St. Elizabeth Medical Center
Combined Heat & Power Facility

Charles A. Gaetano Construction Corp.

BMS System Submittal

Sequence of Operation

General

The Building Management System / Energy Management System (BMS) will include a Graphical User Interface (GUI) for access to systems that are monitored and/or controlled as a part of job. Each user of the BMS will have a unique User Name and Password that they must use to access the BMS. There will initially be two types of users that are assigned to the BMS, "Read Only" and "Change". "Read Only" users will be able to monitor all BMS functions only. "Change" users will be able to monitor all BMS functions as well as change system Setpoints, Schedules and make other adjustments as necessary.

The GUI will be accessible to the facility staff from inside the facility using the existing Ethernet infrastructure, as well as from outside the facility via the Internet. There will be no special or proprietary software required to access the BMS. The BMS can be accessed from any computer that has a standard Web Browser with JAVA support installed. Supported Web Browsers include Microsoft Internet Explorer v6.x and up, or Mozilla Firefox v3.x and up. The URL for browser access to the GUI will be provided to the facility staff during BMS training.

System alarms, alerts and exceptions will be emailed from the BMS to appropriate facility staff for annunciation purposes unless otherwise noted.

All Setpoints referred to in this document will be adjustable via the GUI by any "Change" user.

All physical points will be logged. Analog points will be logged every 15 minutes. Digital points will be logged every change of state. Two days of analog logs will be available for immediate viewing. The last 25 samples of digital changes of state will be available for immediate viewing.

All control processes will be field "tuned" at commissioning time to prevent hunting and unnecessary actuator wear. This includes adjusting dead bands, proportional, integral, and derivative constants. All controlled strategies will incorporate any necessary timing delays to prevent short cycling of equipment. This includes on-delays, off-delays, minimum on-times, minimum off-times and inter-stage on and off delay times.

Sensor Legend

- Temperature
- Humidity
- Enthalpy
- Diff. Pressure
- Absolute Pressure
- Flow Meter
- Velocity
- Voltage
- Current
- Elec. Power
- Level
- Light
- Rotation
- Smoke
- Timer
- Vibration
- Carbon Monoxide
- Carbon Dioxide
- Refrigerant Gas
- Voltage Source
- Resistance Source
- Dry Contact Source
- Potentiometer

Sensor Probe Legend

- Duct Insertion Probe
- Duct Averaging
- Remote Bulb
- Outside Air
- Fire Stat
- Duct Static Pressure
- Diff. Pressure
- Air Averaging Station
- Hot Wire Sensor
- Pitot Tube
- Pressure Tap
- Pipe Well Insertion
- Pipe Surface Mtd.
- Venturi Flow Meter
- Orifice Plate
- Turbine Probe
- Annubar
- Paddle Switch

Body Style Legend

- Pneu. Actuator
- Actuator & Positioner
- Elec. Actuator
- Controller
- Sensor

Mechanical Legend

- Centrifugal Fan
- Propeller Fan
- Vane Axial Fan
- Damper - Opposed
- Damper - Parallel
- Air Filter
- Air Flow Station
- Humidifier
- Water Htg/Clg Coil
- Heating Coil
- Cooling Coil
- Elec Heating Coil
- 2-Way Control Valve
- 3-Way Control Valve
- Water Flow Meter
- Water Pump
- Magnetic Starter
- Variable Speed Drive

GENERAL NOTES

1 PROVIDE 120 VAC 15 AMP CIRCUIT TO EACH PANEL LOCATION.
2 DO NOT MIX LOW VOLTAGE CONTROL WIRING AND 120 VAC WIRING IN THE SAME CONDUIT.

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Communication (BACNet MSTP Bus & IO Expansion bus)

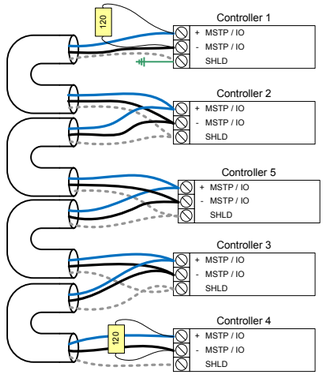
For the purposes of this document all white colored conductors will be drawn as blue.

All Communication Wire (MSTP) will be 18 gauge 2 conductor - shielded, twisted, plenum rated (18/2 SP) with a green jacket.

- Characteristic Impedance between 100 and 130 ohms
- Distributed capacitance between conductors shall be less than 30 pF/Ft
- Distributed capacitance between conductors and shield shall be less than 60 pF/Ft
- Foil or braided shields are acceptable

The MSTP Bus will be run in a daisy chain fashion from controller to controller using the red and black conductors. Polarity must be maintained at each connection + to + and - to -. All sheilds will be landed at the SHLD terminals on the controller. The shields will be earth grounded at one and only one location on the bus.

Each MSTP bus end will be terminated with an End-Of-Line resistor (120 ohm).



Inputs

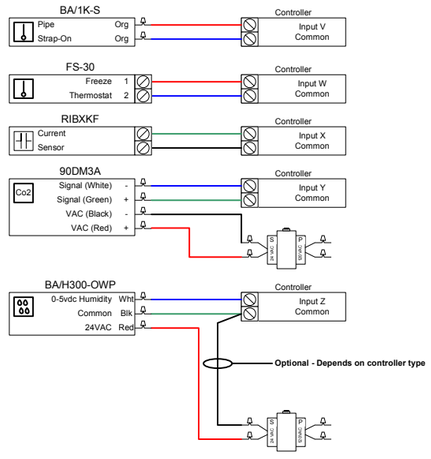
For the purposes of this document all white colored conductors will be drawn as blue.

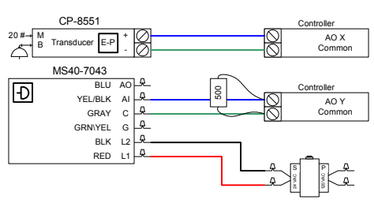
All input Wire will be 22 gauge 4 conductor - shielded, twisted, plenum rated (22/4 SP) with a white jacket

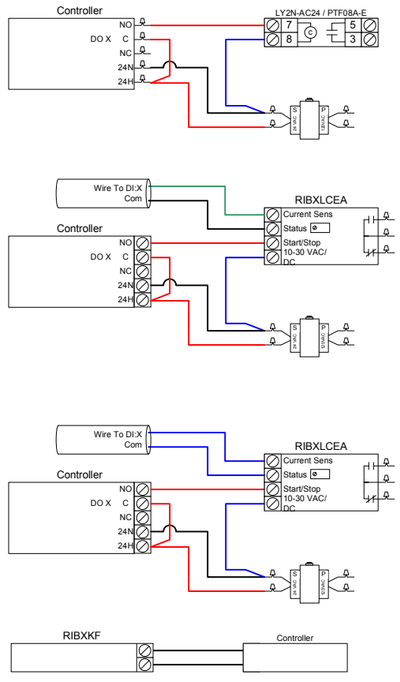
When wiring temperature sensors, freeze stats, alarms, etc., the primary color pair will be the red/white conductors.

When wiring status inputs, the primary color pair will be the green/ black conductors.

When wiring transmitters (humidity, pressure, etc.), the transmitter signal to the controller input will be the white conductor, the transmitter signal common will be the green conductor, the power will be the red conductor and the power common will be the black conductor. When power common and signal common are shared, the green conductor will be used.







Analog Outputs

For the purposes of this document all white colored conductors will be drawn as blue.

All Analog Output Wire will be 18 gauge 4 conductor - unshielded, twisted, plenum rated (18/4 UTP) with a blue jacket

When wiring two wire devices, the primary color pair will be the white(+)/green(-) conductors.

When wiring powered devices, the analog signal pair will be the white(+)/green(-), and the power pair will be red(H)/black(N) conductors.

Resistors may or may not be required depending on the type of controller

Digital Outputs (low voltage)

For the purposes of this document all white colored conductors will be drawn as blue.

All Low Voltage Digital Output Wire will be 18 gauge 4 conductor - unshielded, twisted, plenum rated (18/4 UTP) with a blue jacket

When wiring two wire devices, the primary color pair will be the red(H)/white(N) conductors.

When wiring devices with status feedback, the primary color pair will be the red(H)/white(N) conductors. The status feedback pair will be the green/black conductors

Digital Outputs (high voltage)

For the purposes of this document all white colored conductors will be drawn as blue.

When wiring into high voltage control cabinets (> 120vac) (boiler panels, frequency drives, motor starters, all Digital output wire will be 18 gauge individual THHN conductors.

The Digital Output pair will be the red(H)/white(N) conductors.

The Status Feedback pair will be the blue/blue conductors.

The alarm pair will be the black/black conductors.

BACNet MSTP Controllers - Wiring Practices

Technical Building Services, Inc.
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Remote Customer Access to BMS

Internet

Remote System Suport

BMS Access via existing Customer PC using Web Browser

St.Elizabeths LAN

New User Workstation

Dell Workstation spec to exceed specified pc workstation in 15972.2.8.A. At time of order.

Graphics Server Archive Database

100 BT/ Cat 5

Siemens Large 567-353
TCP-CG1
CHP MER
- BACNet IP Net: 20219 Address: 01
- TAC MNB-1000
- CG-1
- BACNet MSTP Net: 1 Address: 0
- MNB-1000-15
- IO Expansion
- Remote IO Address: 1
- 22/2 Shielded Twisted Pair ULC
- EOL

Siemens Large 567-353
TCP-CG2
CHP MER
- BACNet IP Net: 20219 Address: 02
- TAC MNB-1000
- CG-2
- BACNet MSTP Net: 2 Address: 0
- MNB-1000-15
- IO Expansion
- Remote IO Address: 1
- 22/2 Shielded Twisted Pair ULC
- EOL

Siemens Large 567-353
TCP-CG3
CHP MER
- BACNet IP Net: 20219 Address: 03
- TAC MNB-1000
- CG-3
- BACNet MSTP Net: 3 Address: 0
- MNB-1000-15
- IO Expansion
- Remote IO Address: 1
- 22/2 Shielded Twisted Pair ULC
- EOL

Siemens Large 567-353
TCP-Plant
CHP MER
- BACNet IP Net: 20219 Address: 04
- TAC MNB-1000
- Plant
- BACNet MSTP Net: 4 Address: 0
- MNB-1000-15
- IO Expansion
- Remote IO Address: 1
- MNB-1000-15
- IO Expansion
- Remote IO Address: 2
- MNB-1000-15
- IO Expansion
- Remote IO Address: 3
- MNB-1000-15
- IO Expansion
- Remote IO Address: 4
- 22/2 Shielded Twisted Pair ULC
- EOL

Siemens Large 567-353
TCP-Main
CHP MER

100 BT/ Cat 5

- BACNet IP Net: 20219 Address: 99
- Jene-PC6265
- CHP MER
- LON S/N Address: 1:126
- NA
- NA
- NA
- NA

BMS will communicate to Master Controller via the Modbus TCP/IP Communication Protocol

Caterpillar Cogen Master Controller

Siemens Medium 567-352
TCP-CG3
5th Floor PH MER
- 10/100 BaseT Jack
- EOL
- TAC MNB-300
- HX-7
- MSTP Net: 5 Address: 4
- TAC MNB-300
- HX-6
- MSTP Net: 5 Address: 3

22/2 Shielded Twisted Pair ULC

Siemens Large 567-353
TCP-CG3
2nd Floor PH MER
- BACNet IP Net: 20219 Address: 05
- TAC MNB-1000
- Chiller
- BACNet MSTP Net: 5 Address: 0
- MNB-1000-15
- IO Expansion
- Remote IO Address: 1
- 22/2 Shielded Twisted Pair ULC
- EOL
- TAC MNB-300
- HX-5
- MSTP Net: 5 Address: 2

Siemens Medium 567-352
TCP-CG3
Basement MER
- 10/100 BaseT Jack
- TAC MNB-300
- HX-4
- MSTP Net: 5 Address: 1
- EOL

Bill of Materials

Part Number	Quantity
EOL Resistor	7
Netgear Hub	2
Siemens Large 567-353	6
Siemens Medium 567-352	2

BMS System Architecture

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A. Cogeneration Plant

1. The cogeneration plant consists of one or more co-generator units with associated mechanical and electrical gear. Mechanical gear includes associated pumping, piping, valves, heat exchangers, fuel supply hardware, flow meters, exhaust and ventilation equipment. Electrical equipment includes controls, switch gear, power quality monitoring equipment, transformers and electric metering.

B. Operational Overview

1. The cogeneration plant shall be controlled to provide electric power to the facility based upon electric demand requirements through the electric switchgear synchronous parallel controller. The primary function shall be to meet building electrical demand and usage requirements. The secondary functions shall be to meet building thermal requirements (bottoming cycle). The co-generator unit(s) used in the application use synchronous generators. Heat from the cogeneration loop is distributed to heat exchangers serving the primary heating loop, the domestic hot water supply, absorption Chiller #3, and HX's 5-7 for building loop and AHU coil heating. A dry cooler per engine is provided for selectively rejecting heat to the atmosphere, to allow cooling for the plant during periods of low building thermal requirements. A cooling tower is provided for low grade intercooler rejection.

a) The cogeneration plant is designed and programmed to operate automatically, with owner intervention necessary only when a particular component fails, operates improperly, or the desired sequence of operation is to be hanged within defined limits. Cogeneration Units are controlled via the main Cogeneration panel and thus do not require primary load control under this contract. However, the following I/O is required.

b) Start-up

The DDC system will receive an initial call to run from the system control switchgear. The DDC will then initiate the following procedure. The primary pump dedicated to the first engine being called to run (PHX-X) and the roof mounted supply fan and exhaust fans are started first, by the DDC System. A current proving switch in both the supply and exhaust fans will validate operation of the units. When the supply and exhaust fans and associated loop pump is system control switchgear which will then initiate engine start.

c) Engine run interlock

In the event of failure of the primary pump, supply or exhaust fans during operation of the associated cogeneration unit, the run-enable signal issued by the DDC system during engine operation shall be removed. Upon interruption of this signal the system control switchgear will issue a command for shut down.

d) Black Start

The system control switchgear will issue a black start command and a simultaneous call to run command for the associated cogeneration unit. The new MCC-CHP will be de-energized. Upon start up and stabilization of the first engine, MCC-CHP will be re-energized and the DDC will commence the start up sequence of the dedicated cogen loop pump, supply and exhaust fans.

e) Unit Temperature Control

A self-contained three-way valve in the primary circulation loop for each co-generator unit maintains a maximum return water temperature of 196 degrees F to the unit. The valve protects the unit from shutting down on low water temperature.

C. Heat Exchangers and Dry Cooler

1. The heat exchangers and dry cooler dissipate the waste heat from the cogeneration plant. The heat exchangers connected to building thermal loads allow co-generator heat to be dissipated whenever there is a need for
heat. The dry cooler operates to maintain the return water temperature equal to or less than the return water set-point, when the plant is being operated as described under "Demand and Electrical Operation".

D. Electrical System

1. Each co-generator unit has its own microprocessor controller to check for a variety of alarm conditions and modulate the induction generator speed to control power output. The synchronous generator automatically matches the voltage and frequency (cycles/sec.) as indicated by the synchronous master controller.
2. Control System provider shall provided monitoring interface to the switchgear **(via Modbus TCP/IP Communication Protocol)** to monitor information available via the main switchgear power meter and shall also provide the following I/O:

a) The DDC system shall also have a DO for each engine which confirms with the switchgear that the associated systems are confirmed on within 10 seconds of engine start. Systems which must be confirmed on are after-cooler water flow, after-cooler water temperature acceptable, jacket water temperature acceptable, and jacket water heat exchanger flow confirmed. The DDC System provider shall provide time of day scheduling for each of the engines, and this shall be able to be readily enabled and disabled. Original control strategy will not rely on time of day scheduling.

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A. Cogen Associated Equipment

Each Cogeneration unit shall have interlock functions such that when the unit operates the following associated equipment operates also:

1. P-HX1 thru 3, (primary heat exchanger loop pumps), DCR-1 thru 3 (Drycoolers) CT-2 (Cooling Tower), MAF-1 (Make-up Air Fan), EF-1 (Exhaust Fan), SC-1 thru 3 (Steam Condensers), CEX-1 thru 3 (Heat Recovery Steam Generators) as relating to cogen units CG-1 through 4.

B. CHP Plant Space Temperature Control/Combustion Air supply

1. Exhaust Fan – Excessive heat buildup in the CHP Plant and minimum combustion air supply shall be maintained by operating the interlocked makeup-air fan (MAF-1) and exhaust fan (EF-1). Make up air volume and exhaust air volume shall be the same. The fans will maintain a minimum supply volume equal to that of the number of engines call to run. Both MAF-1 and EF-1 will employ VFD's for speed control. The minimum air delivery for combustion per engine is 1,500 CFM. Upon a rise in temperature above 78F, the fans will ramp up to the maximum rated flow of the MAF-1 at 30,000 CFM. Upon a decrease in temperature below CHP Plant set-point, the reverse shall occur.
2. Unit Heater – Upon a decrease in space temperature below 55F, the unit heaters shall be energized. Upon an increase above setpoint the reverse shall occur, with a 10F deadband.

C. Cogeneration Loop Temperature Control

1. High Limit (primary): (Described at CG-1, typical to all units) Whenever the loop water return temperature at TE-106 rises above 186°F, the 3-way modulating valve on the hot side of the HX (provided by the engine manufacturer) shall modulate to maintain the TE-106 set point temperature of 186°F. Once the EWT to DCR-1 reaches 210° F the drycooler fans shall be indexed on for DCR-1 and their speed maintained by VFD to maintain the TE-106 set point temperature.
2. Low Limit: The control system shall maintain the low limit of the loop to 180°F at TE-602. This sh all be accomplished by coordination of TE-602 and the corresponding DCR's in operation and temperature control related to them.

D. Exhaust Heat Recovery Units

All Systems: Water shall flow to the heat recovery steam generators at all times. High pressure steam shall flow from the CEX, and feedwater to the CEX, at all times unless in the event of a CEX failure. In the case of excess steam production, excess pressure will be by-passed by the excess steam pressure valve to SC-1. SC-1 will be enabled by the pressure sensed on the header steam pressure sensor, SP-1.

E. CEX/Existing Boiler Sequence

The CHP Plant will lead in the production of steam with the existing boilers used to supplement the steam load. The DDC system will send a signal to enable an existing boiler when the steam load approaches 90% of the available steam capacity of the operating CEX's. The existing boilers will continue using the existing control system for burner firing based on steam pressure in the header.

F. Aftercooler Loop Temperature Control:

Described at CG-1, typical to all units)

1. High Limit: The temperature at TE-312, EWT to CT-2 shall be maintained at 95°F set point by the differential of TE-312 and TE-311.

G. Domestic Water Temperature Control:

Upon P-CHW-1 indexing on, Domestic Water Temperature set point at TE-606 shall be maintained at 145°F by modulating CV-1. High limit control, If TE-606 setpoint rises above 150°F, an alarm shall be annunciated and P-CHW-1 sh all be indexed off.

H. Whenever heating or chilled water is required, P-CHW-2 shall be indexed on pumping the main loop serving the second and fifth floor penthouse for use CH-3 and HX-5 thru 7. During the cooling season CH-3 will take precedence for cogen heat recovery so as to maximize recovery potential and suppress the use of the existing electric chillers. During the heating season HX-4 thru 7 will recover heat equally not exceeded the minimum return water temperature at TE-602.

Mechanical Control – Sequence of Operations

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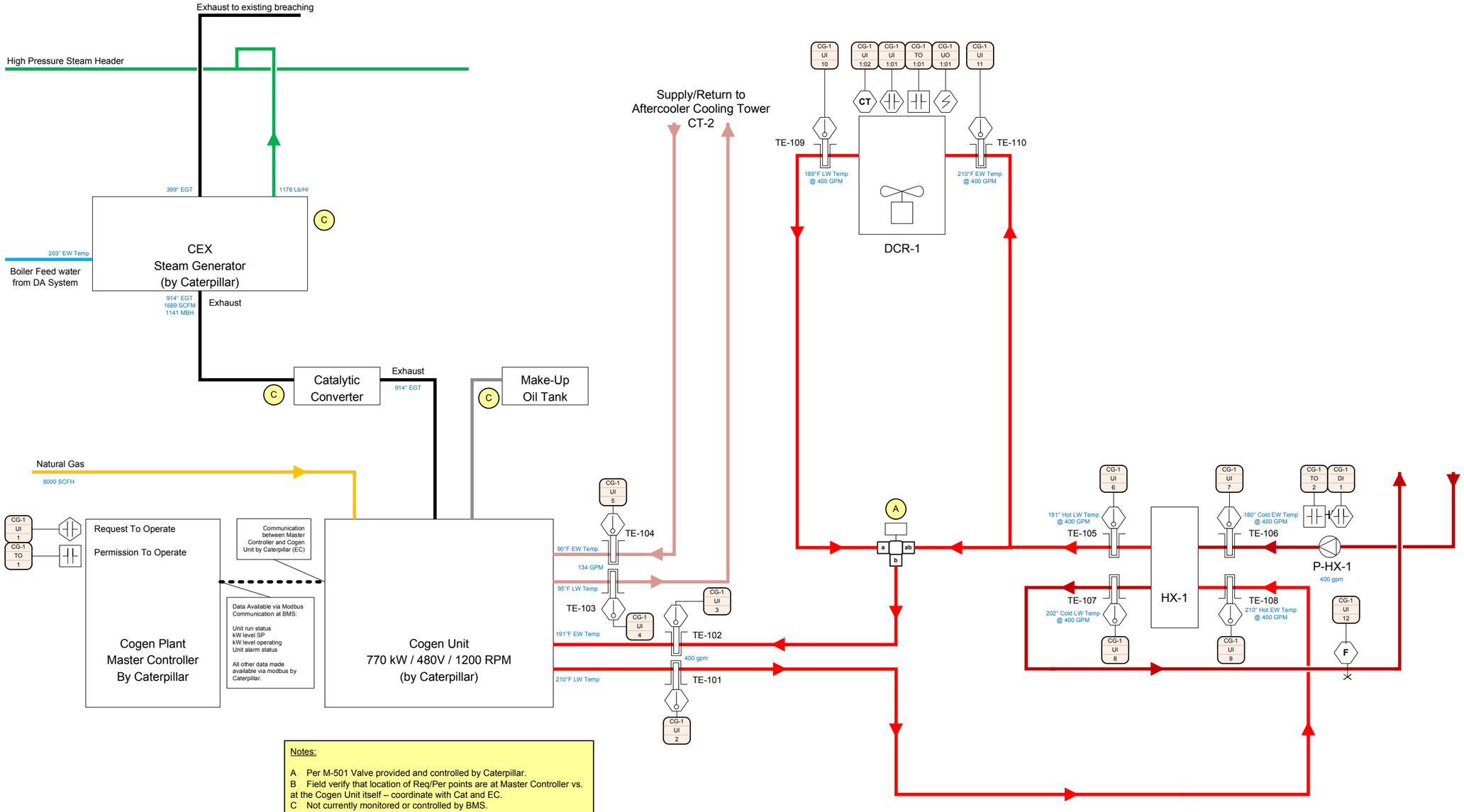

Notes:

A Per M-501 Valve provided and controlled by Caterpillar.
B Field verify that location of Req/Per points are at Master Controller vs. at the Cogen Unit itself – coordinate with Cat and EC.
C Not currently monitored or controlled by BMS.

Cogen Unit 1 (CG-1) Control Schematic

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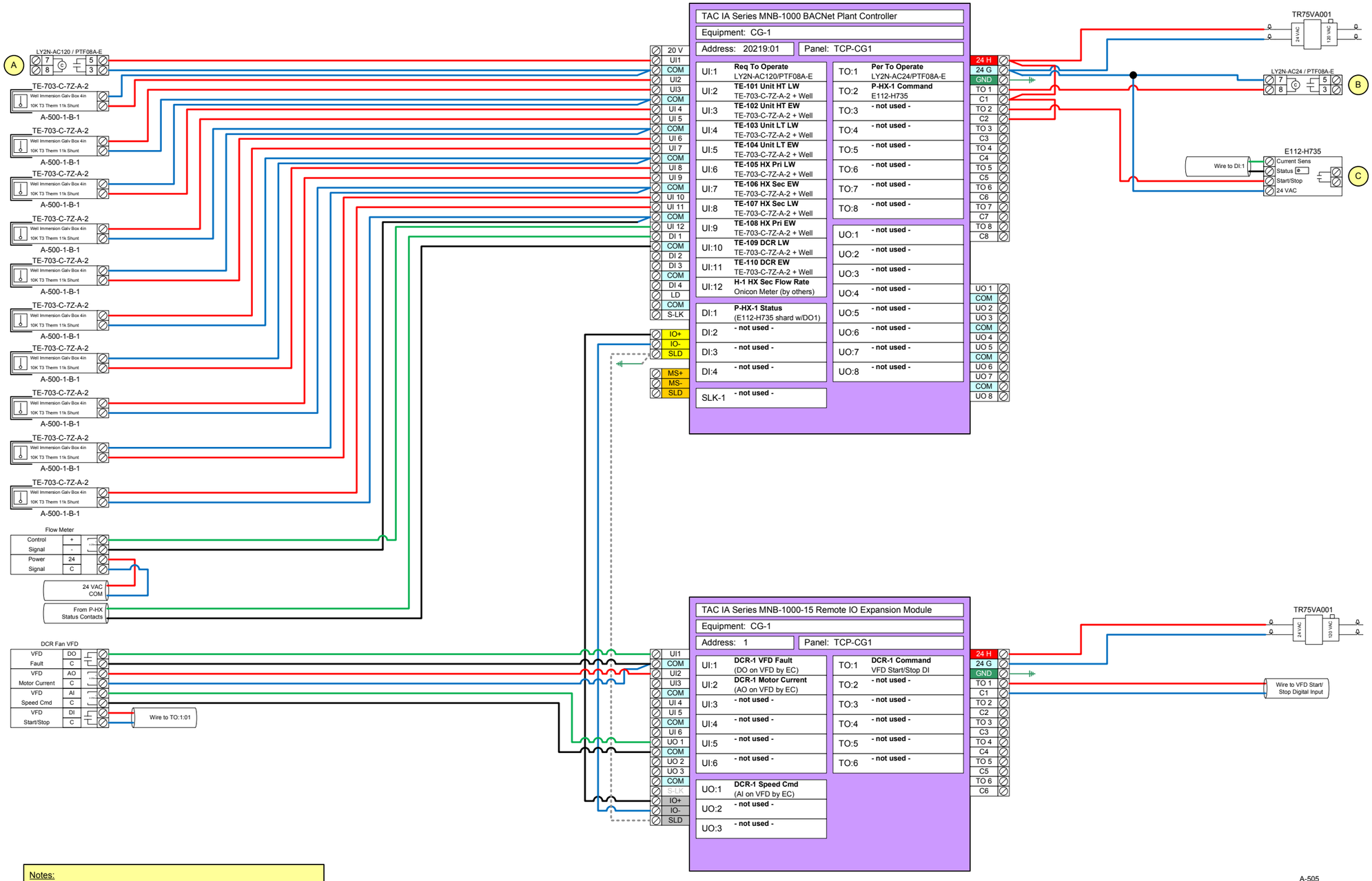

Notes:

A Wire To Request Contact at Cogen Unit or Master Controller – omit relay if Caterpillar contact is dry.
B Wire To Permission Contact at Cogen Unit or Master Controller.
C Wire to 'Auto' circuit of motor starter.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	10
A-505	1
E112-H735	1
LY2N-AC120 / PTF08A-E	1
LY2N-AC24 / PTF08A-E	1
MNB-1000	1
MNB-1000-15	1
TE-703-C-7Z-A-2	10
TR75VA001	2

CG-1 Control Wiring Diagram

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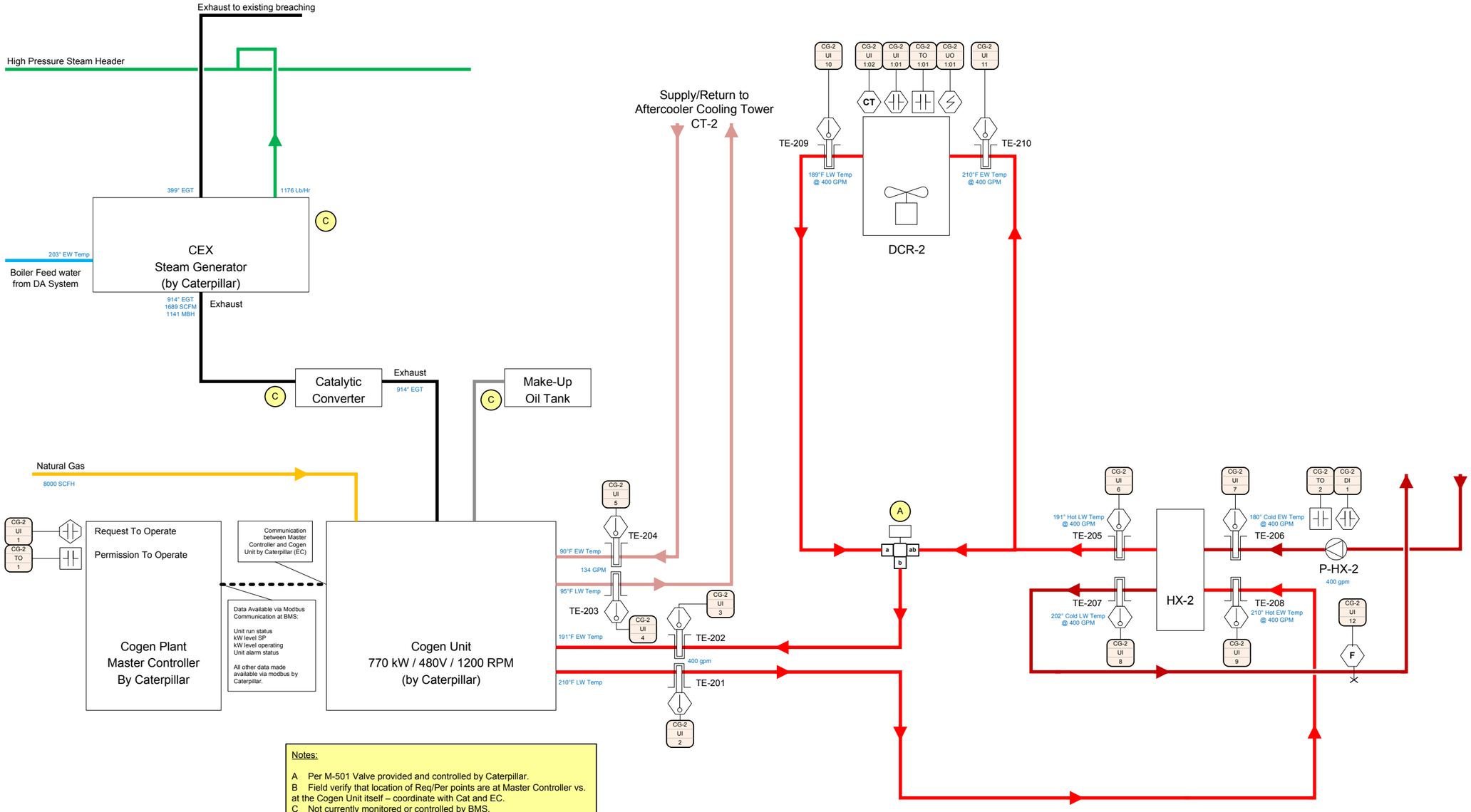

Notes:

A Per M-501 Valve provided and controlled by Caterpillar.
B Field verify that location of Req/Per points are at Master Controller vs. at the Cogen Unit itself – coordinate with Cat and EC.
C Not currently monitored or controlled by BMS.

Cogen Unit 2 (CG-2) Control Schematic

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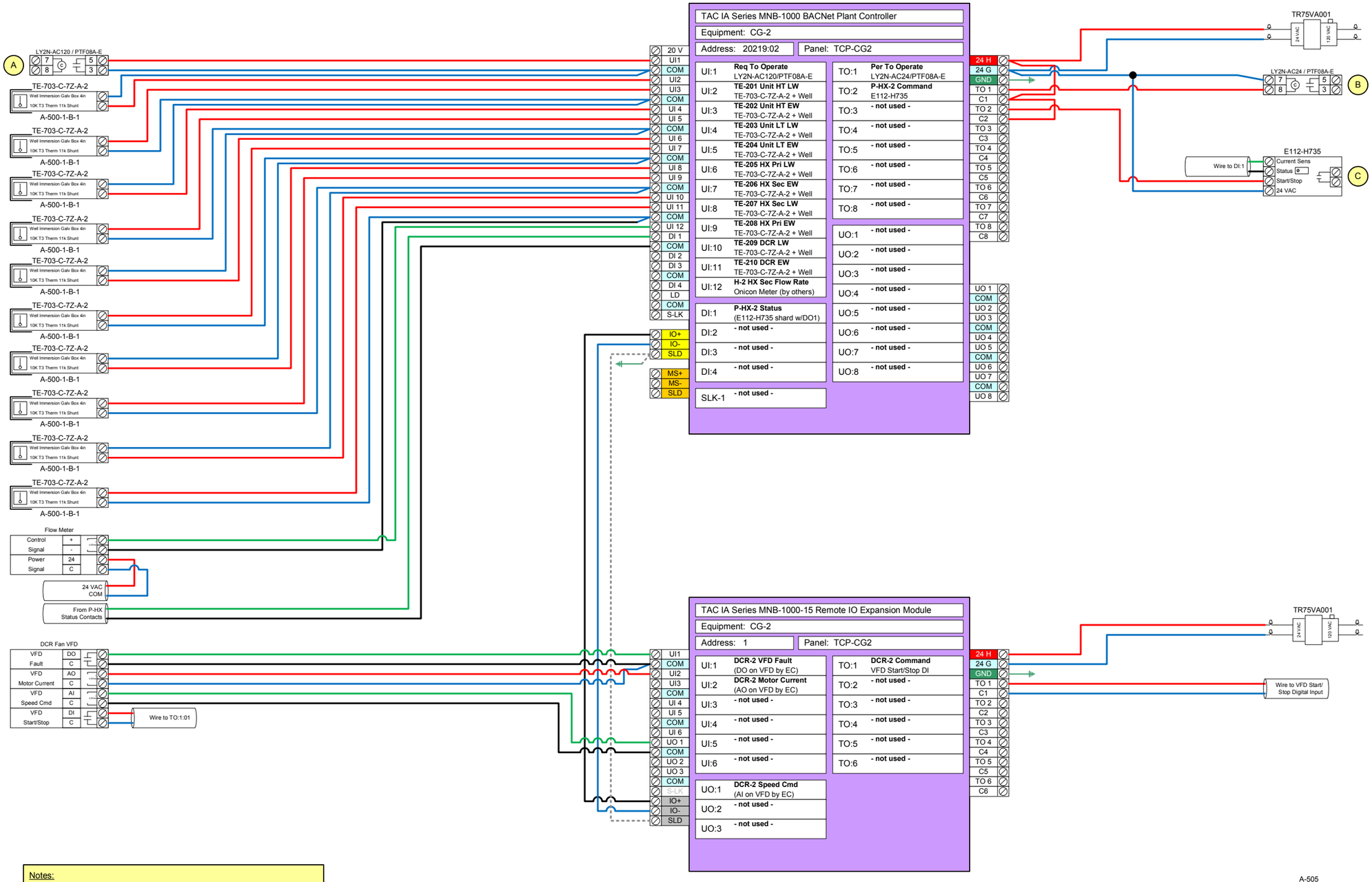

Notes:

A Wire To Request Contact at Cogen Unit or Master Controller – omit relay if Caterpillar contact is dry.
B Wire To Permission Contact at Cogen Unit or Master Controller.
C Wire to 'Auto' circuit of motor starter.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	10
A-505	1
E112-H735	1
LY2N-AC120 / PTF08A-E	1
LY2N-AC24 / PTF08A-E	1
MNB-1000	1
MNB-1000-15	1
TE-703-C-7Z-A-2	10
TR75VA001	2

CG-2 Control Wiring Diagram

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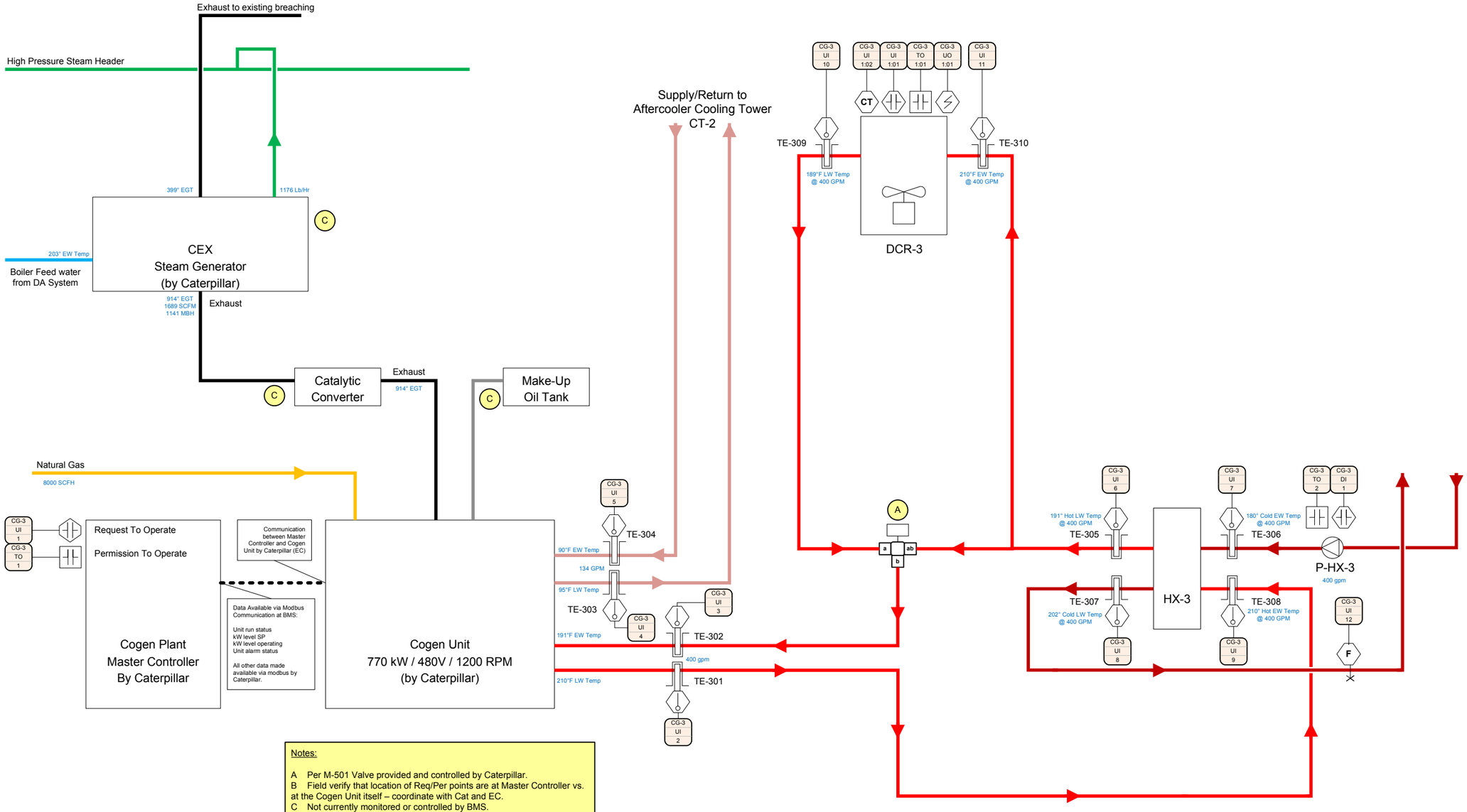

Notes:

A Per M-501 Valve provided and controlled by Caterpillar.
B Field verify that location of Req/Per points are at Master Controller vs. at the Cogen Unit itself – coordinate with Cat and EC.
C Not currently monitored or controlled by BMS.

Cogen Unit 3 (CG-3) Control Schematic

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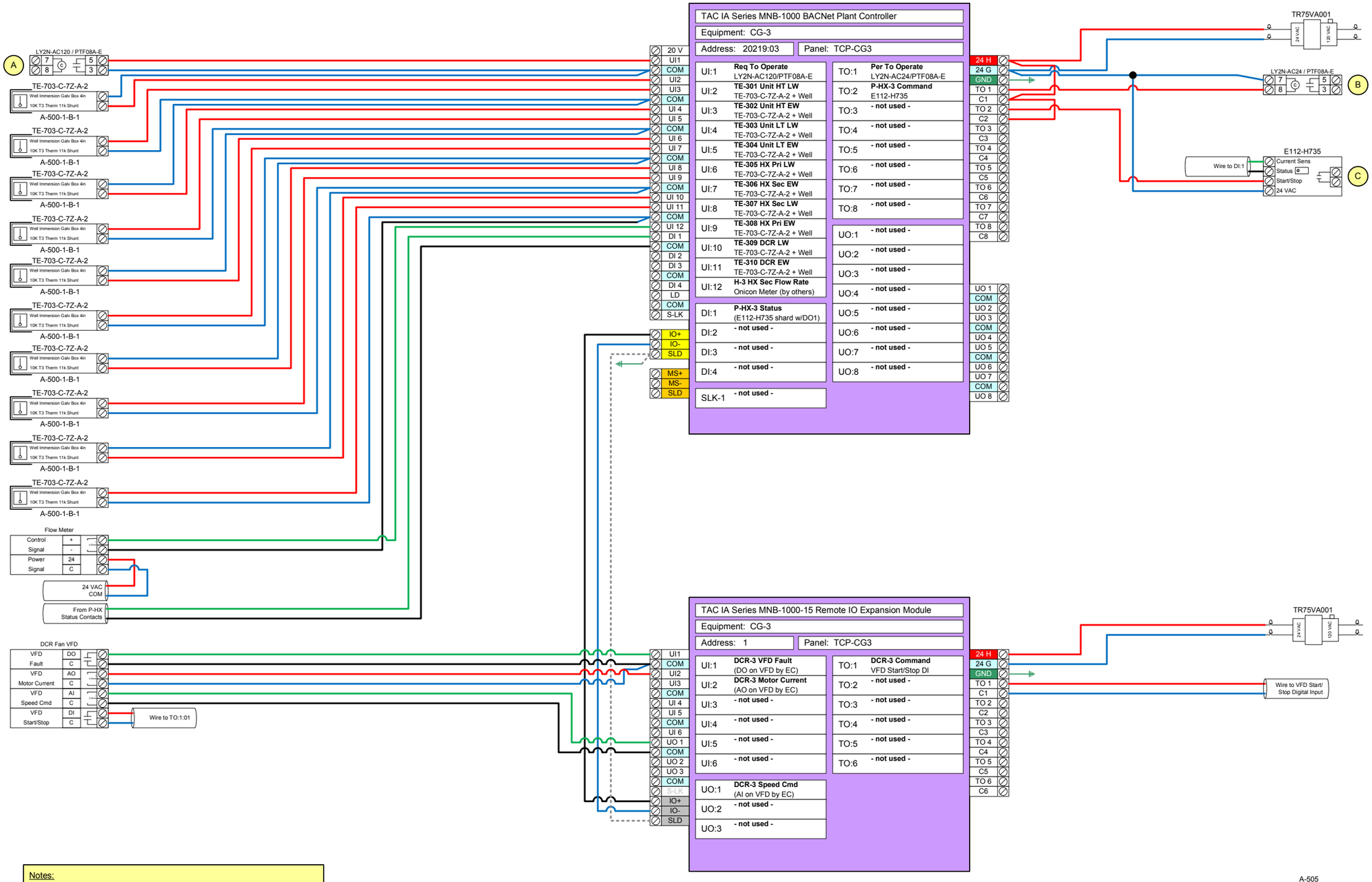

Notes:

A Wire To Request Contact at Cogen Unit or Master Controller – omit relay if Caterpillar contact is dry.
B Wire To Permission Contact at Cogen Unit or Master Controller.
C Wire to 'Auto' circuit of motor starter.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	10
A-505	1
E112-H735	1
LY2N-AC120 / PTF08A-E	1
LY2N-AC24 / PTF08A-E	1
MNB-1000	1
MNB-1000-15	1
TE-703-C-7Z-A-2	10
TR75VA001	2

CG-3 Control Wiring Diagram

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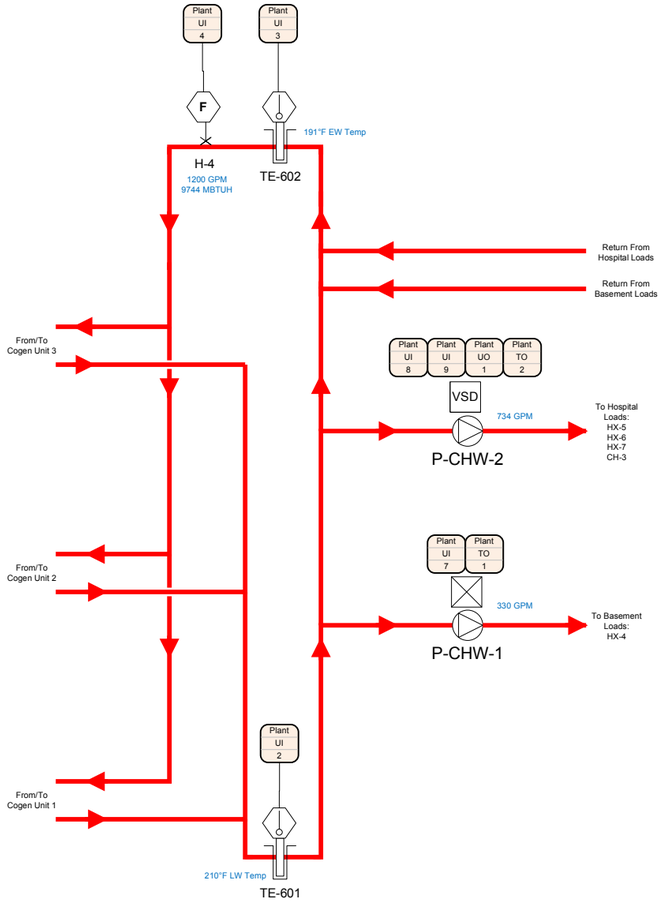
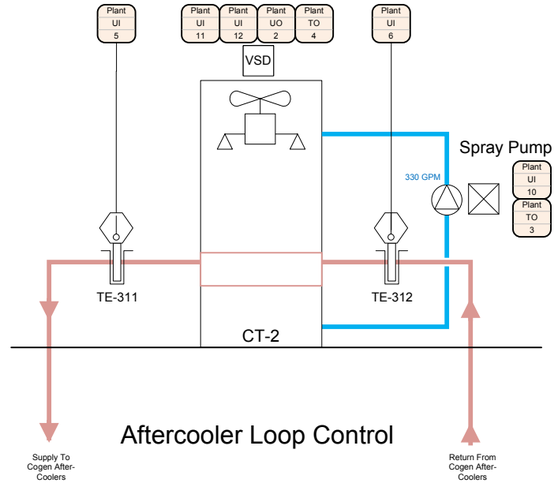
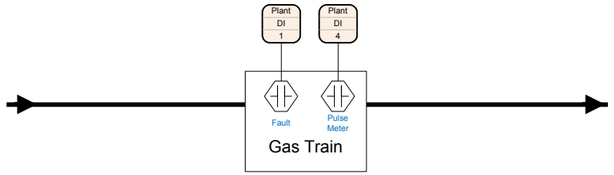


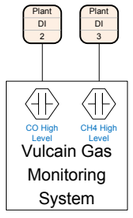
Cogen HW Loop Control



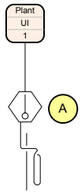
Aftercooler Loop Control



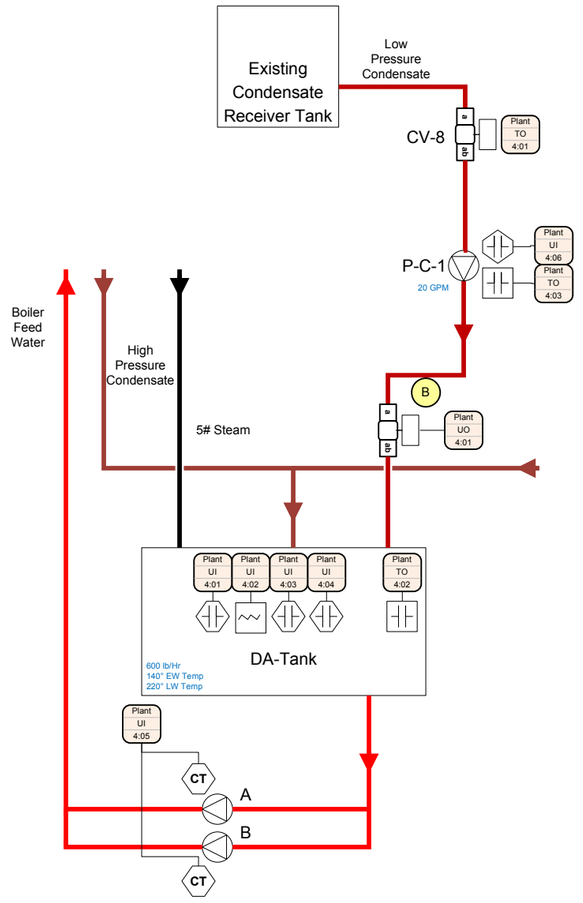
Natual Gas Monitoring



Combustable Gas Monitoring



Outdoor Temperature Monitoring



DA System

Notes:

A Locate on north face of building, away from all doors, windows, vents and with no direct exposure to sun light.
B Valve by DA System Mfg, control by BMS

Plant Controls A

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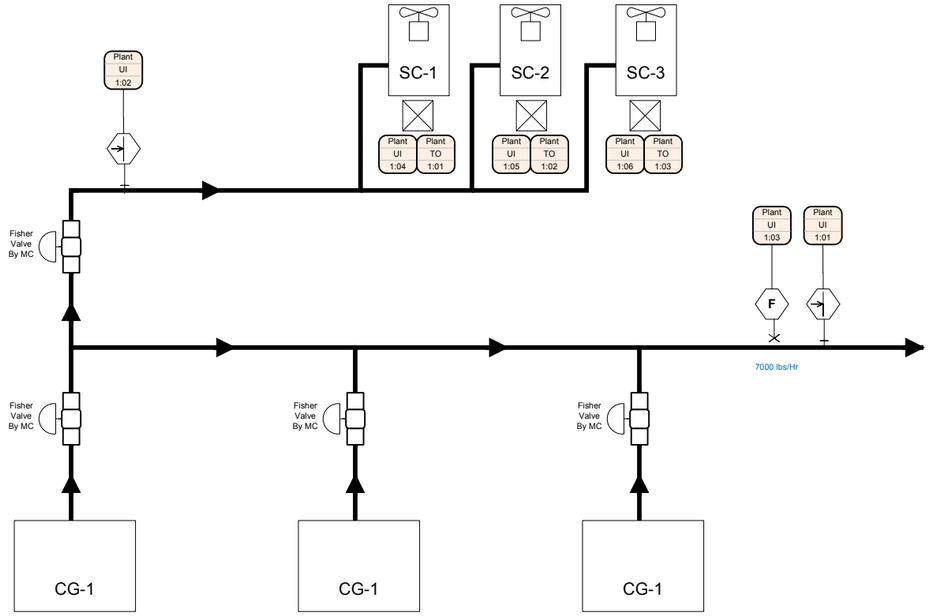
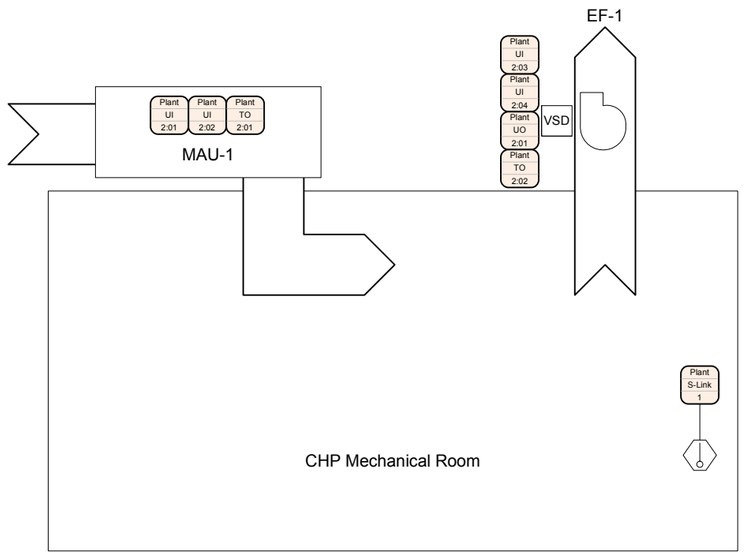
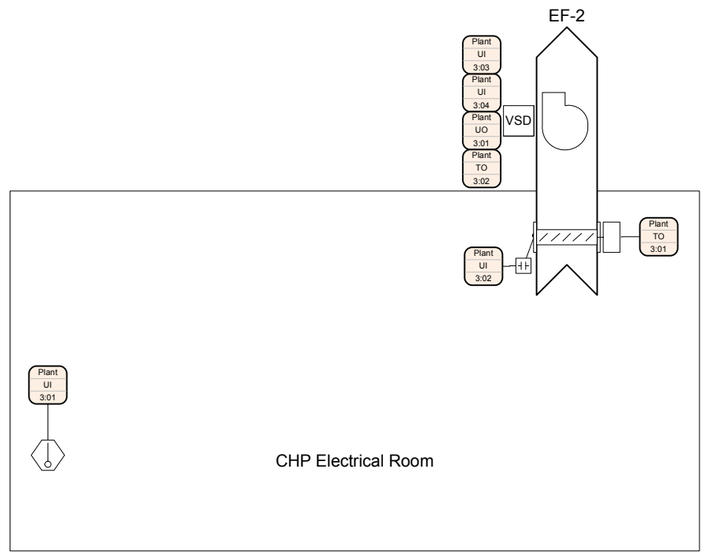


Steam System Control



MAU-1 / EF-1 Control



EF-2 Control

Plant Controls B

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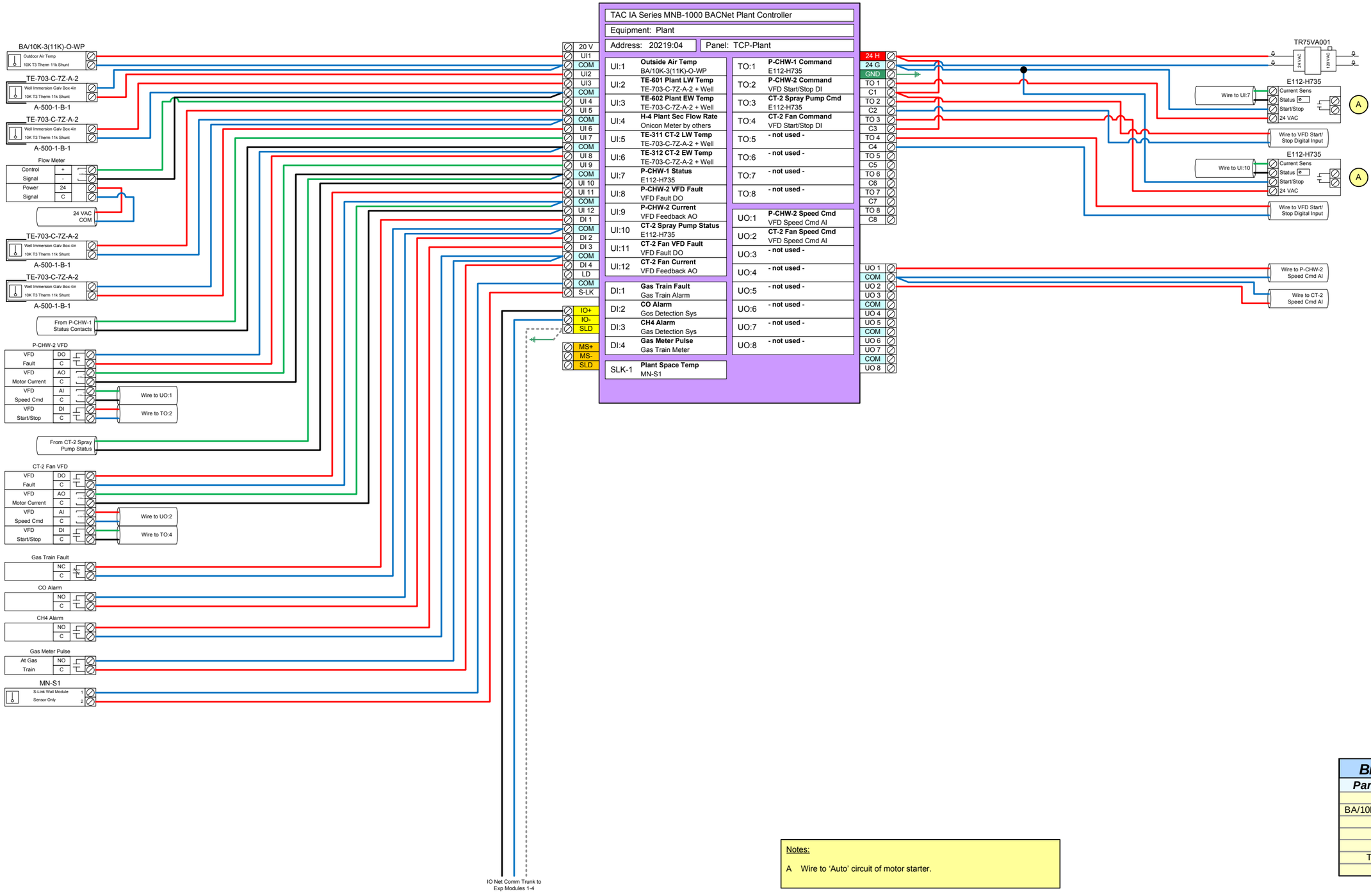

Plant Wiring A – Main Controller

Bill of Materials	
Part Number	**Quantity**
A-500-1-B-1	4
BA/10K-3(11K)-O-WP	1
E112-H735	2
MN-S1	1
MNB-1000	1
TE-703-C-7Z-A-2	4
TR75VA001	1

Notes:

A Wire to 'Auto' circuit of motor starter.

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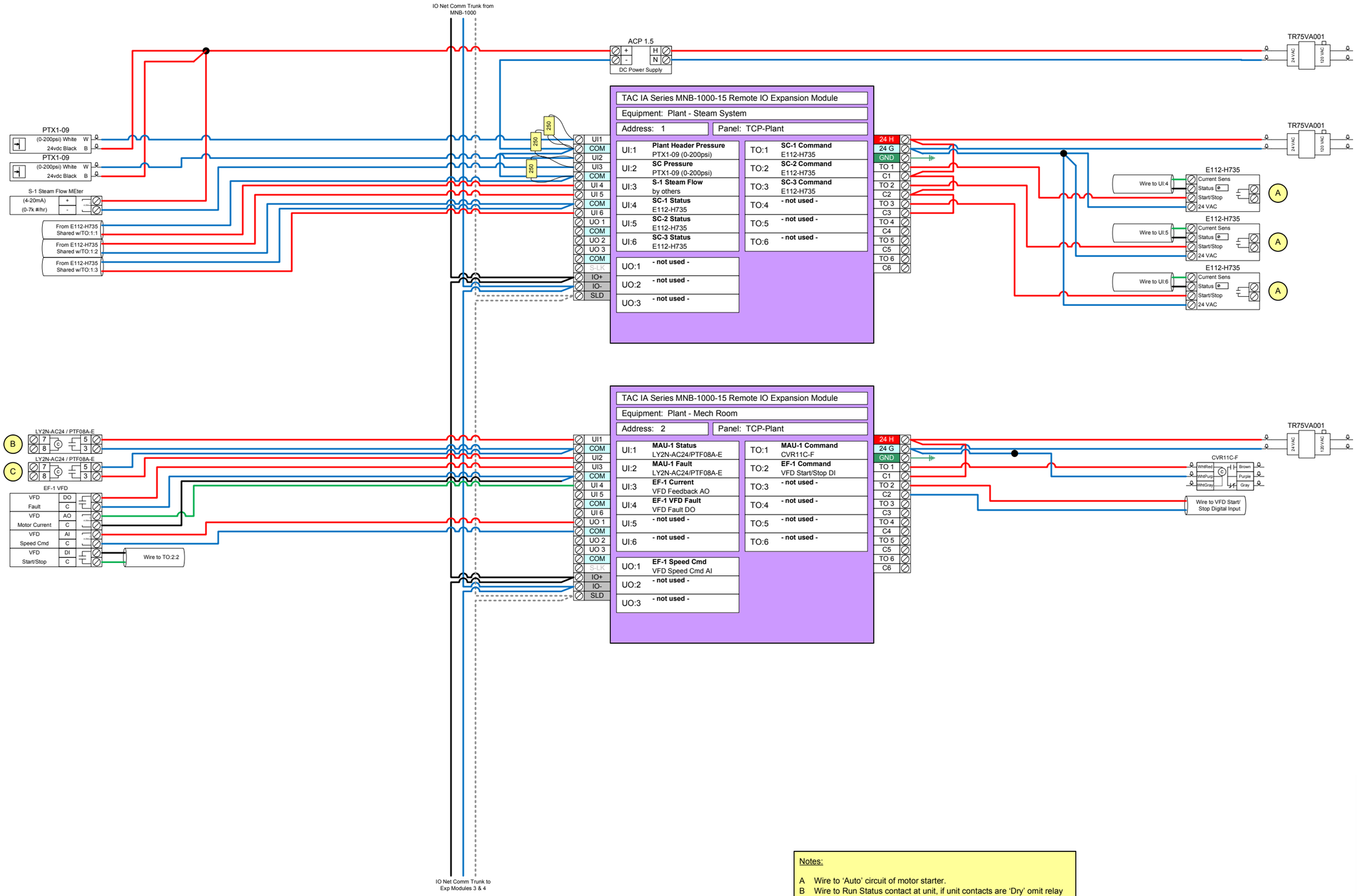

Plant Wiring B – Expansion Modules 1 & 2

Notes:

A Wire to 'Auto' circuit of motor starter.
B Wire to Run Status contact at unit, if unit contacts are 'Dry' omit relay
C Wire to Alarm Status contact at unit, if unit contacts are 'Dry' omit relay

Bill of Materials

Part Number	Quantity
ACP 1.5	1
CVR11C-F	1
E112-H735	3
LY2N-AC24 / PTF08A-E	2
MNB-1000-15	2
PTX1-09	2
Resistor 250	3
TR75VA001	3

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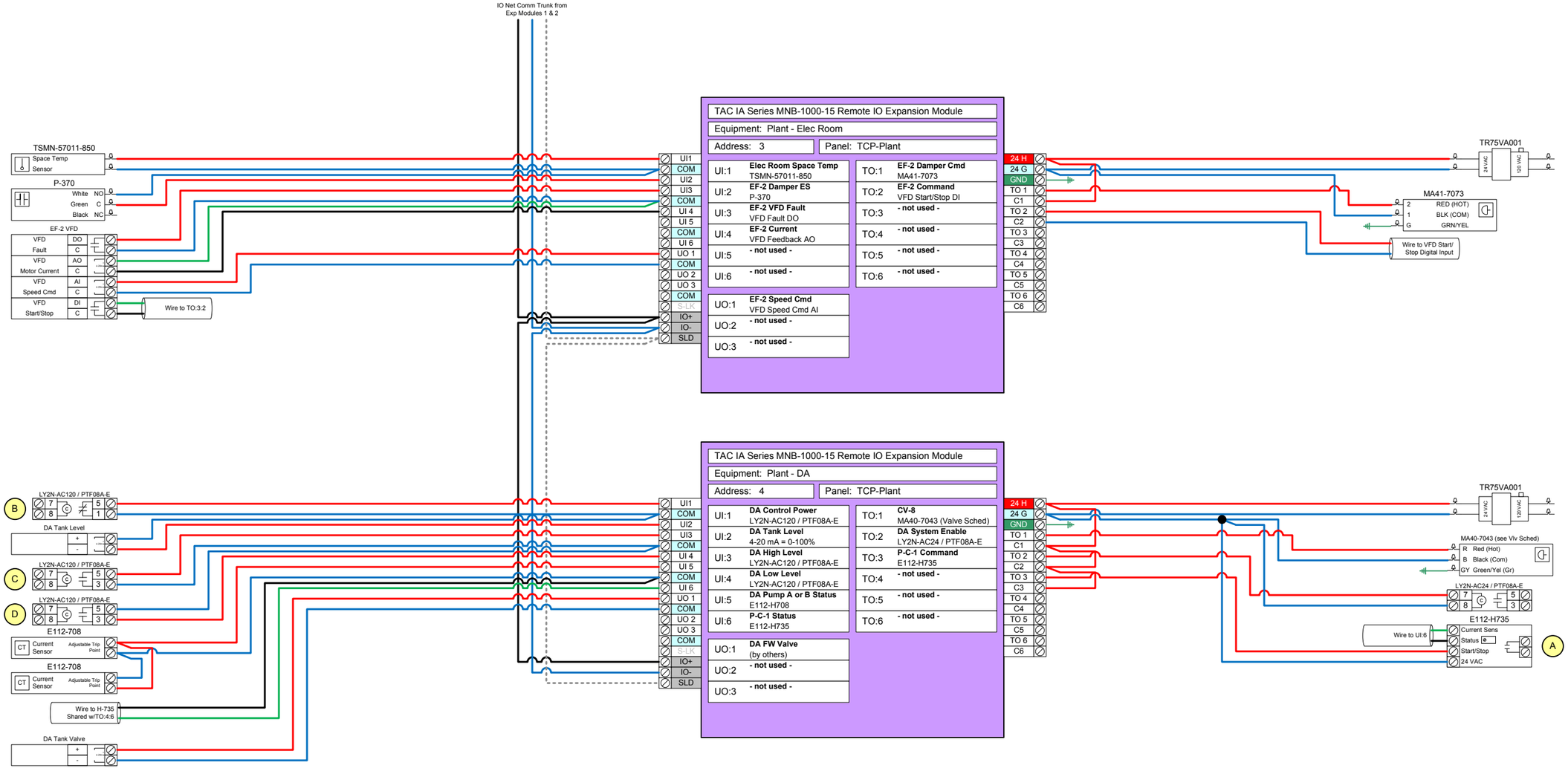

Plant Wiring C – Expansion Modules 3 & 4

Notes:

A Wire to 'Auto' circuit of motor starter.
B Wire to Load Side of Control Power Switch
C Wire to High level contacts – omit relay if contats are dry.
D Wire to Low level contacts – omit relay if contacts are dry.

Bill of Materials

Part Number	Quantity
E112-708	2
E112-H735	1
LY2N-AC120 / PTF08A-E	3
LY2N-AC24 / PTF08A-E	1
MA41-7073	1
MNB-1000-15	2
P-370	1
TR75VA001	2
TSMN-57011-850	1

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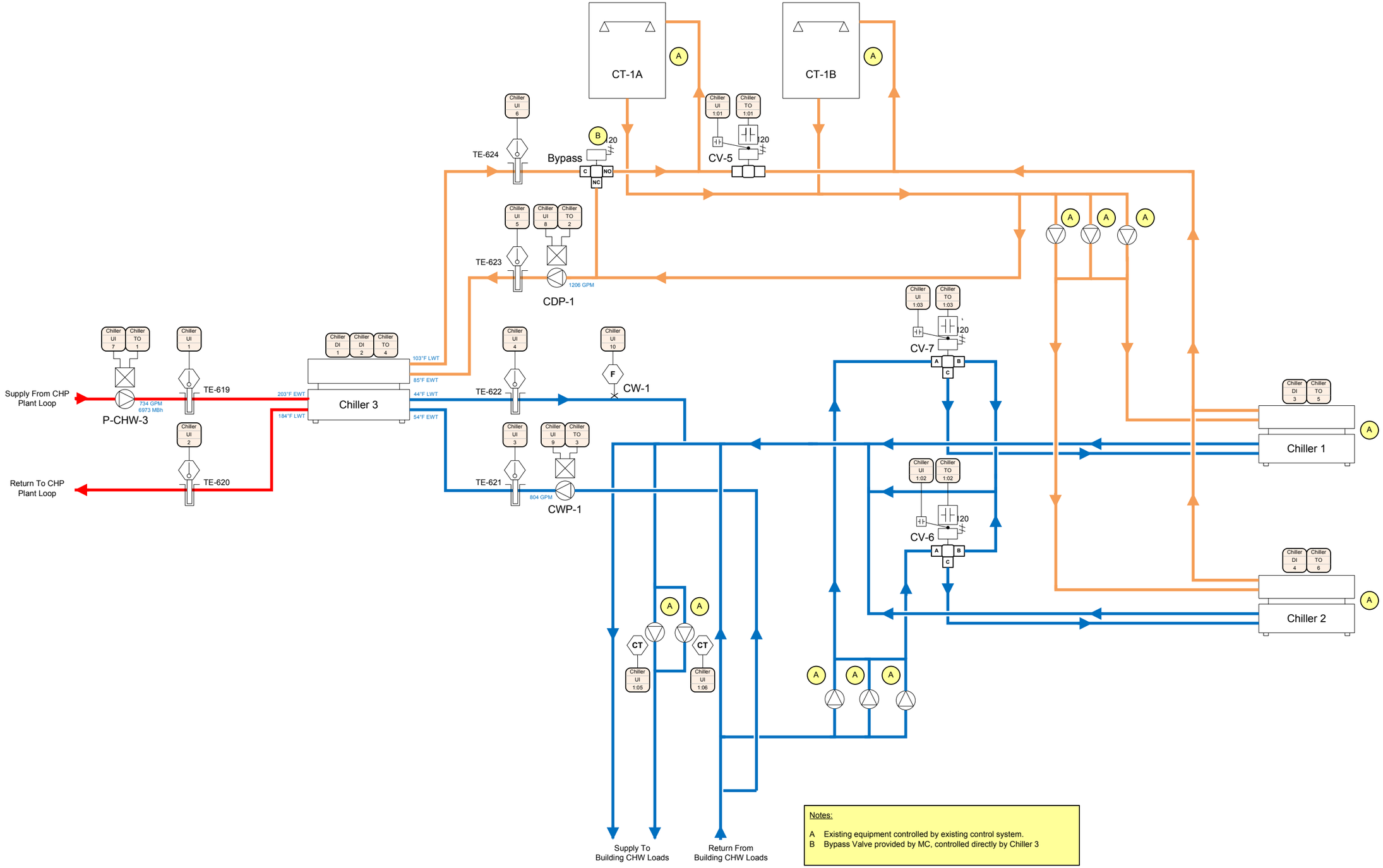

Notes:

A Existing equipment controlled by existing control system.
B Bypass Valve provided by MC, controlled directly by Chiller 3

Chiller Control

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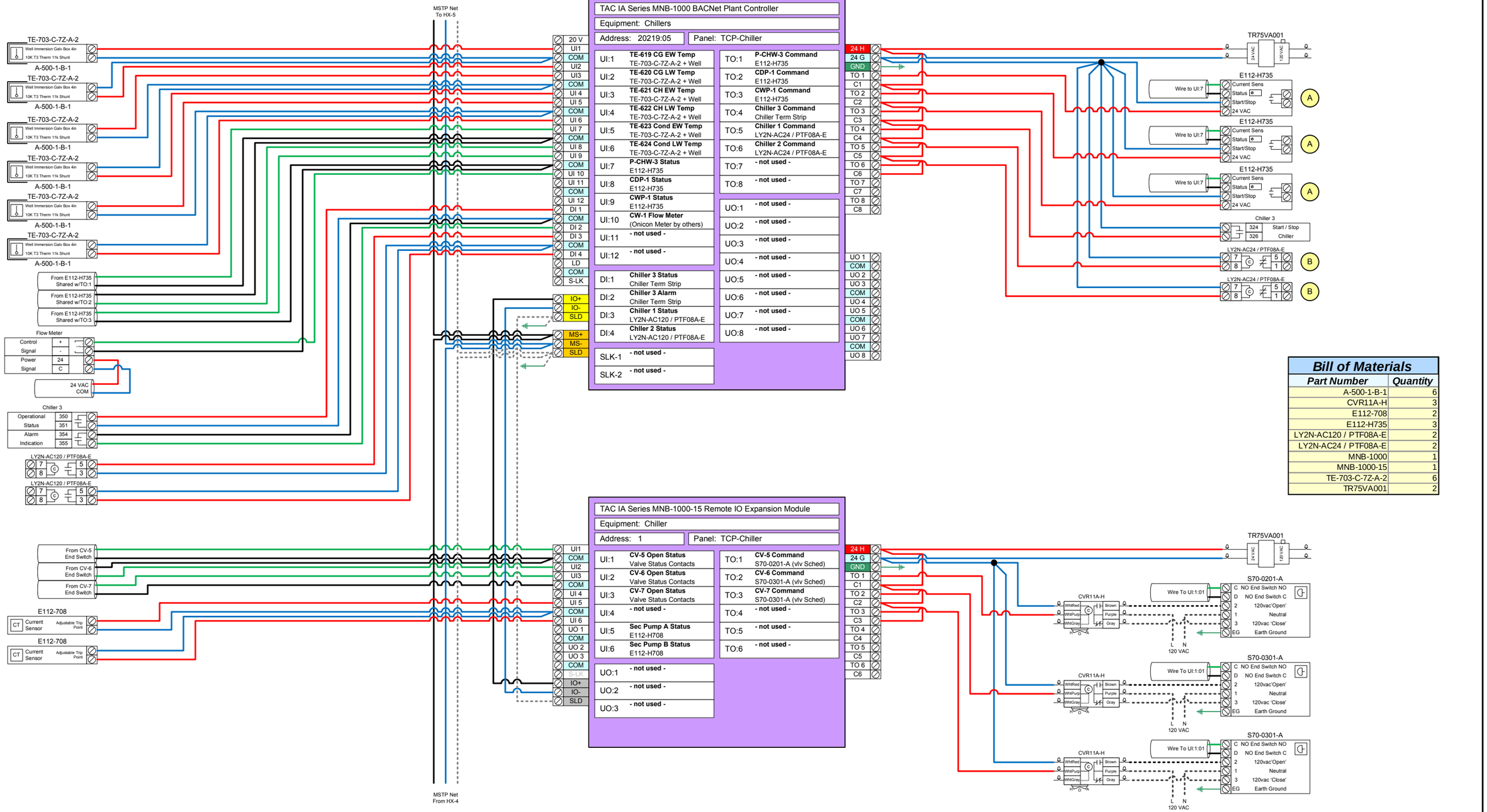

Bill of Materials

Part Number	Quantity
A-500-1-B-1	6
CVR11A-H	3
E112-708	2
E112-H735	3
LY2N-AC120 / PTF08A-E	2
LY2N-AC24 / PTF08A-E	2
MNB-1000	1
MNB-1000-15	1
TE-703-C-7Z-A-2	6
TR75VA001	2

Notes:

A Wire to 'Auto' circuit of motor starter.
B Wire NC Contacts in series with existing Chiller controls

Chiller Wiring

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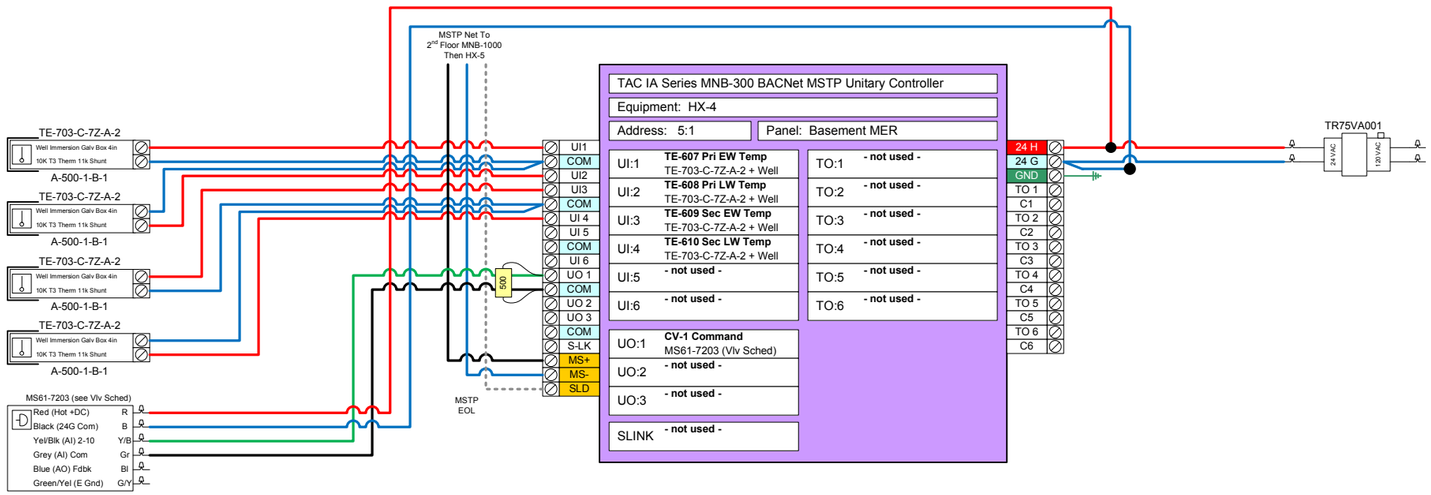

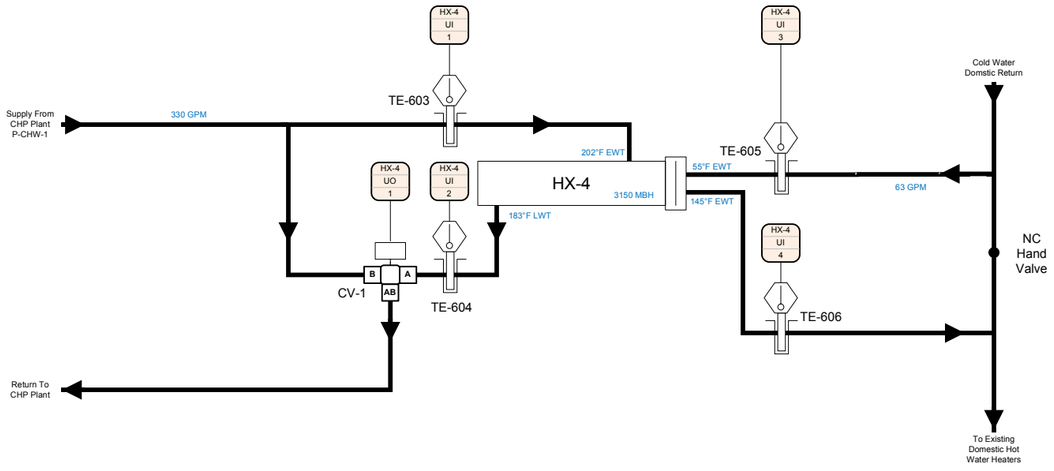

Heat Exchanger Control

The following conditions must be true in order for the heat exchanger and its control valve to operate:

- The CHP plant must have at least 1 Cogen Unit operating
- P-CHW-1 must prove to be operational
- The CHP plant leaving water temp at TE-601 must be greater than 180℉, adjustable
- The HX must be manually enabled from the GUI

Once all the above conditions have been met, the control valve will be allowed to modulate from the full bypass position towards full flow through the heat exchanger. The valve will be modulated to maintain an initial secondary loop leaving water temperature set point of 145℉, adjustable (at TE-606).

If either primary or secondary pump should fail to prove its operation within 3 minutes, an alarm will be generated.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	4
MNB-300	1
Resistor 500	1
TE-703-C-7Z-A-2	4
TR75VA001	1

HX-4

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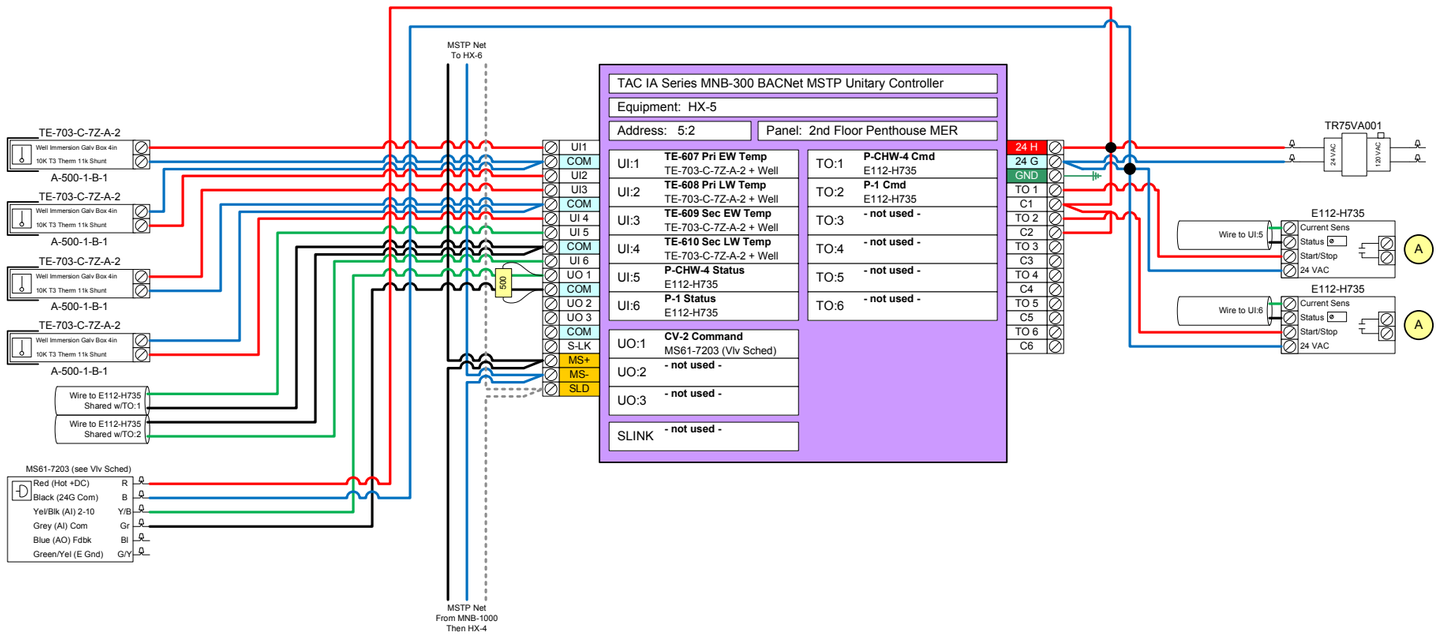

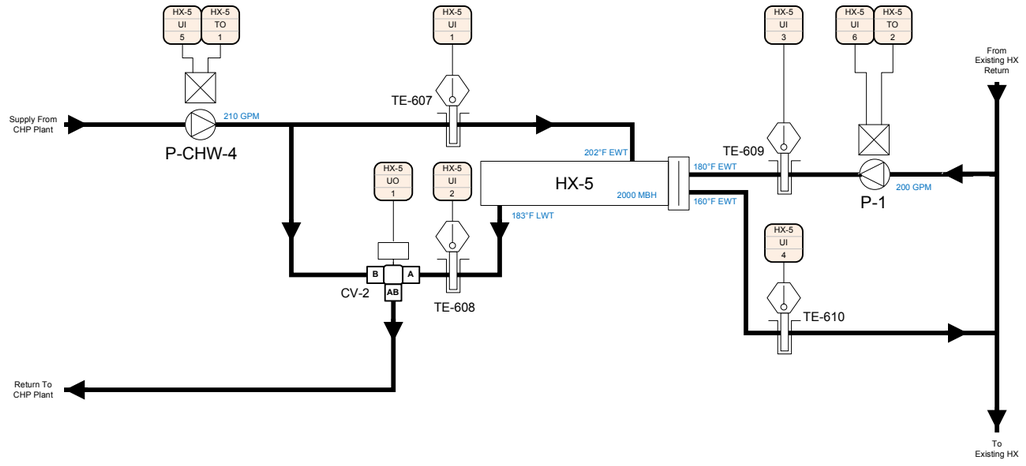

HX-5 Control

Heat Exchanger Control

There will be an adjustable heating season, initially defined as September 1st through May 31st. The following conditions must be true in order for the heat exchanger and its associated pumps and control valve to operate:

- The heating season must be active
- The outside air temperature must be less than 60°F , adjustable
- The CHP plant must have at least 1 Cogen Unit operating
- P-CHW-2 must prove to be operational
- The CHP plant leaving water temp at TE-601 must be greater than 180°F, adjustable
- The HX must be manually enabled from the GUI

Once all the above conditions have been met, the primary and secondary pumps will both be started. When both pumps have proven their respective operation through a current sensing switch, the control valve will be allowed to modulate from the full bypass position towards full flow through the heat exchanger. The valve will be modulated to maintain an initial secondary loop leaving water temperature set point of 180°F, adjustable (at TE-610).

If either primary or secondary pump should fail to prove its operation within 3 minutes, an alarm will be generated.

Notes:

A Wire to 'Auto' circuit of motor starter.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	4
E112-H735	2
MNB-300	1
Resistor 500	1
TE-703-C-7Z-A-2	4
TR75VA001	1

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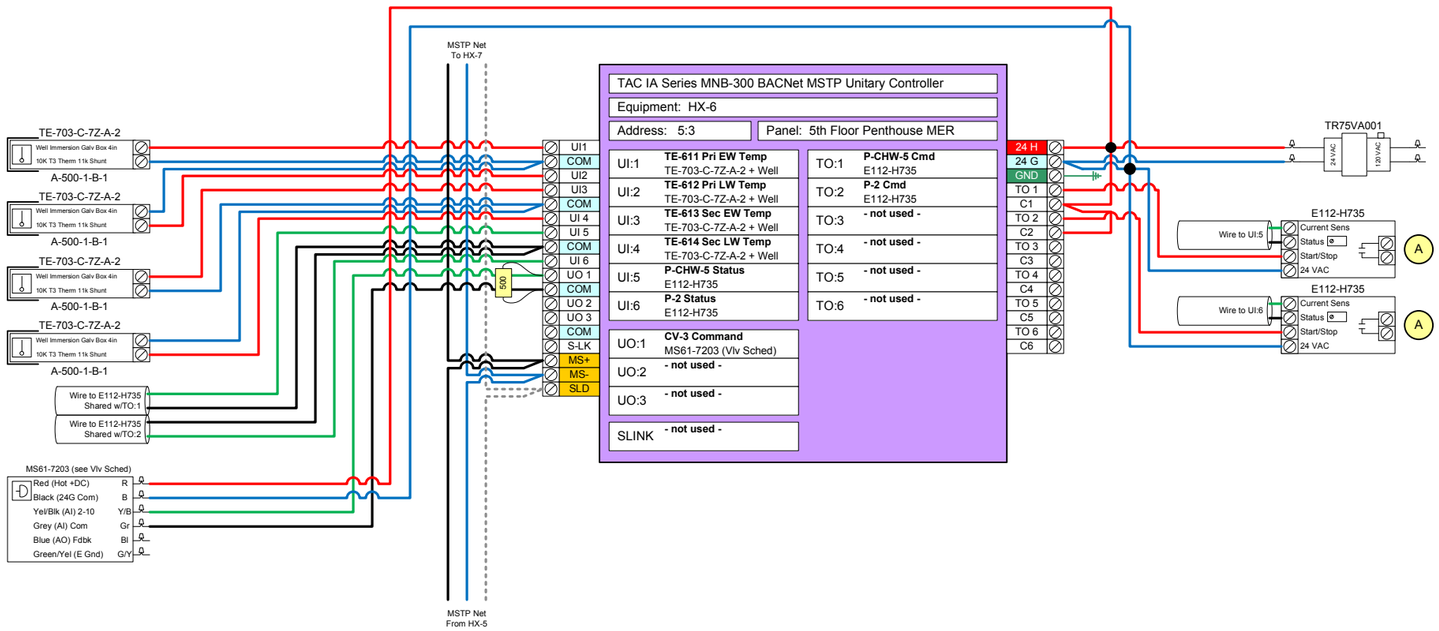


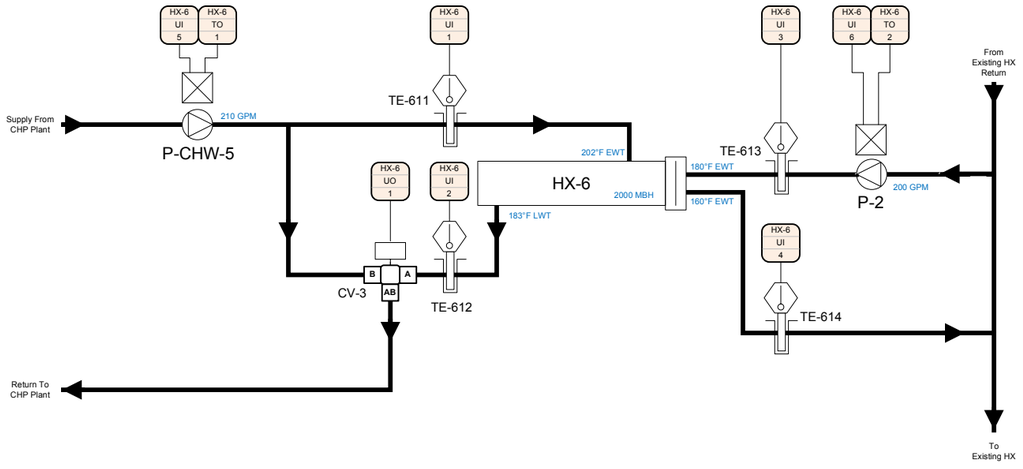
Heat Exchanger Control

There will be an adjustable heating season, initially defined as September 1st through May 31st. The following conditions must be true in order for the heat exchanger and its associated pumps and control valve to operate:

- The heating season must be active
- The outside air temperature must be less than 60°F , adjustable
- The CHP plant must have at least 1 Cogen Unit operating
- P-CHW-2 must prove to be operational
- The CHP plant leaving water temp at TE-601 must be greater than 180°F, adjustable
- The HX must be manually enabled from the GUI

Once all the above conditions have been met, the primary and secondary pumps will both be started. When both pumps have proven their respective operation through a current sensing switch, the control valve will be allowed to modulate from the full bypass position towards full flow through the heat exchanger. The valve will be modulated to maintain an initial secondary loop leaving water temperature set point of 180°F, adjustable (at TE-614).

If either primary or secondary pump should fail to prove its operation within 3 minutes, an alarm will be generated.



HX-6 Control

Notes:

A Wire to 'Auto' circuit of motor starter.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	4
E112-H735	2
MNB-300	1
Resistor 500	1
TE-703-C-7Z-A-2	4
TR75VA001	1

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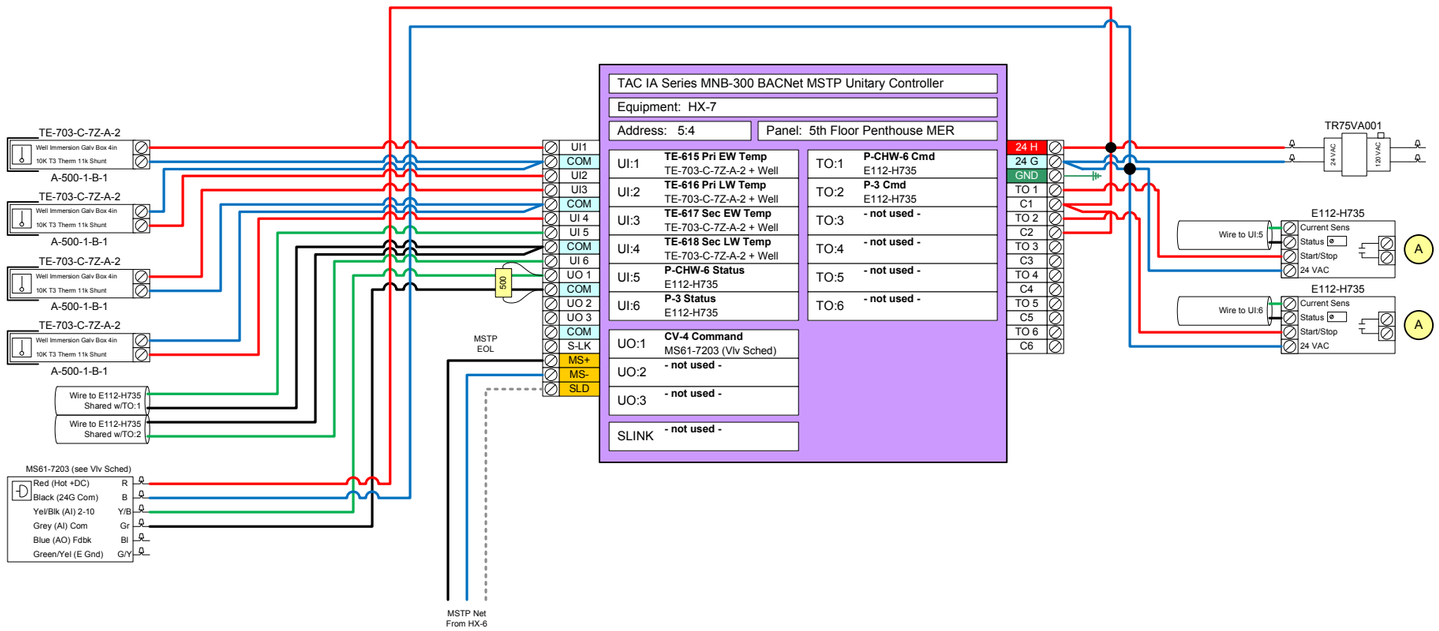

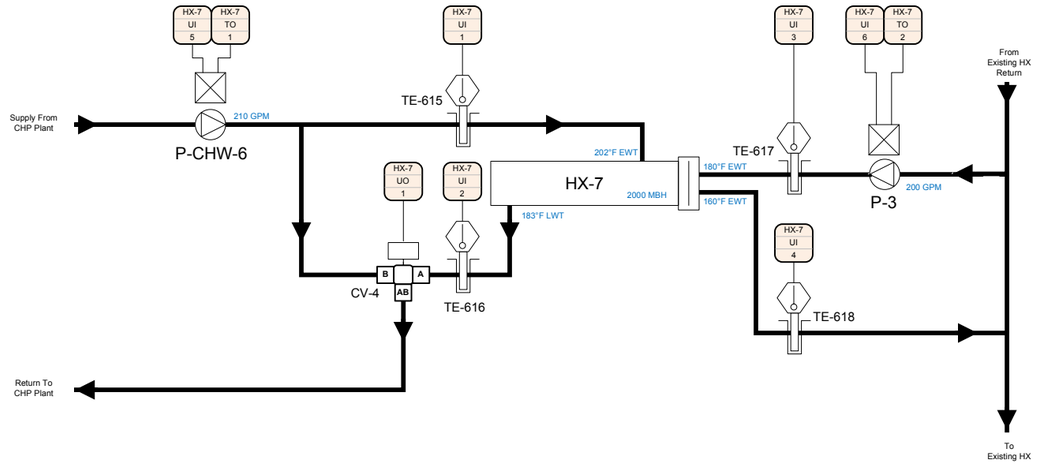

HX-7 Control

Heat Exchanger Control

There will be an adjustable heating season, initially defined as September 1st through May 31st. The following conditions must be true in order for the heat exchanger and its associated pumps and control valve to operate:

- The heating season must be active
- The outside air temperature must be less than 60°F, adjustable
- The CHP plant must have at least 1 Cogen Unit operating
- P-CHW-2 must prove to be operational
- The CHP plant leaving water temp at TE-601 must be greater than 180°F, adjustable
- The HX must be manually enabled from the GUI

Once all the above conditions have been met, the primary and secondary pumps will both be started. When both pumps have proven their respective operation through a current sensing switch, the control valve will be allowed to modulate from the full bypass position towards full flow through the heat exchanger. The valve will be modulated to maintain an initial secondary loop leaving water temperature set point of 180°F, adjustable (at TE-6 18).

If either primary or secondary pump should fail to prove its operation within 3 minutes, an alarm will be generated.

Bill of Materials

Part Number	Quantity
A-500-1-B-1	4
E112-H735	2
MNB-300	1
Resistor 500	1
TE-703-C-7Z-A-2	4
TR75VA001	1

Notes:

A Wire to 'Auto' circuit of motor starter.

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Bill of Materials

Part Number	Quantity
A-500-1-B-1	56
A-505	3
ACP 1.5	1
BA/10K-3(11K)-O-WP	1
CVR11A-H	3
CVR11C-F	1
E112-708	4
E112-H735	18
EOL Resistor	7
LY2N-AC120 / PTF08A-E	8
LY2N-AC24 / PTF08A-E	8
MA41-7073	1
MN-S1	1
MNB-1000	5
MNB-1000-15	8
MNB-300	4
Netgear Hub	2
P-370	1
PTX1-09	2
Resistor 250	3
Resistor 500	4
Siemens Large 567-353	6
Siemens Medium 567-352	2
TE-703-C-7Z-A-2	56
TR75VA001	18
TSMN-57011-850	1

Job Bill of Materials

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