Digital Technologies

"ASHRAE"

Jan.17th

Montreal, QC

By

Andre Patenaude C.E.T.

EMERSON

Topics for ASHRAE

1. **Digital Compressor Technology**
2. **Digital Compressor Efficiency**
3. **Benefits of Electronic Control Valves**
4. **Synchronization Controller for Superheat and Digital Compressor Operation**

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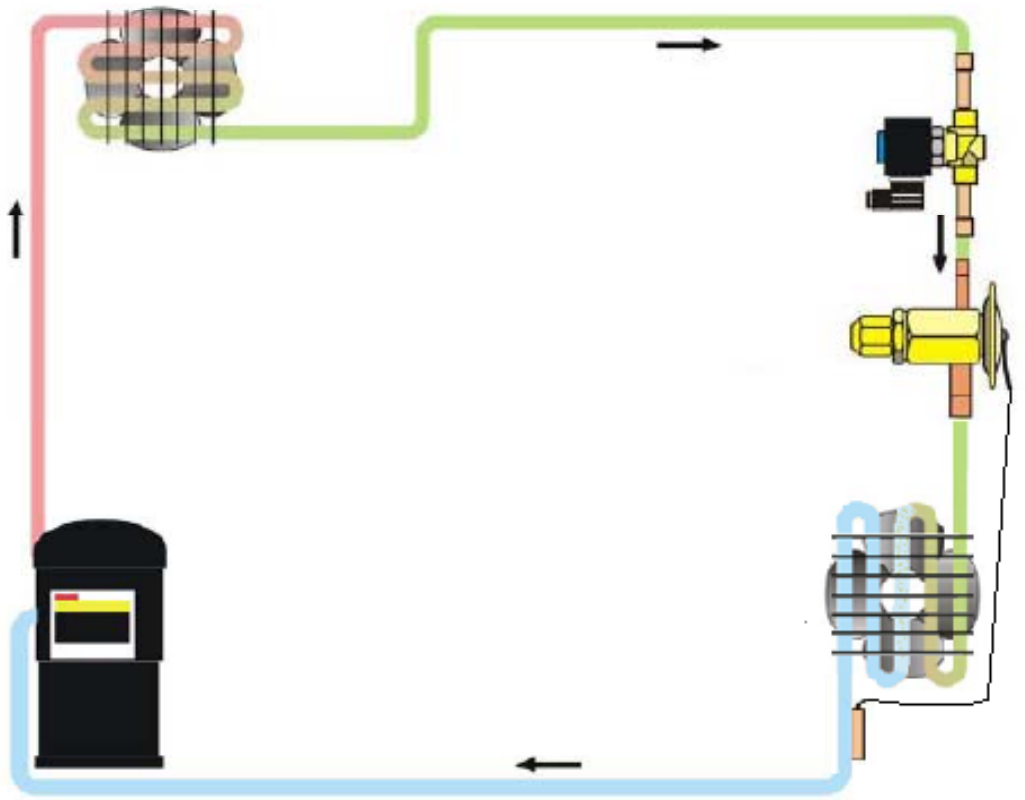
Conventional System Diagram



With Relatively Constant Head Pressures and Constant Loads System will Run Effectively with Minimum Issues

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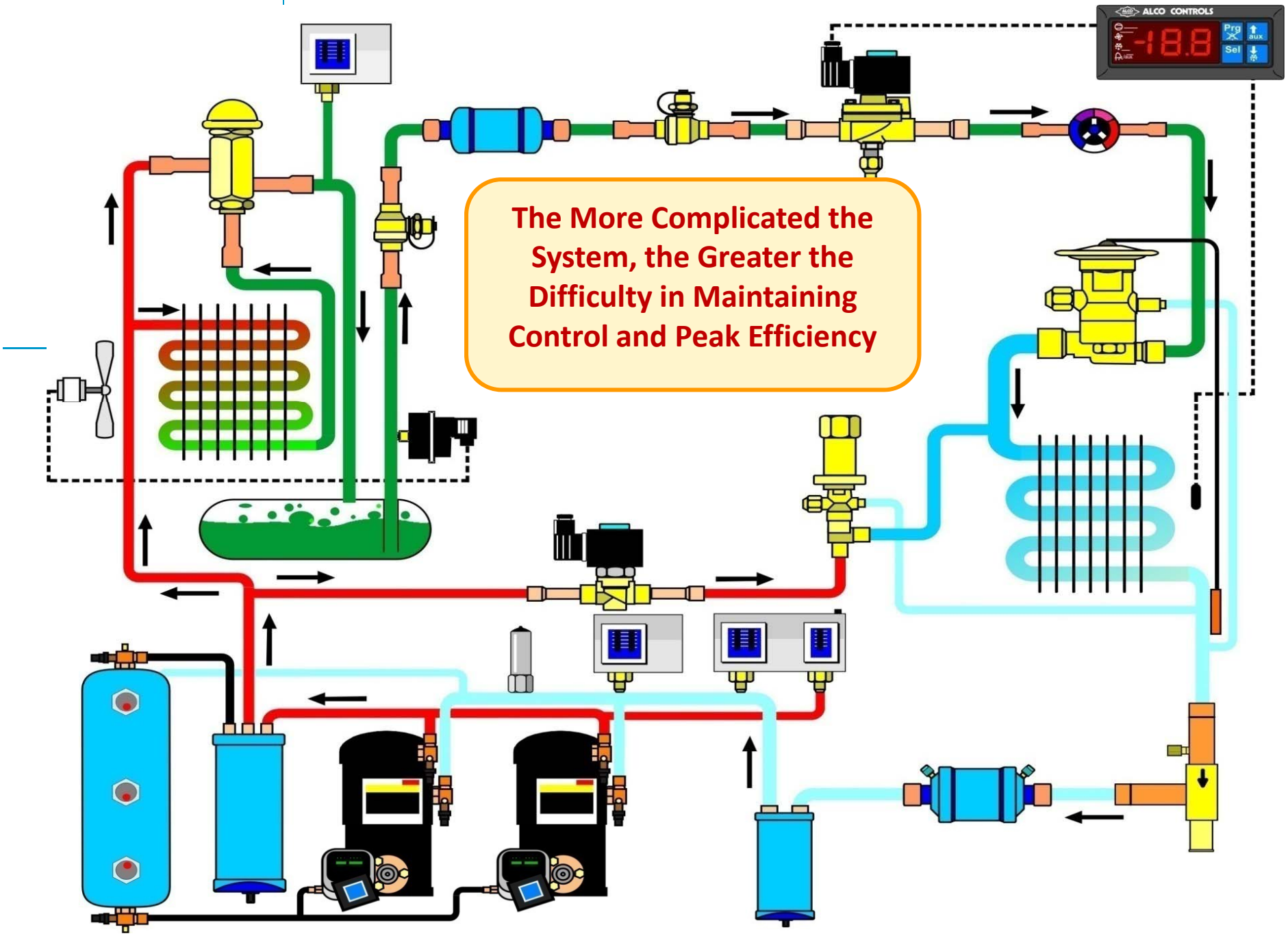
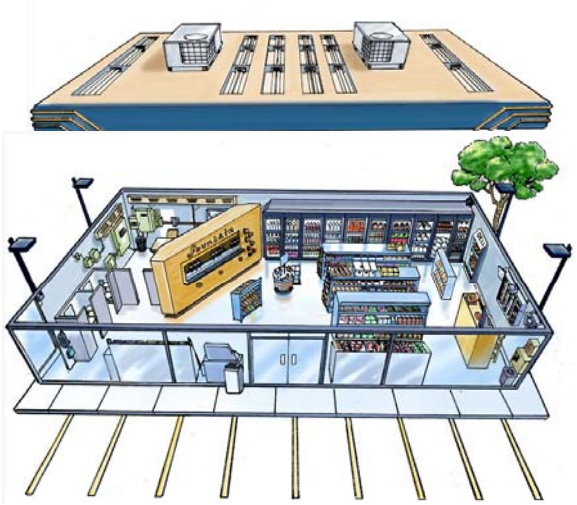

ALCO CONTROLS
-18.8
Prg
aux
Sel
The More Complicated the System, the Greater the Difficulty in Maintaining Control and Peak Efficiency

System Challenges

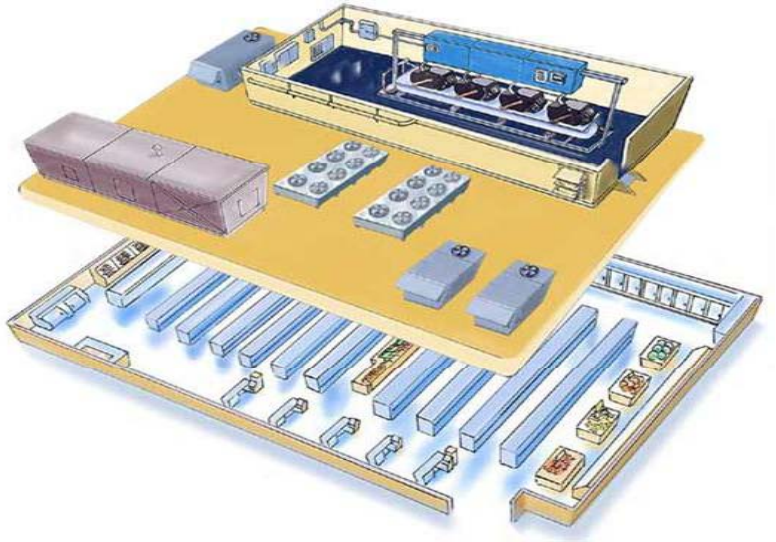
C- Stores



- Design to Max Conditions
- Capacity Control
  - Multi Compressor
  - Comp. Un-loaders
  - Hot Gas Bypass
- Suction Pressure
- Condensing Pressure
- Heat Reclaim
- Sub-Cooling
- Defrost
- Etc….

- Commercial A/C
- Precision A/C
- Air Dryers

Supermarkets



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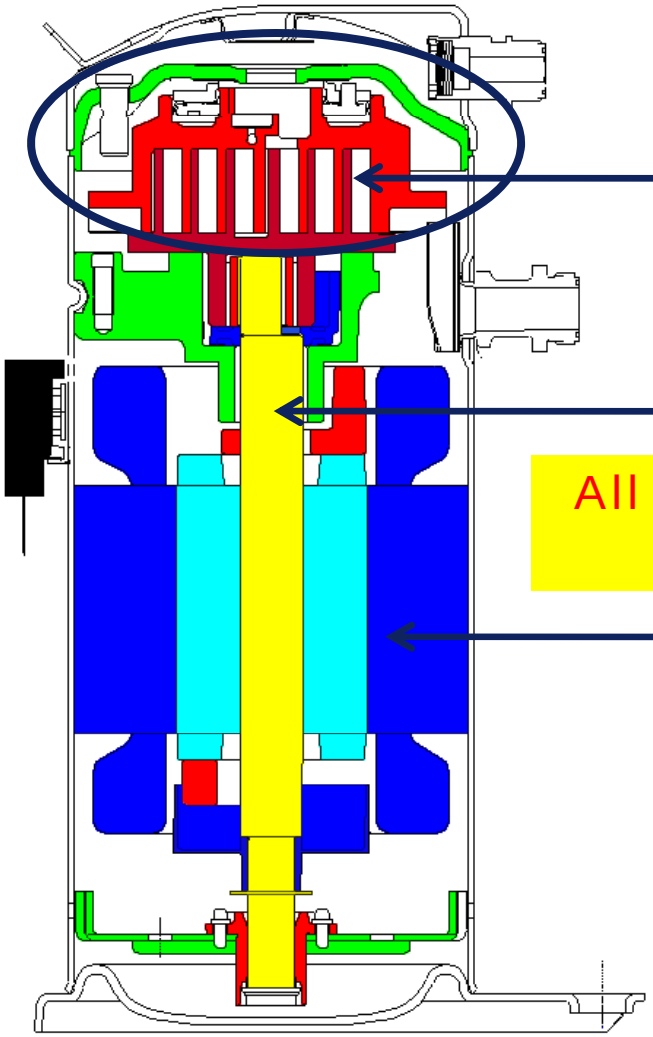
Scroll Compressor - Construction



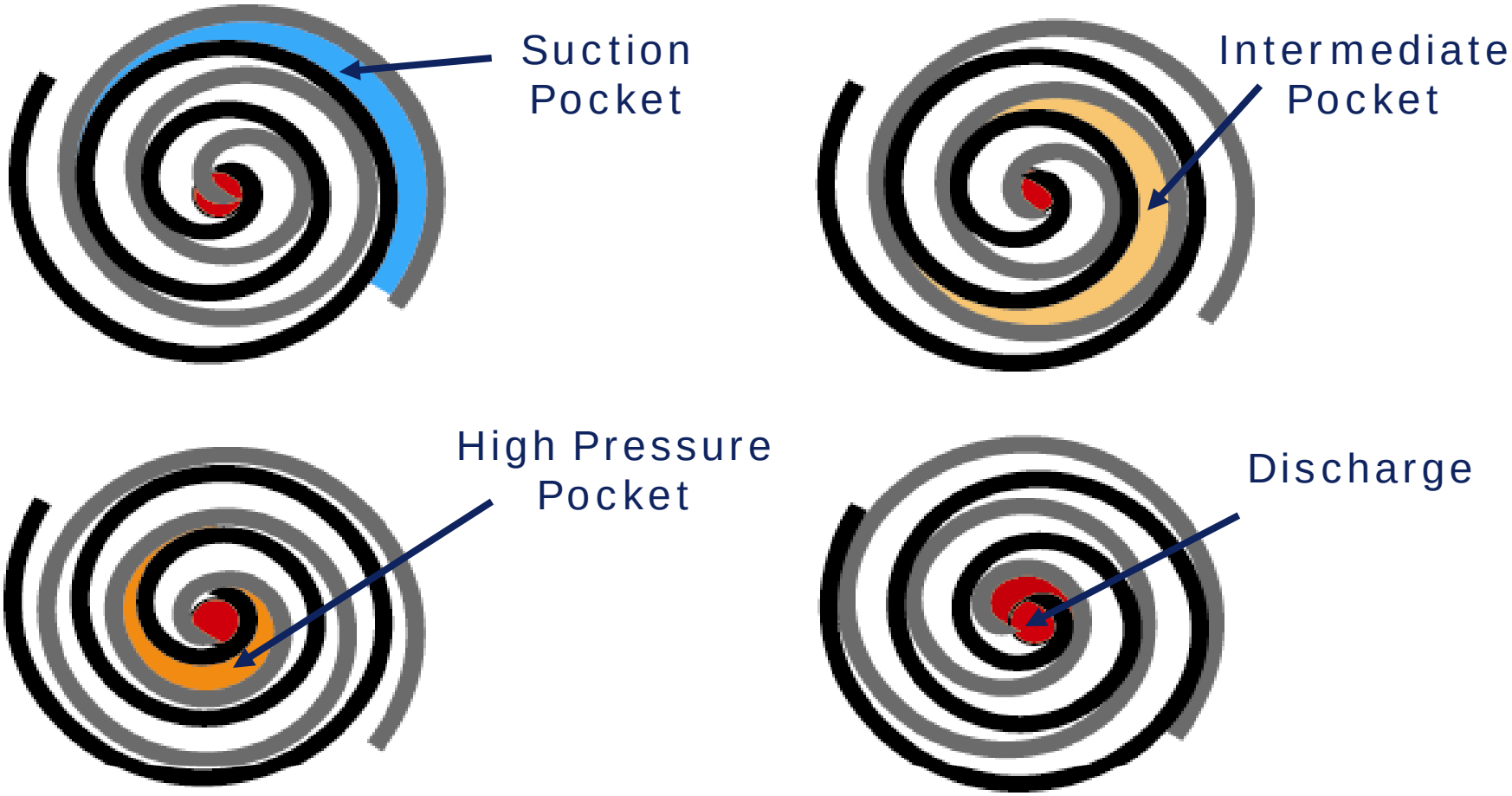
Compression Area

Crankshaft

All scrolls use 2 pole motors operating at 3500 rpm

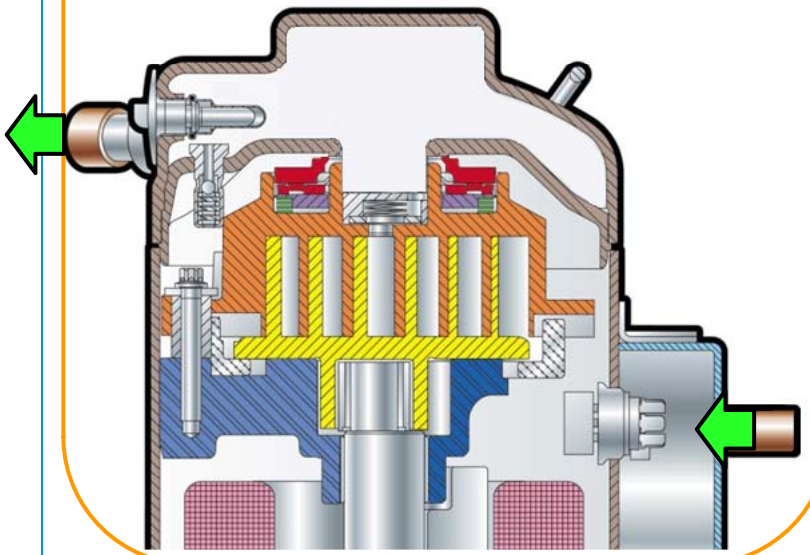
Motor

How a Compliant Scroll Works

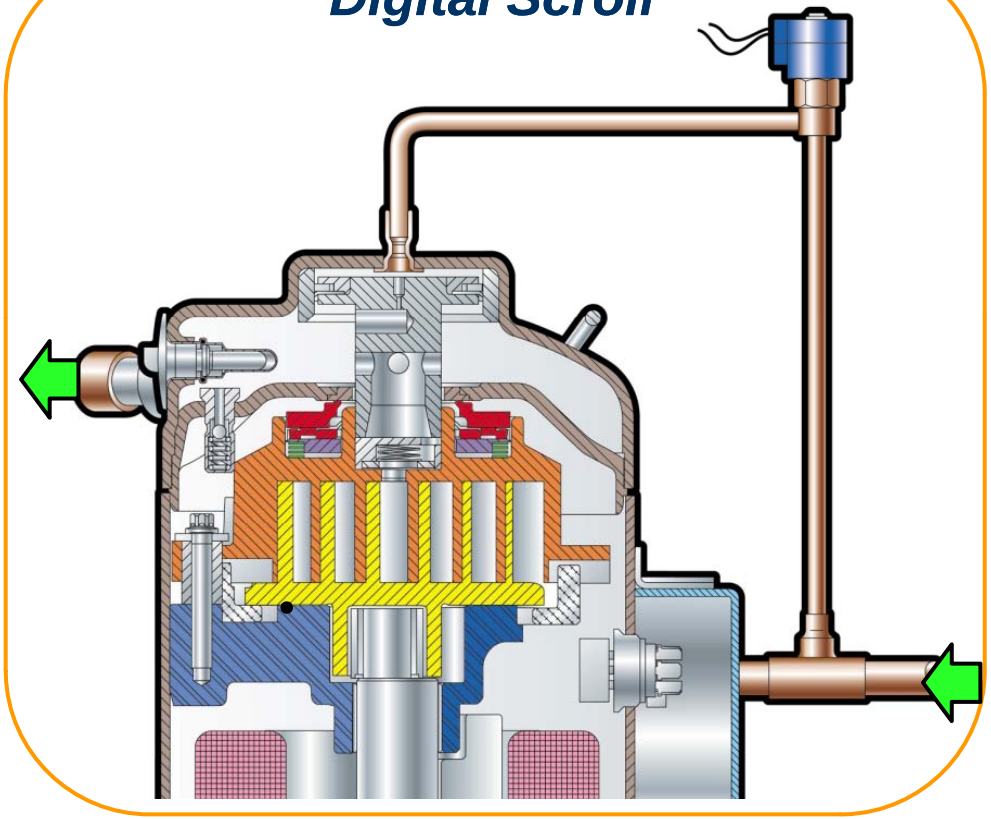


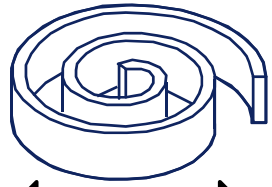
Copeland Scroll™ Digital Compressor Operation (Capacity Modulation 10 to 100%)

Standard Scroll

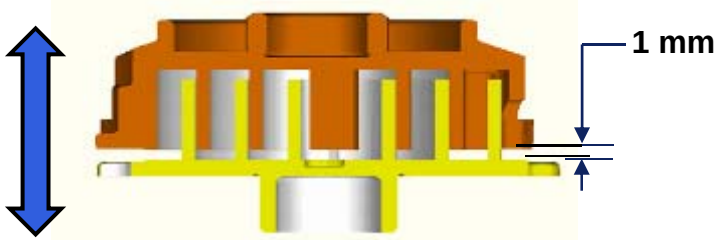


Digital Scroll



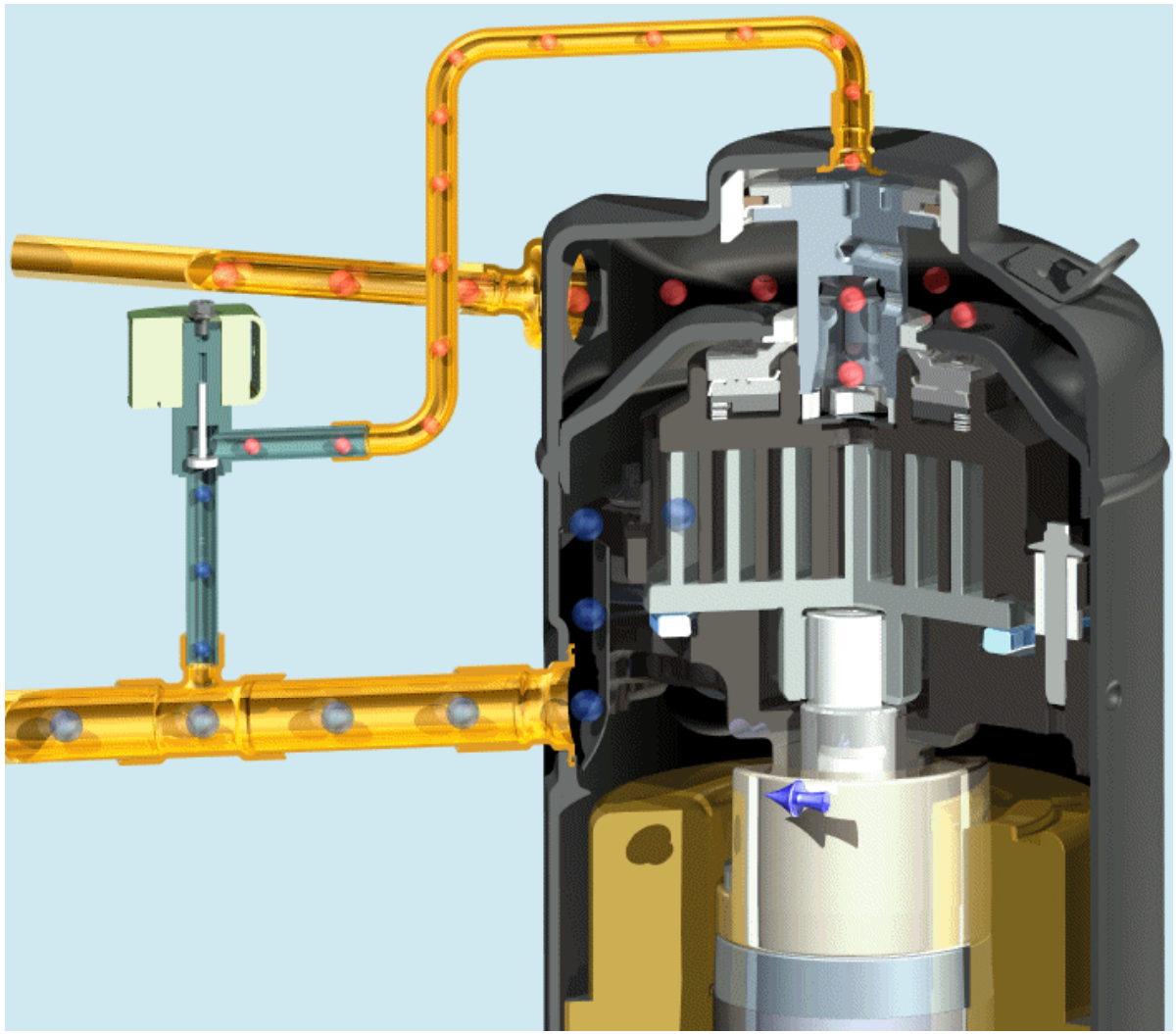


Radial Compliance



Axial Compliance

Digital Gas Flow Animation



Capacity

Modulation

10 to 100%

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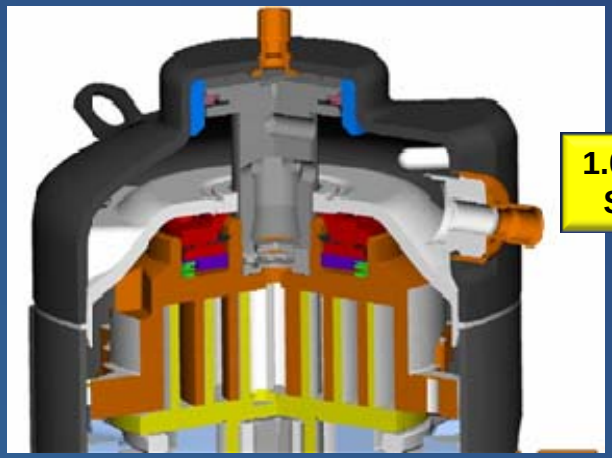
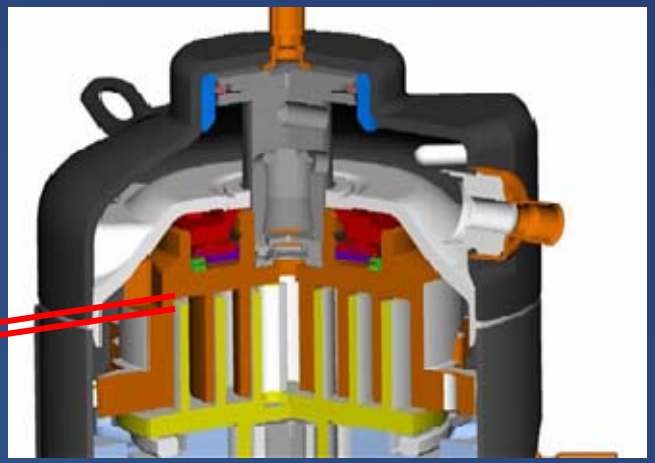
Copeland Scroll™ Digital Compressor Operation

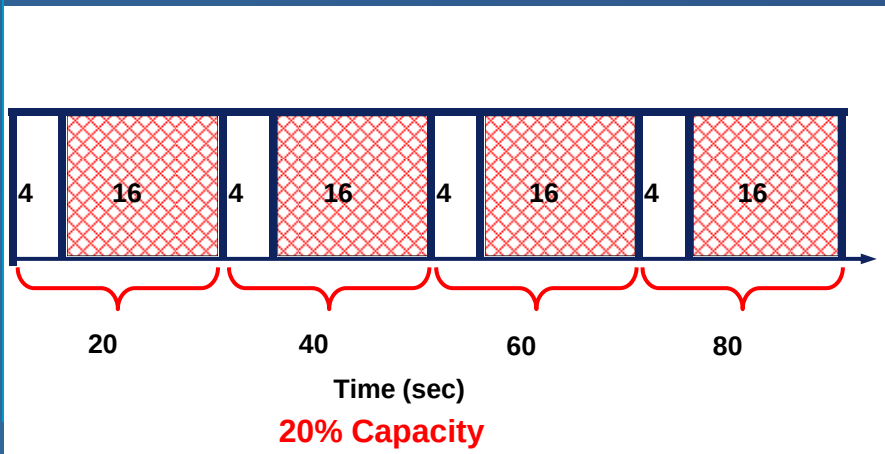


1.0 mm Scroll Separation

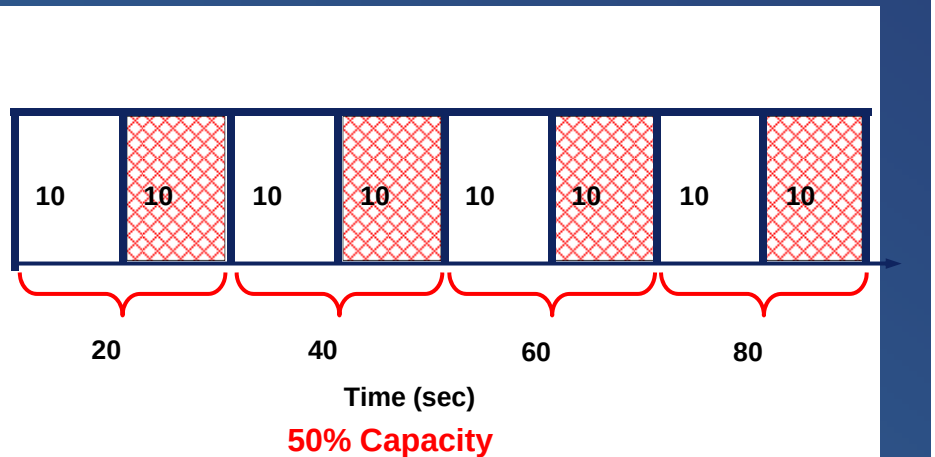


Loaded (1)
Full Capacity

Unloaded (0)
Zero Capacity



20% Capacity



50% Capacity

Copeland Discus™ Digital Technology

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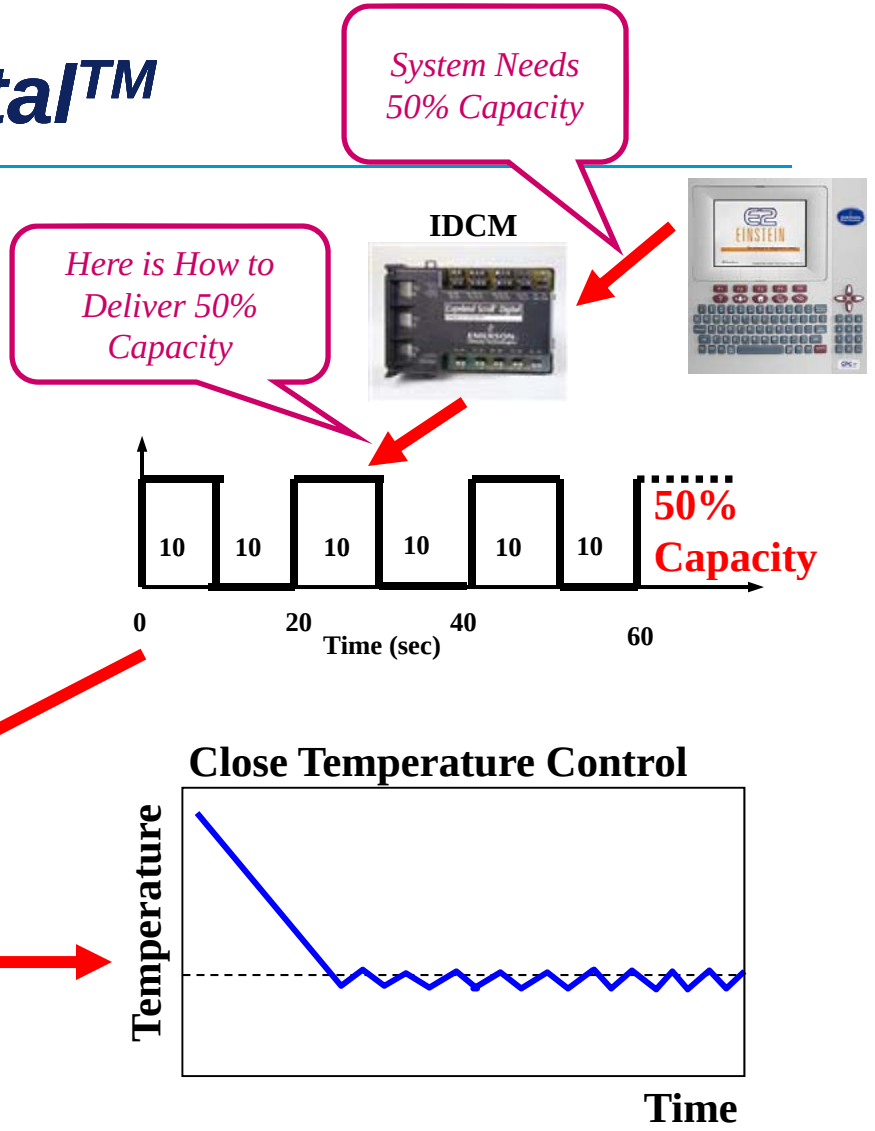
Capacity Modulation 10 to 100%

Copeland DISCUS Digital™

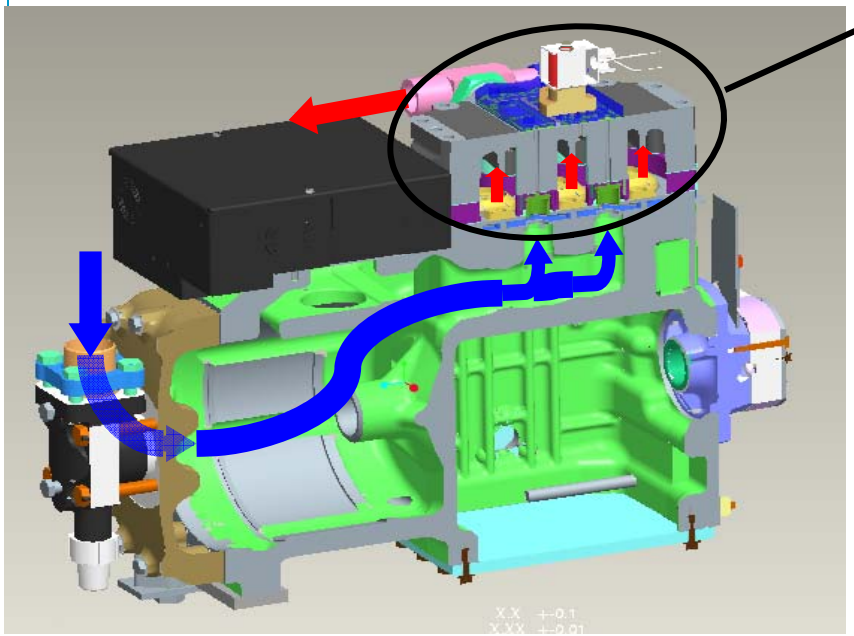
- Digital Modulation Concept Applied To Discus Compressors
- Continuous Modulation 10 … 100%
  - 3D, 4D, & 6D Compressors
- Copeland Intellectual Property
  - Patent Pending



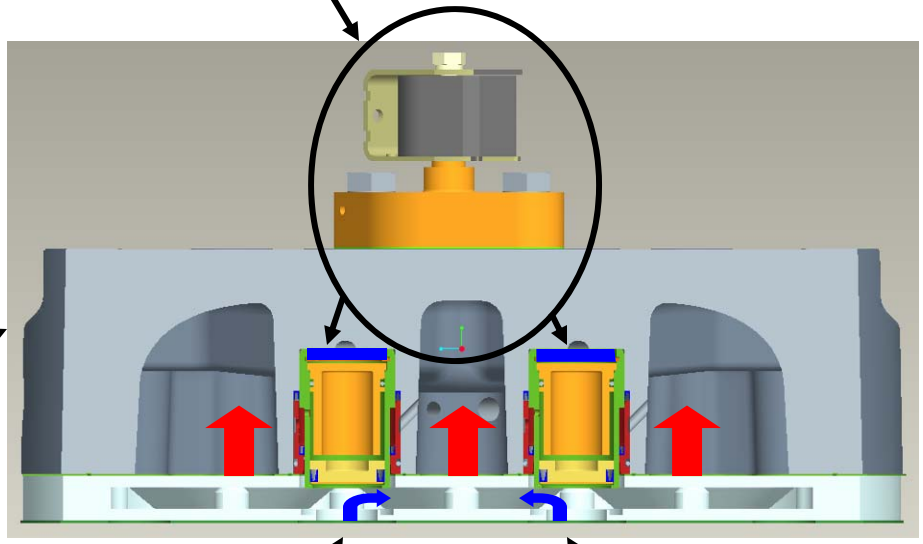
Discus Digital Refrigerant Gas Flow

Loaded

1. Enters Compressor
2. Passes Through Body
3. Into Valve Plate
4. Compressed by Pistons
5. Exits Compressor



Valve assembly routes suction gas above unloader pistons

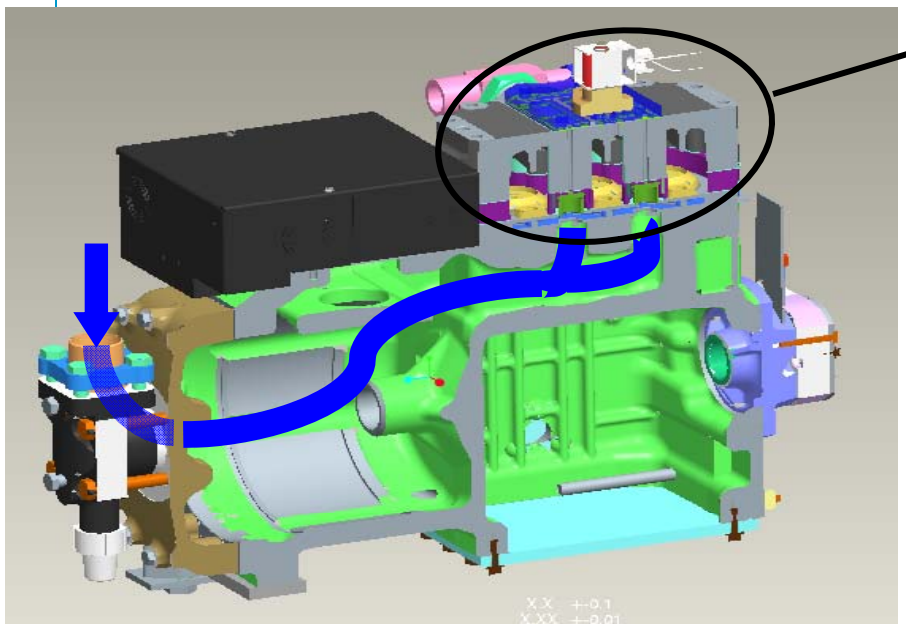


Unloader pistons allows suction gas flow into valve plate

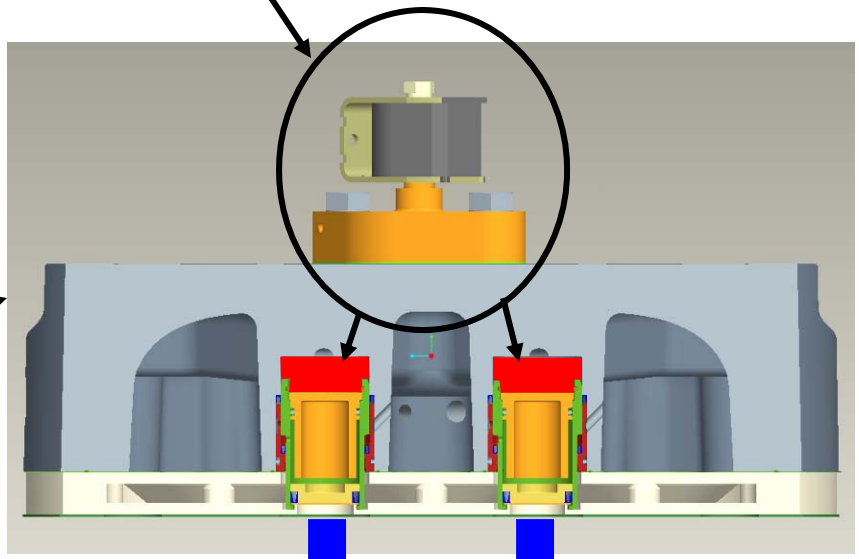
Discus Digital Refrigerant Gas Flow

Unloaded

1. Enters Compressor
2. Passes Through Body
3. 4 Unloader Pistons Block Gas Before Entering Valve Plate



Valve assembly routes discharge gas above unloader pistons



Unloader pistons block suction gas flow into valve plate

Operating Envelope

Digital Compressor vs. Inverter

Copeland® brand products

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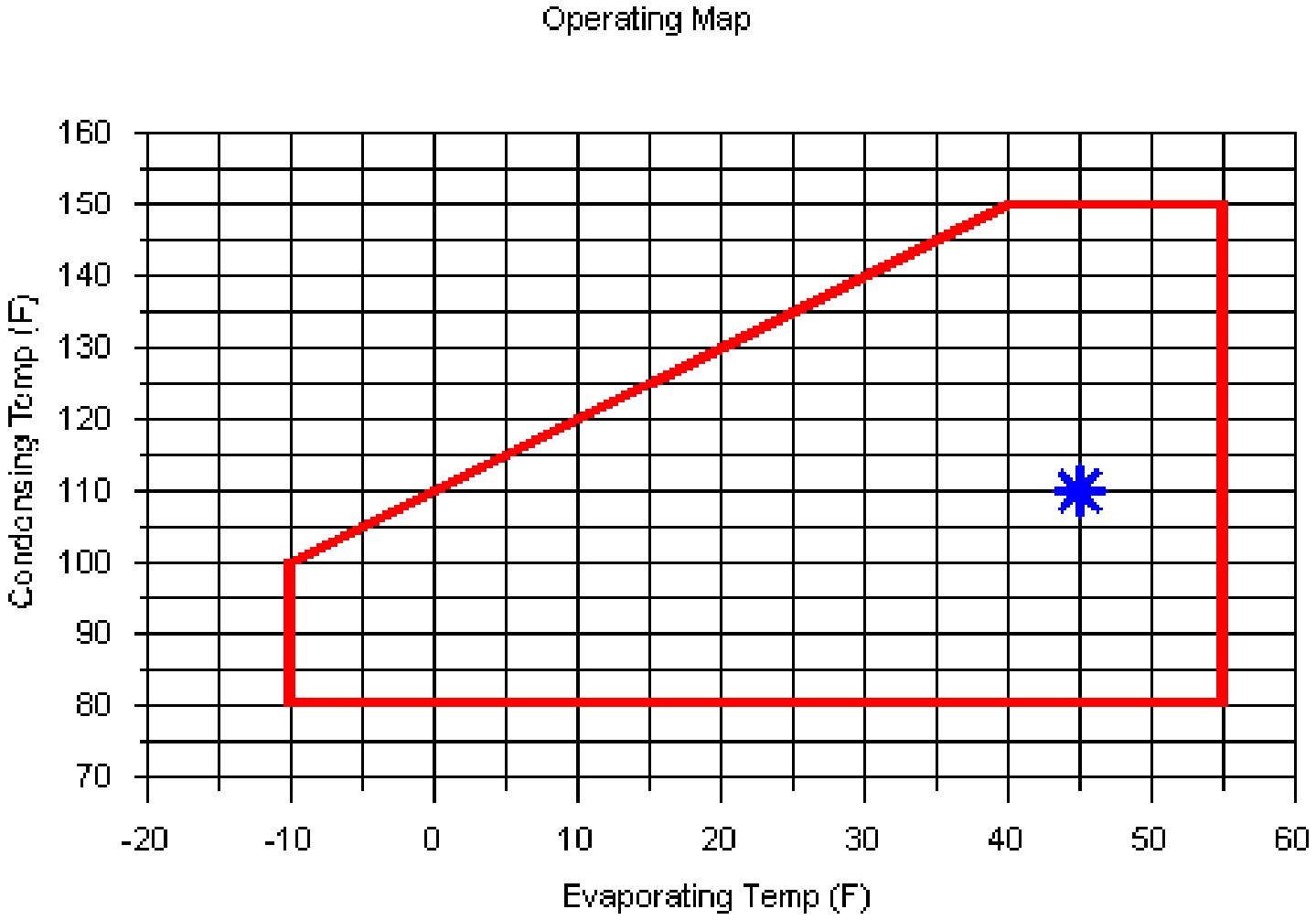
Digital Scroll Operating Envelope

ZRD125KCE-TFE R407C



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Energy Efficiency

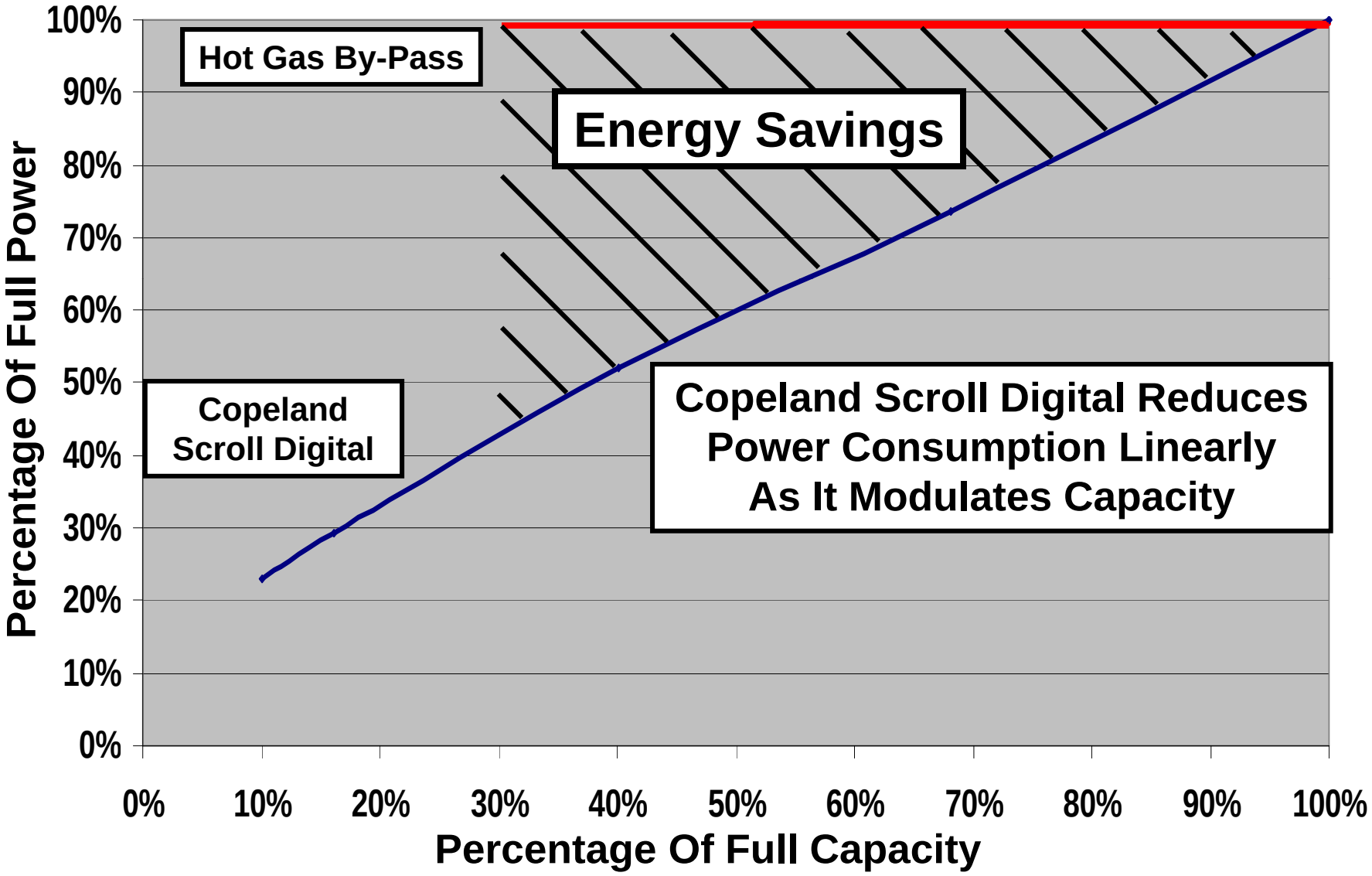
- **Hot Gas Bypass**
  - **Poor. 100% compressor power consumption under all conditions.**
- **Blocked suction unloading**
  - **Average/Poor. Better than hot gas bypass only, but power reduction is not linear compared to the amount of unloading. Efficiency drops with additional stages of unloading**
- **Multiple-Step (Tandem) Compressor**
  - **Good only at 50% and 100%, where modulation does not require hot gas bypass. Poor in the steps where hot gas bypass must be used.**

Energy Efficiency

- **Inverter Technology**
  - **Average. Inverter loss accounts for approximately 15% of total power consumption. Inefficient hot gas bypass method must be used for low capacities. Liquid injection must be used under conditions of high ambient temperature.**

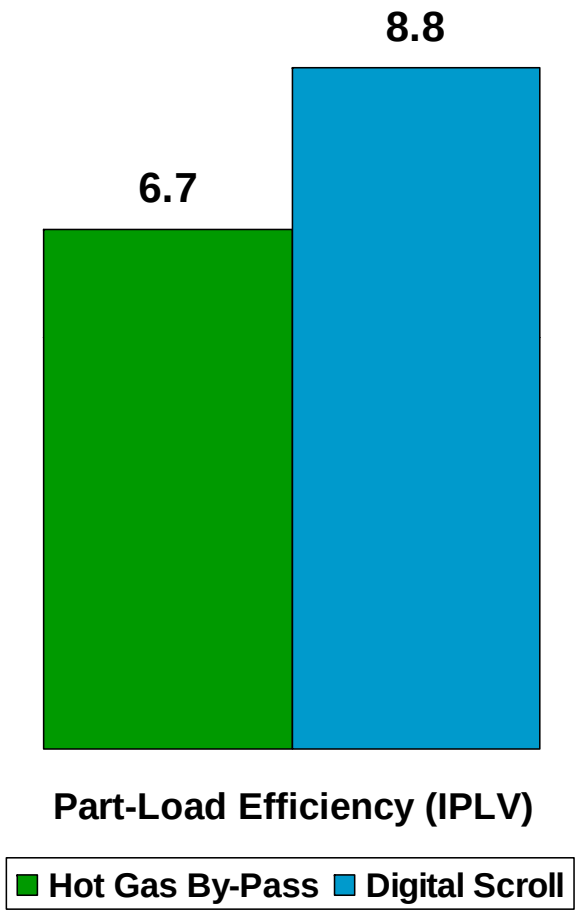
- **Digital Scroll Technology**
  - **Excellent. No inverter loss and low power consumption in the unloaded state (only 10% of full load power) means low average power consumption and high partial load efficiency**

Copeland Scroll Digital™ Power Savings



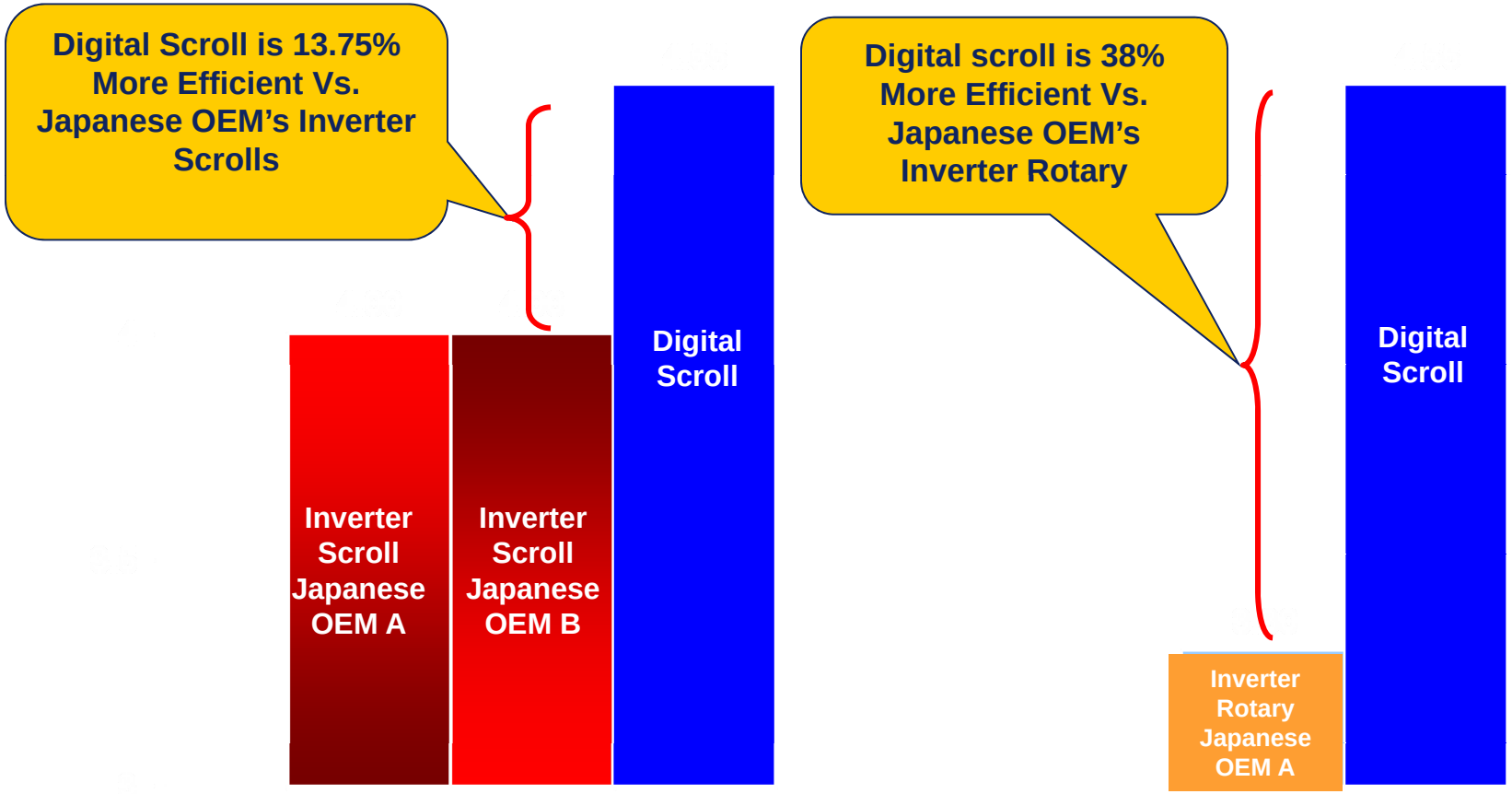
Digital Scroll Offers Superior Part-Load Efficiency Versus Hot Gas By-Pass

% Full Capacity	Hot Gas By-Pass EER	Digital Scroll EER	IPLV Weighting
25%	2.9	6.3	12%
50%	5.7	8.2	45%
75%	8.6	10.0	42%
100%	11.5	11.3	1%
Integrated Part Load Value	6.7	8.8	100%



30% Part-Load Efficiency Improvement With Copeland Scroll Digital!

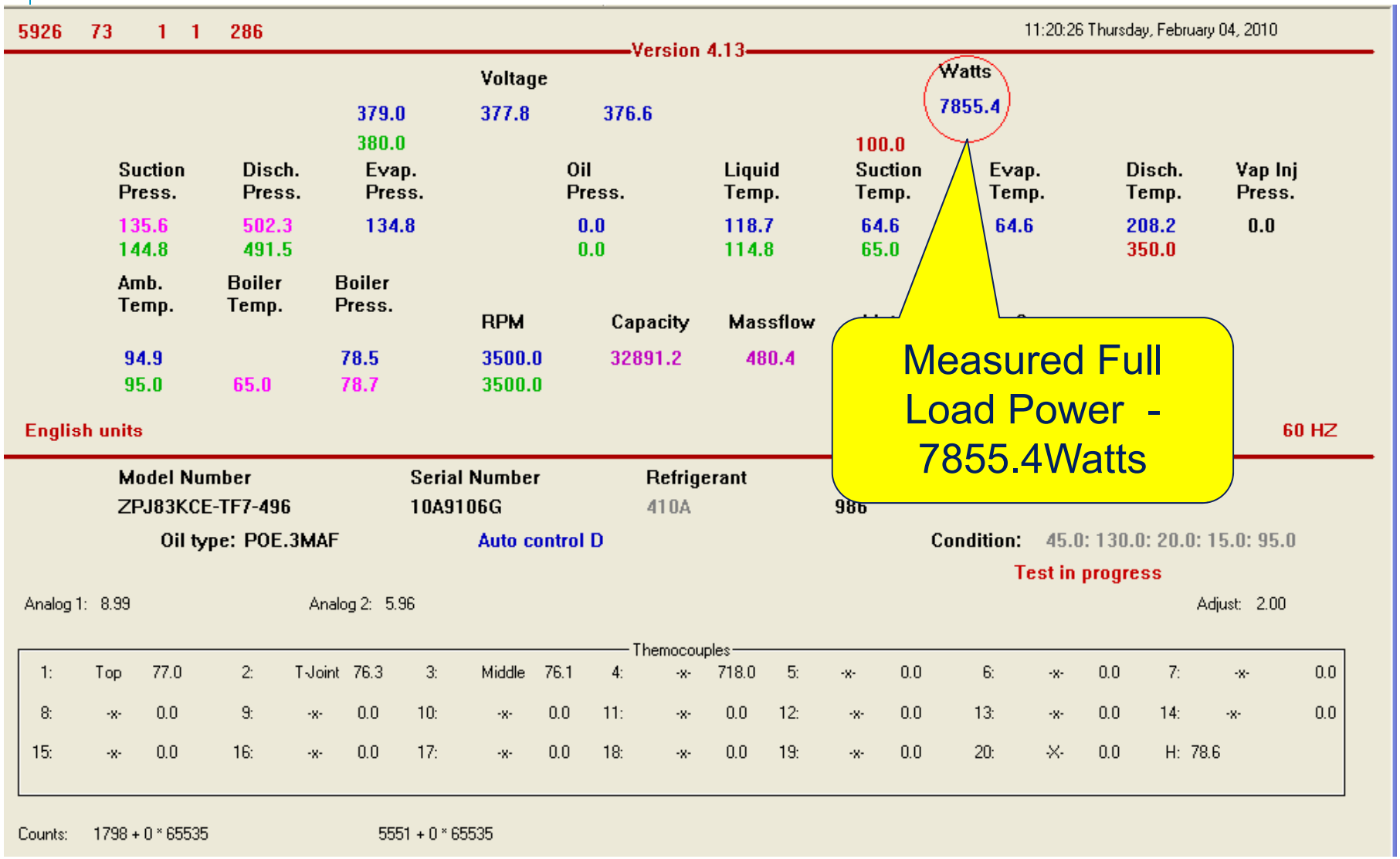
Performance: Digital Scroll & DC Inverter
Testing Results At China Govt. Laboratory At Hefei



IPLV
10 HP

Partial Load performance – Digital Scroll

Snap Shot of Actual Calorimeter Test



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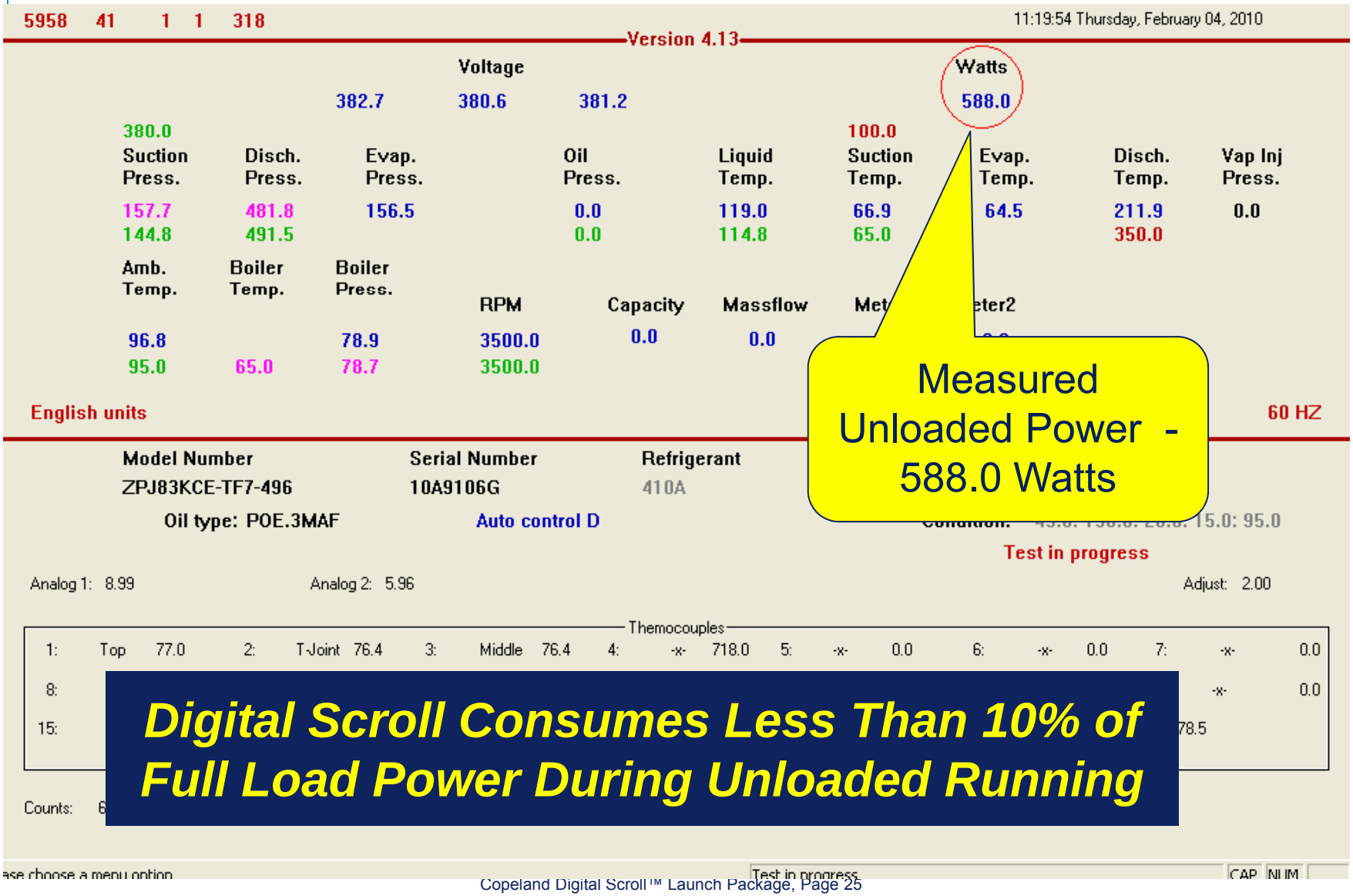

Load Matching

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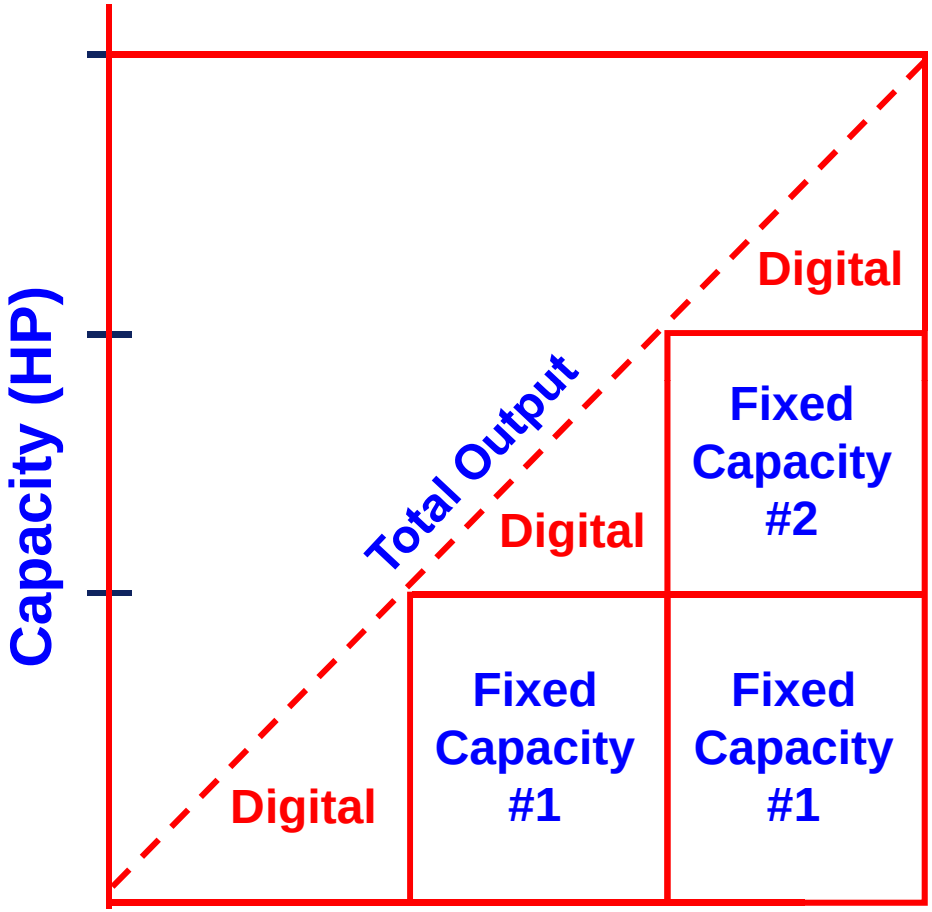
Digital Modulation Over Larger Capacities

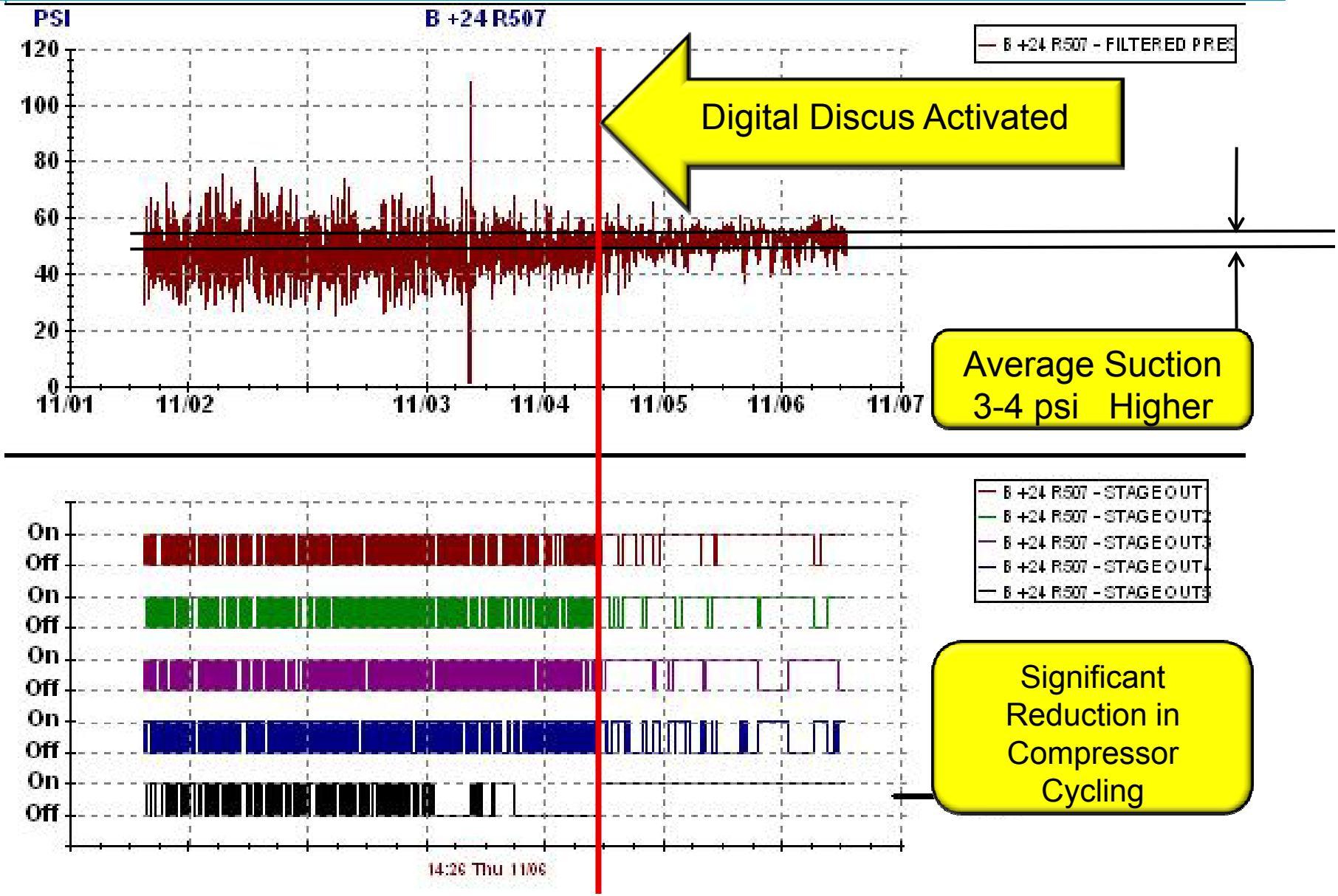


- Digital Can Be Used In Parallel With Fixed Capacity Scrolls To Get Even Wider Range Of Capacities
- Power Savings Still Follow The Same Line
- Leverages The Cost And Capability Of One Digital Over Larger Systems

Digital Discus Retrofit

Nov'08

Digital Discus Activated

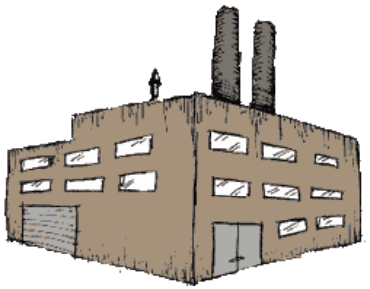


Energy Savings from Increase Suction Pressure

1 Psig Increase In Suction Pressure = 2% Reduction In Compressor Power Consumption.

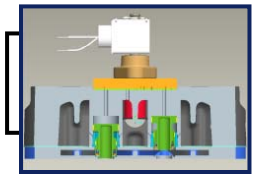
3.5 psig = 7% x 800,000 Kwh/Store →

Savings
56,000 Kwh



56,000 Kwh x 9 Cents Per Kwh →

$5,040



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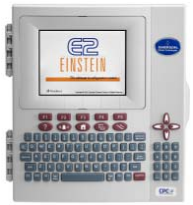

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$5,040/Store/Year

Note: Based On 80,000 Ft^2 Store With 3 Racks

Reliability/Ease of Application

Digital vs Inverter

Copeland® brand products

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Inverter Technology Is Complex

- **Capacity Range Of Inverter Modulation Typically Limited To 40%- 100%**
- **Inverter Generates Electro-Magnetic Interference (EMI)**
- **Inverters Are Relatively Expensive**
- **Variable Speed Compressor Designs Require Special Consideration To Avoid Mechanical Resonances**
- **Require Complex Electronic Controls**
- **Variable Speed Necessitates Complicated Piping Circuits To Ensure Oil Return**
- **Complexity Adversely Affects Reliability**
- **Not Easy To Service**

Digital Advantage - Reliability

- **Inherent Reliability From Fixed Capacity Compressor**
  - Copeland Scroll Floating Seal Design Provides Radial And Axial Compliance Which Enhances Liquid Handling Capability
  - Digital Discus based on a Proven Compressor Design
  - Robust, Proven Reliable Oil Lubrication System
- **Digital Compressor Inherent Characteristics**
  - Constant Shaft Speed Eliminates Concern On Lubrication
  - Modulated Parts Designed And Tested For 32 Million Cycles
- **Digital Compressor Systems Inherent Characteristics**
  - Same Oil Flow Velocity Regardless of Modulation Rate
  - No Complex Electronics Means No Electromagnetic Interference (EMI)
  - No Need To Avoid System Natural Frequencies Since The Motor Is Turning At The Same Speed Regardless Of Modulation Rate

Digital Advantage – Ease of Application

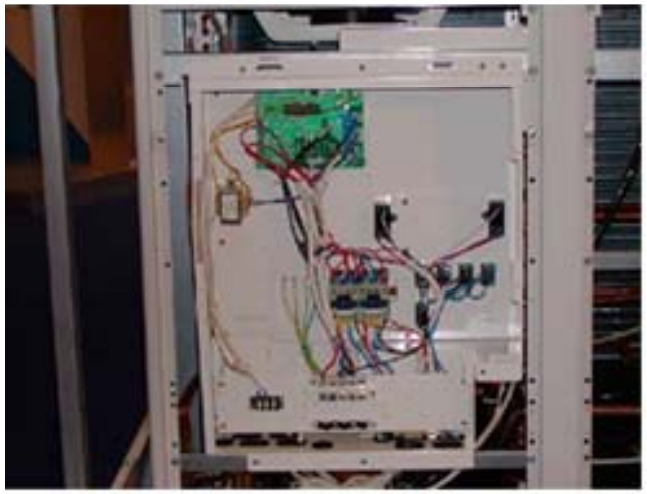
	Digital Scroll System	AC Inverter System
Capacity Range	10-100%	40-100%
Electronic Hardware	Simple	Complex
Electromagnetic Interference	No	Yes
Software Complexity	Low	High
Oil Management	Simple	Complex
Valve & Piping	Simple	Complex
Serviceability	Easy	Difficult
Reliability	High	Low
Full Load Efficiency	Better	Good
Part Load Efficiency	← Comparable →	
Temperature Control	←Comparable→	
Continuous Capacity Control	Yes	Yes

System Simplicity = Reliability

10 Horsepower, Heat Pump System Example

Non Digital Scroll System

Digital Scroll System



Reliability - Oil Return

- **Consistent Oil Return During Low Loads**
  - **No Oil "Pump Out" During Unloading**
  - **Loaded Cycle Gas Velocity Sufficient To Return Oil**
  - **Oil separator not required for most applications**

Digital Advantage

- **Precise Control Of Suction Pressure And Temperature**
  - **Minimum Temperature Fluctuation**
  - **More Consistent operation of mechanical valves and regulators for parallel set up**
- **Reduced Cycling Of Compressors**
  - **Longer Contactor Life**
  - **Longer Compressor Life**
  - **Reduction in Inrush Current**
- **System Efficiency Improvement**
  - **Eliminates Over/Under Shooting Of Suction Pressure Set Point**
  - **Potential To Run System At Higher Suction Pressure Set Point**
- **Change In System Design**
  - **No Need For Uneven Paralleling For Compressor Staging**
  - **Using Common Compressor Selections Simplifies Replacement Needs**

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EX4/EX5/EX6/EX7/EX8 Electrical Control Valve

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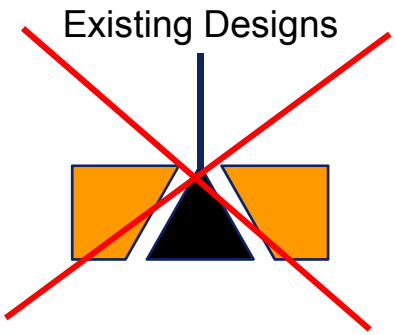
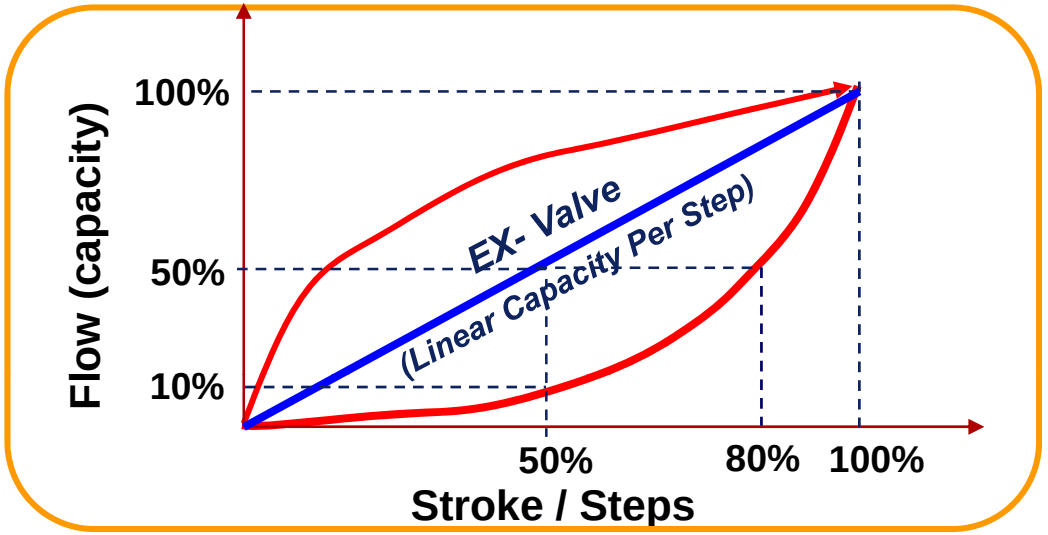
Benefits of Emerson's Electronic Valve Gate Port Design

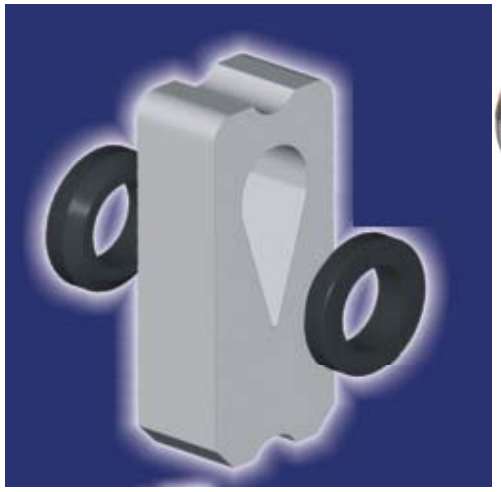
2





Emerson EX – Valve

Gate Port Design



Valve	Capacity Range	Travel Time
EX4 =	0.5 - 5T,	750 Steps / 1.5 Seconds
EX5 =	1.5 - 14T,	750 Steps / 1.5 Seconds
EX6 =	3 - 34T,	750 Steps / 1.5 Seconds
EX7 =	9 - 94T,	1,600 Steps / 3.2 Seconds
EX8 =	25 - 250T,	2,600 Steps / 5.2 Seconds

EXV Range

EX8 (250 tons)

EX7 (100 tons)

EX6 (30 tons)

EX5 (15 tons)

EX4 (5 tons)

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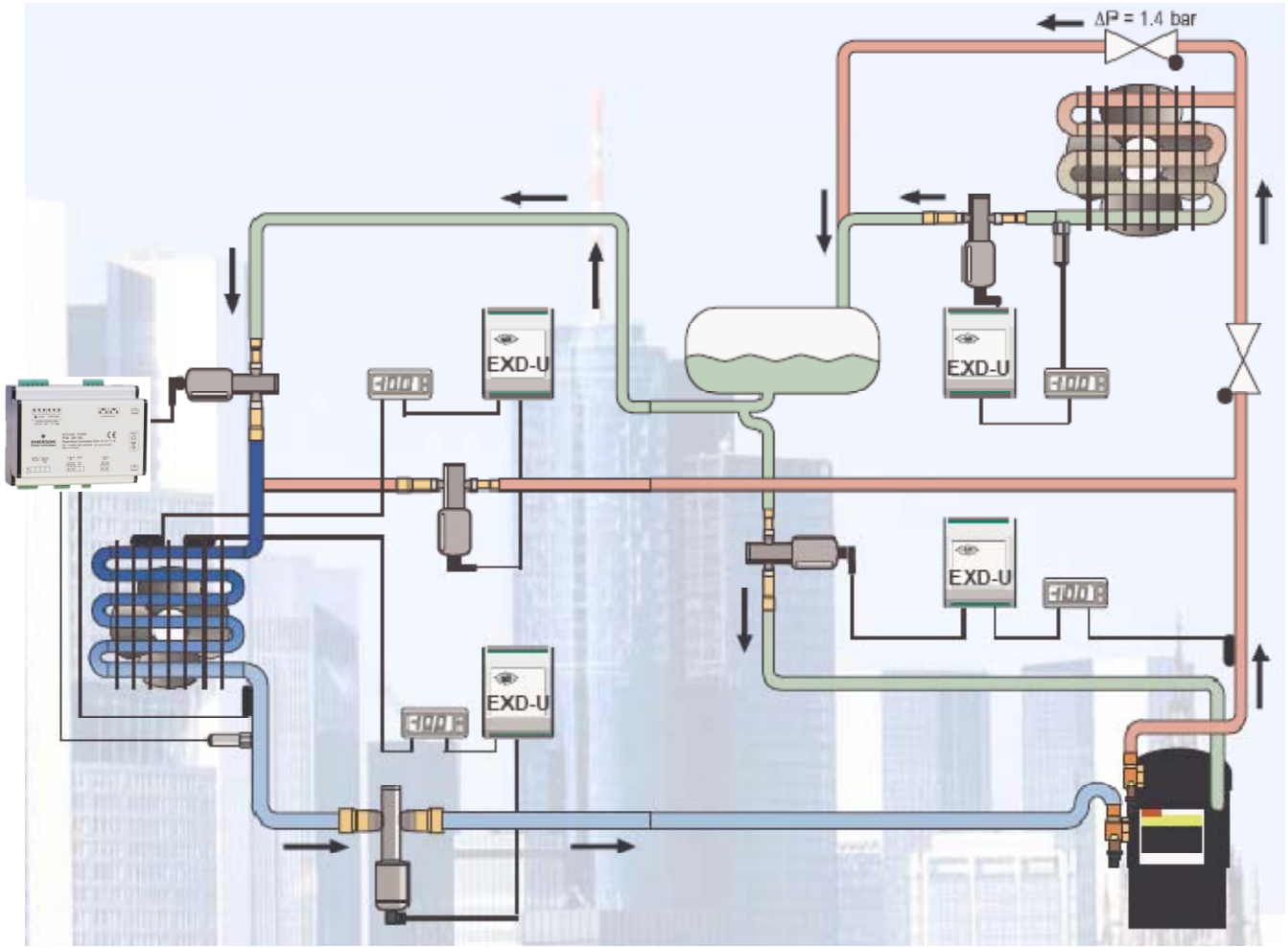
Electronic Solutions



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EC3-X?? Complete Kits

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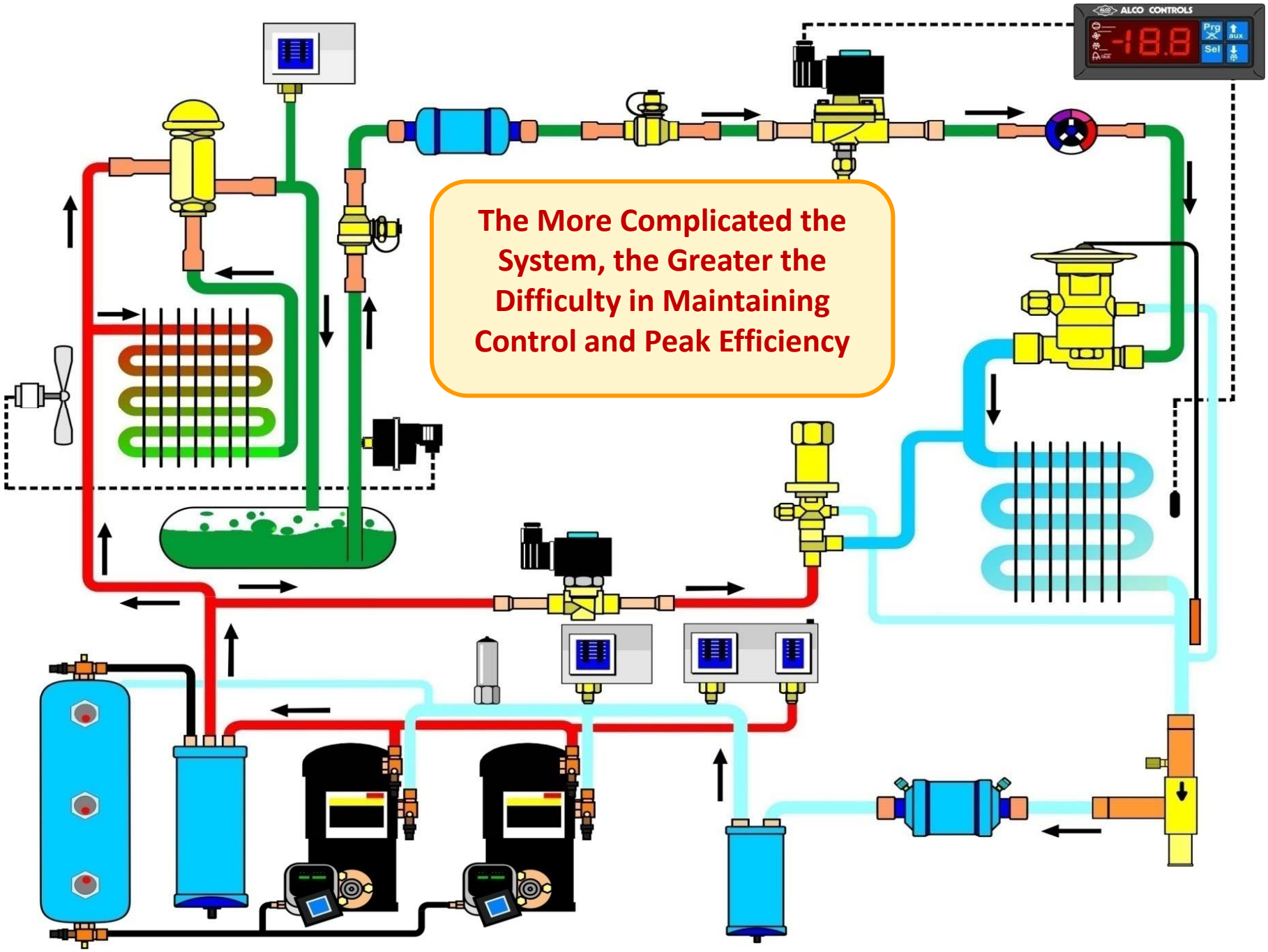
ALCO CONTROLS
-18.8
Prg
aux
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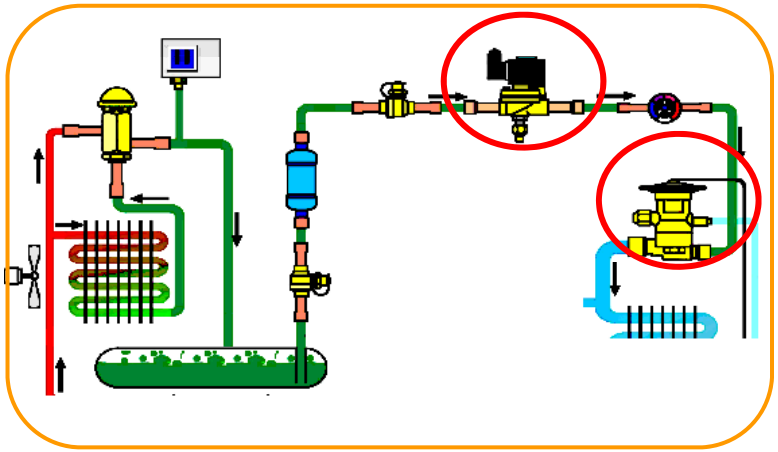
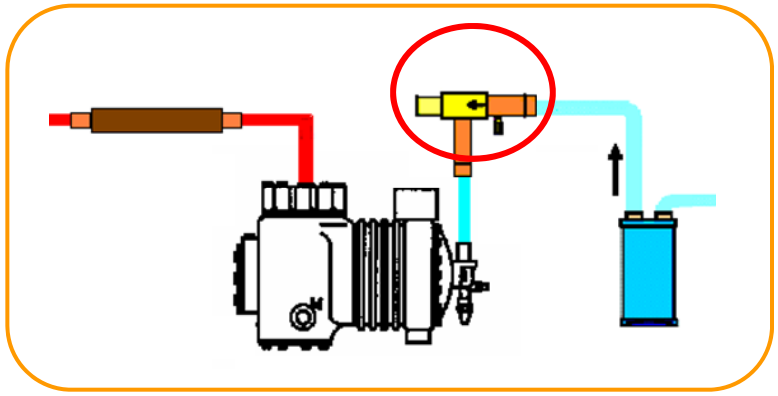
The More Complicated the System, the Greater the Difficulty in Maintaining Control and Peak Efficiency

EC3 and EX Valves

Superheat Controller and Electronic Valve

- **Replaces:**
  - Liquid Line Solenoid Valve
  - TXV
  - Crankcase Press Regulators
- **System Challenges:**
  - Wide Load Variations
  - Floating Head Pressure
  - Inconsistent Liquid Quality
  - Large Evap. Performance (SH Ctrl)
  - Cryogenics (Ultra Low)
  - Poor / Lack of Maintenance





EC3-D72 and EX Valves

Superheat Controller and Electronic Valve

- **Benefits:**
  1. **Precise Temperature Control**
     - **10 to 100% Capacity Modulation**
  2. **Saves Energy / Operating Cost**
     - **Quicker Pull Down, Without Adjustments**
     - **Reaches Set Point Faster**
     - **Reduces Run Time**
     - **Tighter Superheat Control**
     - **No Pump Down Required (Most Instances)**
  3. **System Protection**
     - **Prevents Compressor Flood Back from Burnt out Evaporator Fan Motor**
     - **Alarm Notification IE Low Superheat**
  4. **Simplifies System with Added Flexibility**
     - **Reduces Commissioning Time / Labor Cost**
     - **Lower Refrigerant Charge Due to Low Floating Head**

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2. **Digital Compressor Efficiency**
3. **Benefits of Electronic Control Valves**
4. **Synchronization Controller for Superheat and Digital Compressor Operation**

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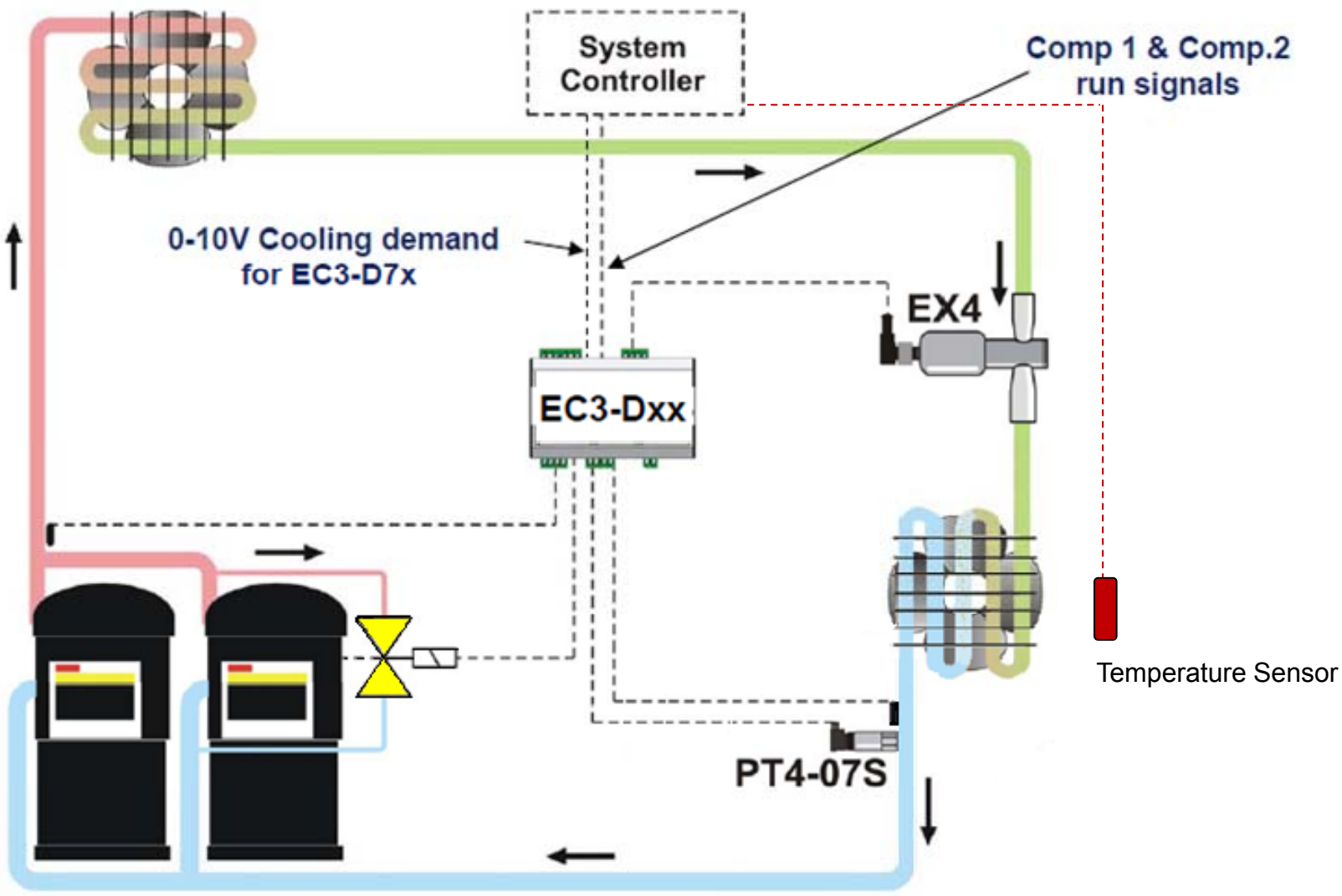
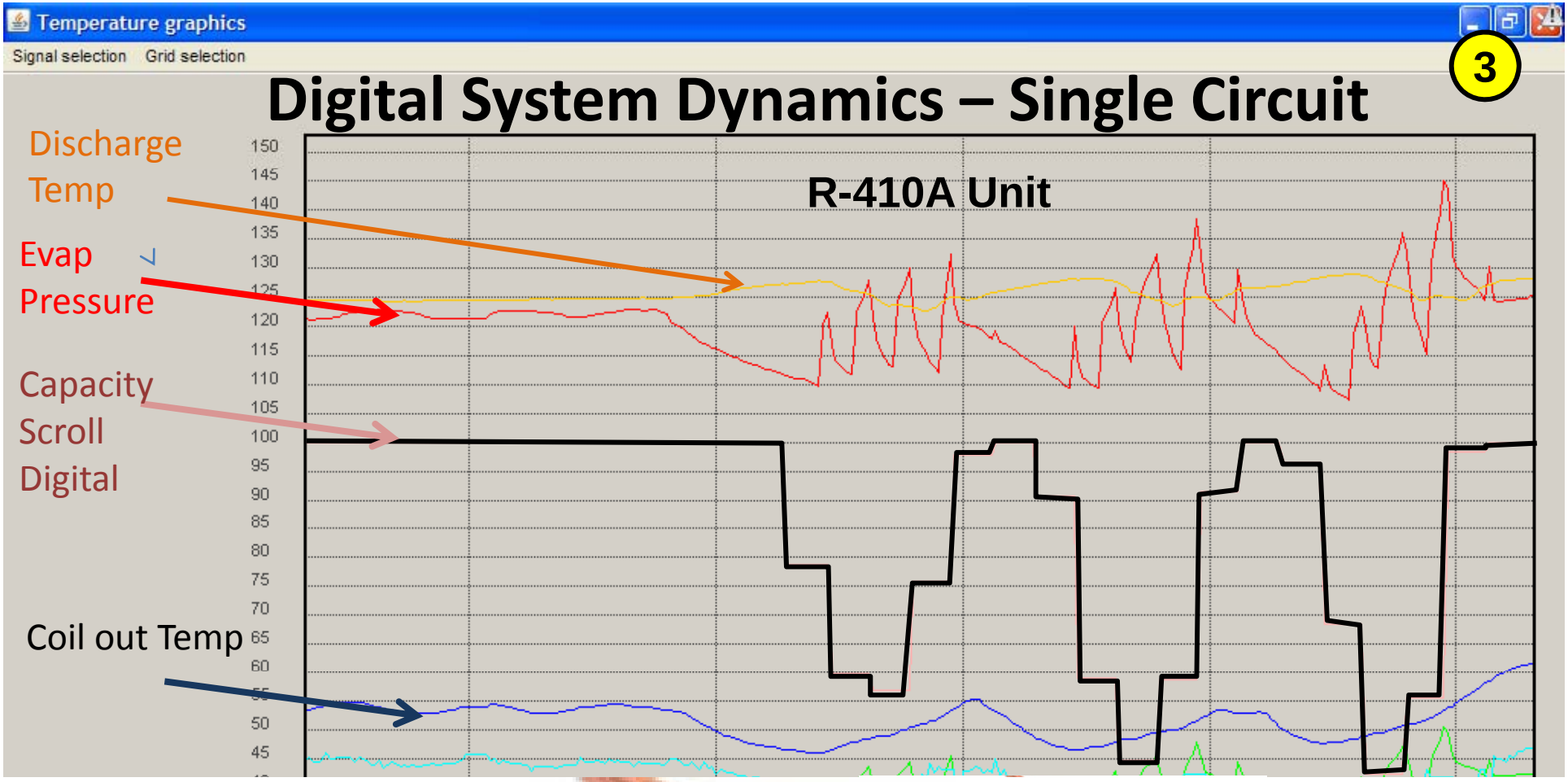
Digital Scroll System Diagram



Working Demo Unit – R410A

Digital System Dynamics – Single Circuit

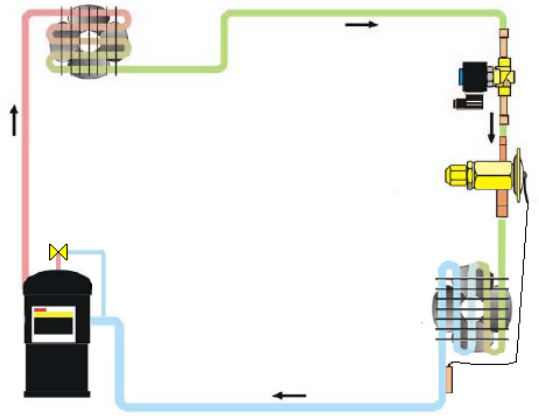


Mechanical TXV

Rapid Fluctuations in Evaporator Pressure = Will result in Premature Diaphragm Failure.
1,314,000 Fluctuations / Year

Diaphragm Design 500,000 Cycles

Limitations of Digital Compressors and W/ Single Circuits



- **Severe Mechanical Stress on TXV Diaphragm (6 to15 psi for Full Gradient SH)**
- **Evaporating and Condensing Pressures Rapidly Changing when Digital Scroll Operates**
  - 10 to 15 Years Life Expectancy = 32 Million Scroll Cycles @ 20 Sec. Cycle Time
    - Liquid Slugging

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Digital & Superheat Controller Advantage

- **Need to Synchronize Superheat Control with Digital Scroll Valve Cycling**
  - Superheat Control Active Only when Compressor is "Pumping"
  - Superheat Idle when Compressor "Unloaded"
- **Fast Reacting EXV Required to Enable Functionality**
  - Opening/Closing Time < Min Compressor "Pump" Time

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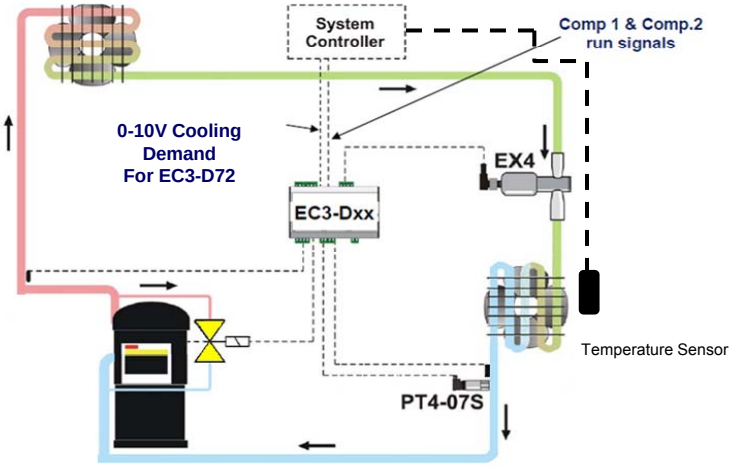
Synchronization = Smart Valve Control EC3-D72 Controller

3

- **Load > 70% = > 7 Volts**
  - EX Valve "Freezes" at the Current Opening % When The Compressor is Unloaded (Not Pumping)
- **Load < 70% = < 7 Volts**
  - EX Valve Closes to 0% When The Compressor is Unloaded (Not Pumping)
- **When the Second Compressor is Active**
  - The Superheat Control Loop is Continually Running

Third Party Controller
Johnson Controls C450CPN-1



Digital Compressor

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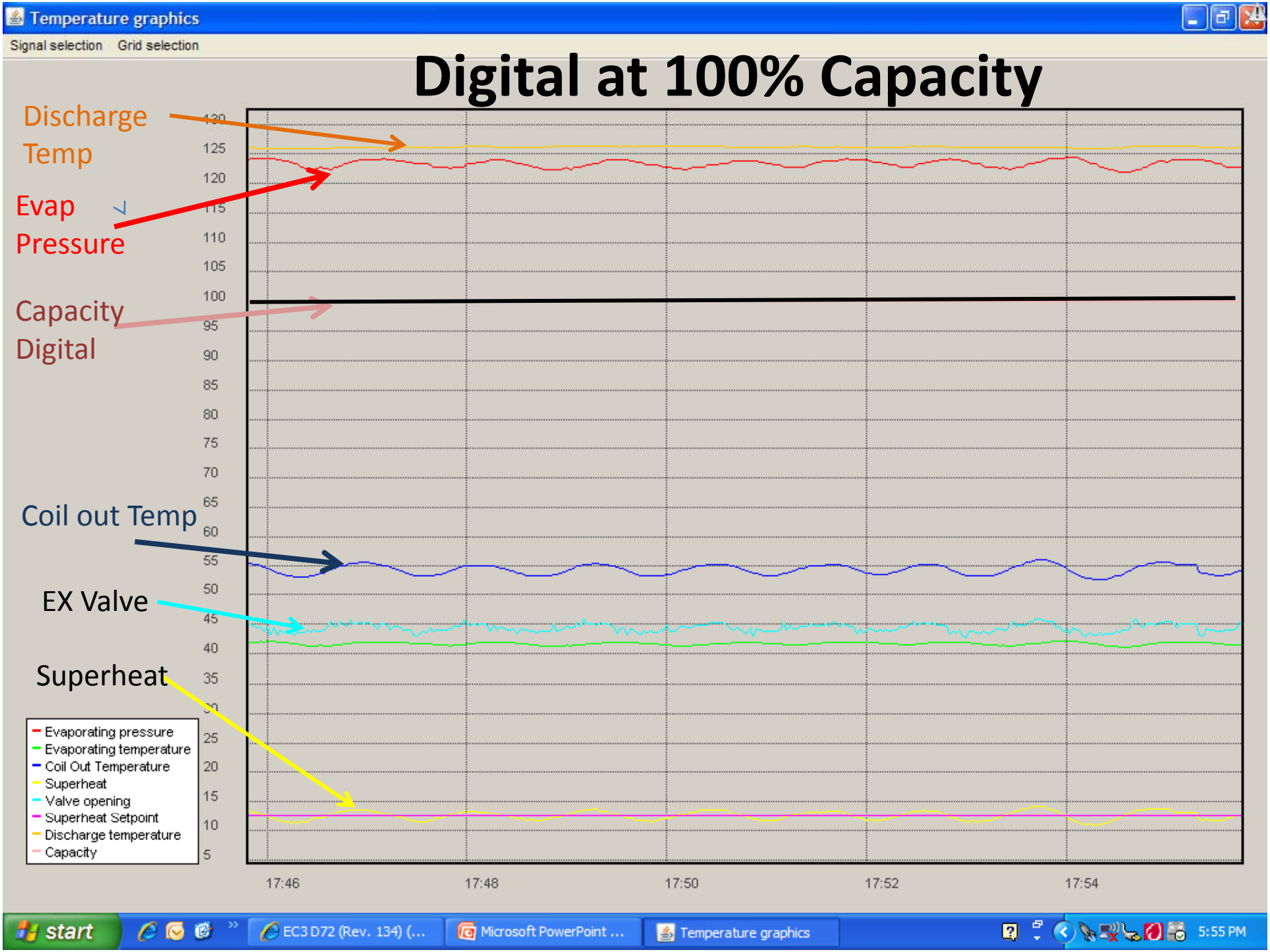
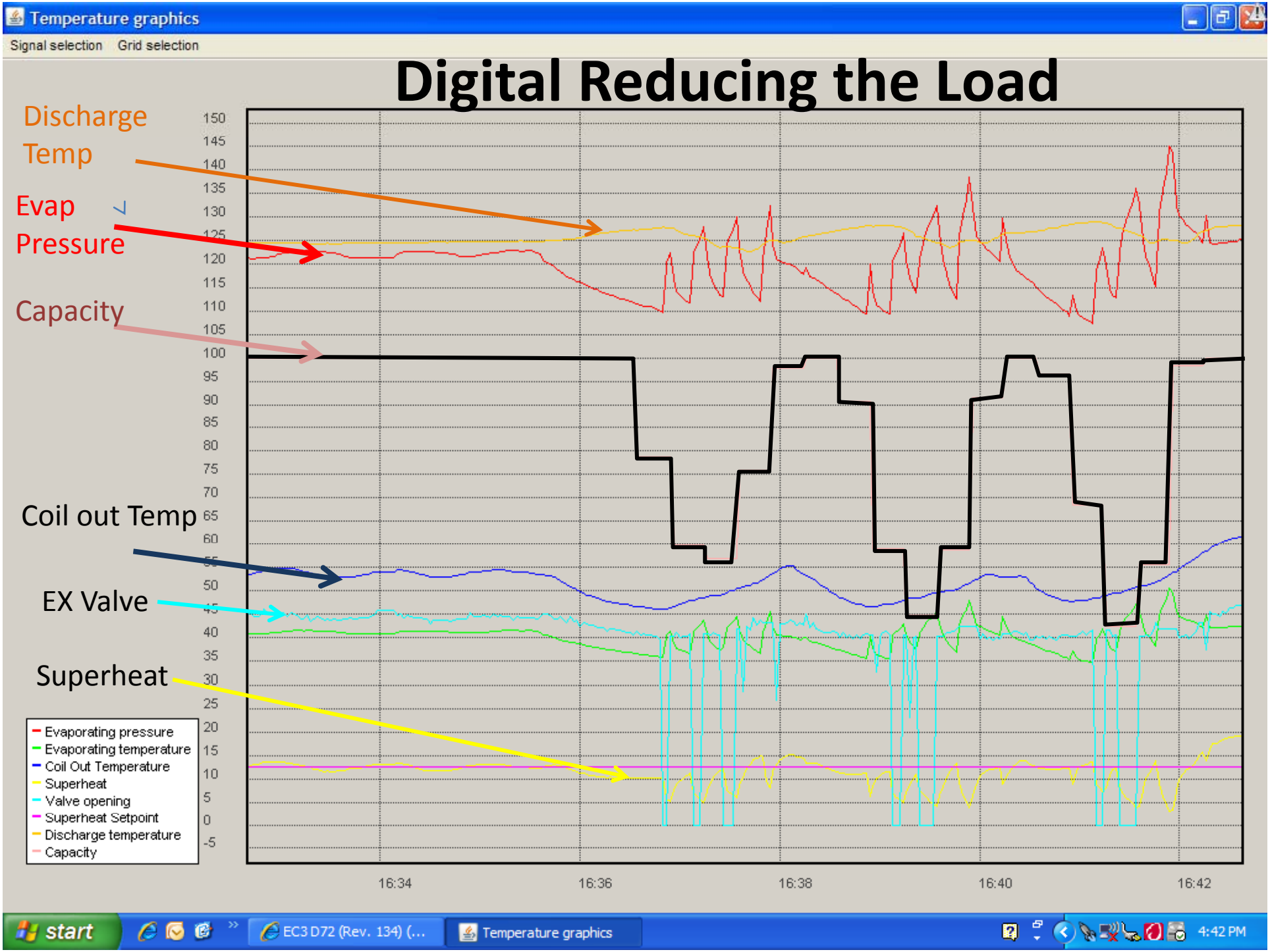
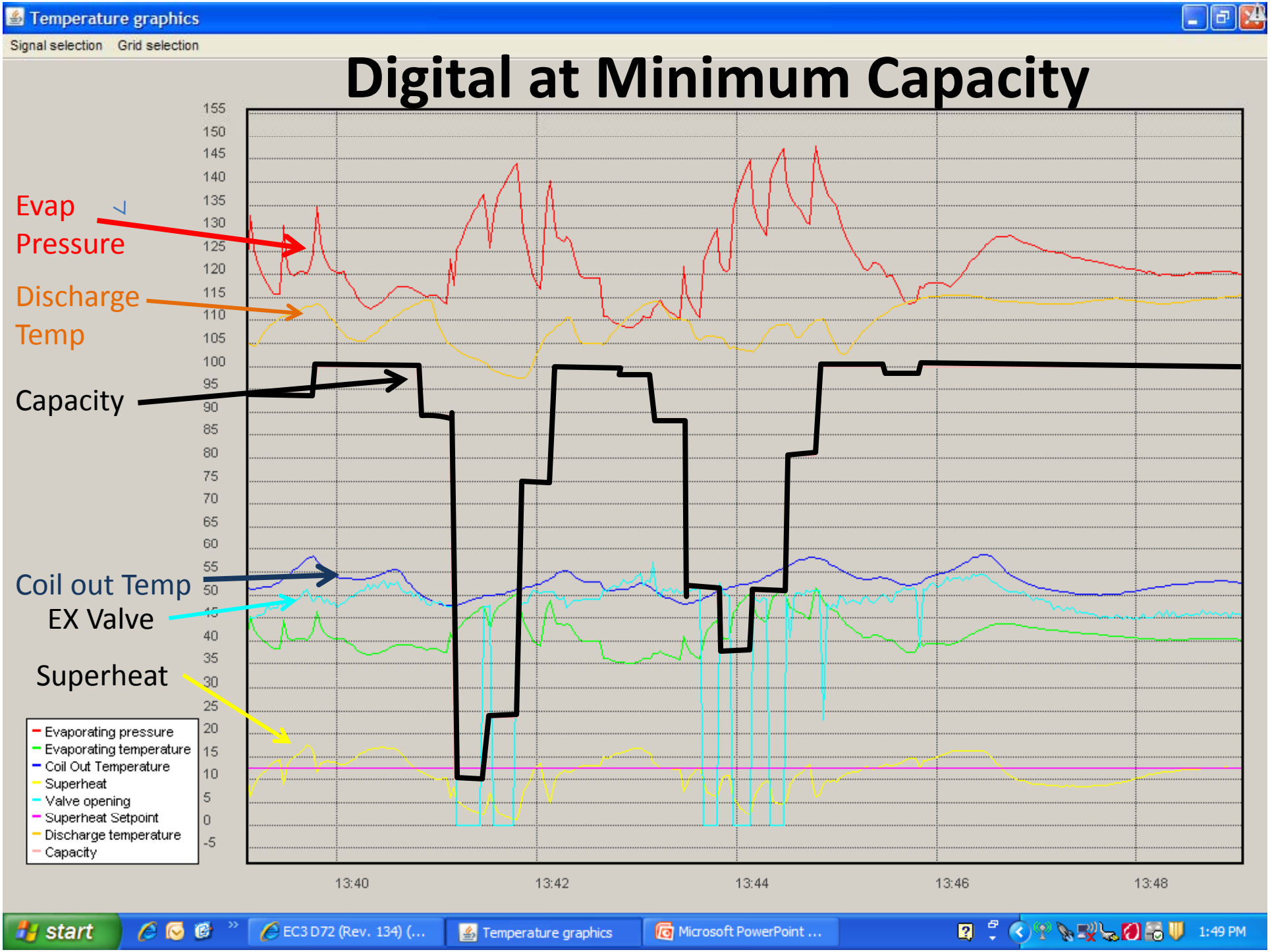
Digital at 100% Capacity



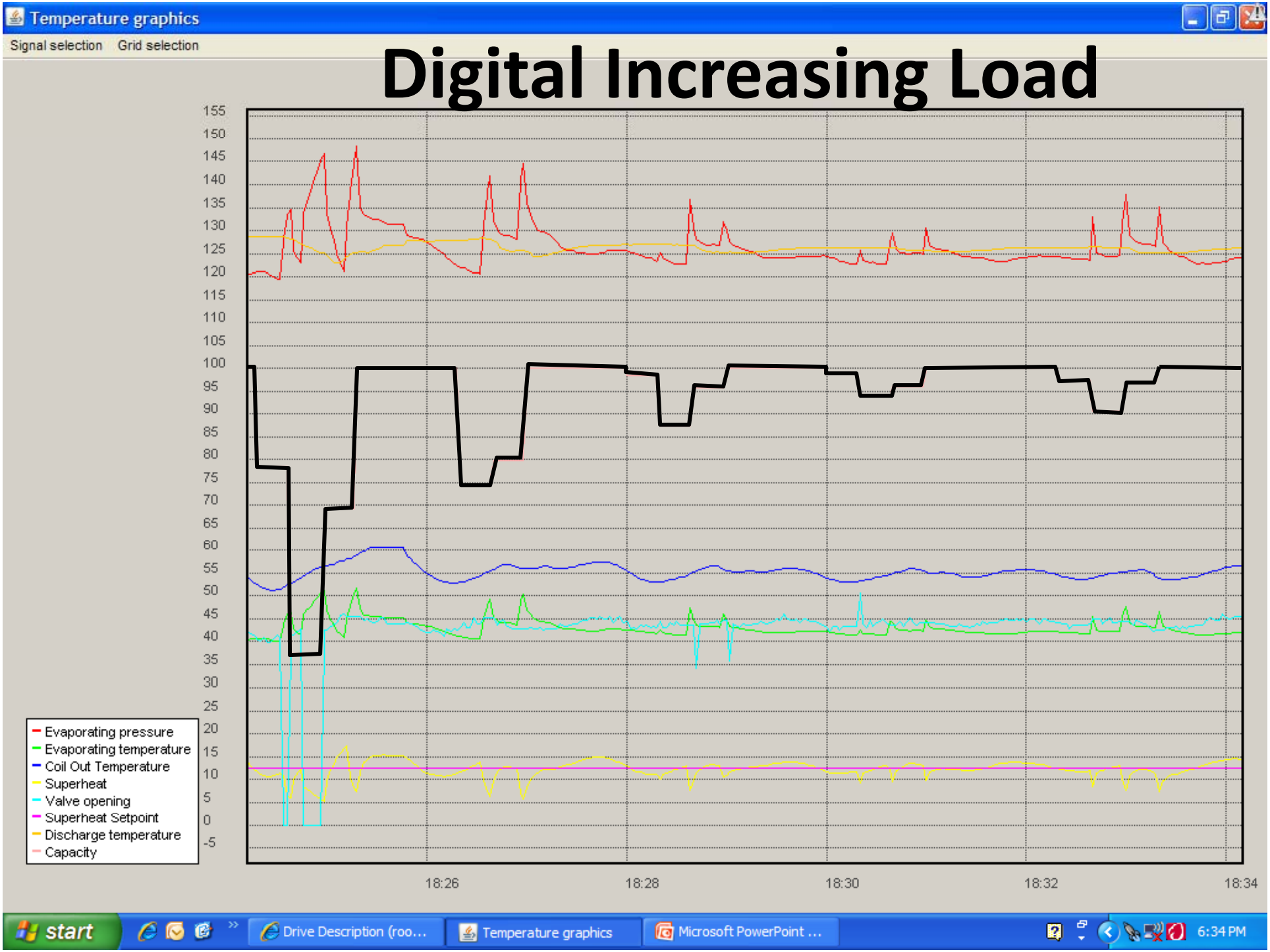
Digital Reducing the Load



Digital at Minimum Capacity



Digital Increasing Load



Emerson's Capacity Modulation Solution

Condenser VFD

Digital Scroll (10 to 100%)

Superheat & Digital Scroll Control

Electronic Valve (10 to 100%)

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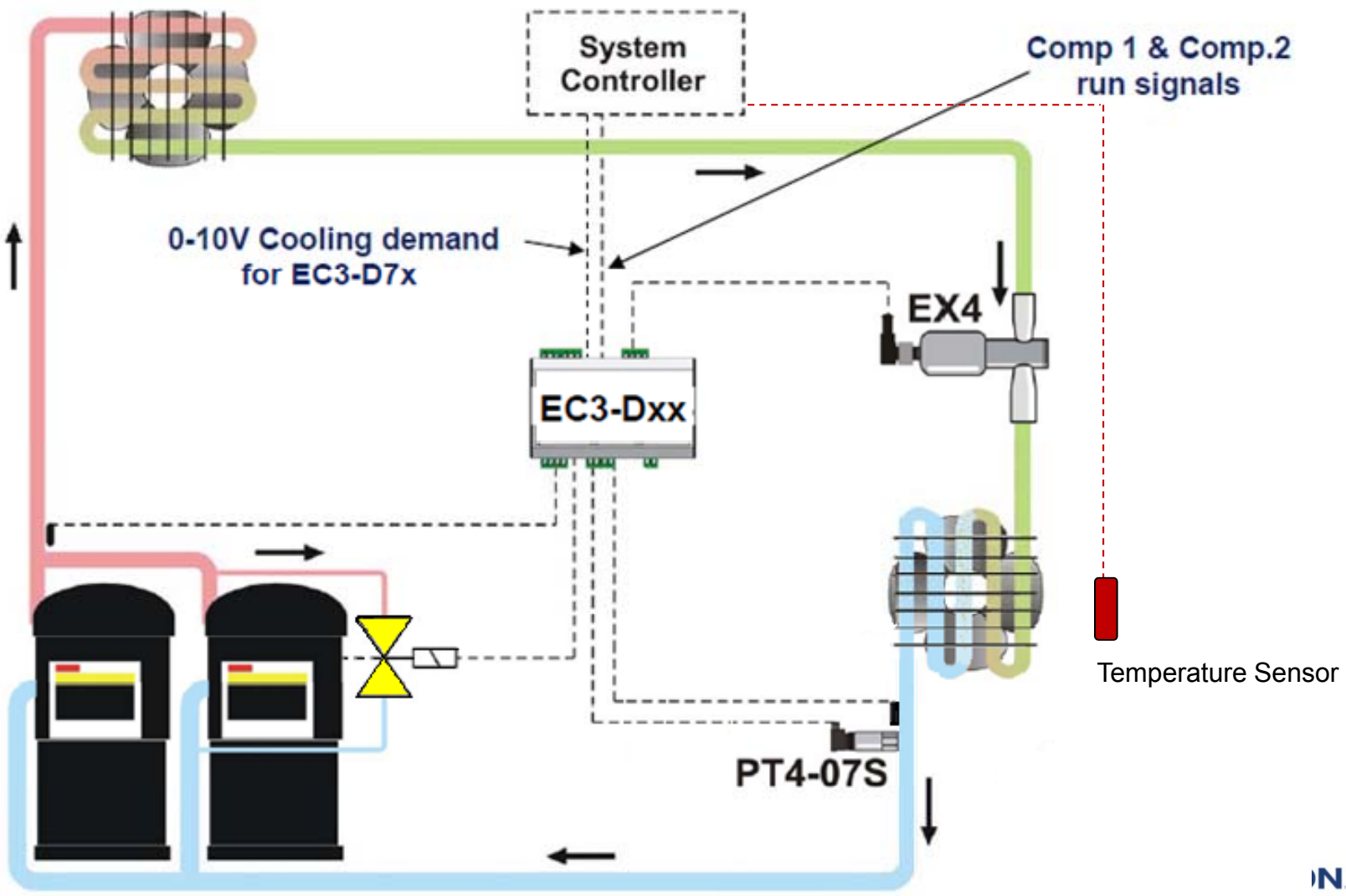
Digital Scroll System Diagram



EC3-D72
Superheat and Digital Synchronization Controller

Option 1

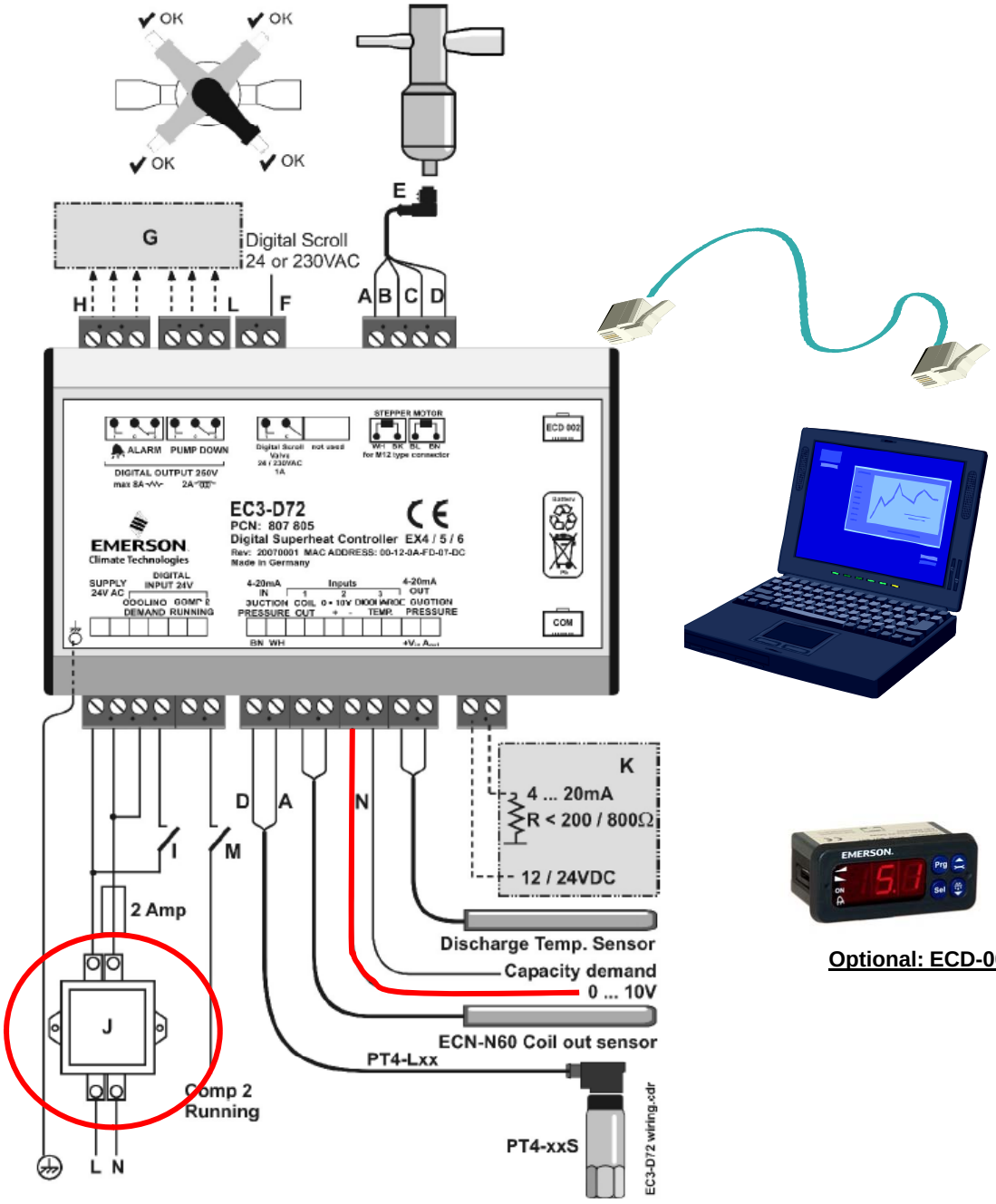
Direct connection to an individual PC

- **It requires “cross over/link” cable**
- **Configuration of TCP/IP of PC**
  - **TCP/IP Network knowledge required**

Option 2

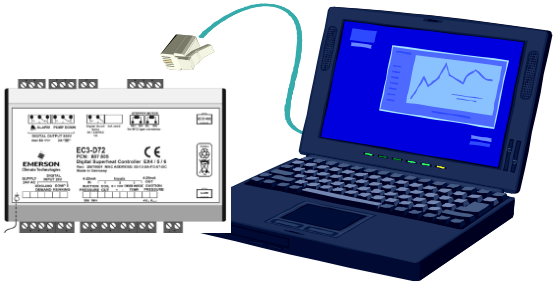
Router with DHCP-Server Automatically assign dynamic IP-address for PC and EC3-X32

Router



Optional: ECD-002

EC3-D72
Superheat Controllers with Built in Synchronization Control for Copeland Digital Compressors
Set Up



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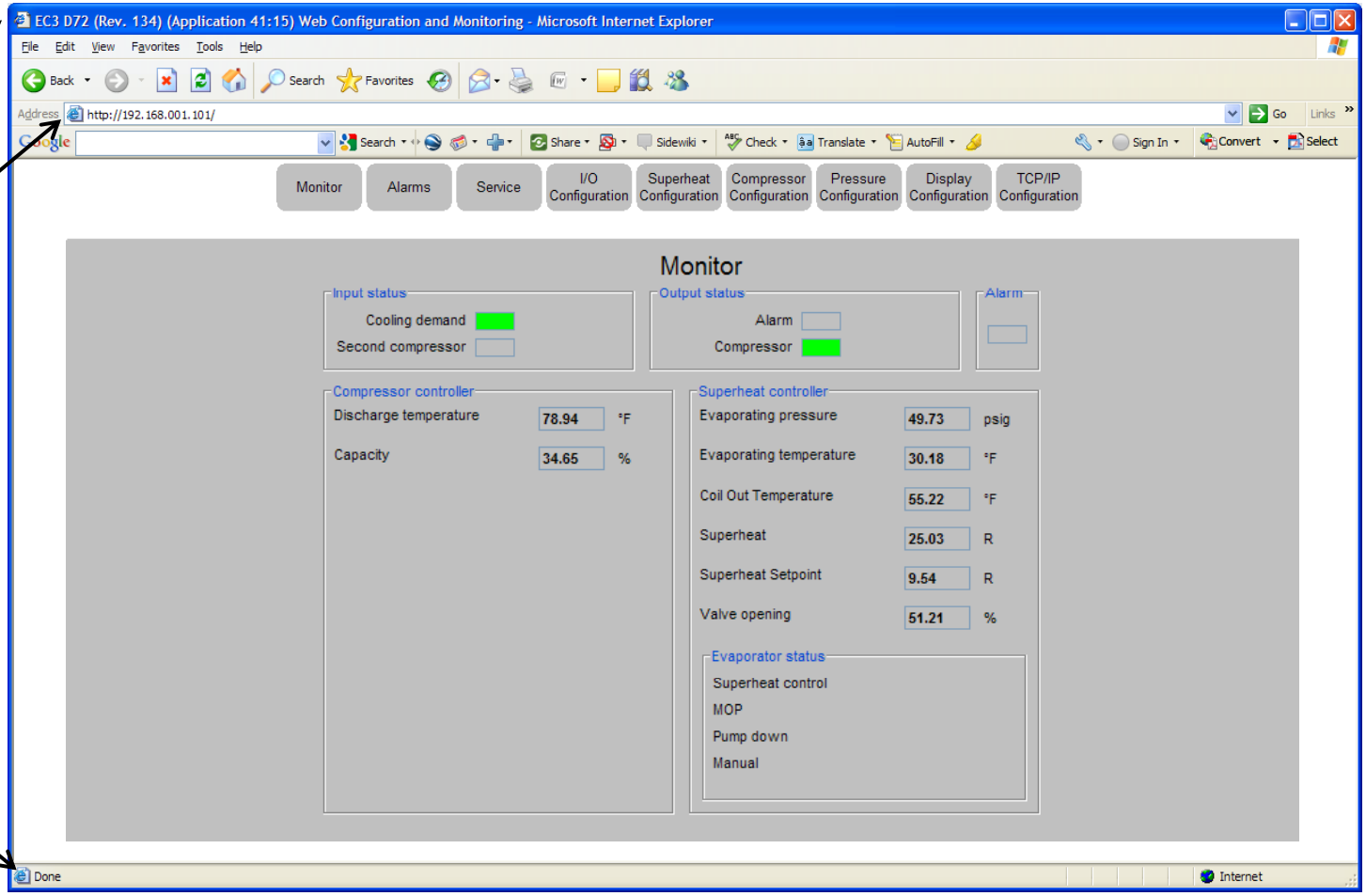
Default Monitoring Page “Read Only”

Model and Revision Number

IP address
Use Discover IP Utility Tool
192.168.001.101

Moving Icon Shows Web Page Is Active, Icon Change 1/sec.



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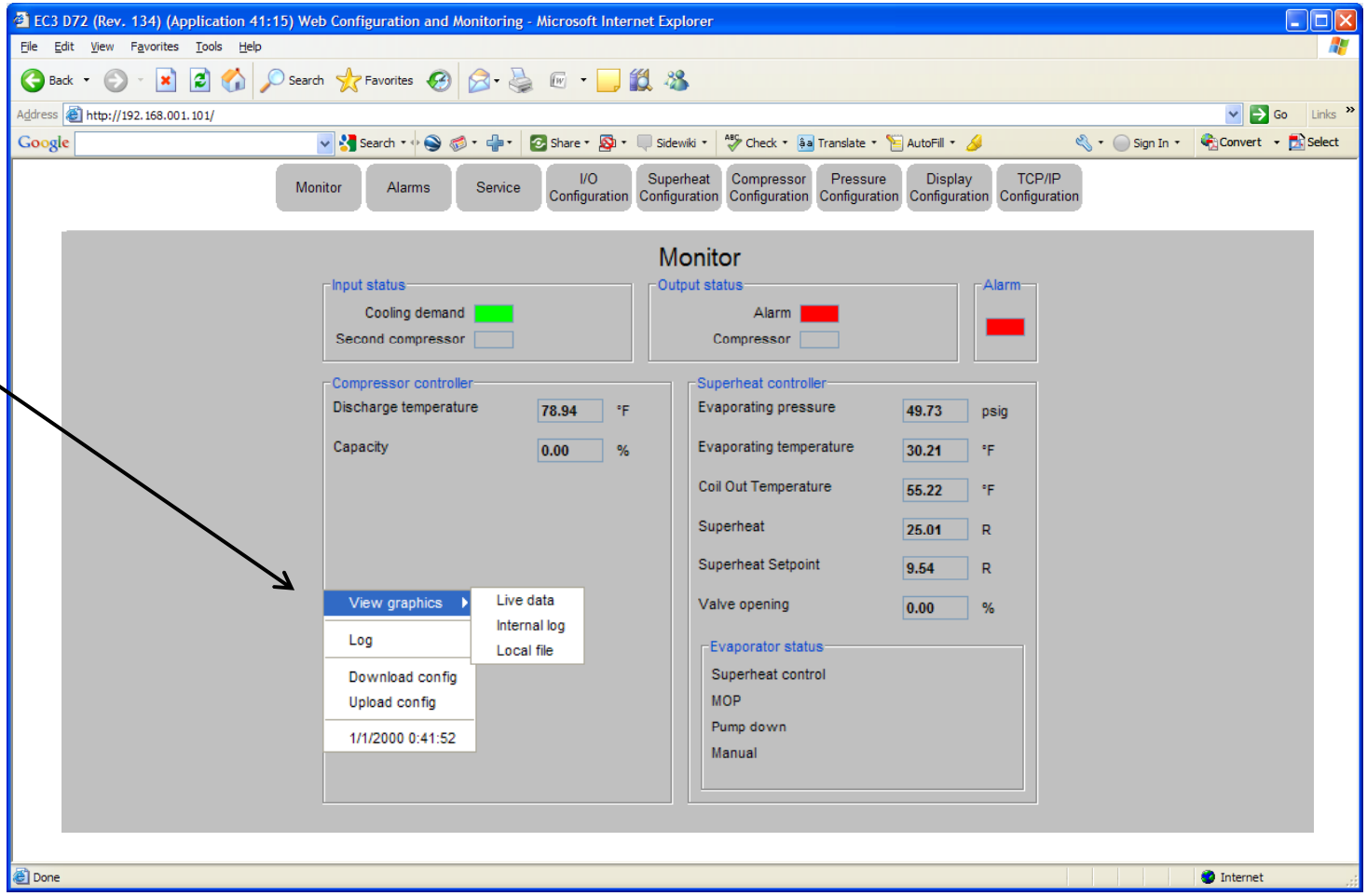
Default Monitoring Page "Pop Up Menu"

Right Mouse Click Within Active Window To show "pop up" Window

Live Data Rolling 10 min Graph, Only Active when Monitoring Page Is Open

Internal Log: 30 day 15min. Log of Suction Pressure

Local File: Visualization Of all Files Stored Local on PC



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Digital Technologies Seminar

Thank You

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