - Btu/hr}$$

$$A = \text{Open fluid surface area - sq. ft.}$$

$$H = \text{Combined heat loss from the fluid surface per square foot - Btu/hr-sq. ft.}$$

H is selected from Table 6.3

The H values were developed for water. Fluids other than water have different heat loss characteristics. However, the majority of heated tanks have water solutions therefore for estimating purposes these H values are adequate.

Table 6.1

Heat Losses from Steel Flat Surfaces "U_l"*

(Btu/hr - sq ft - F deg temp. difference between surface and air)

Temperature Difference F Deg Between Surface
and Surrounding Air Air at 80 F

	50	100	150	200	250	300	350	400
Vertical Surface	1.84	2.14	2.42	2.70	3.00	3.30	3.62	4.00
Horizontal Surface Facing Upward	2.03	2.37	2.67	2.97	3.28	3.59	3.92	4.31
Horizontal Surface Facing Downward	1.61	1.86	2.11	2.36	2.64	2.93	3.23	3.60

*ASHRAE Handbook of Fundamentals, 1972

Table 6.2
Heat Losses from Insulated Flat Surfaces " U_2 "*

(Btu/hr - sq ft - F deg temp. difference between surface and air)

Temperature Difference Surface to Air deg F	Actual Surface Temperature Air=70 deg F deg F	Thickness of Insulation (Inches)						
		1	1.5	2	2.5	3	4	5
50	120	0.36	0.30	0.24	0.18	0.14	0.12	0.10
100	170	0.38	0.27	0.21	0.17	0.15	0.12	0.10
120	190	0.42	0.30	0.25	0.19	0.16	0.13	0.11
169	239	0.40	0.28	0.23	0.18	0.15	0.12	0.10
200	270	0.40	0.28	0.22	0.18	0.15	0.12	0.10
254	324	0.41	0.30	0.23	0.18	0.15	0.12	0.10
280	350	0.41	0.29	0.23	0.18	0.16	0.12	0.10
300	370	0.42	0.29	0.23	0.19	0.16	0.12	0.10
350	420	0.42	0.30	0.23	0.19	0.16	0.12	0.10
400	470	0.43	0.30	0.23	0.19	0.16	0.13	0.10

*Kent-Mechanical Engineers Handbook, Power Volume, Twelfth Edition

Table 6.3

Heat Loss from Water Surface "H"
(Btu/hr - sq ft)

Air at 80 Deg F, 70% Relative Humidity

Water Temp., Deg F	Air Velocity, Feet per Second						
	0	0.5	1	2	5	10	20
80	17	34	40	49	66	106	185
100	58	96	113	135	185	280	460
110	210	285	320	380	540	780	1,250
120	315	420	470	560	760	1150	1,850
130	460	580	660	780	1,090	1620	2,600
140	640	780	900	1,060	1,480	2200	3,600
150	860	1,020	1,200	1,420	1,970	2950	4,800
160	1,150	1,330	1,590	1,800	2,550	3800	6,300
170	1,500	1,730	2,050	2,500	3,400	5200	8,500
180	2,000	2,400	2,750	3,400	4,700	7100	12,000
190	2,550	3,400	3,900	4,800	6,600	10,000	17,000
200	3,330	4,850	5,600	6,900	9,500	14,000	24,000

*Handbook of Air Conditioning, Heating and Ventilating, C. Strock and R. L. Koral

6.1-15

6.1.6 SAMPLE CALCULATIONS

Estimate the heat loss from the tank before and after the installation of a cover and insulation.

Process Tank

4 feet wide, 8 feet high, 19 feet long

Uncovered

Solution temperature 180 deg. F.

Wall temperatures, uninsulated, approx. 180 deg. F

Tank not in contact with the floor

Shop, ambient temperature 80 deg. F.

Process is such that cover can be added.

6.1.6.1 Preliminary Calculations

Vertical wall area = $(2 \times 4 \times 6) + (2 \times 6 \times 19) = 276$ sq. ft.

Bottom area = $(4 \times 19) = 76$ sq. ft.

Liquid surface area = $(4 \times 19) = 76$ sq. ft.

Proposed Cover Area = $(4 \times 19) = 76$ sq. ft.

6.1.6.2 Estimated Wall and Bottom Heat Loss Without Insulation Using the Steps in Section 6.1.5.1

a. Vertical Wall Area (A_V) = 276 sq. ft.
Bottom Area (A_B) = 76 sq. ft.

b. From Table 6.1 for a temperature difference of 100 deg. F

U_1 for vertical surface = 2.14 Btu/hr - sq. ft. - deg. F

U_1 for horizontal surface facing downward = 1.86 Btu/hr - sq. ft. - deg. F

c. T_L (180 deg F) - T_A (80 deg F) = 100 deg F

d. Heat Loss from walls and bottom

$$\begin{aligned} Q &= (U_1 A_V + U_1 A_B) \times 100 \\ &= ((2.14 \times 276) + (1.86 \times 76)) \times 100 \\ &= 73,200 \text{ Btu/hr} \end{aligned}$$

6.1.6.3 Estimated Wall and Bottom Loss with Insulation Using the Steps in Section 6.1.5.1

- a. Vertical wall area (A_V) = 276 sq. ft
Bottom area (A_B) = 76 sq. ft
- b. From Table 6.2 for 1 inch insulation and surface to air temperature difference of 100 deg. F
 $U_2 = 0.38 \text{ Btu/hr} - \text{sq. ft.} - \text{deg. F}$
- c. $T_L (180 \text{ deg. F}) - T_A (80 \text{ deg. F}) = 100 \text{ deg. F}$
- d. Heat loss from walls and bottom with insulation
$$Q = (U_2 A_V + U_2 A_B) \times 100$$
$$= (0.38 \times 276 + 0.38 \times 76) \times 100$$
$$= 13,376 \text{ Btu/hr}$$

6.1.6.4 Estimated Heat Loss from a Fluid Surface with No Cover

- a. Liquid surface area = 76 sq. ft.
- b. From Table 6.3 heat loss from a water surface at a temperature of 180 deg. F and air velocity of 0.5 ft per second = 2,400 Btu/hr - sq. ft.
- c. Combined heat loss from a fluid surface with no cover.
$$Q_c = 76 \times 2400$$
$$= 182,400 \text{ Btu/hr}$$

6.1.6.5 Estimated Heat Loss with a Cover

- a. Cover area = 76 sq. ft.
- b. From Table 6.1 for a temperature difference of 100 deg. F
 $U_1 \text{ for horizontal surface facing upward} = 2.37$
$$\text{Btu/hr} - \text{sq. ft.} - \text{deg. F}$$
- c. $T_L (180 \text{ deg. F}) - T_A (80 \text{ deg. F}) = 100 \text{ deg. F}$
- d. Heat loss from cover = $A \times U_1 \times 100 \text{ deg. F}$
$$= 76 \times 2.37 \times 100$$
$$= 18,012 \text{ Btu/hr}$$

6.1.6.6 Summary

	No Insulation Or Cover	Insulation No Cover	Insulation And Cover
Wall and Bottom Heat Loss (Btu/hr)	73,200	13,376	13,376
Surface Heat Loss (Btu/hr)	<u>182,400</u>	<u>182,400</u>	<u>18,012</u>
Total (Btu/hr)	256,600	195,776	31,388

DATA ANALYSIS

Sheet 1 of 2

DEPT OF NAVY - NAVFAC BUILDING NO.:
 ENERGY CONSERVATION AUDIT SHOP NO.: I.D. NO.
 ACTIVITY LOCATION: FL BAY

Estimated Heat Loss Before Energy Conservation Action

Tank Surfaces:	Size:	<u> </u> ft,	W	<u> </u> ft,	H	<u> </u> ft
Bottom	=	L x W	=			sq ft
Sides	=	2 x L x H	=			sq ft
Ends	=	2 x H x W	=			sq ft

Total Area = sq ft

Estimated Wall Heat Loss:

 Btu/hr

Estimated Bottom Heat Loss:

 Btu/hr

Estimated Liquid Surface Heat Loss:

 Btu/hr

Estimated Total Heat Loss:

 Btu/hr

CALCULATED BY: DATE

DATA ANALYSIS

Sheet 2 of 2

DEPT OF NAVY - NAVFAC

BUILDING NO.: _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ _ BAY _ _ _ _

Estimated Heat Loss After Energy Conservation Actions

<u>ITEM</u>	<u>Estimated Heat Losses</u> <u>MBTU/HR</u>
Addition of Lid, Cover or hollow plastic spheres	_ _ _ _ _
Additional Wall Insulation	_ _ _ _ _
Additional Bottom Insulation	_ _ _ _ _
Change in Operating Temperature	_ _ _ _ _
Change in Ventilation Flow Rates	_ _ _ _ _

Annual Total Energy Savings based on the Above Items as Well as a Change In Scheduling (List below)

_ _ _ _ _
_ _ _ _ _
_ _ _ _ _
_ _ _ _ _

Annual Total

HTW or Steam Heating _ _ _ _ MBTU

Electric _ _ _ _ MBTU

CALCULATED BY: _ _ _ _ _ DATE _ _ _ _ _

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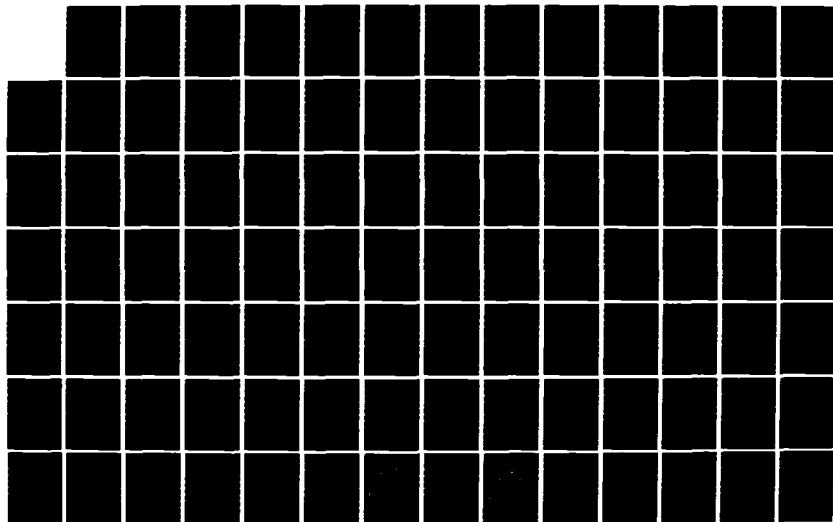
ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U)
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

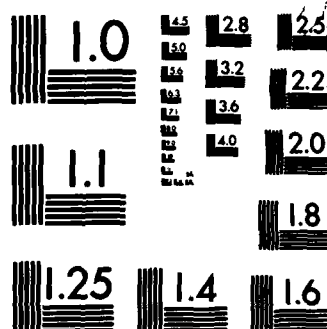
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CHECKLIST - PROCESS TANKS

SHEET 1 of 5

DEPT OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ _ BAY _ _ _ _

Before evaluating specific process tanks it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	<u>Applies</u>	
	<u>Yes</u>	<u>No</u>
1. Consider insulating the paint line wash tanks and piping to reduce heat loss or use cold solutions. Some plant operators estimate they have achieved up to 20% fuel reduction in metal pretreatment operations after insulating tanks. Evaluation: _ _ _ _ _ _ _ _ _ _		
2. Check whether process cooling water that is presently being discharged to a sewer can be rerouted as make-up water for the tanks. Evaluation: _ _ _ _ _ _ _ _ _ _		
3. Check whether washers should run during downtime periods, and mealtimes. Evaluation: _ _ _ _ _ _ _ _ _ _		

CHECKLIST - PROCESS TANKS

SHEET 2 of 5

DEPT OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

4. Can heat loss be reduced by floating plastic balls on top of the fluid in the tank?

Applies	
Yes	No

Evaluation: _____

5. Check whether steam condensate from tank heating coils can be piped to a power spray washer.

Evaluation: _____

6. Check whether steam condensate from tank heating coils can be rerouted and recovered with a heat exchanger.

Evaluation: _____

7. Determine whether there is a formal shutdown procedure for the plating tanks. Namely, the temperature reduction and the amount of rinse water left running.

Evaluation: _____

CHECKLIST - PROCESS TANKS

SHEET 3 of 5

DEPT OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

	<u>Applies</u>	
	<u>Yes</u>	<u>No</u>
8. Can the temperature of any of the tanks be reduced without impairing productivity? Evaluation: _____ _____		
9. Determine whether the washer can be eliminated by selecting a paint compatible with the lubricant being cleaned from the part. Evaluation: _____ _____		
10. Can the temperature of any of the washers be reduced with the use of low temperature detergents? Evaluation: _____ _____		
11. Minimize leaks, overflow and other fluid losses from heated process or rinse tanks. Evaluation: _____ _____		

CHECKLIST - PROCESS TANKS

SHEET 4 of 5

DEPT OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ _ BAY _ _ _ _

12. Can the overflow from the rinse tank be used as make-up water for the wash tank?

Applies	
Yes	No

Evaluation: _ _ _ _ _

13. Check whether the wash tank overflow can be passed through a heat exchange to preheat the make-up water.

Evaluation: _ _ _ _ _

14. Cover all heated tanks when not in actual use.

Evaluation: _ _ _ _ _

15. Heavy parts degreasing is normally done in one of four ways: steam cleaning, high pressure washing, cold solvent wash, or hot vapor degreasing. Investigate the fifth and fairly new process of foam cleaning. A foam compound is sprayed on the item, left for about 15-30 minutes, and washed off. The process is far less energy intensive than steam cleaning and

CHECKLIST - PROCESS TANKS

SHEET 5 of 5

DEPT OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ _ _ BAY _ _ _ _ _

Applies	
Yes	No

normally less energy intensive than high
pressure washing.

Evaluation: _ _ _ _ _

16. Often compressed air is bubbled through the
fluid in the tanks to provide agitation.

Consider installing times to cycle the air flow,
rather than have a continuous flow of air
bubbles.

Evaluation: _ _ _ _ _

17. If compressed air is bubbled through the fluid
in the tanks, consider the use of a high
pressure blower in lieu of throttling high
pressure compressed air.

Evaluation: _ _ _ _ _

6.2 PAINT BOOTHS AND TUNNELS

6.2.1 INTRODUCTION

Spray-finishing facilities range in size from one or several booths or tunnels, to entire aircraft hangers. Typically, outdoor air is filtered, heated, humidified, and delivered to one end of the area, flows across the work to remove entrained mist, passes through a mist-capturing device, and is exhausted to the outside. Newer facilities may provide for some recirculation of air (up to 60%) although this is relatively rare. Large quantities of air are required, since air flow is usually about 100 ft. per minute. Consequently, heating and humidification costs are considerable, and the opportunity for energy conservation is large.

6.2.2 SPRAY FINISHING FACILITIES

The conditions required for the particular spray process are usually determined from OSHA requirements and specifications provided by Process Engineering. These will include minimum air flow, temperature, and humidity limitations for each operation performed in the facility.

In the paint mixing/storage areas, minimum ventilation must be provided on a continuous basis (per OSHA requirements), with additional ventilation, such as hood exhaust for paint-mixing, provided only during the actual activity. For maximum effectiveness, these systems should be as automatic as possible. Flow sensors in spray apparatus will be utilized to initiate full air flow and turn on the water fall when sprayings

tarts. Sensors will then turn off waterfalls and reduce ventilation for initial drying when spraying ceases. Rotary-timed switches will operate hood exhaust for 30 minute periods for paint-mixing activities.

6.2.3 RESOURCES FOR A SURVEY

Data Collection Forms	.6.2-3
Sample Calculation-Paint Spray Booth.	.6.2-6
Data Analysis Sheet	.6.2-3
Check Lists	.6.2-8

Where Applicable:

Compressed Air.	7.1
Process Air: Heating, Ventilating and Exhaust Systems.	7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications provided by the facility process engineers. Heat from the loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements	Appendix B.4

Review of instrumentation, data gathering, and calculations.

Fans and Electric Motors	Appendices F&E

Proper operating operating schedules as well as sizing and speeds can offer energy savings.

Air Compressors.	Appendix H

Important to consider when dedicated (exclusively for the paint booths and tunnels) air compressors are used.

DATA COLLECTION - PAINT SPRAY

Sheet 1 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____

1. EQUIPMENT:

_____ Water-wash spray booth (located in spray room)
 _____ Water wash spray tunnel (or plant floor, one end
 wall made up of filter pads.
 _____ Dry-type spray booth with baffles or filter pads.
 Approximate dimensions at walk-in opening ____ ft x ____ ft

2. OPERATING REQUIREMENTS:

Temperature _____ deg. F, Relative Humidity _____ percent

3. AIR FLOW

Supply Source: _____ Plant Air, _____ Outdoor Air.

Flow Rate: Supply Air Fan _____ cfm
 Booth _____ cfm
 Make-up from plant _____ cfm

4. OPERATING SCHEDULE

Day	Operating Hours	Equipment Shutdown	
		When Unloaded	At End of Shift
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____

CONDUCTED BY _____ DATE _____

DATA COLLECTION - PAINT SPRAY

Sheet 2 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____ ITEM: _____

ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____

ACTIVITY _____ LOCATION FL _____ BAY _____

5. AUTOMATIC CONTROLS

Air Temp _____, Relative Humidity _____

Supply Fan: Damper _____ Speed _____

Exhaust Fan: Damper _____ Speed _____

Water Wash Pumps _____

Fans and water flow automatically controlled by flow
sensor in spray apparatus _____

6. HEAT RECLAIM SYSTEM:

7. POSSIBLE SAVINGS

Compare the data collected with the checklist.

Consider the applicable data analysis forms in Section
7.2, and Appendices E, F and G.

CONDUCTED BY _____ DATE _____

6.2.4 SAMPLE CALCULATIONS-PAINT SPRAY BOOTH

Estimate the amount of heat required for a paint spray booth using 100% outside air during a 21 week heating season. The flow rate is 15,000 cfm and the booth operates 16 hours a day, 5 days a week. The average outdoor temperature is 40°F and the discharge temperature of the make-up air is 80°F. How many BTU's are required? How many gallons of oil (140,000 BTU/gal) are required if the efficiency of the heating system is 60 per cent?

Preliminary Calculations

Specific heat of air = 0.24 BTU/lb-°F

Density of air = 0.075 lb/cubic ft.

$$0.24 \times 0.075 \times 60 \text{ /min/hr} = 1.08 \frac{\text{BTU-min}}{\text{hr-cubic ft-°F}}$$

T_M = Temperature of make-up air

$$T = (T_M - T_A)$$

T_A = Temperature of ambient air

$$\text{then: cfm} \times 1.08 \times \Delta \text{ temp} = \text{BTU/hr}$$

Sample Calculations

Heating requirements

$$\text{cfm} \times 1.08 \times \Delta \text{ temp} = \text{BTU/hr}$$

$$15,000 \times 1.08 \times (80-40) = 648,000 \text{ BTU/hr}$$

then:

$$21 \text{ weeks} \times 5 \text{ days/week} \times 16 \text{ hrs/day} \times 648,000 \text{ BTU/hr} = 1.088 \text{ million BTU}$$

Fuel requirements

$$\frac{1,088,000,000 \text{ BTU}}{140,000 \text{ BTU/gal} \times 0.6} = 12,950 \text{ gallons}$$

NOTE: the fan power requirements must also be considered.

CHECKLIST - PAINTING SYSTEM SHEET 1 of 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____ ITEM: _____

ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____

ACTIVITY _____ LOCATION FL _____ BAY _____

Before evaluating specific painting systems it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

1. Check booth velocity carefully to avoid over exhausting. Consider using electrostatic spray since this usually permits a reduction of booth velocity of about 40%.

Evaluation: _____

2. Consider the installation of an automatic damper in the paint spray booth stack to shut off the air flow when no painting is taking place.

Evaluation _____

3. Reduce spray booth make up air temperature to 65°-68°. Use outdoor air if possible, with heat recovery as necessary.

Evaulation: _____

Applies	
Yes	No

CHECKLIST - PAINTING SYSTEM SHEET 2 of 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____ ITEM: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____

Applies	
Yes	No

4. Consider heat recovery equipment, such as heat pipes", in spray booth stacks. If heat recovery equipment is used, a regular maintenance program is required to minimize heat losses caused by paint residue build up.

Evaluation: _____

5. Be sure all air filters are kept clean.

Evaluation: _____

6. Consider use of airless spray instead of air spray paint application. While it requires about 9.5 hp to atomize 1 gpm using air spray, it requires about 1.3 hp to atomize 1 gpm using airless spray. Airless spray is particularly suited to large, heavy work pieces that must be painted in place, such as heavy equipment, barges, structural steel, ships, cranes, etc.

Evaluation: _____

7. Investigate conversion to water base painting materials. Water base usually cuts energy consumption by reducing spray booth air flow, oven exhaust, air makeup requirements, and oven times. In some cases, finishing lines have reduced total natural gas consumption up to 45%.

Evaluation: _____

6.3 PAINT DRYERS AND OVENS

6.3.1 INTRODUCTION

Areas controlled to temperature levels to accommodate processes, are often much higher than is necessary for the process. For example, paint drying time is reduced when the surrounding air temperature is raised. This phenomenon is particularly true for the older enamels. The new two-part epoxy and polyurethane paints will cure well at lower temperatures. Paint hanger temperature can be reduced from the traditional 85°F to 70°F for drying with little increase in drying time and huge annual energy saving. Paint preparation areas (i.e., stripping, steam cleaning, anodizing, and masking) might be controlled to no more than 70°F during the heating season. For specific data concerning drying time/temperature consult paint manufacturers' literature.

6.3.2 RESOURCES FOR A SURVEY

Data Collection Forms	.6.3-3
Data Analysis Sheet	.6.3-5
Check Lists	.6.3-6

Where Applicable: (Paint Dryers and Ovens)

Process Air; Heating, Ventilating and Exhaust Systems. . 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements and facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the feasibility of such a system.

Air Flow Measurements Appendix B.4

Review of instrumentation, data gathering, and calculations.

Fans and Electric Motors Appendix F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Heat Treat Furnaces/ovens Appendix G

For ovens, items on the data collection sheets such as surface temperatures, operation cycles and floor dimensions are useful in analyzing cycle efficiency and insulation improvement.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness of the equipment often requires the use of the generalized forms. The forms are found in Appendix K.

Data Collection Form K-3

Sketch Sheet K-4

Data Analysis Form K-5

DATA COLLECTION - DRYING OVENS

SHEET 1 of 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

1. EQUIPMENT:

Electric Gas Fired Oil Fired . . .

Approximate Rating: KW . . . cfm . .gpm

Dimensions: ft x ft x ft.

2. TEMPERATURES: deg F

Ambient, Plant Area: deg F

Oven Operating Temperature: deg F

Outside Oven Wall Temperature deg F

3. TYPES OF PAINTS;

Primers Enamel, ...

4. OPERATING SCHEDULE:

<u>Day</u>	<u>Operating Hours</u>	<u>No. of</u> <u>Batches</u>	<u>Percent</u> <u>Loaded</u>
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____
_____	_____ am to _____ pm	_____	_____

CHECKLIST - DRYING OVENS

Sheet 1 of 6

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____

ENERGY CONSERVATION AUDIT SHOP NO.: _____ I-D NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

5. AUTOMATIC CONTROLS

Temperature Process Timers

Electric Demand Interlocks

Automatic Warm-up

Automatic Exhaust Fan Controls

6. OVEN EXHAUST SYSTEM

Intake: Plant Air, Outside Air

Flow Rate: (If Available cfm)

7. HEAT RECLAIM SYSTEM

.

8. POSSIBLE SAVINGS

Compare the Data Collected with the Checklist.

Consider the applicable data forms in Section 7.2

and Appendices E, F and G.

CHECKLIST - DRYING OVENS

Sheet 1 of 6

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _ _

Before evaluating specific paint dryers and ovens or drying operations it is desirable to refer to the following checklist. Although no form applying to each point is presented in this guide a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. If batch ovens are used, maximize loading and optimize working hours for highest energy efficiency. Similarly, minimize warm up time as much as possible.

Evaluation: _ _ _ _ _

_ _ _ _ _

2. Consider installation of oil fired paint ovens instead of gas fired. New oven technology can minimize paint discoloration and soot problems if a light, low sulfur (1%), oil is used.

Evaluation: _ _ _ _ _

_ _ _ _ _

CHECKLIST - DRYING OVENS

Sheet 2 of 6

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

3. Consider installation of direct fired paint oven instead of indirect fired. The heat transfer coefficient for direct fired is about 97% versus 60% for indirect fired, with comparable differences in fuel consumption.

Evaluation: _ _ _ _ _
_ _ _ _ _

4. Investigate converting paint ovens to the "Raw Oven Exhaust Recycle Process". This system returns part of the oven exhaust back to the oven after passing through an incinerator.

Evaluation: _ _ _ _ _
_ _ _ _ _

5. Conduct fuel gas analysis on burners at least once per year.

Evaluation: _ _ _ _ _
_ _ _ _ _

CHECKLIST - DRYING OVENS

Sheet 3 of 6

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYesNo

6. Investigate installing electric ovens instead of gas or oil fired. Higher operating costs are somewhat offset by better temperature control, constant one-fuel operation, and more readily controllable over atmosphere.

Evaluation: _ _ _ _ _
_ _ _ _ _

7. Consider heat recovery equipment, such as "heat pipes", in bake oven stacks. If heat recovery equipment is used, a regular maintenance program is required to minimize heat losses caused by paint residue build up.

Evaluation: _ _ _ _ _
_ _ _ _ _

CHECKLIST - DRYING OVENS

Sheet 4 of 6

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

8. Consider additional paint oven wall insulation. Doubling the present thickness (usually only 2") will cut wall losses in half. Since most paint oven heat is lost through oven roofs, this portion in particular should be well insulated.

Evaluation: _ _ _ _ _

_ _ _ _ _

9. If applicable, consider, converting to high intensity infra-red curing which uses as little as 10% of the energy required for a comparable gas fired oven.

Evaluation: _ _ _ _ _

_ _ _ _ _

CHECKLIST - DRYING OVENS

Sheet 5 of 6

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

AppliesYes No

10. Check that prime paint oven temperature is not higher than necessary.

Evaluation: _ _ _ _ _

11. Investigate changing to a primer that requires a lower bake temperature.

Evaluation: _ _ _ _ _

12. Investigate switching from conventional finishes to low temperature curing coating, such as urethanes. Oven temperature can often be reduced from 350°F to as little as 150-180°F. Often, only a partial tack free oven cure is required. Final curing takes place at room temperature.

Evaluation: _ _ _ _ _

CHECKLIST - DRYING OVENS

Sheet 6 of 6

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

13. Investigate conversion to water base painting materials. Water base usually cuts energy consumption by reducing spray booth air flow, oven exhaust, air makeup requirements, and oven times. In some cases, finishing lines have reduced total natural gas consumption up to 45%.

Evaluation: _ _ _ _ _

14. Consider the feasibility of using a water base paint that allows the dipping of wet phosphated parts into paint tanks.

Evaluation: _ _ _ _ _

15. Investigate conversion to airless paint drying from conventional oven baking. This system holds oven oxygen content to as low as 1%, with resulting reductions in oven exhaust and gas requirements.

Evaluation: _ _ _ _ _

6.4 CHILLING WELL

6.4.1 INTRODUCTION

Chilling wells are used as soaking pits for parts. It is one element in a process that develops special mechanical properties in the parts.

The wells are open pits in the plant floor. This allows an overhead crane to move, raise and lower parts and sheets in and out of the pit. Cold air is circulated within the well on a continuous basis.

Scheduling and Operating Temperature. If the operating temperature of the pit is, for example zero degrees F determine how high the temperature can rise during unused periods and produce savings!

Pit covers. Presently pit covers do not appear feasible on the larger units. They must be insulated properly and structurally capable of frost loading. Furthermore, the covers must be easily stored during unused periods.

6.4.2 RESOURCES FOR A SURVEY

Data Collection Form and Analysis	6.4-2
Refrigeration Plant Data	8.4.4
Checklist	8.4.12

DATA COLLECTION - CHILLING WELL Sheet 1 of 1

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ I-D NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

1. DIMENSION: . . . ft deep x . . . ft long x . . . ft wide

2. TEMPERATURES

Ambient, Plant Area, ... degrees F

Pit Operating Temperature degrees F

3. MATERIAL

Material chilled inches

Maximum thickness of material

4. SCHEDULE OF PIT TEMPERATURES NON-SOAKING HOURS

Weekdays: pm to am deg F

Weekends: pm to am deg F

5. REFRIGERATION SYSTEM

	Motor	Estimated Operating
<u>Location</u>	<u>Size, HP</u>	<u>Hours Per Day</u>
Compressor		
Pit Fans		
Cooling Tower		
		

6. POSSIBLE SAVINGS; Consider programmed pit temperature changes during unloaded pit conditions. During the testing provide recorders on the motors to determine if real savings are occurring.

CONDUCTED BY _____ DATE _____

6.5 HEAT TREATING

6.5.1 INTRODUCTION

Ovens and heat treat furnaces vary considerably in size and shape, and may be heated electrically or by gas or by steam for lower temperature ovens. Heat losses from furnaces and ovens occur by conduction through the walls and by poorly fitting doors and other leakage paths. Old furnaces and ovens with damaged insulation should be repaired or completely insulated with materials having higher "R" factors, a measure of thermal resistance. Applying additional insulation over the metallic outer skin of an oven or furnace is not recommended as a fix because the temperature rise can result in thermal distortion and rupture of the skin. Leakage at door seals and other openings can result in a significant energy loss; much of this can be avoided by routine (annual) inspection and maintenance as dictated.

Salt Baths are usually maintained at constant temperatures. Hence, the amount of insulation, the fit of the tank covers, and the duty cycle become important factors in energy conservation.

6.5.2 OVENS AND HEAT TREAT FURNACES

Ovens and furnaces are frequently allowed to run when not actually in use simply because it is convenient to do so. The time during which any furnace or oven is heated should be minimized, using the latest start-up and earliest

shutdown times consistent with scheduling requirements. It is often possible to shutdown for prolonged periods by adopting batch processing. Automatic timers are generally recommended for ovens.

To reduce thermal losses, additional insulation may be added to the interior of the furnace wall over existing firebrick or other refractory using new fibrous or cellular materials applied with mechanical fasteners and/or adhesives. Manufacturers literature should be consulted for specific installation criteria. Insulation cannot be added to the outside of a furnace, because exterior shell temperatures, normally about 140°F, could be raised several hundred degrees, resulting in excessive thermal expansion and furnace failure. Door seals are critical and a procedure of scheduled maintenance, to replace seals before visible breakdown, is recommended.

Ventilation requirements may vary considerably, depending on the nature and quantity of the vapor or fumes given off. Exhaust should be reduced to the minimum necessary to control area pollutants and excess heat. A canopy hood located 3 to 4 feet above a furnace door is more efficient than a general area exhaust fan. Consideration should be given to recovery of the waste heat by an appropriate heat exchanger for utilization in other applications; e.g., space heating, hot water, preheating

furnace combustion air, etc. Heat treat furnaces and ovens usually operate above 650°F. There are many equipment classifications. Some are:

Direct internal fired - oil or gas burners

Indirect internal fired (radiant tube furnace).

Direct external fired recirculation gas.

Special atmosphere furnaces.

Induction treat furnaces.

Induction treating furnaces.

Dielectric heating furnaces.

Electric coil ovens and furnaces.

6.5.3 SALT BATHS

Salt baths are tanks, heated electrically or by gas, containing a melted salt at approximately 1000°F, usually for solution heat-treating of aluminum. The salt bath is generally maintained at operating temperatures on a continuous basis. Therefore, the tanks should be well insulated, with a close-fitting insulated cover. It is imperative for energy conservation that cover seals be in good condition and that the cover fits tightly. Specific ventilation for control of air contaminants is generally not required. It may be possible to lower the bath temperature during periods of non-use of one or more days. Extreme care must be exercised to prevent the temperature from falling so low that the salt recrystallizes,

since the remelting process requires considerable time and energy. The recommended procedure for determining potential savings is to monitor the duty cycle (energy input) of the bath at operational temperature then shut down the furnace and closely monitor the temperature decay. At the end of the anticipated shut-down period, or before, if lower temperature limit is approached, restart the heaters and monitor duty cycle as the temperature returns to normal. For example, a typical salt pot heater may be rated at 200 KW, and operate at a 25% duty cycle while maintaining 1000°F. The temperature of the salt bath may decay to 600°F in a 24-hour period, which for our example, is 100°F above the melting point of the salt. It may require 6 hours to attain the operating temperature (1000°F), during which time our typical bath heater was on a total of 6 hours (duty cycle = 100%).

Savings are as follows:

$$200 \text{ KW} \times 25\% \times (24+6) - 200 \text{ KW} \times 6 = 1500 \text{ KWH} - 1200$$

$$\text{KWH} = 300 \text{ KWH.}$$

Yearly energy savings from 52 weekly 24 hour shutdowns will total 15,600 KWH, which at \$0.38 saves \$593.

6.5.4 RESOURCES FOR A SURVEY

Data Collection and Analysis Sheets

Ovens 6.5-7, Appendix G

Appendix J items on the data collection sheets such as wall surface temperatures and floor dimensions are useful in analyzing insulation improvement.

Heat Treat Furnaces Appendix G

Checklists 6.5-8

Where Applicable

Process Air: Heating, Ventilating and Exhaust

Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses.

Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements Appendix B.4

Review of instrumentation, data gathering, and calculations.

Fans and Electric Motors Appendix F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

MILCON Forms Section 10.8

Sample data on Calculations for a Heat
Balance on a Batch Furnace.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness of the equipment often requires the use of
the generalized forms. The forms are found in Appendix K.

Data Collection Form K-3

Sketch Sheet K-4

Data Analysis Form K-5

DATA COLLECTION - HEAT TREAT OVENS

SHEET 1 of 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO. _ _ _

I.D. NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

1. EQUIPMENT:

Electric Gas Fired . . .Oil Fired . . .

Approximate Rating: KW . . .cfm . . . gpm

Dimensions: ft x ft x ft.

2. TEMPERATURES: deg F

Ambient, Plant Area: deg F

Oven Operating Temperature: deg F

Outside Oven Wall Temperature deg F

3. TYPES OF PAINTS;

Primers Enamel, ...

4. OPERATING SCHEDULE:

<u>Day</u>	<u>Operating Hours</u>	<u>No. of</u> <u>Batches</u>	<u>Percent</u> <u>Loaded</u>
_ _ _ _	_ _ _ am to _ _ _ pm	_ _ _ _	_ _ _ _
_ _ _ _	_ _ _ am to _ _ _ pm	_ _ _ _	_ _ _ _
_ _ _ _	_ _ _ am to _ _ _ pm	_ _ _ _	_ _ _ _
_ _ _ _	_ _ _ am to _ _ _ pm	_ _ _ _	_ _ _ _

DATA COLLECTION - HEAT TREAT OVENS

SHEET 2 of 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

5. AUTOMATIC CONTROLS

Temperature Process Timers

Electric Demand Interlocks

Automatic Warm-up

Automatic Circulating Fan Controls

Automatic Exhaust Fan Controls

6. OVEN EXHAUST SYSTEM

Intake: Plant Air, Outside Air

Flow Rate: (If Available). cfm

7. HEAT RECLAIM SYSTEM

.

8. POSSIBLE SAVINGS

Compare the Data Collected with the Checklist.

Consider the applicable data forms in Section 7.2

and Appendices E, F and G.

CHECKLIST - HEAT TREAT OVENS

Sheet 1 of 4

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION AUDIT SHOP NO.: _____ I-D NO.: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific heat treat ovens or operations it is desirable to refer to the following checklist. Although no specific form applying to each point as presented in this guide a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. Determine whether furnaces can be turned off when there is no scheduled production. Consider whether starting and stopping the furnaces will harm production.

Evaluation: _____

2. Consider whether an automatic low-fire control is feasible when no parts are being heat treated.

Evaluation: _____

CHECKLIST - HEAT TREAT OVENS

Sheet 2 of 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

3. Check furnace for heat losses from casing, ducts, etc. Use _ infrared survey instrument, _ surface pyrometer, other _ _ _ _ _ for tests. Some hot spots may be due to loss of fire brick.

Evaluation: _ _ _ _ _
_ _ _ _ _

4. Check roof of furnace for insulation and determine if additional roof insulation is feasible.

Evaluation: _ _ _ _ _
_ _ _ _ _

5. Determine whether flue gas is being cooled with heated plant air. Consider the ducting of outside air for cooling the flue gas.

Evaluation: _ _ _ _ _
_ _ _ _ _

CHECKLIST - HEAT TREAT OVENS

Sheet 3 of 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

Applies

Yes

No

6. Heat recovery is at a maximum through the use of _ air preheater, waste heat recovery from stack, _ other,

specify _ _ _ _ _

Evaluation: _ _ _ _ _

_ _ _ _ _

7. Burners are inspected and maintained on a scheduled basis. Check whether existing burners are as efficient as available.

Evaluation: _ _ _ _ _

_ _ _ _ _

8. Furnace controls should include either _ a portable O₂ analyzer for furnaces over 25 to 50 million Btu/hr or _ automated combustion controls.

Evaluation: _ _ _ _ _

_ _ _ _ _

CHECKLIST - HEAT TREAT OVENS

Sheet 4 of 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

AppliesYesNo

9. Excess air should be monitored _
continuously, _ daily, weekly, _ monthly
to keep within the recommended range for
the fuel. Check furnace for air leaks.
Evaluation: _ _ _ _ _
_ _ _ _ _
10. Fuel oil atomization is optimum with fuel
oil supply at correct temperature _.
Atomizing steam is dry _, and at correct
pressure _ and minimum volume _. Air
atomization is used _.
Evaluation: _ _ _ _ _
_ _ _ _ _

6.6 MACHINE TOOLS (PROCESS MACHINERY)

6.6.1 INTRODUCTION

Machine tools (process machinery) includes all metal cutting and forming equipment from a drill press to a numerically controlled jig borer. Also included are wood working tools, structural and hydraulic test equipment, and powered hand tools. Although the combined total of all process machinery is seldom significant when compared with other categories of power users, it cannot be ignored without due consideration.

Pneumatic, electric and hydraulic tool selection will depend on the facilities available power source. However, there are advantages and disadvantages associated with each type. Pneumatic tools: can vary speed from maximum to stall, are typically lighter and smaller, are highly reliable and simple to repair. Pneumatic tools are subjected to extremely hard usage and abuse resulting in accelerated wear. Electric tools require thorough maintenance or can be dangerous to operate. Hydraulic tools run quieter but require careful observation of hydraulic pumps, hoses and possible coupling failure.

6.6.2 DEVELOPING ENERGY CONSERVATION OPPORTUNITIES FOR MACHINE TOOLS.

Measuring actual power consumption for process machinery is not a practical approach for vast manufacturing areas. Nameplate data along with loading factors and duty cycle will permit estimating power used.

Many of the metal fabricating processes are low power consumers and therefore are not candidates for energy saving modifications. The discipline of shutting off machines in this category, when not in use, is generally good. One related function which often yields energy saving is ventilation air flow used to exhaust contaminated air from work area. Frequently exhaust fans are allowed to run when the machines are not operating and even when work areas are unoccupied. Correcting this problem is not easy because it is usually not obvious when an exhaust fan is on or off. One method which has been used successfully is to interlock exhaust fan motor start/stop functions with fabricating machinery switchgear.

6.6.3 RESOURCES FOR A SURVEY

Data Collection Forms 6.1-3

Data Analysis Sheet 6.1-5

Checklists 6.1-6

Where Applicable:

Compressed Air 7.1

The checklist, particularly when air is used for agitation, or cleaning dies.

Process Air: Heating, Ventilating and Exhaust

Systems 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses.

Process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements. Appendix B.4

Review of instrumentation, data gathering, and calculations.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness of the equipment often requires the use of the generalized forms. The forms are found in Appendix K.

Data Collection Form K-4

Sketch Sheet K-5

Data Analysis Form K-6

CHECKLIST - MACHINE TOOLS

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

Before evaluating specific machine tool it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	Consider, for a grinding operation, different (smaller) water cooling nozzles: Evaluation: _ _ _ _ _ _ _ _ _ _		
2.	Determine if equipping a press or other machine tool with an automatic shutdown switch when it is idle for more than 10 or 20 minutes, would be feasible. Evaluation: _ _ _ _ _ _ _ _ _ _		
3.	Install solenoid valves on machine air lines so that air is used only when the machine is productive. Evaluation: _ _ _ _ _ _ _ _ _ _		
4.	The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or		

CHECKLIST - -MACHINE TOOLS

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I-L NO.: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _

AppliesYes No

individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity.

Evaluation: _ _ _ _ _
_ _ _ _ _

5. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is

known not to exceed that load, determine the true horsepower requirements. This will yield a power factor improvement when the motor is replaced with a smaller one.

Evaluation: _ _ _ _ _
_ _ _ _ _

6. If a motor or group of motors runs lightly loaded most of the time yet full power is needed occasionally, it (they) usually cannot be replaced

CHECKLIST - MACHINE TOOLS

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

with smaller ones. Consider a motor capacitor or capacitor for the group.

Evaluation: _ _ _ _ _

_ _ _ _ _

7. Often compressed air must be bubbled through soluble machining oil. Consider installing timers to cycle the air flow, rather than have a continuous flow of air bubbles.

Evaluation: _ _ _ _ _

_ _ _ _ _

8. Determine whether a continuous stream of compressed air is necessary to blow scale and dirt from the dies on a mechanical power press.

Consider installing cams or solenoids to produce short blasts of air.

Evaluation: _ _ _ _ _

_ _ _ _ _

6.7 CHEMICAL MILLING OPERATIONS

6.7.1 INTRODUCTION

Chemical milling is a process applied to the manufacture of structural parts used in the aerospace industry. It is used where conventional machinery and forming methods are too difficult to be practical. Chemical milling selectively reduces the thickness of a part, by the immersion of the work piece in a liquid-chemical bath and the resulting dissolving of the exposed metal. The process is not new since it is basically controlling surface etching. What is important is its production capability.

6.7.2 THE STEPS IN THE PROCESS

There are five steps in the process:

- a. cleaning the workpiece
- b. masking - applying a protective coating over the areas of the workpiece that is not to be etched.
- c. scribing - removing any masking material from the material removal areas of the workpiece.
- d. etching - removing the material from the workpiece by immersing it in a solution.
- e. demasking - removing the residual masking material.

6.7.3 TANKS AND EQUIPMENT

The tanks and equipment will vary from installation to installation. The reader should review Section 6.1, Process Tanks, particularly the following articles:

6.1.1 Introduction

6.1.2 Vapor Degreasers

6.1.3 Chemical Process Lines

The unique tanks in the line will be the etching tanks. The energy conservation team should recognize that the system usually is designed with operator safety as the first priority and the cost of heat and process chemicals lost by evaporation as a minor priority.

Furthermore, the etching tanks must have a reliable heat source. The dissolved material in an etchant can precipitate as a result of the drop in temperature, and can be extremely difficult to remove from the tank.

An installation for a titanium chemical milling plant could contain the following:

Cleaning Line:

De-scaling tank (hot caustic)

Rinse

Hydrofluoric - nickle pickle tank

Rinse

Drying Tank

Chemical - Milling Line:

Etching Tank

Rinse Tank

Second Etching Tank (depending on the amount of chemical
milling)

Both lines will also have fume extraction equipment.

6.7.4 RESOURCES FOR A SURVEY

Data Collection Forms

Tanks 6.1-7

Tanks 6.1-8

Estimating Heat Losses

From Tanks 6.5

Data Analysis 6.1-19

Checklist 6.1-21

Where Applicable:

Compressed Air 7.1

The checklist, particularly when air is used
for agitation.

Process Air: Heating, Ventilating and Exhaust

Systems 7.2

Exhausting conditioned (heated or cooled)
process air usually accounts for large energy
losses. Process air flow specifications are
determined from OSHA requirements facility
process engineers. Heat from the exhaust is
often recovered with run-around-loop systems.
A number of equipment manufacturers offer
computer programs to determine the economic
feasibility of such a system.

Air Flow Measurements. Appendix B.4

Review of instrumentation, data gathering and
calculations.

Pumps and Electric Motors Appendices D&E

Fans and Electric Motors Appendices F&E

Proper operating schedules as well as sizing and speeds
can offer energy savings.

Air Compressors Appendix H

Important to consider when dedicated (exclusively for the
tanks) air compressors are used.

6.8 WELDING, BRAZING AND FLAME CUTTING

6.8.1 INTRODUCTION

Welding, Brazing, and Flame Cutting is often categorized with machine tools (process machinery). The uniqueness of some of the processes, welding in particular, warrants this special category.

6.8.2 RESOURCES FOR A SURVEY

Process Air: Heating, Ventilating and Exhaust

Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses.

Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements. Appendix B.4

Review of instrumentation, data gathering and calculations.

Fans and Electric Motors Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

6.8.3 DATA COLLECTION AND ANALYSIS FORMS

When additional items, such as those found on the checklist, are applicable then the generalized forms can be used.

Data Collection Form K-3

Sketch Sheet. K-4

Data Analysis Form K-5

CHECKLIST - WELDING SYSTEMS SHEET 1 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _
 ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _
 ACTIVITY _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _

Before evaluating specific welding systems it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

SYSTEMS

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	Investigate converting torch cutting equipment fuel from acetylene, natural gas, or propane to methylacetylene propadiene, stabilized (MAPP). This gas may result in the improved performance, higher cutting speeds, and reduced oxygen consumption. Discuss with welding engineer or vendor's representative. Evaluation: _ _ _ _ _ _ _ _ _ _		
2.	If applicable, consider utilizing seam welding (RSEW) instead of coated electrode metal arc welding (SMAW), metallic inert-gas welding (GMAW), or submerged arc welding (SAW). The process is also less energy intensive than most other applicable welding processes. Evaluation: _ _ _ _ _ _ _ _ _ _		
3.	Consider utilizing electronic precipitators to "scrub" welding exhaust fumes and thereby eliminate building exhaust with its attendant heat loss, or investigate bag type filters. Evaluation: _ _ _ _ _ _ _ _ _ _		

CHECKLIST - WELDING SYSTEMS SHEET 2 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _
 ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _
 ACTIVITY _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _
SYSTEMS

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
4.	Install solenoid valves on welder or water-cooled welding equipment supply lines to limit cooling water flow to actual welder-operating periods. Evaluation: _ _ _ _ _		
5.	Consider the installation of smoke detectors to control welding exhaust fans. Evaluation: _ _ _ _ _		
6.	If welding shop workload varies widely, investigate ordering new transformer-type welders with built-in power factor correcting capacitors. Evaluation: _ _ _ _ _		
7.	Investigate the installation of automatic cutting torches, which normally operate at maximum speed, thus yielding maximum cutting for minimum gas consumption. Their cutting speed and accuracy can often replace more energy-intensive alternative manufacturing methods. Evaluation: _ _ _ _ _		

CHECKLIST - WELDING SYSTEMS SHEET 3 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____
SYSTEMS

	Applies	
	Yes	No
8. Consider operating automatic cutting torches on natural gas or propane instead of acetylene. Acetylene has a higher flame temperature than normally required for steel cutting. Evaluation: _____ _____		
9. Be sure gas welding equipment connections and hoses are tight. Leaks of waste expensive gas are fire hazards. Evaluation: _____ _____		
10. Investigate using high frequency induction heating for brazing operations instead of hand-held torch or a furnace. Evaluation: _____ _____		
11. Replace continuous pilot lights for gas welding torches with conventional flint lighters. Evaluation: _____ _____		
12. Be careful to avoid over-welding, either during design or fabrication. Refer to applicable standards. Evaluation: _____ _____		

CHECKLIST - WELDING SYSTEMS SHEET 4 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _
 ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _
 ACTIVITY _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _
SYSTEMS

	<u>Applies</u>	
	<u>Yes</u>	<u>No</u>
13. Use flame gouging instead of chipping hammers to remove tack welds, full welds, defects, blow holes, or sand inclusions. Consider using flame deseaming or scrafining instead of chipping hammers to remove cracks, seams scabs, and crowsfeet. Hot scarfing can clean up forgings without the cooling and reheating required by chipping. Evaluation: _ _ _ _ _		
14. In general, transformer-type arc welders are more energy efficient than motor-generator welders. At full rated load, transformer-type welders will consume slightly less power than a comparable motor-generator welder. At partial or no load, however, motor generator efficiency and power factor drop appreciably. Evaluation: _ _ _ _ _		
15. Investigate "stack cutting" with automatic cutting torches. In many cases, a thicker cut uses proportionately less oxygen per piece than a thinner cut. Cutting accuracy is a maximum below 2" total thickness and gradually deteriorates until the normal maximum cutting thickness of 6" is attained. Evaluation: _ _ _ _ _		

CHECKLIST - WELDING SYSTEMS SHEET 4 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: _____
 ACTIVITY _____ LOCATION FL _____ BAY _____

SYSTEMS

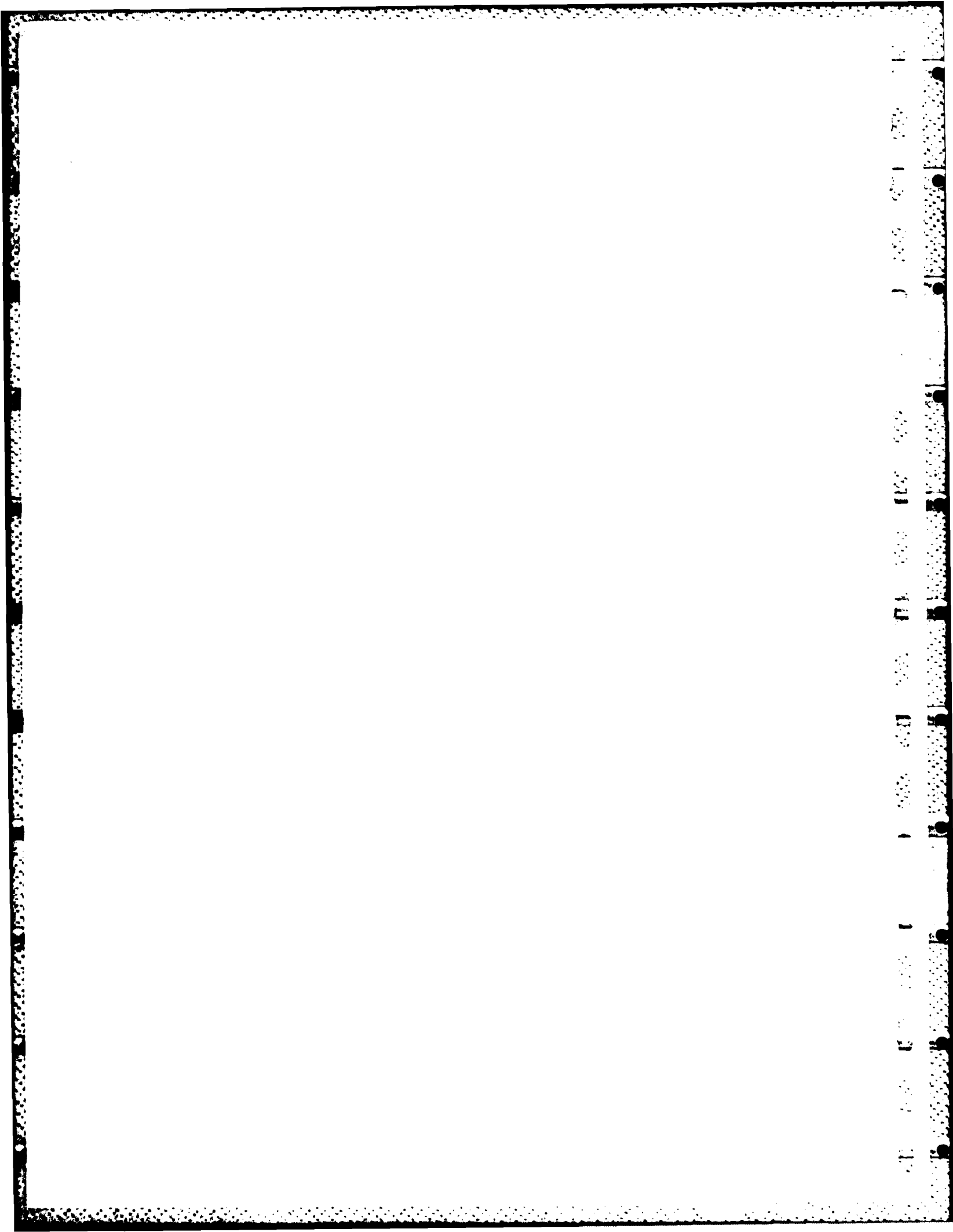
Applies	
Yes	No

16. Shut down transformer type and motor-generator arc welders when not in use and during breaks and lunch. Savings will be minimal with transformer type welders, but will become increasingly significant when motor-generator welders are stopped.

Evaluation: _____

17. Be sure unused automatic torches are turned off when not in use. Avoid excessive idle time.

Evaluation: _____



6.9 FOUNDRY

6.9.1 INTRODUCTION

The foundry at a shipyard might contain furnaces, corebake ovens, casting machines, grinders, sand blast equipment, melt pots, etc. Energy conservation efforts usually are in the areas of operation and scheduling.

The typical foundry likely to be found in a naval rework facility would contain one or more spot or crucible furnaces for the melting of lead and/or zinc for use in making molds. The major potential for energy reduction usually lies in the area of minimizing exhaust of conditioned plant air. Ventilation requirements for molten metal and fluxes must be determined, and minimum ventilation rates established. If the furnace is gas-fired, a separate gas flue may not exist, especially if it is a tilting crucible. In such cases, installation of a separate flue should be considered, particularly if the hood or canopy exhaust can safely be turned off. Zinc mold compounds, such as Kirksite, may not require ventilation, if non-fuming fluxes are used and temperatures do not become excessively high. Lead-pots, however, will require instant ventilation when heated, since lead vapor is a cumulative, systemic poison. Shutdown of melting furnaces for weekends and holiday periods should be studied carefully, since

long melt-times and various metallurgical problems may result. Covers are, of course, generally desirable to minimize surface heat loss.

6.9.2 RESOURCES FOR A SURVEY

Process Air: Heating, Ventilating and Exhaust

Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses.

Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements. Appendix B.4

Review of instrumentation, data gathering and calculations.

Fans and Electric Motors Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Where Applicable

Heat Treat Furnaces and Ovens Appendix G

MILCON Forms Section 10.8

Sample Data and Calculations for a Heat on a Batch Furnace

ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS

Sometimes, the uniqueness of the equipment requires the use of generalized forms. The forms are found in Appendix K.

Data Collection Form	.K-3
Sketch Sheet	.K-4
Data Analysis Form	.K-5

CHECKLIST - FOUNDRY

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _

Before evaluating specific equipment within the foundry or foundry operations it is desirable to refer to the following checklist.

Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. Determine whether it is feasible to preheat ingots or materials in the flue sections of reverbatory furnaces.

Evaluation: _ _ _ _ _

2. Consider the use of Hi-Low firing systems in forging furnaces to reduce the temperature during idle periods.

Evaluation: _ _ _ _ _

3. Furnace controls should include either -- a portable O₂ analyzer for furnaces over 25 to 50 million Btu/hr or -- automated combustion controls.

Evaluation: _ _ _ _ _

_ _ _ _ _

CHECKLIST - FOUNDRY

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

AppliesYes No

4. Excess air should be monitored -- a --
continuously, -- daily, -- weekly, --
monthly to keep within the recommended range
for the fuel. Check furnace for air leaks.

Evaluation: _ _ _ _ _

5. Check furnace for heat losses from casing,
ducts, etc. Use -- infrared survey
instrument, -- surface pyrometer, --
other _ _ _ _ _
for tests. Some hot spots may be due to
loss of fire brick.

Evaluation: _ _ _ _ _

6. Burners are inspected and maintained on a
scheduled basis. Check whether existing
burners are as efficient as available.

Evaluation: _ _ _ _ _

CHECKLIST - FOUNDRY

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

7. Fuel oil atomization is optimum with fuel oil supply at correct temperature -- . Atomizing steam is dry -- and at correct pressure -- and minimum volume -- . Air atomization is used

Evaluation: _ _ _ _ _

8. Heat recovery is at a maximum through the use of -- air preheater, waste heat recovery from stack, -- other, specify _ _ _ _ _ .

Evaluation: _ _ _ _ _

6.10 ENGINE TEST FACILITIES AND STATIONARY ENGINES.

6.10.1 INTRODUCTION

The large amount of heat rejection from aircraft engines during production testing as well as the heat rejected by stationary engines at a facility suggests that this energy should be put to some useful end.

6.10.2 ENGINE TEST CELLS

Engine testing consumes large energy rates for short duty cycles. To determine an annual consumption and typical duty cycle requires a review of engine test facility data sheets which will give time at all engine power settings and fuel flow at each setting. Typical time and fuel flow data for each engine type should be recorded on a unique data sheet. Exhaust gas data is not usually available as mass flow or volume flow and will be calculated using engine design data. A proposed data collection sheet is on page 6.10-3. Economic evaluation should follow the MILCON format, Section 10.8

6.10.3 STATIONARY ENGINES

Heat recovery from stationary engines is not new. However, at each installation, the economic justification must be carefully developed for heat recovery equipment. A data collection sheet is on page 6.10-5. A data analysis sheet is on page 6.10-6. Economic evaluation should follow the MILCON format, Section 10.8.

6.10.4 RESOURCES FOR A SURVEY

 Data Collection Forms

 Engine Test Cells 6.10-3

 Stationary Engines 6.10-4

 Data Analysis Sheets

 Stationary Engines 6.10-7

 Checklists 6.10-8

 MILCON Forms, Sample

 Data and Calculations 6.10.8

DATA COLLECTION STATIONARY ENGINES

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ I-D NO.: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ BAY _ _ _

ENGINE TEST CELLS-THERMAL DATA

BLDG. NO. _ _ _

(NOTE: EACH ENGINE TYPE REQUIRES ITS OWN DATA SHEET)

ENGINE DATA

TYPE ENGINE _ _ _ _ _

TULE FUEL USED _ _ _ _ _

EXHAUST GAS DATA

TEMPERATURE, FLOW RATE, AND VELOCITY

IDLE _ _ _ °F _ _ _ LB./SEC. _ _ _ FT./MIN.

MILITARY POWER _ _ _ °F _ _ _ LB./SEC. _ _ _ FT./MIN.

AFTER BURNER _ _ _ °F _ _ _ LB./SEC. _ _ _ FT./MIN.

NO. OF ENGINES TESTED PER YEAR PER TEST CELL _ _ _

FUEL QUANTITY USED PER ENGINE TEST _ _ _ GALS.

NUMBER OF TEST CELLS USED _ _ _

CONDUCTED BY _ _ _ _ _ DATE: _ _ _ _ _

DATA COLLECTION STATIONARY ENGINES

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

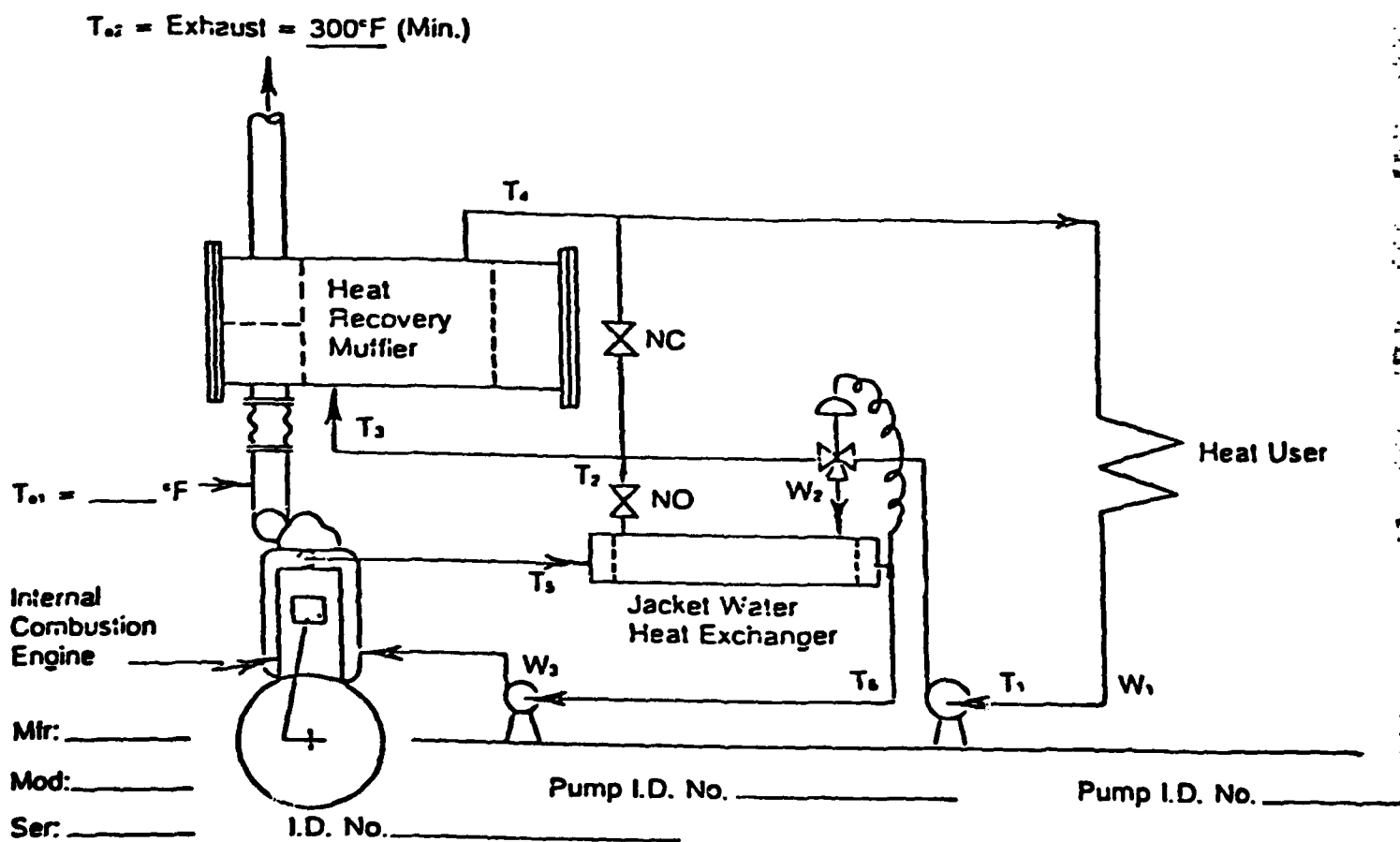
BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _



DATA COLLECTION STATIONARY ENGINES

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _

<u>Symbol</u>	<u>Item</u>	<u>Reading</u>
E1	Exhaust from engine	_ _ °F
E2	Exhaust from muffler	_ _ °F
T1	Return water	_ _ °F
T2	Jacket water temp at outlet	_ _ °F
T3	Water to muffler	_ _ °F
T4	Water from muffler	_ _ °F
T5	Water to jacket	_ _ °F
T6	Water from jacket	_ _ °F
W1	Heat recovery water	_ _ Gal/min x 500 = _ _ lb/hr
W2	Jacket heat recovery water	_ _ Gal/min x 500 = _ _ lb/hr
W3	Jacket water	_ _ Gal/min x 500 = _ _ lb/hr

OPERATING TIME: _ _ _ _ hrs/day _ _ _ _ hrs/wk _ _ _ _ hrs/yr

Heat Recovery Equipment: Jacket Water _ _

Exhaust Heat Recovery _ _

CONDUCTED BY _ _ _ _ _ DATE: _ _ _ _ _

DATA ANALYSIS - STATIONARY ENGINES

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _ _

EXHAUST HEAT RECOVERY:

Engine BHP = _ _ _ _ _

Constants: 1b Exhaust/BHP-hr = 13.

Specific Heat = 0.25 Btu/lb-°F.

$$\begin{aligned} \text{--- BHP} \times \text{---} \frac{\text{1b Exhaust}}{\text{BHP-hr}} \times \text{Sp. Ht} \times (T_{el} - 300^{\circ}\text{F}) &= \text{---} \frac{\text{Btu}}{\text{hr}} \\ \text{--- BHP} \times 13 \times 0.25 (\text{---} - 300) &= \text{---} \frac{\text{Btu}}{\text{hr}} \end{aligned}$$

JACKET WATER HEAT RECOVERY: Heat Exchanger Efficiency = Exe
(Est. 80%)

$$\text{JWHR} = W_3 \times (T_5 - T_6) \times \frac{\text{EXE}}{100} = W_2 \times (T_1 - T_2) = \text{---} \frac{\text{Btu}}{\text{hr}}$$

(where, W_2 and W_3 are expressed as lb/hr)TOTAL HEAT RECOVERY:

Exhaust Heat + Jacket Water Heat = Total Heat Recovered

$$\text{--- Btu/hr} + \text{--- Btu/hr} = \text{--- Btu/hr}$$

Cost of Heat = _ _ _ \$/MBtu, for engine fuel

$$\text{--- Btu/hr} \times \text{--- hrs/yr} \times \text{---} \frac{\text{\$/MBtu}}{\text{---}} = \text{---} \frac{\text{\$/yr saving}}{\text{---}}$$

ACTION PROPOSED: _ _ Heat Recovery Muffler _ _ Heat Exchanger
_ _ Other, Specify _ _ _ _ _

Estimated Cost of Equipment Installed: \$ _ _ _ _ _

PAYBACK TIME:

$$\frac{\text{\$/Year Heat Recovery Saving}}{\text{\$/Year Heat Recovery Saving}} = \text{---} \text{ yrs Payback Time}$$

CALCULATION BY _ _ _ _ _ DATE: _ _ _ _ _

CHECKLIST - STATIONARY ENGINES

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _

Before evaluating stationary engines or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes NoENERGY CONSERVATION OPORTUNITIES:

1. Diesel, gas, or gasoline fired engines are used as stationary prime movers _ _ _ or test run for substantial periods _ _ _ _
Evaluation: _ _ _ _ _

2. In addition to useful shaft work (30%-33%), such engines, provide waste heat recoverable from lubrication oil (3%-5%), jacket cooling water (22%-32%), and exhaust (22%-30%). This waste heat is recoverable as hot water or low pressure steam.
Evaluation: _ _ _ _ _

3. Economic recovery depends on: _ _ _
substantial running time, _ _ _ _ uses for the recovered heat, economic justification based on life-cycle cost compared t heat sources, and _ _ _ other considerations such as safety and reliability.
Evaluation: _ _ _ _ _

CHECKLIST - STATIONARY ENGINES

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _ _

Applies

Yes No

ENERGY CONSERVATION OPORTUNITIES:

4. Nearby heat uses are: _ _ _ hot water
(domestic), hot water (industrial), _ _ _ hot
water or steam for absorption
refrigeration, _ _ _ low pressure steam
line, _ _ _ hot water recovery sump, _ _ _
other _ _ _ .
Evaluation: _ _ _ _ _
_ _ _ _ _

6.11 WASTE OIL PROCESSING

6.11.1 INTRODUCTION

The use of waste oil as a potential energy recovery area primarily depends upon the quantity available for reprocessing. Typical sources for waste oil are used engine crankcase lubrication oil, used machine cutting oil, and substandard or contaminated aircraft fuels.

The cost of the oil refinement equipment (purifiers, centrifuges) could result in a cost/benefit ratio that would discourage any capital investment in this effort. Each area would have to be self-evaluated to determine the potential available. Used engine crankcase oil is currently being burned on a trial basis in some boilers normally utilizing No. 6 fuel oil with little processing other than coarse filtration. One positive feature is that waste oil can be collected on a "when-available" basis and the refinement process can be based on a minimum accumulation.

6.11.2 A PLAN FOR DATA COLLECTION

Tabulate all liquid waste sources from your facility.

Evaluate the largest waste sources first, because these have the largest potential for savings and for energy generation.

Indicate the location of each waste. Consider its closeness to a possible energy need, or existing furnace.

6.11.3 ITEMS TO CONSIDER IN ANALYZING THE DATA

The data analysis sheet is a tool to evaluate each waste stream. It should be reproduced as many times as necessary to evaluate all waste streams.

Identify the process which produces the waste. This will provide clues to characteristics of the waste material that may not otherwise be identified.

Describe the location of the wastes, both source and collection point or storage.

When necessary, a complete analysis of the waste should be performed in order to determine its composition. If the analytical report is available, attach it to the form.

The moisture content of a waste has a profound effect on its combustibility. Waste containing over 50-percent water should be considered separately, and a complete analysis should be performed to determine available heat.

The ash content of a waste affects flame propagation and temperature. Too high an ash content will reduce combustibility. Ash disposal also poses a problem. As a rule, if the waste contains more than 50-percent ash, the economics of incineration are unfavorable; such cases should be considered separately.

Carefully consideration should be given to the possibility that the waste may contain explosive, toxic, corrosive, or other hazardous components that must be handled separately. (Refer to the Federal Register of 1 February 1978 for information on the Hazardous Waste Manifest System.)

The heating value should be determined in the analysis. If no analysis has been performed, the heating value should be estimated from Appendix B.

Measure or estimate the total amount of waste generated by the process in a year. Indicate also if the waste is generated in a constant flow or at what time intervals.

Before use, the combustibility should be tested by sending a sample to the manufacturer of the burner. Before mixing wastes with other wastes or with existing liquid fuels, a check of compatibility should be run in the lab.

DATA COLLECTION - LIQUID WASTE

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

<u>No.</u>	<u>Material/Source</u>	<u>Location</u>	<u>Quantity/Year</u>	<u>Combustible?</u>
1	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
2	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
3	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
4	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
5	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
6	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
7	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
8	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
9	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
10	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
11	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
12	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
13	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
14	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
15	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
16	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
17	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
18	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
19	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
20	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _

CONDUCTED BY _ _ _ _ _ DATE _ _ _ _ _

DATA COLLECTION - LIQUID WASTE

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

LIQUID WASTE DATA:

Waste Number: _ _ _ _ _

Source(s): _ _ _ _ _

Location(s) _ _ _ _ _

Composition: _ _ _ _ _

(If know ingredient, otherwise
submit sample for analysis and
record below)

Analytical Data _ _ _ _ _

Density Lbs/Gal

Viscosity: SUS or CP @ _ _ _ °F

°F: Flash Point (Open Cup)

Combustibility Test:

Compatibility Test:

*Moisture: _ _ _ _ _ %

*Ash: _ _ _ _ _ %

Dangerous

Components: _ _ _ _ _

Heating Value: _ _ _ _ _ Btu/Gal

Amount of Waste Available: _ _ _ _ _ Gal/Yr.

*If moisture or ash exceeds 50 percent, do not proceed with the
calculation unless there is good reason to assume (by analysis
or otherwise) that it appears worthwhile.

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

DATA ANALYSIS - LIQUID WASTE

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

TOTAL AVAILABLE HEAT: _ _ _ _ _ Btu/Year

Approximate value of available heat vs present fuel
@ _ _ _ \$/gal

=
$$\frac{\text{Total available heat (Btu/Yr)}}{\text{Heating Value of present fuel (Btu/gal)}} \times \text{cost of present fuel (\$/gal)}$$

PRESENT DISPOSAL METHOD:

PRESENT DISPOSAL COST:

\$ _ _ _ _ _ per year

PRESENT SALE RECEIPTS:

\$ _ _ _ _ _ per year

Savings possible through on-site energy utilization:

Approximate value + disposal cost = \$ _ _ _ per year
or

Approximate value - sale receipts = \$ _ _ _ per year

Comment: If the waste liquid is being sold at a higher
value than its value as fuel, such sale should
be continued.

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

EVALUATION - LIQUID WASTE

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

<u>Waste No.</u>	<u>Name</u>	<u>Available Heat Btu/Yr</u>	<u>Approx. Value \$/Yr</u>	<u>Disposal Cost \$/Yr</u>	<u>Total Savings \$/Yr</u>
1	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
2	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
3	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
4	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
5	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
6	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
7	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
8	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
9	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
10	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
Totals		_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

CHECKLIST - LIQUID WASTE

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ BAY _ _ _

Before evaluating specific liquid waste and handling operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. Lubricating oils should be sampled and tested to establish whether they are ready for replacement. Apply testing to reservoirs of about 25-gal capacity and up.

Evaluation: _ _ _ _ _

2. Used lubricating oils may be recovered by draining and collecting until a large enough quantity is obtained when the oil can be processed by heating, settling, dehydrating, filtering, and use of the restoring additives.

Evaluation: _ _ _ _ _

SECTION 7

7.1 AIR COMPRESSORS

7.1.1 INTRODUCTION

Compressors which supply shop process air are usually large energy consumers. Compressor drive motors typically range in size from 75 to 500 horsepower. The compressors are often multistaged piston type with unloading valves. Electric power consumed by these motors is high for all load conditions due to high no-load losses in the compressors. Typically the motor will draw about 40% of maximum rated power when the compressor is supplying zero flow. Air generating/distribution systems often have several compressors feeding a common manifold and all too often there is more capacity on line than is required, resulting in much wasted energy. This inefficiency is the result of high mechanical losses in the compressors and also the power needed to supply internal leakage losses.

7.1.2 COMPRESSOR SCHEDULING

Ideally shop air compressors should be automated to detect low manifold pressure and then start-up as required. Many industrial sites allow "standby" compressors to operate in case the flow demand should exceed the capacity of one

machine. This practice is wasteful. A 250 hp motor "idling" at a 40% power draw, no compressor flow situation, will cost about \$25,00/year with power priced at \$0.38KWH. "No Load" data should be developed for all large compressors.

When process areas are not inhabited, the air compressors supplying these areas should be shut down. Applications requiring low pressure control air, such as HVAC control systems, should be run from small, dedicated air compressors.

7.1.3 DETECTING AIR DISTRIBUTION SYSTEM LEAKAGE

Leaky air distribution systems also waste power. One of two methods are usually used to detect system leakage. Both rely on the collection of data during non-working hours when there is no compressed air demand.

One method is outlined in Appendix H. The percent of time a compressor runs during non-working hours at full-load, 3/4 load, etc. is determined and the estimated air leakage is calculated. The data collection requirements are shown in Appendix H, sheet H-2. The data analysis is shown on sheet H-5.

7.1.4 HEAT RECOVERY

Heat recovery systems must be carefully developed to make certain they are compatible with the compressors specifications. A data collection sheet is shown on sheet Appendix H, Sheet H-3. A data analysis sheet is shown on sheet H-6. Economic evaluation should follow the MILCON format, Section 10.8.

7.1.5 RESOURCES FOR A SURVEY

Data Collection Forms

Air Compressor Appendix H, H-1,
H-2, H-3

Electric Motor Appendix E, E-3

Data Analysis Sheet

Air Compressor Appendix H, H-5,
H-6

Electric Motor Appendix E, E-4,
E-5

Checklists

Air Compressor 7.1-5

Electric Motors E-11

CHECKLIST - AIR COMPRESSORS SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific air compressors it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	Consider using a high pressure blower in lieu of compressed air for drying, or the agitation of a fluid in a tank. Evaluation: _____ _____		
2.	Instead of using evaporative type towers to reduce the air compressor cooling water temperature, consider using a heat exchanger to preheat either boiler or process make-up water. Evaluation: _____ _____		
3.	Determine the minimum air pressure required on weekends and whether an operating change is warranted. Evaluation: _____ _____		

CHECKLIST - AIR COMPRESSORS SHEET 2 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

4. Consider installing chain operated valves on compressed air headers so they can be closed when off-shift, and thus reduce leaks.

Evaluation: _____

5. Consider installing timers on dessicant type air dryers to allow recharging cycles to more nearly follow actual needs.

Evaluation: _____

6. Consider the installation of a number of small satellite compressors to carry off-shift and week-end loads, and allow the main compressor to be shut down.

Evaluation: _____

CHECKLIST - AIR COMPRESSORS SHEET 3 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

7. The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity.

Evaluation _____

8. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one.

CHECKLIST - AIR COMPRESSORS SHEET 4 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

Evaluation _____

9. If a motor or group of motors runs lightly loaded most of the time yet full power is needed occasionally, it (they) usually cannot be replaced with smaller ones. Consider a motor capacitor or capacitor for the group.

Evaluation _____

7.2 PROCESS AIR: HEATING, VENTILATING AND EXHAUST SYSTEMS

7.2.1 INTRODUCTION

These systems are designed to handle large flow rates of air. Typical systems are concerned with paint stripping and cleaning, painting, and sanding. Depending on the process, the air might be drawn directly from the outside and passed through the area "untreated". Other processes will require heating humidification and sometimes cooling.

Exhausting process air accounts for more energy loss than most other causes. Exhaust flow rates in many industrial buildings far exceed the amount of make-up air which is normally supplied for employee comfort. As a result of these large exhaust flows from process fans, more make-up air must enter a building through leakage paths or from supply fans. This air is generally mixed with air in the temperature controlled zone and heated or cooled by the building HVAC system. For most industrial plants, more energy is wasted in the winter time when the heat load can be at an order of magnitude greater than it would be if no process air were exhausted. During warm weather, providing the building is not

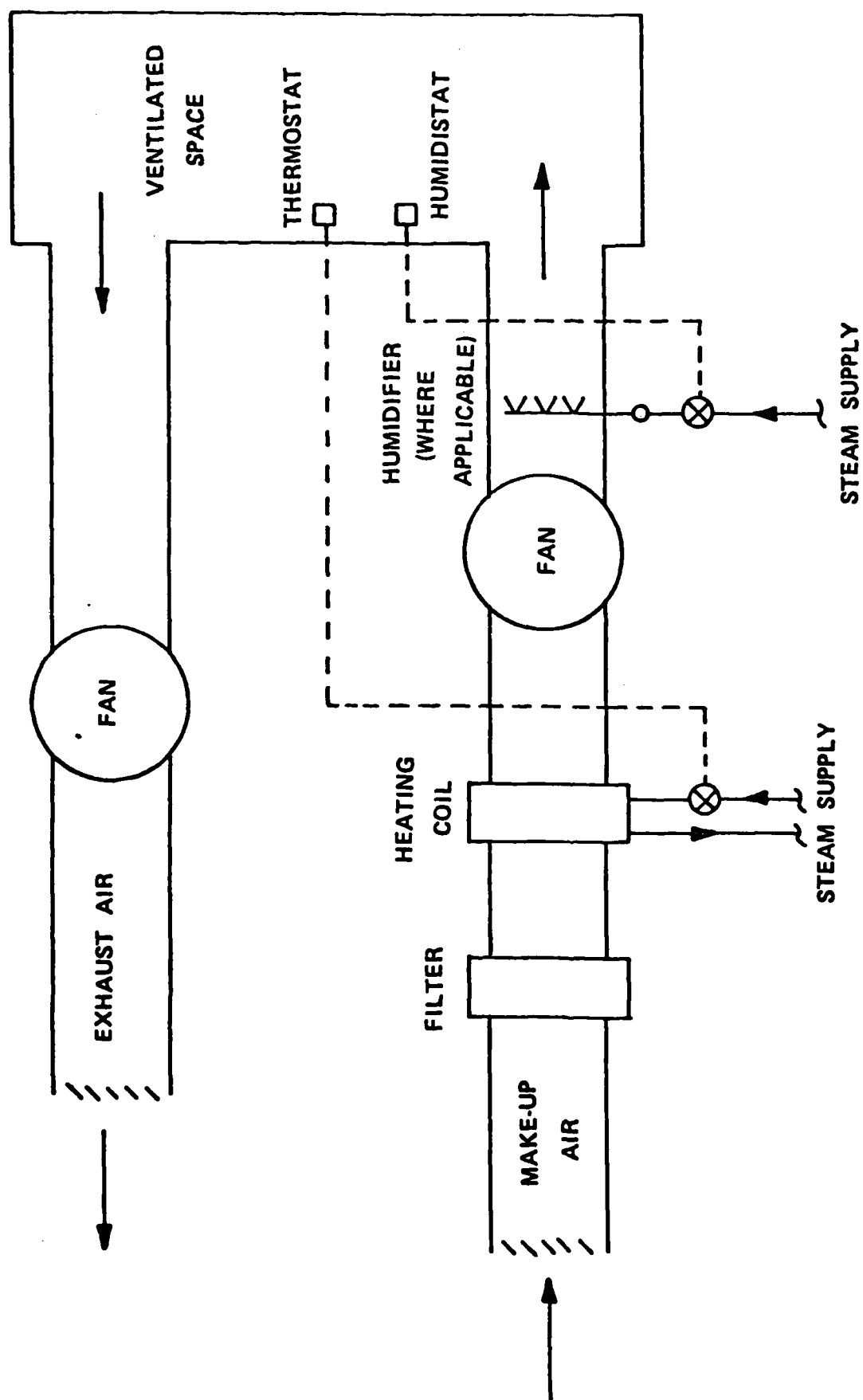
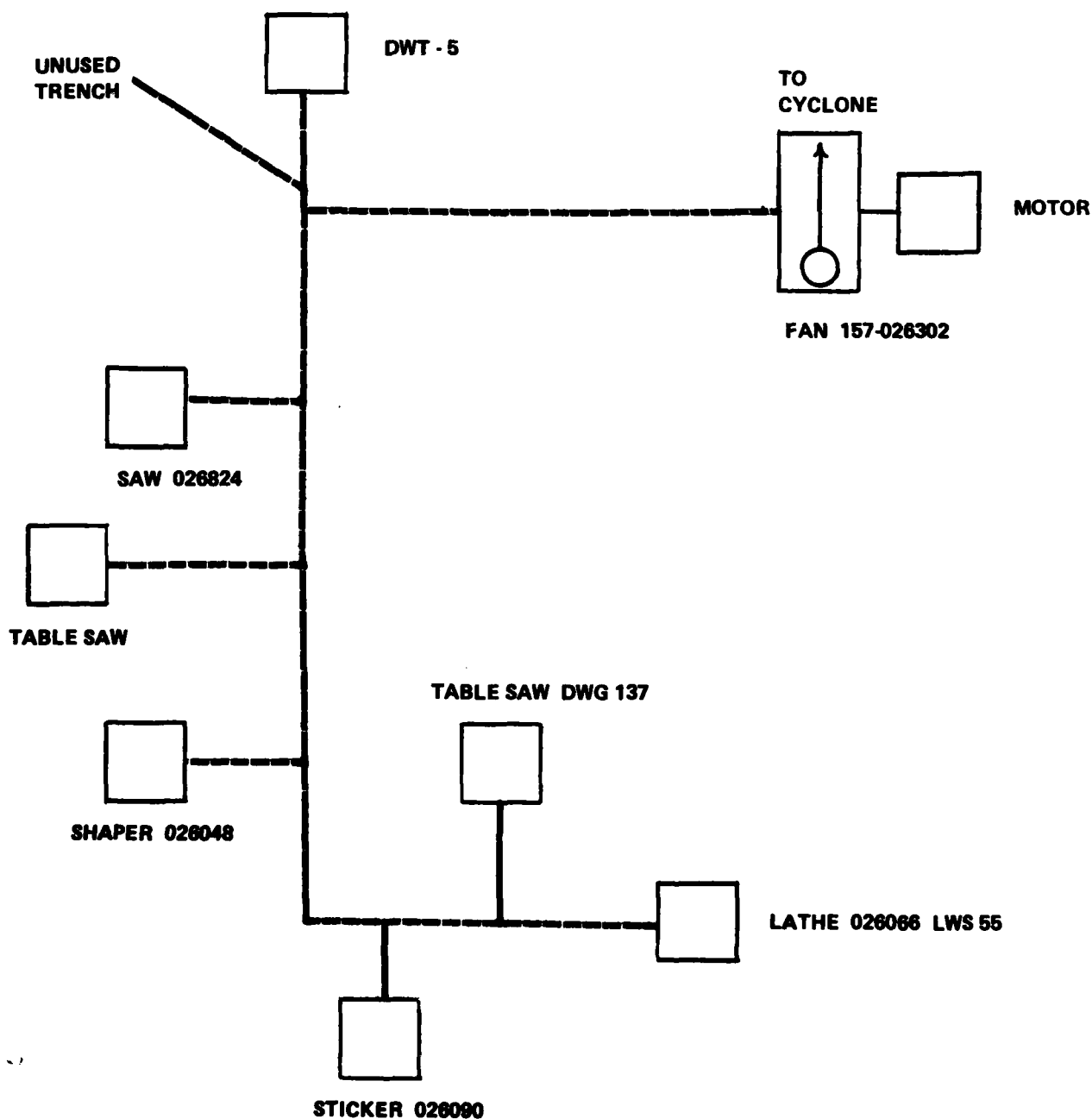


FIGURE 7.2-1
TYPICAL VENTILATING SYSTEM

Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.2-2

TYPICAL EXHAUST SYSTEM



SOURCE: Industrial Energy Field Survey Report, Philadelphia Naval Shipyard, Philadelphia, Pa., Atlantic Division, NAVFAC, 1979

cooled with mechanical refrigeration systems, energy loss due to exhausted process air decreases and is limited to the electric power used by the fan drive motors.

7.2.2 RESOURCES FOR A SURVEY

Data Collection Forms

Heating with 100% Outside Air . . 7.2-14

Cooling with 100% Outside Air . . 7.2-17

Data Analysis Sheet 7.2-20

Checklists 7.2-22

Where Applicable:

Electric Motors Appendix E

Air Compressors Appendix H

Computer programs have been developed by various organizations to aid in energy conservation analysis. The energy conservation team at a facility should review any programs that are available to determine if they will be effective at the facility as well as economical to run.

ANNUAL HEATING DEGREE-DAYS*

Anchorage, AK	10,864
Boston, MASS	5,634
Buffalo, NY	7,062
Charleston, SC	2,033
Chicago, ILL	5,882
Detroit, MI	6,232
Jacksonville, FLA	1,239
Los Angeles, CA	2,061
Memphis, TN	3,232
Milwaukee, WIS	7,635
Minneapolis, MN	8,382
New York NY	4,871
Norfolk, VA	3,421
Pittsburgh, PA	5,987
Portland, ME	7,511
St. Louis, MO	4,484
San Diego, CA	1,458
San Francisco, CA	3,015
Seattle, WA	4,424
Washington, DC	4,224

* For definition of Degree-Day Method refer to:

ASHRAE Handbook & Product Directory, 1976 Systems

FIGURE 7.2-2

In Figure 7.2-3 the energy used per year was determined as follows:

$\text{BTU/yr.} = (1000 \text{ cfm}) (\text{Degree Days/yr.}) (24 \text{ hr./day}) (1.08)$ Since degree days are based on 65°F, the other temperatures in the lower section of the figure are directly proportional to the 65°F line. The upper section proportions the hours of system operation with 168 hr./week being 100%.

Source: Guidelines for Saving Energy in Existing Building
ECM-1, FEA 1975

How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings - An Energy Conservation Manual, Noyes Data Corp., 1976

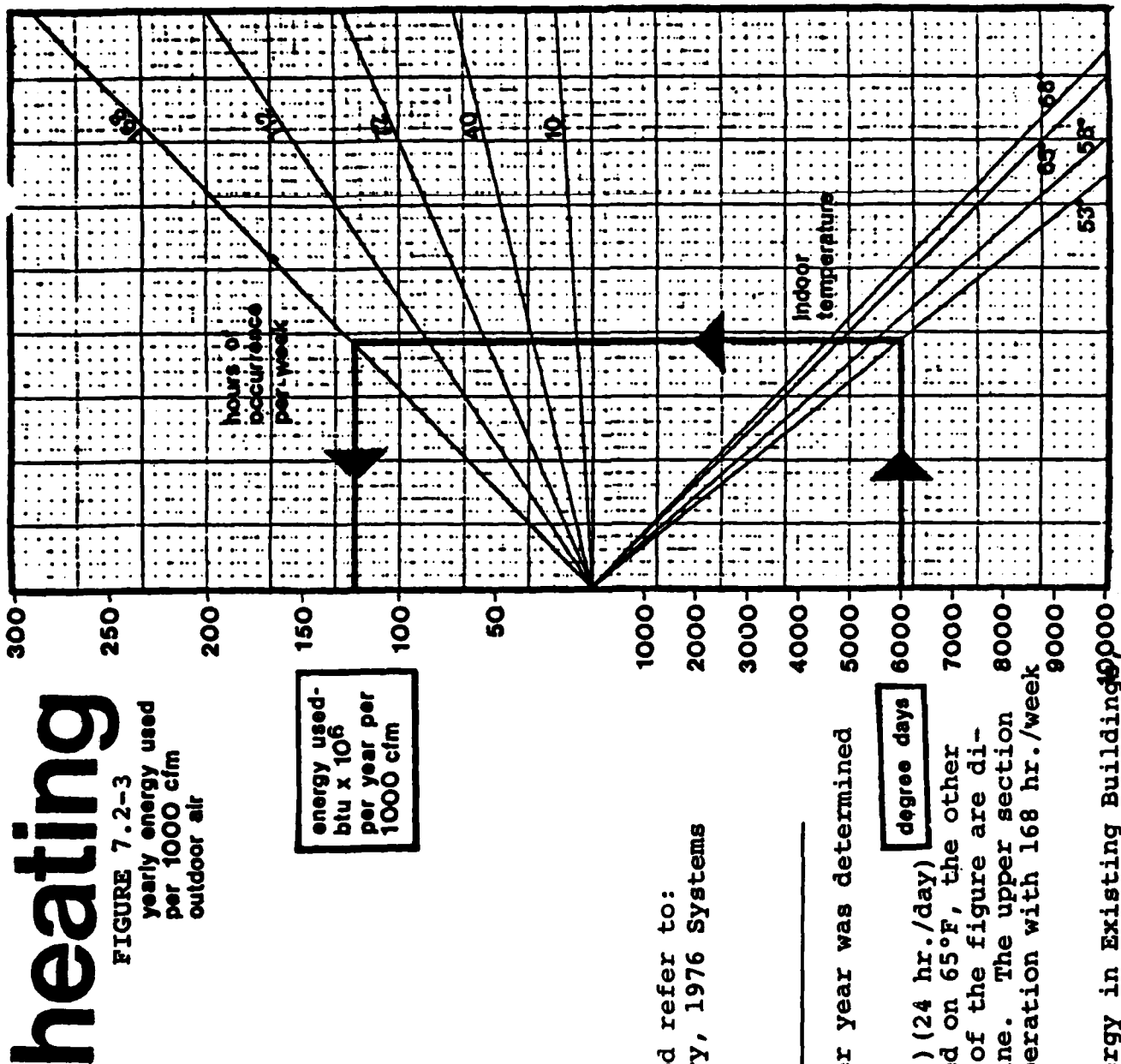
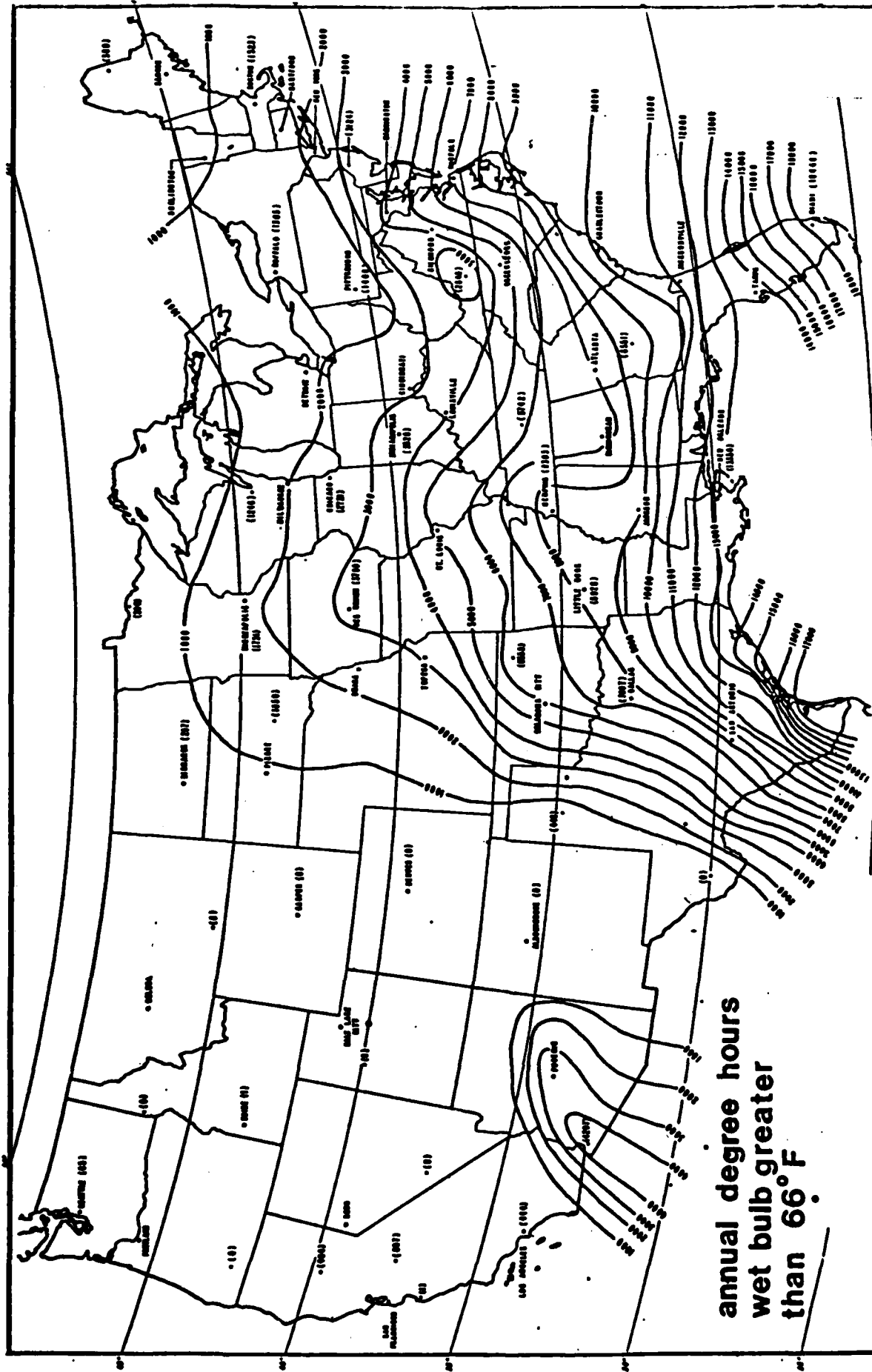


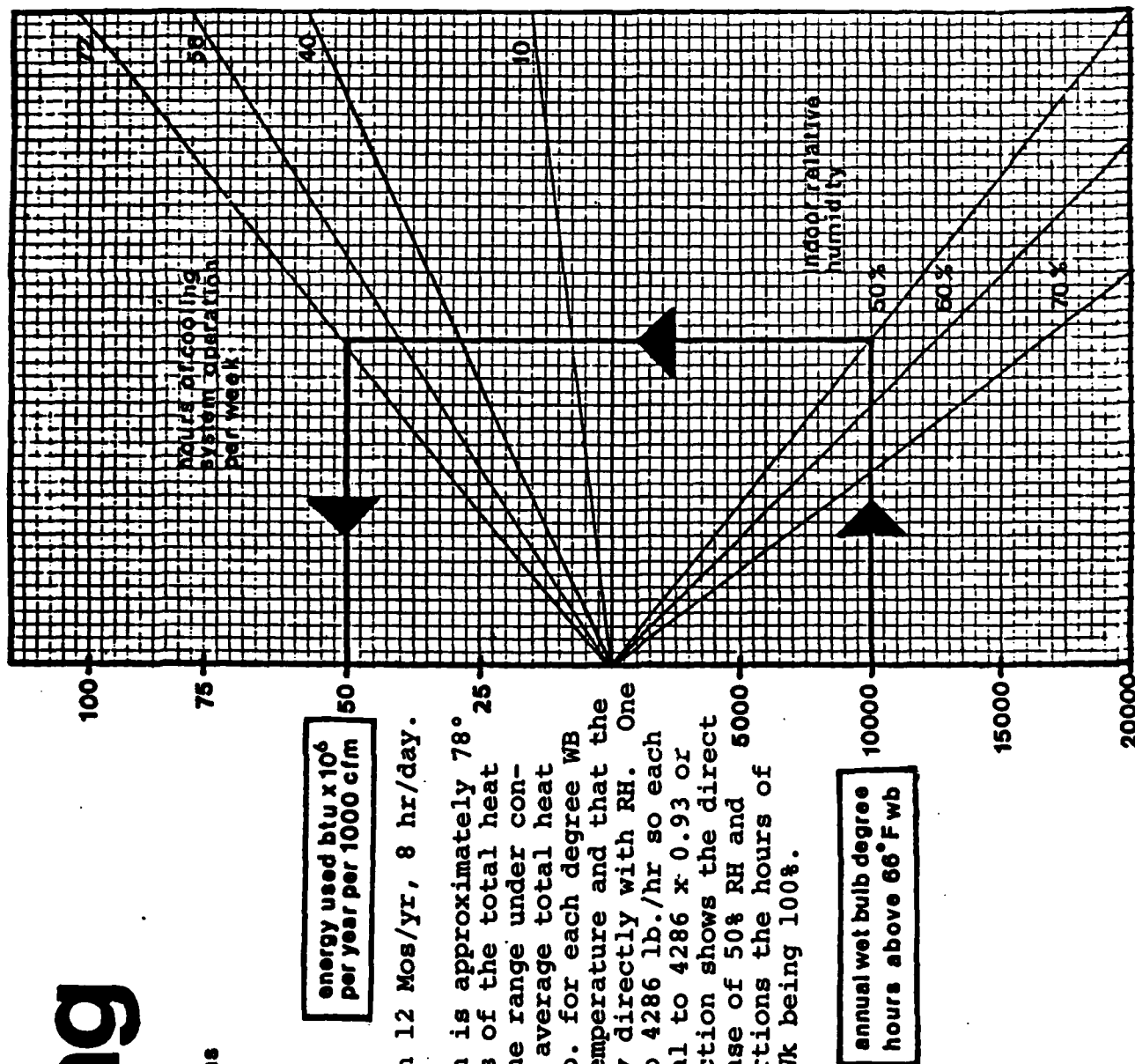
FIGURE 7.2-4



Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975
How to Save Energy and Cut Costs in Existing Industrial and
Commercial Buildings - An Energy Conservation Manual, Noyes Data Corporation, 1976

cooling

FIGURE 7.2-5
yearly energy used
per 1000 cfm to maintain
various humidity conditions



WB degree hours based on 12 Mos/yr, 8 hr/day.

The base RH is 50% which is approximately 78° DB, 66° WB. An analysis of the total heat content of the air in the range under consideration indicates an average total heat variation of 0.93 Btu/lb. for each degree WB change at constant DB temperature and that the total heat varies nearly directly with RH. One thousand CFM is equal to 4286 lb./hr so each degree F WB hour is equal to 4286 x 0.93 or 3986 Btu. The lower section shows the direct relationship from the base of 50% RH and 5000 the upper section proportions the hours of system operation 56 Hr/Wk being 100%.

Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975

How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings -
An Energy Conservation Manual, Noyes Data Corporation, 1976.

TABLE 7.2-1

RECOMMENDED AND MAXIMUM DUCT VELOCITIES DESIGNATION

DESIGNATION	RESIDENCES	SCHOOLS, THEATERS, PUBLIC BUILDINGS	INDUSTRIAL BUILDINGS
RECOMMENDED VELOCITIES, fpm			
OUTSIDE AIR INTAKES	700	800	1000
FILTERS	250	300	350
HEATING COILS	450	500	600
AIR WASHERS	500	500	500
SUCTION CONNECTIONS	700	800	1000
FAN OUTLETS	100-1600	1300-2000	1600-2400
MAIN DUCTS	700-900	1000-1300	1200-1800
BRANCH DUCTS	600	600-900	800-1000
BRANCH RISERS	500	600-700	800

DESIGNATION	RESIDENCES	SCHOOLS, THEATERS, PUBLIC BUILDINGS	INDUSTRIAL BUILDINGS
MAXIMUM VELOCITIES, fpm			
OUTSIDE AIR INTAKES	800	900	1200
FILTERS	300	350	350
HEATING COILS	500	600	700
AIR WASHERS	500	500	500
SUCTION CONNECTIONS	900	1000	1400
FAN OUTLETS	1700	1500-2200	1700-2800
MAIN DUCTS	800-1000	1100-1600	1300-2200
BRANCH DUCTS	700-1000	800-1300	1000-1800
BRANCH RISERS	650-800	800-1200	100-1600

Source: ASHRAE Handbook and Product Directory, 1960 Fundamentals.

7.2.3 SAMPLE CALCULATIONS/HEATING

Estimate the energy savings during the heating season when the operating hours of a ventilating system are changed. Develop a rough estimate using heating degree days as a guide.

The work space is located in Norfolk, Va. The space is conditioned to 68°F with 100% outside air. The ventilation system moves 55,000 cfm through the space. The supply air fan discharge static pressure is 1 inch of water. The exhaust fan operates on 3 phase power, 220 volts, approximately 27 amps. A sketch of the system resembles figure 7.2-1.

The fan had been operated 16 hours per day, 6 days per week. The new schedule is 10 hours per day, 5 days per week. The heating season is approximately 25 weeks. The efficiency of the heating system is approximately 75 per cent. Fuel Oil, No. 2, costs are estimated at \$0.75 per gallon, and electricity costs are estimated at \$0.06 per kilowatt-hour. Heating Degree Days, figure 7.2-3 are estimated at 3421.

Before the schedule change:

$$\text{Operating hours, per week} = 16 \frac{\text{hrs}}{\text{day}} \times 6 \frac{\text{days}}{\text{week}} = 96 \frac{\text{hours}}{\text{week}}$$

From figure 7.2-3, a determination of the approximate annual heating energy requirements per 1000 cfm of outdoor air is accomplished using Degree days, Fig, 7.2-3, indoor temperature, and hours of occurrence per week. After determining the degree-days, draw a horizontal line on fig. 7.2-3 to the desired space temperature. From that point draw a vertical line to the approximate hours of occurrence per week.

From that point draw a horizontal line to determine the energy used in millions of BTU's per year per 1000 cfm. The annual energy is estimated at 53,000,000 BTU per 1000 cfm.

From fig F.1 the electrical power requirements can be estimated. On the basis of 1000 cfm, a vertical line is drawn to the one-inch of water static pressure line. From that point a horizontal line is drawn to determine the annual Kwh. From fig F-1 the estimated electrical power for 8760 hours is 2000 Kwhrs per 1000 cfm for the supply fan.

The corrected power is:

$$\frac{25 \text{ weeks} \times 96 \text{ hrs per week}}{8760 \text{ hrs.}} \times \frac{2000 \text{ Kwh}}{1000 \text{ cfm}} \times 55000 \text{ cfm} = 30,140 \text{ Kwh}$$

The exhaust fan electrical power is estimated from the collected data and the motor load input equation, Appendix E, sheet E-4.

$$\text{Motor Load} = \frac{1.732 \times \text{Volts} \times \text{Amps} \times \text{P.F.}}{1000} \text{ KW}$$

$$\text{Motor Load} = \frac{1.732 \times 220 \times 27 \times .85}{1000} = 8.745 \text{ KW}$$

$$\text{Electrical Power} = 8.745 \text{ Kw} \times 25 \text{ wks} \times 96 \frac{\text{hrs}}{\text{WK}} = 20988 \text{ Kwh}$$

After the schedule change:

10 hrs. per day x 5 days per week = 50 hours per week.

From fig 7.2-3 annual heating energy used per year per 1000 cfm is estimated at 30,000,000 Btu.

For the supply fan:

$$\frac{50 \text{ hrs per week}}{96 \text{ hrs. per week}} \times 30,140 \text{ Kwh} = 15698 \text{ Kwh}$$

For the exhaust fan:

$$\frac{50 \text{ hrs. per week}}{96 \text{ hrs. per week}} \times 20988 \text{ Kwh} = 10931 \text{ Kwh}$$

Savings

Fuel:

System efficiency estimated at 70%

$$(53,000,000 - 30,000,000) = 23,000,000 \quad \frac{\text{Btu}}{1000 \text{ cfm}}$$

$$\frac{23,000,000 \text{ Btu}}{.7 \text{ (system eff.)}} \times \frac{1 \text{ gal}}{138,700 \text{ Btu}} = \frac{236.9 \text{ gallons}}{1000 \text{ cfm}}$$

$$55,000 \text{ cfm} \times \frac{236.9 \text{ gallons}}{1000 \text{ cfm}} = 13030 \text{ gallons}$$

$$13030 \text{ gallons} \times \frac{\$1.00}{\text{gallon}} = \$13,030$$

Electricity:

$$(30,140 + 20988) - (15698 + 10931) = 24,500 \text{ Kwh}$$

$$24,500 \text{ Kwh} \times \$0.06/\text{Kwh} = \$1470$$

7.2.4 SAMPLE CALCULATIONS/COOLING

Estimate the cooling energy savings when the operating hours of ventilation system are changed. Develop a rough estimate using "Annual Degree Hours Wet Bulb Temperature Greater than 66F", as a guide.

Workspace located in Charleton, South Carolina. The space is conditioned to a relative humidity of 50% with 100% outdoor air. The ventilation system moves 55,000 cfm through the space. The supply air fan discharge pressure is 1 inch of water. The exhaust fan operates on 3 phase power, 220 volts, approximately 27 amps.

The fan had been operated 16 hours per day, 6 days per week. The new schedule is 10 hours per day, 5 days per week. The cooling season is approximately 25 weeks. The mechanical refrigeration system has a coefficient of performance, COP, of 3.0. This means that for every Btu of energy used to run the equipment, 3.0 Btu's are extracted from the air stream. Electricity costs are estimated at \$0.06 per Kilowatt-hour.

7.2.4.1 Before the schedule change:

$$\text{Operating Hours, per week} = 16 \frac{\text{hrs}}{\text{day}} \times 6 \frac{\text{day}}{\text{week}} = 96 \frac{\text{hours}}{\text{week}}$$

From figure 7.2-5, a determination of the approximate annual cooling energy requirements per 1000 cfm of outdoor air is accomplished using Degree-Hours Wet Bulb Temperature Greater than 66F, the indoor relative humidity, and the hours of occurrence per week. After determining the annual wet bulb degree hours above 66F WB, draw a horizontal line on fig. 7.2-5 to the desired space relative humidity. From that point draw a vertical line to the approximate hours of cooling system operation per week. From that point draw a horizontal line to determine the energy used in millions of BTU's per year per 1000 cfm. The annual energy is estimated at 85,000,000 BTU per 1000 cfm.

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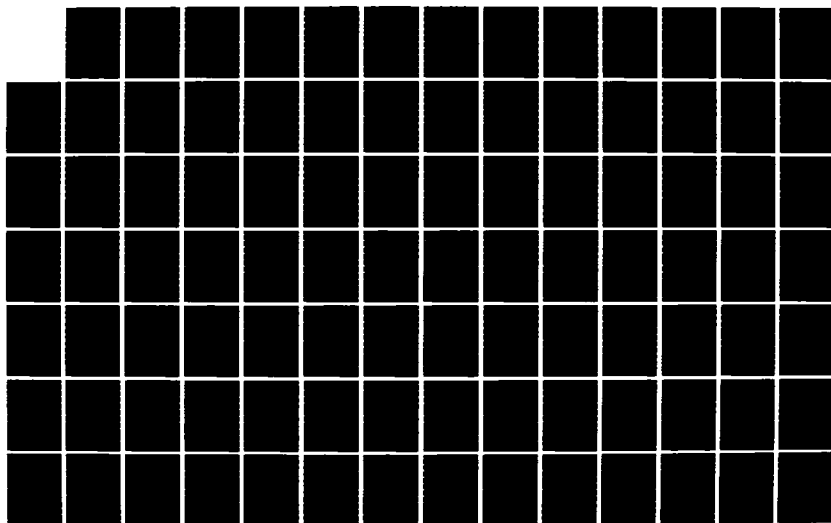
ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U)
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

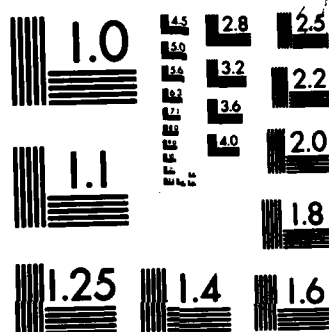
3/5

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The fan power is approximately the same as in the previous example, 7.2.3. Supply fan plus exhaust fan power is $10,140 + 20988 = 51,128$ Kwhr.

7.2.4.2 After the schedule change:

10 hrs. per day x 5 days per week = 50 hours per week. From figure 7.2-5 the cooling energy used is estimated at 35,000,000 BTU. The fan power is approximately the same as in the previous example, 7.2.3. Supply fan plus exhaust fan power is $15,698 + 10931 = 26,629$ Kwh

Savings:

Electricity, mechanical refrigeration system.

$$\frac{50,000,000 \text{ BTU}}{3.0 \text{ (system cop)}} \times \frac{1 \text{ Kwh}}{3414 \text{ BTU}} = 4881.8 \frac{\text{Kwh}}{1000 \text{ cfm}}$$

$$4.881.8 \frac{\text{Kwh}}{1000 \text{ cfm}} \times 5500 \text{ cfm} = 268499 \text{ KWH}$$

$$268499 \text{ Kwh} \times \frac{\$.06}{\text{Kwh}} = \$16,109$$

Electricity, fan power

Same as sample calculation for previous example, 7.2.3.

Electricity cost = \$1470

DATA COLLECTION

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ BAY _ _ _ _

VENTILATING SYSTEMS WITH HEATING

System: Heating with 100% outside air

Type of Estimate: Rough Estimate Using Heating Degree-Days

WORKSPACE CONDITIONING

	Zone Control, Temp, °F	Humidification, R. H.
Painting	_____	_____
Drying	_____	_____
Masking	_____	_____
Non-Working	_____	_____
Stripping	_____	_____
_____	_____	_____

HEATING COIL CAPACITY, BTU/hr.

PERCENT OF USEFUL SYSTEM LOADS

(A sketch is a valuable aid)

Fan capacity venting running equipment Approx. _ _ _ %

Fan capacity venting idle equipment Approx. _ _ _ %

DATA COLLECTION

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ ID NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

AIR FLOW EQUIPMENT(Collect Data for one of three groups below)Supply fanExhaust fan

GROUP I

Fan capacity _____ cfm _____ cfm

Static Pressure Discharge _____ in, H₂O _____ in, H₂O

GROUP II

Motor Voltage _____ volts _____ volts

Motor Line Current _____ amps _____ amps

GROUP III

Area of Duct _____ ft² _____ ft²

Air Flow* _____ ft/min _____ ft/min

Static Pressure Disch. _____ in, H₂O _____ in, H₂O

*If Air Flow cannot be measured use Table 7.2-1

ENERGY COSTS

Fuel Type _____, Cost: \$ _____/_____

System Heating Efficiency _____ %

Electrical, Cost: \$ _____/Kwhr

Estimated Motor Efficiency _____ %

DATA COLLECTION

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

OPERATING HOURS

_ _ _ _ hrs/day, _ _ _ _ hrs/week

Length of Heating Season _ _ _ _ weeks

DEGREE DAYS (65 Degree-Day Basis)

Weather Station Location _ _ _ _ _

Degree Days _ _ _ _ _

SKETCH SHEET (If needed) Use copy of sample sheet found in Appendix
K.

CONDUCTED BY: _ _ _ _ _ DATE _ _ _ _ _

DATA COLLECTION

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

VENTILATING SYSTEMS WITH COOLING

System: Cooling with 100% outside air

Type of Estimate: Rough Estimate Using Annual Degree Hours
with wet bulb temperature greater than 66F.

WORKSPACE CONDITIONS

	Zone Control Temp, °F	Humidification, R. H.
Painting	_____	_____
Drying	_____	_____
Masking	_____	_____
Non-Working	_____	_____
Stripping	_____	_____
_____	_____	_____

COOLING COIL CAPACITY, Btu/hr

DATA COLLECTION

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AIR FLOW EQUIPMENT

(Collect Data for one of the three groups below)

GROUP I

Supply fanExhaust fan

Fan capacity _____ cfm _____ cfm

Static Pressure Disch. _____ in, H₂O _____ in, H₂O

GROUP II

Motor Voltage _____ volts _____ volts

Motor Line Current _____ amps _____ amps

GROUP III

Supply FanExhaust FanArea of Duct _____ ft² _____ ft²

Air Flow* _____ ft/min _____ ft/min

Static Pressure Disch. _____ in, H₂O _____ in, H₂O

* If Air Flow cannot be measured use Table 7.2.1

ENERGY COSTS

Electrical, Cost: \$ _____ /Kwh.

Estimated Motor Efficiency _____ %

OPERATING HOURS

_____ hrs/day _____ hrs/week

Length of cooling season _____ weeks

DATA COLLECTION

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

OPERATING HOURS

_____ hrs/day _____ hrs/week

Length of Cooling Season _____ weeks

ANNUAL DEGREE HOURS WITH WET BULB

Weather Station location or nearest large city on Fig 7.2-6

TEMPERATURE GREATER THAN 66F

Degree hours with wet bulb temperature greater than
66F _____.

SKETCH SHEET (IF REQUIRED) Use copy of sample sheet found in
Appendix K.

CONDUCTED BY: _ _ _ _ _ DATE _ _ _ _ _

DATA ANALYSIS PROCESS AIR SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Note - Proposed Schedule Changes

Savings are often developed by:

- Modifying startup and shutdown schedules
- Finding open dampers at production equipment which is idle.

HEATING SAVINGS

	From Date Collection Sheet	Proposed Schedule Change
No. of Heating Degree Days	_____	_____
Approximate Control Temp.	_____	_____
No. of Operating Hours per Week	_____	_____
M BTU's/1000 CFM (Fig. 7.2-3)	_____	_____
M BTU's Saved/1000 CFM	XXXXXXXXXXXXXXXXXX	_____
Required CFM/1000	XXXXXXXXXXXXXXXXXX	_____
Total M BTU's Saved	XXXXXXXXXXXXXXXXXX	_____
Heating Energy Cost, \$/M BTU	XXXXXXXXXXXXXXXXXX	_____
Estimated Annual Savings	XXXXXXXXXXXXXXXXXX	_____

DATA ANALYSIS PROCESS AIR SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

FANS (ELECTRICAL POWER) SAVINGS

If data collected is found in:

GROUP I. Use Fig. H-1. Compare the number of actual running hours with 8760 hours and adjust the annual Kwh.

GROUP II. Motor, if over 5 hp is 3 phase. then Kwh = 1.732 x volts x amps x estimated power factor x no. of hrs. operated.

GROUP III. Find Kwh using GROUP I method.

ELECTRICAL SAVINGS

	From Date Collection Sheet	Proposed Schedule Change
<u>Supply Fan</u> Total KWH	_____	_____
Total KWH Savings	XXXXXXXXXXXXXXXXXX	_____
<u>Exhaust Fan</u> Total KWH	_____	_____
Total KWH Savings	XXXXXXXXXXXXXXXXXX	_____
Grand Total KWH Savings	XXXXXXXXXXXXXXXXXX	_____
Fan Operating Costs, \$/KWH	_____	XXXXXXXXXXXXXXXXXX
Estimated Annual Savings	XXXXXXXXXXXXXXXXXX	_____

CALCULATED BY: _____ DATE _____

DATA ANALYSIS PROCESS AIR (COOLING) SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Note - Proposed Schedule Changes

Savings are often developed by:

- a. Modifying startup and shutdown schedules
- b. Finding open dampers at production equipment which is idle.

	From Date Collection Sheet	Proposed Schedule Change
<u>COOLING SAVINGS</u>		
Annual Degree Hours, WB more than 66°F	_____	_____
Approximate Indoor Relative Humidity	_____	_____
No. of Operating Hours per Week	_____	_____
M BTU's/1000 CFM (Fig. 7.2-5)	_____	_____
M BTU's Saved/1000 CFM	XXXXXXXXXXXXXXXXXX	_____
Required CFM/1000	_____	_____
Total MBTU's Saved	XXXXXXXXXXXXXXXXXX	_____
MMBTU of Energy Required = <u>Total M BTU's Saved</u> <u>Refrig. System COP</u>	XXXXXXXXXXXXXXXXXX	_____
Kwh = <u>M BTU of Energy Req'd</u> 3414	XXXXXXXXXXXXXXXXXX	_____
Refrig. System Operating Costs, \$/Kwh	_____	_____
Estimated Annual Savings	XXXXXXXXXXXXXXXXXX	_____

*For Fans (Electrical Power) Savings use 7.2-21

CALCULATED BY _____ DATE _____
 7.2-22

CHECKLIST - PROCESS AIR

SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

Before evaluating specific air compressors it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	Shut down: process exhaust __, dust collection __, smoke and fume exhaust __ when not needed for: machine not running __, break time __, lunch time __, off hours __. Evaluation: _ _ _ _ _ _ _ _ _ _		
2.	Interlock the exhaust system to the machine it serves. Evaluation: _ _ _ _ _ _ _ _ _ _		
3.	For multi-user exhaust systems, interlock the exhaust damper to the machine it serves. Evaluation: _ _ _ _ _ _ _ _ _ _		

CHECKLIST - PROCESS AIR

SHEET 2 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

AppliesYes No

4. Provide exhaust systems which clean exhaust air and return it to the room, using one of the following: _ bag filter, _ electrostatic precipitator, or _ scrubber.

Evaluation: _ _ _ _ _

5. Consider changing machining (drilling coolant) from a hydraulic oil to a water soluble synthetic oil. Estimate the reduction in exhaust requirements.

Evaluation: _ _ _ _ _

6. Determine whether to install thermostats in the circuits of roof exhausters to turn them off when the outside temperature falls below a preset number.

Evaluation: _ _ _ _ _

CHECKLIST - PROCESS AIR

SHEET 3 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

7. Minimize fan power by supplying only sufficient flow; if duct velocity is higher than necessary change the pulley ratio between the motor and the fan. Reducing duct velocity by 1/2, reduces fan power to 1/8.

Evaluation: _ _ _ _ _

8. If possible, use covers on process tanks. This can negate the need for exhausting except when the tank is open.

Evaluation: _ _ _ _ _

9. Investigate all old applications of exhaust fans over tanks to determine if a fan is required. Changing functions of tanks in a process line has resulted in venting empty tanks and water rinse tanks.

Evaluation: _ _ _ _ _

CHECKLIST - PROCESS AIR

SHEET 2 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

AppliesYes No

10. For new process or updated process areas consideration should be given to ducting outside air to ventilated processes, rather than allowing ventilation air to mix with conditioned air. This can eliminate a major part of the ventilation energy loss.

Evaluation: _ _ _ _ _
_ _ _ _ _

11. Recovery of a portion of the waste heat in the exhaust by use of a heat exchanger. The heat recovered may be applied to any one or combination of several uses dependent upon the economic analysis of costs and savings involved in each of the options. Some uses for waste heat recovery are space heating, heating of hot water supply, preheating of hot water supply, preheating combustion air, etc. (See NBS Handbook 121 "Waste Heat Management Guide".)

Evaluation: _ _ _ _ _
_ _ _ _ _

7.3 PROCESS/BUILDING HVAC SYSTEM

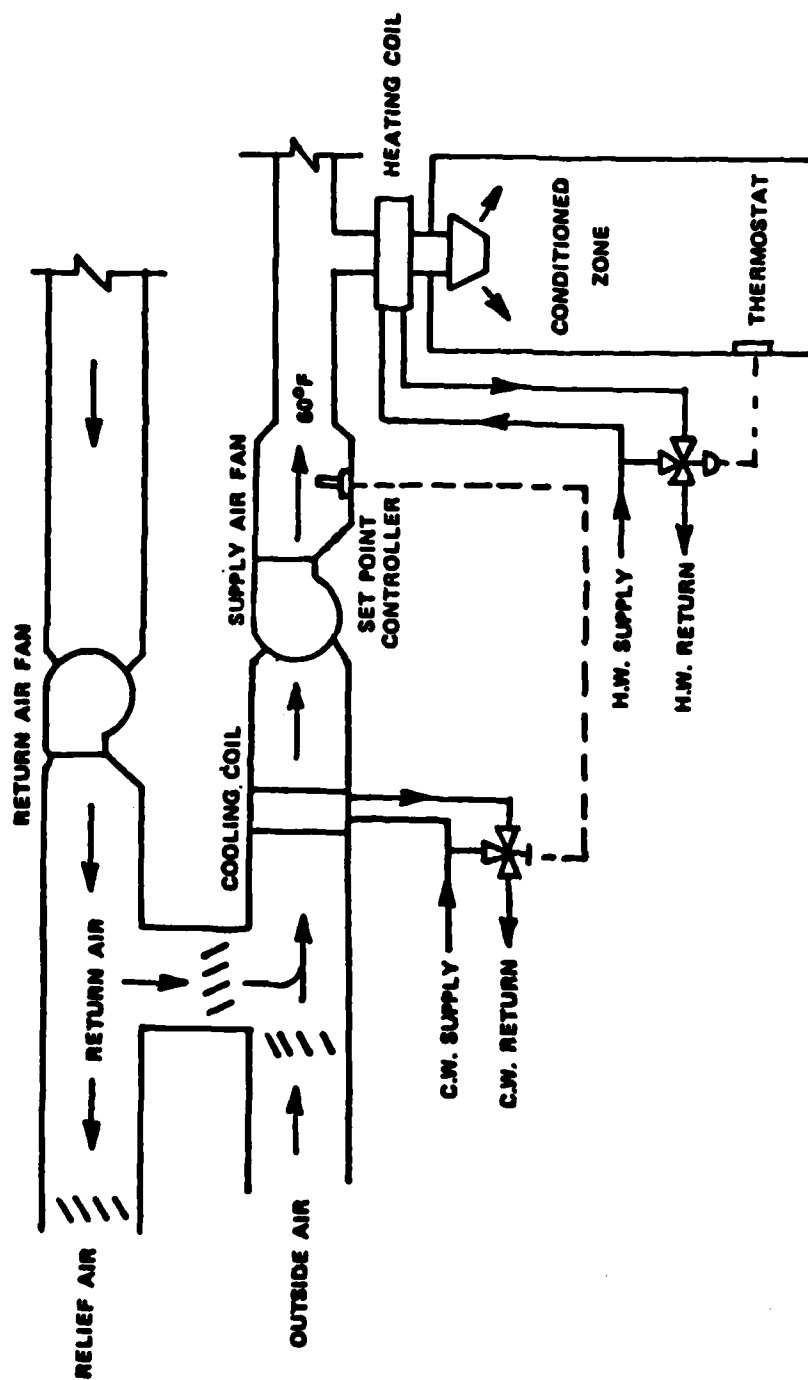
7.3.1 INTRODUCTION

Heating, ventilating and air conditioning systems (HVAC) are used in clean rooms, laboratories, computer rooms, etc. The environmental conditions imposed by the operational requirements for such applications are generally more stringent than for office areas. As a result, there are usually high energy expenditures associated with the operation of such systems. Brief discussions of four control systems are presented as well as methods of saving energy in HVAC systems.

7.3.2 SETPOINT REHEAT SYSTEMS

Setpoint Reheat Systems (see Figure 7.3-1) are characterized by a setpoint control which maintains air temperature out of a cooling coil at a predetermined value (usually 55-60°F). This temperature is the dewpoint required to maintain the approximate relative humidity in the conditioned area. The air is subsequently reheated as required to control the temperature within the conditioned zone, regulated by the zone (room) thermostat. These systems were particularly popular during the era of low-cost energy due to their low initial cost and effectiveness in controlling temperature and humidity. They waste large amounts of energy as a result of simultaneous heating and cooling when the cooling load is below design level. Operation of the system is as follows:

Air returning from the conditioned zone is mixed with outside air as controlled by the return air, outdoor and exhaust air dampers. The mixed air is drawn through a filter, preheat coil (if used), and cooling coil where dehumidification takes place. A temperature sensor downstream of the cooling coil modulates the coolant flow valve to maintain coil discharge temperature to a constant, predetermined setpoint. A room thermostat in the zone modulates a valve in the reheat coil to add sufficient heat to maintain zone temperature. Decreasing of illumination level or increasing thermostat settings during the summer will not decrease energy consumption, since the reheat coils will be required to add more heat.



Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-1
TYPICAL SETPOINT/REHEAT AIR HANDLING SYSTEM

7.3.3. DEMAND CONTROL SYSTEMS

Demand Control Systems (See Figure 7.3.2) represent a common, simple method of avoiding the inherent waste associated with setpoint reheat control, by minimizing simultaneous cooling and heating except as required to limit humidity. Cooling or heating, but not both simultaneously, are controlled by the zone thermostat. Operation of the system is similar to that of the setpoint reheat except the temperature of air discharging from the cooling coil is controlled by the zone thermostat and is varied to provide cooling equal to the zone cooling load. Only after the cooling coil valve has completely closed will the heating coil valve open, providing heat equal to the zone heating load. A humidistat located in the return air flow will override the cooling coil to lower its discharge temperature when the high humidity limit is reached. If many zones are served, or if humidity limits are severe, much of the savings normally expected of this system may be lost.

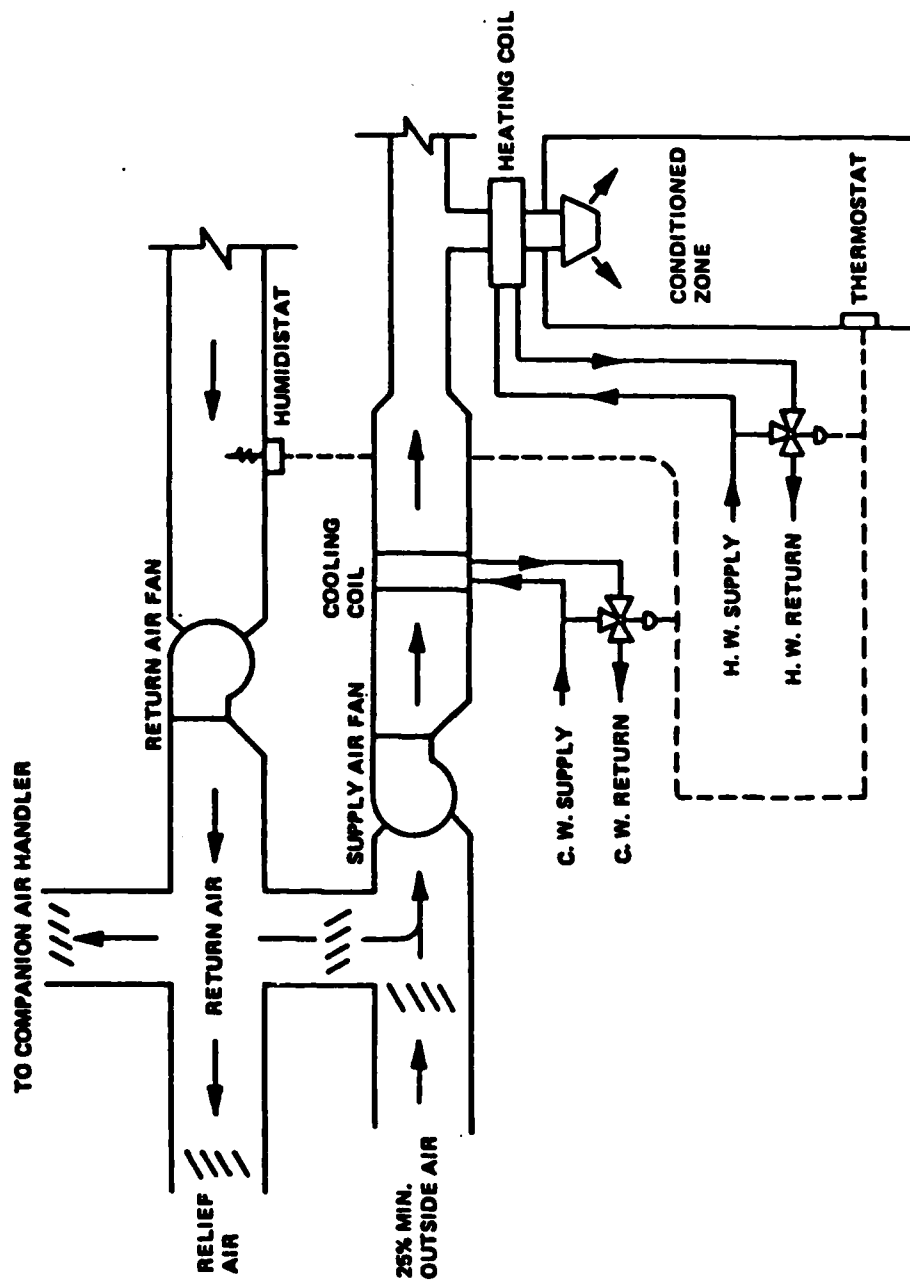


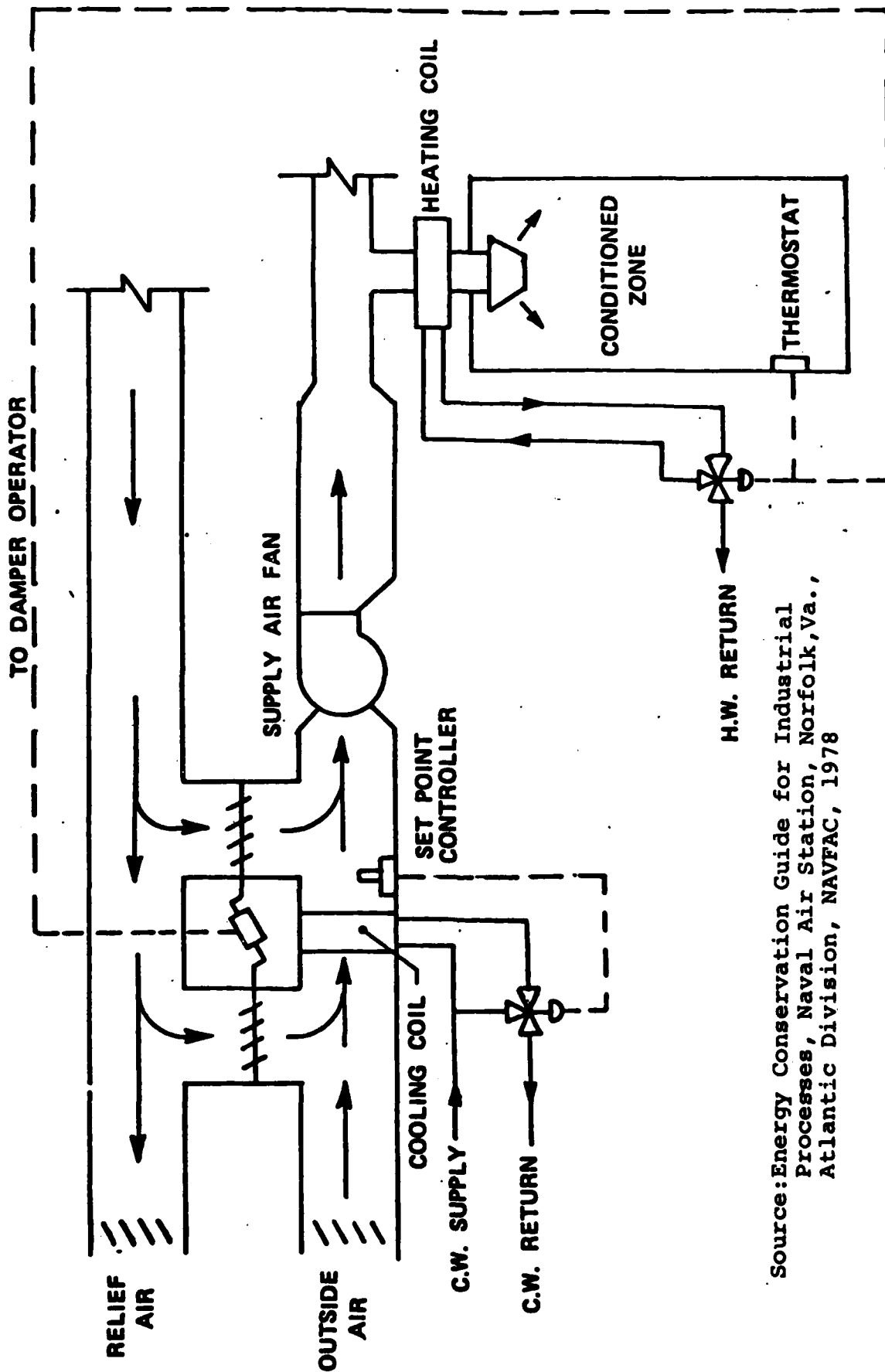
FIGURE 7.3-2

TYPICAL DEMAND CONTROL WITH TERMINAL REHEAT

Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

7.3.4 COIL BYPASS SYSTEMS

Coil Bypass Systems (see Figure 7.3-3) are an effective method of obtaining close control of humidity without excessive simultaneous cooling and reheating. This is made possible by cooling only as much as is necessary for zone load and humidity control, and allowing the balance to bypass the cooling coil. Operation of this system is similar to the setpoint/reheat and demand system already discussed. The zone thermostat modulates the return air and bypass dampers to provide a supply air temperature to the zone low enough to handle the zone load. The cooling coil valve is controlled by cooling coil setpoint controller. As the zone temperature decreases, the percentage of return air which bypasses the coil is increased until the maximum bypass position is reached. Only then will reheat be provided, as signaled by the zone thermostat. This is generally the most energy-efficient system when humidity is to be limited. Again, if the number of zones is large, potential savings are reduced. This modification can often be difficult to accomplish because of air handling unit configuration or layout.

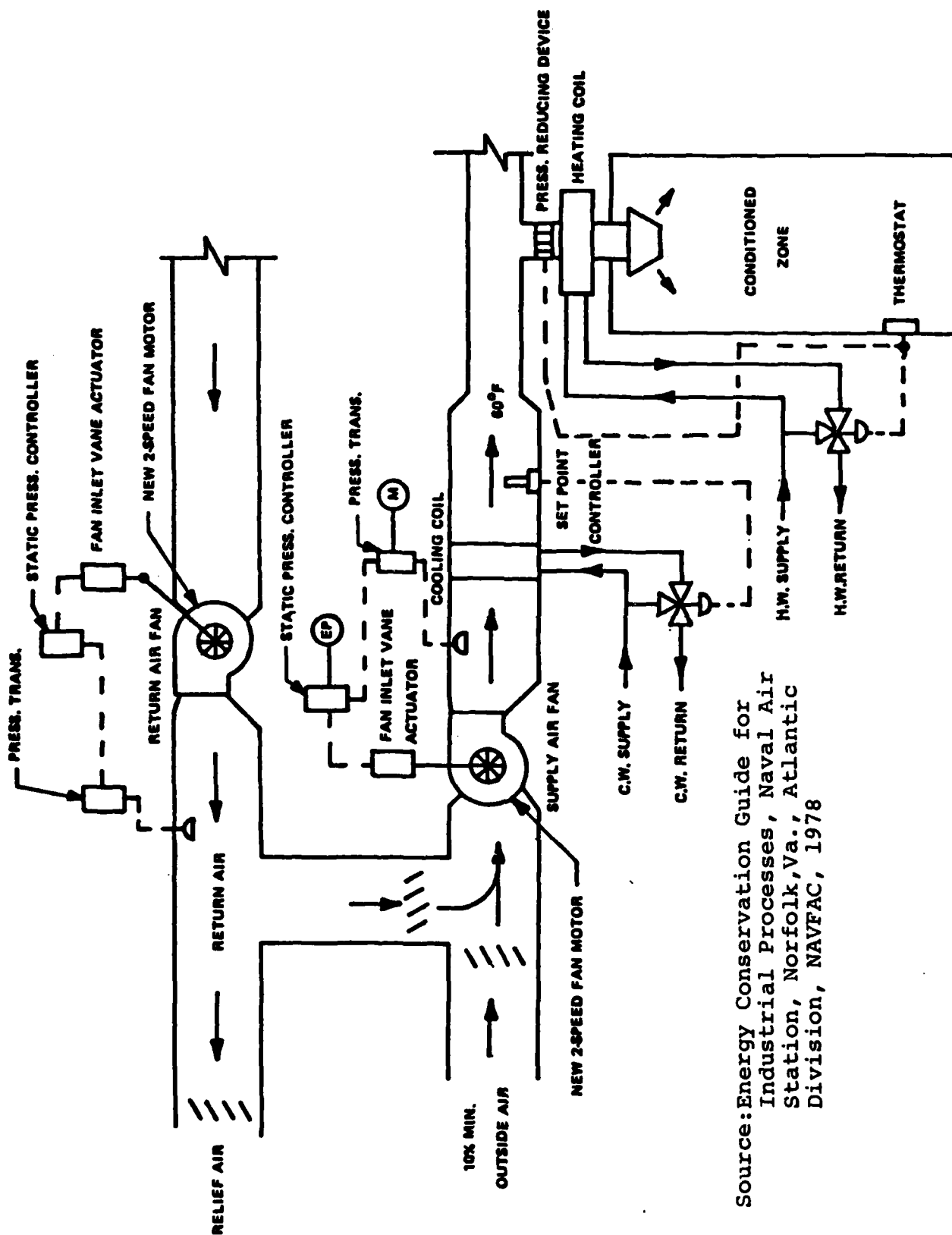


Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-3
TYPICAL COOLING COIL BYPASS WITH TERMINAL REHEAT

7.3.5 VARIABLE AIR VOLUME SYSTEMS

Variable Air Volume Systems (see Figure 7.3-4) are particularly efficient for those installations where many zones (10 or more) are serviced by a single HVAC unit. Since with a demand control system, the zone with the largest cooling loads will govern the cooling coil outlet temperature, the supply air will be over-cooled for all other zones. The standard terminal reheat adds heat to the other zones, sufficient to maintain the desired zone temperature, thereby still wasting considerable energy. The variable air volume (VAV) system operation differs in that each branch duct has a pressure control device upstream of the reheat coil, which reduces air flow in response to falling zone temperature. Only after the flow is at its minimum, is reheating introduced. This reduces the consumption of reheat energy, since less air is heated. In addition, as flow into the various zones is lessened, a static pressure sensing device reduces air delivery, either through fan outlet dampers, varying inlet vane geometry, fan motor speed reduction, or a combination of both, which may result in a reduction in fan motor energy consumption.



Source: Energy Conservation Guide for
Industrial Processes, Naval Air
Station, Norfolk, Va., Atlantic
Division, NAVFAC, 1978

FIGURE 7.3-4
VARIABLE VOLUME AIR HANDLING SYSTEM

7.3.6 SAVINGS ON HVAC COSTS BY CONSIDERING CONTROL MODIFICATIONS

One general method for reconfiguring the operating modes of HVAC systems is by modifications to control equipment. This technique has been without peer in saving energy in building systems management.

In the days of low cost energy, little attention was paid to the economic considerations. Commonly, HVAC systems were configured to what is known as "setpoint reheat" types. In concept, this system cools return air and make-up air to a "setpoint" temperature and then adds heat as required by the zone temperature control system. The result is high energy costs because heating and cooling may occur simultaneously through all seasons.

To remedy this situation, the common solution is to modify control functions to the "demand system". The result is that heating and cooling operate in series, not simultaneously. This type system is energy efficient but lacks the capability to remove sufficient humidity when in a cooling mode unless the system is compromised to some extent by adding a "humidity override" feature.

Heating, cooling, humidification and dehumidification requirements must be reviewed for all processes. It is a common practice for environmental requirements to be more rigorous than are actually needed. Manufacturers of computer systems often specify tight tolerances be maintained on cooling air temperature and humidity.

Practice has proven that much broader tolerances can be adopted with no degradation in reliability.

Laboratory areas should be surveyed with several objectives in mind. Can zone setpoint temperature be raised without compromising equipment cooling? Equipment exiting temperatures should be measured. Is it feasible to collect cooling air as it exits from equipment racks/chassis so that it can be exhausted outside the controlled area? Many laboratories and clean rooms have more limited use as compared to other type industrial facilities; one shift each day for five days a week is common. During non-working hours, the cooling load is reduced by turning off lights and workers leaving. The ideal HVAC system will reduce cooling output. One way to accomplish this result is to bypass air around the cooling coils in response to a zone temperature sensor. Another way is to reduce air delivery by means of a two-speed fan, with the additional advantage of fan power savings.

Computer programs are available from various organizations to calculate the annual energy consumption of a particular system. One key to its accuracy is the data that is used to represent the weather at the facility. The energy conservation team at a facility should review any programs that are available to determine if they will be effective at the facility or economical to run.

**7.3.7 SAVING ON HVAC COSTS BY IMPLEMENTING PREVENTIVE
MAINTENANCE PROGRAMS FOR AIR HANDLING AND TEMPERATURE
CONTROL EQUIPMENT**

There is no substitute for routine equipment checks and maintenance. Lack of vigilance can result in wasted energy. Filters must be changed at regular usage intervals to prevent degradation in air flow and increased fan motor power. Fan belts should be inspected for wear and tension, and bearings routinely lubricated. Temperature controls require routine servicing and calibration. The most commonly used industrial controls are pneumatically operated and have their own unique servicing problems. Control line filters must be cleaned routinely. Actuators and sensors must be checked to validate that control functions are being accomplished. If an economizer control calls for closure to minimum position of the outside air louvers at 70°F, for instance, this must be verified. Setpoints and modulation ranges are tabulated on control diagrams for reference while verifying operation of controls.

**7.3.8 SAVING ON HVAC COSTS BY MINIMIZING HUMIDIFICATION
REQUIREMENTS**

A reduction in humidity can result in significant energy saving. Humidity is added to dry air by water spray or saturated steam through nozzles which are installed in duct systems. The question which must be answered is, "Is

humidification really necessary?". In recent years, there has been an industry-wide trend to eliminate humidification by shutting off steam jet manifolds and removing control equipment. This deletion applies to HVAC equipment used for people comfort and for process control.

Paint drying no longer requires a lower limit on humidity. The new paints dry well even in the presence of very dry winter air which is heated but not humidified. The need for humidification in laboratories and clean rooms should also be carefully reviewed. Don't be locked into humidification by an obsolete process specification; challenge the need for humidification and make the users defend the requirement.

7.3.9 SAVING ON HVAC COSTS BY REDUCING THE
VENTILATION RATE:

This method is one of the most effective ways to save on HVAC costs. However, it is important that the new rates comply with the codes and process needs.

7.3.10 SAVING ON HVAC COSTS BY REDUCTION OF AIR FLOW

Reduction of Air Flow during periods of low cooling loads, (usually at night or when lights are off), can be achieved in all HVAC systems through the installation of two-speed fan motors. Motor power savings can be significant, especially if unoccupied periods are a major portion of the operating time.

7.3.11 SAVING ON HVAC COSTS BY COOLING WITH OUTDOOR AIR

The typical laboratory, clean room or computer facility has relatively high cooling loads, and is frequently located on an interior building zone with little or no exterior walls or windows. Cooling is, therefore, required year-round. When outdoor air temperatures are below those of the conditioned zone much of the year, then this cooler air can be utilized to provide inexpensive cooling. Generally, the quantity of outdoor air taken into the HVAC system is controlled in one of three ways:

7.3.11.1 Fixed dampers allow a constant flow of outside air whenever the HVAC unit is operating. The percentage of system flow which is introduced directly from outdoors may be set anywhere from the minimum required for personnel ventilation (5-10%), up to 100%. Obviously the low settings lose much available free cooling, whereas the higher settings cause excessive heating in cold weather and excessive cooling during warmer weather.

7.3.11.2 An Economizer control system positions the outside air damper in relation to return air damper to maintain the mixture at the desired temperature. In setpoint reheat systems the temperature sensor is in the mixed air stream;

for demand control systems damper control is by zone (room) thermostat. An economizer changeover temperature is selected from an analysis of the weather profile for the area and the heating and cooling loads for the zone. Above the selected economizer changeover temperature the O.A. damper is closed to minimum O.A. position. Below this temperature the O.A. damper opens wider with increasing temperature to take full advantage of the relatively cooler O.A. (cooler than return air) to provide free cooling. During extreme winter weather, the "too" cold outdoor air is mixed with the right proportion of warmer air returning from the conditioned space so that the mixture temperature will counterbalance the cooling load of the zone. Thus, the economizer control system will avoid or at least minimize the use of steam for reheating.

7.3.11.2 Enthalpy control systems are utilized to select the optimum changeover temperature. The instrument measures the indoor and outdoor conditions of both temperature and humidity, and selects the air with the lower enthalpy. Thus, in humid areas, changeover may occur at 65°F dry bulb or less, while when humidity is low, the changeover temperature may approach 80°F dry bulb. Enthalpy

controllers are relatively expensive, and therefore, a careful analysis is required to determine their appropriateness in any given situation.

7.3.12 DATA COLLECTION for PROCESS/BUILDING HVAC

The data collection sheets concentrate on the following aspects of the system:

7.3.12.1 The Air Distribution System-Comparison of field observations with air balancing records.

7.3.12.2 Filter Replacement Schedule

7.3.12.3 An Assessment of the Damper Controls and Damper Fit. - Requires the availability of temperature readings of:

Outside air

Return air

Mixed air

7.3.12.4 The Operating Hours and How They are Controlled.

DATA COLLECTION - HVAC SYSTEMS

SHEET 1 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

AIR BALANCE REPORT

Firm _____

Date Air Balance Report Completed: _____

Review the above Report to determine if there are any items with a large variance between the "actual" and "design" data. Use the report as a basis to determine if equipment modifications can be made to conserve energy. Can additional modifications be made?

Most Air Balance Reports contain three types of data sheets:

- . Air Moving Equipment Test Sheet
- . Static Profile of the Supply Duct Sheet
- . Velocity Traverse Sheet

Data from the Air Moving Equipment Test Sheet will be used. The data is collected from the AIR BALANCE REPORT. If the report is not available, omit this section but consider the merits of having the system tested and balanced using the procedures outlined by the American Society of Heating, Refrigerating and Air Conditioning Engineers.

DATA COLLECTION - HVAC SYSTEMS

SHEET 2 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

AIR BALANCE REPORT - AIR MOVING EQUIPMENT TEST SHEET

Fan. No.	Location	Electric Motor			
		Design Amps	Actual Amps	Design horsepower	Actual horsepower
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----

Fan No.	Location	Outdoor Air		Return Air	
		Design CFM	Actual CFM	Design CFM	Actual CFM
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

AIR BALANCE REPORT - AIR MOVING EQUIPMENT TEST SHEETFILTER REPLACEMENT SCHEDULE

<u>System</u> <u>No.</u>	<u>Location</u>	<u>Outdoor Air</u> <u>Filter*</u>	<u>Return Air</u> <u>Filter*</u>	<u>Fan Inlet</u> <u>Filter*</u>
-----	-----	-----	-----	-----
-----	-----	-----	-----	-----
-----	-----	-----	-----	-----
-----	-----	-----	-----	-----
-----	-----	-----	-----	-----

*Replacement Method

If differential pressure:

first indicate change-over P and then the type of
instrumentation used to determine P

Example: p = 2 in, permanent draft gage

If replacement on a scheduled basis, indicate frequency
or months.

Example: Dec, May

DATA COLLECTION - HVAC SYSTEMS

SHEET 4 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

OUTSIDE AIR CONTROL: Design _____ % ASHRAE 90-75 _____ %

Percent outside air test: close outside air damper to its
minimum open setting.

Outside air temperature _____ °F (TOA)

Return air temperature _____ °F (TRA)

Mixed air plenum temperature _____ °F (TMA)

$$\text{Minimum \% Outside Air} = \frac{\text{TRA} - \text{TMA}}{\text{TRA} - \text{TOA}} \times 100 = \text{_____ \%}$$

$$\text{Minimum Outside Air-System Air Handling Capacity} \times \frac{\text{Min. O.A.}}{100} = \text{_____ CFM}$$

If primarily a "peopleload":

$$\frac{\text{Min. O.A., CFM}}{\text{No. of People}} = \text{_____ CFM/person}$$

Proceed with data analysis if outside air exceeds 5 CFM/person
for either season.

If primarily as process load:

refer to design data concerning minimum CFM

minimum CFM _____

Percent outside air damper per leakage: close O.A. damper fully,
measure temperatures as above.

$$\% \text{ O. A. Damper Leakage} = \frac{\text{TRA} - \text{TMA}}{\text{TRA} - \text{TOA}} \times 100 = \text{_____ \%}$$

Proceed with data analysis if over 1-2%.

DATA COLLECTION - HVAC SYSTEMS

SHEET 5 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

OPERATING DATA:

System No. _____

Cooling Season: from _____ (month) to _____ (month)

Heating Season: from _____ (month) to _____ (month)

	<u>Weekdays</u>	<u>Saturdays</u>	<u>Sundays and Holidays</u>
"Occupied" Operating Hours	from ____ to ____	from ____ to ____	from ____ to ____
Method of Stop-Start	_____	_____	_____
" Occupied" Temp	_____	_____	_____
RH	_____	_____	_____
"Unoccupied" Temp	_____	_____	_____
RH	_____	_____	_____

DATA ANALYSIS - HVAC SYSTEMS

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

OUTSIDE AIR CONTROL: Minimize damper leakage.

The following calculations assume that a damper leaking 5 to 30% is replaced with one leaking 1% maximum.

T1 = Average Indoor Temperature for the Specific Season

T0 = Average Outdoor Temperature for the Specific Season

Heating Season:
$$\text{Air Handled (CFM)} \times \frac{100 - \% \text{ Damper Leakage}}{100} \times 1.08$$
$$\times (T_1 - T_0) \times \text{Unoccupied hrs/wk} \times \frac{\text{weeks}}{\text{heating season}}$$
$$\times \frac{\text{Cost of Heat (\$/MBtu)}}{1,000,000} = \text{\$ Saved}$$
Cooling Season:
$$\text{Air Handled (CFM)} \times \frac{100 - \% \text{ Damper leakage}}{100} \times 4.5$$
$$\times (T_1 - T_0) \times \text{Unoccupied hrs/wk} \times \frac{\text{weeks}}{\text{cooling season}}$$
$$\times \frac{\text{Cost of Cooling \$/MBtu}}{1,000} = \text{\$ Saved}$$

CONDUCTED BY _____

DATE: _____

DATA ANALYSIS - HVAC SYSTEMS

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

OUTSIDE AIR CONTROL: Control outside air to 5 CFM/person.

(Where Applicable).

Heating Season:

Excess Outdoor Air = Min. Outdoor Air CFM/person - 5
CFM/person = _____ CFM/person

Excess Outdoor Air CFM/person x No. of People x 1.08 x
operating hours/week x (Ti - To) x No. of weeks
(heating season) x 1/1,000,000 x \$/MBtu

Cooling Season

Excess Outside Air = Min. Outside Air CFM/person - 5
CFM/person = _____ CFM/person

Excess Outside Air CFM/person x No. of People x 4.5 x
operating hours/week x (Ti - To) x No. of weeks
(cooling season) x 1/1,000,000 x \$/MBtu

CALCULATIONS BY: _____ DATE: _____

CHECKLIST - HVAC SYSTEMS SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific HVAC systems or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1. Heating, ventilating, and air conditioning systems are part of a scheduled inspection and maintenance program.	Evaluation: _____		

2. Optimum control settings have been established for all systems, i.e., heating, cooling, and between seasons, with daily, weekly and seasonal operating and maintenance schedules.	Evaluation: _____		

3. Engineers, supervisors, technicians or contract personnel are trained and qualified.	Evaluation: _____		

CHECKLIST - HVAC SYSTEMS SHEET 2 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ ID. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Applies

Yes No

- For the heating season (weather up to 55°F outdoors), heating thermostats are set at 68°F or _____ °F. Unoccupied spaces are kept at _____ °F manually or by timer.

Evaluation: _____

- Check outdoor air damper for leakage and correct for replace with a low leakage damper. For offices, reduce ventilation with outdoor air to zero when building, zone, or space is unoccupied. Reduce ventilation with outdoor air to 5 cfm per person or other suitable value per ASHRAE 90-75 and 62-73.

Evaluation: _____

- For the cooling season, are thermostats set and locked at 78°F or other _____ °F? During off-hours, can cooling be shut off?

Evaluation: _____

CHECKLIST - HVAC SYSTEMS SHEET 3 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

7. Can air temperature leaving the cooling coil be as high as 58°F? Can the chilled water temperature be raised 2°F? Can the economizer control be adjusted to use outdoor air for cooling when it is below 65°F?

Evaluation: _____

8. Can static pressure be reduced on fans consistent with delivery to the farthest end of the system?

9. When considering changes which can be manual, consider automation as well, involving both timers and controls based on changing outdoor conditions.

Evaluation: _____

CHECKLIST - HVAC SYSTEMS SHEET 4 OF 4

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ ID. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Applies

Yes No

10. Have heat recovery units been considered for
exhaust, process, transformer vaults, or others?

Evaluation: _____

11. Has the air distribution system been tested and
balanced? Are records or reports available?

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 1 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific material-handling equipment operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	Install large double air lock type doors to prevent both sets being opened simultaneously. Evaluation _____ _____		
2.	Install a flexible covering, such as rubber or canvas strip over scrap conveyor openings in building walls. Evaluation: _____ _____		
3.	Shrouds should be used in all dock doors when possible. Investigate using air curtain fans if shrouds are not applicable. Evaluation: _____ _____		

CHECKLIST - MATERIAL HANDLING SHEET 2 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

4. Consider the installation of two-way radio equipment on material-handling equipment to reduce the number of empty return trips.
 Evaluation: _____

5. Investigate installing automatic door openers to minimize door "open time" with its resultant heat loss. Install adjacent 36"-48" passage doors for personnel and hand trucks.
 Evaluation: _____

6. Discourage passenger use of freight elevators.
 Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 3 OF 9

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ ID. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Applies

Yes No

CRANES AND HOISTS:

1. Avoid making a habit of using a drastically oversized crane for a drastically undersized load. If a machine frequently requires a crane to load small work pieces, consider installing a small jib crane with an electric hoist. This both frees up the main crane for heavier jobs and saves energy.

Evaluation: _____

2. Install automatic timers to shut down crane motor generators if no crane moves are made within ten minutes.

Evaluation: _____

3. Consider installing electrical hoists rather than air-operated hoist since a "1 horsepower" air hoist requires about 5 compressor horsepower, while a "1 horsepower" electric hoist requires only 1 horsepower.

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 4 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

FORK LIFTS:

1. Be sure fork lift air cleaners are clean. High dust locations will require centrifugal pre-cleaners to prolong filter element life.
 Evaluation: _____

2. Consider purchasing diesel fule fork lifts. Their reduced fuel consumption and lower maintenance should result in substantial savings over gasoline or propane lifts.
 Evaluation: _____

3. Where applicable, investigate replacing internal combustion fork lifts with electric fork lifts. In many cases, operating cost (and energy consumption) will be lower, and maintenance costs may be 30 percent lower. Electric trucks also have lower downtime, are non-polluting, and are quieter.
 Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 5 OF 9

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO.: _____ ID. NO. _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Applies

Yes No

4. Replace old, out-moded and inefficient motor-generator battery chargers with new solid state, power-factor corrected, high-efficiency battery chargers.

Evaluation: _____

5. Be careful to adjust the carburetor only when the fork lift is operating at rated water temperature, has a clean air filter, and is idling at the manufacturer's recommended speed.

Evaluation _____

6. Avoid excessive choke use. An LPG fueled enginer should require a choke only for starting, while a gas engine's should be opened after about 3-4 minutes.

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 6 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

7. An engine is most efficient operating at the manufacturer's recommended temperature. A "Cold" engine cannot adequately vaporize fuel, while a "hot" engine loses power and tends to vapor lock. See that the thermostat matches the manufacturer's.

Evaluation: _____

8. Be careful to select the correct weight engine lubricating oil. Too light an oil doesn't lubricate sufficiently, while heavy oil increases engine "drag". Use 10 from 0 to 32°F, 20W from 32 to 75°F, and 30W above 70°F.

Evaluation: _____

9. Be sure fork lift hydraulic relief valves are set correctly. Higher than required pressure increase horsepower needs and heat oil excessively, while low hydraulic pressure can also overheat oil and reduce machine performance.

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 7 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

10. Be sure hydraulic valves and controls open fully. Partial opening results in slow response and excessive oil heating.

Evaluation: _____

11. Don't downshift to slow down. Fork lift transmissions were never designed for this kind of load, and it wastes fuel.

Evaluation: _____

12. Limit internal combustion fork lift operation to the shift with the heaviest material handling load. Other shifts should utilize electric lifts as much as feasible.

Evaluation: _____

13. Avoid opening a door any higher than necessary during the heating season.

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 8 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

14. Install overspeed governors on all internal
 combustion material handling equipment,
 particularly fork lifts, to eliminate hot rodding.

Evaluation: _____

15. Investigate fork lift records or contact
 manufacturers to discover the best fork lift fuel
 consumption. Log all machine fuel to determine
 operator errors or machine deterioration.

Evaluation: _____

16. Fork lifts are designed to lift, travel, and
 lower, with travel limited to 100 yards or so.
 For greater distances and many trips, consider
 using a suitable truck.

Evaluation: _____

17. Be sure pneumatic fork lift tires are properly
 inflated. Underinflation both damages tires and
 wastes fuel, about 3 to 5% at slow speeds.

Evaluation: _____

CHECKLIST - MATERIAL HANDLING SHEET 9 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

18. Avoid using a far larger fork lift than
 required. For instance, use a 2,000 pound lift
 to maneuver oil barrels rather than a 6,000 pound
 lift.

Evaluation: _____

19. Avoid excessive fork lift idling. Start a lift
 only when there is work to be done, and stop if
 as soon as it is completed.

Evaluation: _____

SECTION 8

8.1 ELECTRICAL DISTRIBUTION

8.1.1 INTRODUCTION

Large transformers can be the source of wasted energy. For evaluation of energy conservation, a compilation of all transformer data will permit an analysis of energy losses and the feasibility of minimizing these losses by several means, e.g.: combining light loads to eliminate transformers, shutdown of transformers to match duty cycle of load.

Since most electric power companies have additional charges in their rate schedule for power factors lower than a specified limit, there is often an incentive to improve the power factor. Usually this is accomplished with capacitors and sometimes with synchronous motors. Care must be taken to insure that any proposed savings are practical.

8.1.2 TRANSFORMERS

There are two sources of energy loss in both oil-filled and dry-type transformers; these are core, sometimes called iron or hysteresis loss, and copper losses.

Core loss is a function of the transformer design and is constant as long as the transformer is energized.

Copper losses are a function of load current squared with a maximum at full load.

Listed in Table 8.1 are typical transformer losses. These figures are derived from manufacturer acceptance test results.

The actual losses of any specific transformer are specified on the transformer test report furnished by the manufacturer. Where this data is not available, the core loss may be approximated from Table 8.1, while the copper loss may be obtained by measuring current and computing the I^2R loss based on nameplate impedance. In many cases, data may be

TABLE 8.1 TRANSFORMER LOSSES

Dry Type Transformer Losses		
KVA Range	Approx. Core Loss % of Full Load Rating	Approx. *Copper Loss % Of Load
30 - 225	0.75%	0.50%
300 - 500	0.50%	0.50%
700 - 1000	0.32%	0.50%
Oil Filled Transformers		
750	0.40%	0.50%
1000	0.35%	0.50%
1500	0.30%	0.50%
*At Assumed 50% Loading		

Source: Load vs. Heat Rating in Selecting Dry Type Transformers for Lowest Operating, Cost, Electric Construction and Maintenance, June 1976.

obtained from manufacturers records by furnishing serial number and other pertinent nameplate data.

8.1.3 POWER FACTOR

Some common causes of lagging power factor in an industrial facility are lightly loaded induction motors and welding machines. Usually, lighting applications are equipped with high-power-factor ballasts.

A cost-justified solution usually employs capacitors. Power factor correcting capacitors can be installed at the motor or welding machine. Often they are installed on the distribution system supplying banks of motors or welding machines.

There are economic constraints that must be considered. For example, providing more power factor correction than the power company's lower limit won't reduce the power bill. Sometimes the justification for power factor correction is to reduce plant expansion costs by eliminating the need to add a new feeder cable. In other words, high current flow in a feeder cable due to low power factor will be corrected so that new loads can be added without installing a new cable.

Power factor correction techniques are best developed by an engineering group well versed in the state-of-the-art.

Of prime importance to an energy conservation survey team would be:

- 8.1.3.1 To determine the annual costs of power factor penalties when compared to the annual billing.
- 8.1.3.2 If applicable, to review the recommendations of the most recent report at the facility concerning the its power factor and the recommendations that have been made.

8.1.4 RESOURCES FOR A SURVEY

Data Collection Forms

Transformers	8.1- 7
Data Analysis Sheet	8.1- 9
Checklists	8.1-10

Where Applicable:

Electric Motors.	Appendix E

8.1.5 ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS

Sometimes, the uniqueness of the equipment requires the use of generalized forms. The forms are found in Appendix K.

Data Collection Form	K-2
Sketch Sheet	K-3
Data Analysis Form	K-4

DATA COLLECTION - TRANSFORMERS

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION AUDIT SHOP NO.: _____ I.D. NO.: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

TRANSFORMERS

Transformer No. _____, Dry _____, Oil filled _____
Power Rating _____ KVA
Primary Voltage _____ volts
Secondary Voltage _____ volts
Core Losses _____ watts
Copper Losses _____ watts
Hours/week de-energized _____ hrs.

Transformer No. _____, Dry _____, Oil filled _____
Power Rating _____ KVA
Primary Voltage _____ volts
Secondary Voltage _____ volts
Core Losses _____ watts
Copper Losses _____ watts
Hours/week de-energized _____ hrs.

Transformer No. _____, Dry _____, Oil filled _____
Power Rating _____ KVA
Primary Voltage _____ volts
Secondary Voltage _____ volts
Core Losses _____ watts
Copper Losses _____ watts
Hours/week de-energized _____ hrs.

CONDUCTED BY _____ DATE _____

CHECKLIST - TRANSFORMERS

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION SHOP NO.: _____ I.D. NO.: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific transformers and operations it is desirable to refer to the following checklist.

Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity.

Evaluation: _____

CHECKLIST - TRANSFORMERS

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION SHOP NO.: _____ I.D. NO.: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

AppliesYes No

2. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one.

Evaluation: _____

8.2 STEAM

8.2.1 RESOURCES FOR A SURVEY

Data Collection Forms

Boiler Steam 8.2-9

Condensate 8.2-10

Data Analysis Forms

Excess Air 8.2-11

Stack Temperatures 8.2-12

Condensation 8.2-13

Checklist 8.2-14

Where Applicable:

Electric Motors. Appendix E

Furnaces, Fired Heat Exchangers Appendix G

Table 8.2.2

HEAT LOSS FROM PIPES BARE AND INSULATED
(Btu/hr - Linear Foot - Degree F)

<u>Diameter</u> <u>Inches</u>	<u>Bare*</u> <u>Pipe</u>	<u>Insulation Thickness</u>						
		<u>1/2"</u>	<u>3/4"</u>	<u>1"</u>	<u>1-1/2"</u>	<u>2"</u>	<u>2-1/2"</u>	<u>3"</u>
1/2	0.62	0.117	0.100	0.090	0.077	0.069	0.064	0.060
3/4	0.75	0.149	0.125	0.110	0.092	0.082	0.079	0.075
1	0.93	0.180	0.148	0.129	0.106	0.093	0.085	0.079
1-1/4	1.15	0.210	0.171	0.147	0.120	0.104	0.094	0.087
2	1.59	0.298	0.237	0.200	0.159	0.136	0.120	0.110
2-1/2	1.90	0.357	0.280	0.235	0.184	0.155	0.137	0.124
3	2.28	0.415	0.323	0.269	0.208	0.175	0.153	0.138
4	2.87	0.531	0.409	0.337	0.257	0.213	0.185	0.165
5	3.49	0.647	0.494	0.404	0.346	0.250	0.215	0.191
6	4.11	0.762	0.578	0.472	0.352	0.287	0.246	0.217
8	5.26	0.993	0.748	0.605	0.447	0.361	0.306	0.268
10	6.47	1.224	0.917	0.739	0.541	0.433	0.366	0.319
12	7.58	1.454	1.085	0.872	0.635	0.506	0.425	0.369

K for insulation = 0.30 Btu and wind velocity of 0 mph.

h x ft² x °F/ft

*Source: ASHRAE Handbook and Product Directory 1977 Fundamentals,
 American Society of Heating, Refrigerating and Air-Conditioning
 Engineers, Inc.

**

The following equation is used to determine the heat loss for insulated pipes

$$Q = \left(\pi \cdot \frac{r_2}{6} \right) \frac{r_2 \cdot \ln r_2}{\frac{r_1}{k} + \frac{1}{f}}$$

where:

Q = Rate of heat transfer, Btu/hr-linear foot - °F

r1 = Inside radius of insulation, inches

r2 = Outside radius of insulation, inches

k = k factor of insulation, Btu-ft/hr - °F - sq ft

f = Outside air film coefficient (usually 1.65)

**Source: Heat Transfer, Third Edition, J. P. Holman,
McGraw-Hill Book Co. 1972.

HEAT LOSS IN STACK

Table 8-2

Source: Architects and Engineers Handbook, by Industrial

Combustion Inc., 1967

Add 2% radiation loss if insulated boiler and 4% if uninsulated to get total heat loss as % of Heat in Oil lost. 100% minus total heat loss in % equals overall efficiency.

CO ₂	Excess Air %	FUEL OIL NO. 2							
		Stack Temperature - °F							
		300	400	500	600	700	800	900	1000
15	2	10.5	13.0	15.2	17.0	19.0	21.0	23.0	25.3
14	9	11.0	13.5	15.7	17.5	20.0	22.0	24.0	26.6
13	16	11.5	14.0	16.2	18.5	21.0	23.0	25.2	27.8
12	27	12.0	14.6	16.7	19.5	22.0	24.0	26.5	29.1
11	40	12.5	15.3	17.5	20.5	23.0	25.2	28.0	30.8
10	53	13.0	16.0	18.5	21.5	24.0	27.0	30.0	33.0
9	70	13.5	17.0	19.5	23.0	26.0	29.0	32.0	35.6
8	91	14.2	18.0	21.0	25.0	28.0	32.0	35.0	39.3
7	120	15.3	19.2	23.0	27.0	31.0	35.0	39.0	43.5
6	155	16.8	21.0	26.0	30.0	35.0	39.0	44.0	48.4
5	210	18.5	24.0	29.5	35.0	40.0	45.5	51.0	56.0
4	290	21.5	28.0	34.5	41.0	47.5	54.0	61.0	69.0

FUEL OIL NO. 5									
CO ₂	Excess	Stack Temperature - °F							
	Air	300	400	500	600	700	800	900	1000
16	0	9.9	13.1	15.0	17.0	19.0	21.0	23.0	25.2
15	7	10.8	13.5	15.7	17.5	19.7	21.7	24.0	26.4
14	14	11.3	14.0	16.5	18.6	21.0	22.9	25.2	27.8
13	23	11.8	14.6	17.2	19.7	22.3	24.0	26.4	29.2
12	34	12.4	15.3	17.9	20.4	23.2	25.2	27.7	30.6
11	47	12.9	15.8	18.6	21.3	23.9	26.3	29.3	32.9
10	61	13.3	16.7	19.3	22.6	25.3	28.4	30.0	33.0
9	80	13.9	17.8	20.3	24.2	27.2	30.2	33.8	37.7
8	100	14.7	18.7	22.0	26.2	29.2	33.3	36.9	41.3
7	130	15.6	20.1	24.0	28.2	32.3	36.7	41.0	45.6
6	170	17.3	22.0	27.0	31.6	36.7	40.8	46.0	50.4
5	220	19.2	24.7	30.4	36.2	41.7	47.3	53.1	58.6
4	300	22.1	28.6	35.3	42.0	49.2	55.8	63.1	71.1

Add 2% radiation loss if insulated boiler, and 4% radiation loss if uninsulated.
Also heat in unconsumed particles in smoke and ashes. % of Heat in Coal as fired
that is lost in stack.

BITUMINOUS COAL (80% CARBON - 4% HYDROGEN)

CO ₂	Excess Air	Stack Temperature - °F						
		400	500	600	700	800	900	1000
18	3	7.	9.	11.5	15.	16.5	18.5	20.
17	10	9.5	11.5	14.	17.	18.5	20.	22.
16	17	10.5	12.5	15.	18.	20.	22.	24.5
15	25	11.	13.	16.	19.	21.	24.	26.5
14	33	11.5	14.	17.	20.	22.	25.	27.5
13	44	12.	15.	18.	21.	24.	27.	30.
12	58	13.	16.	19.	22.	26.	28.5	32.
11	70	14.	17.	20.	24.	28.	30.	33.
10	89	15.	18.	22.	26.	30.	32.	35.
9	110	16.	20.	24.	28.	32.	36.	40.
8	132	18	22.	27.	31.	36.	40.	44.
7	170	20.	25.	30.	35.	40.	46.	51.
6	213	24.	30.	36.	42	47.	54.	60.

Add 2% of radiation loss if insulated boiler and 4% radiation loss if uninsulated.
Add losses from CO in stack.

NATURAL GAS (GROSS 115 BTU PER CU FT)

N₂ .005
CO₂ .005
CH₄ .830
C₂H₆ .160

CO ₂ Excess		Stack Temperature - °F						
Air		400	500	600	700	800	900	1000
%								
12.1	0	17.0	19.0	20.9	23.3	25.9	28.0	30.5
11	10	17.5	19.7	21.7	24.2	26.7	29.2	31.7
10	20	18.2	20.6	22.7	25.3	27.8	30.5	33.1
9	32	18.9	21.4	23.9	26.8	29.5	32.4	37.7
8	47	19.8	22.5	25.4	28.6	31.4	34.5	37.7
7	67	21.0	24.2	27.4	30.8	34.2	37.6	41.0
6	93	22.5	26.2	29.7	33.4	37.5	41.3	44.9
5	130	25.1	29.5	33.6	38.3	43.4	47.6	52.1
4	190	27.9	33.2	38.0	43.9	49.2	54.1	60.1

DATA COLLECTION - STEAM

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC
ENERGY CONSERVATION AUDIT
ACTIVITY

BUILDING NO. _____
SHOP NO. _____ I.D. NO.: _____
LOCATION: FL _____ BAY _____

NAME PLATE DATA:

Manufacturer: _____ Model: _____
Age: _____ Condition: _____

Generation: Steam _____ psig

Capacity Steam: _____ lb/hr

AUDIT DATA: EXCESS AIR: Flue Gas Sampling Location

Flue Gas Analysis: ORSAT O₂ Meter Reading _____

CO₂ Reading _____ O₂ _____

O₂ Reading _____ O₂ _____

CO Reading _____ CO _____

Analysis Total _____

% N₂ = 100% - Analysis Total % = N₂ _____

Excess Air = 3.78 (O₂ - CO/2) x 100 = _____

N₂ - 3.78 (O₂ - CO/2) _____

Where O₂, CO and N₂ are expressed as %/100.

Minimum Excess Air % Required _____

Fuel Temperature _____ Pressure _____

AUDIT DATA: STACK

Flue Gas Temperature: _____ °F Location _____

Feedwater Temperature: _____ °F

Feedwater Rate: _____ GPM or lb/hr

Economizer Inlet Temperature: _____ °F

Economizer Outlet Temperature: _____ °F

DATA COLLECTION - STEAM

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

BOILER UTILIZATION:

Steam Production Rate: _____ $\frac{\text{lbs}}{\text{hr}}$ Rated Steam Capacity: _____ $\frac{\text{lbs}}{\text{hr}}$ $\frac{\text{Actual Steam Rate}}{\text{Rated Capacity}} \times 100 =$ _____ Percent UtilizationBlowdown Rate: _____ $\frac{\text{lbs}}{\text{hr}}$

Pressure: _____ psig

Temperature: _____ °F

Make-Up Water Rate: _____ $\frac{\text{lb}}{\text{hr}}$ BOILER CHEMICAL TREATMENT COSTS

\$ _____ per 1000 gallons

DATA COLLECTION - STEAM

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

CONDENSATE RETURN:Condensate Return Rate: _____ lbs
_____ hr
$$\text{Percent Condensate Returned} = \frac{\text{lb/hr Condensate Rate} \times 100}{\text{lb/hr Steam Rate}} = \text{ } \text{ } \text{ } \%$$

Condensate Temperature: _____ °F

Make-Up Water Temperature: _____ °F

Condition: _____

_____Comments: _____

CONDUCTED BY: _____ DATE: _____

DATA ANALYSIS - STEAM SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

SAVINGS DUE TO REDUCING EXCESS AIR: Refer to Page 8.2.2

Temperature _____ °F

Present Excess Air _____ % _____ % Required Fuel (over
 theoretical)

Proposed Excess Air _____ % _____ % Required Fuel

Improvement _____ % x _____ Fuel Used = Fuel Saved/Year
 100 Units/yr

Fuel Saved x _____ \$/Unit Fuel Cost = _____ \$Saved/
 Year

Action Proposed: _____ Leak Correction, _____ Air/Fuel
 Adjustment

Other, specify _____

CONDUCTED BY: _____ DATE: _____

DATA ANALYSIS - STEAM SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

SAVINGS DUE TO REDUCING STACK TEMPERATURE: Refer to Page 8.2-2

Present Stack Temp _____ % _____ % Loss at Stack
 Proposed Stack Air* _____ % _____ % Loss at Stack
 Improvement = Present - Proposed = _____ % Loss Reduction at Stack
 _____ Fuel Saved x _____ \$/Unit Fuel Cost = _____ \$ Saved/Year
 Action Proposed: _____ Feed Water Economizer, _____ Air Preheater,
 Other, specify _____

COMMENTS: _____

*Note: Select a stack temperature 100 to 150°F above boiler steam temperature to estimate savings achieved with a feed water economizer.

CALCULATIONS BY: _____ DATE: _____

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. I.D. NO.:

ACTIVITY

LOCATION: FL BAY

SAVINGS DUE TO CONDENSATE COLLECTION AND RETURN:

Condensate Temp* _____ °F Water Supply Temp _____ °F

$$T = T_C - T_S = \text{---} \text{---} \text{---} \text{---} ^\circ \text{F}$$

Condensate To Be Returned = **1b/hr**

$$\text{--- lb/hr} \times T \text{ } ^\circ\text{F} \times 1 \text{ (Btu/lb-}^\circ\text{F)} = \text{--- Btu/year}$$

$$\text{--- Btu/hr} \times \text{--- hr/ year} = \text{--- Btu/year}$$

_____ Btu/year \$ ____/Btu = \$ ____/year, heat saving.

Boiler Water Treatment Cost = \$ /1,000 gal

$$\text{\$ } \underline{\hspace{1cm}} / 1,000 \text{ gal} \times \frac{1,000 \text{ gal}}{8,350 \text{ lb}} \times \underline{\hspace{1cm}} \text{ lb/hr} \times \underline{\hspace{1cm}} \text{ hr/year} = \text{\$ } \underline{\hspace{1cm}} / \text{yr}$$

$$\text{Heat Saved} + \text{Water Treatment Saved} = \text{Total Saved Due to Condensate/Return}$$

\$ _____ year + \$ _____ year = \$ _____ year

Action Proposed:

Traps Insp. and Repair

Return Line-Install-Repair-Insulate

Other, specify _____

COMMENTS:

***Notes:**

Do calculation for each different temperature source quantity.

CALCULATIONS BY:

DATE: _____

CHECKLIST - BOILER STEAM

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

Before evaluating specific boilers or boiler operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYes No

1. Determine whether some boilers can be shut down on weekends. (Originally this was believed to be a poor practice, some experimenters have shown otherwise.)

Evaluation: _ _ _ _ _
_ _ _ _ _

2. Consider various heat sources for pre-heating make up water--hot cutting oils, process water, condensate, etc.

Evaluation: _ _ _ _ _
_ _ _ _ _

3. Consider the development of a summer steam shutdown list. It will show what valves are to be closed to reduce steam distribution line losses.

Evaluation: _ _ _ _ _
_ _ _ _ _

CHECKLIST - BOILER STEAM

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

AppliesYesNo

4. Determine if the steam pressure can be reduced without affecting production.

Evaluation: _ _ _ _ _

_ _ _ _ _

5. Determine whether the steam trap maintenance program can be simplified by using temperature indicating tapes.

Evaluation: _ _ _ _ _

_ _ _ _ _

8.3 HOT WATER, PROCESS

8.3 RESOURCES FOR SURVEY

Data Collection Forms

Boiler 8.3-2

Data Analysis Forms

Excess Air 8.3-4

Stack Temperatures 8.3-4

Checklist 8.3-5

Where Applicable

Electric Motors. Appendix E

DATA COLLECTION - BOILER HEATING HOT WATER SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

NAME PLATE DATA:

Manufacturer: _____ Model: _____
 Age: _____ Condition: _____
 Generation: High Temperature Hotwater: _____
 Capacity Hot Water: _____ GPHR

AUDIT DATA: EXCESS AIR: SAMPLING LOCATION _____

Flue Gas Analysis: ORSAT O2 Meter Reading _____
 CO₂ Reading _____ O2 _____
 O₂ Reading _____ O2 _____
 CO Reading _____ CO _____
 Analysis Total _____

% N₂ = 100% - Analysis Total % = N₂ _____

Excess Air = $3.78 (O_2 - CO/2) \times 100$ = _____
 $N_2 - 3.78 (O_2 - CO/2)$

Minimum Excess Air Required _____

Fuel Temperature _____ °F Pressure _____ psig

AUDIT DATA: STACK

Flue Gas Temperature: _____ °F Location _____
 Air Preheater Inlet Temperature: _____ °F
 Preheater Outlet Temperature: _____ °F

*Express O₂, CO and N₂ as %/100.

DATA COLLECTION - BOILER HEATING HOT WATER

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

BOILER UTILIZATION:

Heat Out: _____ Btu/lb - Heat In _____ Btu/lb = _____ Btu/lb

HTHW Production Rate = GPH x 8.34 = _____ lbs/hr

Btu Rate = _____ lbs/hr x _____ Btu/lb = _____ Btu/hr

Rated HTHW Capacity _____ Btu/hr

$\frac{100 \times \text{Actual HTHW Rate}}{\text{Rated Capacity}} = 100 \times \text{_____} = \text{Percent Utilization}$

CONDUCTED BY: _____ DATE: _____

DATA ANALYSIS - BOILER HEATING HOT WATER

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

SAVINGS DUE TO REDUCING EXCESS AIR: (See Page 8.2-2)

Proposed Operating Efficiency _____

Present Operating Efficiency _____

Efficiency Improvement (EI) _____

_____ % EI x _____ Fuel Consumed/year = _____ Fuel Saved/
100 Year

_____ Fuel Saved x \$ _____ Fuel Unit Cost = \$ _____ Saved/
Year

SAVINGS DUE TO REDUCING STACK TEMPERATURE: (See Table J-2)

Proposed Operating Efficiency _____

Present Operating Efficiency _____

Efficiency Improvement _____

_____ % EI x _____ Fuel Consumed/Year = _____ Fuel Saved/
100 Year

_____ Fuel Saved x \$ _____ Fuel Unit Cost = \$ _____ Saved/
Year

COMMENTS: _____

CONDUCTED BY: _____ DATE: _____

DATA COLLECTION - BOILER HEATING HOT WATER

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO.: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific heating equipment or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

1. If process hot water is now heated by steam _____, electricity _____, HT hotwater _____, fuel oil _____, or gas _____, consider these alternatives:
Recovered heat from nearby process or utility systems

- _____ Flue gases
- _____ Heat from internal combustion engines
- _____ Heat of compression from air or refrigeration
- _____ Compressor
- _____ Solar. May need back-up or boost system (existing).

Evaluation: _____

Applies	
Yes	No

DATA COLLECTION - BOILER HEATING HOT WATER

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO. _____

ENERGY CONSERVATION AUDIT

SHOP NO. _____ I.D. NO.: _____

ACTIVITY _____

LOCATION: FL _____ BAY _____

Applies

Yes No

2. Heat only to the temperature required for process; used recovered waste heat for preheating and a prime heat source for boost or backup.

Evaluation: _____

3. If circulation pumps are used, turn off pumps during non-working hours.

Evaluation: _____

8.4 REFRIGERATION SYSTEMS

8.4.1 INTRODUCTION

The selection of a refrigeration system for an industrial facility depends on many factors.

Two types of refrigeration systems are encountered:

1. Mechanical vapor compression systems are the most commonly used. The compressors are driven by electric motors or steam. However, gas compared to a liquid, requires much more energy to be compressed over the same pressure range.
2. The absorption system takes advantage of the lower amount of energy required to pump a liquid. Furthermore, the absorption system can use low pressure steam or high temperature water as the major energy source.

8.4.2 REFRIGERATION PLANT - DATA COLLECTION

The collection of data for an energy conservation survey should be developed around the following list of items. It is important to remember that many factors go into the selection of a refrigeration system, hence some items will be of major importance in one facility, but will not be significant in another. A general outline of the topics covered in the data collection form are:

- I. Current Operating Conditions
- II. System Sized to Load
- III. Condenser/Cooling Tower/Well Water

- IV. Refrigeration Piping
- V. Compressor (Mechanical Vapor Compression)
- VI. Generator (Absorption)
- VII. Evaporator

The form is used to indicate areas that could be developed for energy conservation. Data taking is minimized initially to allow the team to identify the areas. Next, each facility will develop its own data collection and data analysis forms for the specific parts of the system that can be optimized.

REFRIGERATION, CHILLED WATER

8.4.3 RESOURCES FOR A SURVEY

Data Collection Forms

Preliminary	.8.4-4
Developed at Site	.8.4-9
Data Analysis	.8.4-11
Checklist	.8.4-12

Where Applicable:

Economic Analysis and Project

Documentation	.Section 10
Pumps	.Appendix D
Electric Motors	.Appendix E
Fans	.Appendix F

DATA COLLECTION - REFRIGERATION

SHEET 1 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

System Capacity _ _ _ _ _

Type _ _ _ _ _ (Mechanical Vapor Compression or Absorption)

Mechanical Vapor Compression:

Type of Compressor _ _ _ _ _

Type of Drive _ _ _ _ , _ _ _ _ hp

Refrigerant _ _ _ _ _

Absorption: Ammonia-Water _ _ _ _ _

Lithium Bromide _ _ _ _ _

I. CURRENT OPERATING CONDITIONS

Are operating temperatures monitored and compared with
the design conditions at various loads? _ _ _ _ _

Is the above temperature data used to indicate which heat
transfer surfaces require cleaning? _ _ _ _ _

II. SYSTEM SIZED TO LOAD

Present full production periods

Is the system sized properly?

_ _ _ _ _
_ _ _ _ _

DATA COLLECTION - REFRIGERATION SHEET 2 OF 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION AUDIT SHOP NO.: _____ I-D NO.: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

II. SYSTEM SIZED TO LOAD (Cont.)

Present low production loads

How is the load controlled? Is it hot gas by-pass?

Is it possible to calculate the cost of operation
during low load operation?

III. CONDENSER/COOLING TOWER/WELL WATER

Well Water.

Is well water presently used or available?

Would well water (based on electricity costs to run
cooling tower fans, etc) be a practical alternative
to cooling towers? At high loads, at low loads? Is
a study available?

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

III. CONDENSER/COOLING TOWER/WELL WATER (Cont.)

Cooling Tower.

Is a study available to indicate if the savings associated with a lower cooling water temperature is justified by increasing cooling tower capacity, increasing fan speed, increasing the size of the fans. _ _ _ _ _

Is it feasible to investigate an energy conservation cycle to pump, treat, and clean cooling tower water so that it can be used in the process chilled water circuits. _ _ _ _ _

Condenser.

Is there the ability to recognize:

High cooling water flow _ _ _ _ _

Fouled tubes _ _ _ _ _

DATA COLLECTION - REFRIGERATION

SHEET 4 OF 5

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _

I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

IV. REFRIGERATION PIPING

Are the pipe surfaces insulated properly? _ _ _ _ _

_ _ _ _ _

V. COMPRESSOR. (Mechanical Vapor Compression)

Is there any indication that lengthy running times
could be the cause of an inefficient compressor? _ _ _

_ _ _ _ _

Suction Pressure. Is the pressure lower than
design, indicating that the actual load could be
greater than the design load? _ _ _ _ _

_ _ _ _ _

Discharge Pressure. Determine the saturation
pressure of the refrigerant for the average
temperature of the cooling water in the condenser.
Is the discharge pressure too high when compared to
the saturated pressure? _ _ _ _ _

_ _ _ _ _

_ _ _ _ _

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ _ I-D NO.: _ _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

VI. GENERATOR (Absorption)

Is the generator temperature too low? Then the efficiency falls rapidly. See manufacturer's data.

_ _ _ _ _

_ _ _ _ _

Is there a method, using plant readings to determine if the tubes are fouled? _ _ _ _ _

_ _ _ _ _

VIII. EVAPORATOR

Compare the design "approach temperature" with the actual "approach temperature". "Approach temperature" is defined as the difference between the refrigerant temperature entering the evaporator and the temperature of the cooled fluid leaving the evaporator. The manufacturer's catalog should be consulted. Generally, the approach temperatures are as low as 3°F and as high as 18°F. This however, depends on the type and cost of the system.

_ _ _ _ _

_ _ _ _ _

_ _ _ _ _

8.4.4 ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS

After the areas that need further investigation have been identified, specialized forms must be developed. The generalized format for the forms are found in Appendix K.

Data Collection Form K-3

Sketch Sheet K-4

Data Analysis Form K-5

CHECK LIST - REFRIGERATION

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _

Before evaluating specific refrigeration equipment or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYesNoENERGY CONSERVATION OPPORTUNITIES:

1. Operate water-cooled chillers with the condensing water temperature as low as possible without the risk of damage.

Evaluation: _ _ _ _ _

_ _ _ _ _

2. Provide the system with sufficient test wells and gauge connections to allow operators to check water and air flows, temperatures, and pressures.

Evaluation: _ _ _ _ _

_ _ _ _ _

3. Avoid fixed settings. Allow for adjustments and corrections to achieve maximum efficiency.

Evaluation: _ _ _ _ _

_ _ _ _ _

CHECKLIST-REFRIGERATION

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYes No

4. Re-adjust settings as often as necessary to ensure the most economical operation. Set up the timer control once a schedule is established.

Evaluation: _ _ _ _ _

5. Clean exterior of cooling and air-cooled compressor coils annually or as often as necessary.

Evaluation: _ _ _ _ _

6. For chillers with water-cooled condensers, remove the condenser heads annually and clean tubes and water box. Clean the water side of the evaporator every three years or so.

Evaluation: _ _ _ _ _

CHECKLIST - REFRIGERATION

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

Applies

Yes No

7. Maintain cooling towers annually.

Evaluation: _ _ _ _ _

8. Determine the practicality of installing
thermostats to automatically control the fans
on the cooling towers.

Evaluation: _ _ _ _ _

9. Consider interconnecting lightly loaded systems
and eliminating extra pumping, etc.

Evaluation: _ _ _ _ _

THE UNIVERSITY OF CHICAGO

SECTION 9

SCHEDULING AND CONSOLIDATION

9.1.1 INTRODUCTION

Until recently, energy consumption was not an important consideration when scheduling industrial processes. Now, large manufacturers are attempting to minimize demand peaks during the day when electrical rates are at a premium. Another technique which is becoming more popular is to schedule batch processing. This permits equipment shutdown for prolonged periods between batches.

9.1.2 EQUIPMENT SHUTDOWN WHEN NOT IN USE

The most efficient way to reduce power consumption is to automate equipment shutdown. Micro-processors and switching equipment are now commercially available to implement energy management, data collection, and display.

Lighting, although not defined as a "process", is the largest energy waster at most industrial locations. Air handling fans, which could be shut off during non-working hours, are the second worst violators. Process exhaust air is also a source of much wasted energy.

Large motors, particularly older configurations, do not easily lend to automation, i.e. chiller motors and compressor motors. In these cases, manual operating procedures must be invoked; this shutdown discipline is best maintained by entering power down/up in a daily log book.

9.1.3 THE SHUTDOWN OF PROCESS HEAT DURING NON-WORKING HOURS

Liquid filled cleaning tanks, vapor degreasers, electroplating tanks, curing ovens and heat treating furnaces are all candidates for shutdown, when not in use. The importance of shutdown is directly related to thermal loss of each structure, large uninsulated tanks with high temperature contents being the higher energy users.

The duty cycle of tanks, ovens, and furnaces may be low enough to permit prolonged periods of shutdown. One approach to saving energy is to let work accumulate for several days before turning on the process. This concept may require some salesmanship to convince manufacturing scheduling managers that it is workable and will not impact timely performance.

9.1.4 CONSOLIDATING SHOPS OF SIMILAR ACTIVITY

Combining several shops of similar activity into one will usually produce significant energy savings. Duplicate equipment can be eliminated where usage is low. Ancillary benefits are reduction of building services and equipment costs. Convenience may be compromised, but good production scheduling may prevent any serious problems.

Selling the concept of consolidation to shop and industrial management personnel may be met with resistance. In addition to more efficient equipment usage, job functions can also be consolidated, thus eliminating the need for so many workers and shop supervisors. Combining shops obviously

includes many considerations which are more far reaching than energy conservation. Decisions should be based upon an economic trade-off study which includes all contributing factors.

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ I.D. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Before evaluating specific scheduling procedures it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

AppliesYesNoSCHEDULING:

1. Three shift operations concentrated in one building may permit shut-downs elsewhere.
 Operations recommended: heat treating.
 Evaluation: _____

2. Operate equipment at full load for one shift instead of partly loaded for two. Operations recommended: vapor or hot cleaning tanks, heat treat furnaces.
 Evaluation: _____

3. Operate with controlled cycle times in oven and furnace operations to reduce heating hours to a minimum.
 Evaluation _____

CHECKLIST - SCHEDULE

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
ENERGY CONSERVATION AUDIT SHOP NO.: _____ I.D. NO. _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

AppliesYes No

4. Between oven and furnace cycles, reduce heat using a cool down/reheat chart that shows the time to reheat from a given temperature.

Evaluation: _____

5. Assign a person to make certain that machines and equipment are shut down during breaks, lunch hours and off-shifts.

Evaluation: _____

EQUIPMENT OR PROCESS:

1. Evaluate new equipment or replacement purchases in relation to energy costs over the life cycle.

Evaluation: _____

2. Interlock machine services such as compressed air, cooling water, exhaust damper, etc., so that they shut off when the machine is turned off.

Evaluation: _____

CHECKLIST - SCHEDULE

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

AppliesYesNo

3. Install timers on certain machines to shut them down if left idling over 10 minutes.

Evaluation: _ _ _ _ _

4. Avoid substantially over sizing equipment, since it will waste power while running underloaded.

Evaluation: _ _ _ _ _

5. Study each machine tool operation to make sure the machine is loaded near its capacity.

Evaluation: _ _ _ _ _

6. Minimize test time on engines -- or use the power to generate electricity, to pump water, or to compress air.

Evaluation: _ _ _ _ _

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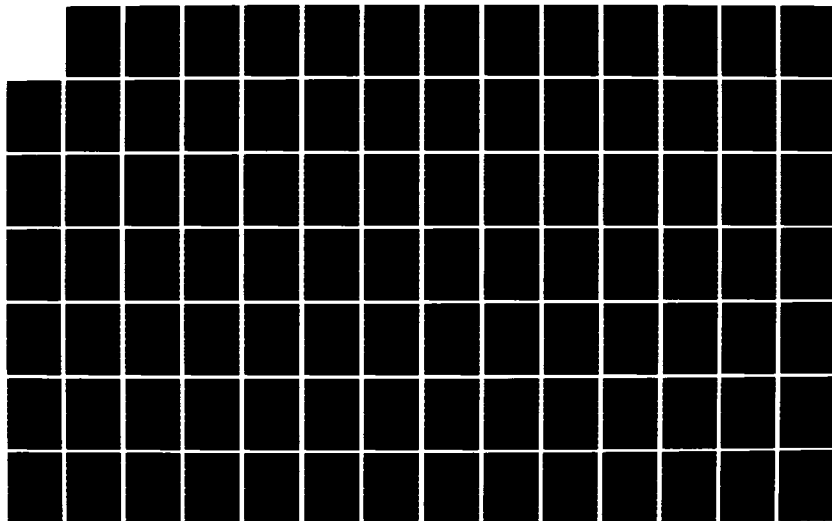
ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U)
SVSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

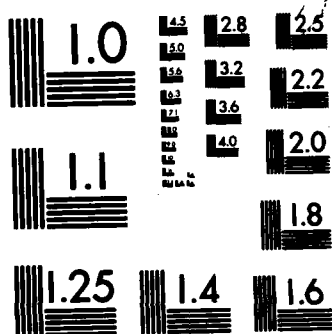
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SECTION 10
ECONOMIC ANALYSIS
AND PROJECT DOCUMENTATION

10.1 INTRODUCTION

Energy Conservation and economics are inseparable. Regardless of the techniques employed, the result must provide a means for establishing the worth of an energy saving project and method for setting priorities.

An Energy Conservation Project is developed as either a Military Construction Project (MILCON) or a Special Project.

The procedures and criteria used in the preparation of the preliminary engineering documents are outlined in this section. In Section 10.5, Preliminary Engineering Forms Used with Energy Conservation Projects, the most current engineering forms are contained. However, in Section 10.7, Special Project ETAP Forms - Sample Data and Calculations contained outdated forms.

**10.2 PRELIMINARY ENGINEERING DOCUMENTS USED IN THE PREPARATION
OF MILCON PROJECTS AND SPECIAL PROJECTS.**

<u>Project</u> <u>Type:</u> Military Construction Projects (MILCON)	Special Projects
<u>Funding:</u> Energy Conservation Investment Program (ECIP) <u>Reference</u> <u>Documents:</u> Guidelines on Preparing an Economic Analysis for Military Construction Projects for the Energy Conservation Investment Program. (ECIP)	Energy Technology Applications Program (ETAPS) Use ECIP Guidelines

**10.2 PRELIMINARY ENGINEERING DOCUMENTS USED IN THE PREPARATION
OF MILCON PROJECTS AND SPECIAL PROJECTS. (Cont'd.)**

Project (cont'd)

Type:

Military Construction Projects
(MILCON)

Special Projects

Supporting

Documents:

Form 11000/4

NAVFAC 9-11014/64

(2 sheets)

DD Form 1391

NAVDOKS 11013/7

DD Form 1391c

X

NAVFAC 11013/7

X

Plain white sheets for:

Energy Calculations

Economic Analysis

Cost Estimate

ECIP Cost Analysis Summary

Plain white sheets for:

Energy Calculations

Energy Analysis

Cost Estimate

ECIP Cost Analysis Summary

10.3 ENERGY CONSERVATION INVESTMENT PROGRAM CRITERIA

NORTHERN DIVISION

GUIDELINES ON PREPARING AN ECONOMIC ANALYSIS FOR
MILITARY CONSTRUCTION PROJECTS FOR THE ENERGY

CONSERVATION INVESTMENT PROGRAM (ECIP)

1. Military construction projects for the Energy Conservation Investment Program qualify on the basis of their energy savings and self-amortization of the investment.
2. Projects must be cost effective, that is, they must have a savings-to-investment (SIR) ratio of greater than one based on a life cycle cost analysis.
3. Projects must have an energy savings to cost ratio of at least the following values:

<u>PROGRAM YEAR</u>	<u>ENERGY SAVINGS PER \$1,000 OF PROJECT COST</u>
FY-80	22 MBTU/\$1000
FY-81	20 MBTU/\$1000
FY-82	19 MBTU/\$1000
FY-83	18 MBTU/\$1000
FY-84	17 MBTU/\$1000

4. Projects must have a budget cost of at least \$100,000 (FY ____). Projects can include a number of different items of work.

5. Projects shall be supported with engineering calculations in sufficient detail to allow validation of energy savings. Many projects will also require supplementary sheets showing such calculations as changes in insulation "U" factors, heat loss rates, and kilowatt demand reductions.

6. Actual fuel heating value rates should be used when known. If not known, the following conversion factors will be used to permit standardized project evaluation comparisons:

Distillate Fuel Oil	.138,700 BTU/Gal
Residual Fuel Oil	.150,000 BTU/Gal
Natural Gas	.1,031,000 BTU/100 cu ft.
LPG, Propane, Butane	.95,500 BTU/GAL
Bituminuous Coal	.24,580,000 BTU/SHORT TON
Purchased Steam	.1,390 BTU/LB
Electrical Source Fuel	.11,600 BTU/KWH

7. Boiler efficiencies should be included in the calculation of savings from reduced steam consumption. The resulting reduction in fuel input and boiler feedwater represent a real cost avoidance when steam consumption is reduced. The "as-consumed" cost of fuel and electricity shall be used in determining energy dollar savings. The energy costs as reported by each activity in the monthly Defense Energy Information System (DEIS-II) report are "as-consumed" costs. An "Activity Rate" or "Host Rate" which includes overhead and maintenance costs, should not be used for calculating savings. Such costs do not normally change with small percentage reductions in over all steam consumption.

8. Energy, material, and labor prices should be escalated from current rates to those projected for 30, September of the fiscal year for which the project is submitted for funding. Unless more definitive future prices can be determined or predicted for an individual activity, the following rates are to be used for escalation:

	<u>FY-78</u>	<u>FY-79</u>	<u>FY-80</u>	<u>FY-81</u>	<u>FY-82</u>	<u>FY-83</u>
SIOH Construction	8.0%	7.0%	6.5%	6.0%	6.0%	6.0%
Operations & Maintenance	7.1%	6.4%	6.2%	5.6%	5.6%	5.6%
Coal	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Fuel Oil	16.0%	16.0%	16.0%	14.0%	14.0%	14.0%
Natural Gas & LPG	15.0%	15.0%	15.0%	14.0%	14.0%	14.0%
Electricity (KWH & KW)	16.0%	16.0%	15.0%	13.0%	13.0%	13.0%

9. The life cycle cost analysis used to determine the project's savings-to-investment ratio shall utilize a base fiscal year commencing on 1, October following the project's programmed year. The long-term differential escalation rates below are to be used for computing the present work of recurring annual costs and benefits if more definitive data is not available at individual activities.

Operations and Maintenance	.0%
Natural Gas and LPG	.8%
Coal	.5%
Electricity (KWH and KW)	.7%
Fuel Oil	.8%

10. The present worth factors for multiplication of recurring annual savings can be selected from the appropriate differential escalation rate column in the DISCOUNT FACTORS TABLE.

11. Economic life is the period of time over which the life cycle benefits to be gained from a project may reasonably be expected to accrue. As such, the economic life may differ from its physical and technological life. The economic lives below may be used as guides, and ordinarily will not be exceeded.

UTILITIES (plants and distribution systems) _ _ _ 25 years

ENERGY MONITORING AND CONTROL SYSTEMS _ _ _ _ _ 15 years

CONTROLS (thermostats, limit switches, ignition

devices, clocks, photo-cells, flow controls,

sensors, etc. - when these constitute the

major and item of the project). _ _ _ _ _ 15 years

REFRIGERATION COMPRESSORS _ _ _ _ _ 15 years

EQUIPMENT _ _ _ _ _ 15 years

12. A sample calculation is attached to show the method of making an economic analysis to determine the savings-to-investment ratio (SIR). The standard MILCON forms are to be used for ECIP project documentation. In addition to the economic analysis, summary energy data plus supporting engineering calculations should be included on the MILCON forms to assist in project review. For some projects, the simplified economic analysis illustrated may not be correct. For example

when a one-time cost or benefit occurs in years after construction is complete (such as a major component replacement during the economic life of the retrofit project), then non-recurring discount factors shall be used as provided in NAVFAC P-422, "Economic Analysis Handbook".

15. The project cost used in the economic analysis is the cost of construction plus the cost of supervision, inspection and overhead.

16. Check with the Activity Public Works Department for the appropriate fiscal year (FY) for which MILCON projects and Special Projects are to be developed to support recommendations of this survey.

10.4 DISCOUNT FACTORS TABLE

ECIP INFLATION - DISCOUNT FACTORS

Discount Rate = 10%, Differential Inflation Rate = From 0 to 5%

Economic
Life in
Years

	0%	1%	2%	3%	4%	5%
1	0.954	0.959	0.963	0.968	0.972	0.972
2	1.821	1.839	1.856	1.874	1.892	1.910
3	2.609	2.647	2.684	2.723	2.761	2.800
4	3.326	3.389	3.452	3.527	3.583	3.650
5	3.977	4.070	4.165	4.261	4.360	4.461
6	4.570	4.695	4.825	4.958	5.095	5.235
7	5.108	5.270	5.437	5.610	5.789	5.974
8	5.597	5.797	6.005	6.221	6.446	6.680
9	6.042	6.281	6.531	6.793	7.067	7.353
10	6.447	6.726	7.020	7.329	7.654	7.996
11	6.815	7.134	7.472	7.830	8.209	8.610
12	7.149	7.509	7.892	8.300	8.734	9.196
13	7.453	7.853	8.281	8.739	9.230	9.755
14	7.729	8.169	8.642	9.151	9.699	10.288
15	7.980	8.459	8.977	9.536	10.142	10.798
16	8.209	8.726	9.287	9.897	10.561	11.284
17	8.416	8.970	9.575	10.235	10.958	11.748
18	8.605	9.195	9.842	10.552	11.333	11.191
19	8.777	9.401	10.089	10.848	11.687	12.614
20	8.933	9.590	10.319	11.126	12.022	13.018
21	9.074	9.764	10.531	11.386	12.339	13.403
22	9.203	9.924	10.729	11.629	12.638	13.771
23	9.320	10.070	10.911	11.857	12.921	14.122
24	9.427	10.205	11.081	12.070	13.189	14.458
25	9.524	10.328	11.238	12.270	13.442	14.777
26	9.612	10.442	11.384	12.457	13.681	15.083
27	9.692	10.546	11.519	12.632	13.908	15.374
28	9.765	10.642	11.645	12.796	14.121	15.653
29	9.831	10.730	11.761	12.950	14.324	15.918
30	9.891	10.810	11.869	13.093	14.515	16.172

10.4 DISCOUNT FACTORS TABLE

ECIP INFLATION - DISCOUNT FACTORS

Discount Rate = 10%, Differential Inflation Rate = From 0 to 5%

Economic
Life in
Years

	6%	7%	8%	9%	10%
1	0.982	0.986	0.991	0.995	1.000
2	1.928	1.946	1.964	1.982	2.000
3	2.839	2.879	2.919	2.959	3.000
4	3.718	3.787	3.857	3.928	4.000
5	4.564	4.670	4.777	4.887	5.000
6	5.380	5.529	5.681	5.839	6.000
7	6.166	6.364	6.569	6.781	7.000
8	6.923	7.177	7.440	7.715	8.000
9	7.653	7.968	8.296	8.640	9.000
10	8.357	8.737	9.136	9.557	10.000
11	9.035	9.485	9.961	10.465	11.000
12	9.688	10.212	10.770	11.366	12.000
13	10.317	10.920	11.565	12.258	13.000
14	10.924	11.608	12.346	13.142	14.000
15	11.508	12.278	13.112	14.018	15.000
16	12.071	12.930	13.865	14.886	16.000
17	12.614	13.563	14.603	15.746	17.000
18	13.137	14.180	15.329	16.598	18.000
19	13.641	14.779	16.041	17.443	19.000
20	13.127	15.363	16.740	18.279	20.000
21	14.595	15.930	17.427	19.109	21.000
22	15.046	16.482	18.101	19.930	22.000
23	15.480	17.019	18.762	20.745	23.000
24	15.899	17.541	19.412	21.551	24.000
25	16.303	18.049	20.050	22.351	25.000
26	17.692	18.543	20.676	23.143	26.000
27	17.066	19.023	21.291	23.928	27.000
28	17.427	19.491	21.895	24.706	28.000
29	18.775	19.946	22.488	25.477	29.000
30	18.111	20.388	23.070	26.241	30.000

ECIP DIFFERENTIAL ESCALATION RATES

Economic Life In Years	O&M Costs 0%	Coal 5%	Electricity 7%	Oil & Gas 8%
1	0.945	0.977	0.986	0.991
2	1.821	1.910	1.946	1.964
3	2.609	2.800	2.879	2.919
4	3.326	3.650	3.787	3.857
5	3.977	4.461	4.670	4.777
6	4.570	5.235	5.529	5.681
7	5.108	5.974	6.364	6.569
8	5.597	6.680	7.177	7.440
9	6.042	7.353	7.968	8.296
10	6.447	7.996	8.737	9.136
11	6.815	8.610	9.485	9.961
12	7.149	9.196	10.212	10.770
13	7.453	9.755	10.920	11.565
14	7.729	10.288	11.608	12.346
15	7.980	10.798	12.278	13.112
16	8.209	11.284	12.930	13.865
17	8.416	11.748	13.563	14.603
18	8.605	12.191	14.180	15.329
19	8.777	12.614	14.779	16.041
20	8.933	13.018	15.363	16.740
21	9.074	13.403	15.930	17.427
22	9.203	13.771	16.482	18.101
23	9.427	14.458	17.541	19.412
24	9.524	14.777	18.049	20.050
25	16.303	18.049	20.050	22.351

PRELIMINARY ENGINEERING FORMS USED WITH ENERGY
CONSERVATION PROJECTS

MILITARY CONSTRUCTION PROJECTS (MILCON)

OPNAV Form 11000/4	Project Summary Sheet
DOD Form 1391	Project Description
DOD Form 1391c	Energy Analysis and Economic Analysis
NAVFAC 11013/7 (1-78)	Cost Estimate
ECIP Analysis Form	Summary of Energy and Economic Analysis

SPECIAL PROJECTS

NAVFAC Form 9-11014	Project Description
NAVFAC 11013/7(1-78)	Cost Estimate
ECIP Analysis Form	Summary of Energy and Economic Analysis

21. PROJECT DESCRIPTION/JUSTIFICATION

CLASSIFICATION

1. COMPONENT		FY 19__ MILITARY CONSTRUCTION PROJECT DATA			2. DATE	
3. INSTALLATION AND LOCATION				4. PROJECT TITLE		
5. PROGRAM ELEMENT		6. CATEGORY CODE	7. PROJECT NUMBER		8. PROJECT COST (\$000)	
9. COST ESTIMATES						
ITEM				U/M	QUANTITY	COST (\$000)
10. DESCRIPTION OF PROPOSED CONSTRUCTION						

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA		2. DATE
3. INSTALLATION AND LOCATION			
4. PROJECT TITLE		5. PROJECT NUMBER	

ECIP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION _____ P- _____

TITLE OF PROJECT _____ FY- _____

INVESTMENT

1. PROJECT COSTS (Economic life of _____ years)
 - a. Project cost escalated to end of program year \$ _____
 - b. Design costs not yet obligated \$ _____
 - c. Total Project Cost (a + b) \$ _____

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH:
 - a. Equivalent energy; KWH x 0.0116 (MBTUS: _____)
 - b. Cost per KWH at end of program year \$ _____
 - c. First year annual dollar savings (KWH x b) . . . \$ _____
 - d. Differential escalation present worth factor. _____
 - e. Discounted savings (c x d) \$ _____
3. ANNUAL ENERGY SAVINGS (TYPE: _____ MBTUS: _____)
 - a. Cost per MBTU at end of program year \$ _____
 - b. First year annual dollar savings \$ _____
 - c. Differential escalation present worth factor. _____
 - d. Discounted savings (b x c) \$ _____
4. ANNUAL ENERGY SAVINGS (TYPE: _____ MBTUS: _____)
 - a. Cost per MBTU at end of program year \$ _____
 - b. First year annual dollar savings \$ _____
 - c. Differential escalation present worth factor. _____
 - d. Discounted savings (b x c) \$ _____
5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
 - a. Labor \$ _____
 - b. Material & Other \$ _____
 - c. Total (a + b) \$ _____
 - d. 10% Discount Factor \$ _____
 - e. Discounted Other-than-energy savings (or costs) \$ _____
6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c+3b+4b+5c) . . . \$ _____
7. TOTAL DISCOUNTED SAVINGS (2e+3d+4d+5e) \$ _____

COST ESCALATION

Current	* ELEC	\$	_____	x	_____	x	_____	x	_____	=	\$	_____
rates	* OIL	\$	_____	x	_____	x	_____	x	_____	=	\$	_____
as of	* GAS	\$	_____	x	_____	x	_____	x	_____	=	\$	_____
	*	\$	_____	x	_____	x	_____	x	_____	=	\$	_____

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) _____
9. TOTAL MBTU SAVINGS _____ ÷ (Line 1a ÷ 1000) _____
10. SIMPLE PAYBACK PERIOD (1a ÷ Line 6) _____ YRS

STEP TWO SUBMISSION

1. ACTIVITY SUB. NO.		ACTIVITY NAME AND LOCATION			DATE SUBMITTED	
2. PROJECT NO.		TITLE				
3. TYPE						
☐ MAINT./REPAIR ☐ MINOR CONSTRUCTION/ALTERATION ☐ AIR CONDITIONING ☐ EQUIPMENT INSTALLATION						
4. DEDUCE AND STATE FUNCTION OF FACILITY					5. PROPERTY RECORD CARD NO.	
					6. NAVY CATEGORY CODE	
					7. BLDG. OR STRUCTURE NO.	
8. WHAT IS THE EFFECT OF THIS PROJECT ON THE MISSION OF THE ACTIVITY?						
9. THE ASSIGNMENT FOR THE FACILITY IS BASED ON:						
☐ A CHANGE IN MISSION ☐ FULL-TIME CONTINUING NEED ☐ 3 TO 5 YEAR NEED ☐ LESS THAN 3 YEARS NEED ☐ CURRENTLY REQUIRED LESS THAN 50% OF TIME ☐ RESERVED FOR FUTURE REQUIREMENTS						
10. EST. FUNDING COST		11. EST. PROJECT COST		12. EST. PLANNING COST		13. TOTAL FUNDING REQUESTED
\$		\$		\$		\$
14. DATE FACILITY CONSTRUCTED		15. IS FACILITY ON AN APPROVED BASIC FACILITY REQUIREMENTS LIST? If "NO," how was need determined?				
		☐ YES ☐ NO				
16. IS PROJECT LISTED ON ANNUAL INSPECTION SUMMARY? If answer is "YES," and AS is appropriate, explain conditions.						
☐ YES ☐ NO ☐ N.A.						
17. DEDUCE CONDITION TO BE CORRECTED, OR PROBLEM TO BE SOLVED WITH PROPOSED SOLUTION. Attach additional description of necessary, ONE PAGE ONLY.						
18. WHY IS THE PROPOSED SOLUTION BEST - AND WHAT ALTERNATIVES WERE CONSIDERED?						
19. WERE ANY RECOVERY EXPERTS INVITED TO REVIEW THE PROBLEM AND THE SOLUTION? Explain effect on decision.						
☐ YES ☐ NO						
20. HAS SPO DESIGN DIVISION REVIEWED SOLUTION?		☐ YES ☐ NO		21. CAN ANOTHER FACILITY BE ECONOMICALLY ADAPTED FOR THIS FUNCTION?		☐ YES ☐ NO
22. CAN PROJECT BE FUNDED IN FISCAL YEAR (How many)?		☐ YES ☐ NO				
23. THE PROJECT IS THE RESULT OF:						
☐ INADEQUATE MAINTENANCE ☐ FACILITY AGE ☐ DEFICIENT CONSTR. ☐ DEFICIENT DESIGN ☐ OTHER: _____						
24. HAS THE SPECIFIC PROBLEM BEEN CORRECTED PREVIOUSLY?						
☐ YES ☐ NO How? _____						
25. HOW LONG WILL PROPOSED CORRECTIVE ACTION LAST? _____ YEARS						

18. ARE COMPONENTS BEING INCREASED IN SIZE OR CAPACITY? Explain the difference, including cost.

☐ YES ☐ NO

19. ARE MATERIALS PROPOSED FOR USE THE SAME AS THOSE EXISTING? If "NO," explain the difference, including cost.

☐ YES ☐ NO

20. PROJECT IS PLANNED TO BE ACCOMPLISHED BY

a. ☐ STATION LABOR b. ☐ CONTRACT

21. HAS A PROJECT EVER BEEN SUBMITTED FOR THE REPLACEMENT OF THIS OR SIMILAR FACILITIES? Check and explain if "YES."

a. ☐ YES b. ☐ NO *None?*

22. ANTICIPATED SAVINGS IF PROJECT IS DONE THIS YEAR AS COMPARED TO A DEFERRAL OF ONE YEAR.

PROBABLE INCREASE IN PROJECT COST FOR ANY JUSTIFIABLE REASON

REDUCTION IN CURRENT MAINT. COST

REDUCTION IN CURRENT OPERATIONS COST

\$

\$

\$

JUSTIFY ANY SAVINGS INDICATED

WHAT IS PAY BACK PERIOD
OF PROJECT? (in years)

WILL ACCOMPLISHMENT GENERATE REQUIREMENTS
FOR ADDITIONAL M&O FUNDS OR PERSONNEL?

a. ☐ NO b. ☐ YES *Est. Ann.*

23. WHAT WOULD BE THE EFFECT OF DEFERRING THE PROJECT ONE YEAR?

24. IF THE PROJECT IS NOT ACCOMPLISHED NOW, IN HOW MANY YEARS WILL THERE BE SERIOUS DAMAGE TO THE FACILITY AND/OR ITS CONTENTS OR IMPAIRMENT TO ESSENTIAL OPERATIONS?
Explain, include loss value to facility and/or contents.

YEARS BEFORE SERIOUS DAMAGE OCCURS _____

25. HAS THE REQUESTED UTILIZATION OF THIS SPECIFIC FACILITY AFFECTED A LARGE FACILITY SYSTEM OPERATION? Explain.

☐ YES ☐ NO

BY HOW MUCH? _____ %

26. ARE THERE ANY OTHER FACTORS INVOLVED? Check and explain.

☐ MORALE ☐ HEALTH c. ☐ PUBLIC RELATIONS d. ☐ SAFETY e. ☐ FIRE PROTECTION f. ☐ SECURITY g. ☐ OTHER

27. CERTIFICATION BY RESPONSIBLE OFFICER AT ACTIVITY: I am personally cognizant of the need for, the essentiality of, and the proposed method of accomplishment of this project and certify that the above information is correct, and that this project meets all criteria specified in OPNAVINST 11010.20 and subsequent changes thereto.

SIGNATURE	TITLE	DATE

28. SFO TECHNICAL VALIDATION (if required) (see para 7303, OPNAVINST 11010.20C)

SIGNATURE	TITLE	DATE

ENCLOSURES

a. ☐ ENGINEERING EST. (NAVFAC 2417) b. ☐ LOCATION PLANS c. ☐ DRAWINGS d. ☐ PHOTOGRAPHS

*NOT applicable to Minor Construction, Alterations, or Equipment Installation

ETAP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION _____

TITLE OF PROJECT _____ FY- _____

INVESTMENT

1. PROJECT COSTS (Economic life of _____ years)
 - a. Project cost \$ _____
 - b. Design costs \$ _____
 - c. Total Project Cost (a + b) \$ _____

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH: _____
 - a. Equivalent energy; KWH x 0.0116..... (MBTUs: _____)
 - b. Cost per KWH \$ _____
 - c. First year annual dollar savings (KWH x b)... \$ _____
 - d. Differential escalation present worth factor. _____
 - e. Discounted savings (c x d)..... \$ _____
3. ANNUAL ENERGY SAVINGS (TYPE: _____ MBTUs: _____)
 - a. Cost per MBTU \$ _____
 - b. First year annual dollar savings..... \$ _____
 - c. Differential escalation present worth factor. _____
 - d. Discounted savings (b x c)..... \$ _____
4. ANNUAL ENERGY SAVINGS (TYPE: _____ MBTUs: _____)
 - a. Cost per MBTU \$ _____
 - b. First year annual dollar savings..... \$ _____
 - c. Differential escalation present worth factor. _____
 - d. Discounted savings (b x c)..... \$ _____
5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
 - a. Labor..... \$ _____
 - b. Material & Other..... \$ _____
 - c. Total (a + b)..... \$ _____
 - d. 10% Discount Factor.....
 - e. Discounted Other-than-energy savings (or costs) \$ _____
6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c+3b+4b+5c).... \$ _____
7. TOTAL DISCOUNTED SAVINGS (2e+3d+4d+5e)..... \$ _____

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) _____
9. TOTAL MBTU SAVINGS _____ ÷ (Line 1c ÷ 1000) _____
10. SIMPLE PAYBACK PERIOD (1c ÷ Line 6)..... YRS _____

10.6 ECIP COST ANALYSIS FORM - SAMPLE DATA AND CALCULATIONS.

Description:

Building V-38 houses a paint shop on the southwestern half of the building and a mothballing shop on the northeastern half. The air supply for both halves of the building is identical. Air enters from the outside through dampers and then passes through a steam coil heat exchanger. The supply fan is located downstream of the coil. Finally the air goes through turning vanes, through a filter and into the room.

In the paint shop half of the buildings, the exhaust passes through a water wash. In the moth ball shop, the exhaust system was recently renovated. This exhaust system consists of a total of 20 individual ducts. Eight ducts manifold together to a single duct where a 10 HP fan exhausts the air. Another set of eight ducts is identically configured as described above. The four remaining ducts manifold together to a single duct where a 5 HP fan exhausts the air. Two supply air fans are driven with 35 hp electric motors.

Analysis: . .

During a site survey of this building, it was determined that savings could be achieved by adding unit heaters to keep the building warm during hours when the building is occupied and no painting or moth-balling is being done.

Summary of Estimated Annual Savings:

A total of 2175 MBTU can be saved if heating is done with unit heaters when ventilation is not required. Since the fans will be used less frequently, 25,300 Kwh can be saved.

Estimated Retrofit Costs:

The cost estimate for installing unit heaters in Building V-38 is shown below:

<u>Item</u>	<u>Cost</u>
8 Unit Heaters	\$2120
Piping	710
Wiring	110
Steam Traps	930
Steam Valves	<u>930</u>
Sub-total	\$4800
Controls (15%)	<u>720</u>
Total	\$5520

The above costs include hardware, labor, overhead and profit. Allowing 20% for engineering and 25% contingencies, the total comes to \$8000. This is the 1978 cost. Assuming the project will be completed in FY 1982, the escalated cost is:

$$8000 \times 1.07 \times 1.065 \times 1.06 \times 1.06 = \$10,243$$

where the factors 1.07, 1.065, etc., are escalation factors for 1979 through 1982.

Note that according to the ECIP Guidelines, the retrofit does not qualify (\$10,243 vs \$100,000) as a MILCON Project.

Estimated Energy Costs:

FY'79 unit energy costs are:

Electricity	\$.0275/KWH (\$2.37/MBTU source)
Oil	\$2.03/MBTU

Data for ECIP Form, Page 10-26:

Line 1 Economic Life

From ECIP Guidelines, Item 11. Equipment Life, 15 years.

Line 2d Escalation Rates

From ECIP Guidelines, Item 9. The long term differential escalation rate for electricity is 7%. From discount factors table use economic life 15 years and differential inflation rate, 7%. Then differential escalation, present worth factor becomes 12.278.

Line 3C Escalation Rates

From ECIP Guidelines, Item 9. The long term differential escalation rate for fuel oil is 8%. From discount factors tables use economic life 15 years and differential inflation rate, 8% then differential escalation present worth factor becomes 13.112.

ECIP-ECONOMIC ANALYSIS SUMMARY

Activity and Location: NARF NORFOLK P-
 Title of Project: V-38 ADD UNIT HEATERS FY-81

INVESTMENT

1. Project cost (Economic life of 15 years)
 - a. Project cost escalated to end of program year \$ 10,243
 - b. Design costs not yet obligated \$ X
 - c. Total project Cost (a + b) \$ 10,243

SAVINGS

2. Annual Electricity Savings: (KWH: 25,300)
 - a. Equivalent Energy: KWH x 0.0116 MBTU's 293
 - b. Cost per KWH at End of Program Year \$ 0.0472
 - c. First Year Annual Dollar Savings (KWH x b) \$ 1194
 - d. Differential Escalation Present Worth Factor \$ 12.278
 - e. Discounted Savings (c x d) \$ 14,660
3. Annual Energy Savings (Type: #2 Fuel Oil) MBTU's 2175
 - a. Cost per MBTU at End of Program Year \$ 3.55
 - b. First Year Annual Dollar Savings \$ 7721
 - c. Differential Escalation Present Worth Factor \$ 13,112
 - d. Discounted Savings (b x c) \$ 101,238
4. Annual Energy Savings (Type: X) MBTU's X
 - a. Cost per MBTU at End of Program Year \$
 - b. First Year Annual Dollar Savings \$
 - c. Differential Escalation Present Worth Factor \$
 - d. Discounted Savings (b x c) \$
5. Annual Other-Than-Energy Savings (Or Costs)
 - a. Labor \$ X
 - b. Material and Other \$
 - c. Total (a + b) \$
 - d. 10% Discount Factor \$
 - e. Discounted Other-Than-Energy Savings (Or Costs) \$
6. Total First Year Annual Savings (2c+3b+4d+5c) \$ 8,915
7. Total Discounted Savings (2e+3d+4d+5e) \$ 115,898

COST ESCALATION

Current	*ELEC	$\$.0275 \times 1.16 \times 1.13 \times 1.13 \times 1.13 =$	\$0.0472
rates of	*OIL	$\$2.03 \times 1.16 \times 1.16 \times 1.14 \times 1.14 =$	\$3.55
as of	*GAS	\$ <u> </u> x <u> </u> x <u> </u> x <u> </u> =	\$ <u> </u>
1979	*	\$ <u> </u> x <u> </u> x <u> </u> x <u> </u> =	\$ <u> </u>

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c) 11.3
9. E/C Ratio (Total MBTU Saved divided by 1a/1000) 241
10. Simple Payback Period (Line 1a divided by Line 6) 1.15 YRS

Ref: NAVFAC ltr. 1113F/RHB dated 6 September 1978

Another ECIP Economic Analysis Summary is shown on page 10-28. In this case, an energy monitoring and control system is analyzed. Note that Item 4, Annual Energy Savings, is electric demand. It is not included in the total MBTU savings, Item 3 MBTU savings represent energy consumption.

Line 2c, total first year annual savings, includes the effect of line 5c. Line 5c is a negative number that accounts for the labor and service contract.

ECIP - ECONOMIC ANALYSIS SUMMARY

Activity and Location: SAMPLE NAVAL BASE #2 P-0001
 Title of Project: ENERGY MONITORING AND CONTROL FY-81
SYSTEM

INVESTMENT

1. Project cost (Economic life of 15 years)	
a. Project cost escalated to end of program year	\$1,000,000
b. Design costs not yet obligated	\$ 30,000
c. Total project Cost (a + b)	<u>\$1,030,000</u>

SAVINGS

2. Annual Electricity Savings: (KWH: <u>5,100,000</u>)	\$ 59,160
a. Equivalent Energy: KWH x 0.0116 MBTU's	\$ 0.0511
b. Cost per KWH at End of Program Year	\$ 260,610
c. First Year Annual Dollar Savings (KWH x b)	\$ 12,278
d. Differential Escalation Present Worth Factor	<u>\$3,199,776</u>
e. Discounted Savings (c x d)	
3. Annual Energy Savings (Type: <u>Fuel Oil #2</u>) MBTU's	38,000
a. Cost per MBTU at End of Program Year	\$ 4.44
b. First Year Annual Dollar Savings	\$ 168,720
c. Differential Escalation Present Worth Factor	13.112
d. Discounted Savings (b x c)	<u>\$2,212,250</u>
4. Annual Energy Savings (Type: Electric Demand) MBTU's	4800 KW
a. Cost per MBTU at End of Program Year	\$ 6.82
b. First Year Annual Dollar Savings	\$ 32,736
c. Differential Escalation Present Worth Factor	12.278
d. Discounted Savings (b x c)	<u>\$ 401,933</u>
5. Annual Other-Than-Energy Savings (Or Costs)	
a. Labor (4160 man-hours x 10.05)	\$ (41,808)
b. Material and Other (Service Contract)	\$ (60,000)
c. Total (a + b)	\$ (101,808)
d. 10% Discount Factor @ 0%	\$ 7.980
e. Discounted Other-Than-Energy Savings (Or Costs)	<u>\$ 812,428</u>
6. Total First Year Annual Savings (2c+3b+4d+5c)	<u>\$ 360,258</u>
7. Total Discounted Savings (2e+3d+4d+5e)	<u>\$5,001,532</u>

COST ESCALATION

		'78	'79	'80	'81		
Current	*ELEC	\$0.03	x1.12	x1.16	x1.16	x1.13	= \$0.0511
rates of	OIL	\$2.60	x1.12	x1.16	x1.16	x1.14	= \$4.44
as of	*GAS	\$4.00	x1.12	x1.16	x1.16	x1.13	= \$6.82
1 Jan	*LABOR	\$8.00	x1.053	x1.064	x1.064	x1.056	= \$10.05
78							

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c)	4.86	
9. E/C Ratio (Total MBTU Saved divided by 1a/1000)	<u>97.2</u>	
10. Simple Payback Period (Line 1a divided by Line 6)	<u>2.8</u>	YRS

Ref: NAVFAC ltr. 1113F/RHB dated 6 September 1978

10.7 SPECIAL PROJECT (ETAP) FORMS - SAMPLE DATA AND
CALCULATIONS

<u>Form</u>	<u>Description</u>
NAVFAC 9-11014	Indicates the total funds requested to reduce fuel consumption and to save energy in Batch Furnace No. 3. Describes the improvement to the furnace.
NAVFAC 11013/7(1-78)	Cost estimate worksheet for the improvement.
ECIP Economic Analysis Survey	Based on current year program. Note that the analysis indicates that the project does not meet the criteria in the ECIP Guidelines (ECIP Guidelines, Item 2 indicates that SIR must be greater than one.) Line 8 of the ECIP Economic Analysis Summary indicates a SIR of 0.8.

DEPARTMENT OF THE NAVY
SPECIAL PROJECTS REQUEST

NAVFAC 9-11018/64 (11-68) Supersedes NAVDOCKS 7950 S/M 0105-004-0228

SHEET 1 OF 2

1. ACTIVITY AND NO.		ACTIVITY NAME AND LOCATION		DATE SUBMITTED
		BOSTON NAVAL SHIPYARD, BOSTON, MA		4 APR 78
2. PROJECT NO.		TITLE		
		IMPROVEMENTS TO BATCH FURNACE NO. 3, BLDG. 17, FORGE SHOP		
3. TYPE				
☐ A. MAINT./REPAIR ☐ B. MINOR CONSTRUCTION/ALTERATION ☐ C. AIR CONDITIONING ☐ D. EQUIPMENT INSTALLATION				
4. DESCRIPTION AND FUNCTION OF FACILITY				5. PROPERTY RECORD CARD NO. 6. NAVY CATEGORY CODE 7. BLDG. OR STRUCTURE NO.
BATCH FURNACE NO. 3 HEAT STEEL FOR FORGING OPERATIONS.				

5. WHAT IS THE EFFECT OF THIS PROJECT ON THE MISSION OF THE ACTIVITY?

REDUCE FUEL CONSUMPTION AND SAVE ENERGY

6. THE REQUIREMENT FOR THE FACILITY IS BASED ON:					
☐ A. A CHANGE IN MISSION ☒ B. FULL-TIME CONTINUING NEED ☐ C. 3 TO 5 YEAR NEED ☐ D. LESS THAN 3 YEARS' NEED ☐ E. CURRENTLY REQUIRED LESS THAN 50% OF TIME ☐ F. RESERVED FOR FUTURE REQUIREMENTS					
7A. EST. FUNDED COST		7B. EST. PROJECT COST		7C. EST. PLANNING COST	
\$ 20,000		\$ 18,000		\$ 2,000	
7D. DATE FACILITY CONSTRUCTED		7E. IS FACILITY ON AN APPROVED BASIC FACILITY REQUIREMENTS LIST? If "NO," how was need determined?			
N/A		☐ YES ☐ NO N/A			

10. IS PROJECT LISTED ON ANNUAL INSPECTION SUMMARY? If answer is "NO," and AIS is applicable, explain exclusion.

☐ YES ☐ NO ☒ N.A.

11. 3 LINE DESCRIPTION OF CONDITION TO BE CORRECTED, OR PROBLEM TO BE SOLVED WITH PROPOSED SOLUTION. Attach additional description if necessary. ONE PAGE ONLY.

excess heat loss thru inadequately insulated furnace walls. Remove existing insulation and replace with new 10" insulation.

12. WHY IS THE PROPOSED SOLUTION BEST - AND WHAT ALTERNATIVES WERE CONSIDERED?

Least costly and requires no modifications to furnace. No other solutions considered.

13. WERE ANY NON-NAVY EXPERTS INVITED TO REVIEW THIS PROBLEM AND THIS SOLUTION? Explain effect on solution.

☒ A. YES ☐ B. NO DEVELOPED BY ENERGY CONSERVATION TEAM.

14. HAS EFD DESIGN DIVISION REVIEWED SOLUTION?		15. CAN ANOTHER FACILITY BE ECONOMICALLY ADAPTED FOR THIS FUNCTION?	
☒ A. YES ☐ B. NO		☐ C. YES ☒ D. NO	

16. CAN PROJECTS BE FUNDED IN INCREMENTS? How?

☐ A. YES ☒ B. NO

17. THIS PROJECT IS THE RESULT OF

☐ A. INADEQUATE MAINTENANCE
 ☒ B. FACILITY AGE
 ☐ C. DEFICIENT CONSTR.
 ☐ D. DEFICIENT DESIGN
 ☐ E. OTHER:

18. HAS THIS SPECIFIC PROBLEM BEEN CORRECTED PREVIOUSLY?

☐ A. YES ☒ B. NO When?

HOW LONG WILL PROPOSED CORRECTIVE ACTION LAST? 15 Years YEARS

19. ARE COMPONENTS BEING INCREASED IN SIZE OR CAPACITY? Explain the difference, including cost.

☐ A. YES ☒ B. NO

20. ARE MATERIALS PROPOSED FOR USE THE SAME AS THOSE EXISTING? If "NO," explain the difference, including cost.

a. ☒ YES b. ☐ NO

21. PROJECT IS PLANNED TO BE ACCOMPLISHED BY

a. ☐ STATION LABOR b. ☒ CONTRACT

22. HAS A PROJECT EVER BEEN SUBMITTED FOR THE REPLACEMENT OF THIS OR SIMILAR FACILITIES? Check and explain if "YES".

a. ☐ YES b. ☒ NO When?

23. ANTICIPATED SAVINGS IF PROJECT IS DONE THIS YEAR AS COMPARED TO A DEFERRAL OF ONE YEAR.

PROBABLE INCREASE IN PROJECT COST FOR ANY JUSTIFIABLE REASON

REDUCTION IN CURRENT MAINT. COST

REDUCTION IN CURRENT OPERATIONS COST

\$ 1,260

\$ 0

\$ 1,215.

JUSTIFY ANY SAVINGS INDICATED

Fuel oil consumption reduced by 2,960 gallons per year.

WHAT IS PAY BACK PERIOD OF PROJECT? (In years)

15

WILL ACCOMPLISHMENT GENERATE REQUIREMENTS FOR ADDITIONAL WAG FUNDS OR PERSONNEL?

a. ☒ NO b. ☐ YES Est. Ann.

24. WHAT WOULD BE THE EFFECT OF DEFERRING THE PROJECT ONE YEAR?

Increase Cost

25. IF THE PROJECT IS NOT ACCOMPLISHED NOW, IN HOW MANY YEARS WILL THERE BE SERIOUS DAMAGE TO THE FACILITY AND/OR IT'S CONTENTS OR IMPAIRMENT TO ESSENTIAL OPERATIONS? Explain, include loss value to facility and/or contents.

YEARS BEFORE SERIOUS DAMAGE OCCURS N/A

26. HAS THE REDUCED UTILIZATION OF THIS SPECIFIC FACILITY AFFECTED A LARGE FACILITY SYSTEM OPERATION? Explain.

☐ YES b. ☒ NO BY HOW MUCH? \$.

27. ARE THERE ANY OTHER FACTORS INVOLVED? Check and explain.

a. ☐ MORALE b. ☐ HEALTH c. ☐ PUBLIC RELATIONS d. ☐ SAFETY e. ☐ FIRE PROTECTION f. ☐ SECURITY g. ☒ OTHER

ENERGY CONSERVATION

28. CERTIFICATION BY RESPONSIBLE OFFICER AT ACTIVITY: I am personally cognizant of the need for, the essentiality of, and the proposed method of accomplishment of this project and certify that the above information is correct, and that this project meets all criteria specified in OPNAVINST 11010.20 and subsequent changes thereto.

DATE	TYPED NAME OF OFFICER AND POSITION	SIGNATURE

EFO EVALUATION BY RESPONSIBLE ENGINEER: I hereby certify that this project has been thoroughly evaluated, that it is an essential project, and that it is both economically and technically sound. A rating factor is hereby assigned.

29. VALID FOR RATING FACTOR	30. EFO RATING				
	(1)	(2)	(3)	(4)	(5)
	_____ X _____ X _____ X _____ X _____ X 100 = _____				
	31. DATE	TYPED EVALUATOR'S NAME AND POSITION		SIGNATURE	

ENCLs:
a. ☐ ENGINEERING EST. (NAVOCKS 2417) b. ☐ LOCATION PLAN(S) c. ☐ DRAWINGS d. ☐ PHOTOGRAPHS

64700643 24174 (REV. 5-62)

SHEET 1 OF 1

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ASIAN

LOCATION

TABLE 2

1. **מנהל**

BOSTON NAVSHIPYD

BOSTON, MA

ENCLOSURE: 20 1100 1100 1100

REINSULATE BATCH FURNACE NO. 3. BLDG. 17. FORGE SHOP

[illegible]

000000 00 0000

JOHN SMITH

40000-66 87

FRANK JONES

• 26 20 ORGANIZATION

AEF COMPANY

DATE

15 MAR 79

Activity and Location: ECIP ECONOMIC ANALYSIS P-
 Title of Project: IMPROVEMENTS TO BATCH FURNACE FY-78
NO. 3

INVESTMENT

1. Project cost (Economic life of 15 years)
 - a. Project cost escalated to end of program year \$20,000
 - b. Design costs not yet obligated \$ X
 - c. Total project Cost (a + b) (for current year program) \$20,000

SAVINGS

2. Annual Electricity Savings: (KWH: X)
 - a. Equivalent Energy: KWH x 0.0116 MBTU's \$
 - b. Cost per KWH at End of Program Year \$
 - c. First Year Annual Dollar Savings (KWH x b) \$
 - d. Differential Escalation Present Worth Factor \$
 - e. Discounted Savings (c x d) \$
3. Annual Energy Savings (Type: Fuel Oil #2) MBTU's 411
 - a. Cost per MBTU at End of Program Year \$ 2.97
 - b. First Year Annual Dollar Savings \$ 1221
 - c. Differential Escalation Present Worth Factor 13.112
 - d. Discounted Savings (b x c) \$16,009
4. Annual Energy Savings (Type: X) MBTU's
 - a. Cost per MBTU at End of Program Year \$
 - b. First Year Annual Dollar Savings \$
 - c. Differential Escalation Present Worth Factor \$
 - d. Discounted Savings (b x c) \$
5. Annual Other-Than-Energy Savings (Or Costs)
 - a. Labor \$
 - b. Material and Other \$
 - c. Total (a + b) \$
 - d. 10% Discount Factor \$
 - e. Discounted Other-Than-Energy Savings (Or Costs) \$
6. Total First Year Annual Savings (2c+3b+4d+5c) \$ 1221
7. Total Discounted Savings (2e+3d+4d+5e) \$16,009

COST ESCALATION (for current year program)

Current	*ELEC	\$	x	x	x	x	=	\$
rates of	*OIL	\$2.97	x	x	x	x	=	\$2.97
as of	*GAS	\$	x	x	x	x	=	\$
	*	\$	x	x	x	x	=	\$

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c) 0.80
9. E/C Ratio (Total MBTU Saved divided by 1a/1000) 20.55
10. Simple Payback Period (Line 1a divided by Line 6) 16.4 YRS

10.8

MILCON FORMS - SAMPLE DATA AND CALCULATIONS

The sheets are arranged to determine the following:

Is there a valid Energy Conservation Project for the Batch Furnace at the Boston Naval Shipyard?

If the project should be requested, what forms are required?

<u>Procedure</u>	<u>Description</u>
Energy Analysis and Calculations on Unlined White Paper	Heat Balance on a Batch Furnace
Economic Analysis on Unlined White Paper	Economic analysis using cost data and ECIP criteria.

The results from the above indicate that a MILCON project should be requested.

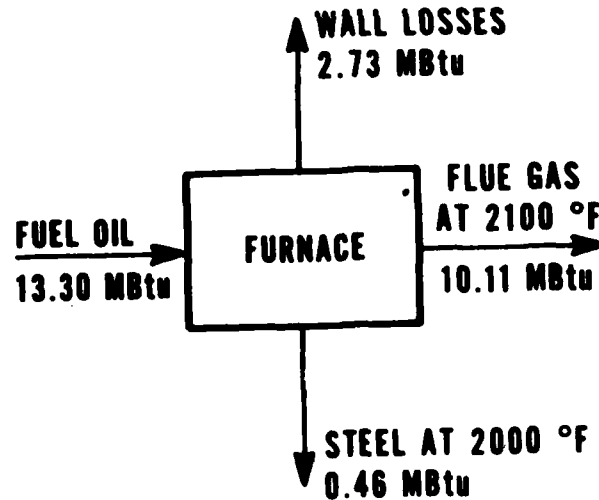
<u>Form</u>	<u>Description</u>
OPNAV 11000/4	Project Summary Sheet
DD 1391	Project Description
DD 1391C	Energy Calculation, Economic Analysis using ECIP Guidelines
NAVFAC 11013/7	Cost Estimates
ECIP Cost Analysis	Not needed - in this case. Analysis was covered on DD 1391C

ENERGY ANALYSIS AND CALCULATIONS

Heat Balance on A Batch Furnace

An oil fired furnace heats one-ton batches of steel to 2000°F for a forging operation. The furnace burns 95 gallons of No. 2 fuel oil during each two-hour cycle. This oil yields 13.3 MBtu (13,300,000 Btu). The stack temperature is 2100°F , and an analysis of the flue gas shows an oxygen content of 11 percent, meaning that the furnace uses 100 percent excess air, twice the amount of air theoretically needed to completely burn the fuel.

The heat is as follows:



For simplicity, this example considers only the fuel used while actually heating a batch of steel. It ignores the fuel used to heat up a cold furnace and to keep it hot while unloading one batch and loading the next. Because of this, actual savings due to a conservation project will be greater than those estimated in this example. Any change which saves energy during operation will also save some energy during warm up and during idling.

The only energy input to this system is the burning fuel oil. At an energy content of 140,000 Btu per gallon for No. 2 oil,

$$\text{Heat Input} = 140,000 \text{ Btu/gal} \times 95 \text{ gal} = 13.30 \text{ MBtu.}$$

The same quantity of energy must also leave the furnace during each cycle; it does so in three forms:

(1) The heat content of the steel is the weight of the steel times its temperature increase times its specific heat of 0.12 Btu/lb^{°F}. If the steel enters the furnace at 100^{°F}, then the energy removed from the furnace by a heated one-ton batch will be:

$$\begin{aligned} \text{Heat in steel} &= 2000 \text{ lb} \times (200-100) \text{ }^{\circ}\text{F} \times 0.12 \text{ Btu/lb}^{\circ}\text{F} \\ &= 456,000 \text{ Btu, or } 0.46 \text{ MBtu.} \end{aligned}$$

(2) The stack loss represents the energy escaping in the hot flue gas. Referring to figure 3 note that a stack temperature of 2100^{°F}, and with 100 percent excess air, the stack loss is 76 percent of the fuel burned.

$$\text{Stack loss} = 13.30 \text{ MBtu} \times 0.76 + \underline{10.11 \text{ MBtu.}}$$

(3) Conduction and radiation losses from the furnace walls and roof must make up the remainder of the energy output

$$\text{Wall losses} = 13.30 - (0.46 + 10.11) = \underline{2.73 \text{ MBtu}}$$

$$\underline{\text{Output}} = 0.46 + 10.11 + 2.73 = \underline{13.30 \text{ MBtu per cycle}}$$

It is evident in this FIRST HEAT BALANCE that most (76 percent) of the energy is wasted up the exhaust stack. Looking at figure 3, one can observe that the stack loss is least when the amount of combustion air is precisely the amount required to completely burn the fuel. If a large amount of excess air is supplied, much of the energy of the fuel is used to heat the air and the stack loss becomes very large. Conversely of course, if insufficient air is supplied, the fuel will not be completely burned and energy will again be wasted. A reasonable quantity of excess air when burning fuel oil is about 20 percent, or when burning natural gas about 5 to 10 percent.

Excess air can be reduced by adjusting the burners, by throttling the air inlets, and by repairing cracks, holes, and ill-fitting doors. The stack damper should also be adjusted to maintain a very slight positive pressure in the fire-box to prevent the infiltration of unwanted air. The goal of 20 percent excess air is reached when, the flue gas analysis shows 3.5 percent oxygen and approximately 13 percent carbon dioxide.

At 20 percent excess air, figure 3 shows that the stack loss is only 46 percent of the fuel energy instead of the original 76 percent. The energy absorbed by the steel remains at 0.46 MBtu. This total $2.73 + 0.46 = 3.19$ MBtu, is now 54 percent of the total input ($100\% - 46\% = 54\%$). The total fuel energy needed per cycle is therefore:

$$\text{Input} = 3.19 \text{ MBtu} / 0.54 = \underline{5.91 \text{ MBtu}}.$$

$$\text{Input} = 3.19 \text{ MBtu} / 0.54 = \underline{5.91 \text{ MBtu}}.$$

With this input, we can make a SECOND HEAT BALANCE:

Input	Output
<u>5.91 MBtu</u>	<u>Steel 0.46 MBtu</u>
(42.2 gal of oil)	Stack 2.72 MBtu
	<u>Walls 2.73 MBtu</u>
	Total 5.91 MBtu

In the second heat balance, even after adjusting the excess air to the practical minimum, energy is being wasted up the stack at the rate of 2.72 MBtu per cycle, or at 500 cycles per year, 1360 MBtu per year.

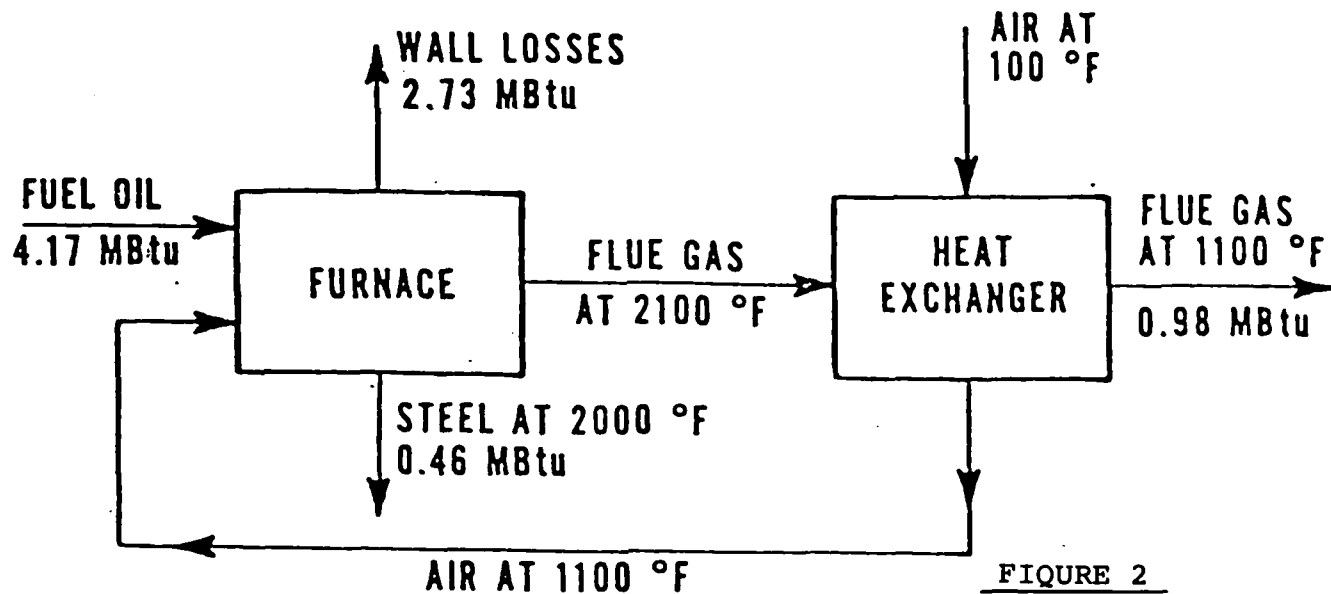
Some of this heat can be recovered by passing the flue gas through a heat exchanger, or through a waste heat boiler. The recovered heat can be used for a variety of purposes; following are some of those frequently suggested.

- (1) Make steam for process use, for electrical power generation, or for space heating.
- (2) Heat water for processing or for space heating.
- (3) Preheat combustion air for the furnace.
- (4) Preheat the product entering the furnace.
- (5) Heat air for space heating.

According to the stack loss vs. excess air chart, at 20 percent excess air and a stack temperature of 1100°F , the stack loss is 23.5 percent of the fuel fired. The other two outputs, the 2.19 MBtu for conduction losses and for heat in the hot steel, must therefore amount to: 100 percent - 23.5 percent = 76.5 percent of the fuel. Under this condition,
Fuel energy = $3.19 \times 1/0.765 = 4.17$ MBtu per cycle.

Stack loss = $4.17 \times 0.235 = 0.98$ MBtu per cycle.

At this point, the largest energy loss in the system is the 2.73 MBtu lost by conduction and radiation through the walls and roof of the furnace.



The best use for the recovered heat depends on the process and the particular plant conditions. In this case, with a batch furnace and possibly a rather uneven schedule, preheating the combustion air might be the best use. Figure 2 shows the heat flow with such an arrangement as a THIRD HEAT BALANCE. The numbers are MBtu of energy for a two hour furnace cycle.

To estimate the fuel usage under these conditions, consider the entire diagram as a single system with one heat input (the air at 100°F is considered not to carry any heat), and three outputs. Two of the outputs are the heat in the steel and the conduction losses. The sum of these outputs is 3.19 MBtu as in the second heat balance. The third output is the waste flue gas at 1100°F . (Since the mass of flue gas is

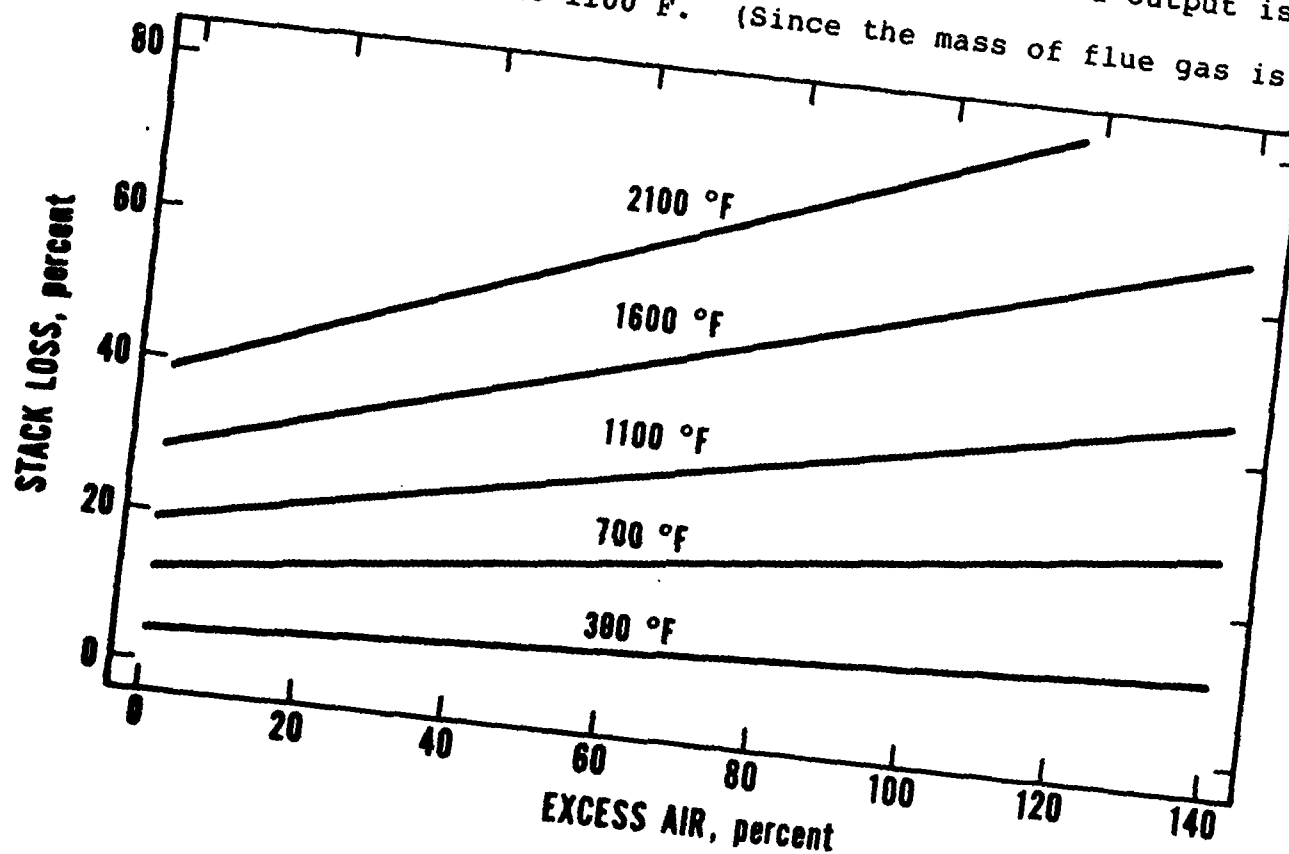


Figure 3

approximately equal to the mass of combustion air, it is reasonable to estimate that if the air is heated by 1000°F , the flue gas will be cooled by the same amount).

If we further assume that suitable repair or addition to the insulation can reduce this loss to 1.90 MBtu per cycle, a FOURTH HEAT BALANCE performed in a similar manner shows that this will reduce the fuel input to 3.08, and the stack loss to 0.72 MBtu per cycle.

The following table summarizes the heat balance analyses of the furnace system:

Batch Furnace Heat Balances (Two-Hour Cycle)

	<u>Condition</u>	<u>Input</u>	<u>Stack Loss</u>	<u>Conduction Loss</u>	<u>Heat in Steel</u>	<u>Efficiency</u>
		MBtu	MBtu	MBtu	MBtu	Percent
(1)	Original system	13.30	10.11	2.73	0.46	3.5
(2)	Reduce excess air	5.91	2.72	2.73	0.46	7.8
(3)	Preheat air	4.17	0.98	2.73	0.46	11.0
(4)	Add insulation	3.08	0.72	1.90	0.46	14.9

Assuming a production rate of 50 cycles per year, the annual energy savings would be:

$$= 500 \text{ cycles per year} \times (13.30 - 3.08) \text{ MBtu's/year}$$

$$= 5,110 \text{ MBtu's/year}$$

For No. 2 fuel oil at 140,000 BTU's per gallon, the annual saving would be:

$$\frac{= 5,110 \times 1,000,000 \text{ BTU's/year}}{140,000 \text{ BTU's/gallon}} = 36,500 \text{ Gallons/year}$$

Extracted from: Energy Management of Furnaces, Kilns and Ovens, National Bureau of Standards, Handbook 124, January 1978.

ECONOMIC ANALYSIS

1. Using the energy analysis and calculations as the basis for an economic analysis:

a. The energy analysis indicates this recommendation would save 36,500 gallons of No. 2 fuel oil per year.

b. From the Activity we have determined that the present day cost for No. 2 fuel oil is \$0.41/gallon. (1978 prices).

c. An engineering cost estimate has been made and it was determined that the construction cost for this recommendation would be \$78,000.

2. Since the present cost of the project is \$78,000, the program year for the MILCON project must be determined. (See paragraph 4 of the Guidelines). To determine if this project would qualify for the ECIP Program, we must make an Economic Analysis (see paragraph 1, 2 and 3 of the Guidelines).

3. If this project does qualify for the ECIP Program, it would be submitted for the FY-81 Program (see paragraph 16 of escalated to the program year (see paragraph 8 of the Guidelines) and therefore all costs and savings must be escalated to the program year (see paragraph 8 of the Guidelines).

4. For this example, we will assume that today's date is April 4, 1978. This date is in the third quarter of FY-78. Therefore, all escalations must be for two quarters of FY-78, all of FY-79, FY-80 and FY-81 (see paragraph 8 of the Guidelines).

- a. To establish the cost savings for this project:
Gallons of Fuel Oil Saved per Year = 36,500
Present day Cost of the Fuel Oil = \$0.41/gallon
Escalation = $\frac{\text{FY-78}}{(1.08)} \times \frac{\text{FY-79}}{(1.16)} \times \frac{\text{FY-80}}{(1.16)} \times \frac{\text{FY-81}}{(1.14)} = 1.66$

$$\text{Cost Savings} = 36,500 \text{ gal} \times \$0.41/\text{gal} \times 1.66 = \$24,840/\text{year}$$

- b. To establish the project cost:

Engineering Co. Estimate = \$78,000

Added Cost for Supervision, Inspection,
Overhead (SIOH) = 5.5%

$$\text{Escalation} = \frac{\text{FY-78}}{(1.04)} \times \frac{\text{FY-79}}{(1.07)} \times \frac{\text{FY-80}}{(1.065)} \times \frac{\text{FY-81}}{(1.06)} = 1.26$$

$$\text{Project Cost} = (\$78,000 + 0.055 \times \$78,000) \times 1.26 = \$103,700$$

*Government administrative costs chargeable to the project.

- c. To determine the ECIP Inflation - Discount Factor,
use the Discount Factors Table.

(1) This project involves repairs and adjustment to the furnace, installation of a heat exchanger and insulation of the furnace. Repairs and adjustments and insulation of the furnace are all associated with the furnace life. Assume the furnace has at least 25 years of service life (we cannot use a longer period for equipment) so these items also will have a 25 year economic life (see paragraph 11 of the Guidelines).

(2) The long term differential escalation rate for fuel oil is 8% (see paragraph 9 of the Guidelines).

(3) The present worth factor for the recurring annual savings is 20.05 (for 8% differential inflation rate and 25 year economic life from the Discount Factors Table).

d. To calculate the savings to investment ratio (SIR):
(see paragraph 2 of the Guidelines).

Cost Savings = \$24,840/year

Project Cost = \$103,700

Present Worth Factor = 20.05

$$\text{SIR} = \frac{(\text{Annual Savings}) (\text{Present Worth Factor})}{\text{Project Cost}} = \frac{\$24,840 \times 20.05}{\$103,700} = 4.8$$

e. To calculate the energy savings to cost ratio:

Energy Savings = 5,110 MBtu's/Year (from the Energy
Analysis and
Calculations
Sheets)

Project Cost divided by 1,000 = 103.7

$$\text{Energy Savings to Cost} = \frac{5,110 \text{ MBtu's}}{103} = 49.3 \text{ MBtu's}/\$1000 \text{ Proj.}$$

f. To calculate the simple amortization period:

Cost Savings = \$24,840/year

Project Cost = \$103,700

Simple Amortization Period

$$= \frac{\text{Project Cost}}{\text{Cost Savings}} = \frac{\$103,700}{\$24,840} = 4.2 \text{ Years}$$

5. This project has a savings-to-investment ratio of greater than one (paragraph 4d shows 4.8) and the energy savings to cost ratio is 49.3 MBtu's/\$1000 Project Cost Paragraph 8 of the Guidelines indicates the minimum requirement for FY-81 of 20 MBtu's/\$1000 Project Cost). This project qualifies for the ECIP Program and should be written up in MILCON Project format.

PROJECT FOR CONNECTION OF FACILITY DEFICIENCY
OPNAV 11000-4 (REV. 3-77)
Navy Order 110-00-25

1. SUBMITTING ACTIVITY NAME AND LOCATION
NORTH AVIAL SHIPYARD, BOSTON, MA

2. PROJECT ACTIVITY AND LOCATION
NAME

3. ACTIVITY UIC
C. AREA CODE
D. CLAIMANT CODE
E. DATE OF LATEST FOR

4. COMPONENT NAME
1. COMPONENT UIC

DATE COMPLETED	PROJECT TITLE	ALTERNATE HOST UIC	SPECIAL REQUIREMENTS	SCOPE		ESTIMATED COST (1000)	EST. COST YEAR	USABLE COMPLETION DATE		PERCENT SATISFIED			INVESTMENT		ECONOMIC ANALYSIS	E I T E	S I T E	MC PHOT-ITV	NO. 30 / 150000	VAL. CODE	21 RELATED PROJECTS NUMB
				QUANTITY	UNIT			W	Code	WAD	Prog	Station	Plan								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
	Repairs to Hatch Furnaces				LS	10.6	78	10	5			70	999	3.14							
	Install Heat Exchanger			1	EA	69.2															
	Insulate Furnace Walls			600	SF	23.9															

34. ACTIVITY CERTIFICATION: I certify that this project is required to support activity/mission functions.

35. EFD CERTIFICATION: This project is supported by SFPS.

36. MAJOR CLAIMANT CERTIFICATION: I certify that this project is required to support activity/mission functions.

37. DO NOT WRITE IN THIS SPACE - FOR NAVFAC USE ONLY.
This project is authorized for entry into the MILCUN H.L.

13. PROJECT DESCRIPTION/JUSTIFICATION

This project will provide repairs to a hatch furnace to reduce excess air use, provision of a heat exchanger to reclaim waste heat and furnace wall insulation to reduce heat loss. Project will result in a savings of 36,500 gallons of No. 2 Fuel Oil and \$24,840 per year.

DATE COMPLETED	REQUIREMENT	EXISTING ASSETS		OTHER ASSETS		PREVIOUS PROJECTS		DEFICIENCY	TOTAL THIS PROJECT	DEFICIENCY REMAINING
		ADG	SUBS	FUND	NON NAVY	QTY	P-REL			
22	23	24	25	26	27	28	29	30	31	32

ATTACHED (4)

CLASSIFICATION

1. DATE 4 Apr 76		2. FISCAL YEAR 1976		3. MILITARY CONSTRUCTION PROJECT DATA		4. DEPARTMENT NAVY		5. INSTALLATION LONDON AVAL SHIPYARD	
6. PROPOSED AUTHORIZATION \$ 103,700		7. P.L.		8. CATEGORY CODE NUMBER PROGRAM ELEMENT NUMBER		9. STATE/COUNTRY		10. PROJECT TITLE BOSTON, MA	
11. PROPOSED APPROPRIATION		12. BUDGET ACCOUNT NUMBER		13. PROJECT NUMBER		14. PROJECT TITLE BOSTON, MA		15. PROJECT TITLE BOSTON, MA	
SECTION A - DESCRIPTION OF PROJECT									
16. TYPE OF CONSTRUCTION									
17. PHYSICAL CHARACTERISTICS OF PRIMARY FACILITY									
18. DESCRIPTION OF WORK TO BE DONE									
19. TYPE OF WORK									
20. TYPE OF DESIGN									
21. STANDARD DESIGN									
22. SPECIAL DESIGN									
23. DRAWING NO.									
SECTION B - COST ESTIMATES									
24. PRIMARY FACILITY									
25. SUPPORTING FACILITIES									
26. TOTAL PROJECT COST									
SECTION C - BASIS OF REQUIREMENT									
27. REQUIREMENT FOR PROJECT									
28. QUANTITATIVE DATA									
29. TOTAL REQUIREMENT									
30. EXISTING REQUIREMENT									
31. EXISTING ADEQUATE									
32. FUNDED, NOT IN INVENTORY									
33. ADEQUATE ADEQUATE									
34. FUNDED PRIOR AUTHORIZATION									
35. INCLUDED IN FY									
36. DEFICIENCY (A - B - C - D)									
37. RELATED PROJECTS									

MISSION AND PURPOSE: The principal mission of the shipyard is the repair, overhaul, alteration, and conversion of naval surface ships and conventional submarines. This project will make improvements to a batch furnace to conserve energy.

NEED/DEFICIENCY: To reduce energy losses due to deteriorated condition of the furnace, excessive heat losses in the flue gases and inadequate insulation.

CURRENT SITUATION: This furnace was installed when energy conservation was not critical and, therefore, has inadequate insulation and no provision for reclaiming heat from the flue gases and, as a result, is consuming more energy than is necessary.

EFFECT IF NOT PROVIDED: 5,100 MBTU of energy and \$24,040 will be wasted annually. This project will save 30,000 gallons of No. 2 fuel oil annually. Energy savings to cost ratio = 45.3 MBTU/\$1,000 project cost. SFR = 3.14.

DD FORM 1391

1 OCT 70

Page No. 1391

1. DATE 4 Apr 76	2. FISCAL YEAR 1966	3. MILITARY CONSTRUCTION PROJECT DATA (Continued)	4. DESIG AND INTRNT NAVY	5. POST OFFICE SYMBOL EOSTON; NAVAL AIRFIELD
6. PROJECT NUMBER		7. PROJECT TITLE ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE		

3. Heat input resulting from reducing excess air to 20% by adjusting burners, throttling air inlets, repairing cracks and holes and badly fitted doors.

Stack losses - From handbook tables for a stack temperature of 2,100°F with 20% excess air, the stack loss is 46% of the fuel energy input.

Heat to steel and wall loss will account for the remainder of the fuel energy input, or 54% of the total.

$$\begin{aligned} .54 \text{ Fuel Energy Input} &= 0.46 \text{ MBTU} + 2.73 \text{ MBTU} \\ \text{Fuel Energy Input} &= \frac{(0.46 + 2.73) \text{ MBTU}}{.54} \end{aligned}$$

$$= 5.91 \text{ MBTU}$$

4. With the above corrections made, install a heat exchanger to use waste heat from the stack gases to preheat the air supplied to the furnace. The heat exchanger selected will raise the temperature of the air by 1,000°F. Since the mass of flue gas is approximately equal to the mass of combustion air, it is reasonable to expect that if the air is heated by 1,000°F, the flue gas temperature will be reduced by the same amount.

Stack losses - From handbook tables, for a stack temperature of 1,100°F with 20% excess air, the stack loss is 23.5% of the fuel energy input.

Heat to steel and wall loss will account for the remainder of the fuel energy input, or 76.5% of the total.

$$\begin{aligned} .765 \text{ Fuel Energy Input} &= 0.46 \text{ MBTU} + 2.73 \text{ MBTU} \\ \text{Fuel Energy Input} &= \frac{(0.46 + 2.73) \text{ MBTU}}{.765} \end{aligned}$$

$$= 4.17 \text{ MBTU}$$

1. DATE 4 Apr 70	2. PROJECT YEAR 1961	3. MILITARY CONSTRUCTION PROJECT DATA (Continued)		4. DEPARTMENT NAVY	5. INSTALLATION BUSHY LAVAL SURFAC
6. PROJECT NUMBER		7. PROJECT TITLE ENERGY CONSERVATION IMPROVEMENT TO BATH HOUSE			

5. By increasing the wall insulation in addition to the above, the wall loss can be reduced to 1.50 MBTU.

Stack losses will remain at 23.5% of the fuel energy input and the heat to steel and wall loss will account for the remainder of the fuel energy input, or 76.5% of the total.

$$\begin{aligned}
 .765 \text{ Fuel Energy Input} &= 0.46 \text{ MBTU} + 1.50 \text{ MBTU} \\
 \text{Fuel Energy Input} &= \frac{(0.46 + 1.50) \text{ MBTU}}{.765} \\
 &= 3.06 \text{ MBTU}
 \end{aligned}$$

6. Energy Saved

$$\begin{aligned}
 &= (13.3 - 3.06) \text{ MBTU} \\
 &= 10.22 \text{ MBTU}
 \end{aligned}$$

7. For 500 cycles per year

$$\begin{aligned}
 \text{Energy Saved} &= 10.22 \text{ MBTU} \times 500 \\
 &= 5,100 \text{ MBTU/year}
 \end{aligned}$$

For No. 2 fuel oil at 140,000 BTU/gallon

$$\begin{aligned}
 \text{Fuel Oil Saved} &= \frac{5,100 \times 10^6 \text{ BTU/year}}{140,000 \text{ BTU/gallon}} \\
 &= 36,500 \text{ gallons/year}
 \end{aligned}$$

1. DATE 4 Apr 76	2. FISCAL YEAR 1961	3. MILITARY CONSTRUCTION PROJECT DATA (Continued)	4. DEPARTMENT NAVY	5. INSTALLATION EASTON NAVAL SHIPYARD
6. PROJECT NUMBER		7. PROJECT TITLE ENERGY CONSERVATION IMPROVEMENT TO BANCH FURNACE		

Economic Analysis

Fuel Oil Saved = 36,500 gallons/year
 Fuel Oil Cost = \$0.41/gallon
 Engineering Cost Estimate = \$78,000

1. Cost Savings

= 36,500 gallons/year x \$0.41/gallon x 1.60*

= \$24,040/year

2. Project Cost

= (\$78,000 + 0.055** x \$78,000) x 1.20*

= \$103,700

3. Savings-to-Investment Ratio (SIR)

$$SIR = \frac{\text{Annual Savings} \times \text{Present Worth Factor}}{\text{Project Cost}}$$

= $\frac{\$24,040 \times 13.112}{\$103,700}$

= 3.14

4. Energy Savings to Cost Ratio

Project Cost ÷ 1.000 = 103.7

Energy Savings to Cost Ratio = $\frac{\$24,040}{103.7}$

= 49.2 MBTU/\$1,000 Project Cost

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U.S. Government Printing Office: 1975 O-251-11000-2-1

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1. DATE 4 Apr 76	2. FISCAL YEAR 1961	3. MILITARY CONSTRUCTION PROJECT DATA (Continued)	4. DEPARTMENT NAVY	5. INSTALLATION DESIGN NAVAL SHIPYARD
6. PROJECT NUMBER		7. PROJECT TITLE ENERGY CONSERVATION IMPROVEMENT TO NAVAL FURNACE		
5. Simple Amortization Period $P^* = \frac{\text{Project Cost}}{\text{Cost Savings}}$ $= \frac{\\$103,700}{\\$24,040}$ $= 4.2 \text{ Years}$				
* Escalation factor based on an assumed increase in fuel oil costs of 4% for 6 months of FY-76 and 16% each year for FY-77, FY-78, and FY-79 and an assumed increase in construction costs of 4% for 6 months of FY-76, 7% for FY-77, 8.5% for FY-78, and 9.0% for FY-79. per latest NAVFAC guidance. ** 5.5% government administration costs chargeable to the project.				

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Page No.

6-1-7

COST ESTIMATING FORM - WORKSHEET
DA FORM 2417A (REV. 3-63)

SHEET 1 OF 1

0 10 5. 3 1 3. 3000

100-1946

ACTIVITY

LOCATION

CATEGORY CODE NUMBER

1. NO

BOSTON NAVSHIPYD

BOSTON, MA

SUBJECT OF THE REPORT TITLE

**ENERGY CONSERVATION IMPROVEMENTS TO BATCH FURNACE, NO. 3, BLDG. 17,
FORGE SHOP**

[illegible]

000000: 07 10000

JOHN SMITH

APPROVED BY

FRANK JONES

TITLE OR ORGANIZATION

AGE COMPANY

DATE

15 MAR '78

APPENDIX A
ENERGY CONVERSION FACTORS

A.1 ENERGY CONVERSION FACTORS, ELECTRICAL

Electrical (Site)	3,413 BTU/KWH
Electrical (Source)	11,600 BTU/KWH

Site electrical energy is the energy measured at the input to the site electrical substations. The site energy conversion factor is 3,413 BTU/Kwh. Source energy refers back to the electric power generating plant. Source energy gives the true picture of the cost to generate electric power because it includes the power plant inefficiencies. The commonly used source conversion factor is 11,600 BTU/Kwh, which is to say, that it takes 11,600 BTU worth of oil to produce 1 Kwh.

A.2 FUEL HEATING VALUES

Typical fuel heating values are listed in the following table:

<u>Fuel</u>	<u>Typical Fuel Heating Value</u>
Natural Gas	1,031 BTU/SCF
Fuel Oil No. 6*	150,000 BTU/Gallon
Fuel Oil No. 2*	138,700 BTU/Gallon
Coal	12,290 BTU/Lb.
LPG (Propane or Butane)	95,500 BTU/Gallon
Crude Oil	5.8 x 10 ⁶ BTU/Barrel (Barrel=42 Gallons)
Gasoline (Auto)	125,000 BTU/Gallon
Aviation Gas	125,000 BTU/Gallon

**A.3 TYPICAL HEATING VALUES OF COMPONENTS OF INDUSTRIAL SCRAP
AND MUNICIPAL, REFUSE**

INDUSTRIAL SCRAP

	<u>Btu/lb</u>
Rubber	12,420
Tires, bus and auto	18,000
Leather scrap	8,140
Cork scrap	12,400
Paraffin	16,803-18,600

WASTE LIQUIDS

Industrial Sludge	3,700-4,200
Dirty Solvents	10,000-16,000
Naphta	20,250
Spent Lubricants	10,000-14,000
Gasoline	20,700
Naphthalene	18,500
Fuel Oil Residue	18,000
Paint Wastes	6,000-10,000

PAPER WASTES

Brown Paper	7,090
Cardboard	6,800
Corrugated Board	6,830
Tarpaper	10,120
Waxed Paper	10,790

DOMESTIC REFUSE

Paper, cardboard, cartons, bags	7,840
Wood carts, boxes, crapwood	7,825
Garbage	2,230
Rags-cotton-linen	6,540
Textiles, natural	8,040
Textiles, synthetic	15,000
Refuse Derived Fuel, Municipal	5,500

Source: Consumat - An Alternate Energy Source, Energy Bulletin
No. 10-874, Consumat Systems, Inc.

APPENDIX B
ENERGY MEASUREMENT
TECHNIQUES

B.1 ELECTRICAL MEASUREMENTS

Large electric motors, such as those used to drive air compressors and chiller compressors, are usually installed with instrumented control panels which display line voltage, line current, and sometimes power factor. By monitoring these meters at regular intervals during a typical day, energy consumption can be estimated by integrating the area under a trace of power and time.

Older motor installations and motors which are smaller than 100 HP usually do not have "built-in" instrumentation. In order to obtain accurate energy consumption profiles, "clamp-on" electric meters can be used. The most convenient device is a recording ammeter. It provides a continuous trace of current and thus enables the computation of power at any time. By monitoring for a day or week, typical load profiles are obtained.

In order of relative significance, the principal factors which identify large energy users are nameplate ratings, load ratios, and equipment duty cycles.

B.1 (cont'd)

Electrical nameplate ratings indicate maximum input and output power.

Equipment load factor ratio is average power in divided by nameplate power in. Many large motors are used at a fractional part of their rated capacity, consequently the nameplate data may not in itself classify it as a heavy energy consumer. Load factor ratio data is necessary to further identify the heavy energy users.

Duty cycle is a profile of equipment usage over a periodic work cycle, usually one day or one week.

The large users of electric power in industrial process areas are exhaust fans, which often run continuously and pump heated or cooled air to the outside environment; air compressors, process tanks, and chiller drive motors.

One problem associated with measuring electric power to a motor is finding a convenient place to clamp the "current transformer" type sensor of the recording meter. Power leads to and at the motor are usually inaccessibly shrouded in conduit. Motor control panels often provide the access to exposed leads. Survey members should not attempt to connect meters. This is a job for the maintenance electrician normally assigned to that building.

Voltage and frequency variations are assumed to be minimal and have a negligible effect on the energy computations suggested in this guide. Power factor may be measured or measured conveniently, assume a value of 0.90 lagging.

B.2 SUGGESTED LIST OF TEST EQUIPMENT FOR ELECTRICAL
MEASUREMENTS

<u>Name</u>	<u>Function</u>
1. Clamp-on ammeter -	Used to measure amperage of various circuits -- motors, etc.
2. Power Factor Meter	Used to measure system or motor power factor..
3. Recording Ammeter	Used to continuously monitor system or motor loads.
4. Recording Voltmeter	Used to measure voltage variations on a system.
5. Voltmeter 0-150 volts 0-300 volts 0-600 volts	Used to measure system voltage and balance between phases.
6. _____	_____ _____ _____
7. _____	_____ _____ _____

B.3 STEAM MEASUREMENTS

Even modern industrial facilities seldom have a steam monitoring system which gives consumption on a per building basis. Central steam plant metering gives daily recordings of flow from each boiler.

Steam usage by individual process is necessarily a computational method requiring knowledge of thermal losses, and steam enthalpy. Many industrial sites produce saturated steam for heating and process usage. Steam flow to a convector type heat exchanger is calculated taking the convector rating in Btu/Hr and dividing by the change in enthalpy of the steam. Enthalpy "in" is read from a saturated steam table at heat exchanger pressure or zero in the case of a system with no return. Steam flow to turbines and engines is usually estimated by measuring the output loading machine, such as an alternator. This output energy rate divided by system efficiency (alternator and turbine) gives input energy rate. Measuring steam pressure and temperature in and exhaust steam temperature and pressure allows one to look up enthalpy change and in a manner similar to the convector, steam flow is estimated.

Often steam consumption is measured by determining the number of times a condensate receiver pump motor operates. The pump is usually controlled with level switches in the condensate well. Prior to the test, personnel determine the average amount of condensate pumped each time the pump motor

B.3 STEAM MEASUREMENTS (cont'd)

operates to reduce the condensate level in the well. The consumption is the result of the number of times the pump runs times the average amount of condensate discharged for each pump operation.

B.4 AIR FLOW MEASUREMENTS

PITOT TUBE

The most widely used instrument for the measurement of duct velocities. The manometer water leg (inches of water) is used to measure the velocity.

$$V = 10.96.5 \sqrt{\frac{\text{inches of water}}{\text{specific weight of air}}}$$

where:

V	= velocity, feet per minute
inches of water	= manometer reading
specific weight of air	= weight of cubic foot of dry air plus the weight of the moisture in the same cubic foot of air.

Unless the velocity in the duct is considered uniform, a traverse of the duct cross section is made. The American Society of Heating, Refrigerating and Air Conditioning Engineers (Publishers of the ASHRAE Fundamentals Volume) suggests the following traverses when using a pitot tube:

Rectangular Ducts. Divide the cross section into equal rectangular areas. Measure the velocity in the center of each area. The suggested number of areas to select is 16 to 64. ASHRAE suggests that for less than 64 equal areas, the centers of the areas should not be more than 6 inches apart. The velocity results for each of the areas in the traverse are then averaged.

Circular Ducts. In each quadrant of the cross section, starting from the centerline of the duct, measure the velocities at 0.316R, 0.548R, 0.707R, 0.837R, 0.949R. The circular cross section can be divided into smaller sectors of wedges than the four quadrants. The velocity results from each of the areas in the traverse are then averaged.

Anemometer (Wheel-Type)

A widely used instrument. It contains a miniature bladed wheel. The wheel revolves in the air stream and drives a pointer. A stop watch is usually required to convert the meter reading to velocity (feet per minute). When used at supply or exhaust grilles, calculations, involving correction factors are required. Furthermore, the dial on the anemometer must be faced in a particular direction depending on whether the grille is for supply or exhaust. The anemometer manufacturer's operating and calculating procedures should be followed.

OTHER ANEMOMETERS

Various types of anemometers are available such as: deflecting vane, heated thermocouple and hot wire. An outline of applications, ranges, precision, etc., is contained in the ASHRAE Fundamentals Volume.

DATA COLLECTION - AIR FLOW SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO. _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

Air System Name: _____

Associated With the Following Process _____

LOCATION OF THE VELOCITY MEASUREMENTS:

Supply _____

Return _____

Exhaust _____

DAMPER POSITIONS (If Required):

Outside Air Damper _____ Percent Open

Return Air Damper _____ Percent Open

Exhaust Air Damper _____ Percent Open

DUCT OR GRILLE DIMENSIONS:

Duct _____ Circular _____

Dimensions _____

Gross Area _____ Square Feet

Net Free Area (Supply Grilles) _____ Square Feet

INSTRUMENT:

Pitot Tube _____

Anemometer _____, Type _____

DATA COLLECTION - AIR FLOW

SHEET 2 OF 3

DEPT. C. NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

DUCT STATIC PRESSURE (If needed) _____ inches of water

AIR STREAM:

Dry Bulb Temperature _____ degrees F

Wet Bulb or Relative Humidity (If Needed) _____

SKETCH OF CROSS SECTION AREA:

Location	Pitot Tube	Vane-Type Anemometer
	Inches of Water	Indicator Time Interval

CONDUCTED BY: _____ DATE: _____

DATA COLLECTION - AIR FLOW

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _____
 ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO. _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

RESULTS FROM FOLLOWING CALCULATIONS:

Average Velocity _____ Feet Per Minute
 Flow _____ Feet Per Minute

<u>Location</u>	<u>Calculated Velocity FPM</u>

SAMPLE CALCULATIONS:

For pitot tube, include specific weight of air and velocity equation for rotating vane anemometer follow manufacturers instructions. If a flow factor is used, please indicate it.

CONDUCTED BY: _____ DATE: _____

B.5 SUGGESTED LIST OF TEST EQUIPMENT FOR
MECHANICAL EQUIPMENT MEASUREMENTS

	<u>Name</u>	<u>Function</u>
1.	Orsat Analyzer	Flue gas analyzer, measures CO ₂ , O ₂ and CO.
2.	O ₂ Analyzer	Flue gas analyzer used to find O ₂ and combustibles.
3.	Thermocouples	A selection of thermocouple probes to handle temperature measurements of air flow, surface, liquid, or other. Read with a portable digital temperature meter or a potentiometer.
4.	Inclined Manometer 0.05" to 0.25" H ₂ O	Used to measure small pressure differentials.
5.	"U" Tube Hg Manometer 0.26" Hg	Used to measure higher pressure differentials.
6.	Pitot Tube a. "S" Type b. Standard Type	Used to measure air velocity and pressure
7.	Portable pH Meter	Used to check pH of the boiler, water, condensate and aqueous waste streams.
8.	Portable Conductivity Meter	Used to check conductivity of boilerwater, feedwater, condensate, and aqueous waste streams.
9.	Bimetallic Thermometers	Used to measure fluid temperature where there is no permanent thermometer, or as a check.
10.	Glass Thermometers	Used to measure temperatures from 0-250 deg F.

B.5 SUGGESTED LIST OF TEST EQUIPMENT FOR MECHANICAL
EQUIPMENT MEASUREMENTS (cont'd)

11. Psychrometers	A hygrometer that uses the difference in readings between two thermometers, one having a wet bulb ventilated to cause evaporation and others having a dry bulb as a measure of atmospheric moisture.
12. Surface Pyrometer a. 0-500 deg F b. 0-800 deg F c. 0-1,200 deg F	Used to measure surface temperature of vessels, pipes, and other objects.
13. Calibrated Buckets	Used to measure the volume of a stream for checking amount of fluid flow.
14. Stop-watch	Used to time the flow of a liquid into a measured bucket to determine flow rate.
15. Velometer	Used to measure airflow directly, employing a dial indicating meter calibrated directly in feet per minute. Replacement probes enable measurements in ducts or in free space.
16. Hot-Wire Anemometer	Used to measure air flow in a duct.
17. Van Anemometer	Used to measure air flow.
18. Pressure Gages 0-60 psig; 0-600 psig 0-100 psig; 0-1,000 psig 0-300 psig	Used to measure various system pressure.
19. Recording Thermometer	Used to monitor temperature for a period of time.
20. Fluid Leak Detector	Used to check for any gaseous leaks on systems connections.
21. Strobo-Tachometer	Used to measure RPM's of a rotating machinery part.
22. _____	_____

APPENDIX C

ENERGY ESTIMATING TECHNIQUES

C.1 ESTIMATING ELECTRIC ENERGY COSTS

Generally, electric energy cost is based upon three factors; peak demand during the billing period, total Kwh usage, and time-of-day usage. Another contributing factor is fuel cost which is factored into the computation of utility bills as a Fuel Adjustment Factor. When it is necessary to make projected energy costs, one must be aware of the fuel adjustment factor trend.

Energy consumption can sometimes be re-scheduled to take advantage of lower cost power. By limiting power demand during the billing interval in the on-peak time, demand charges can be greatly reduced. Large process users which run after "peak time" will realize large cost savings. For example, Plant A operates two work shifts per day with a peak demand of 2,000 KW and a monthly consumption of one million Kwh. Plant B operates three work shifts per day with a peak demand of 1500 KW and a monthly consumption of one million Kwh. The savings on electric power can be \$2100/month, which is entirely attributable to reducing the demand charge.

C.2 ESTIMATING THE COST OF STEAM CONSUMPTION

The absence of steam flow measuring instrumentation requires a computational method for estimating the cost of steam consumed by individual processes.

Steam cost purchased from a utility is usually based on total usage, and includes a fuel adjustment factor. Peak demand and time of day usage rates are often not a part of the rate. Usually, steam generated at the facility is back-charged to the various users. The facility often develops its own steam costs. It allocates the costs of operating and maintenance labor, equipment, and fuel costs to the users.

Steam generating plant efficiency can usually be obtained from a Facilities/Utilities Engineering group. If this is not available, use $E = 82\%$ as representative value. Distribution losses may also be obtained from Facilities/Utilities Engineering. In the event that no data is available, assume a distribution loss of 12%.

Since steam consumption by an individual process is seldom, if ever, measured directly. Estimating steam flow and total consumption must then be arrived at by a computation based on thermal characteristics. For a tank, such as discussed in 6.3 steam flow to the heater coil can be approximated by estimated heat losses to the surrounding environment, Q_L , and dividing this number by the enthalpy change in the coil.

APPENDIX D

PUMPS

DATA COLLECTION - PUMP CENTRIFUGAL SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ I.D. NO.: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _

NAME PLATE DATA

Manufacturer: _ _ _ _ _ Mod. No.: _ _ _ _ _ Ser. No. _ _ _ _
Size and Type: _ _ _ _ _ Stages: _ _ _ _ _
Pump Curve No. _ _ _ _ _ Discharge Size: _ _ _ _ _ in.
Suction Size: _ _ _ _ _ In. Cap.: _ _ _ _ _ gpm Head: _ _ _ _ f
RPM: _ _ _ _ _ Impeller Diameter: _ _ _ _ _
Motor HP: _ _ _ _ _ Motor I-D No.: _ _ _ _ _

AUDIT DATA

Motor Load: _ _ _ _ _ Volts: _ _ _ _ _ Amps: _ _ _ _ _
Pressures: Suction: _ _ _ _ _ psig Discharge: _ _ _ _ _ psig
Fluid Pumped: _ _ _ Temperature: _ _ °F Specific Gravity _ _ _
Noise: _ _ Yes _ _ No Gland Leakage _ _ Yes _ _ No
Hours of Operation Per: Day _ _ _ Week _ _ _ Year _ _ _
Flow Rate _ _ _ _ _ gpm

CONDUCTED BY: _ _ _ _ _ DATE: _ _ _ _ _

DATA COLLECTION - PUMP CENTRIFUGAL SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _____
 ENERGY CONSERVATION AUDIT SHOP NO.: _____ I.D. NO.: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

PUMP EFFICIENCY

Note: Used when flow rate is known.

IDEAL PUMP HORSEPOWER REQUIREMENTS:

$$\text{Ideal BHP} = \frac{Q \times H \times S}{3960} = \frac{\quad}{3960} = \quad \text{Hp}$$

Where Q = Flow, gpm

H = System head, ft.

S = Specific gravity of liquid being pumped.

ACTUAL MOTOR INPUT HORSEPOWER: (3 Phase)

$$P = \frac{1.7321 \times E \times I \times \text{Power Factor}}{746} = .00232 \times \quad$$

$$= \quad \text{Horsepower}$$

Where:

E = Line neutral volts

I = Line current. amps.

MOTOR HORSEPOWER DELIVERED TO PUMP COUPLING:

Actual Pump HP = Actual Motor Input Horsepower x Motor EFF.

$$= \quad \times \quad$$

$$= \quad \text{Horsepower}$$

$$\text{PUMP EFFICIENCY} = \frac{\text{Ideal BHP}}{\text{Actual Pump BHP}} \times 100$$

$$= \quad \times 100$$

CONDUCTED BY: _____ DATE: _____

DATA ANALYSIS - PUMP CENTRIFUGAL

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT SHOP NO: _____ I.D. NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

COMPARISON OF PUMP EFFICIENCY:

Compare the pump efficiency with appropriate pump performance curves.

Small (Booster) centrifugal pumps have efficiencies that range from 45 to 70 percent.

Comparision:

From pump curves _____ percent.

From pump efficiency calculations _____ percent.

PUMP OPERATIONAL CHECK

Note: Used When Flow Rate is Not Metered

If the process permits, close the discharge valve and record the inlet and discharge pressures:

Inlet pressure _____

Discharge pressure _____

Compare the actual total head with the pump curves at zero flow.

From pump curves _____

From observed data _____

CONDUCTED BY: _____ DATE: _____

APPENDIX E

ELECTRIC MOTORS

E.1 ESTIMATING ELECTRICAL MOTOR LOAD CONSUMPTION

Nameplate

Nameplate motor ratings should be used with caution and experienced engineering judgment. For a more accurate estimate of true power consumption some measurements must be made.

Motor Load Factor or Equipment Loading Ratio

The ideal approach, time permitting, would be to install a recording ammeter to the motor supply for a period of time representative of normal operations. The record may then be integrated visually or mechanically over a fixed time period to determine total load for that period. This actual load may then be compared to nameplate data to determine the motor loading factor (MLF) or the equipment loading ratio (ELR)

$$\text{Motor Loading Factor} = \text{Equipment Loading Ratio} = \frac{\text{Average Power}}{\text{Peak Power}}$$

In the majority of cases, it is not necessary, nor is time and equipment available for generation of continuous records. In these cases, the use of a clamp-on ammeter and simple voltmeter will provide instantaneous readings which can be used to determine the MLF or ELR.

Duty Cycle

Another factor in determining annual consumption is the duty cycle. Duty cycles relate to the portion of total time during which equipment is operative. Many pieces of equipment are not in continuous use and, when operating, cycle on and off.

E.1 ESTIMATING ELECTRICAL MOTOR LOAD CONSUMPTION (Cont'd)

The use of elapsed time indicators or operational records, where available, would be the preferred source of information to show past and/or present usage. Lacking any proven history of operation one has to rely on the judgement of the shop foreman. If more than one shift operation is involved foremen on both shifts should be consulted and any overtime usage averaged out to sum up an annual (Hrs./Yr.) duty cycle.

Duty cycle, unfortunately, is a more difficult item to arrive at with reasonable accuracy. The use of some equipment may be sporadic, and the true duty is difficult to determine. In many cases, shop foremen feel compelled to defend their area by over-emphasizing the usage of equipment. However, careful observation on a spot check basis over several days can indicate if estimated duty cycles have to be corrected.

Annual electrical consumption may then be calculated as follows: $\text{Annual Consumption (KWH)} = \text{Average Load KW} \times \text{Duty Cycle (Hrs./Yr.)}$

E.2 DATA COLLECTION - ELECTRIC MOTORS

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

NAME PLATE DATA:

Motor Data: Mfr: _____ Mod. No.: _____ Frame Type _____
 Motor Identification No. _____ Serial No. _____
 HP _____ Volts: _____ Amps: _____ Phase: _____ RPM: _____

Equipment Driven Data:

Type of Equipment Driven: _____
 Equipment Identification No. _____
 Manufacturer _____ Mod. No. _____
 Serial No. _____

AUDIT DATA:

	<u>Measured</u>	<u>Assumed</u>	<u>Calculated</u>
Volts:	_____	_____	
Amperes:	_____	_____	
Power Factor:	_____	_____	
Watts:	_____	_____	_____
Operation, Hrs/Day:	_____	_____	
Operation, Days/Week:	_____	_____	

DATA COLLECTION - ELECTRIC MOTORS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

CONDITIONS:

Service: _____

Operation Being Performed: _____

Equipment Condition: _____

COMMENTS: _____

CONDUCTED BY: _____ DATE: _____

E.3. DATA ANALYSIS - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____

ENERGY CONSERVATION AUDIT: SHOP NO.: _____ I-D NO: _____

ACTIVITY _____ LOCATION: FL _____ BAY _____

MOTOR LOAD DATA:

Volts: _____ Amperes: _____ Watts: _____

POWER FACTOR: (3-Phase)

Calculated if watts, volts, and amps have been measured:

$$\frac{\text{watts}}{\text{volts} \times \text{amps} \times 1.732} = \text{_____, power factor}$$

Power factor from manufacturer's data _____.

CALCULATIONS BY: _____ DATE: _____

E.3. DATA ANALYSIS - ELECTRIC MOTORS

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _

MOTOR LOAD (INPUT):

$$\text{Motor Load} = \frac{\text{Volts} \times \text{Amps} \times \text{PF} \times \text{Phase}}{1000} = \text{ _ _ _ _ }$$

(3-Phase)

$$= \frac{\text{v} \times \text{a} \times \text{PF} \times 1.732}{1000} = \text{ _ _ _ _ } \text{ KW}$$

MOTOR LOAD (OUTPUT):

$$\text{Motor Load} = \frac{\text{KW} \times \text{Efficiency}}{0.746} = \text{ _ _ _ _ _ } \text{ HP}$$

MOTOR LOADING FACTOR OR EQUIPMENT LOADING RATIO

$$\text{Motor Loading Factor*} = \frac{\text{Measured Input KW}}{\text{Name Plate Input KW}} \text{ or } \frac{\text{Measured HP}}{\text{Name Plate HP}}$$

$$\text{MLF} = \left(\frac{\text{ _ _ _ _ _ }}{\text{ _ _ _ _ _ }} \right) = \text{ _ _ _ _ _ }$$

$$\left(\frac{\text{ _ _ _ _ _ }}{\text{ _ _ _ _ _ }} \right) = \text{ _ _ _ _ _ }$$

*If over 1.0, the motor is overloaded. If under 0.6, the motor is underloaded.

E.4 POWER FACTORS

APPROXIMATE POWER FACTORS - MOTOR OPERATING AT RATED FULL-LOAD

<u>Motor Rating Hp</u>	<u>Power Factor</u>	
	<u>Conventional</u>	<u>High Efficiency</u>
5	.79	.87
7.5	.80	.88
10	.81	.88
15	.82	.88
20	.83	.88
25	.83	.88

APPROXIMATE POWER FACTORS - CONVENTIONAL MOTORS OPERATING AT LESS THAN RATED FULL-LOAD

<u>Motor Rating, %</u>	<u>Power Factor</u>
100	.80
75	.74
50	.62
25	.44

E.5 MOTOR EFFICIENCIES - FULL LOAD

APPROXIMATE MOTOR EFFICIENCIES - MOTOR OPERATING AT RATED

FULL-LOAD

Motor Rating Hp	Efficiency %	
	<u>Conventional</u>	<u>High Efficiency</u>
5	83	87
7.5	85	88
10	86	89
15	87	90
20	88	91
25	89	91

E.6 ECONOMIC EVALUATION - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT: SHOP NO.: _____ I-D NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

ECONOMIC EVALUATION OF MOTOR LOAD CORRECTION:

Proposed Corrective

Action: _____

Estimate of Installed Cost: \$ _____

SAVINGS FROM MOTOR LOAD CORRECTION:

If the motor load factor is 0.6 or less, select a possible replacement motor whose horsepower rating just exceeds the measured load and complete the following:

	HP	Efficiency	KW Input = $\frac{HP \times 0.746}{Efficiency}$
Existing Motor	__	_____	_____
Proposed Motor	__	_____	_____

Power Savings = Existing Motor - Proposed Motor = __ KW
 Savings
 (if
 possible)

ECONOMIC EVALUATION - ELECTRIC MOTORS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT: SHOP NO.: _____ I-D NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

$$\frac{W}{1000} \times \frac{\text{Hours}}{\text{Days}} \times \frac{\text{Days}}{\text{Years}} = \text{KWH Saved/Year}$$

$$\text{_____ KWH Saved} \times \text{_____ \$/KWH} = \$ \text{_____ Saving/Year}$$

PAYBACK FOR MOTOR LOAD CORRECTION

$$\text{Payback Period (Years)} = \frac{\text{Installed Cost}}{\text{Annual Savings}} = \$ \frac{\text{_____}}{\text{\$/yr}} = \text{Years}$$

COMMENTS: _____

ECONOMIC EVALUATION BY: _____ DATE: _____

CHECKLIST - - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ _ _
 ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO: _ _ _
 ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

Before evaluating specific electric motors or operations it is desirable to refer to the following checklist. Although no specific forms applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

		<u>Applies</u>	
		<u>Yes</u>	<u>No</u>
1.	The electrical distribution system should have a power factor 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity.		
	Evaluation: _ _ _ _ _		
	_ _ _ _ _		

CHECKLIST - - ELECTRIC MOTORS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT: SHOP NO.: _____ I-D NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

Applies

Yes No

2. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one.

Evaluation: _____

3. If a motor or group of motors runs lightly loaded most of the year full power is needed occasionally, it (they) usually cannot be replaced with smaller ones. Consider a motor capacitor or a capacitor for the group.

Evaluation: _____

APPENDIX F

FANS

F.1 INTRODUCTION

Fans are used to circulate gas or air in low pressure systems and are usually one of three types; namely, centrifugal, axial, or propeller. The centrifugal fan is the most widely used. Applications of the axial fan are increasing in the U.S. The propeller fan can move large quantities of air but does not produce any significant pressure increase.

F.2 FAN LAWS

In a system, the following fan laws hold:

1. The capacity is directly proportional to the speed.
Increase the speed of Fan A from 200 rpm @ 70,000 cfm to a speed of 250 rpm. Calculate the change in capacity.

$$70,000 \times \frac{(250)}{(200)} = 87,500 \text{ cfm}$$

2. The pressure (static, velocity, or total) is proportional to the square of the fan speed.
If the static discharge pressure of Fan A was 1 in of water at 200 rpm, calculate the new static pressure.

$$1 \times \frac{(250)^2}{(200)^2} = 1.56 \text{ in water}$$

3. The horsepower required is proportional to the cube of the fan speed.

If the air horsepower of Fan A was 11 hp, calculate the new air horsepower.

$$11 \times \frac{(250)^3}{(200)^3} = 21.5 \text{ hp.}$$

It is also important to recognize that since the duct velocity is directly proportional to the duct flow (capacity), and capacity is directly proportional to the fan speed, then:

- 3a. The horsepower is proportional to the cube of the flow.

If the duct velocity can be reduced by 1/2 then the fan power can be reduced to 1/8.

Three other laws are:

4. At constant discharge pressure, the speed, capacity and horsepower are inversely proportional to the square root of the density.
5. At constant speed and capacity, the pressure and the horsepower are proportional to the density of the air.
6. At constant weight delivered, the capacity, speed and pressure are inversely proportional to the density and the horsepower is inversely proportional to the square of the density.

F.3 ANNUAL FAN ENERGY

In calculating Kwh for figure F-1 the following formulas were used.

$$HP_{air} = \frac{hs/12(62.4) \text{ CFM}}{33,000} = \frac{hs \text{ (CFM)}}{6,350}$$

h_s = Static Pressure in inches of H_2O

CFM = Cubic feet per minute of air delivered

$$\text{Motor HP in} = \frac{HP_{air}}{E_{fan} \times E_{motor}}$$

(Assume $E_{fan} = .6$, $E_{motor} = .85$)

Annual kwh = Motor HP x 0.746 = 8760 hrs/yr

Sample calculation:

Fan, 100,000 cfm, discharge pressure (static) is 1 inch of water, operates 3000 hours per year. Estimate the electric power requirements (Kwh)

$$HP_{air} = \frac{1(100,000)}{6350} = 15.75 \text{ hp}$$

$$\text{Motor HP}_{in} = \frac{15.75}{.6 \times .85} = \frac{15.75}{.51} = 30.9 \text{ hp}$$

$$\text{Annual Kwh} = 30.9 \text{ hp} \times \frac{.746 \text{ kw}}{\text{hp}} \times 3000 \text{ hrs /year} = 69154 \text{ Kwh.}$$

Using Figure F-1:

Determine the kilowatts hour on the basis of each 1000 cfm. At 1000 cfm draw a vertical line to the 1"S.P. line. From that point read to the left, annual Kwh = 2000.

Then

$$\frac{2000 \text{ Kwh} \times 3000}{1000 \text{ cfm} \quad 8760} \times 100,000 \text{ cfm}$$

= 68493 Kwh (which is reasonable when compared to the calculation).

F.4 FAN MOTOR SELECTION FOR CENTRIFUGAL FANS

For centrifugal fans, the fan maximum horsepower and the starting torque should be considered when selecting the fan motor. In an effort to minimize the electric motor size, it is possible that the motor will not be able to accelerate the fan wheel without damaging the motor.

Before equipment changes are made, the fan wheel inertia and the starting torque of the motor should be reviewed.

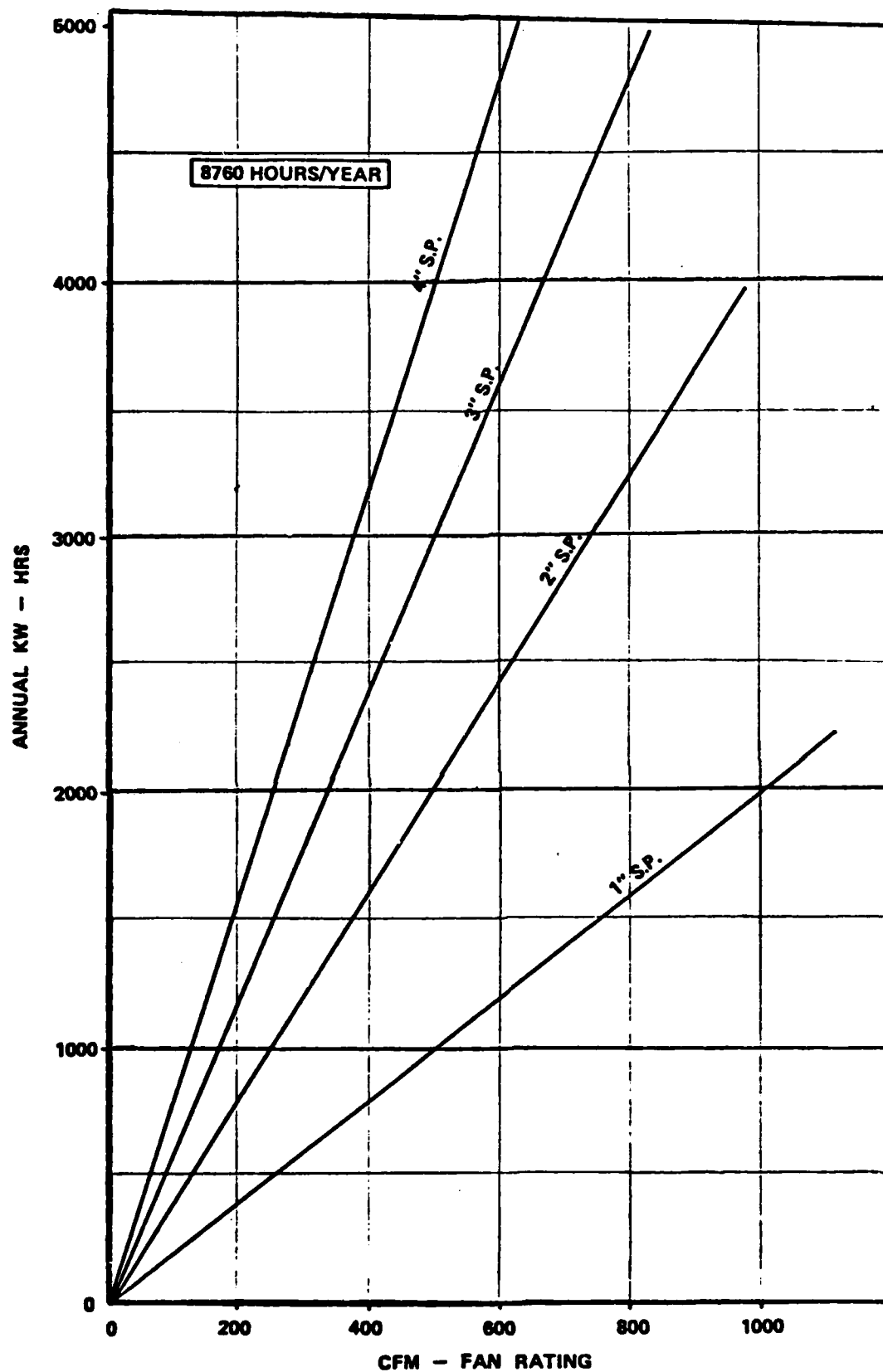


FIGURE F-1
ANNUAL FAN ENERGY - KWH

Prepared by Syska and Hennessy, Inc.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

APPENDIX G

FURNACES - FIRED HEAT EXCHANGERS

G.1 DATA COLLECTION HEAT TREAT FURNACES/OVENS SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

(Cross-Out Inappropriate Items)

AUDIT DATA:

Stack Exhaust _____ °F before Economizer
_____ °F After Economizer
_____ °F In Heat Losses _____
_____ °F Out Air _____ °F
_____ Fuel, Type _____ Rating _____ CFH
GPM
KW

Heat Loss Data: Surface Temps _____ °F Vert
_____ °F Horiz

Economizer: _____ Yes _____ No

Fuel: _____ Heating Value _____

Flue Gas Composition: % Vol: CO² _____ O₂ _____ CO _____ HC _____ N₂ _____

Operation: Batch: _____ Firing Rate: _____ % of Full Firing Rate

PRODUCT DATA:

Batch Weight _____ lbs Sp Ht _____ If data are not available for a
specific steel and temperature
range, use 0.17 Btu/lb-°F.

OPERATION CYCLES:

Hrs/Batch _____ Batches/Day _____ Batches/Yr _____

Time Idle Hot _____ Hrs/Yr _____ Time Idle Cold _____ Hrs/Yr

FLOOR DIMENSIONS:

Length _____
Width _____
Floor Area _____

CONDUCTED BY: _____ DATE: _____

G.2 DATA ANALYSIS - HEAT TREAT FURNACES/OVENS

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

(Cross-Out Inappropriate Items)

CYCLE EFFICIENCY:

Heat Input to Charge:
 $\text{lbs} \times \text{Sp Ht} \times \text{Temp. Rise } ^\circ\text{F} = \text{_____ Btu/Charge}$

Heat Input to Furnace:

$\text{Hrs Op'n} \times \text{Fuel CFH} \times \text{Btu/1000 CF} = \text{_____ Btu/Furnace Cycle}$

Furnace Efficiency =

$\frac{\text{Heat Input to Charge} \times \text{No. Charges/Cycle}}{\text{Heat Input to Furnace Cycle}} \times 100 = \text{_____ \% Efficiency}$

PERCENT EXCESS AIR CALCULATION:

$\text{Excess Air} = \frac{3.78(\text{O}_2 - \text{CO}/2) \times 100}{\text{N}_2 - 3.78(\text{O}_2 - \text{CO}/2)} = \%, \text{ flue gas expressed as \%100.}$

Percent Excess Air Recommended _____% (See Table G-1)

CALCULATIONS BY: _____ DATE: _____

DATA ANALYSIS - HEAT TREAT FURNACES/OVENS

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

CONSIDERATION FOR INSULATION IMPROVEMENT:

	<u>Inches</u>	<u>R-Value</u>
Refractories: (See Table G-2)	_____	_____
Insulation:	_____	_____
Outside Air Film		_____ 0.63 _____
Total:		_____

Heat Transmission Coefficient ("U" value = $1/R$ = Btu/h/sq. ft/°F)
OPERATING CONDITIONS

Total Outside Oven Wall Area: _____ sq. ft.
Operating Oven Temperature: _____ deg. F
Operating Hours/Year _____ hours/yr
Average Room Temperature _____ deg. F

PRESENT OVEN WALL HEAT LOSS

"u" x Outside Oven Wall Area x (Operating Temperature -
Ambient Temperature) x Operating Hours/Year
= _____ Btu/yr. x $\frac{1}{1,000,000}$ = _____ MBtu/yr

CALCULATIONS BY _____ DATE _____

DATA ANALYSIS - HEAT TREAT FURNACES/OVENS

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
 ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
 ACTIVITY _____ LOCATION: FL _____ BAY _____

CONSIDERATION FOR INSULATION IMPROVEMENT

PROPOSED OVEN WALL CONSTRUCTION

	<u>Inches</u>	<u>R-Value</u>
Present Wall:	_____	_____
Ceramic Wall Insulation:	_____	_____
Total:		1/R = "U" new

PROJECTED OVEN WALL HEAT LOSS

"U" new x Outside Oven Wall Area x (Operating Temperature -
 Ambient Temperature) x Operating Hours/Year
 = _____ Btu/yr.

PROJECTED SAVINGS

Heating Energy Savings = Present Oven Wall Heat Loss -
 Projected Oven Wall Heat Loss =
 _____ Btu/yr x $\frac{1}{1,000,000}$ = MBtu

Equivalent Fuel Energy Savings = Heating Energy Savings
 (_____ MBtu)/(MBtu/Unit Fuel Type)

Cost Savings = Heat Energy Savings (MBtu) x \$/MBtu = \$ /year saved

CALCULATIONS BY: _____ DATE: _____

ECONOMIC ANALYSIS HEAT TREAT FURNACES/OVENS

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _____
ENERGY CONSERVATION AUDIT SHOP NO: _____ I-D NO: _____
ACTIVITY _____ LOCATION: FL _____ BAY _____

FUEL SAVINGS DUE TO REDUCING EXCESS AIR: (See Figure J-3)

Percent Excess Fuel Required _____ %

Proposed Excess Fuel Required _____ %

Fuel Efficiency Improvement (FEI) _____ %

$$\text{FEI} \frac{\text{_____}}{100} \% \times \text{_____ Fuel Consumed/Year} = \text{_____ Fuel Saved/Year}$$
$$\text{Unit Fuel Saved} \times \text{MBtu/Unit Fuel} \$ \text{_____ /MBtu} = \$ \text{_____ Saved/Year}$$
INSULATION ECONOMICS:

	<u>Original</u>	<u>New Insulation</u>
Heat-Up Time	_____ hrs	_____ hrs
Heat-Up Fuel Used	_____ units	_____ units
Fuel Used Normal Running	_____ units	_____ units
Fuel Used _____ hrs/day	_____ units	_____ units
Fuel Saved/Day _____ Unit Fuel x _____ No. of Day/Year =		
Units Fuel Saved/Year x MBtu's/Unit Fuel		
MBtu's Fuel Saved/Year x _____ \$/MBtu = _____ \$/Year Saved		

Units are cubic feet for gas and gallons for fuel oil.

CALCULATIONS BY: _____ DATE: _____

ECONOMIC ANALYSIS HEAT TREAT FURNACES/OVENS

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO: _ _ _ _ _ I-D NO: _ _ _ _ _

ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _

SAVINGS DUE TO HEAT RECOVERY

_ _ _ _ Exhaust Gas Recirculation

_ _ _ _ Process Heat Recovery From Exhaust Gas

_ _ _ _ Combustion Air Preheat System (Stack Recuperator)

Comments: _ _ _ _ _
 _ _ _ _ _
 _ _ _ _ _
 _ _ _ _ _
 _ _ _ _ _

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

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ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U)
SYSKA AND HENNESSY INC NEW YORK JAN 81
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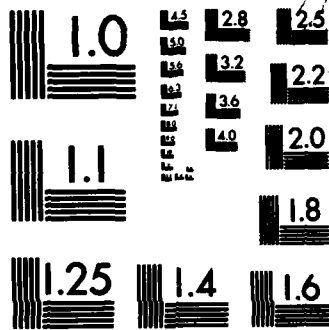
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE G-1

G.4 INDUSTRY GUIDELINES FOR PERCENT CO₂ AND EXCESS AIR**MAXIMUM CO₂ RANGES FOR COMMON FUELS**

<u>Fuel</u>	<u>% CO₂ By Volume</u>
Blast furnace gas	24.6 - 25.3
Bituminous coal	17.7 - 19.3
Anthracite coal	19.3 - 19.85
Coke oven gas (CO 6%)	9.23 - 10.6
Natural gas	11.6 - 12.7
Oil	14.25 - 16.35
Wood	20.1 - 20.5

USUAL AMOUNT EXCESS AIR SUPPLIED TO FUEL-BURNING EQUIPMENT

<u>Fuel</u>	<u>Type of Furnace or Burners</u>	<u>Excess Air % by Weight</u>
Blast Furnace gas	Intertube nozzle- type burners	15-18
Coal	Spreader stoker	30-60
	Water-cooled vibrating-grate stoker	30-60
	Chain-grate and traveling-grate stokers	15-50
	Underfeed stoker	20-50
Natural, coke - oven, and refinery gas	Register-type burners	5-10
	Multifuel burners	7-12
Fuel Oil	Oil burners, register type	5-10
	Multi fuel burners and flat-flame	10-20
Wood	Dutch oven (10-23% through grates) and Hofft-type	20-25

Source: Steam, Thirty-Ninth Edition, The Babcock and Wilcox Company, 1978

TABLE G.2

**G.5 Mean Thermal Resistivity ((sq ft) (hour) (deg F)
(in. Thickness) per Btu) of Typical Refractories**

Refractory Type	Mean temperatures between the hot and cold face, deg. F						
	200	400	800	1200	1600	2000	2400
Alumina (fused)	...	0.05	0.05	0.04	0.04	0.03	0.03
Chrome	...	0.13	0.11	0.10	0.09	0.08	0.08
Fire clay (high-heat duty)	0.20	0.17	0.14	0.13	0.10	0.09	0.08
Fire clay (super duty)	0.17	0.14	0.13	0.11	0.10	0.08	0.08
High-alumina	0.17	0.14	0.13	0.11	0.10	0.08	0.08
Kaolin	...	...	0.09	0.08	0.08	0.08	0.07
Magnesite	...	0.03	0.03	0.03	0.04	0.04	0.04
Refractory proceloin	...	0.07	0.07	0.06	0.06	0.05	0.05
Silica	...	0.13	0.10	0.08	0.08	0.07	0.07
Silicon carbide (clay bonded)	...	...	0.01	0.01	0.02	0.02	0.02
Sillimanite (mullite)	...	0.10	0.09	0.08	0.08	0.07	0.07
Insulating fire-brick (2600F)	...	0.63	0.50	0.50	0.31	0.26	...

Source: Derived from: Standard Handbook for Mechanical Engineers,
Seventh Edition, McGraw-Hill Book Company, 1967.

APPENDIX H

AIR COMPRESSORS

DATA COLLECTION - COMPRESSED AIR

SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO: _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

NAME PLATE DATA:

Manufacturer: _ _ _ _ _ Mod. No. _ _ _ _ _ Ser. No. _ _ _ _ _

Horse Power: _ _ _ _ _ Max Capacity: _ _ _ _ _ CFM

Nominal Discharge Pressure: _ _ _ psi Press. Set Points: High _ _
Low _ _ _

No. of Stages: _ _ _ _ _ Year Built: _ _ _ _ _

AUDIT DATA:

Condition of Equipment: _ _ _ _ _

Name Plate CFM: _ _ _ Name Plate Amps: _ _ _ Name Plate Volts _ _

Actual Amps: _ _ _ _ _ Comp. Disch. Press: _ _ _ _ _ psi

Compressed Air Generation (Actual): _ _ _ _ _ CFM

$$\frac{\text{Name Plate CFM}}{\text{Name Plate Amps}} = \left(\frac{\quad}{\quad} \right) \frac{\text{Actual CFM}}{\text{Actual Amps}}$$

$$\text{CFM Actual} = \frac{\text{Name Plate CFM} \left(\frac{\quad}{\quad} \right) \times \text{Actual Amps} \left(\frac{\quad}{\quad} \right)}{\text{Name Plate Amps}} = \text{CFM}$$

Operating hours/day _ _ _ _ _

Operating days/week _ _ _ _ _

DATA COLLECTION - COMPRESSED AIR

SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO: _ _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ _ BAY _ _ _

GENERAL SYSTEM LEAKAGE: If no major leaks can be located but leaks are suspected, collect the following data during non-working hours when there is no compressed air demand.

<u>Actual Time</u>	<u>Load Rating</u>	<u>Elapsed Time</u>	<u>Percent of Total Elapsed Time</u>	<u>Amperes</u>
_ _ _ _ _	Idle (no Load)	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	1/4 Load	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	1/2 Load	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	3/4 Load	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
_ _ _ _ _	Full Load	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
Total Elapsed Time		_ _ _ _ _	100%	

PRESSURE REDUCTION:

Note: It is energy wasteful to compress air to the pressure requirement of the highest pressure and reduce it for all others. By this data collection we estimate the volume of lower pressure air usage and perhaps its analysis justify the purchase of a lower pressure compressor to satisfy the demand.

DATA COLLECTION - COMPRESSED AIR

SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO: _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _

	Pressure (psig)		Volume
	Min.	Max.	cfm
System Air Pressure	_____	_____	_____
High Pressure Required	_____	_____	_____
1st Reduced Pressure Required	_____	_____	_____
2nd Reduced Pressure Required	_____	_____	_____
3rd Reduced Pressure Required	_____	_____	_____

HEAT RECOVERY-COMPRESSION: BASIC DATA

Compressor Size: _ _ _ _ _ HP

Air Pressure: _ _ _ _ _ psig

Air discharge temperature: _ _ _ _ _ °F

COOLING WATER: TEMPERATURES

Oil-cooler:	_____	°F inlet;	_____	°F outlet
Aftercooler:	_____	°F inlet;	_____	°F outlet
Intercooler:	_____	°F inlet;	_____	°F outlet
Jacket/Head:	_____	°F inlet;	_____	°F outlet
Jacket/Head:	_____	°F inlet;	_____	°F outlet
Jacket/Head:	_____	°F inlet;	_____	°F outlet
Jacket/Head:	_____	°F inlet;	_____	°F outlet

Observe which cooling water items are piped in series. Series piping, when feasible, provides higher temperature in the cooling water and prevents condensation in the compressor cylinders. Check before changing.

CONDUCTED BY: _ _ _ _ _ DATE: _ _ _ _ _

H.2 ECONOMIC ANALYSIS - COMPRESSED AIR

SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO: _ _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

GENERAL SYSTEM LEAKAGE:

Fraction of total elapsed time idling x 0 cfm = 0

Fraction of total elapsed time at 1/4 load
x 1/4 load cfm = _ _ _ _ _

Fraction of total elapsed time at 1/2 load
x 1/2 load cfm = _ _ _ _ _

Fraction of total elapsed time at 3/4 load
x 3/4 load cfm = _ _ _ _ _

Fraction of total elapsed time at full load
x full load cfm = _ _ _ _ _

Estimated leakage, cfm = _ _ _ _ _

PRESSURE REDUCTION, BHP ANALYSIS

	<u>Pressure (psig)</u>		<u>Volume</u>	<u>BHP</u>
	<u>Min.</u>	<u>Max.</u>	<u>cfm</u>	<u>100 cfm</u>
System Air Pressure	_ _ _	_ _ _	_ _ _	_ _ _
High Pressure Required	_ _ _	_ _ _	_ _ _	_ _ _
1st Reduced Pressure Required	_ _ _	_ _ _	_ _ _	_ _ _
2nd Reduced Pressure Required	_ _ _	_ _ _	_ _ _	_ _ _
3rd Reduced Pressure Required	_ _ _	_ _ _	_ _ _	_ _ _

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

ECONOMIC ANALYSIS - COMPRESSED AIR

SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC

BUILDING NO: _ _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO: _ _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _

The following formulas enable one to analyze the operation for potential energy savings. Data necessary to complete these calculations appear on the previous pages.

SAVINGS DUE TO LEAKAGE REDUCTION:

$$\frac{\text{CFM (Est. Leakage)}}{\text{CFM (Max.)}} \times \text{rated HP} \times 0.746 = \text{ _ _ _ KW Saved}$$

$$\text{ _ _ _ KW} \times \text{ _ _ _ hours/day} \times \text{ _ _ _ days/year} = \text{ _ _ _ Kwh/year saved}$$

$$\text{ _ _ _ Kwh/year saved} \times \text{ _ _ _ \$/Kwh} = \text{ _ _ _ \$/year saved}$$

SAVINGS DUE TO AIR PRESSURE REDUCTION:

$$\frac{\text{Rated CFM}}{100 \text{ CFM}} \times \text{ _ _ _ \% full load} \times \text{ _ _ _ HP/100}$$

$$\text{HP/100 CFM Reduction} \times \text{ _ _ _ hr/year operation} \times 0.746 \text{ KW/HP} \times \text{ _ _ _ \$/per Kwh} = \text{ _ _ _ \$ savings/year.}$$

SAVINGS DUE TO HEAT RECOVERY:

$$\text{ _ _ _ gal/hr} \times 8.34 \text{ lb/gal} \times 1 \text{ Btu/lb-}^{\circ}\text{F} \times (\text{T}_1 \text{ _ _ } - \text{T}_2 \text{ _ _ })$$

$$= \text{ _ _ _ Btu/hr saved.}$$

$$\text{ _ _ _ Btu/hr} \times \text{ _ _ _ hrs of operation} = \text{ _ _ _ Btu/yr}$$

$$\frac{\text{Btu/yr}}{1,000,000} \times \text{ _ _ _ \$/MBtu*} = \text{ _ _ _ Cost Savings/Year}$$

*When the heat saved by collecting and recovering the heat from compressor cooling water will replace steam for heating, use the cost of steam (\\$/MBTU). Otherwise, use the appropriate value.

CALCULATIONS BY: _ _ _ _ _ DATE: _ _ _ _ _

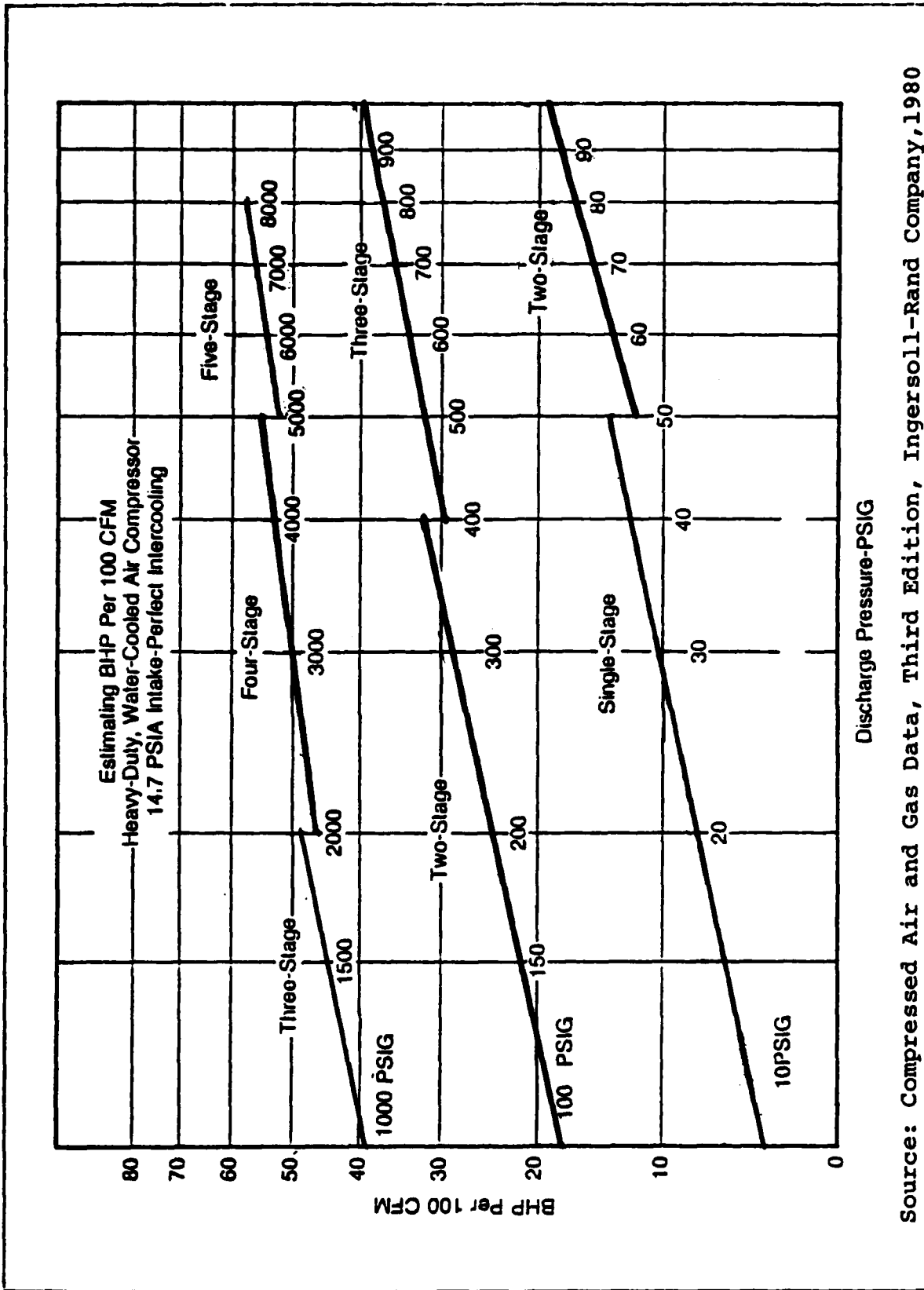


FIGURE I-7 ESTIMATION OF BHP PER 100 CFM FOR HEAVY-DUTY, WATER-COOLER AIR COMPRESSOR

TABLE H.1
INDUSTRIAL TOOL AIR REQUIREMENTS

<u>Tool</u>	<u>Air Required @ 90 PSIG With 100% Use Factor</u>
2-5#	12 CFM
10-15#	30 CFM
Drills	
1/16-3/8"	25 CFM
1" Wood Borer	40 CFM
2" Wood Borer	80 CFM
Grinders	
4" Horizontal	50 CFM
6" Horizontal	50 CFM
8" Horizontal	50 CFM
5" Horizontal	22 CFM
7" Vertical Sander/Grinder	30 CFM
9" Vertical Sander/Grinder	53 CFM
Hoist	
1000 Pound Capacity	1 Cu. Ft./Ft. of Lift
1-5 Ton Capacity	5 Cu. Ft./Ft. of Lift
Impact Wrench	
1/4" Drive Size	5 CFM
3/8"	5 CFM
1/2"	10 CFM
3/4"	20 CFM
1-1/4"	30 CFM

Tool**Air Required @ 90 PSIG
With 100% Use Factor****Angle Nut Setters**

5/16" Capacity	20 CFM
1/2" 3/4" Capacity	30 CFM

Paint Spray Guns

Average	7 CFM
Range	20-20 CFM

Riveters

3/32" - 1" rivets larger weighing 18-22 lbs.	12 CFM

Rammers

1" x 4" cuclinder	25 CFM
1-1/4" x 5" cyclinder	28 CFM
1-1/2" x 6" cyclinder	39 CFM

Screw Drivers

#2-#6 Screw	5 CFM
#6-5/16" Screw	10 CFM

**Source: Compressed Air and Gas Data, Third Edition,
Ingersoll-Rand, 1967**

TABLE H-2

COMPRESSED-AIR LEAKAGE

In cubic feet of free air per minute
at standard atmospheric pressure and 70°F

Gage Pressure before Orifice (psig)	Diameter of Orifice.				
	<u>1/8"</u>	<u>1/4"</u>	<u>1/2"</u>	<u>3/4"</u>	<u>1"</u>
20	8	31	126	283	503
30	10	41	162	365	648
40	12	50	198	446	793
50	15	59	235	528	938
60	17	68	271	609	1082
70	19	77	307	690	1227
80	21	86	343	771	1371
90	24	95	379	853	1561
100	26	104	415	934	1661
110	28	113	452	1016	1806

Table is based on 100% coefficient of flow. For well rounded entrance multiply values by 0.97. For sharp edged orifices a multiplier of 0.61 may be used for approximate results.

The above was calculated by the following formula:

$$W = 0.5303 \frac{ACp_1}{T_1}$$

where: W = discharge in lbs. per sec.

A = area of orifice in sq. in.

c = coefficient of flow

P₁ = upstream total pressure in lbs. per sq. in. absolute.

T₁ = upstream temperature ° abs.

Values used in calculating above table were; C= 1.0,

P₁ = gauge pressure + 14.7 lbs/sq. in.

T₁ = 530°F abs.

Weights (W) were converted to volumes using density factor of 0.07494 lbs./cu. ft.

Source: Compressed Air and Gas Data, Third Edition, Ingersoll-Rand, 1980.

APPENDIX I

INDUSTRIAL ENERGY

CONSERVATION DEFINITIONS

Absorption Chiller	A refrigeration machine using heat as the power input, a salt solution such as lithium bromide as an absorbent and water as a refrigerant.
Air Changes	Expression of ventilation rate in terms of room or building volume, usually air changes/hour.
Ambient Temperature	The temperature of the surrounding space or environment.
British Thermal Unit, Btu	A heat unit equal to the amount of heat required to raise one pound of water one degree Fahrenheit.
Centrifugal Chiller	A refrigeration machine using mechanical energy input to drive a centrifugal compressor to generate chilled water.
Centrifugal Fan	A device for propelling air by centrifugal action. Forward curved fan rotor blades are sloped forward relative to direction of rotation. Backward curved blades are generally more efficient.
Condensate	Water obtained by changing the state of water vapor (i.e., steam or moisture in air) from a gas to a liquid, usually by cooling.
Condenser	A heat exchanger which removes latent heat from a vapor changing it to its liquid state.

Condenser, Refrigerant	A heat exchanger which rejects the heat from compressed refrigerant to an appropriate cooling medium.
Conductivity, Thermal	A measure of the thermal-conducting properties of a single material expressed in units of Btu per (hour) (sq ft) (degree F per inch of thickness).
Cooling Tower	A device that cools water directly by evaporation.
Damper	A device used to vary the volume of air passing through an air outlet, inlet, or duct.
Demand Factor	The ratio of the maximum demand of a system to the total connected load of the system under consideration.
Desiccant	A substance possessing the ability to absorb moisture.
Dry-Bulb Temperature	The measure of the sensible temperature of air.
Economizer Cycle	A method of operating an air conditioning system to reduce refrigeration load. Whenever the outdoor air conditions are more favorable (lower heat content) than return air conditions, the outdoor air quantity is increased.
Efficiency of Utilization	The ratio of useful energy to the total energy consumed. Values for estimating are: electric resistance heating = 1; electric heat pump = 2; fuel fired hot water = 0.6; fuel fired steam = 0.7 to 0.8.
Energy	The capacity of a substance, either latent or apparent, to exert force through a distance, i.e., to do work.

Energy, External	The kind of energy represented by the product of pressure and volume.
Energy, Internal	The energy possessed by a substance because of the motion and configuration of its atoms and molecules.
Energy, Kinetic	The energy a substance possesses by virtue of its motion or velocity.
Enthalpy (Heat Content)	The sum of internal and external energies. In practice, it is the sum of latent and sensible heat.
Evaporator	A process unit which adds latent heat to a liquid changing it to a gaseous state. In a refrigeration system, it is the component which absorbs heat by vaporizing a refrigerant.
Heat, Latent	The quantity of heat required to affect a change in state at a constant temperature, vaporization, condensation, melting, or freezing.
Heat Pump, Reverse Cycle	A refrigeration machine possessing the capability of reversing the flow so that its output can be either heating or cooling. When used for heating, it extracts heat from a low-temperature source raising its temperature to the point where it can be used.
Heat, Sensible	Heat transfer that results in a temperature change, but no change in state.
Heat Source	A quantity of heat available for use, expressed in Btu's.

Heat, Specific	Ratio of the amount of heat required to raise a unit mass of material 1 degree to that required to raise a unit mass of water 1 degree.
Heat Transmission	Any one of a number of coefficients used in the calculation of heat transmission by conduction, convection, and radiation, through various materials and structures. Usually expressed in Btu/hr/sq ft/F. See "U" value.
Humidity, Relative	A measurement indicating moisture content of air, expressed as % of saturation.
Life-Cycle Cost	The cost of equipment over its entire life including material, energy, and maintenance costs.
Load Leveling	Deferment of certain loads to limit electrical power demand to a pre-determined level.
Make-up	Water or other fluid supplied to a system to replace that lost by blowdown, leakage, evaporation, etc.
Orifice Plate	Device inserted in a pipe or duct which causes a pressure drop across it. Depending on orifice size, it can be used to restrict flow or form part of a measuring device.
Orsat Apparatus	A device for measuring the composition of boiler or furnace flue gases.
Orsat Apparatus	A device for measuring the composition of boiler or furnace flue gases.
Power Factor	The ratio W/VA in AC circuits. When the power factor is unity, VA equals W .

R-Value	The resistance to heat flow expressed in units of (sq ft) (hour) (degree F)/Btu; reciprocal of U-Value.
Refuse Derived Fuel (RDF)	Processed municipal refuse, generally with non-combustibles removed, then ground.
Software	Term used in relation to computers, normally describing computer programs.
Ton of Refrigeration	A means of expressing cooling capacity: 1 ton = 12,000 Btu/hour
U-Value	A coefficient expressing the thermal conductance of a composite structure in Btu per (square foot) (hour) (degree F temperature difference).
Vapor Barrier	A moisture-impervious layer designed to prevent moisture migration.
Wet-Bulb Temperature	The lowest temperature attainable by evaporating water in the air without the addition or subtraction of energy. It is measured by a wet bulb psychrometer, and is used with the dry bulb temperature to determine relative humidity.

APPENDIX J

ABBREVIATIONS/SYMBOLS

A, a, or amp(s)	Ampere(s)
AC	Alternating electrical current
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BHP	Brake horsepower
BTU or BTu	British thermal unit
KBTU	Thousands of Btu
MBTU	Millions of Btu
CF or cu ft	Cubic feet
CFM	Cubic feet per minute
1000 CF	Thousands of cubic feet
1000 CFM	Thousands of cubic feet per minute
Chemical Symbols	
CO	Carbon monoxide
CO ₂	Carbon dioxide
H ₂ O	Water
N ₂	Nitrogen
O ₂	Oxygen
COP	Coefficient of performance
CU	Coefficient of utilization
DBT	Dry bulb temperature

DC	Direct electrical current
DEIS	Defense Energy Information System
DIA	Diameter
Dimensions:	
D	Depth
H	Height
L	Length
W	Width
DOD	Department of Defense
ECIP	Energy Conservation Investment Program
EI	Efficiency Improvement
ETAP	Energy Technology Application Program
FC	Foot candles
FT or ft	Feet; linear measure, pressure head
sq ft or ft ²	Square feet - area
Cu ft or ft ³	Cubic feet volume
FY	Fiscal year (Federal starts October 1)
GAL or gal(s)	Gallon(s)
GPM or gpm	Gallons per minute
H	Head of liquid, feet
HID	High intensity discharge lamps
HTHW	High temperature hot water

HVAC	Heating, ventilating, and air conditioning
HZ or hz	Hertz - frequency in cycles per second
ID No.	Identification number (USN)

K	Kilo - prefix for thousands
KVA	Kilovolt ampere(s)
KW	Kilowatt(s)
KWH	Kilowatt hour(s)

LBS or lbs	Pound(s)
MLBS	Thousands of pounds
LPG	Liquefied petroleum gas

M	Millions, e.g., M Btu*
MFR or mfr	Manufacturer's name
MILCON	Military Contruction
MOD. NO.	Model No.
MU	Make-up (Usually water or air)

NAVFAC	Naval Facility

*In some utility billings of gas, it will be reported as MCF meaning thousands of cubic feet of gas.

O.A.	Outside air
OPNAV	Naval Operations
PF	Power Factor (alternating electrical current)
PPM or ppm	Parts per million
PSIA or psia	Pressure (pounds per square inch absolute)
PSIG or psig	Pressure (pounds per square inch gauge)
Q	Flow in gpm
RDF	Refuse derived fuel
RPM or rpm	Revolutions per minute
S or SG	Specific gravity
SCFM	Standard cubic feet per minute (air or gases)
SER. NO.	Serial No. (of equipment)
SIR	Savings/investment ratio
T	Temperature
TI	Temperature, indoor
TO	Temperature, outdoor
T ₁	Temperature, inlet
T ₂	Temperature, outlet
TD or T	Temperature difference
V or v	Volts
Vol	Volume
W or w	Watts
WBT	Wet bulb temperature
WT	Weight

APPENDIX K

GENERALIZED FORMS

DATA COLLECTION

For specialized or unique equipment. Data collection includes information found on nameplates, the design document, and the on-site audit. Format to be developed at and by the facility.

SKETCH SHEET

Used to improve the description of the various systems.

DATA ANALYSIS SHEETS

Used to determine if energy savings are feasible.

The data collection and analysis forms should be developed by considering:

- a. Items from the checklist sheets.
- b. Energy consumption: fuel gas and fuel flow rate, or if electric, the average rated KW.
- c. Usage: number of identical units, number of units typically operating, number of hours operated a week.
- d. Operating conditions: air flow rates, temperatures, loading rates, utilization of preheat and precool.
- e. Applicable systems: can the forms in the Guidebook be used for the pumps, fans, air compressors, etc., associated with the equipment? For example: Section 6.2, Paint-Booths: Are dedicated compressors (Appendix H) used with the spray washers? How are the exhausters (Section 7.2 and Appendix F) operated?

Section 6.3, Paint Dryers and Ovens: Are oven exhaust and make-up air (Section 7.2 and Appendix F) requirements minimized?

Section 6.4, Chilling Well: is a dedicated refrigeration system (Section 8.4) used?

Section 6.5, Heat Treating: A large variety of equipment is available. Equipment operating requirements should be studied carefully. Material can be heated electrically (salt, induction) or it can be heated with fuels? Are fans (Appendix F) and furnaces (Appendix G) involved?

Section 6.6, Machine Tools: Are dedicated pumps (Appendix D) and air compressors (Appendix H) involved?

Section 6.8, Welding: Are cooling systems (Section 8.4) or exhausters (Appendix F) involved?

Section 6.9, Foundry: Often includes equipment listed in Heat-Treating (Section 6.5)

DATA COLLECTION SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ _ _
ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

(DATA COLLECTION FORMAT TO BE DEVELOPED AT THE FACILITY)

NAME PLATE DATA

DESIGN DATA

AUDIT DATA

CONDUCTED BY _ _ _ _ _ DATE _ _ _ _

SKETCH

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ ITEM: _ _ _ _ _
ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _
SKETCH NO.: _ _ _ _ _ DATE: _ _ _ _ _ SCALE: _ _ _ _ _ DRAWN BY: _ _ _ _ _

DATA ANALYSIS

SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ _ _
ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO: _ _ _
ACTIVITY _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _

(DATA ANALYSIS FORMAT TO BE DEVELOPED AT THE FACILITY)

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