Natural Refrigerant Training Summit

Building a Sustainable Workforce

E3 Supervisory Controls with CO2 Applications & New CC200 Case Control

Brent Cheshire

Copeland

NORTH AMERICAN Sustainable Refrigeration Council

COPELAND

E3 Supervisory Controls with CO_2 Applications & New CC200 Case Control

NASRC – Natural Refrigerant Training Summit

St Louis, MO

November 14-16, 2023

NATE Certification Please Fill Out Sheet Provided

Official Recognized Provider Attendance Record

Submit to: NATE • attn: Recognized Provider Recorder
2111 Wilson Blvd. Suite 510 • Arlington, VA 22201

Recognized Provider Name: Copeland Date:

Training Location, City & State: Plumbers & Pipefitters Local 562 Training Center

Course Name: CO2 System Basics / Booster System Ops NATE Course #: 1212-0136

NATE Approved Hours: 2 Course Hours Total: 2

Instructions on filling out this form:

1. If additional sheets are needed, please use copies of this sheet, not blank paper
2. Course name, number and hours must match as submitted and approved by NATE.
3. Records must be received within 60 days to receive credit. Records received after this WILL NOT GET CREDIT.
4. To receive credit, the original roll and all information must be provided. No copies or faxes will be accepted.
5. If handwriting is unclear, credit will not be given.
6. Instructors hours will only be recorded in instructors box at bottom.
7. This record must be used for single-day courses. Multi-day courses use a different form.

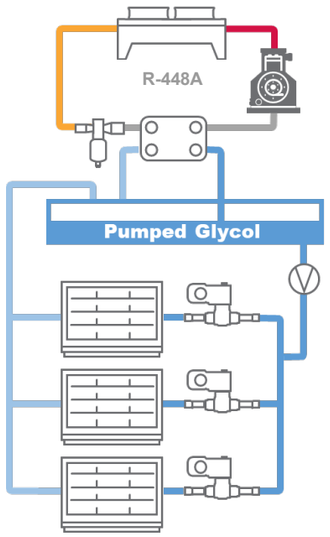
Technician Name Please print as it appears on your NATE ID card	**NATE ID #** **Must be included to receive credit**	**Signature**

CO_2 Refrigeration Systems

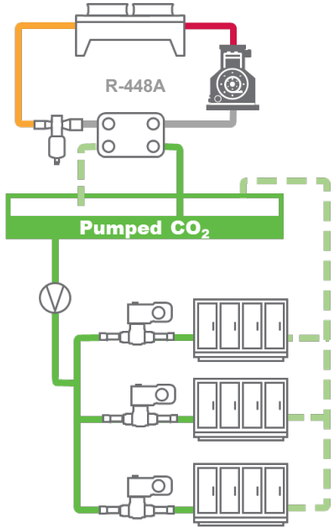
Each System Type can be Effectively Managed With Copeland E3 Platform Like DX HFC Systems

Secondary CO_2

Medium Temp
Glycol Pumped Secondary

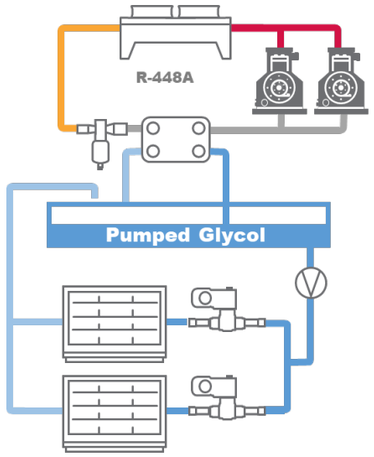


Low Temp
CO2 Pumped Secondary

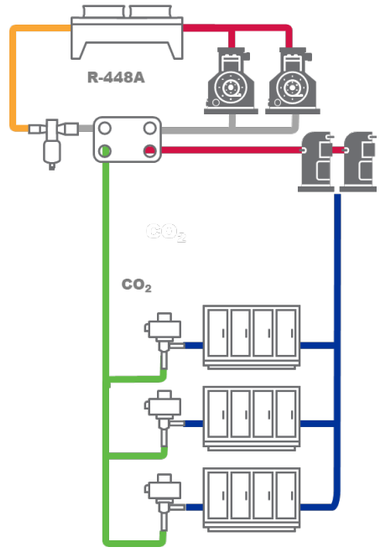


Cascade CO_2

Medium Temp
Glycol Pumped Secondary

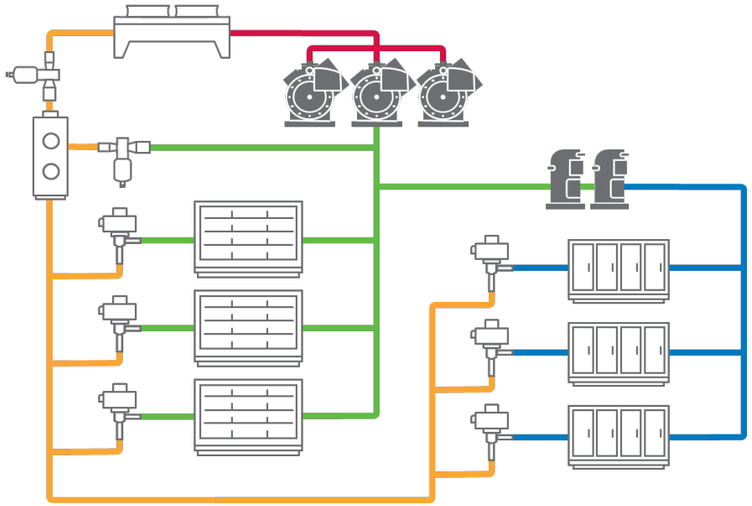


Low Temp
CO2 Cascade



Transcritical CO_2

Low & Medium Temp
Transcritical CO2 Booster



✓ **Primary Focus Today**

Unique Control Application vs. Traditional DX HFC System

- CO_2 Standstill Pressure Considerations
- **Heat Exchanger Superheat Control**
- Pump Skid Control
- **Electronic Expansion Valves/ Case Control**
- Subcritical CO2 Compressor Envelope
- **Flash Tank & Gas Cooler Management/Optimization**

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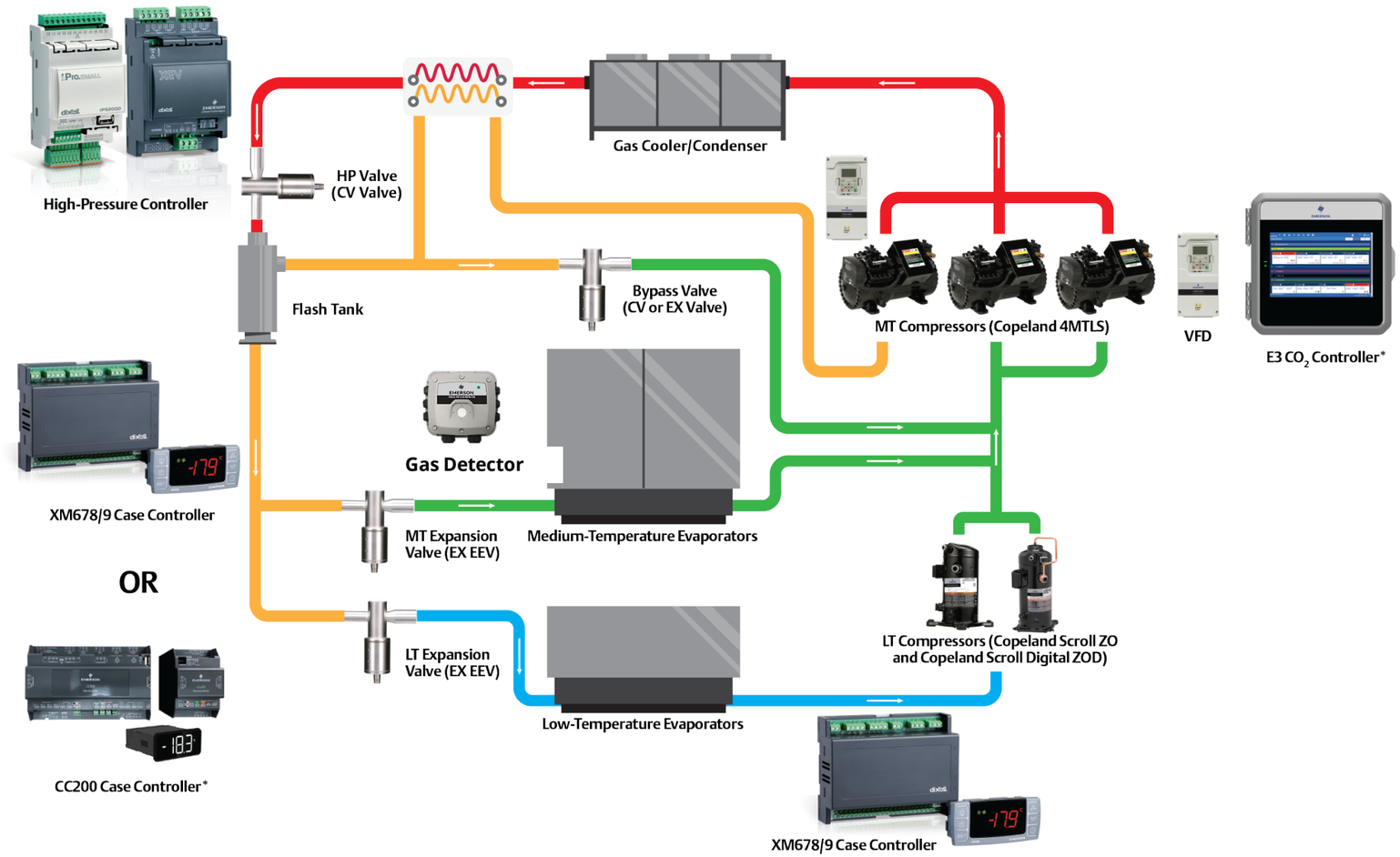
Transcritical CO2 Booster System



System Diagram

R-744 (CO_2) system that uses only CO_2 for medium-temperature and low-temperature refrigeration loads.

Integrated Solutions

Deliver seamless system integration that enables maximum system reliability, efficiency and simplicity.

Enhanced visibility of overall system through E3 CO_2 controller.

Collaborating with Strategic Channel Partners to Simplify CO2 Refrigeration with a Full Suite of Integrated Solutions

End Users

- Consultants
- Original Equipment Manufacturers
- Contractors
- Wholesalers

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Facility Controls and Enterprise Services and Software

Component Controls

Refrigeration Components

Integrated Solutions & Project Services

Insights

Controls

Devices, Compressors, Valves

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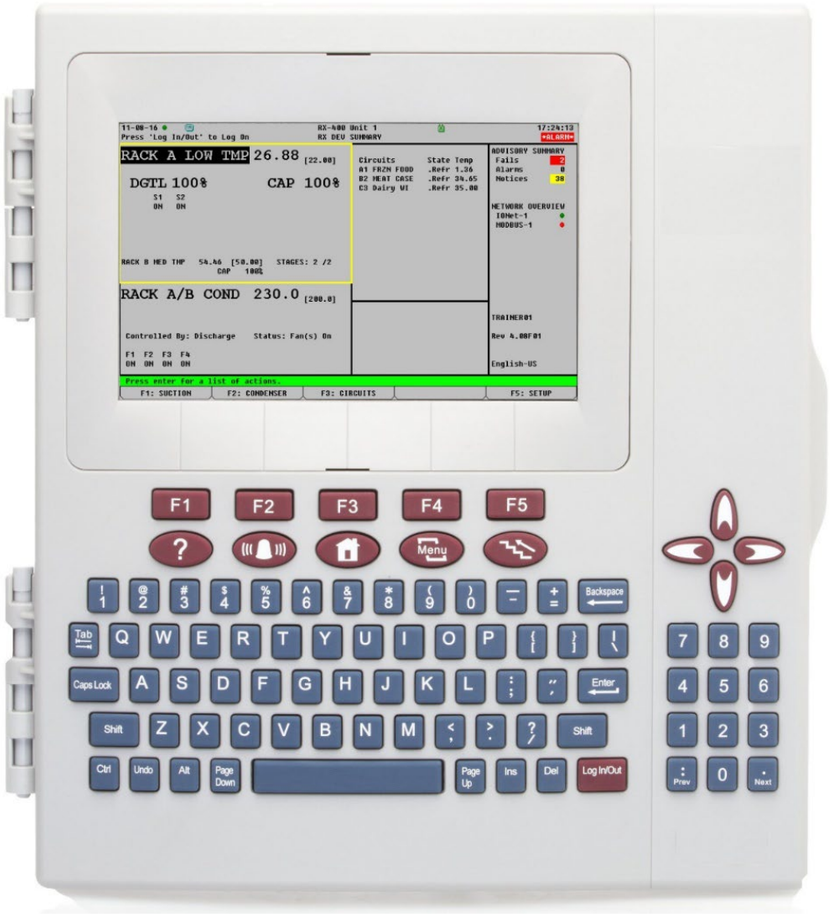
E3 Controller

E3 vs E2

E3 front view

E2e front view



E3 Controller is a Drop-in Replacement for the E2 Product

True E2 Drop-in Replacement

- **Identical** wiring holes, mounting points and vents
- Enclosure fits into existing panel cut-out

Updated Integrated Display

- **Larger** 10” capacitive color touch-screen
- User-friendly interface with on-screen keyboard

Equivalent COM Port Configuration and Power Connections

- **Total of four COM ports** for connected devices with two isolated COM ports
- Easily swap out an E2 with no need for rewiring

Fully Backward Compatible With MultiFlex and IONet Boards

E3 Technical Specifications

Operating Temperature	-40°F to 149°F (-40°C to 65°C)
Operating Humidity **Storage Humidity**	5% - 95% RH non-condensing at 90°F 5% - 100% RH
24 VAC	24 VAC ±20%, 50/60 Hz, Class 2, 80VA
Dimensions	12” L x 12.5” W x 3.75 H”
4 RS485 ports	COMM 1 = RS485 Com 2 A and B COMM 2 = RS485 Com 6 (isolated) COMM 3 = RS485 (isolated) COMM 4 = RS485 Com 4 A and B
2 Ethernet ports	Ports 0,1
2 USB ports	J2, J3

Hardware Enhancements and Modified Applications

Hardware Enhancements

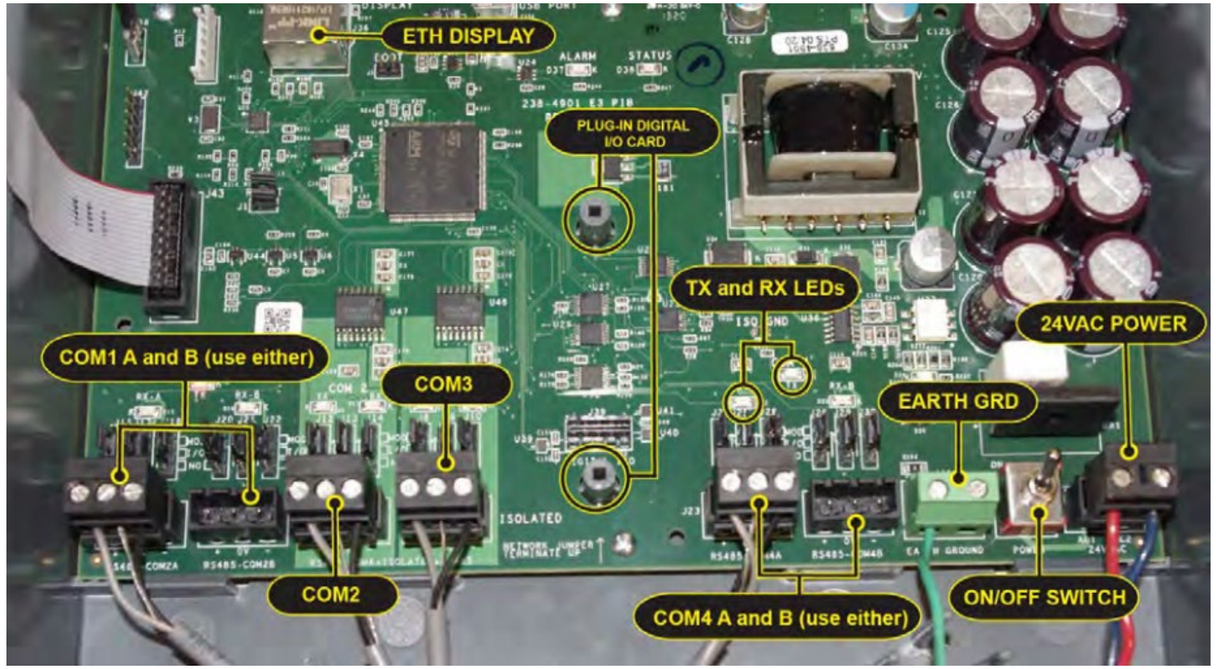
E2 Hardware	E3 Hardware
500 MHz Single Core	1.6 GHz Quad Core
128 MB RAM	2 GB RAM
1 Ethernet Port (1 MAC/PHY)	2 Ethernet Ports (2 MAC/PHY)
3 RS-485 COM Ports	4 RS-485 COM Ports (2 Isolated)
Plug for Optional I/O Daughter Card	Plug for Optional I/O Daughter Card

Modified Applications in E3

E2 Application Name	New E3 Application Name
Eng. Unit Converter	Localization
Heat/Cool Control	Thermostat or Sensor Control
Power Monitoring	Utility Monitoring
Pulse Accumulator	Utility Monitoring
Time Schedule	Scheduler

Twelve times faster processing power and 16X additional memory built in to E3 for faster response time and increased storage.

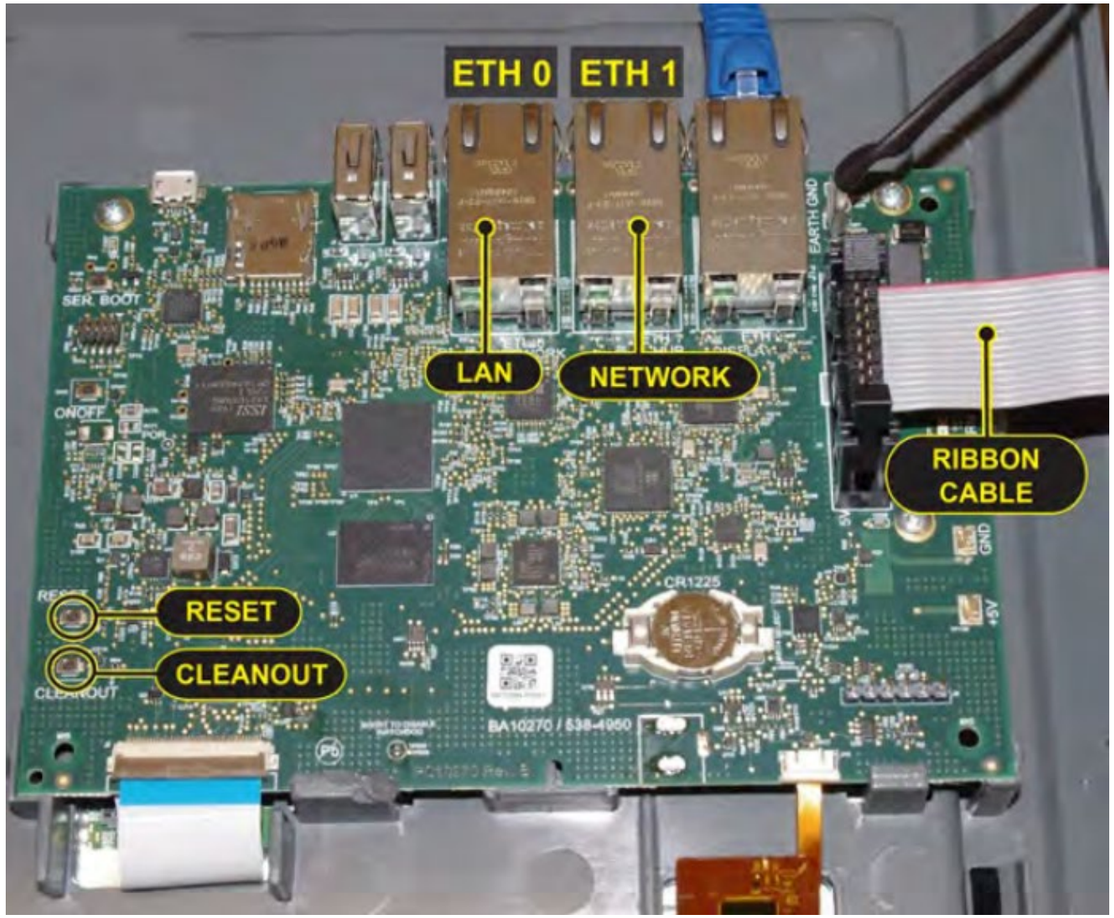
E3 Power Interface Board (PIB)



- 24VAC Transformer Class II
- (4) Universal Communication Ports
  - IO Net, ModBus, BACnet
- Optional Plug-In IO Card

Operating Temperature	-40°F to 113°F (-40°C to 45°C) **Tested to UL60730-1 standard*
Operating Humidity **Storage Humidity**	5% - 95% RH non-condensing at 90°F 5% - 100% RH
24VAC	24 VAC ±20%, 50/60 Hz, Class 2
Dimensions	12" L x 12.5" W x 3.75" H
4 RS485 ports	COM 1 = RS485-COM2A and RS485-COM2B COM 2 = RS485-COM6<ISOLATED> COM 3 = <ISOLATED>RS485 COM 4 = RS485-COM4A and RS485-COM4B
2 Ethernet ports	ETH 0, ETH 1
2 USB ports	J2, J3
External Pollution Rating	All Models: Pollution Degree 3
Rated Impulse Voltage	2500/4000V
Lithium Battery Marking	Caution: The cell used in this device may present a fire or chemical burn hazard if mistreated. Do not disassemble, heat above 212°F (100°C), or incinerate.

E3 Motherboard



- Customer LAN Network (ETH0)
- Service LAN Connection (ETH1)
- Reset and Cleanout buttons

Communication

Device Type	Purpose	Communication Protocol
E3	System Manager (Compressor, Gas Cooler Fans, Circuit Management, Alarms)	Ethernet (Remote) IO Net, Modbus, BACnet (Devices)
MultiFlex Boards	Input/Outputs	IO Net
High Pressure Controller	HPV & BGV Controller	Modbus
XM678D/XM679K	Case Controller	Modbus
CC200	Case Controller	Modbus or BACnet
MRLDS-450	Leak Detection	Modbus
EVM/EVH	Variable Frequency Drive	Modbus or BACnet

BELDEN

Product: 8761

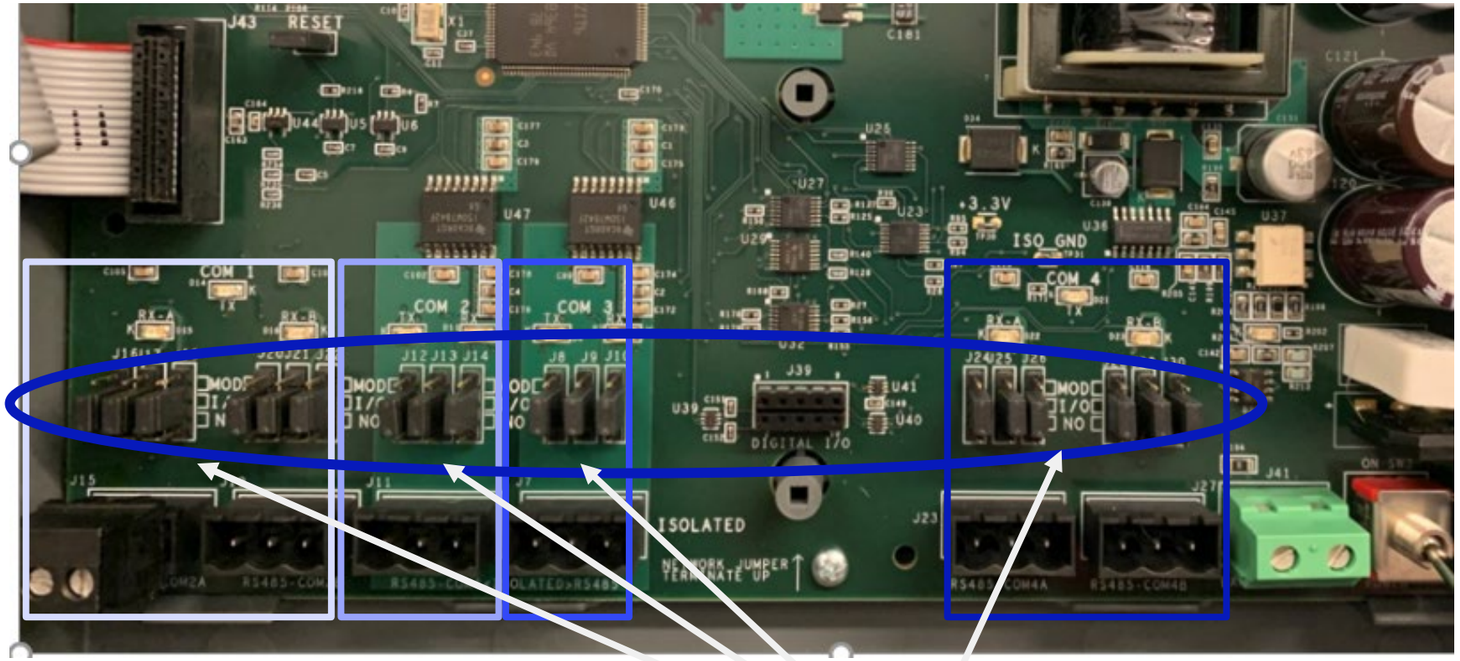
Electronic, 2 C #22 Str TC, PE Ins, OS, PVC Jkt, CM

Request Sample

Product Description

Electronic, 2 Conductor 22AWG (7x30) Tinned Copper, PE Insulation, Overall Beldfoil® Shield, PVC Outer Jacket, CM

E3 Comm Ports and EOL Termination Jumpers



- 150 ohm resistor
- Both ends of comm network loop must be terminated
- IO Net, Modbus, BACnet
- Use Termination Jumpers on E3

https://www.copeland.com/documents/026-4830-termination-blocks-installation-instructions-en-4845978.pdf

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Supervisory Control Software Differences

Features and Benefits

Control Software Features

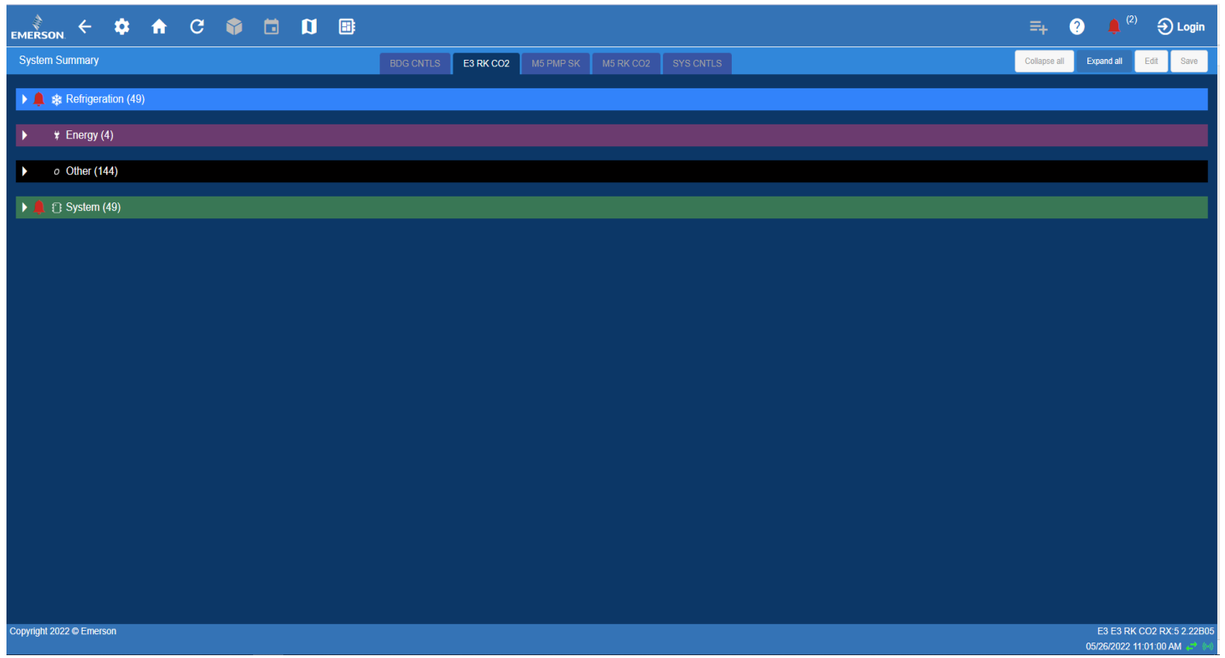
Software Features

Supervisory Control Software provides the Same Control Function as E2, and includes new:

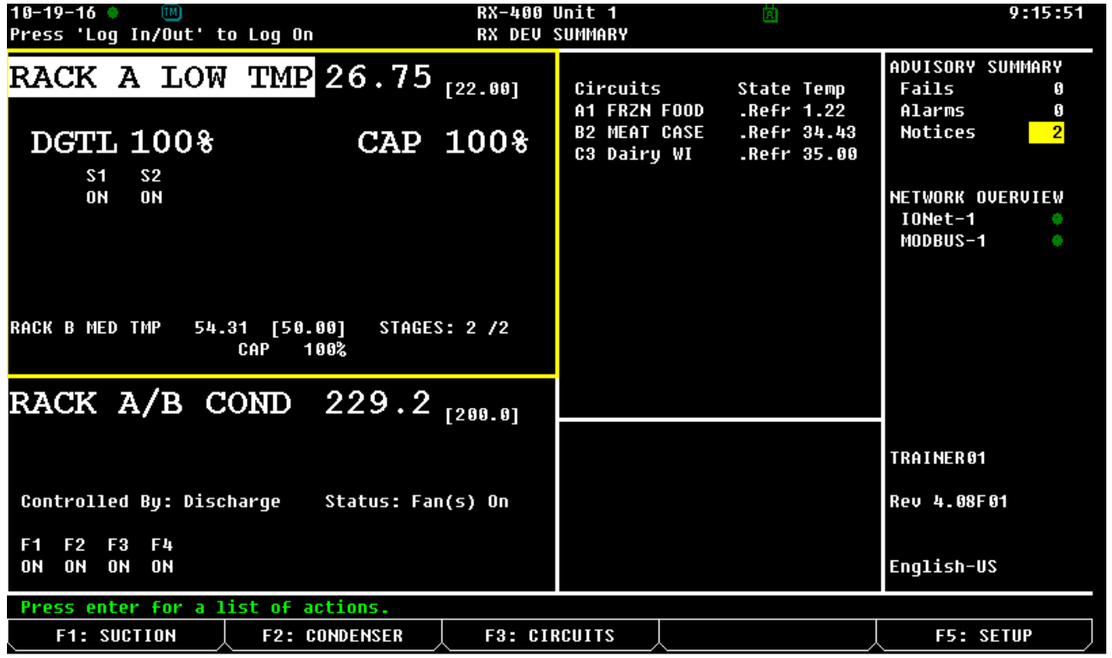
- Faster Response and Navigation
- Text and Email Alerting
- Prioritized Alarms
- Floor Plan Views
- Aggregate Devices
- Enhanced Upstream Communication Capabilities
- Intuitive Navigation with Graphical Interface
- Increased Security
- Increased Network Functionality
- No Additional Software Needed

E3 vs E2

E3 software: Supervisory Control Software



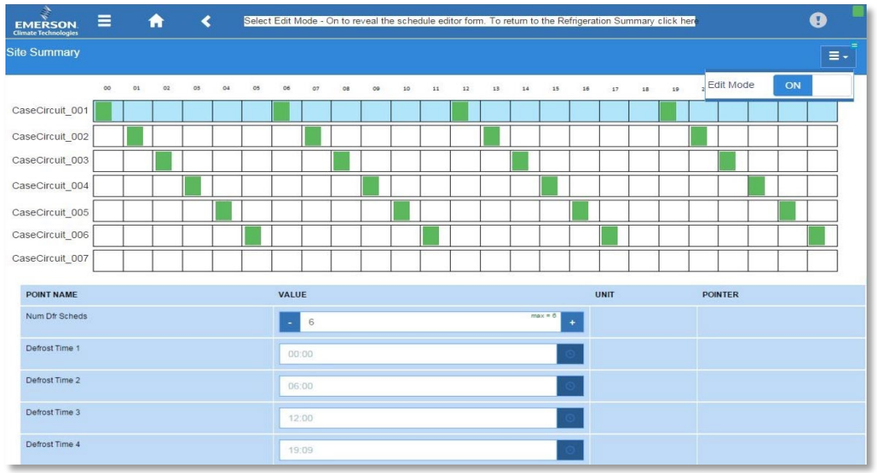
E2 Software:



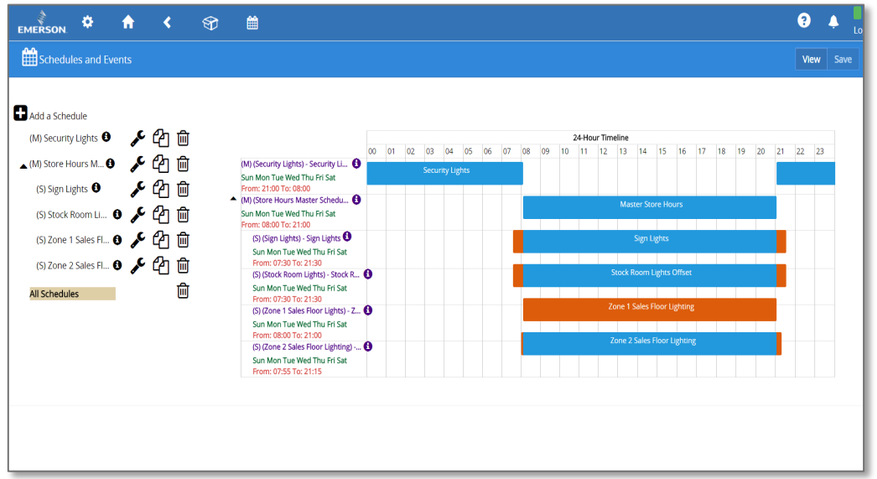
The E3 operates on a shared software platform with Site Supervisor. This new format offers intuitive navigation that technicians will find familiar and easy to use.

Supervisory Control Differentiators vs. E2

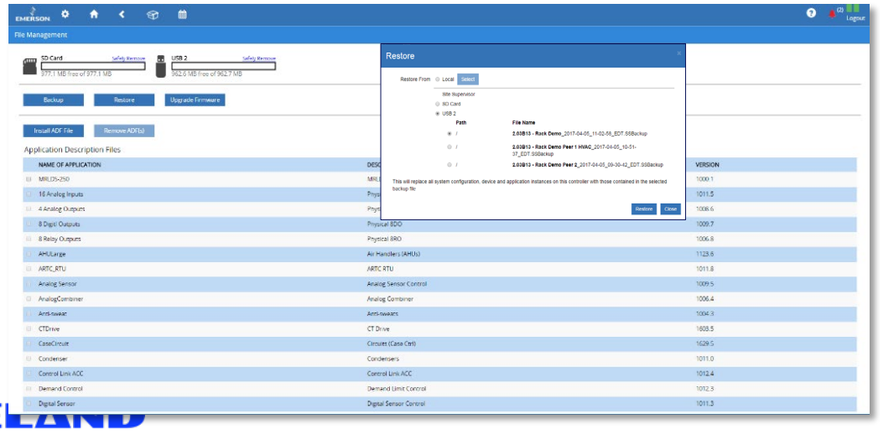
Graphical Defrost Summary



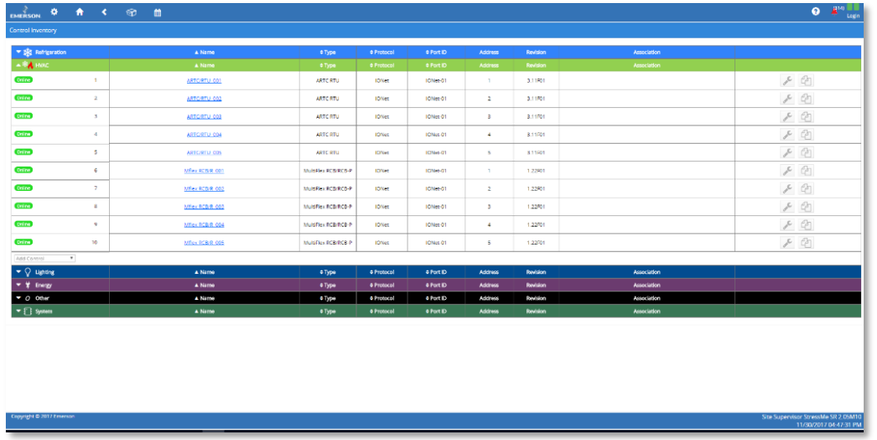
Graphical Schedule



File Management



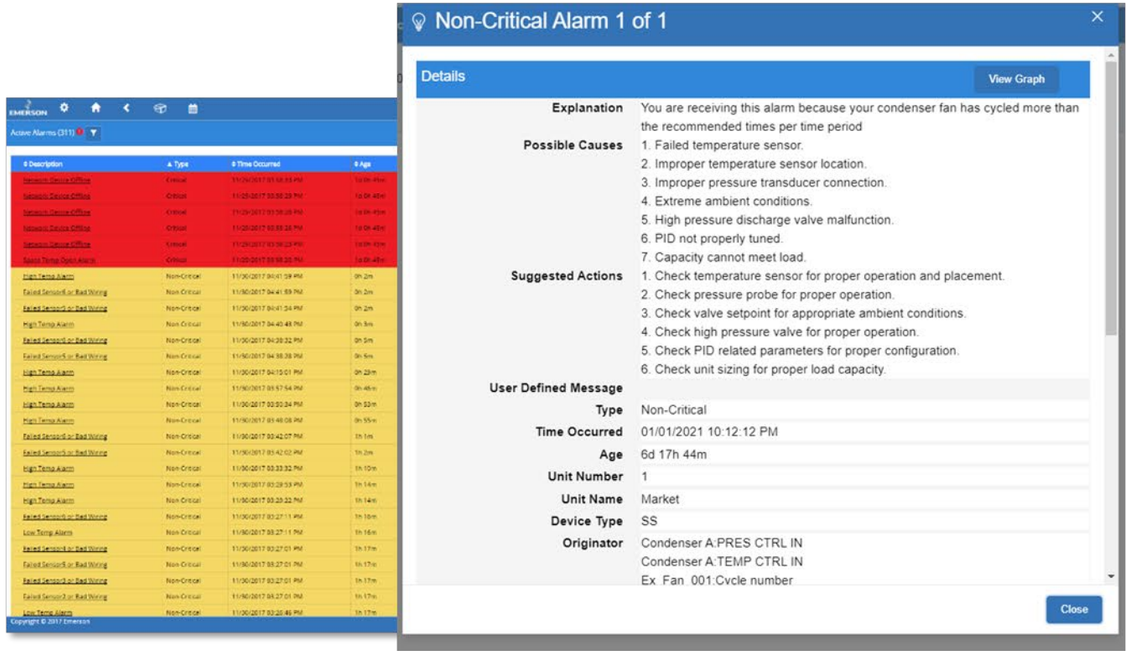
Site Inventory



Fast Troubleshooting via Smart Alarms and Custom Graphing

Smart Alarms

- Provides high level explanation, possible causes, and suggested actions to take. Can enter custom user defined messages.

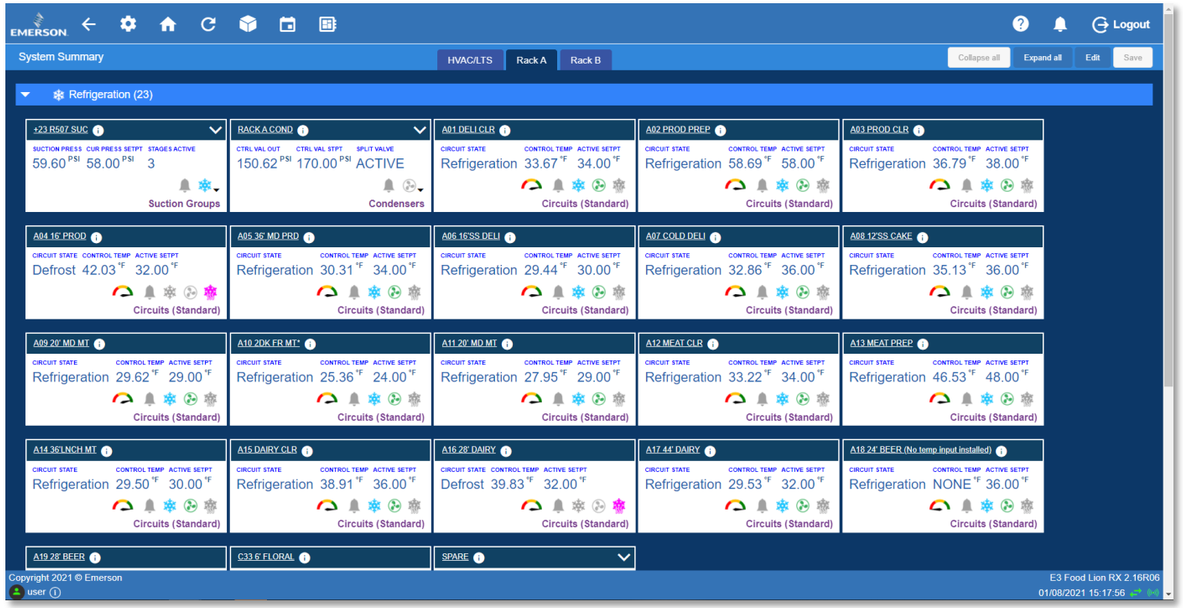


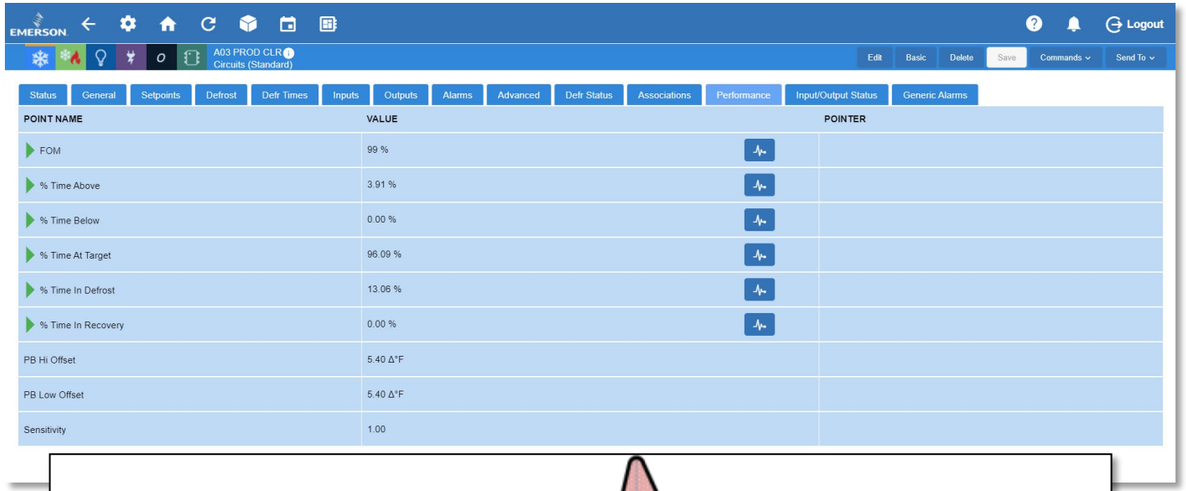
Graphical System Status Pages

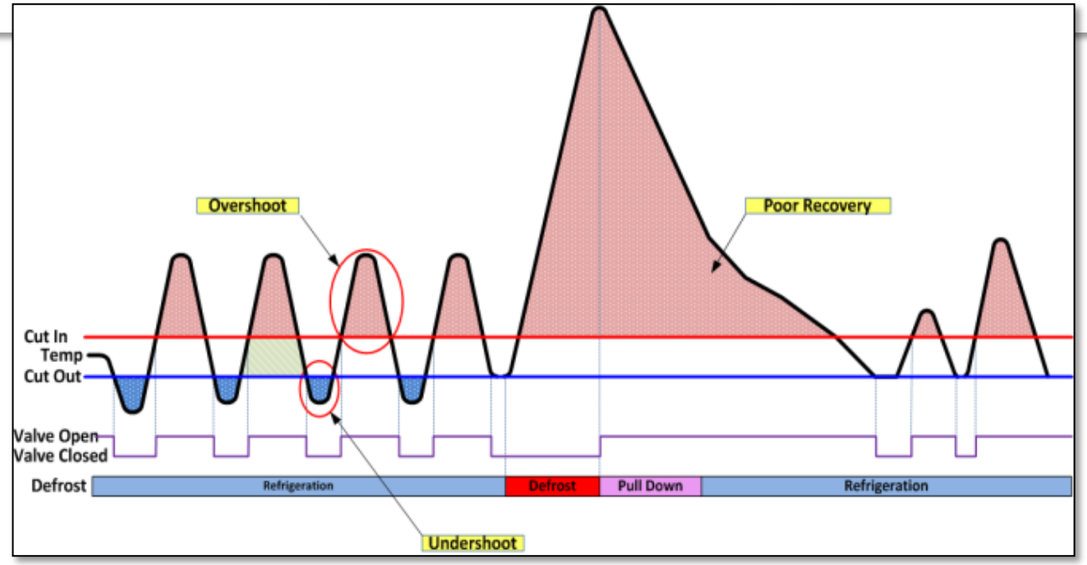
- Monitor system status and performance visually with graph-based reports that identify historical patterns, trends and issues.

Performance Meter, A Simple Way to Recognize Site Performance

- Case performance rolls-up into circuit performance. Graph or download performance data for detailed analysis. Up to 13 months of performance history for seasonal performance comparison is available.







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E2 VS E3

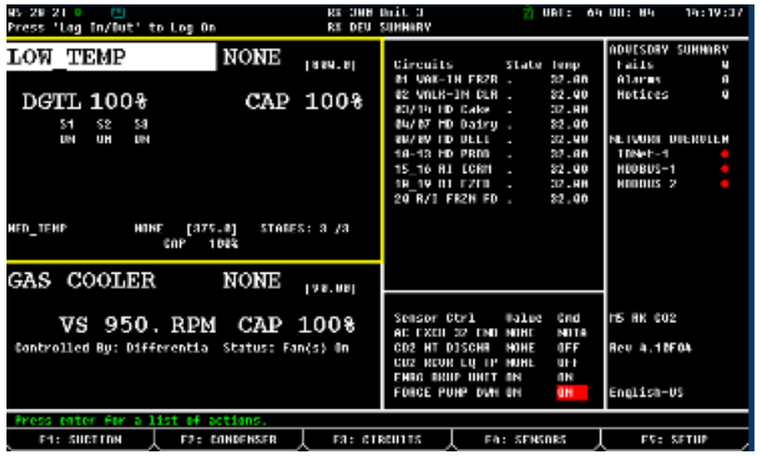
E2 Pro's	E3/SS Pro's
• 500+ CO2 System Installed Today with E2 • Familiar with Current Offerings • Field Service Technicians and Contractors are more Familiar with Operation, Programming, Troubleshooting • Already IT Approved • Compatibility with obsolete devices that may still exist in the field like Echelon and Comtrol device • E2's Alarm Management	• 12x Faster Response, • 16x additional memory, • Intuitive Navigation, • Text and Email Alerting, • Prioritized Alarms, • Floor Plan and Graphical Interface, • Enhanced Upstream Communication Capabilities, Increased Advanced Security, • Increased Network Functionality. • Additional Communication and Ethernet Ports. • Installation Flexibility • Faster System Programming and Commissioning • **CO2 Native Applications** • Smart Alarms • No Possibility to be Phased Out any time soon

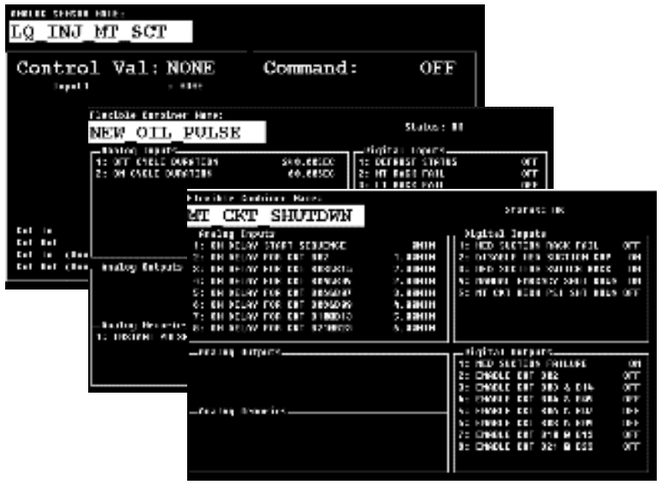
Dedicated CO_2 Application Reduces Programming Efforts and Complexity

CO_2 Suction Group	• Control of CO_2 Transcritical booster systems and parallel compression – centralized control provides ease of use
Advanced Compressor Superheat Management	• Liquid and/or hot gas injection
Load Management	• More precise control and recovery from out-of-range conditions
Enhanced CO_2 System Monitoring	• Additional advisories for out-of-range pressures/temperatures • Works with load management to provide better recovery
Oil Management	• Long compressor service life

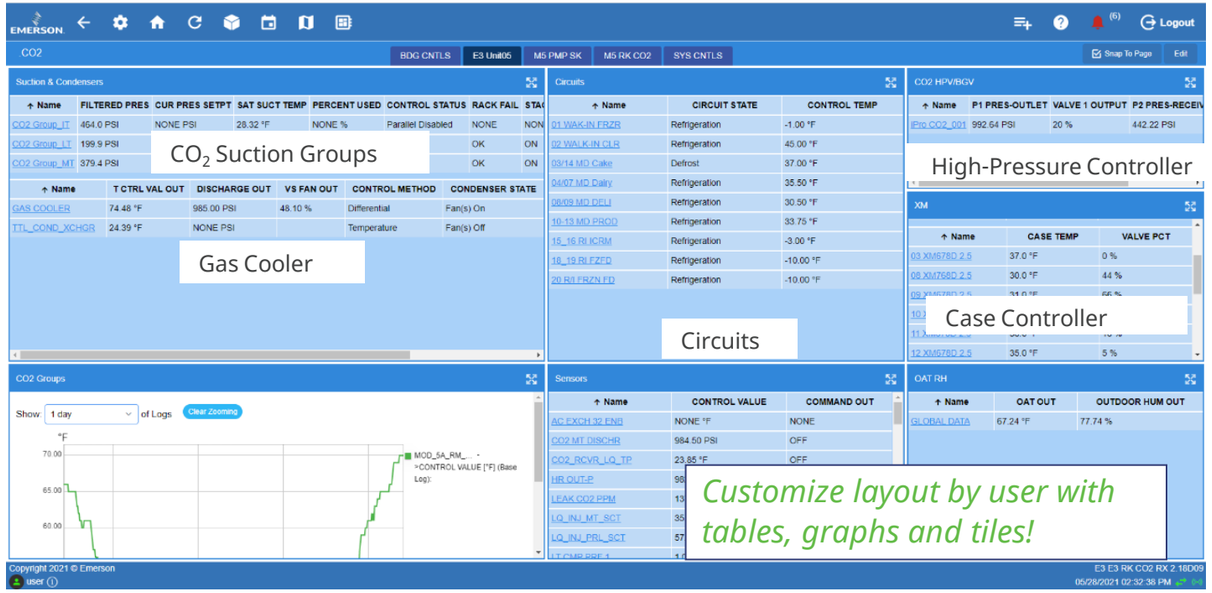
Overview of Entire CO_2 System Operation in One, Customizable View

E2e Control





New E3 for CO_2 Suction Group Control



High-Pressure Controller and Valve Driver

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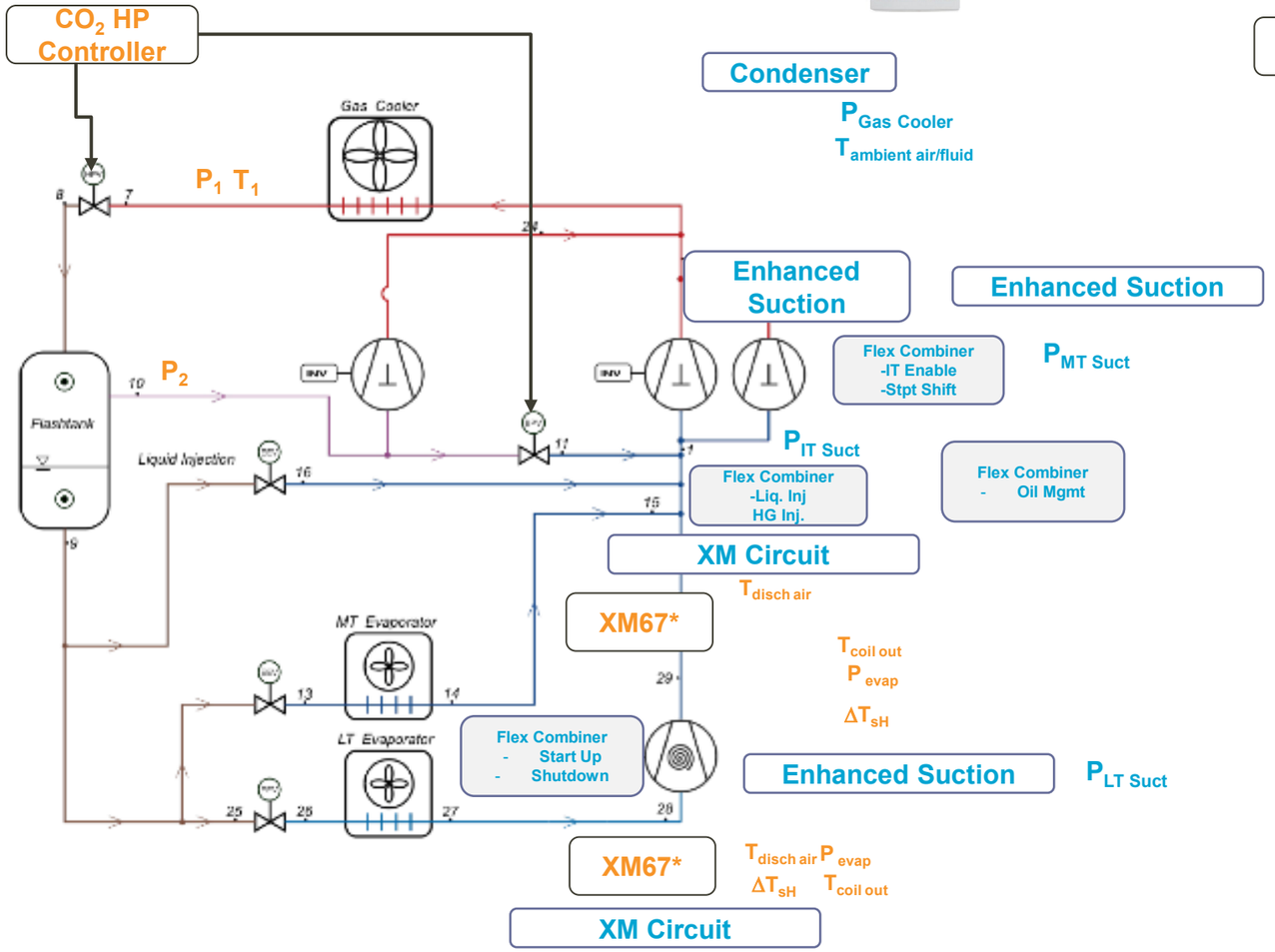
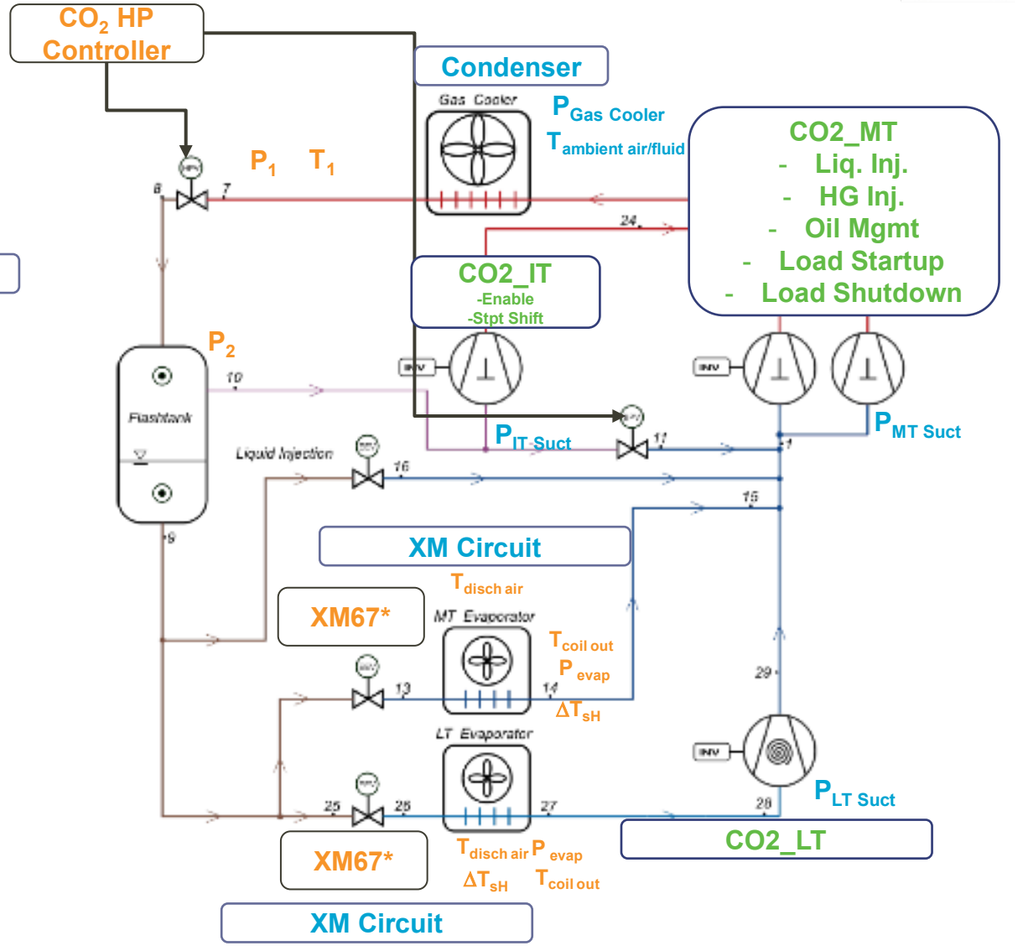
Overview Of Software Updates Going to E3 Supervisory System

Legacy E2e Control



New E3 Native CO2 Control



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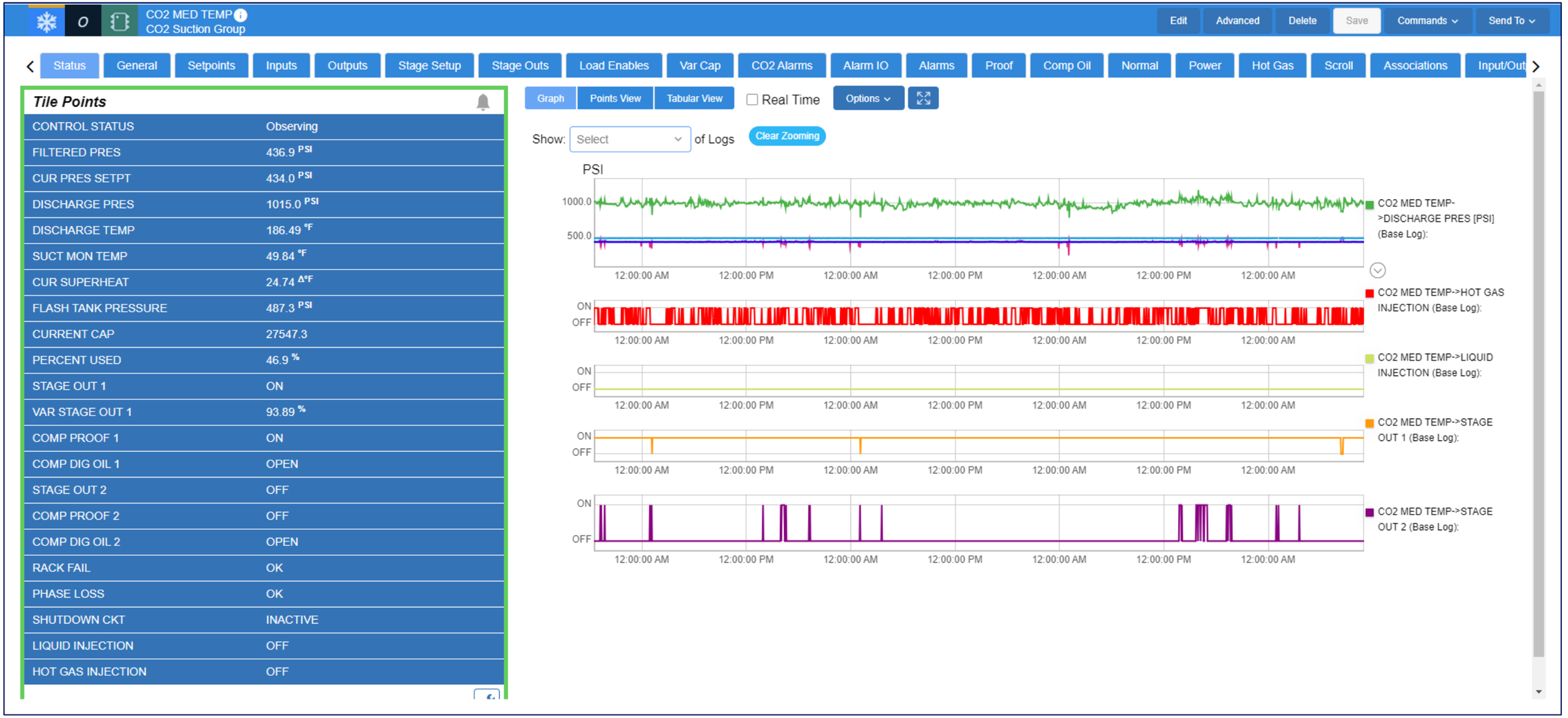
Successfully executed over 450 CO_2 systems with E2

E3 CO_2 Suction Group



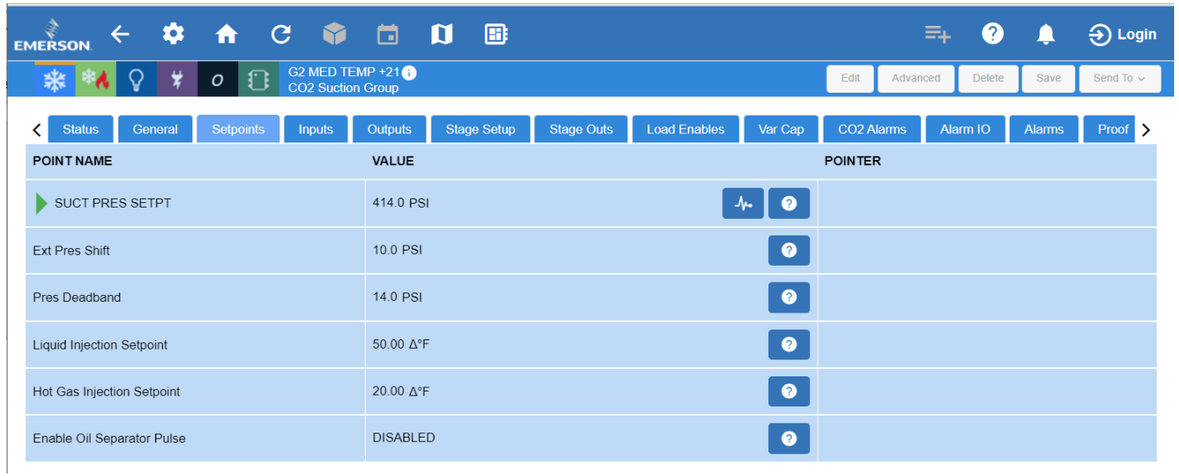
CO2 Group & Load Management Overview

New CO2 Group Application for E3

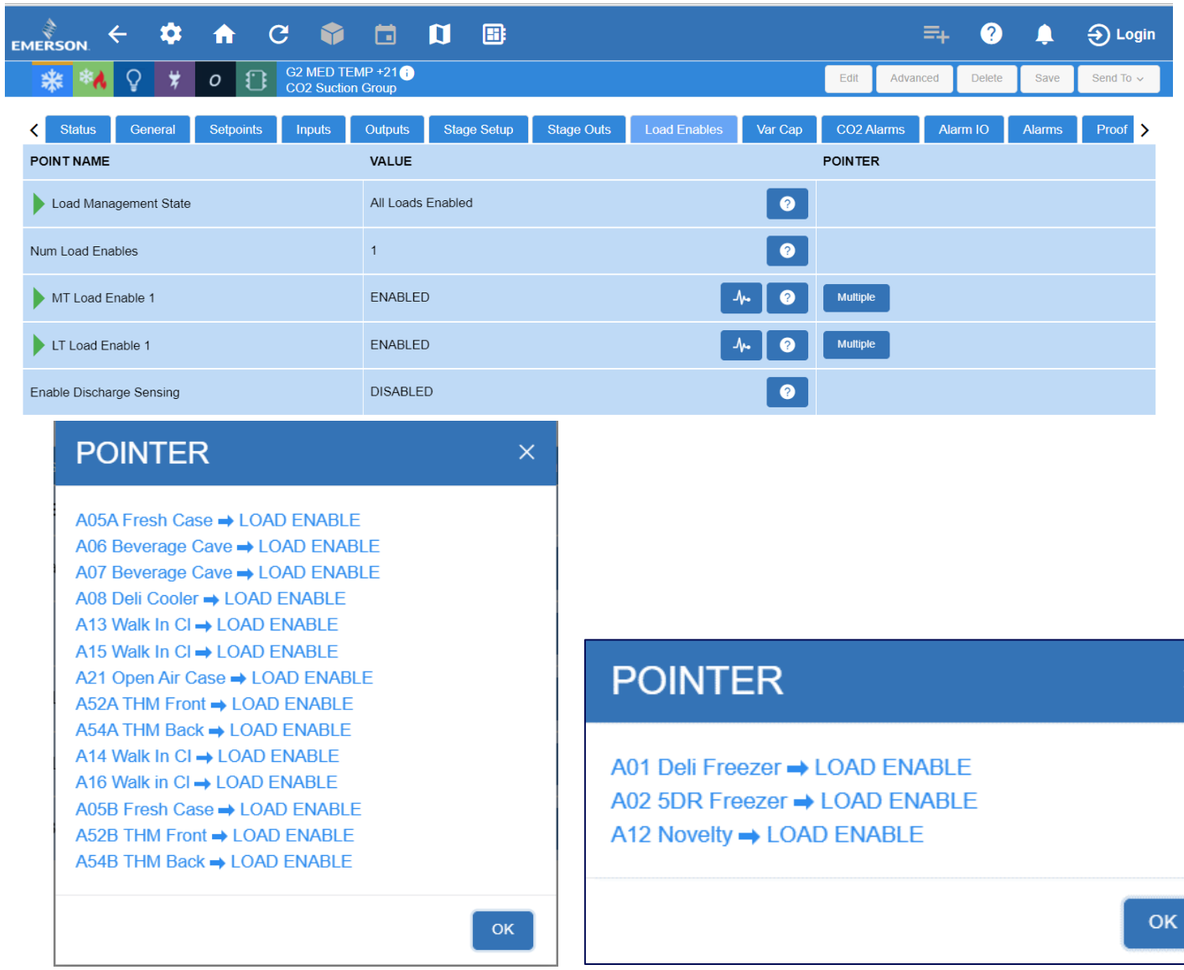
- Enhanced Suction Compressor Control Plus Additional Functionality Necessary for Transcritical CO2 System Operation
  - Superheat Management : Liquid and/or Hot Gas Injection
  - Oil Management : Valve Control Between Oil Separator & Reservoir
  - Load Management : Enable & Disable Evaporator Loads Via Time Delays & Specific CO2 Alarms
  - Parallel Compression Control : Activate Intermediate Temperature Compressors Relative to Flash Tank Pressure and Gas Cooler Outlet Temperature

CO_2 Group Cont'd

Superheat & Oil Management [Setpoints]



Load Enable Sequence



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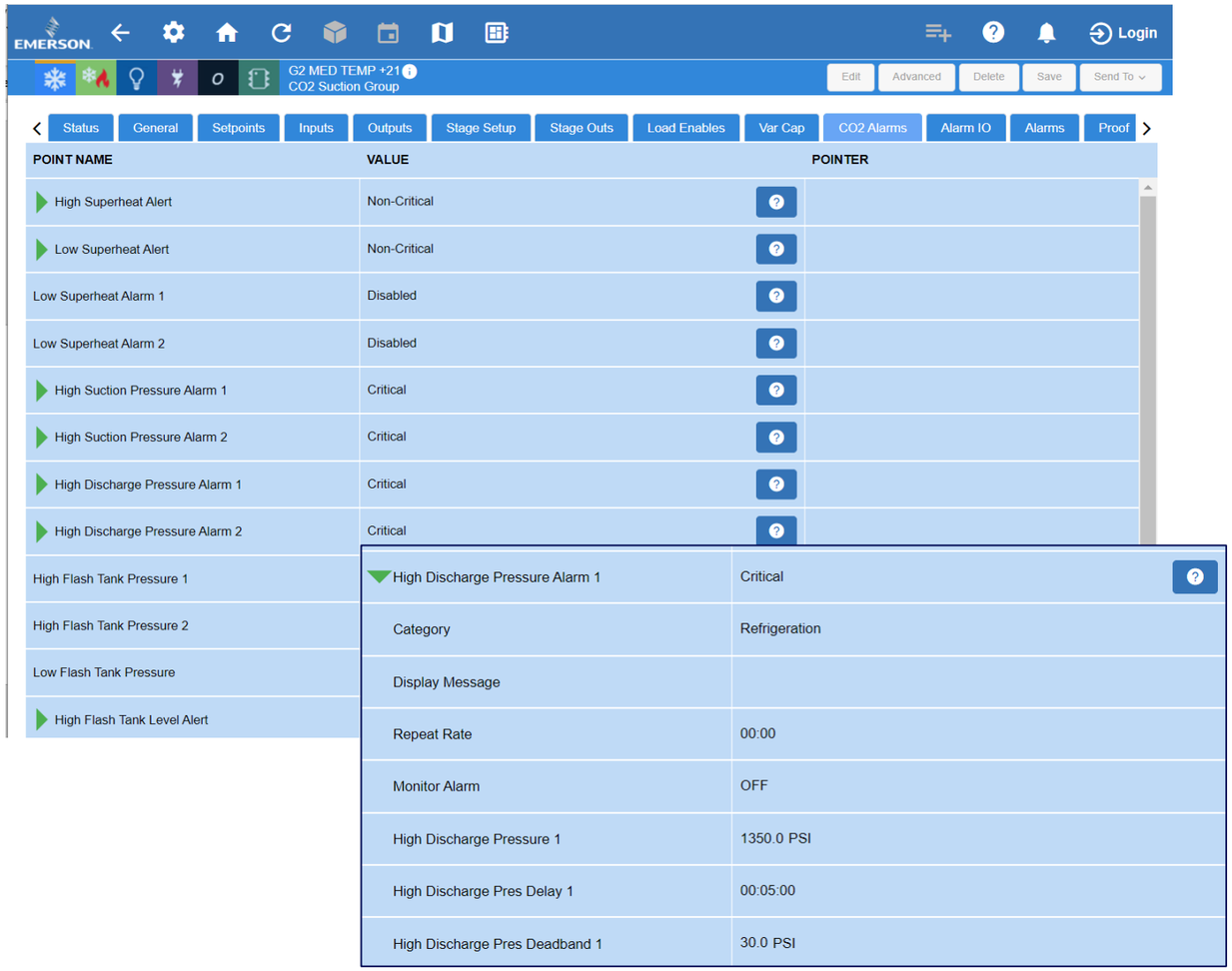
Load Management Continued…

Disable Loads Given Specific Criteria [CO2 Alarms]

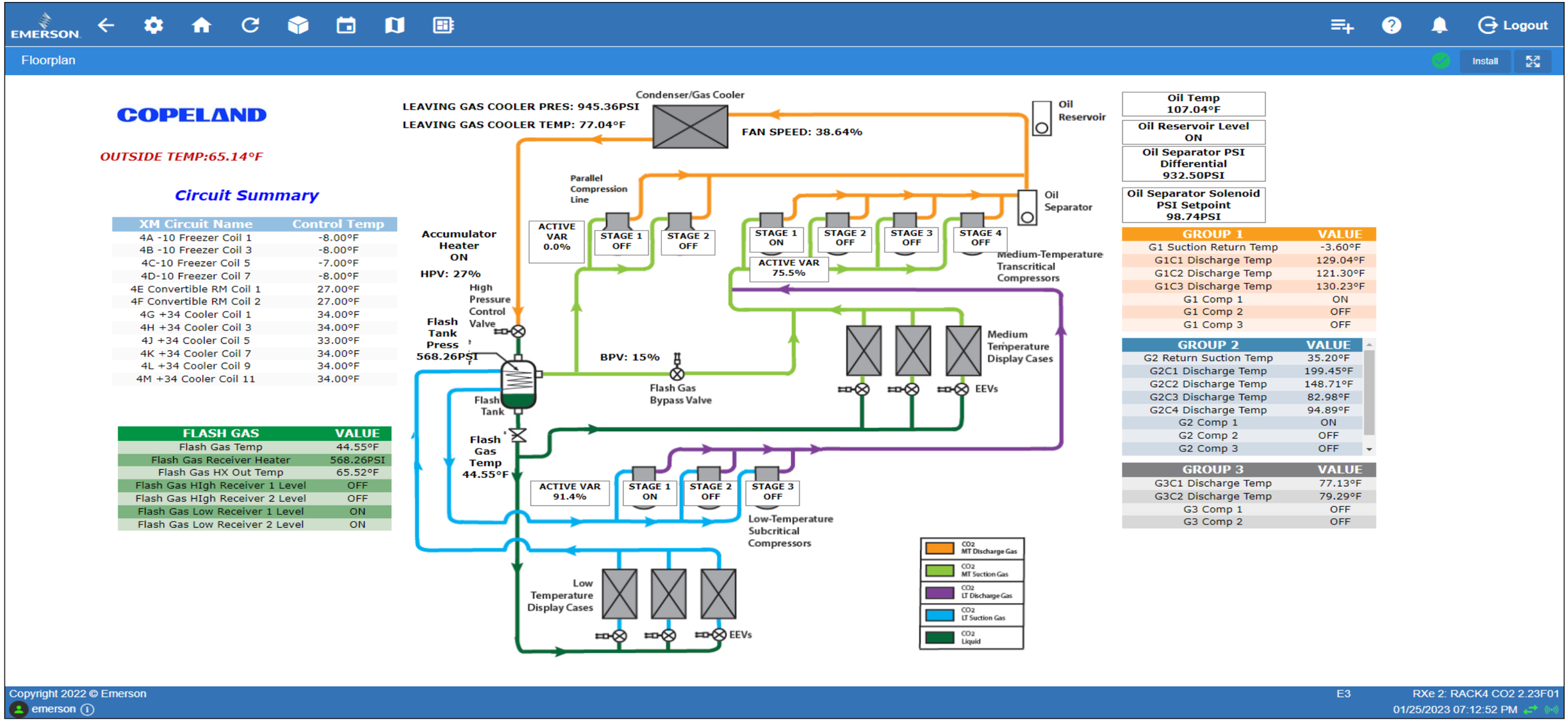
MT Load Enable 1 Alarms	MT-Hi Discharge Pressure 2 Hi Flash Tank Pressure 2
LT Load Enable 1 Alarms	MT-Hi Suction Pressure 2 MT-Hi Discharge Pressure 2 Hi Flash Tank Pressure 1 LT-Hi Suction Pressure 2 LT-Low Superheat 2

CO2 Alarms



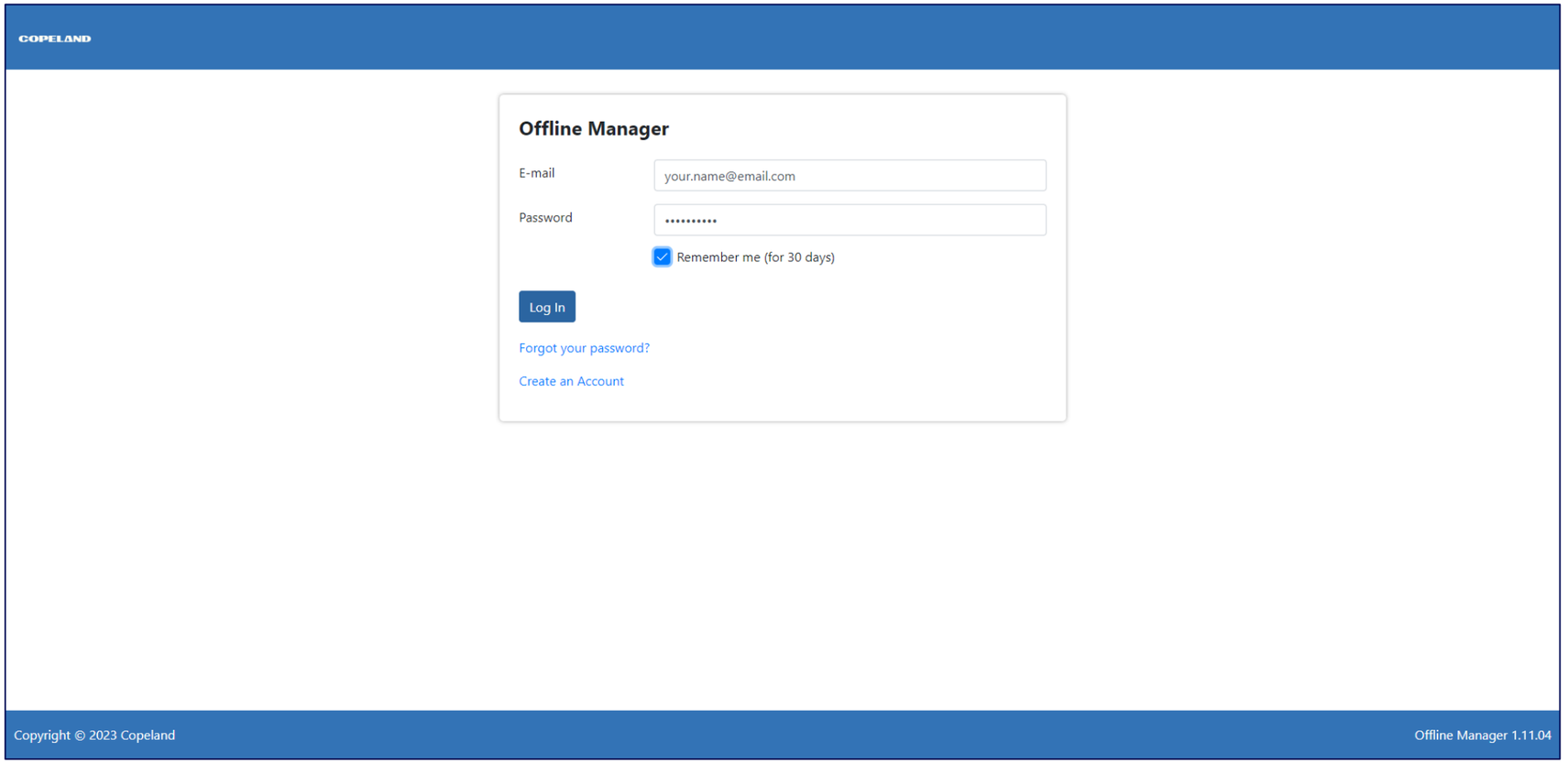
Custom System Graphic in E3

Added real time data on a system circuit drawing for ease of quick overview of system performance



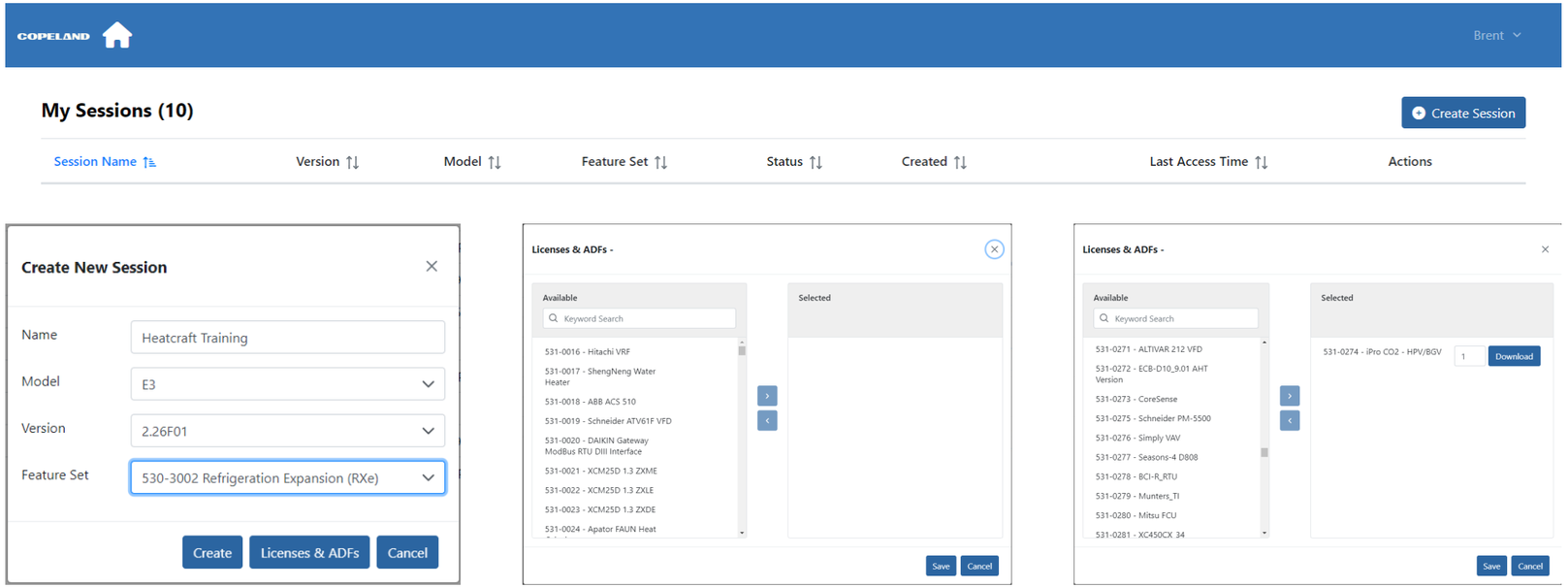
E3 Offline Manager

https://offlinemanager.emerson.com/



- Offline Manager is a programming tool in a cloud environment that provides a virtual E3 or Site Supervisor for you to build programs, upload existing programs and self-train

E3 Offline Manager



- Create a virtual E3 by naming the project, selecting model, version and Feature Set

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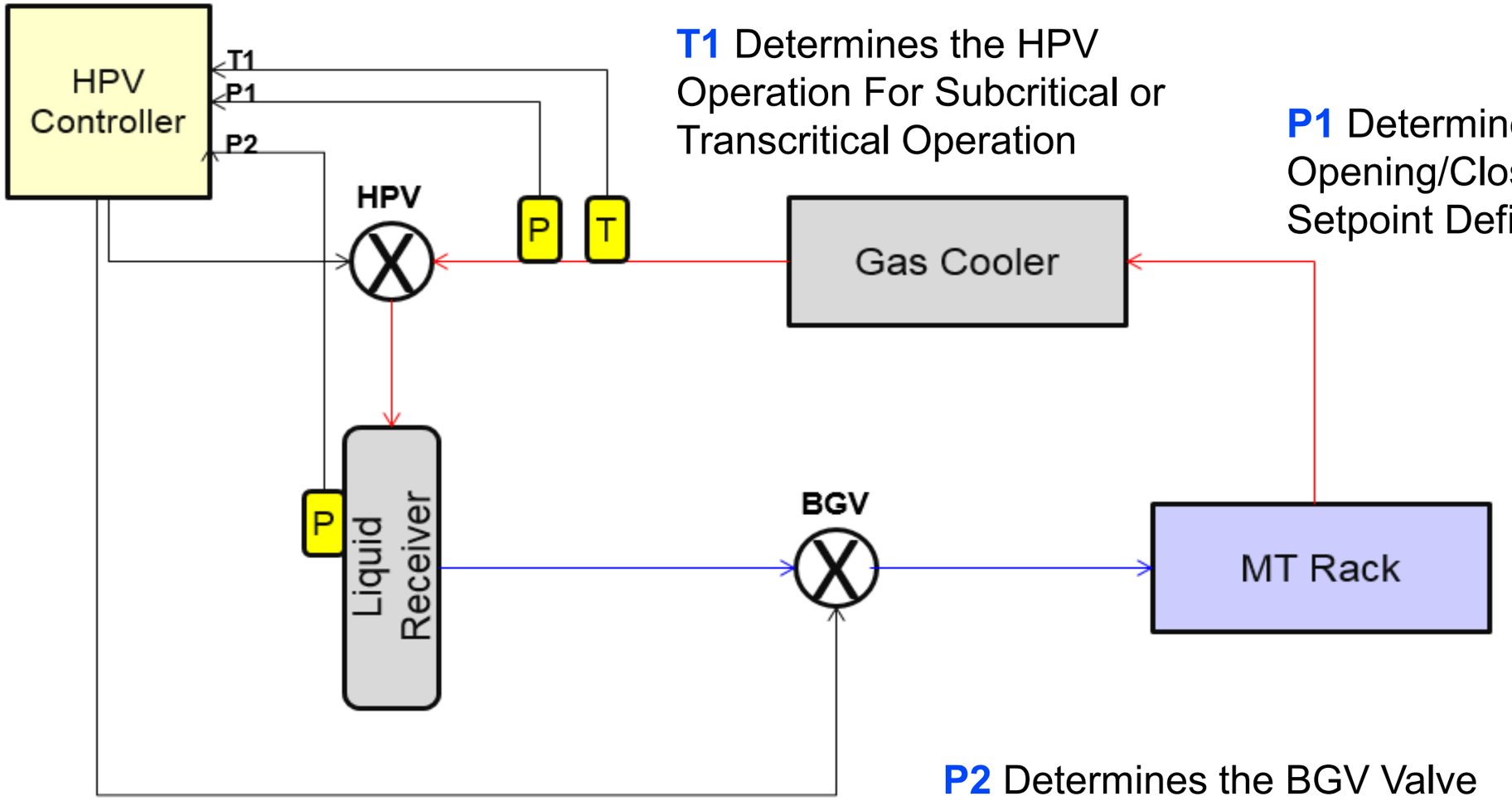
CO_2 High Pressure Controller

CO_2 High Pressure Controller

- Gas Cooler Pressure & Temp, Flash Tank Pressure
- High Pressure Valve & Bypass Gas Valve
- Subcritical & Transcritical Modes
- Optimizes COP In Transcritical Mode
- Heat Reclaim Mode
- Integrated to E3 for visibility and setpoint configuration

CO_2 High Pressure Controller



T1 Determines the HPV Operation For Subcritical or Transcritical Operation

P1 Determines the HPV Valve Opening/Closing to Maintain Setpoint Defined By T1

P2 Determines the BGV Valve Opening/Closing to Maintain BGV Setpoint

CO_2 High Pressure Controller

- Using the Gas Cooler Outlet Temperature (T1) and Gas Cooler Outlet Pressure (P1). The HPV control will switch control modes depending on the temperature or pressure leaving the Gas Cooler.
  - Hold Back - if the pressure is below the minimum gas cooler pressure setpoint, the HPV will abandon the Subcritical algorithm and maintain the minimum pressure setpoint.
  - Subcritical - if the pressure and temperature indicate the system is subcritical, the HPV will maintain a subcooled liquid in the Gas Cooler. The HPV will typically maintain a value of 5°F of subcooling.
  - Transcritical - If the pressure and temperature indicate the system is in Transcritical, the HPV will maintain a pressure setpoint for optimal performance.
- Flash tank pressure is monitored using the Flash Tank Pressure (P2). The Bypass Gas Valve (BGV) has a static liquid receiver pressure setpoint. The valve operates to maintain the setpoint and will open to relieve pressure from the flash tank back to medium temperature suction. It is common for BGV to be closed under low load and low ambient conditions, opening periodically to relieve any pressure once above the flash tank pressure setpoint.
  - It is recommended that the flash tank pressure maintain at least 75psi above the MT Suction Pressure to ensure pressure differential between both liquid and suction pressure and allow positive oil pressure difference.
- Features to protect the rack from a pressure relief event.
  - High flash tank pressure – if the flash tank pressure is above the high-pressure limit, the HPV will start to close to decrease the pressure in the flash tank. If the flash tank pressure is continuing to rise, the HPV may close completely to prevent a pressure relief.
  - Low flash tank pressure – if the flash tank pressure is below the low-pressure limit, the HPV will start to open to raise the flash tank pressure. If the flash tank pressure continues to fall, the HPV may open completely to try to re-pressurize the flash tank.
  - If the gas cooler outlet pressure is lost, failsafe to the remote discharge pressure sensor where installed.
  - If the gas cooler outlet temperature is lost, failsafe to remote temperature sensor where installed.
  - If both fixed sensors and remote sensors are lost, failsafe to fixed valve setting.

CO_2 High Pressure Controller

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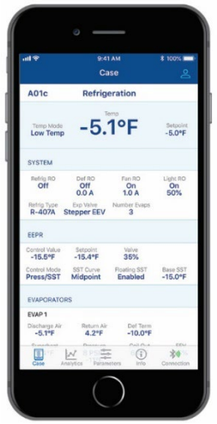
CC200 Case Controller

CC200 Case Controller



- Solenoid Control
- Adaptive Defrost Control
- Advanced superheat control
- Fan Control
- Light Control
- EEV Control
- Suction EEPR Control
- Multiple Evaporator Expansion
- Antisweat Control
- Remote Display
- Mobile App Capabilities
- BACnet & ModBus communication

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Case Controller Series Suitable for Medium & Low Temperature Applications (Multi-Evaporator/EEV & EEPR)

CC200

Controls bipolar or unipolar *stepper* motor with an electronic expansion valve(s) and/or *pulse* electronic expansion valve(s) to control temperature & superheat

Cold Chain Connect Mobile App

Interface with CC200 display via BLE and Mobile Phone/Tablet

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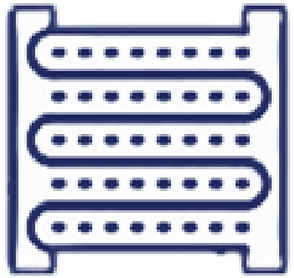
Key Features Focused on Mitigating Customer Pain Points



Modular Design

Plug-in expansion modules allows for seamless installation & integration with your refrigeration setup

Bluetooth Connectivity

Allows for easy controller status check and service

Standalone Technologies

Allows for differentiation from competitors with auto tuning control, leak detection, and demand defrost

Intuitive Interface

Intuitive interface allows for customization of display and easy control setting

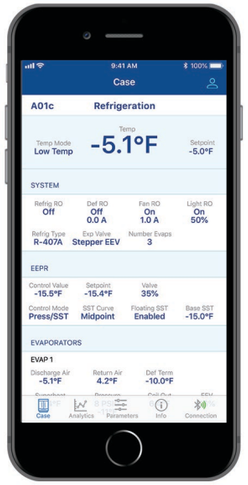
Communication Protocols

Communicates with supervisory controllers allowing for remote access, setpoint configuration, and alarming

CC200 Solution for Multiple Evaporator Control

Main Controller

Expansion Module



Cold Chain Connect App

Case Display

Overall Features

Color coded inputs and outputs and snap on expansion modules allowing up to 3 evaporator coils, superheat control, & an additional valve as an electronic evaporator pressure regulator (EEPR)

Our new mobile app allows OEM team members & contractors to quickly setup and test the controller, saving time on the manufacturing line & the field

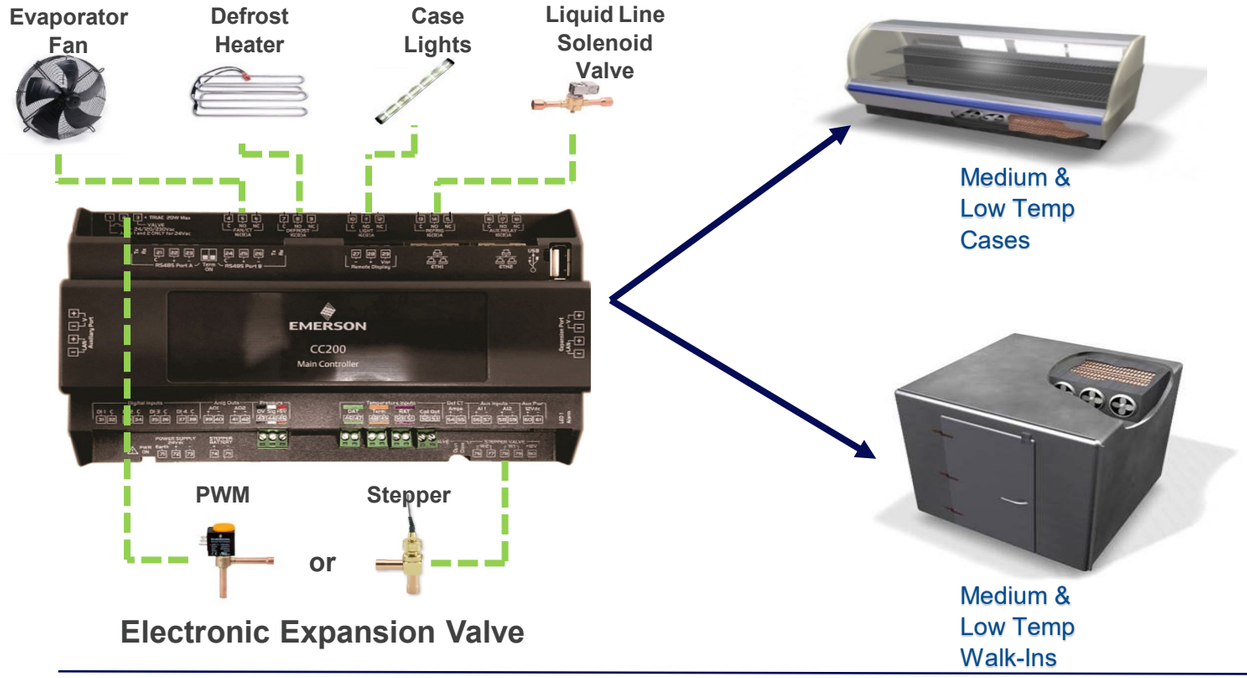
Case Display communicates operating functions with touch integration

Optimized operation with bipolar & unipolar stepper valves or pulse valves

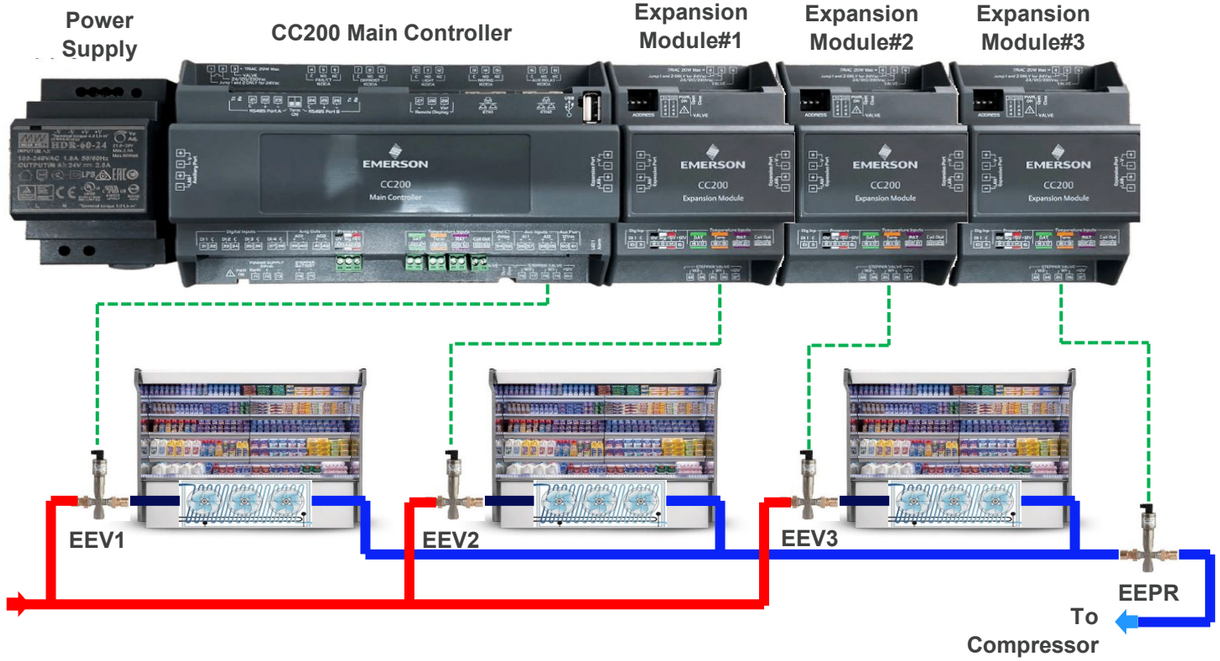
New patented control algorithms

CC200 Technical Overview

Single Evaporator



Multiple Evaporators



Relay Outputs *(Main Controller)*

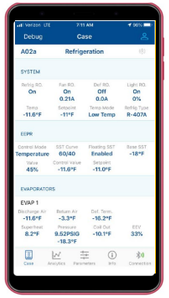
- **Relay Outputs**
  - Defrost
  - Refrigeration (LLSV)
  - Evaporator Fans
  - Lights
  - Auxiliary

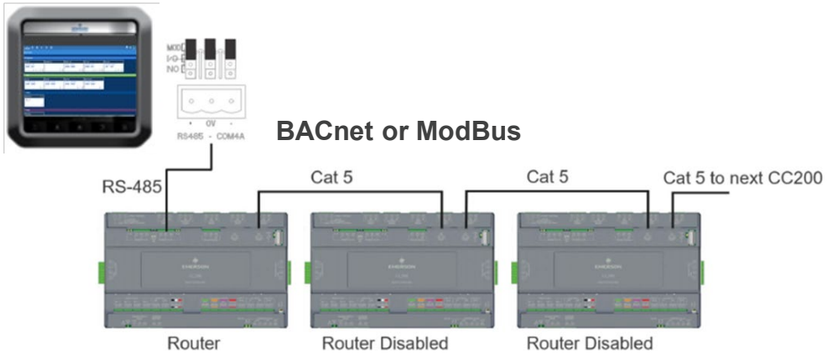
Digital Inputs *(Main Controller)*

- **Configurable DI1-DI4 (Free voltage)**
  - Door Switch
  - Service Switch
  - Dual Temp Switch
  - Defrost Term Switch
  - Leak Shutdown
  - Satellite 1 or 2 for E2e

Analog Inputs *(Main Controller & Expansion Module)*

- **Probe Inputs (non configurable)**
  - Discharge Air Temperature (1 to 3)
  - Return Air Temperature (1 to 3)
  - Suction Pressure (1 to 3)
  - Defrost Termination (1 to 3)
  - Suction Temperature (1 to 3)
  - Fan and Defrost Amps
- **Configurable Inputs (AI1 and AI2)**
  - External fan CT
  - Coil Inlet Temp
  - Product Temp
  - Circuit Suction Temp





The Main Controller Provides Stand-Alone Control

Only Requires 1 24VDC Power Supply with Industry standard Din Rail mounting and Phoenix Connectors

- Auto-tuning superheat control
  - Decreases tune time and hone-in proper settings
  - Allows quicker commission time
- Supports low temp, medium temp and dual temp cases for flexibility in application and simplifies SKU count
- Controls multiple electronic expansion valve types including PWM or stepper valves (both unipolar and bipolar)
- Manage multi-coil case designs (up to 3 with expansion module)
- Patent pending EEPR control algorithm for automatic adjustment to the optimum setpoint for discharge
- New superheat algorithm does not use traditional PID control
- New demand defrost algorithm saves energy and quality

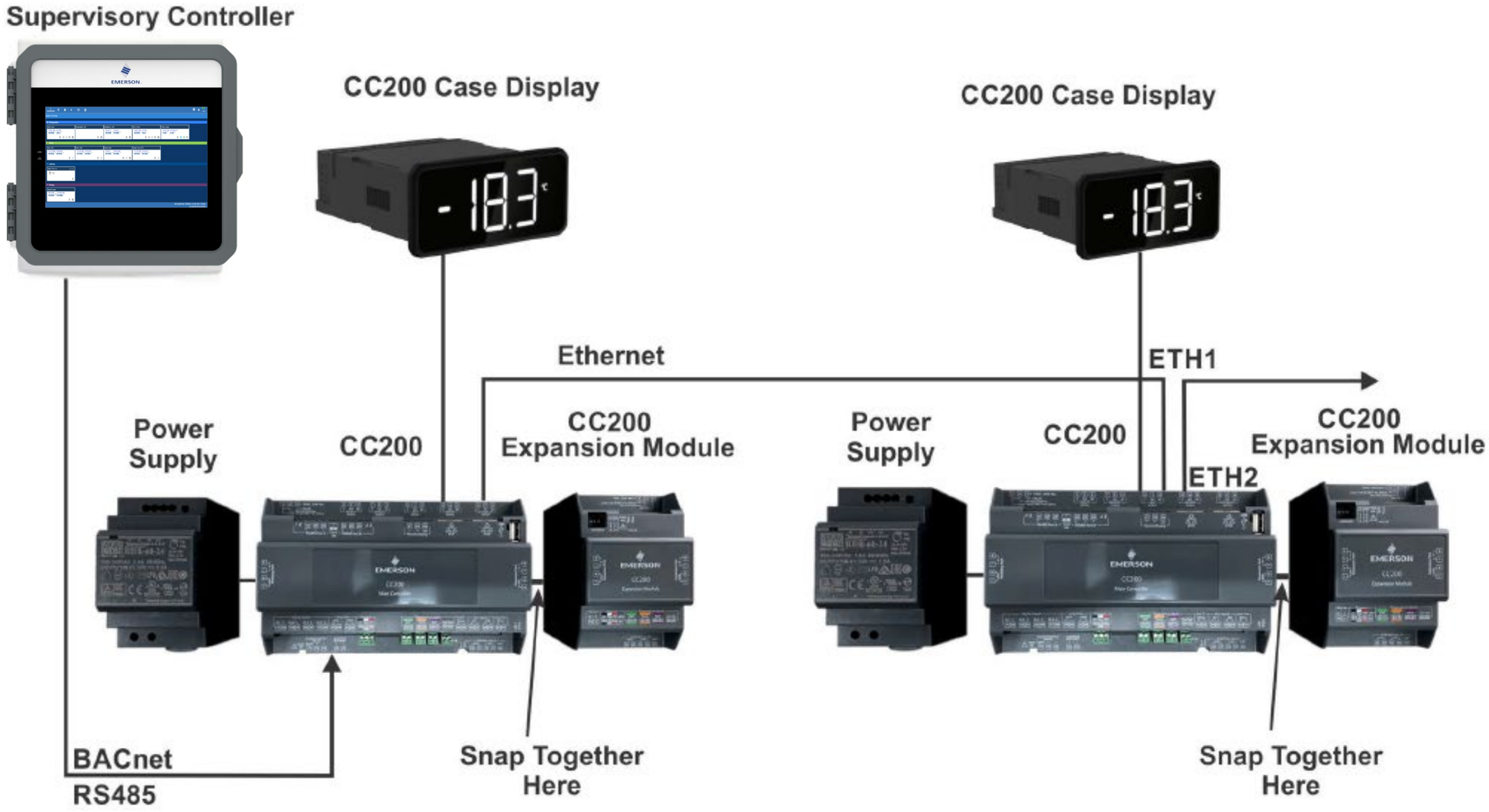
Expansion Module Quickly Snaps on to Main Controller for **Fast Factory Installation**

- Simplified wiring and connections reducing labor and setup time
- Power supply sourced from main controller side connector, eliminating the need for a dedicated power supply
- Paired / optimized operation with bipolar and unipolar stepper valves
  - Controls one PWM EEV or Stepper EEV
- Color-coded temperature inputs
  - 4 Temperature (discharge, return, defrost termination, coil out
  - 1 Pressure
  - 1 DI (software selectable function)

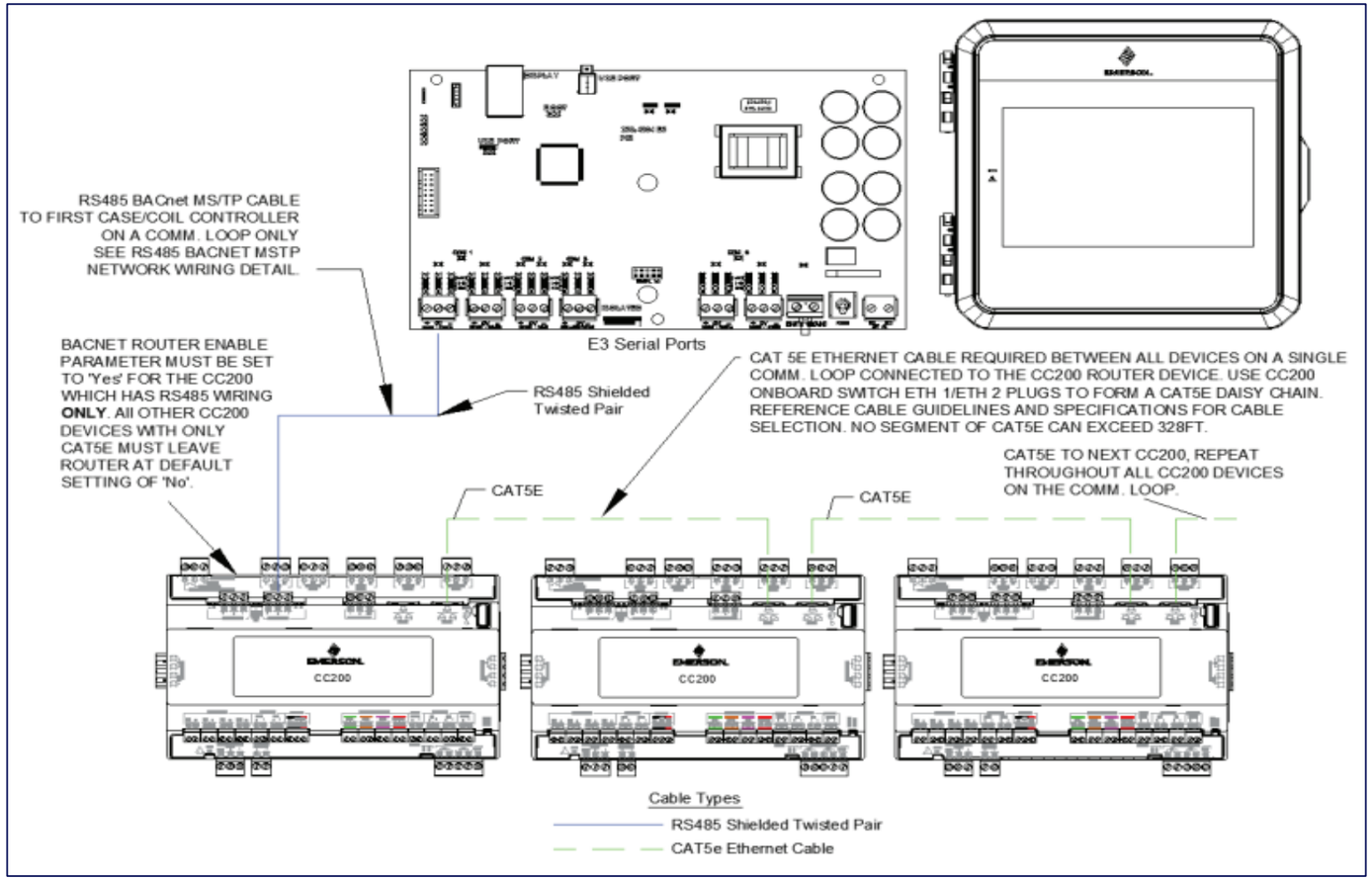
Case Display Communicates Operating Functions with Touch Integration

- Elegant, aesthetic design for more appealing refrigeration fixtures
- Quickly see system operation, status, and alarm information
- Displays activated functions and output with simple screen layout
- Perform quick service actions with one touch
  - Start/Stop manual defrost
  - Service shutdown
  - Reboot CC200
- Set communication parameters to bring CC200 online

CC200 Network Layout Overview

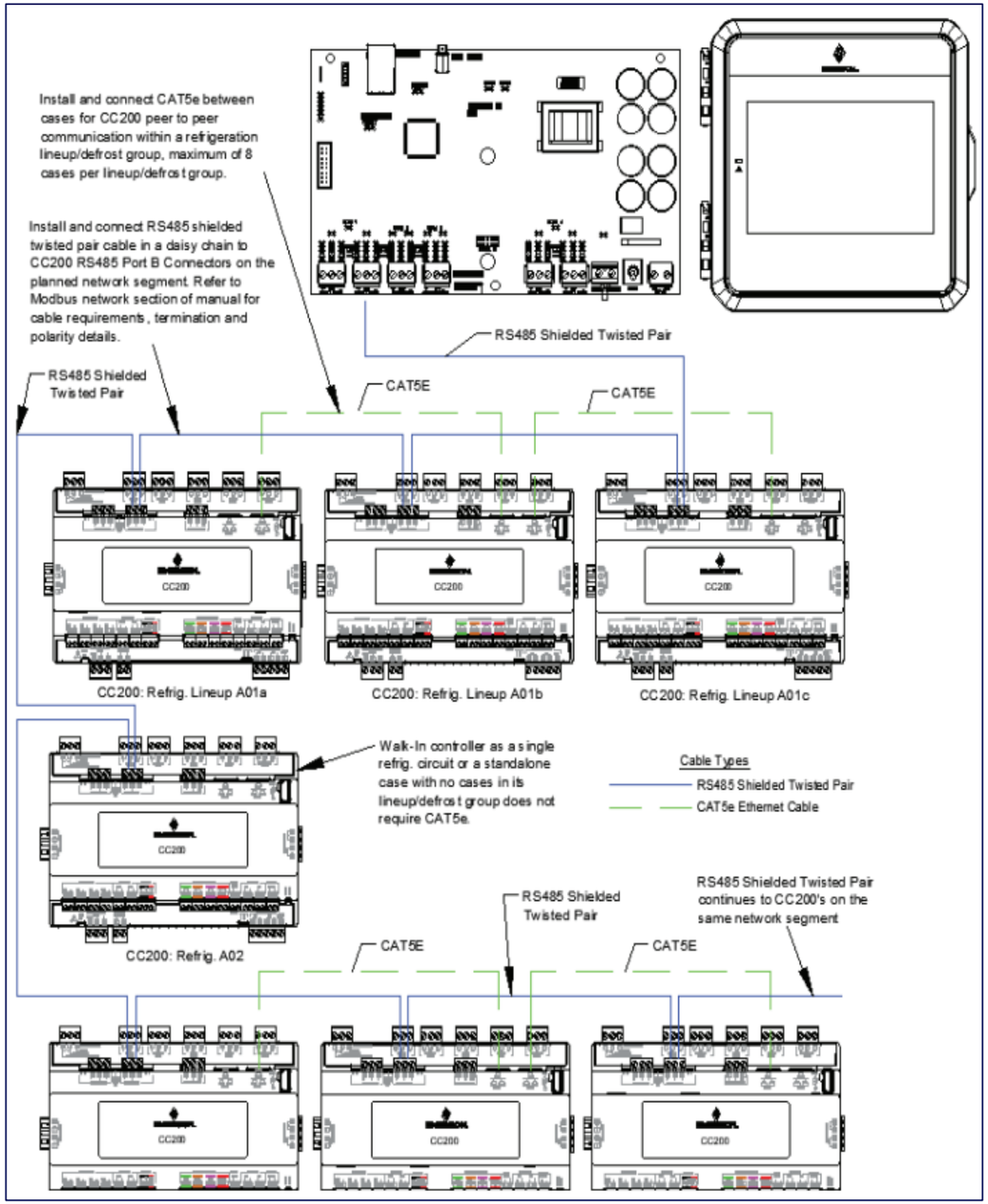


CC200 Network Layout Overview



BACNET MSTP

Up To 70 Devices Per E3; 32 Per Serial Comm Port



Modbus

[*Conservative Estimate*] Up To 75 Devices Per E3; 25 Per Comm Segment

Cold Chain Connect Mobile Application

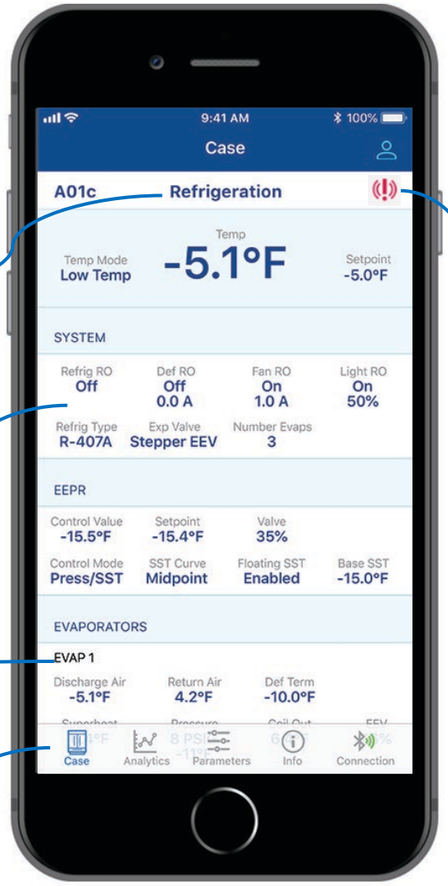
Descriptive alarm info to help troubleshoot system issues

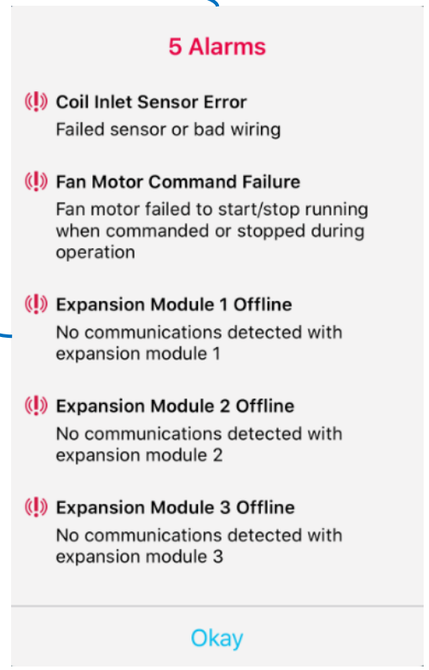
Quickly see CC200 controller state (Refrigeration, Defrost, Pulldown Shutdown…etc.)

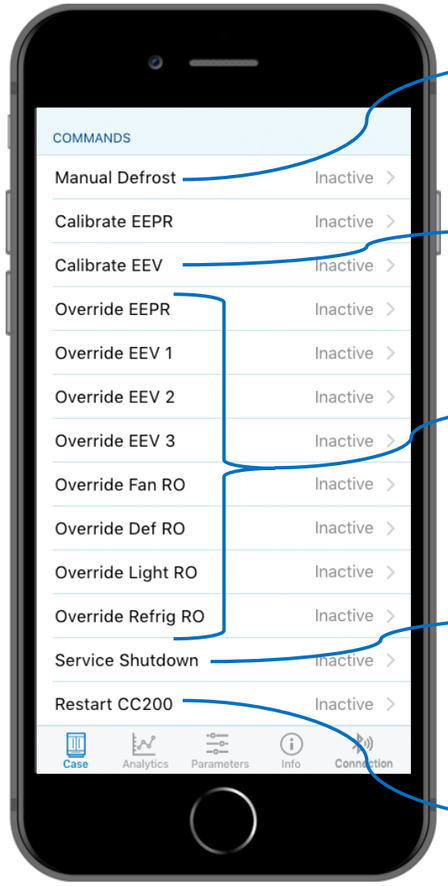
Useful temperature and relevant system details

Meaningful system data section for each evaporator

Intuitive navigation gets the data you need quickly







Perform manual defrost with just a tap

Single tap to calibrate stepper motor valves

Effortlessly perform component and valve checks via available overrides

Tap for service shutdown (case cleaning, inspection, service)

Easy access to Convenient reboot command

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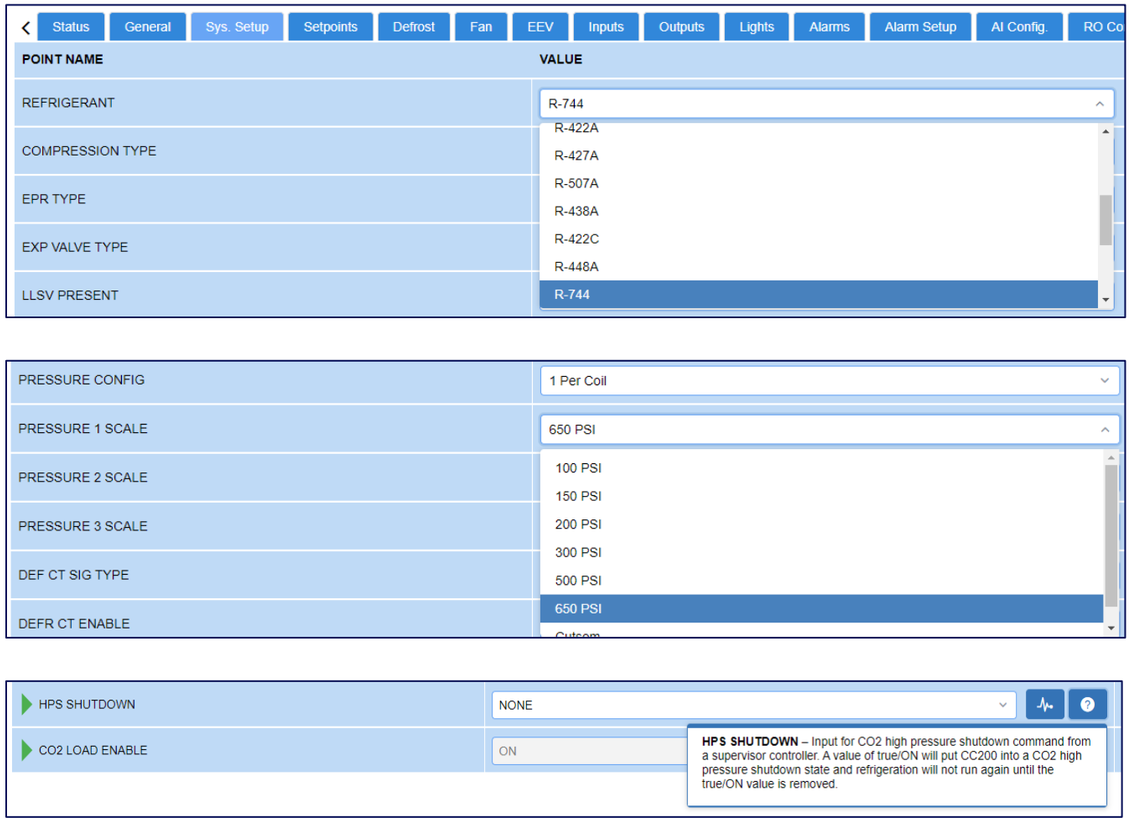
Case Control Additions Specific for CO_2 Booster Systems

- CO_2 Refrigerant Curves to Allow for Precise Superheat and Temperature Control in CO_2 Systems
- Additional Evap Pressure Transducer Selections 100, 200 , 500, 650, 1000 & 2000 PSIG
  - (e.g. 650PSI most common for CO_2 case fixtures)
- Maximum Operating Pressure Protection to Close EEV when High Pressure is Detected (HPS Shutdown)
- Input for CO_2 Load Enable to Better Facilitate Rack Coordination for System Start-up and Shutdown



https://www.kysorwarren.com/sites/www.kysorwarren.com/files/document/FTE-US-One-Page.pdf

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Other System Components

Leak Detection

- CO_2 Refrigerant Monitoring
- Visual & Audible Alerts
- Alarm Monitoring
- Walk-in Shutdown

Variable Frequency Drivers (EVM/EVH)

- Compressor Variable Frequency Control
- Gas Cooler Fans Variable Frequency Control
- Full Integrations to Copeland Supervisory Controls (E2 and E3)
- Optimized for Copeland compressor operations
- Can use for other compressors & motors

Compressor Oil Control (OMC)

- Compressor Oil Level Control
- Auto Fill oil into Compressor Sump
- Alert when low oil detected

Example Solution: E3 Controls & Services for CO_2 Rack

Compressors
Copeland Semi-Hermetic + Scroll

+

Controls
Copeland E3, OMC's, Valves, Electronics

+

Programming Support
Copeland OEM Services

+

Start-Up & Commissioning
Copeland Field Services

+

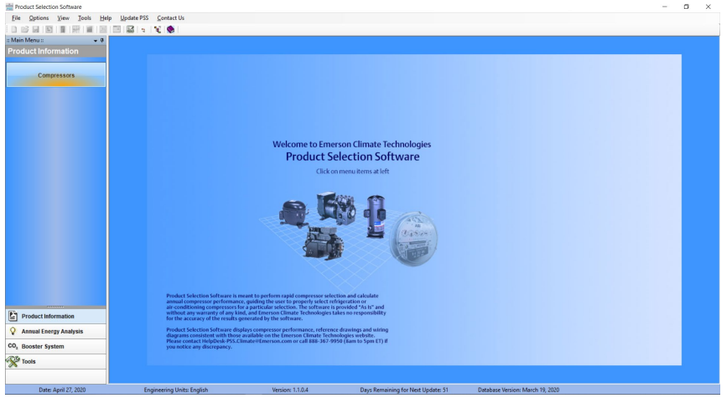
Data Services
Connect +

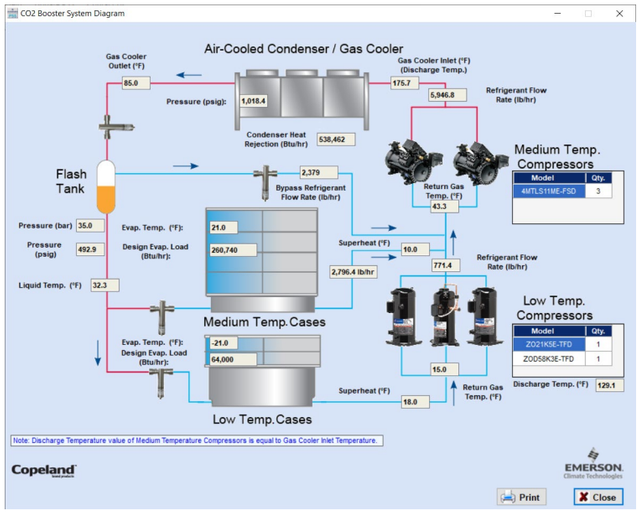
+

Aftermarket Support
Warranty, Replacement, Parts, Recoveries

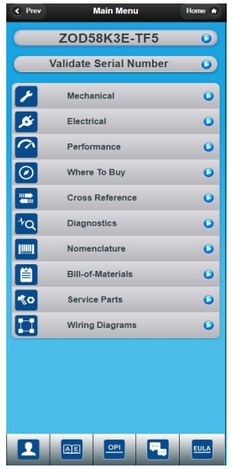
CO_2 Product Information Library

Product Selection Software with Booster Design

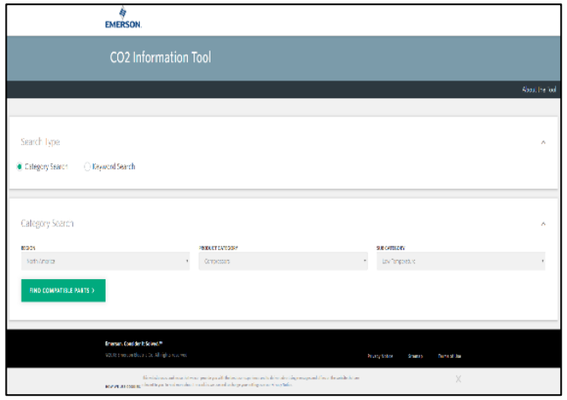




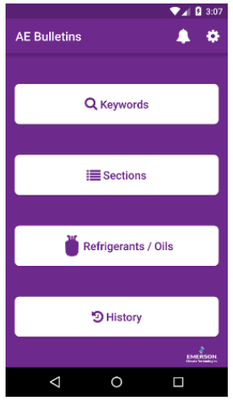
Copeland Mobile



CO2 Information Tool



AE Bulletins



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- **Case Studies**
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- E360 Blog: Home - Copeland E360 Blog
- CO2 Key Pages:
  - CO_2 Refrigeration | Copeland US (overview/training on CO2)
  - CO_2 Product Solutions | Copeland US (CO2 products page)
  - CO_2 in Commercial Refrigeration (copeland.com) (hub for all CO2 content)
- E3 & E3 for CO2 Landing Page: Supervisory Controls E3 | Copeland US
- CC200 Landing Page: CC200 | Copeland US

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Copeland Certificate

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Certificate of Completion

is hereby granted to:

_____

In recognition of completing:

E3 Supervisory Controls with CO2 Applications & CC200 Case Control

1.5 Course Hours
Granted: November 15, 2023

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We Are Engineered for Sustainability