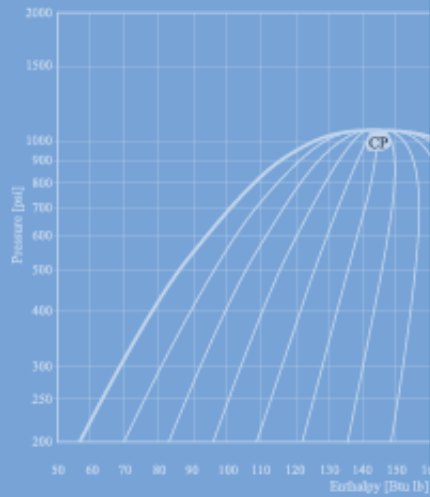


$$\text{COP} \equiv \frac{T_m}{T_m - T_o}$$



# Making Sense

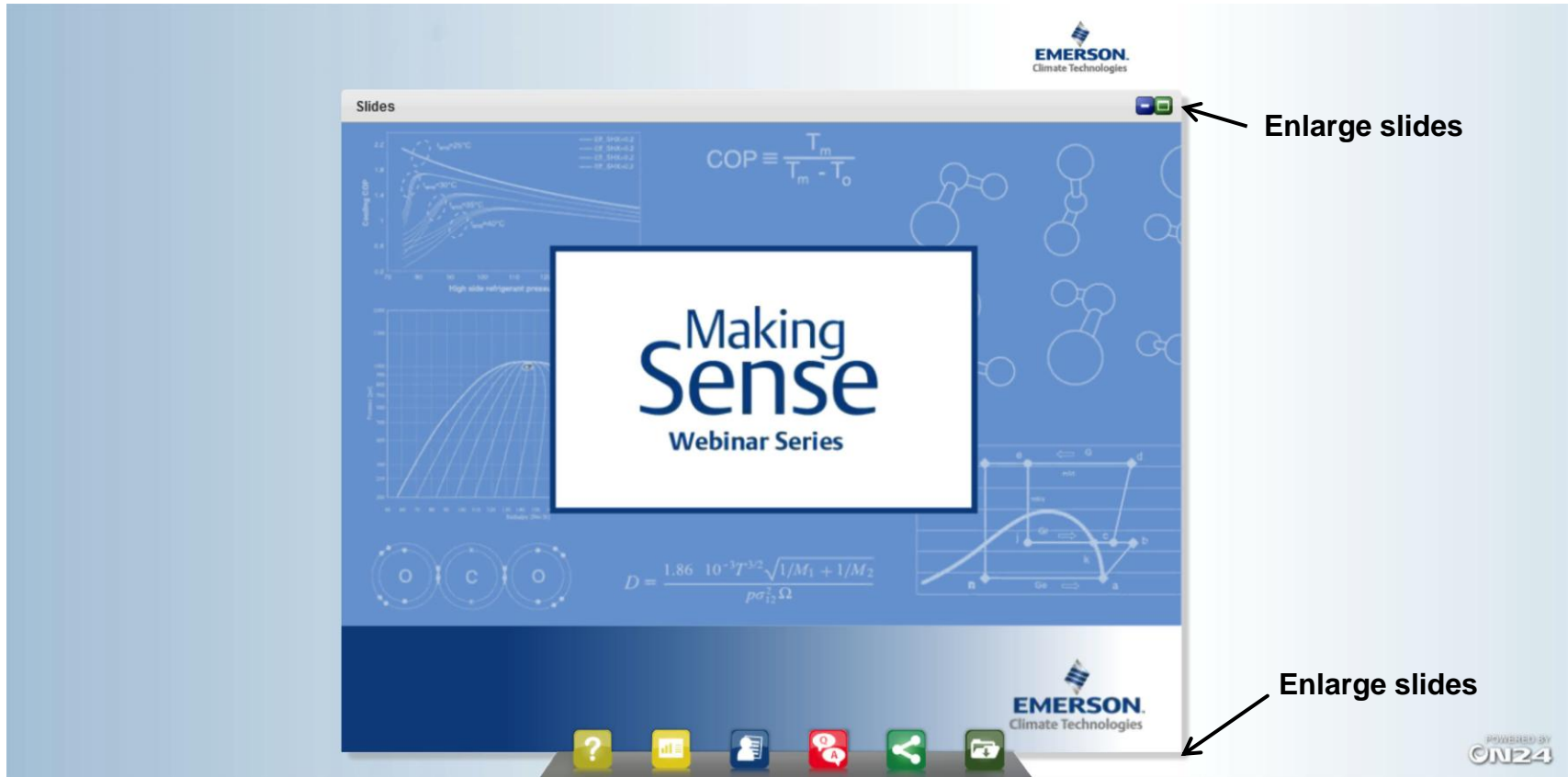
## Webinar Series



$$D = \frac{1.86 \cdot 10^{-3} T^{3/2} \sqrt{1/M_1 + 1/M_2}}{p \sigma_{12}^2 \Omega}$$



# Making Sense Webinars



Enlarge slides

Enlarge slides

Help

Minimize  
slide window

Bios

Q & A

Social  
media

Download  
PowerPoint

Making  
Sense

# Making Sense Webinars

## Emerson and Our Partners Giving Insight on the **Three Most Important Issues** in Refrigeration

We're Making Sense of the promising role of **new refrigerants**.

We're Making Sense of **energy reduction** technologies.

We're Making Sense of the application of electronics to improve **operational visibility**.



**The widespread deployment of cost-effective, energy-efficient refrigeration solutions using natural refrigerants is fast approaching.**

Emerson Climate Technologies invites you to interact with some of the refrigeration industry's most trusted and respected thought leaders on the emerging role of these groundbreaking natural and alternative refrigerants. Don't miss out through providing your name and contact information.

At AHR 2013, we're helping attendees MAKE SENSE of the issues that matter most. Check our website at [www.emersonclimate.com/conferences](http://www.emersonclimate.com/conferences) for presentation schedules and topics. Bring this card with you to one of our presentations and you'll be entered for a chance to win an Apple iPad!

> See what makes sense at the AHR Expo, booth #1605.

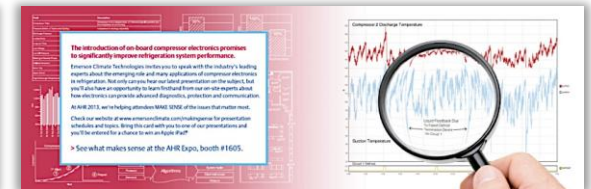


**Advanced energy reduction technologies are enabling us to create a new era of system and equipment optimization.**

Emerson Climate Technologies partners in research with the refrigeration industry's foremost innovators in energy reduction technologies. We will be bringing a presentation about how the improvements in equipment and system technologies are being utilized in today's refrigeration applications. The experts will be present through the event to answer any questions you have about these innovations — from the utilization of digital modulation and electronic expansion valves to the application of scroll and variable speed technologies.

At AHR 2013, we're helping attendees MAKE SENSE of the issues that matter most. Check our website at [www.emersonclimate.com/conferences](http://www.emersonclimate.com/conferences) for presentation schedules and topics. Bring this card with you to one of our presentations and you'll be entered for a chance to win an Apple iPad!

> See what makes sense at the AHR Expo, booth #1605.



**The introduction of on-board compressor electronics promises to significantly improve refrigeration system performance.**

Emerson Climate Technologies invites you to spend with the industry's leading experts about the strategic use and many applications of compressor electronics in refrigeration. Don't miss out through providing your name and contact information.

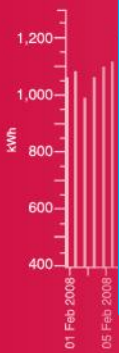
At AHR 2013, we're helping attendees MAKE SENSE of the issues that matter most. Check our website at [www.emersonclimate.com/conferences](http://www.emersonclimate.com/conferences) for presentation schedules and topics. Bring this card with you to one of our presentations and you'll be entered for a chance to win an Apple iPad!

> See what makes sense at the AHR Expo, booth #1605.

Fault	Description
Compressor Trips	Compressor is in a tripped state and the compressor is not running.
Pressure Switch or Thermostat Cycling	Compressor is running and cycling.
Discharge Pressure	Pressure is out of limits or cycling.
Locked Rotor	Low line voltage or locked rotor.
Long run Time	Indicative of low capacity.
Low Voltage	Low line voltage or voltage drop.
Low Oil Pressure	Low oil pressure.
Missing & Revers	Missing or reversing.
Welded Contact	Welded contact.
Motor Trip	Motor trip.
Open Circuit	Open circuit.
High Discharge T	High discharge temperature.

# Making Sense

of the application of electronics to improve **operational visibility.**



Fault	Description
Compressor Trips	Compressor is in a tripped state, but the compressor is not running.
Pressure Switch or Thermostat Cycling	Compressor is running and cycling.
Discharge Pressure	Pressure is out of limits or cycling.
Locked Rotor	Low line voltage or locked rotor.
Long run Time	Indicative of low capacity.
Low Voltage	Low line voltage or voltage drop.
Low Oil Pressure	Low oil pressure.
Missing & Revers	Missing & Revers.
Welded Contact	Welded Contact.
Motor Trip	Motor Trip.
Open Circuit	Open Circuit.
High Discharge T	High Discharge T.

# Best Practices for Evaluating Compressor System Performance

March 11, 2014



Presented By:

**Mike Saunders**

Director of End User Technical Sales and Support  
Emerson Climate Technologies

**Autumn Nicholson**

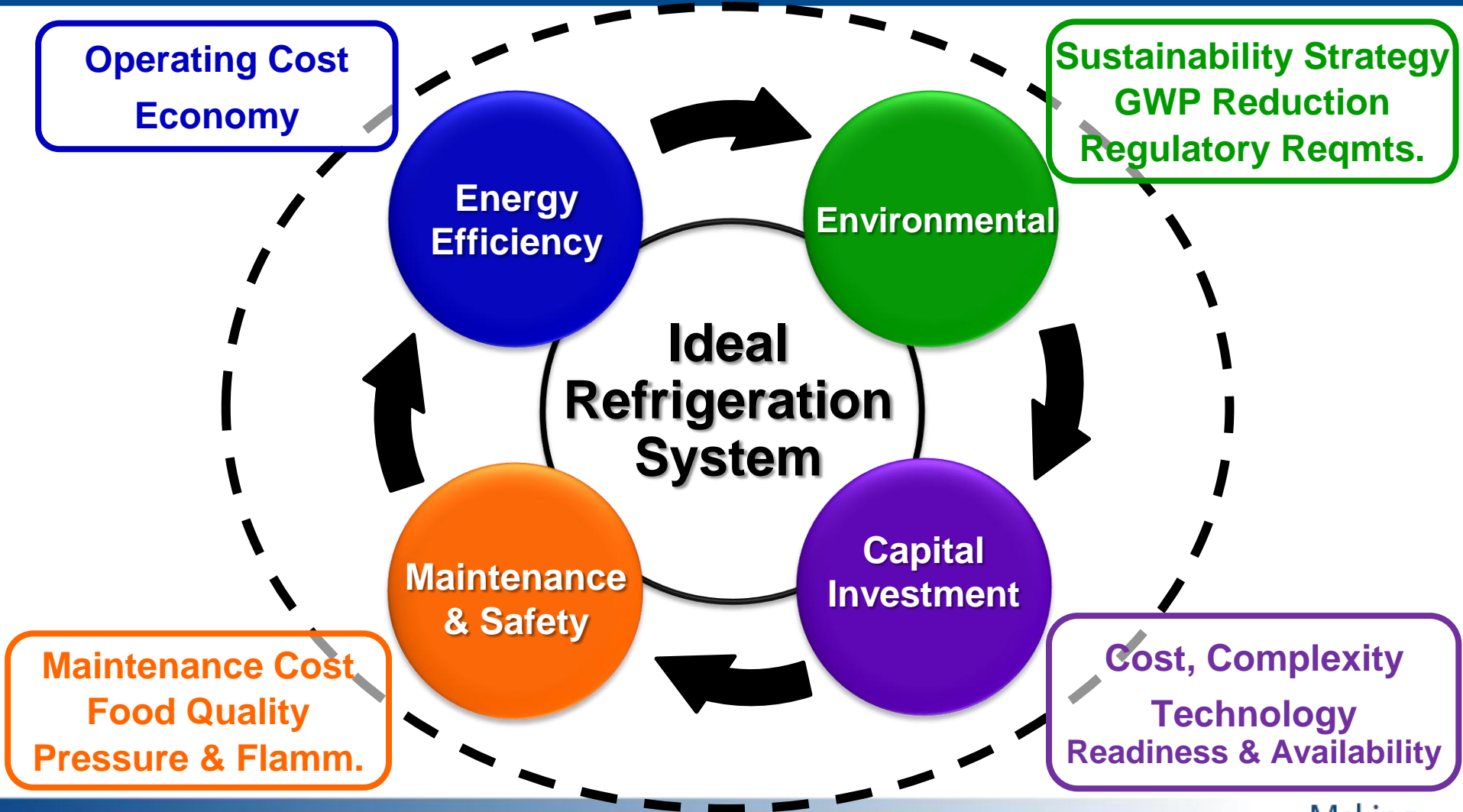
Senior Sales Engineer  
Emerson Climate Technologies

# Agenda

---

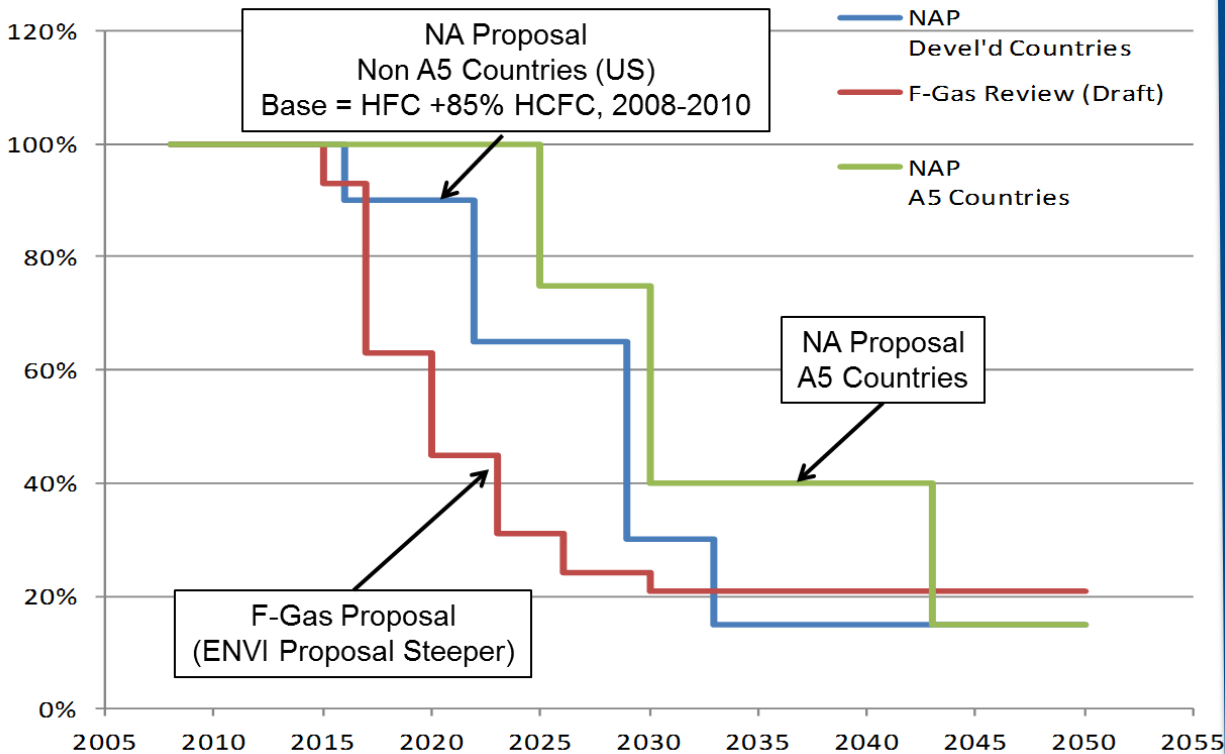
- **Background**
- **What's Important When Selecting Compressors?**
  - Mid-Point/Dew Point Differences
  - Evaporator vs. Compressor Capacity
  - Mechanical Subcooling and Vapor Injection
- **EER vs. AEER**
- **Annual Energy Analysis**

# Industry Market Drivers



What's Important, And How Can I Evaluate Options?

# HFC Phase-Down Proposals: North American Proposal (NAP) and European F-Gas



Will Potential Regulation Drive Me to More or Less Energy-Efficient Options?



# Lower GWP Refrigerant Landscape

## Options for New and Existing Applications

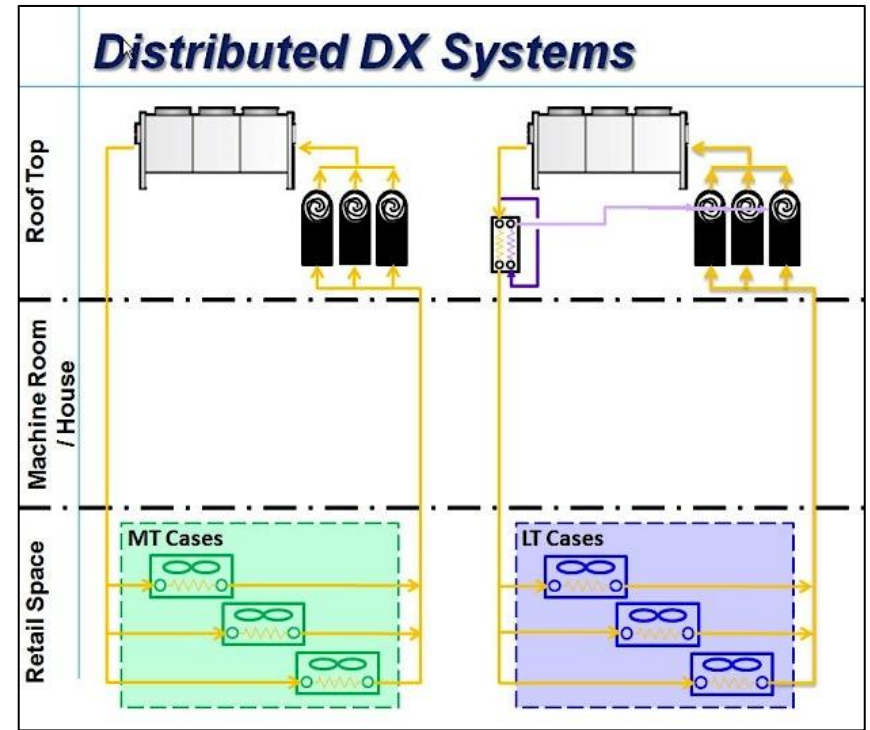
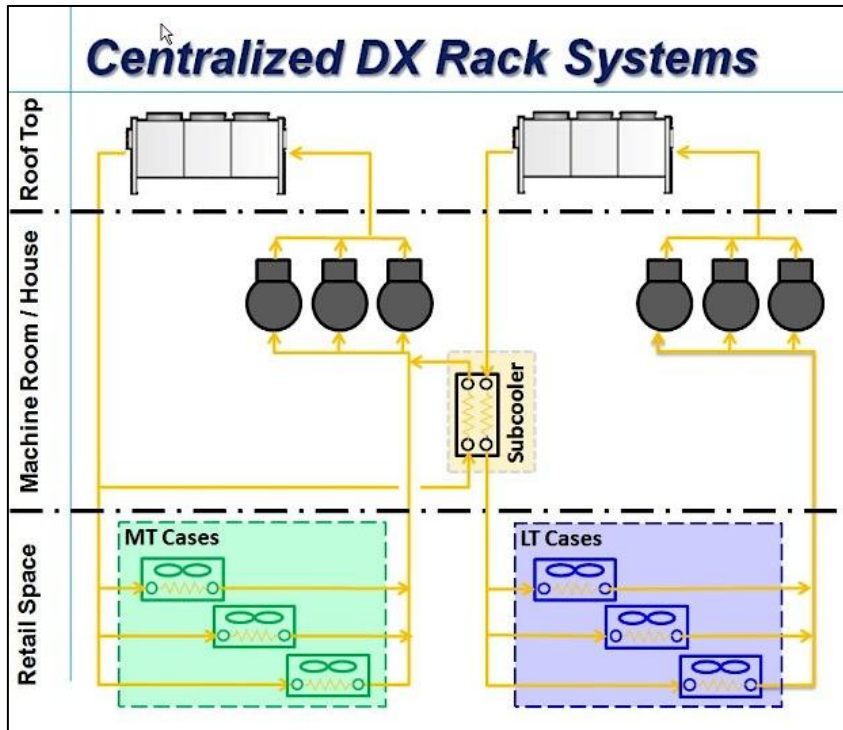


Refrigerant	GWP
R404A	3922
R407A	2107
R407F	1825
R134a	1430
R410A	2088
N40	<1500
XP40	<1500
XP10	<600
N13	<600
L40	<300
DR7	<300
R1234yf	<4
Propane	3
CO <sub>2</sub>	1

Which Refrigerant Is Right For Me?

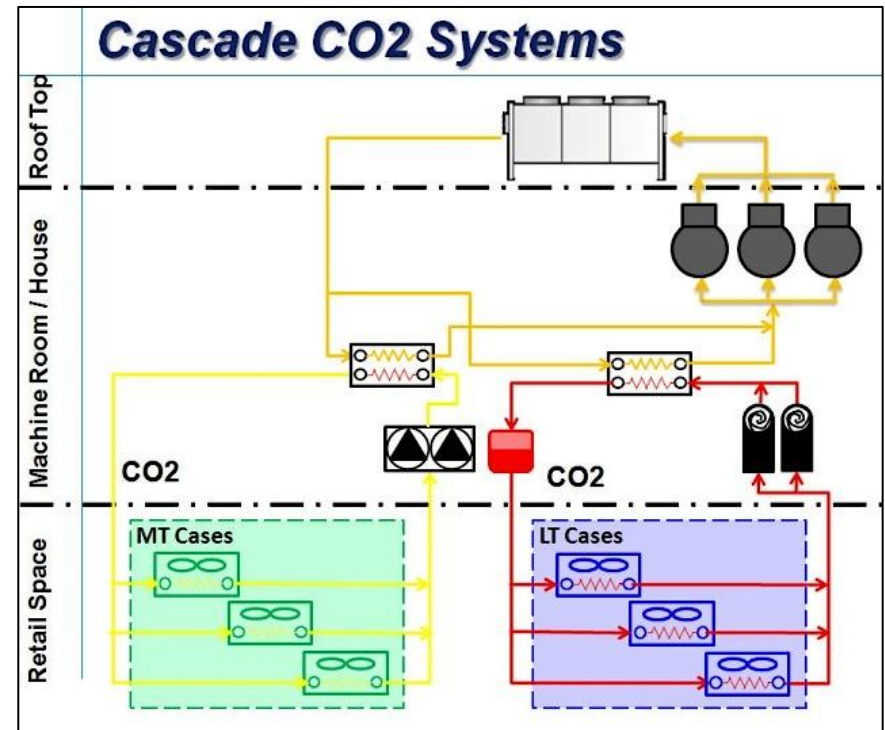
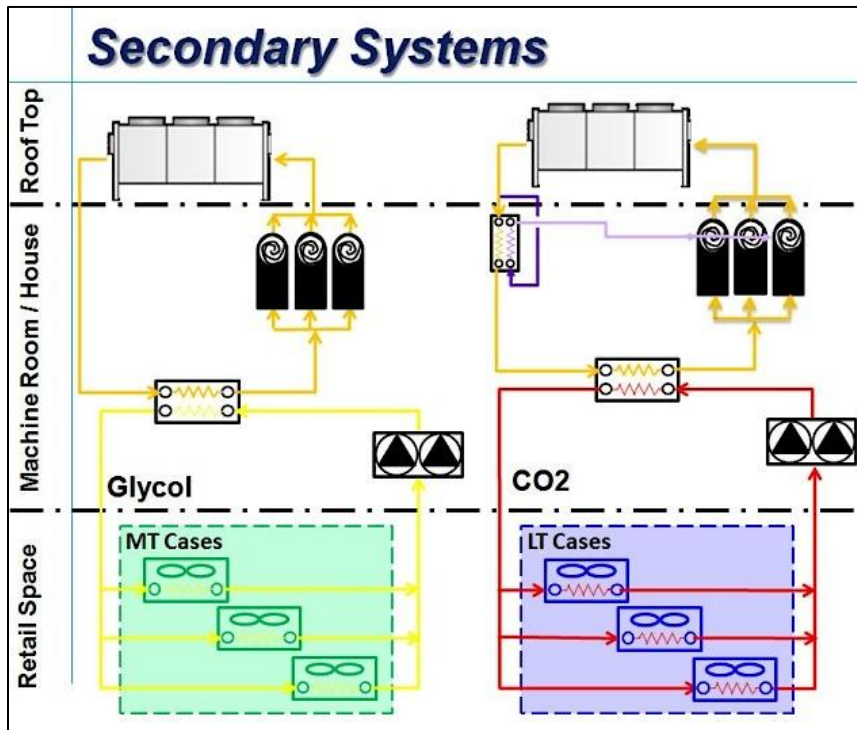
# Increasing Variations in System Architectures

## Traditional Direct Expansion

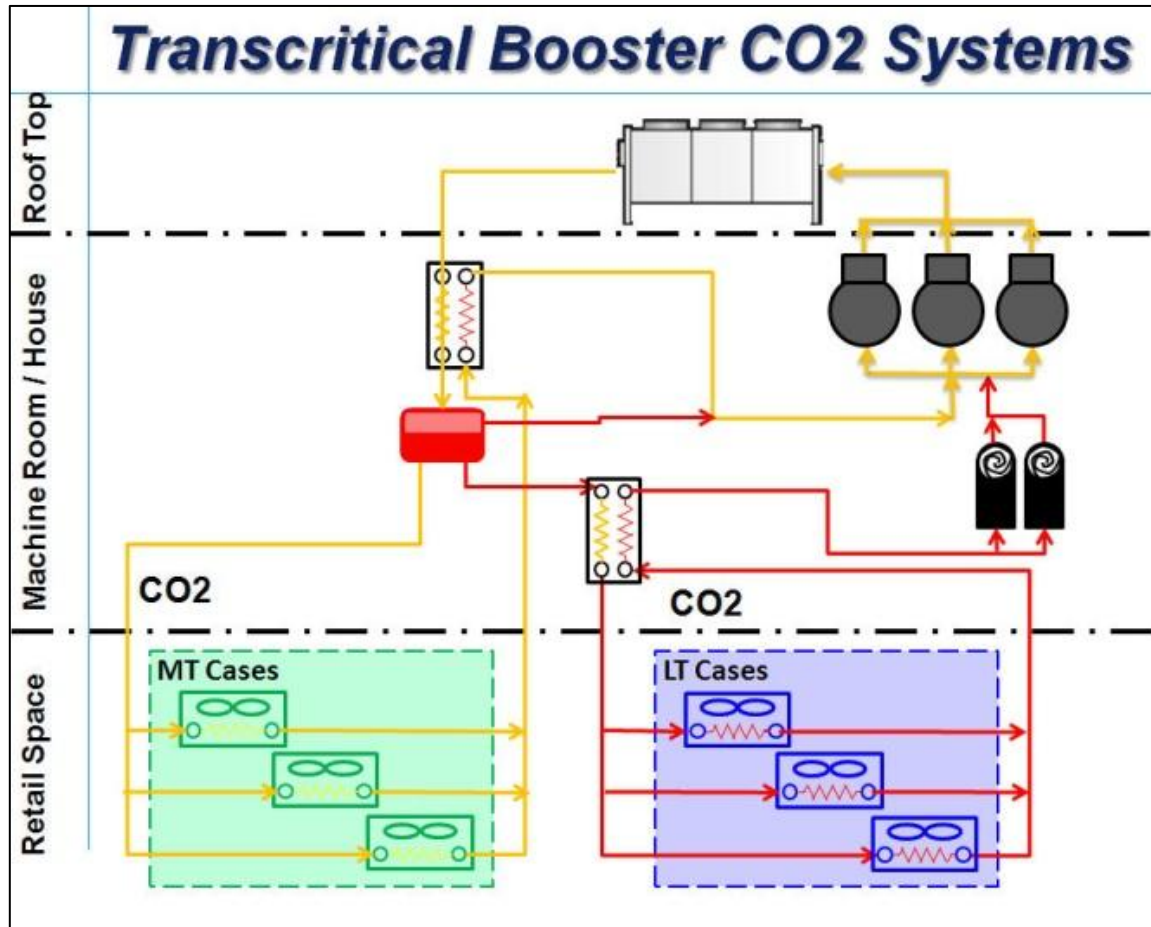


# Increasing Variations in System Architectures

## Increasingly Complex Systems



# Increasing Variations in System Architectures



System Choices And Complexity Are Increasing

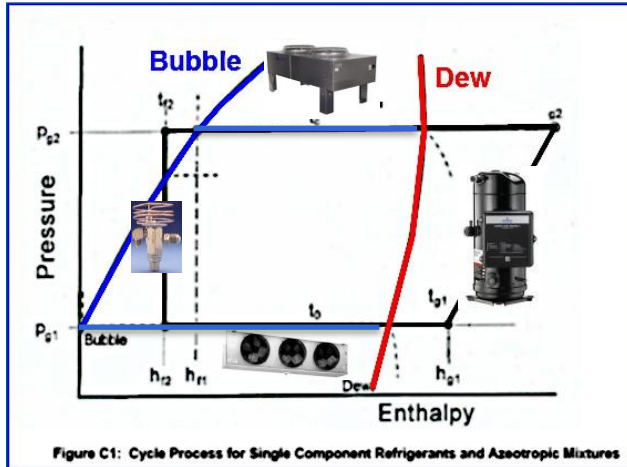
# Agenda

---

- Background
- **What's Important When Selecting Compressors?**
  - Mid Pt/Dew Pt Differences
  - Evaporator Vs Compressor Capacity
  - Mechanical Subcooling and Vapor Injection
- EER vs AEER
- Annual Energy Analysis

# Mid-Point vs. Dew Point

Azeotropic / No Glide



## ■ Per AHRI Standards, Compressors Are Rated Based on Dew Point Pressure/ Temperatures

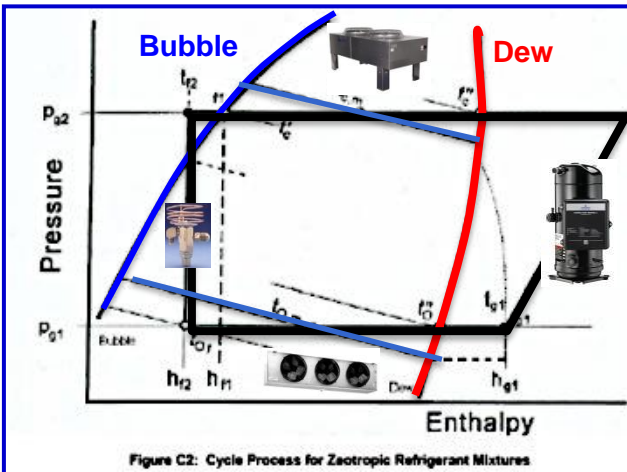
- When there is no glide and assuming little/no pressure drop, the temperature at mid-point equals temperature at dew point

- Mid-Point = Average Coil Temperature

- $T_{\downarrow mid, cond} = T_{\downarrow dew, cond} + T_{\downarrow bubble, cond} / 2$

- $T_{\downarrow mid, evap} = T_{\downarrow evap, in} + T_{\downarrow evap, out} / 2$

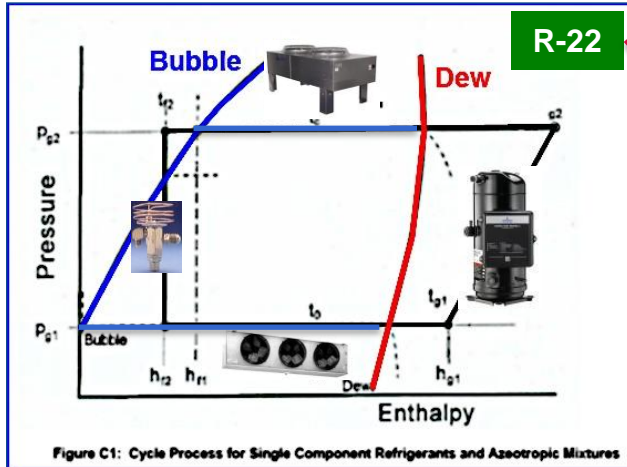
Zeotropic / Glide



<http://www.emersonclimate.com/makingsensewebinars>

# Example: R-22 vs. R-407A Compressor Performance

Azeotropic / No Glide



Mid/Dew Point Conversion

Engineering Units  
 English  Metric

User Conditions  
 Dew Point  Mid Point

Refrigerant: R-22

Mid Point Conditions  
 Evap. Temp. (°F): 20.00  
 Cond. Temp. (°F): 105

Subcooling (F) 0.00  
 Liquid Temp. (°F) 50.00

Dew Point Conditions  
 Evap. Temp. (°F): 20.00  
 Cond. Temp. (°F): 105.00

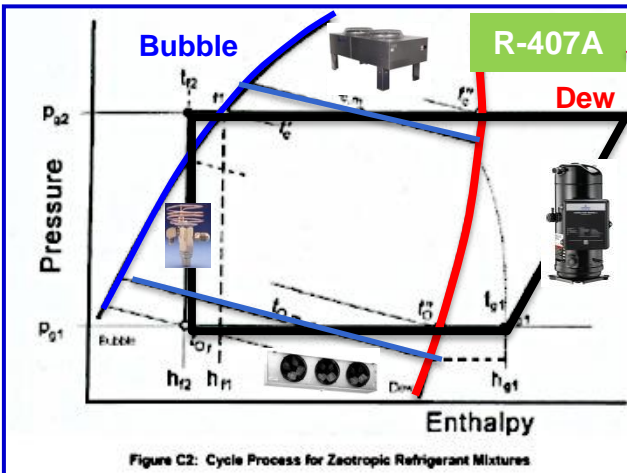
Bubble Pt. Temp. (°F): 105.00  
 Liquid Temp. (°F): 105.00

Calculate

**R-22: 20/105°F**

Compressor Capacity (Btu/hr):  
**48,400**  
 Power (W):  
**4,560**  
 Compressor EER ( Btu/Whr):  
**10.61**

Zeotropic / Glide



Mid/Dew Point Conversion

Engineering Units  
 English  Metric

User Conditions  
 Dew Point  Mid Point

Refrigerant: R-407A

Mid Point Conditions  
 Evap. Temp. (°F): 20.00  
 Cond. Temp. (°F): 105

Subcooling (F) 0.00  
 Liquid Temp. (°F) 50.00

Dew Point Conditions  
 Evap. Temp. (°F): 23.64  
 Cond. Temp. (°F): 108.94

Bubble Pt. Temp. (°F): 101.07  
 Liquid Temp. (°F): 101.07

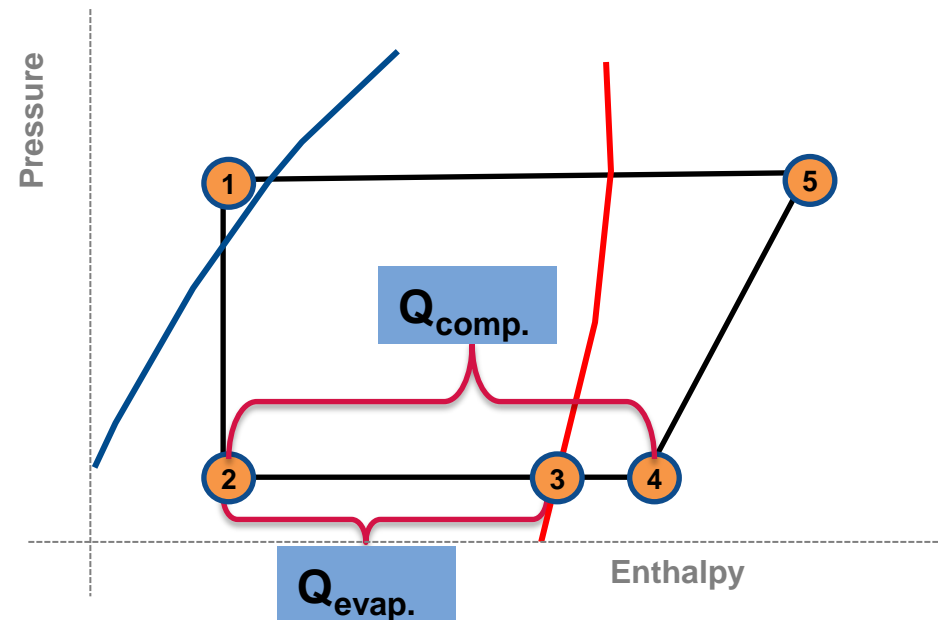
Calculate

**R-407A: 24/109°F**

Compressor Capacity (Btu/hr):  
**50,500**  
 Power (W):  
**5,050**  
 Compressor EER (Btu/Whr):  
**10.00**

# Evaporator Capacity vs. Compressor Capacity

- Evaporator capacity or Net Refrigeration Effect (NRE) is the available effective cooling generated from the system
- Compressor capacity is the cooling capacity generated from the evaporator capacity as well as the heat gained in the line between the exit of the evaporator to suction of the compressor





# Evaporator Capacity vs. Compressor Capacity

- $\dot{Q} = \dot{m}(h_{out,vap} - h_{in,liq})$
- When compressor superheat\* is increased,  $h_{out,vap} \uparrow$ ,  $\dot{m} \downarrow$   
compressor capacity increases and evaporator capacity decreases
- When compressor superheat decreases,  $h_{out,vap} \downarrow$ ,  $\dot{m} \uparrow$   
compressor capacity decreases and evaporator capacity increases





Traditionally, Compressor Selections Are Based on 65°F Return Gas and Compressor Capacity at Dew Point With Enough “Safety Factor” to Ensure There Is Adequate Net Refrigeration Effect for the Required Load

*\*Compressor Superheat (SH) is often considered in terms of Compressor Return Gas Temperature (RGT) where  $RGT = \text{Evap. Temp.} + SH$*

# Example: Capacity at Design vs. Application

- Required Load: 40,000 Btu/hr
- Design Condition: R-407A, +20/105/65RG/0SC/10eSH °F

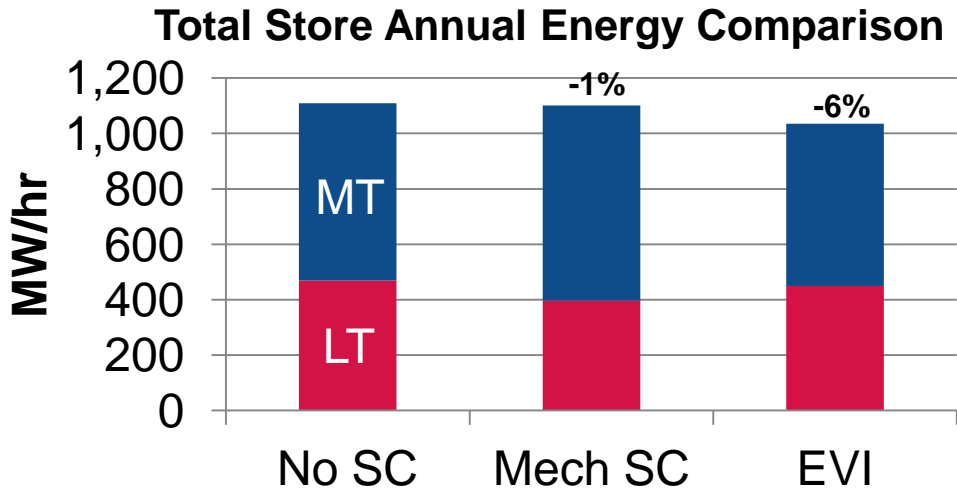
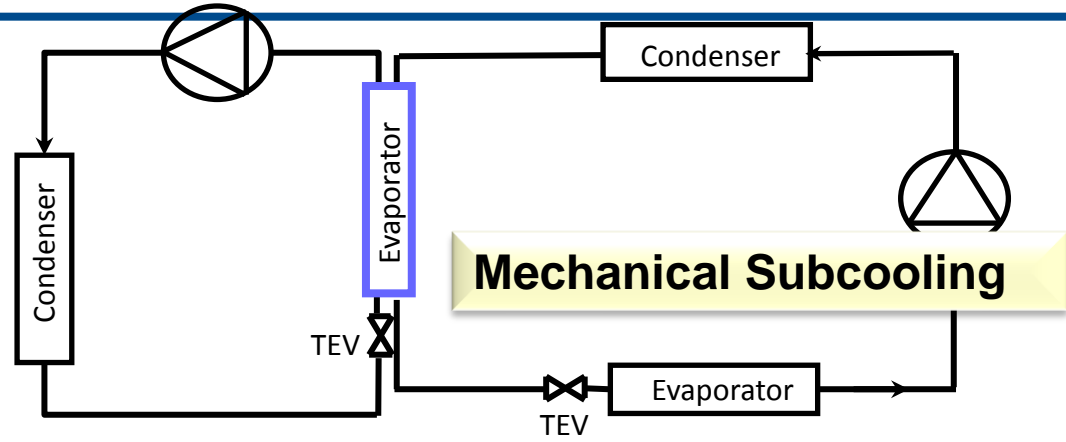
Model	HP	Compressor Capacity (Btu/hr)	Compressor EER (Btu/Wh)	Evaporator Capacity (Btu/hr)	Evaporator EER (Btu/Wh)	Total Req'd Load (%)	Cond. Heat Rejection (Btu/hr)
ZB45KCE-TFD	6.00	47,800	10.04	42,700	8.97	119.5	64,046

Condition 407A, ZB45KCE-TFD 20/105/65RG/10eSH °F	Comp. Cap. (MBH)	Vs. Design Load	Evap. Cap. (MBH)	Vs. Design Load
Dew Point Design	47.8	119%	42.7	107%
Mid-Point Design	50.5 	126%	45.3 	113%
45RG/10eSH (Lower RG)	49.6 	124%	47.7 	119%
ZB38KCE-TFD (Smaller Comp)	43.3	108%	41.6	104%

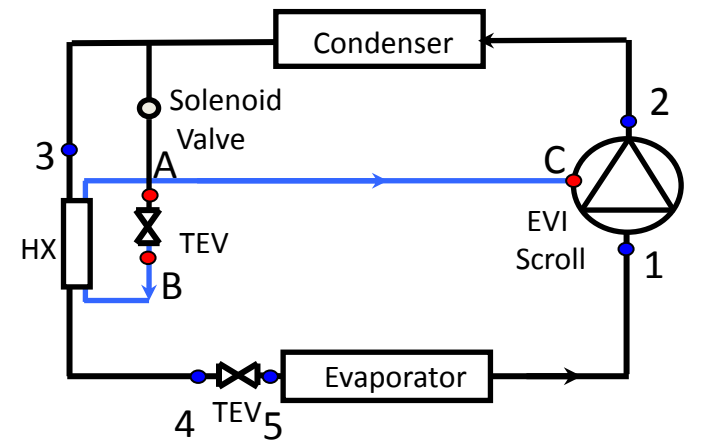
# Subcooling

**Mechanical SC System:**  
 $Q_{LT} = \text{LT Case Load}$   
 $Q_{MT} = \text{MT Case Load} + \text{SC Load}$

**EVI System**  
 $Q_{LT} = \text{LT Case Load}$   
 $Q_{MT} = \text{MT Case Load} + \text{SC Load}$



Assumes LT: 300MBH, MT: 900MBH in Atlanta, GA



**“Self” Subcooling With EVI**

# Agenda

---

- Background
- What's Important When Selecting Compressors?
  - Mid Pt/Dew Pt Differences
  - Evaporator Vs Compressor Capacity
  - Mechanical Subcooling and Vapor Injection
- **EER vs AEER**
- **Annual Energy Analysis**

# EER vs. AEER

- **EER (Energy Efficiency Ratio) is the measure of compressor efficiency at a single rating condition found by dividing the capacity by input power at that rating condition**
  - Often, the rating condition is based on design for “worst case” condition for the system/location
- **AEER (Annual Energy Efficiency Ratio) is a weighted average performance for a refrigeration system, using varying condensing temperatures tied to the actual weather data for a location**

# EER vs. AEER Example: Atlanta, Georgia

## Design Ambient

2013 ASHRAE Handbook - Fundamentals (IP) © 2013 ASHRAE, Inc.

ATLANTA MUNICIPAL, GA, USA WMO#: 722190

Lat: 33.64N Long: 84.43W Elev: 1027 StP: 14.16 Time Zone: -5 (NAE) Period: 86-10 WBAN: 13874

**Annual Heating and Humidification Design Conditions**

Coldest Month	Heating DB		Humidification DP/MCDB and HR				Coldest month WSMCDB				MCWS/PCWD to 99.6% DB			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
(a) 1	(b) 21.5	(c) 26.4	(d) 4.2	(e) 7.1	(f) 28.6	(g) 9.1	(h) 9.1	(i) 32.2	(j) 24.9	(k) 39.9	(l) 23.5	(m) 40.0	(n) 11.9	(o) 320

**Annual Cooling, Dehumidification, and Enthalpy Design Conditions**

Hottest Month	Cooling DB/MCWB		Evaporation WB/MCDB				MCWS/PCWD to 0.4% DB								
	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD					
(a) 7	(b) 17.0	(c) 93.9	(d) 74.2	(e) 91.7	(f) 73.9	(g) 89.8	(h) 73.5	(i) 77.3	(j) 88.5	(k) 76.4	(l) 86.7	(m) 75.4	(n) 85.0	(o) 8.7	(p) 300

**Extreme Annual Design Conditions**

Extreme Annual WS		Extreme Max WB		Extreme Annual DB		n-Year Return Period Values of Extreme DB	
1%	2.5%	5%	Max	Mean	Standard deviation	n=5 years	n=50 years
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
21.5	19.0	17.1	82.4	14.1	96.7	4.4	3.3

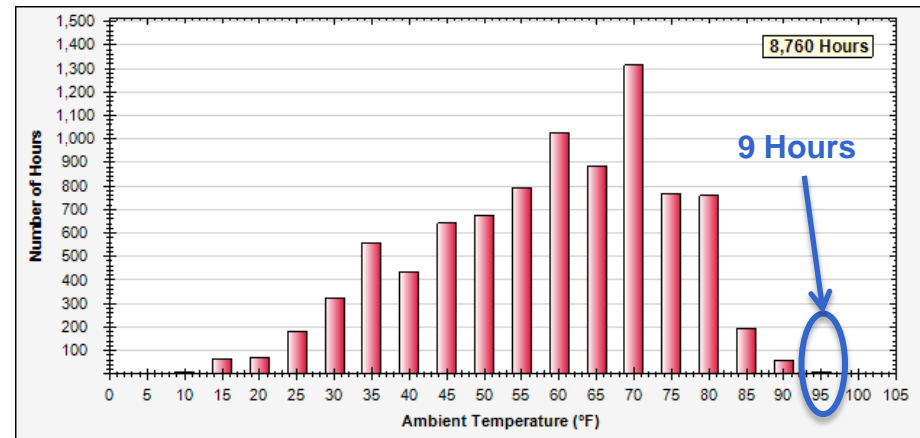


**Extreme Annual Design Conditions**

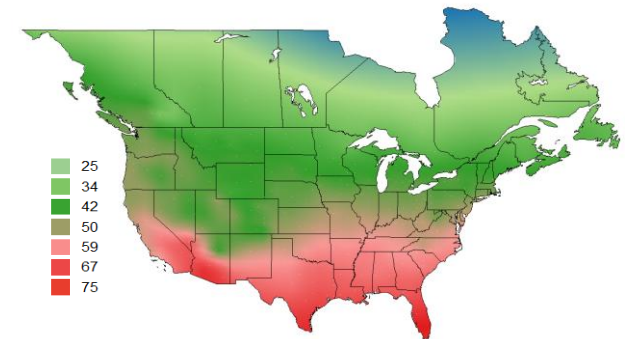
Extreme Annual WS			Extreme Max WB	Extreme Annual DB			
1%	2.5%	5%		Mean	Standard deviation	Min	Max
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
21.5	19.0	17.1	82.4	14.1	96.7	4.4	3.3

2013 ASHRAE Handbook Fundamentals (IP)

## Annual Ambient



Weather Data Based on Typical Metrological Year (National Solar Radiation Database, Years: 1961 – 1990).



<https://www.ashrae.org/news/2014/revisions-to-climate-data-standard-from-ashrae-include-new-climate-zone-climatic-data>

# Estimated kWh/yr for 15MBH Design R-404A, +20/112/40RG/0SC/10eSH °F

## ▪ EER

Results	
Compressor Capacity (Btu/hr):	15,950
Net Refrigeration Effect (Btu/hr):	15,150
Power (W):	2,050
Compressor EER (Btu/Wh):	7.78
Evaporator EER (Btu/Wh):	7.39

## ▪ AEER

Output			
Annual (Hours):	8,760	Annual Energy Used by Primary Comp. (kWh):	9,445
Evap. Capacity (Btu/hr):	15,150	Annual Energy Used by Mech. Subcooling Comp. (kWh):	0
Evap. Capacity Over Design (%):	1.0	Annual Energy Used by Evap. Fan (kWh):	0
Overall AEER (Btu/Wh):	13.91	Annual Energy Used by Cond. Fan (kWh):	0
Design Point			
System Capacity (Btu/hr):	15,150	Total Annual Energy Used (kWh):	9,445
System EER (Btu/Wh):	7.39	Total Annual Energy Cost (\$):	756
Cond. Heat Rejection (Btu/hr):	22,947		

- Atlanta, GA
- Fixed Load
- Min. Cond 70°F
- Evaporator Based

# Emerson Product Selection Software Annual Energy Analysis

**Design Conditions**

Refrigerant: R-407A Temp Range: Low Temp.

Dew Point  Mid Point

Evap. Temp. (°F): -22.0 Compressors: Copeland

Cond. Temp. (°F): 105.0 Vapor Injected Compressor(s):  Yes  No

Minimum Cond. Temp. (°F): 50.0

Evap. Superheat (°F): 5

Const. Return Gas Temp. (°F)  Const. Compressor Superheat (°F)

Return Gas Temp. (°F): 40

**Required Load Basis**

Evaporator  Compressor

130,000 148,148

**Load Profile**

Fixed  Variable

Simple  Advanced

**Basis: Bin Analysis**

Mid Point  Even

**Liquid Subcooling**

Required:  Yes  No

Constant Liquid Temp.

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

**Energy**

Rate (\$/kWh): 0.08

**Heat Sink**

Variable  Constant

Condenser-Ambient  $\Delta T$  (°F): 10

**Fan**

Evaporator (W): 0  Include  Exclude

Condenser (W): 0  Include  Exclude

**Buttons:** Analysis >> Report Save As Load Reset Close

**Note:** Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.



# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Design Conditions

Refrigerant: R-407A

Temp Range: Low T

Required Load Basis: Compressor 148,148

Dew Point  Mid Point

Evap. Temp. (°F): -22.0

Cond. Temp. (°F): 105.0

Minimum Cond. Temp. (°F): 50.0

Evap. Superheat (°F): 5

Const. Return Gas Temp. (°F)  Const. Compressor Superheat (°F)

Return Gas Temp. (°F): 40

Liquid Subcooling

Required:  Yes  No

Constant Liquid Temp.

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

Energy Rate (\$/kWh): 0.08

Heat Sink

Variable  Constant

Condenser-Ambient  $\Delta T$  (°F): 10

Fan

Evaporator (W): 0  Include  Exclude

Condenser (W): 0  Include  Exclude

Analysis >> Report Save As Load Reset Close

Select "Mid-Point" for Refrigerants With High Glide (>2°F)

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Design Conditions

Refrigerant: R-407A

Temp Range: Low Temp.

Dew Point  Mid Point

Evap. Temp. (°F): -22.0

Cond. Temp. (°F): 105.0

Minimum Cond. Temp. (°F): 50.0

Evap. Superheat (°F): 5

Const. Return Gas Temp. (°F)  Const. Compressor Superheat (°F)

Return Gas Temp. (°F): 40

Compressors: Copeland

Vapor Injected Compressor(s):  Yes  No

Required Load Basis

Evaporator  Compressor

130,000 148,148

Load Profile

Fixed  Variable

Simple  Advanced

Basis: Bin Analysis

Mid Point  Even

Liquid Subcooling

Required:  Yes  No

Constant Liquid Temp.

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

Energy Rate (\$/kWh): 0.08

Heat Sink

Variable  Constant

Condenser-Ambient  $\Delta T$  (°F): 10

Fan

Evaporator (W): 0  Include  Exclude

Condenser (W): 0  Include  Exclude

Analysis >> Report Save As Load Reset Close

Required Load Basis,  
Matches Compressors  
Based on Evaporator or  
Compressor Capacity

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Design Conditions

Refrigerant: R-407A

Temp Range: Low Temp.

Required Load Basis:  Evaporator 130,000  Compressor 148,148

Dew Point  Mid Point

Evap. Temp. (°F): -22.0

Cond. Temp. (°F): 105.0

Compressors: Copeland

Minimum Cond. Temp. (°F): 50.0

Evap. Superheat (°F): 5

Load Profile:  Variable  Advanced

Const. Return Gas Temp. (°F)  Const. Compressor Superheat (°F)

Return Gas Temp. (°F): 40

Basis: Bin Analysis  Mid Point  Even

Liquid Subcooling

Required:  Yes  No

Constant Liquid Temp.

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

Energy Rate (\$/kWh): 0.08

Heat Sink:  Variable  Constant

Condenser-Ambient  $\Delta T$  (°F): 10

Fan: Evaporator (W): 0  Include  Exclude

Condenser (W): 0  Include  Exclude

Analysis >> Report Save As Load Reset Close

**Minimum Condensing Temperature**

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

Design Conditions

Refrigerant: R-407A

Temp Range: Low Temp.

Required Load Basis

Evaporator: 130,000

Compressor: 148,148

Load Profile

Fixed

Vapor Injected Compressor(s)

Yes

Liquid Subcooling

Required: Yes

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

Energy Rate (\$/kWh): 0.08

Fan

Evaporator (W): 0

Condenser (W): 0

Analysis >> Report Save As Load Reset Close

Select Vapor Injected Compressor(s) When Using EVI Scrolls for Subcooling

Or Indicate Mechanical Subcooling and Required Liquid Temperature Here

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Design Conditions

Refrigerant: R-407A

Temp Range: Low Temp.

Required Load Basis: Evaporator (130,000) Compressor (148,148)

Load Profile: Fixed (selected) Variable Simple Advanced

Basis: Bin Analysis: Mid Point Even

Liquid Subcooling: Required: Yes No Constant Liquid Temp. Condenser Subcooling (F): 0.0 Natural Subcooling (F): 0.0 Economizer Subcooling (F): 51.0 Total Subcooling (F): 51.0 Liquid Temp. (°F): 50.0

Heat Sink: Variable Constant Condenser-Ambient  $\Delta T$

Fan: Evaporator (W): 0 Condenser (W): 0

Energy Rate (\$/kWh): 0.08

Analysis >> Report Save As Load Reset

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can perform Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

Modify Load Profile

Variable Load Profile for Low Temperature Applications

Ambient Air Temperature (°F)	Fraction of Design Load
0	0.8
40	0.8
80	1.0
140	1.0

Source: Oak Ridge National Laboratory.

# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Design Conditions

Refrigerant: R-407A

Temp Range: Low Temp.

Dew Point  Mid Point

Evap. Temp. (°F): -22.0

Cond. Temp. (°F): 105.0

Minimum Cond. Temp. (°F): 50.0

Evap. Superheat (°F): 5

Const. Return Gas Temp. (°F)  Const. Compressor Superheat (°F)

Return Gas Temp. (°F): 40

Compressors: Copeland

Vapor Injected Compressor(s):  Yes  No

Required Load Basis

Evaporator  Compressor

130,000 148,148

Load Profile

Fixed  Variable

Simple  Advanced

Basis: Bin Analysis

Mid Point  Even

Liquid Subcooling

Required:  Yes  No

Constant Liquid Temp.

Condenser Subcooling (F): 0.0

Natural Subcooling (F): 0.0

Economizer Subcooling (F): 51.0

Total Subcooling (F): 51.0

Liquid Temp. (°F): 50.0

Energy Rate (\$/kWh): 0.08

Heat Sink

Variable  Constant

Condenser-Ambient  $\Delta T$  (°F): 10

Fan

Evaporator (W): 0  Include  Exclude

Condenser (W): 0  Include  Exclude

Analysis >> Report Save As Load Reset Close

Adjust Condenser-Ambient TD

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

The screenshot shows the 'Weather' tab selected in the software interface. The interface is divided into several sections for configuring design parameters:

- Design Conditions:** Includes fields for Refrigerant (R-407A), Temp Range (Low Temp.), Evap. Temp. (-22.0), Cond. Temp. (105.0), Minimum Cond. Temp. (50.0), Evap. Superheat (5), and Return Gas Temp. (40).
- Required Load Basis:** Includes Evaporator (130,000) and Compressor (148,148) load values.
- Load Profile:** Includes options for Fixed (selected) or Variable, Simple or Advanced, and Basis: Bin Analysis (Mid Point or Even).
- Liquid Subcooling:** Includes options for Required (Yes/No) and Constant Liquid Temp. (selected), with fields for Condenser Subcooling (0.0), Natural Subcooling (0.0), Economizer Subcooling (51.0), Total Subcooling (51.0), and Liquid Temp. (50.0).
- Heat Sink:** Includes options for Variable (selected) or Constant, and Condenser-Ambient  $\Delta T$  (10).
- Fan:** Includes options for Evaporator (W) and Condenser (W) to be included or excluded.

At the bottom, there are buttons for Analysis >>, Report, Save As, Load, Reset, and Close.

Choose Weather Data Here

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

# Emerson Product Selection Software Annual Energy Analysis

Design Weather Project

Weather City

Country: USA Latitude: 84 1W  
State: OH Longitude: 39 54N  
City: Dayton Min. Temp. (°F): -5  
Max. Temp. (°F): 91

Analysis Period


Full Year  Partial Year

Start Date (MM/DD): Jan 1  
End Date (MM/DD): Dec 31

Time Frame

24 Hr/Day  User Defined

Start: 00 AM  
End: 00 PM

 **Analysis >>** Report Save As Load Reset Close

Note: Choose Save button after entering Project Information, Selection of Weather City and specifications of Design Parameters. Next, choose Close button to close Project Details Window. Next, select Analysis from Main Screen to perform Annual Energy Calculations. You can proceed directly to Annual Energy Analysis without saving Project Details contents by selecting Analysis button.

After Project Details Are Finalized, Click "Analysis"



# Emerson Product Selection Software Annual Energy Analysis

Product Selection Software - [PSSProject]

File Options View Tools Windows Help

Search Box - Compressors

Compressor Selection : Step 1 Heat Exchanger : Step 1.1 Modulation Steps : Step 2

Results

Model	Refrig.	HP	Compressor Capacity (Btu/hr)	Compressor EER (Btu/Wh)	Evaporator Capacity (Btu/hr)	Evaporator EER (Btu/Wh)	Return Gas Temp. (°F)	Total Subcooling (F)	Volts	Ph.	Hz	Current (Amps)	RLA (MCC/1.4) (Amps)	LRA (Amps)	Total Req'd Load (%)	Cond. Heat Rejection (Btu/hr)	Subcooling Capacity (Btu/hr)	Comp. A.EER (Btu/Wh)	Modulation	Notes
ZF13KVE-TFD	R-407A	NA	16,900	5.58	14,900	4.92	40.0	51.0	460	3	60	5.30	8.9	62.0	13	27,241	3,750	16.55	EVI	--
ZF18KVE-TFD	R-407A	NA	25,000	5.77	22,000	5.08	40.0	51.0	460	3	60	7.20	9.4	70.0	19.2	39,778	5,542	17.13	EVI	--
ZF25KVE-TFD	R-407A	7.50	31,100	5.98	27,200	5.23	40.0	51.0	460	3	60	8.20	11.9	99.0	23.9	48,848	6,873	17.67	EVI	--
ZF34KSE-TFD	R-407A	NA	41,500	6.20	36,400	5.44	40.0	51.0	460	3	60	12.90	16.4	100.0	31.9	64,333	9,183	18.06	EVI	--
ZF41KSE-TFD	R-407A	NA	51,600	6.20	45,300	5.44	40.0	51.0	460	3	60	15.95	17.9	125.0	39.7	79,996	11,414	18.05	EVI	--
ZF49KSE-TFD	R-407A	NA	61,900	6.23	54,300	5.47	40.0	51.0	460	3	60	16.15	20.0	139.0	47.6	95,791	13,696	18.14	EVI	--
ZFD13KVE-TFD	R-407A	NA	16,900	5.58	14,900	4.92	40.0	51.0	460	3	60	5.30	8.9	62.0	13	27,241	3,750	16.55	EVI + Digital	--
ZFD18KVE-TFD	R-407A	NA	25,000	5.77	22,000	5.08	40.0	51.0	460	3	60	7.20	9.4	70.0	19.2	39,778	5,542	17.13	EVI + Digital	--
ZFD25KVE-TFD	R-407A	NA	31,100	5.98	27,200	5.23	40.0	51.0	460	3	60	8.20	11.9	99.0	23.9	48,848	6,873	17.67	EVI + Digital	--

1 of 9 Ready Reset Print [Click here to view Search Window](#)

+ Add Remove Save As Reset Project Details Ventil. Air Comp. Sel. Report

Compressors for AER Calculation

Qty.	Capacity Step Up	Capacity Step Down	Model	HP	Compressor Capacity (Btu/hr)	Compressor EER (Btu/Wh)	Evaporator Capacity (Btu/hr)	Evaporator EER (Btu/Wh)	Total Req'd Load (%)	Cond. Heat Rejection (Btu/hr)	Subcooling Capacity (Btu/hr)	Comp. A.EER (Btu/Wh)	Volts	Ph.	Hz	Current (Amps)	RLA MCC/1.4) (Amps)	LRA (Amps)	Modulation	Notes	Application
1	↑	↓	ZFD25KVE-TFD	NA	31,100	5.98	27,200	5.23	20.9	48,848	6,873	17.67	460	3	60	8.20	11.9	99.0	EVI + Digital	--	Low Temp, Econo
1	↑	↓	ZF18KVE-TFD	NA	25,000	5.77	22,000	5.08	16.9	39,778	5,542	17.13	460	3	60	7.20	9.4	70.0	EVI	--	Low Temp, Econo
1	↑	↓	ZF34KSE-TFD	NA	41,500	6.20	36,400	5.44	28.0	64,333	9,183	18.06	460	3	60	12.90	16.4	100.0	EVI	--	Low Temp, Econo
1	↑	↓	ZF41KSE-TFD	NA	51,600	6.20	45,300	5.44	34.8	79,996	11,414	18.05	460	3	60	15.95	17.9	125.0	EVI	--	Low Temp, Econo
4			<b>Total</b>		<b>149,200</b>	<b>6.08</b>	<b>130,900</b>	<b>5.33</b>	<b>100.7</b>	<b>232,955</b>	<b>33,012</b>										

Note: Right mouse click selected compressor from list to view: Specific Point or Full Matrix Performances, Operating Envelope, Estimate Electrical Current, Cond. Heat Rejection, Annual EER, Drawing, Wiring Diagram, BOM, System Report & Mech. Room Ventil. Air.

Date: February 17, 2014 Engineering Units: English Version: 1.0.40 (6) Days Remaining for Next Update: 72 Database Version: January 30, 2014

Select Compressors,  
Then Click "Modulation  
Steps"

# Emerson Product Selection Software Annual Energy Analysis

Product Selection Software - [PSSProject]

File Options View Tools Windows Help

Search Box - Compressors

Compressor Selection : Step 1 Heat Exchanger : Step 1.1 Modulation Steps : Step 2 Overall AEER : Step 3 Summary - Annual Analysis : Step 4 Compressor - Info : Step 5

From "Modulation Steps", Select "Overall AEER"

NA Contact: NA Location: Dayton, OH (USA)

Refrigerant: R-407A Annual (Hours): 8,760 Liquid Temp. (°F): 50.0  
 Dew Point Mid Point Return Gas Temp. (°F): 40 Economizer Subcooling (F): 51  
 Evap. Temp. (°F): -22 Minimum Cond. Temp. (°F): 50 Natural Subcooling (F): 0  
 Cond. Temp. (°F): 105 Condenser-Ambient ΔT (°F): 10 Overall AEER (Btu/Wh): 9.59  
 Evap. Superheat (°F): 5

Design Load  
 Design Evap. Load (Btu/hr): 130,000  
 Evap. Capacity (Btu/hr): 130,900  
 Econo. Subcooling Capacity (Btu/hr): 37,353  
 Natural Subcooling Capacity (Btu/hr): 0

Power Supply: 460V, 60Hz, 3 Ph Analysis Period: Full Year Load Profile: Variable, Advanced (Low)

Ambient Air Temp. (°F)	Bin (Hours)	Cond. Temp. (°F)	Evap. Design Load (Btu/hr)	Evap. Capacity (Btu/hr)	Total Subcooling (F)	Comp. Power (W)	Actual Comp. Power (W)	Mech. Subcooler Evap. Capacity (Btu/hr)	Mech. Subcooler Comp. Power (W)	Actual Mech. Subcooler Power (W)	Total Actual Power (W)	Mech. Subcooler Energy
-10	1	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	
-5	19	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	
0	80	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	
5	87	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	
10	156	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	
15	292	50	104,000	114,500	0	12,730	11,563	--	--	--	11,563	

Notes: Vapor Injected Compressor(s) based Systems do not require Mechanical Subcooling Compressor. For this reason, AEER value show only Primary Compressor(s).  
 User specified Subcooling or Liquid Temperature may not be constant for all Temperature Bins for AEER Analysis of VI compressors due to design of Economizer Cycle.

Change Settings Report Close

Report Bin Analysis Results

Note: Right mouse click selected compressor from list to view: Specific Point or Full Matrix Performance, Operating Envelope, Estimate Electrical Current, Cond. Heat Rejection, Annual EER, Drawing, Wiring Diagram, BOM, System Report & Mech. Room Vent. Air.

Date: February 17, 2014 Engineering Units: English Version: 1.0.40 (6) Days Remaining for Next Update: 72 Database Version: January 30, 2014

# Emerson Product Selection Software Annual Energy Analysis

**Change Settings**

Weather City  
 Country: USA  
 State: OH  
 City: Dayton

Minimum Cond. Temp. (°F): 50

Basis: Bin Analysis  
 Mid-Point  
 Even

Load Profile  
 Fixed  
 Variable  
 Simple  
 Advanced Low Temp.

AEER Calculation Method  
 By EER  
 By Capacity

Buttons: Reset, OK, Cancel

Notes: Vapor Injected Compressor(s) based Systems do not require Mechanical Subcooling Compressor. For this reason, AEER value show only Primary Compressor(s).  
 User specified Subcooling or Liquid Temperature may not be constant for all Temperature Bins for AEER Analysis of VI compressors due to design of Economizer Cycle.

Mech. Subcooler Evap. Capacity (Btu/hr)	Mech. Subcooler Comp. Power (W)	Actual Mech. Subcooler Power (W)	1st Actual Power (W)
--	--	--	11,563
--	--	--	11,563
--	--	--	11,563
--	--	--	11,563
--	--	--	11,563
--	--	--	11,563

Buttons: Change Settings, Report, Close

**Change Some Project Details and Re-Run for Comparison of Results**

- ✓ Change Location
- ✓ Increase Minimum Cond. Temp.
- ✓ Modify Load Profile
- ✗ Change Refrigerant
- ✗ Change Design Load
- ✗ Change Design Condition

**Requires a New "Project"**

# Emerson Product Selection Software Annual Energy Analysis

Product Selection Software - [PSSProject]

File Options View Tools Windows Help

Search Box - Compressors

Compressor Selection : Step 1 Heat Exchanger : Step 1.1 Modulation Steps : Step 2 Overall AEER : Step 3 **Summary - Annual Analysis : Step 4** Compressor - Info : Step 5

**“Summary: Annual Analysis”**

Design Condition

Refrigerant: R-407A Liquid Temp. (°F): 50.0  
Dew Point Mid Point Economizer Subcooling (F): 51  
Evap. Temp. (°F): -22 Natural Subcooling (F): 0  
Cond. Temp. (°F): 105 Electricity Rate (\$/kWh): 0.08  
Evap. Superheat (°F): 5 Condenser Fan (W): 0  
Condenser-Ambient ΔT (°F): 10 Evaporator Fan (W): 0  
Return Gas Temp. (°F): 40 Load Profile: Variable: Advanced (Low Temp.)  
Minimum Cond. Temp. (°F): 50  
Analysis Period: Full Year  
Design Evap. Load (Btu/hr): 130,000

Project Information

Project Name: NA Contact: NA Location: Dayton, OH (USA)

Output

Annual (Hours): 8,760 Annual Energy Used by Primary Comp. (kWh): 118,804  
Evap. Capacity (Btu/hr): 130,900 Annual Energy Used by Mech. Subcooling Comp. (kWh): 0  
Evap. Capacity Over Design (%): 0.7 Annual Energy Used by Evap. Fan (kWh): 0  
Overall AEER (Btu/Wh): 9.59 Annual Energy Used by Cond. Fan (kWh): 0  
Design Point  
System Capacity (Btu/hr): 130,900 Total Annual Energy Used (kWh): 118,804  
System EER (Btu/Wh): 5.33 Total Annual Energy Cost (\$): 9,504  
Cond. Heat Rejection (Btu/hr): 232,955

Capacity Delivered By	Evaporator(Btu/hr)	Compressor(Btu/hr)
Primary Compressors (@ 51°F Total Subcooling)	130,900	149,200
Primary Compressors (@ 0°F Subcooling)	93,547	111,636
Natural Subcooling (@ 0°F)	0	0
Economizer Subcooling (@ 51°F)	33,012	33,012

Selected: Primary Compressors  
ZFD25KVE-TFD (1), ZF18KVE-TFD (1), ZF34K5E-TFD (1), ZF41K5E-TFD (1)

Selected: Mechanical Subcooling Compressors  
NA

Notes: Vapor injected Compressor(s) based Systems do not require Mechanical Subcooling Compressor. For this reason, AEER value show only Primary Compressor(s).  
User specified Subcooling or Liquid Temperature may not be constant for all Temperature Bins for AEER Analysis of VI compressors due to design of Economizer Cycle.

System Report Change Settings Report X Close

Note: Right mouse click selected compressor from list to view: Specific Point or Full Matrix, Performance, Operating Envelope, Estimate Electrical Current, Cond. Heat Rejection, Annual EER, Drawing, Wiring Diagram, BOM, System Report & Mech. Room Vent. Air.

Date: February 17, 2014 Engineering Units: English Version: 1.0.40 (6) Days Remaining for Next Update: 72 Database Version: January 30, 2014

Software Available From Online Product Information (OPI) at <http://www.emersonclimate.com>

Making  
Sense

# Thank You!

---

## Questions and Answers

### DISCLAIMER

Although all statements and information contained herein are believed to be accurate and reliable, they are presented without guarantee or warranty of any kind, expressed or implied. Information provided herein does not relieve the user from the responsibility of carrying out its own tests and experiments, and the user assumes all risks and liability for use of the information and results obtained. Statements or suggestions concerning the use of materials and processes are made without representation or warranty that any such use is free of patent infringement and are not recommendations to infringe on any patents. The user should not assume that all toxicity data and safety measures are indicated herein or that other measures may not be required.