



# POWER AND MOBILITY



Michigan Chapter  
**NDIA**  
National Defense Industrial Association

## High Efficiency Variable Speed Versatile Power Air Conditioning System

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**GVSETS**

## Report Documentation Page

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- Improved Energy Efficiency
- Improved reliability
- Power versatility, can run from AC and DC sources
- Cooling load adaptive, variable Speed
- Fully operable up to 140 degrees Fahrenheit

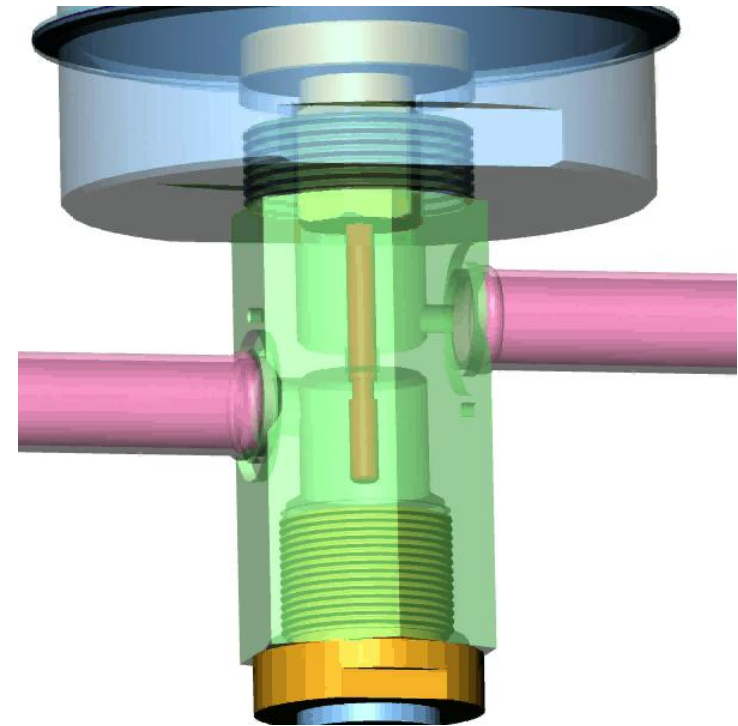


- Pulsing Refrigerant Flow Control Air Conditioners
  - Advanced Refrigerant Flow Control
  - Advanced Refrigerant Distribution with Enhanced Heat Transfer
  - Enhanced Reliability, Energy Saving
- Variable Frequency Drive Air Conditioners
  - VSD Compressor Optimization with use of Pulsing TXV
  - AC/DC Power Management Design, DC-BUS
  - Weight, Volume and Energy Savings; Lower Noise

## Advanced Pulsing Thermal Expansion Valve (PTXV)

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- Rocky Research Innovation
- No small orifices and no plugging problems.
- Pulsing operation allows precise superheat control over a wide range of refrigerant flow rates.
- Pressure sensing determines pulsation frequency, thus ensuring precise superheat control.
- Fully mechanical, no electronics are required.

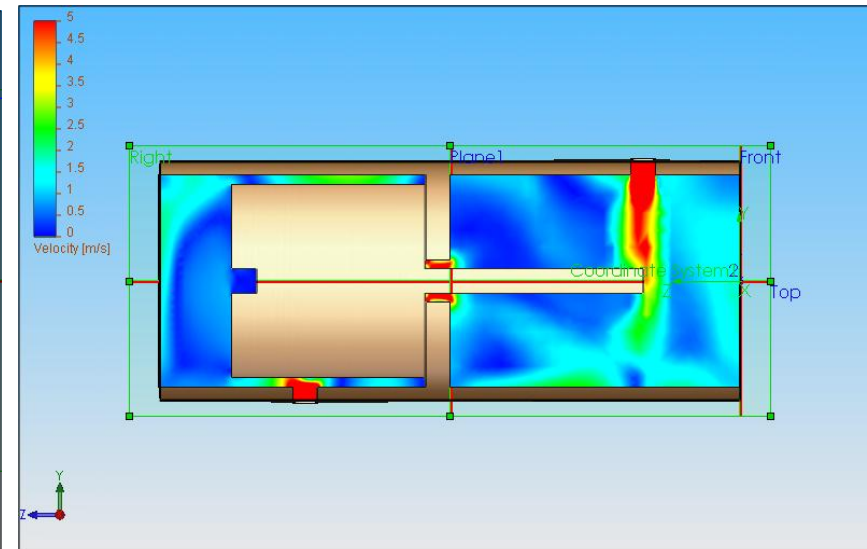
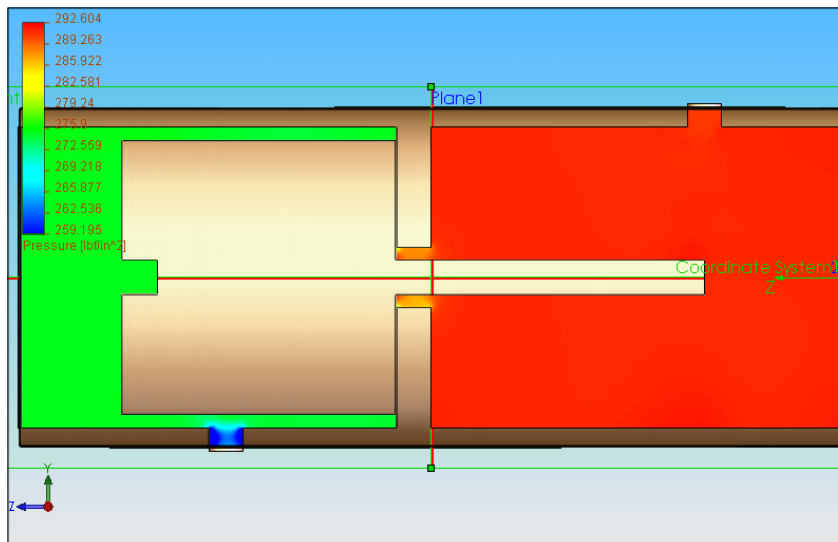


U.S. Patent No 5,675,982 and 6,843,064

# PTXV CFD Analysis

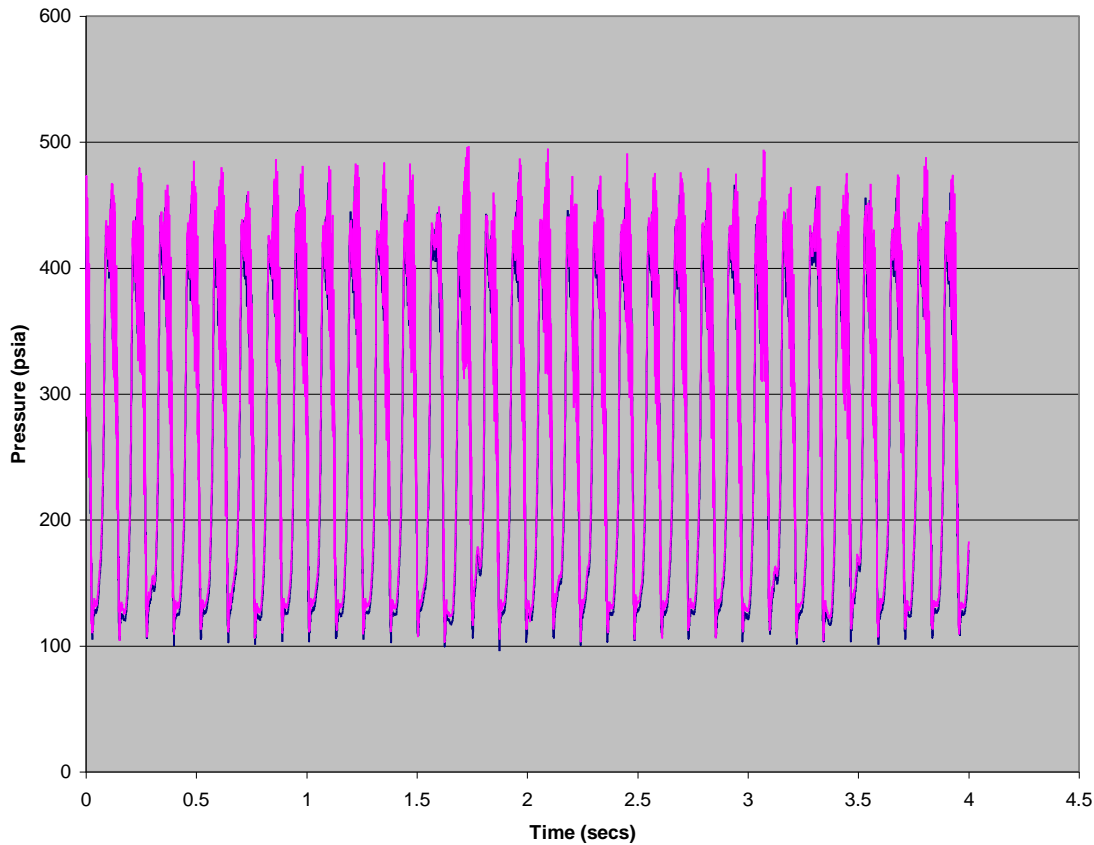
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- Optimized geometry
- Design concept applicable for wide range of HVAC and refrigeration systems
- One TXV size can be used for a wide range of cooling capacity

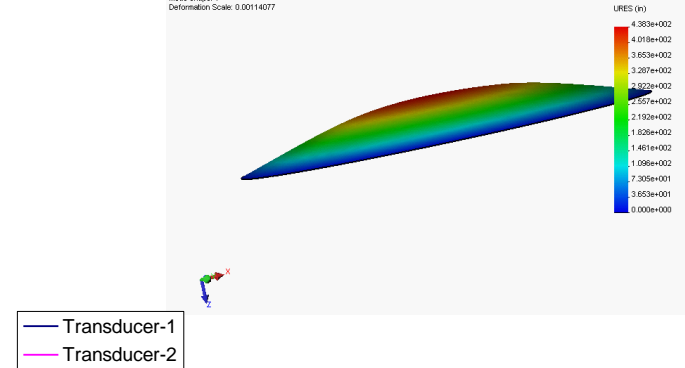


# Pressure Pulsation Measurement

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Model name: Diaphragm  
Study name: Freq-1  
Plot type: Frequency-Plot  
Mode shape: 1  
Deformation Scale: 0.00114077



# Advantages

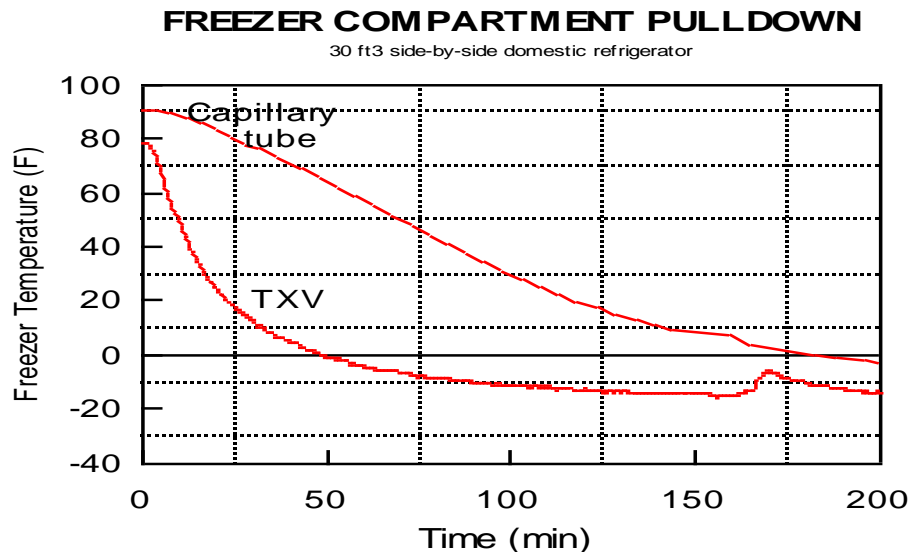
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- Improved energy efficiency
- Improved cooling capacity
- Faster pull-down or compressor size reduction for the same pull-down
- Facilitates and/or optimizes use of multiple/variable speed compressors

# Side-by-Side Refrigerator

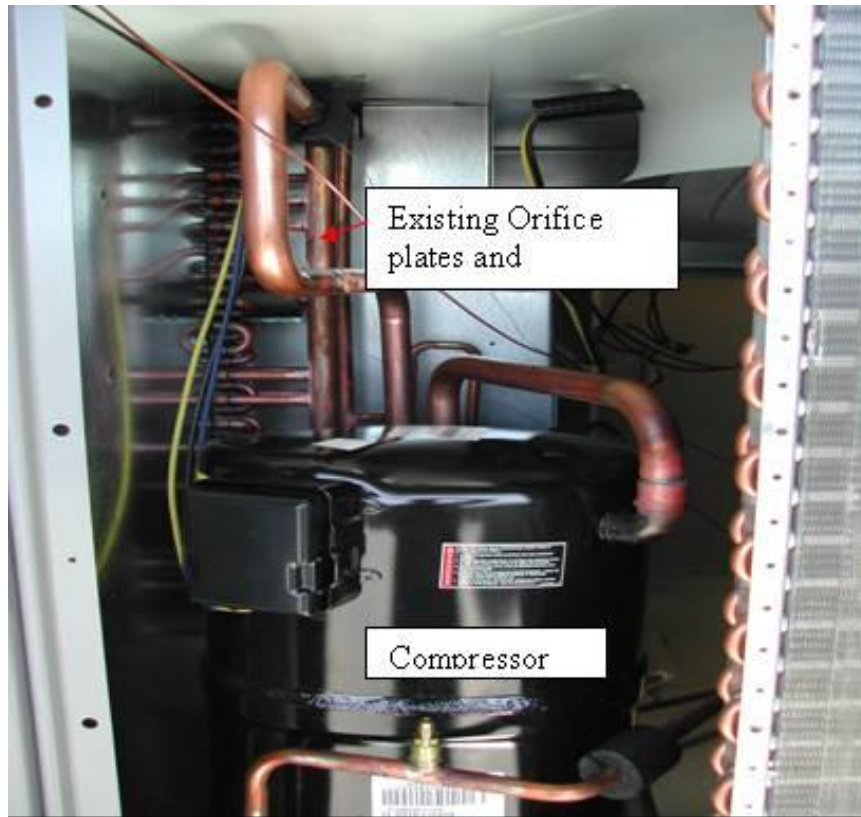
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- 30 cubic-foot side-by-side domestic unit
- 350% pull down improvements over a capillary
- TXV suitable for use in high volume manufacturing



# Test of Carrier 5 ton, R22, 50TM006 model

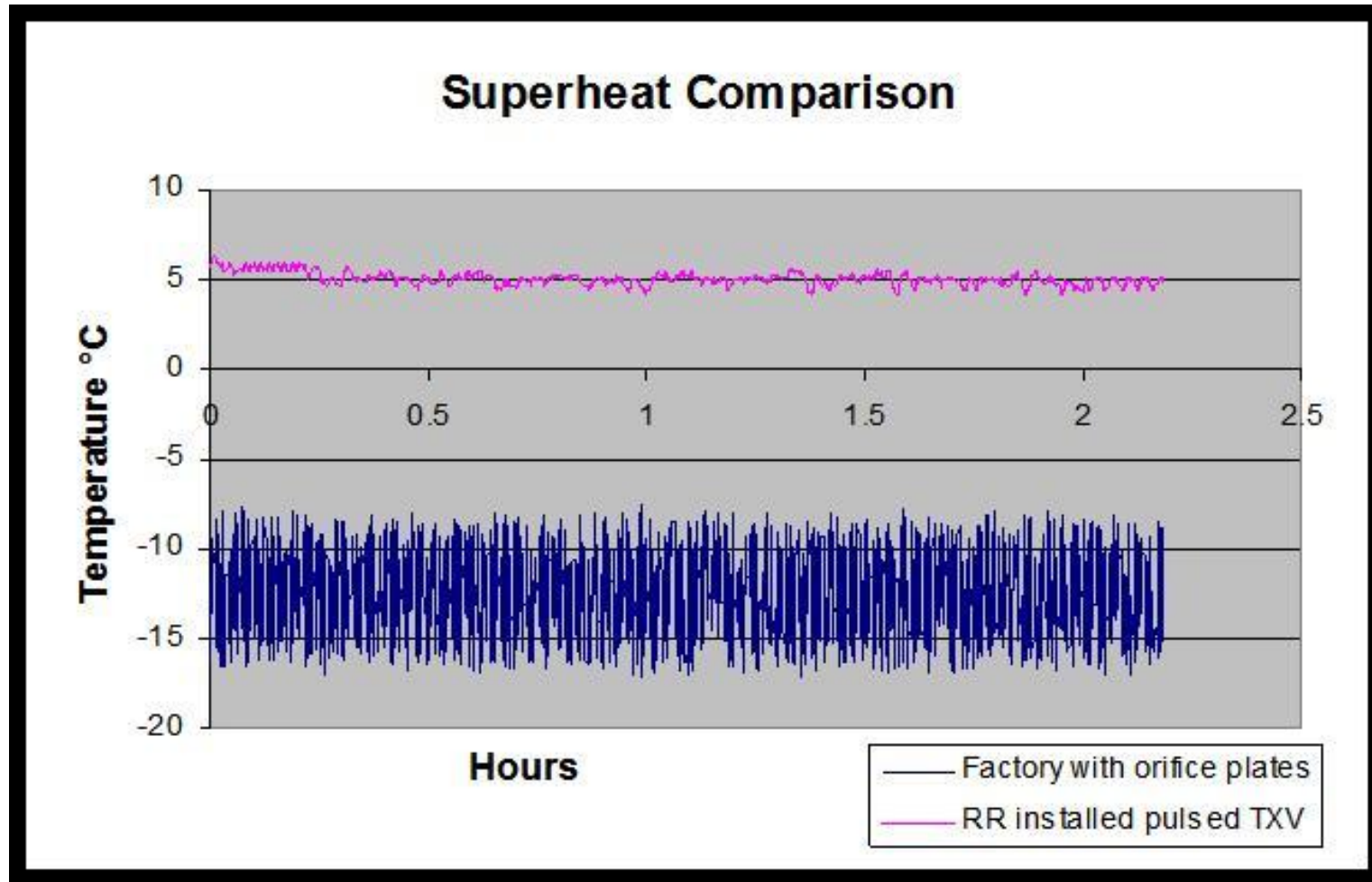
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# UNCLASSIFIED Superheat Test Results of Carrier 5 ton, R22, 50TM006 model

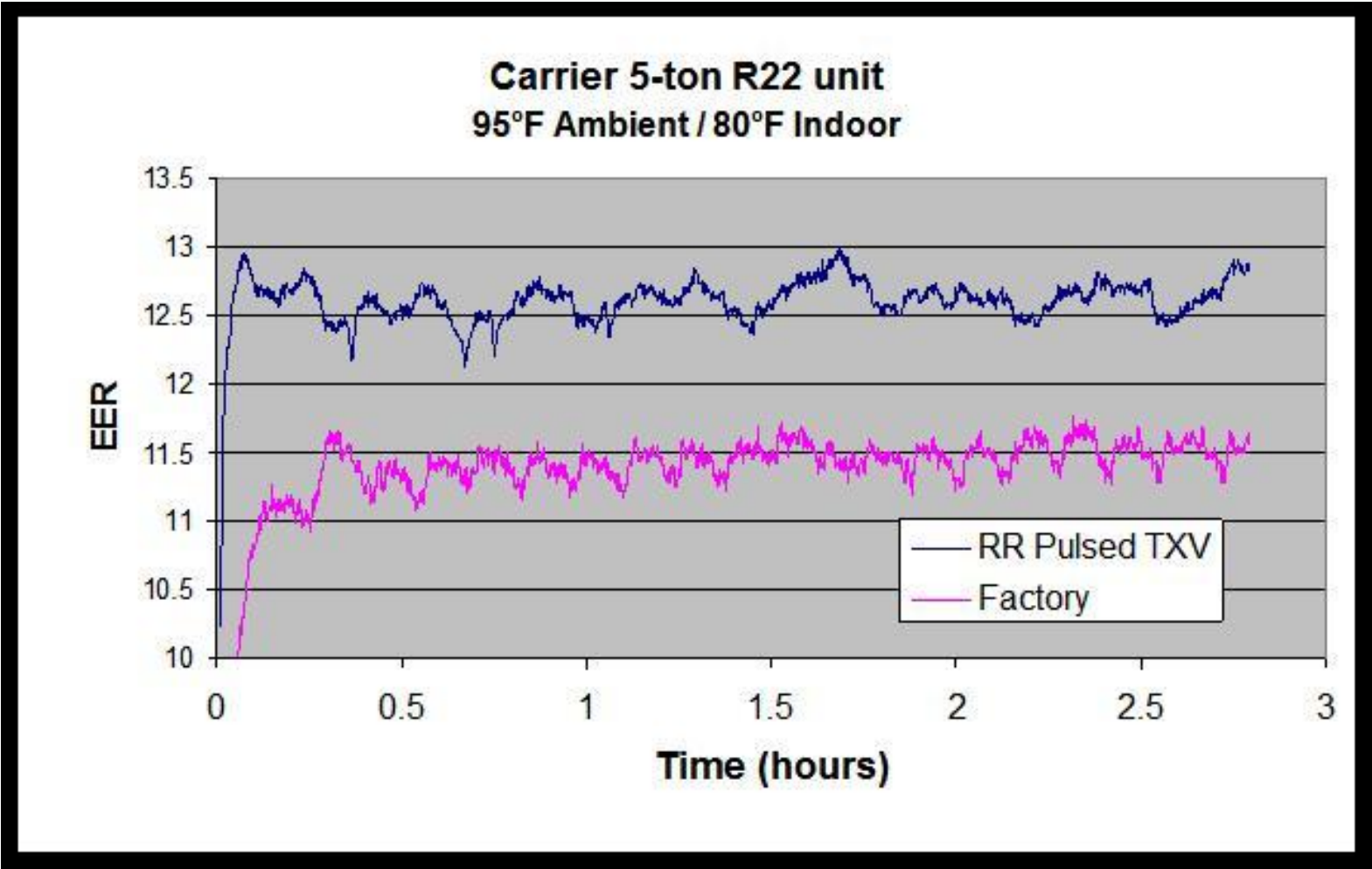
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UNCLASSIFIED

# EER Test Results of Carrier 5 ton, R22, 50TM006 model (single speed)

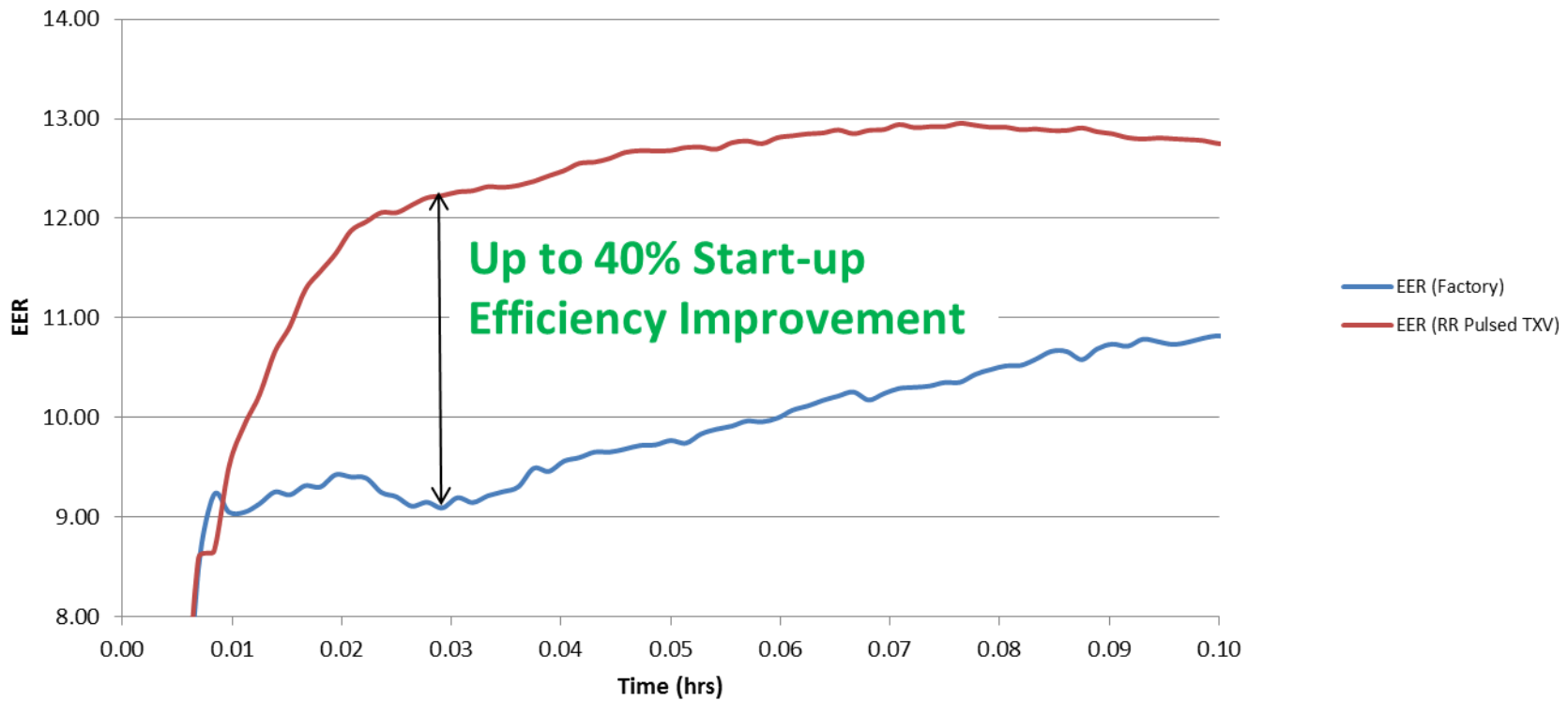
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# Carrier 5-ton EER Start-up Comparison

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Carrier 5-ton R22 Unit  
95° F Ambient/ 80° F Indoor - Startup





# Manufacturing /Reliability



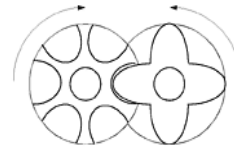
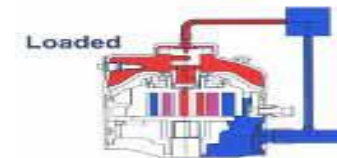
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- Established TXV Reliability (on-going tests)
  - More than 500 million cycles (> 10 years) with TXVs installed on different systems
- Established First Cost Competitiveness
- Validated Manufacturing Process and QC

## High Efficiency Scroll Compressor

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- High efficiency due to near 100% volumetric efficiency
- Hermetic
- Requires no tip seals that wear out
- Light, compact and small footprint
- single speed to variable speed conversion for further enhanced efficiency



# Variable Speed Compressor Test Stand

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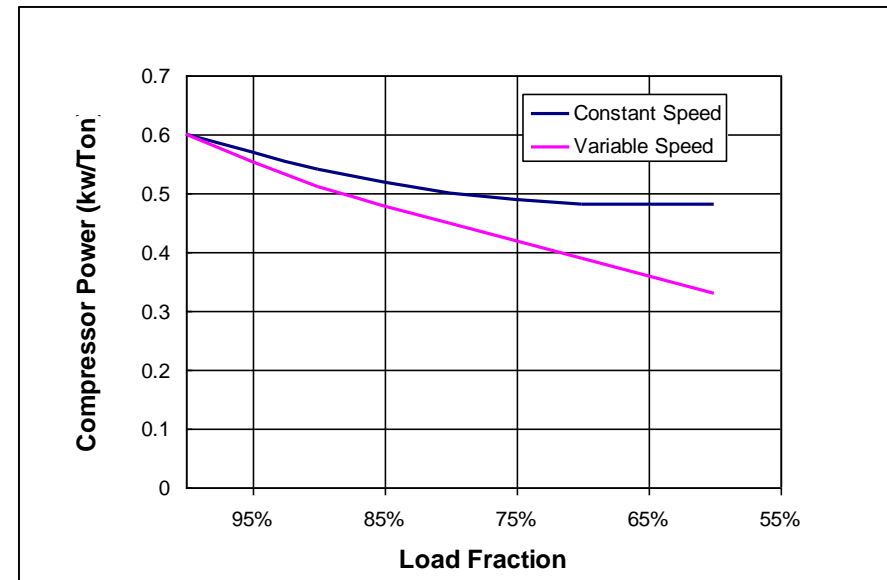
- Calorimetric test stand to measure capacity and power draw
- Evaporator air temperature is regulated using resistant heaters
- Refrigerant flow and air flows are measured
- Power is measured



# Advantage of Variable Speed Control

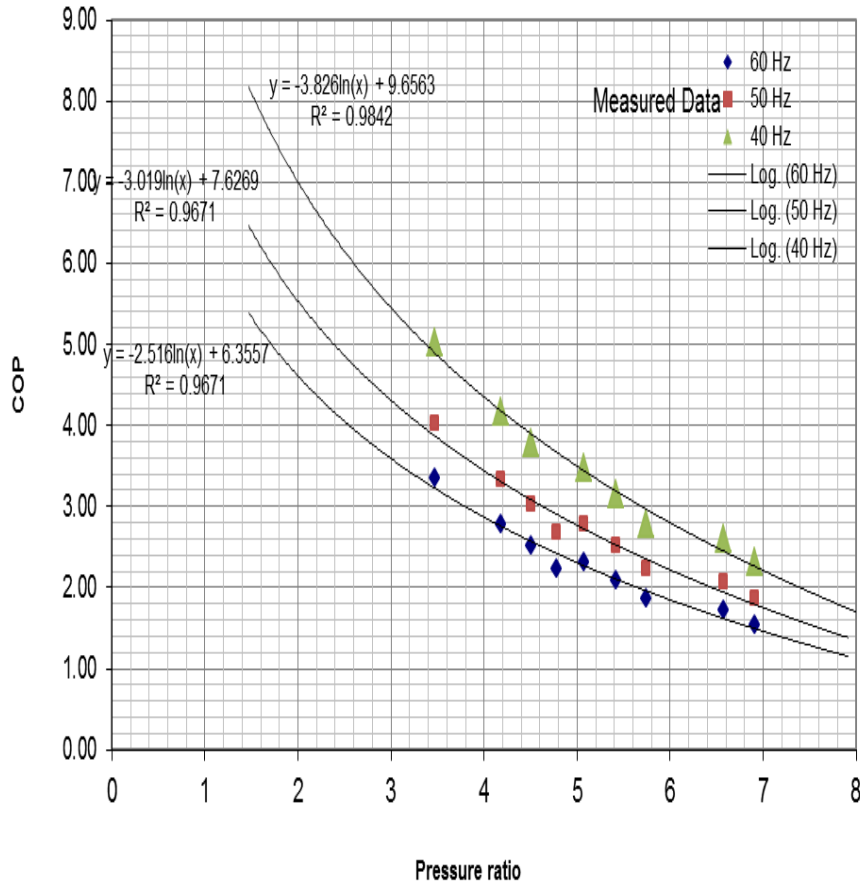
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- Higher efficiency
- Matching loads
- Reduced fuel consumption
- Reduced wear
- Torque/frequency modulation considerations

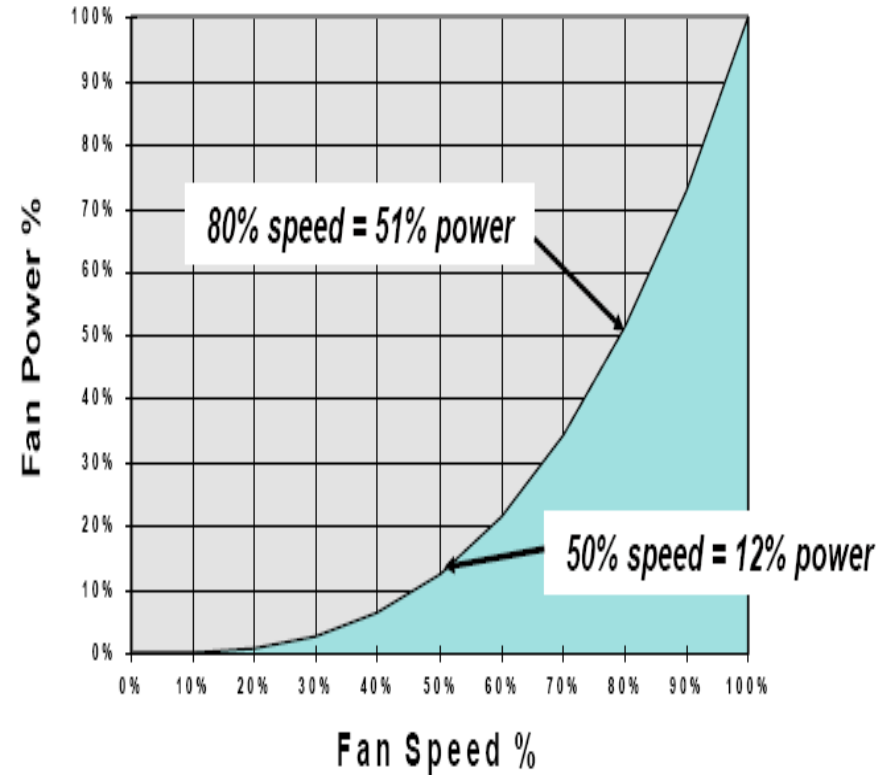


## Test Results

### COP with 3-phase hermetic compressor



### Variable Speed Fan Control

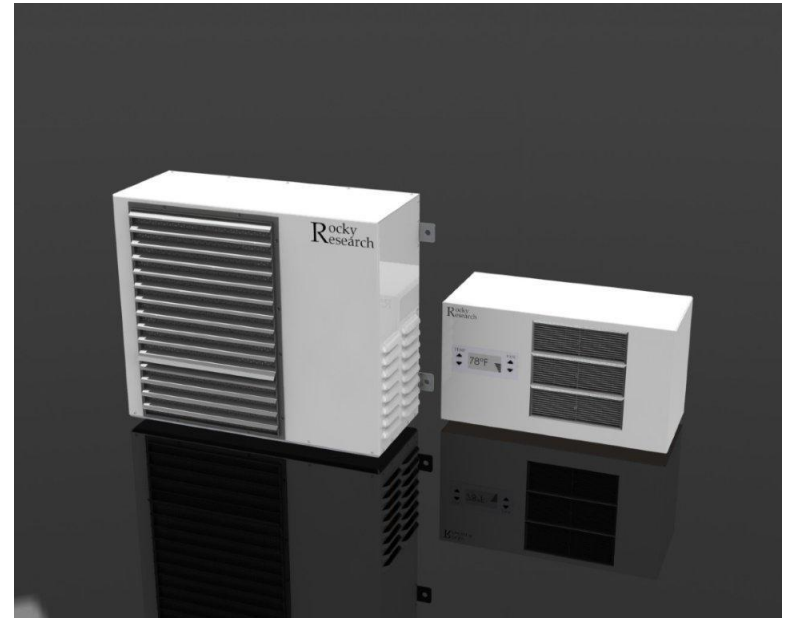


- Capacity varies directly with change in airflow
- Fan power varies with cube of change in airflow

# Split System Proof of Concept

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- Variable speed
- Runs from either/or 120VAC or 12VDC
- Hermetic Scroll compressor (460-3phase)
- PTXV



System	Design Capacity in 125°F ambient (BTU/h)	Indoor unit volume (ft <sup>3</sup> )	Outdoor unit volume (ft <sup>3</sup> )	Mass (lbs)
vapor compression	6000	1.5	3.2	150
vapor compression	12000	1.5	4.1	175

# Test Chambers

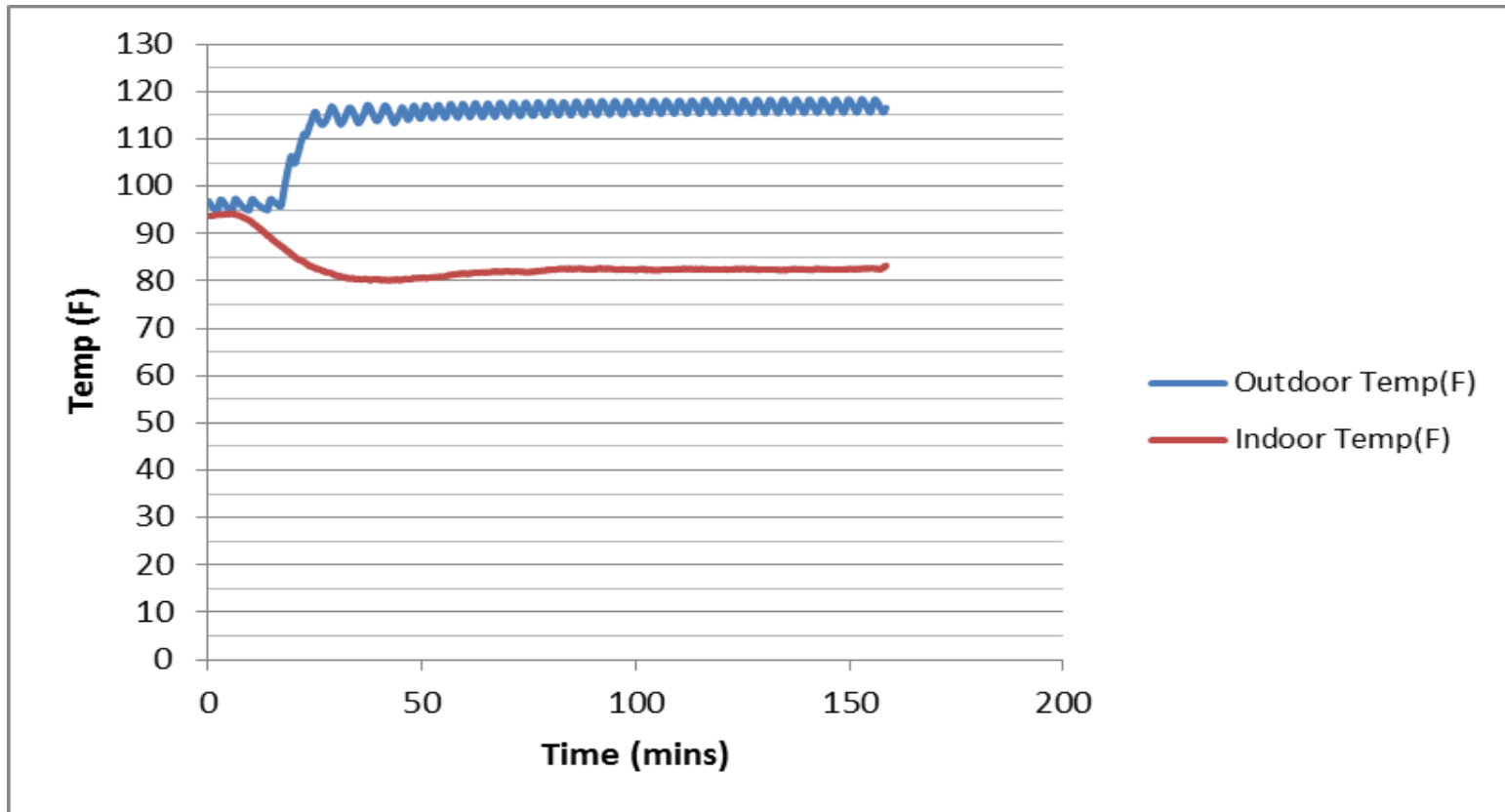
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- One hydronic and one air-cooled/heated
- Indoor and outdoor section air temperature is regulated; heat added or removed is measured
- Refrigerant, air flow, and power are measured



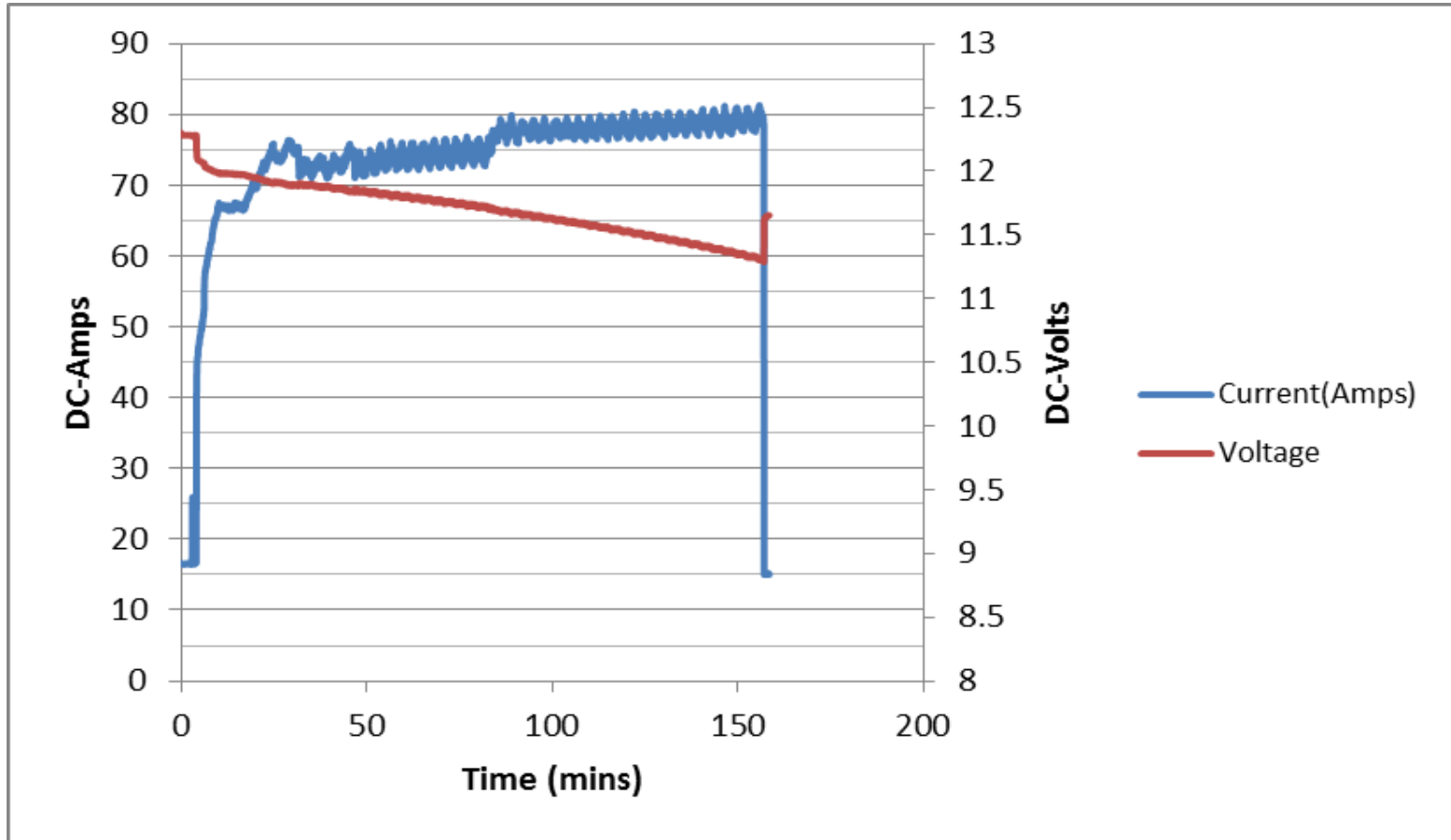
# Test Chamber Temperatures

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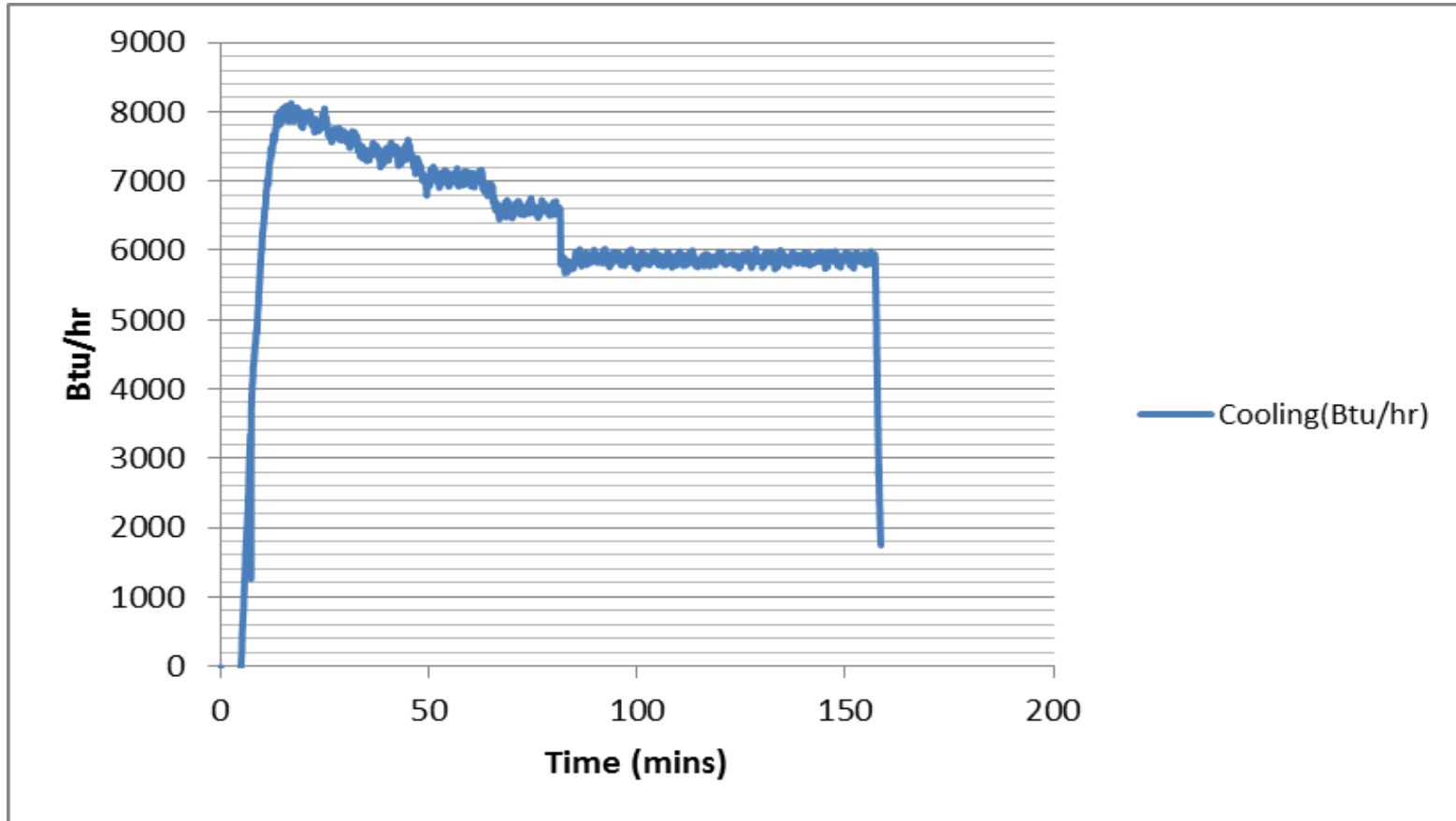
# Power Draw Measurements

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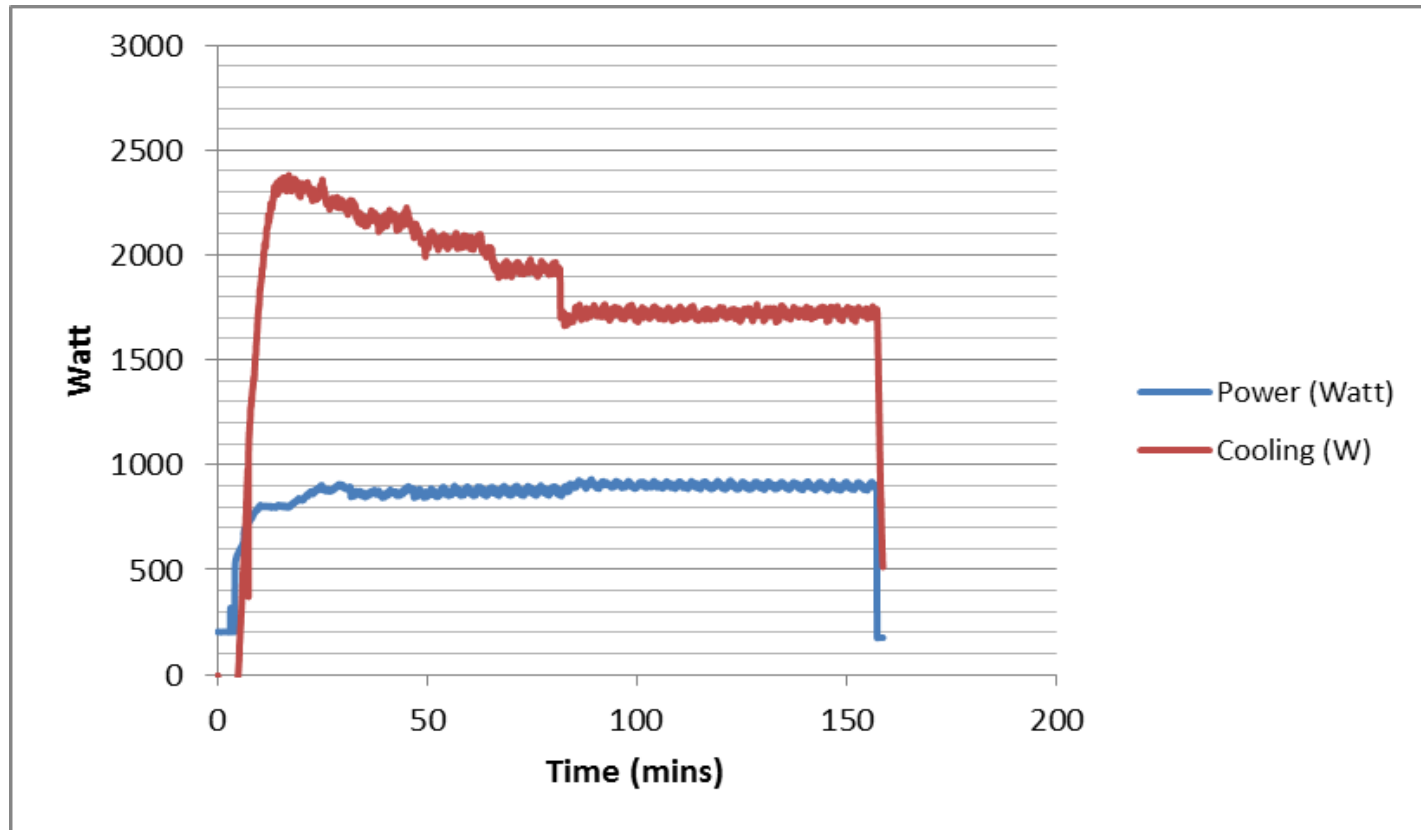
# Cooling Capacity Measurement

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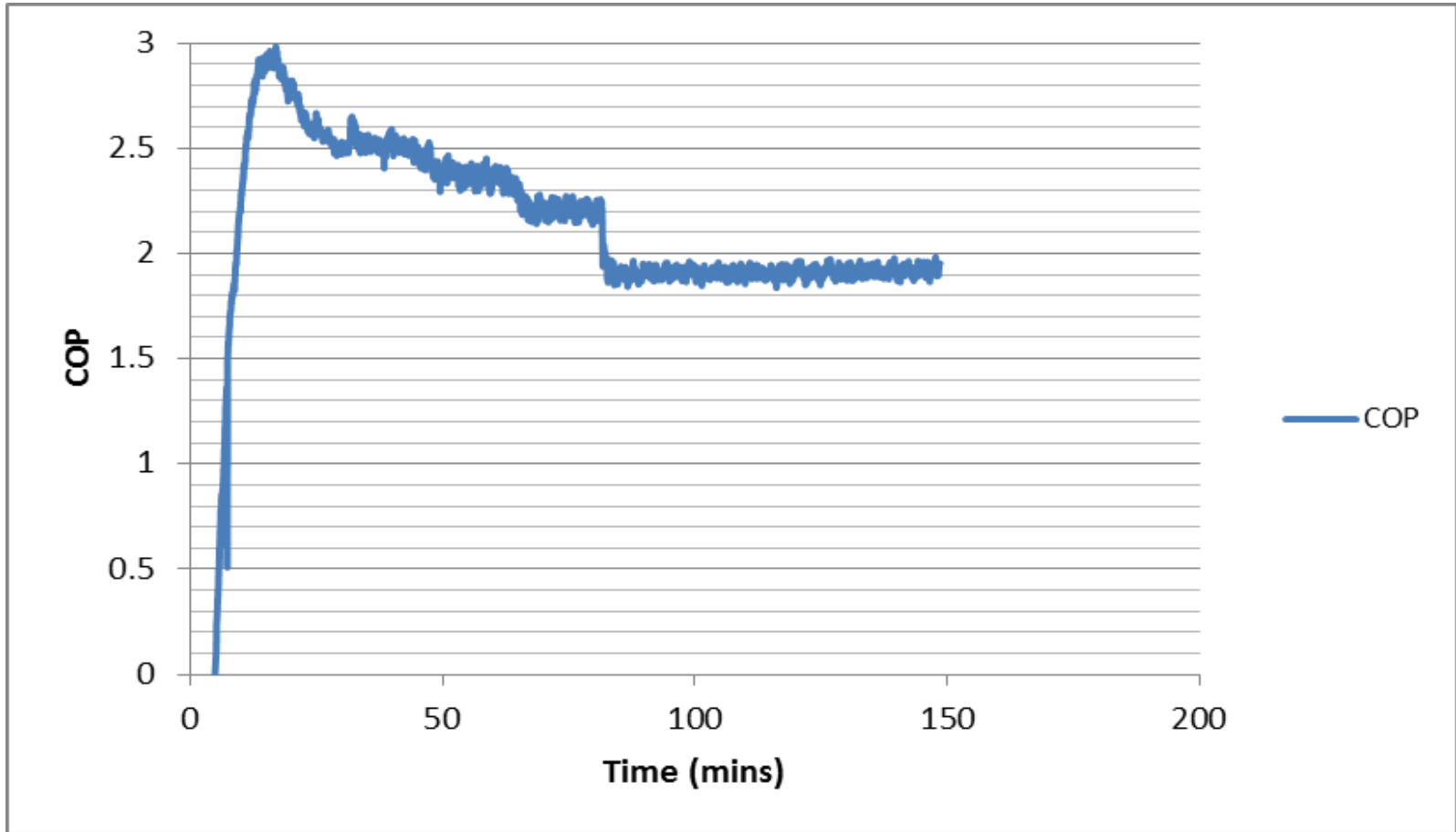
# Power Draw and Capacity

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# Efficiency

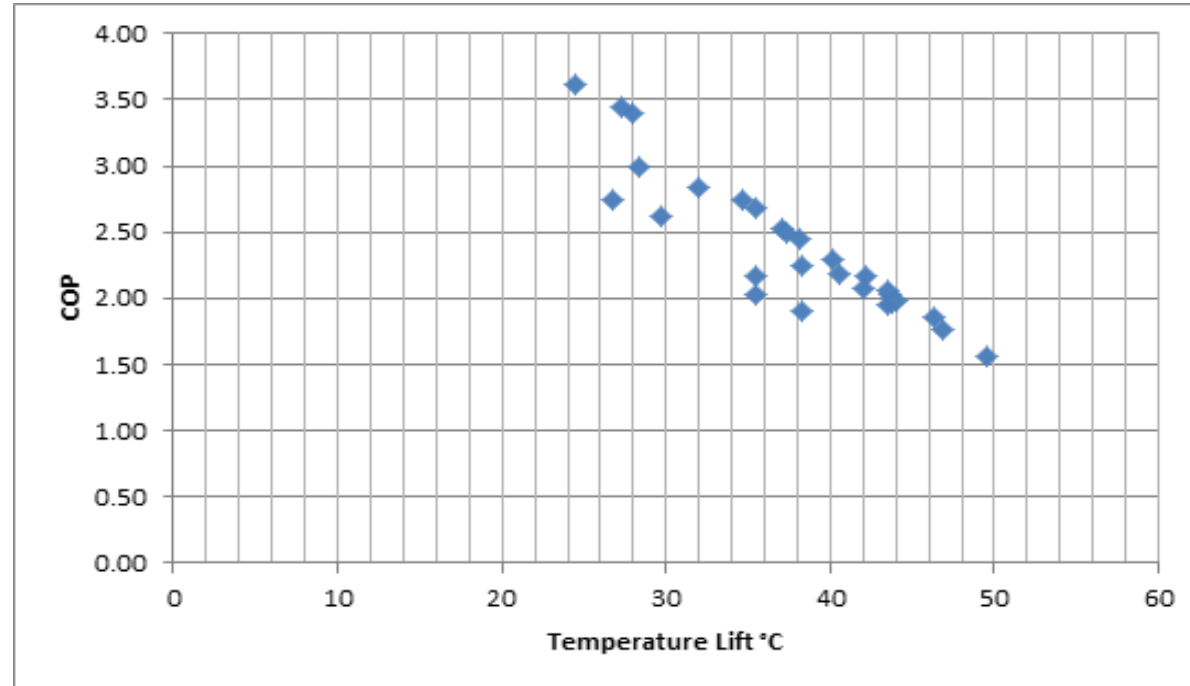
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# Test Results at Other Conditions

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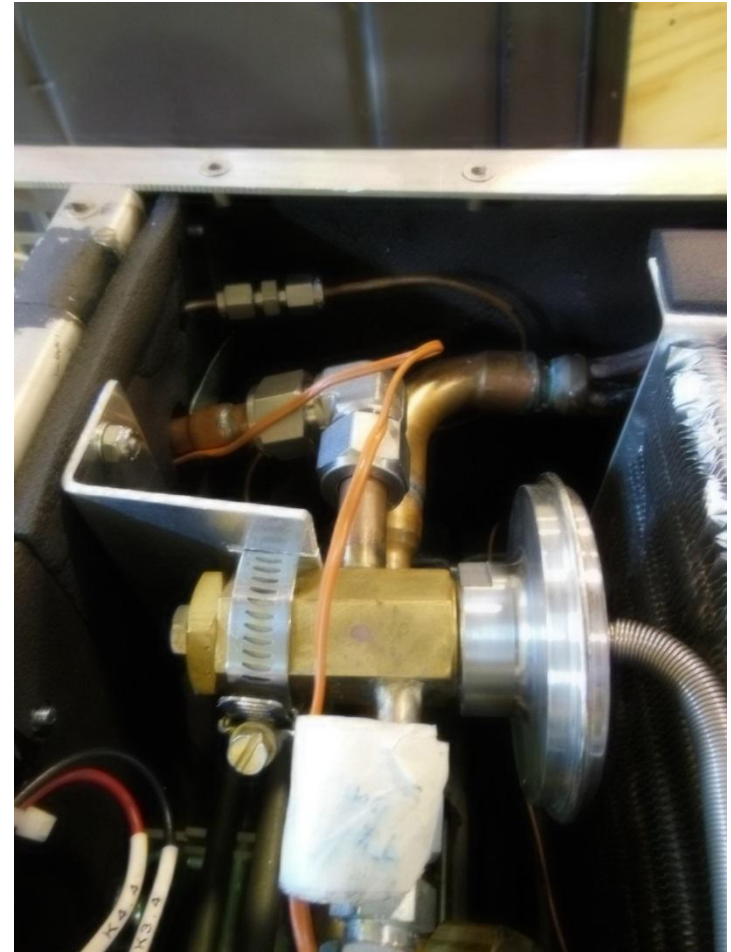
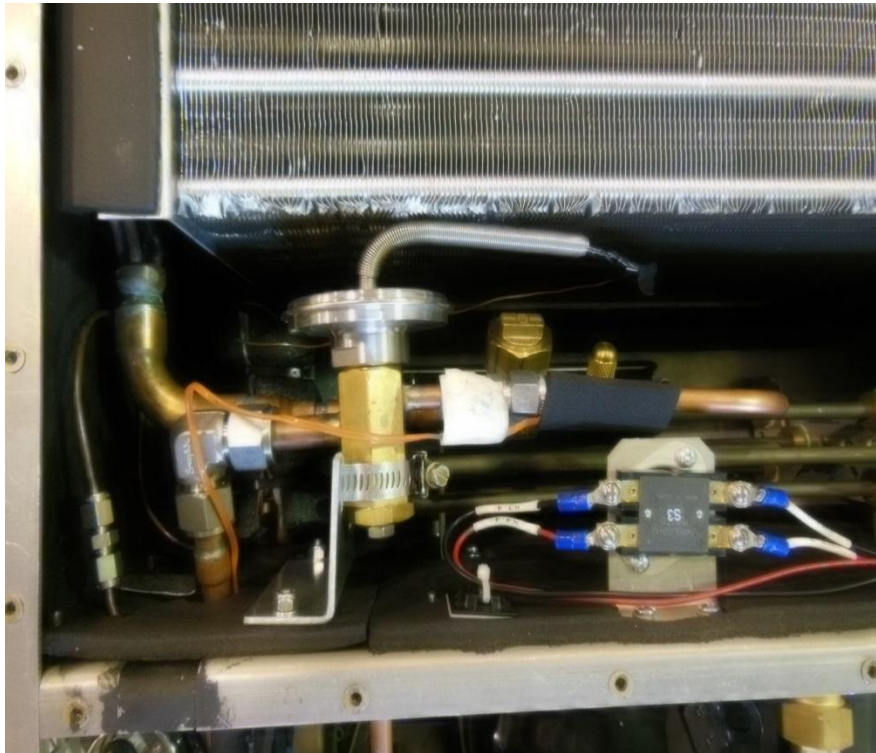
Condenser Temperature (C)	Evaporator Temperature (C)	Cooling (W)	Power In (W)	COP
36.2	0.8	976	449	2.17
39	0.7	1204	633	1.90
39.6	4.1	1312	647	2.03
43.7	14	1852	708	2.62
46.3	19.6	2039	742	2.75
43.9	19.4	1938	536	3.61
40.7	12.3	1514	505	3.00
46.4	18.5	2235	657	3.40
47.6	20.3	2320	674	3.44
43.55	-0.001	1556	795	1.96
38.8	0.5	1176	522	2.25
41.8	9.8	1640	578	2.84
44.7	-2.2	1531	870	1.76
50.1	6.4	2118	1041	2.03
55.4	13.3	2663	1226	2.17
55.2	11.7	2706	1311	2.06
50.1	3.8	2117	1141	1.86
47	-2.6	1578	1008	1.56
44	0.2	1575	799	1.97
47.9	7.8	2102	914	2.30
52.4	14.3	2575	1052	2.45
50.8	15.4	2481	925	2.68
47.5	10.4	2112	839	2.52
43.2	2.7	1592	731	2.18
41	-1	1413	680	2.08
45.8	8.5	1996	800	2.50
50.7	16	2542	925	2.75
55.5	11.4	2746	1383	1.98



# Back Up

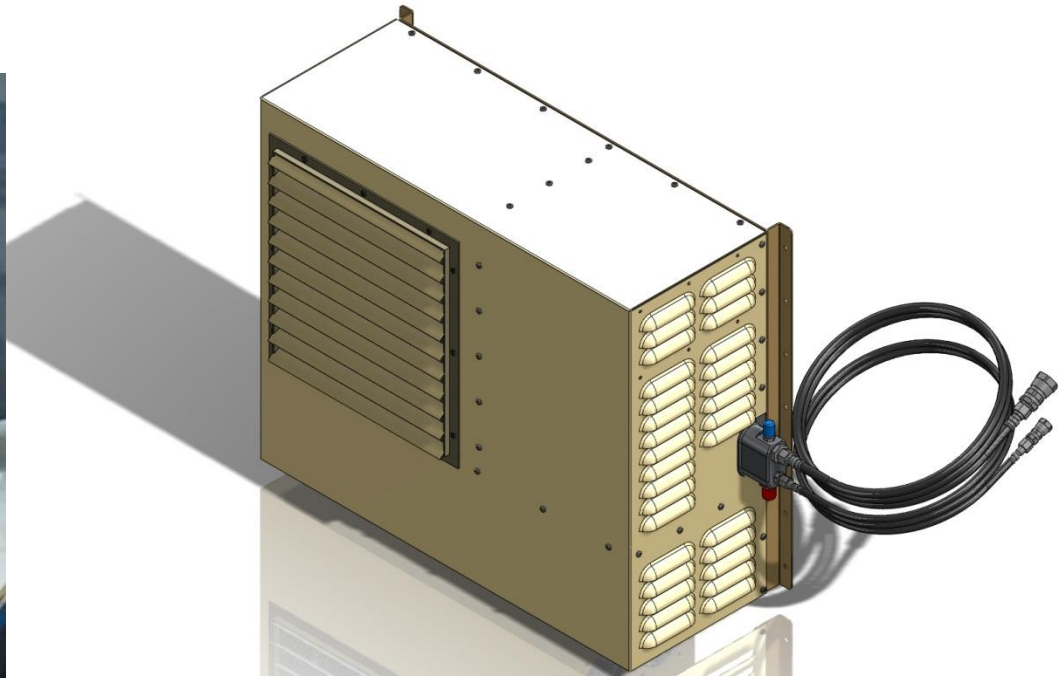
PTXV

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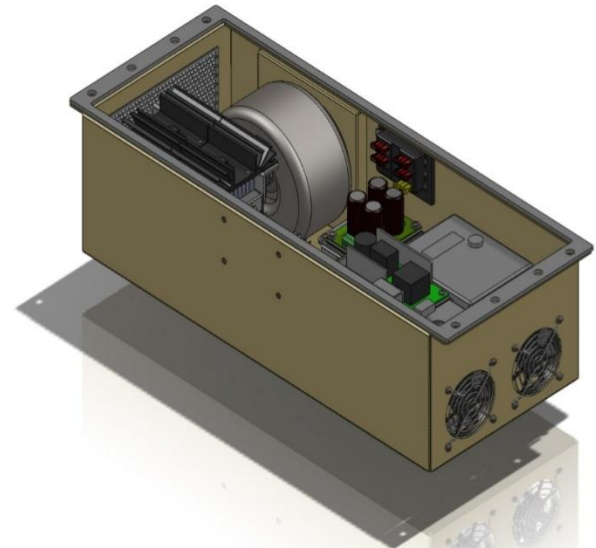
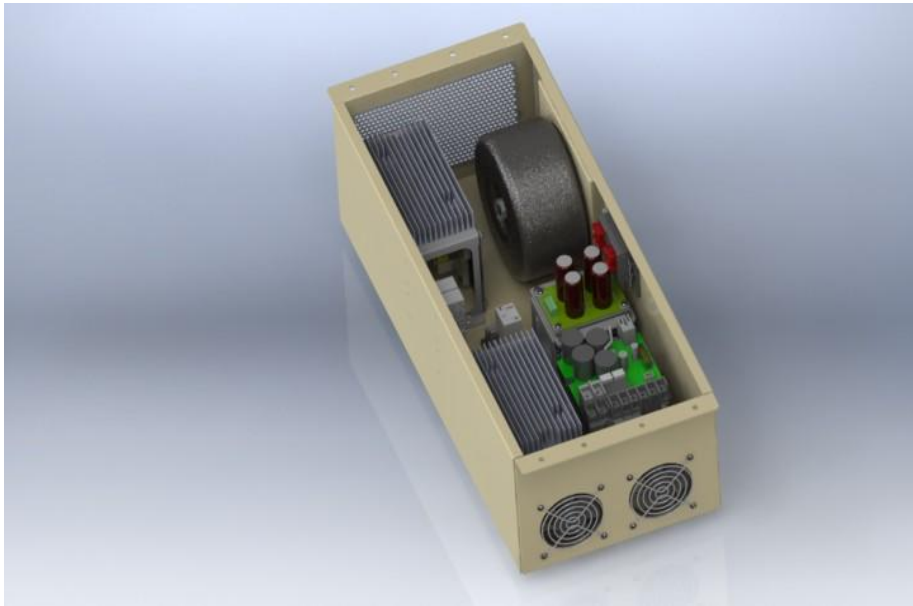
# Condensing Section

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# Power Electronics and Controls

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# Indoor Section

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