Fermilab

CMS CO_2 COOLING TEST STAND

PROCESS CONTROL SYSTEM, INSTRUMENTATION, and FIELD EQUIPMENT

Location: FermiLab \ Lab C and South Clean Room

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ENGINEERING NOTE

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I. Introduction

This document fulfills electrical documentation requirements set forth by the Electrical Design Standards for Electronics to be used in Experiment Apparatus at Fermilab document and EED/Infrastructure Doc. No:H011228A document published by the PPD/Electrical department.

The CMS CO_2 Cooling Test Stand is a Carbon Dioxide cooling system which is currently located in the Lab C West aisle and the Lac C South clean room at FermiLab. The aisle and clean room are both ODH class 0, and have CO_2 risk factors comparable with ODH class 0, see PPD Doc-1348 for details.

This process system has approximately 25 electronic input sensing devices and 7 output devices. Input devices include RTD's, pressure transmitters, level transmitters, thermocouples, flow switches, CO_2 monitors, and heater and pump feedback. Output devices include a motorized valve, two heaters, a variable speed motor controller, and three solenoid valves controlling three condensing units.

All electronic and electrical control system equipment is air cooled and does not require any forced air cooling or water cooling. Cabinet air vents are provided for certain devices where appropriate.

The control system equipment components are all commercially available products which are UL listed. The process control system has been designed and built following all the required rules and standards such as the NEC. All premises wiring was installed by Fermi Electrical contractors and licensed electricians.

II. Process Control System

a. Description

The CMS CO_2 Cooling Test Stand will be controlled by a Beckhoff PLC with Beckhoff supplied I/O modules networked on a Profibus network. This PLC system will be programmed using the TwinCat engineering programming software.

Human machine Interface controls will be provided through a touch screen display as well as GEFANUC's iFIX software. iFIX connects to the PLC through Private Ethernet using an OPC driver purchased from Kepware. iFIX will handle all operator security, computer alarming, and remote operator controls via the PPD-iFIX server. iFIX will also provide historical data through the PPD-iFIX historian. This historical data will be viewable in iFIX picture displays or on the web through the iFIX proficy portal server //on D0-HIST2/proficyportal machine.

b. Electric Power and Circuit Protection

Sheet 1 of drawing "9213.750-EE-486150 CMS/Detectors PIXEL Control System Wiring" shows the PLC cabinet equipment layout. It also shows the AC and DC power distribution and circuit protections. All conductors are either copper or tinned copper grade. All heaters, the CO_2 pump, and the three condensing units are powered by 208VAC-3 phase power.

AC Circuit Conductor:

Min of 8 AWG downstream of 60A or less circuit protection
Min of 12 AWG downstream of 25A or less circuit protection
Min of 14 AWG downstream of 15A or less circuit protection
Min of 16 AWG downstream of 10A or less circuit protection

DC circuit Conductor AWG:

Min of 14 AWG downstream of 15A or less circuit protection
Min of 16 AWG downstream of 10A or less circuit protection
Min of 22 AWG downstream of 5A or less circuit protection

III. Field Devices and Components

a. Heater HTR210

i. Description

Heater HTR210 is a commercial 6000 watt bayonet style electrical resistance heater. This heater has an analog power control circuit for variable power control. The heater has an internal "k" thermocouple which is connected through the PLC to a limit control device with a power disconnect relay. This limit control scheme sets the high temperature trip and shuts off the heater both by setting the PLC output to zero, as well as mechanically disconnects electrical connection to the heater. This limit control device will protect the heater element from destructive high heater temperatures caused by equipment malfunctions and operator errors.

ii. Electric Power and Circuit Protection

Heater 210 is powered by 208VAC 3 phase power. The power is fed from a 30 amp disconnect (20A fused) installed solely for the heater. The heater control box is connected to this disconnect using 10 AWG copper wire. The heater disconnect has internal 20A fuses on the heater power circuit and the control circuit. The downstream conductors are sized and rated to meet the minimum current capacity of these fuses.

b. Heater HTR506

i. Description

Heater HTR506 is a commercial 6000 watt bayonet style electrical resistance heater. This heater has an analog power control circuit for variable power control. The heater has an internal "k" thermocouple which is connected through the PLC to a limit control device with a power disconnect relay. This limit control scheme sets the high temperature trip and shuts off the heater both by setting the PLC output to zero, as well as mechanically disconnects electrical connection to the heater. This limit control device will protect the heater element from destructive high heater temperatures caused by equipment malfunctions and operator errors.

ii. Electric Power and Circuit Protection

Heater 210 is powered by 208VAC 3 phase power. The power is fed from a 30 amp disconnect (20A fused) installed solely for the heater. The heater control box is connected to this disconnect using 10 AWG copper wire. The heater disconnect has internal 20A fuses on the heater power circuit and the control circuit. The downstream conductors are sized and rated to meet the minimum current capacity of these fuses.

c. VFD (Variable Frequency Drive) for CO_2 Pump

i. Description

The VFD is a commercial unit designed to run a standard AC 3 phase motor at variable speeds given a standard control analog input signal. A discrete input will direct the VFD to the off or run mode. The Beckhoff PLC will monitor various CO_2 system process parameters and provide programmed interlocks and speed control from the Beckhoff PLC.

ii. Electric Power and Circuit Protection

The VFD is fed from premises power with a 15A fused disconnect (Using 12 AWG wire) within sight of the VFD and motor. The VFD will be programmed with the motor data. The VFD unit itself has internal safety interlocks which shut down the pump in case of over/under current draw, or other abnormal pump conditions. This unit was recommended and supplied by the pump manufacturer to protect the pump and 3 HP pump motor.

d. CO_2 Monitoring System

i. Description

The CO_2 monitoring system deploys two remote MSA CO_2 heads, one in the West aisle, and one in the South clean room. The sensor in the west Aisle is within 5 feet of the heater vessel and pump, and underneath the CO_2 storage Tank. The head in the clean room is in close proximity to the phase separator and all other sources of potential leaks. Since CO_2 is heavier than and can release solid CO_2 which will fall to the floor, the sensors are about a foot off the floor. There are two sets of ODH warning horns and strobe lamps, one set is located in the West Aisle and one in the South clean room. There is a ventilation fan that pulls air out of the Lab C aisle and vents it outside. This fan is automatically controlled by the Beckhoff PLC and can also be run manually by turning it on via the PLC. This ventilation fan will be tested daily by the PLC and flow switch and a trouble code sent in case of a fault. The South clean room has a McQuay roof mounted air handling unit which runs constantly. The operation of this air handler will be verified by a flow switch mounted in the ducts and a trouble code sent in the event there is no flow in the duct.

The CO_2 Sensors are MSA model A-ULTIMAX-GP-G-36-04D2-0000-100 and have a span of 0-2%. Each sensor is wired to an MSA electronic controller which provides an analog output signal wired to the Beckhoff PLC. A concentration of 0.3% CO_2 will send a trouble alarm. A concentration exceeding 0.5% in the Lab C West aisle will activate the ventilation fan, and a reading of this same value will

close the will isolate the clean room via the motorized isolation valve. Readings above 1.5% will trigger relays wired directly to the warning horns and strobe lamps located in the Lab C West aisle and South clean room. The MSA electronic unit also provides a trouble relay output which is also wired to the PLC and FIRUS. The trouble output is a wired in a failsafe manner, such that loss of power or blown fuse to the ODH controls will generate a trouble alarm.

ii. Electric Power and Circuit Protection

The MSA equipment is wired directly to its own self contained control circuitry in its own enclosure which can be seen in illustration 5. This self contained enclosure has its own power supply which is independent of the PLC control system, allowing the ODH system to function independently of the PLC control system. The power for this ODH system comes from the UPS.

e. Condensing Unit #1

i. Description

The commercial condensing unit #1 is the smallest of three units. The unit uses R-404a as a refrigerant and uses a 2 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #1 if fed from premises 208VAC-3 phase power with a 15A fused disconnect placed within sight of the unit. The electrical connection from the disconnect to the unit uses 12 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

f. Condensing Unit #2

i. Description

The commercial condensing unit #2 is the middle sized of three units. The unit uses R-404a as a refrigerant and uses a 3.5 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the

opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #2 if fed from premises 208VAC-3 phase power with a 25A fused disconnect placed within sight of the unit. The electrical connection from the disconnect to the unit uses 12 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

g. Condensing Unit #3

i. Description

The commercial condensing unit #3 is the largest of the three units. The unit uses R-404a as a refrigerant and uses a 7.5 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #3 if fed from premises 208VAC-3 phase power with a 60A fused disconnect placed within sight of the unit. The electrical connection from the disconnect to the unit uses 8 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

h. Motorized Isolation Valve (EV-406)

i. Description

The motorized valve consists of a Worchester 75 series quarter turn electronic actuator attached to a Sharpe 99 series quarter turn ball valve. The valve is controlled by the PLC which switches a double pole double throw relay attached to a 24V DC power supply.

ii. Electric Power and Circuit Protection

The valve operates on 24VDC-and 2.1 Amps is listed on the unit as maximum current draw. The valve is fused with a 3 Amp fuse and is wired with 22 AWG wire.

i. U.P.S

i. Description

The control system U.P.S. is commercial 900 W unit supplied by SEPS Inc; model PW9130-1000VA/900W Tower. The U.P.S. input power is fed from a 120VAC-1 phase premises powered outlet using the U.P.S. input line cord.

ii. Electric Power and Circuit Protection

The U.P.S. is powered by its own 20A dedicated circuit and has standard outlets located on the rear of the cabinet. All relevant control system electronics, the PLC and CO_2 monitors, are plugged into the PLC outlets.

IV. References

a. Drawings

I. 9213.750-EE-486150 CMS/DETECTORS PIXEL Control System Wiring

II. 9212.750-ME-466879 CMS/DETECTORS PIXEL CMS CO_2 COOLING P&ID

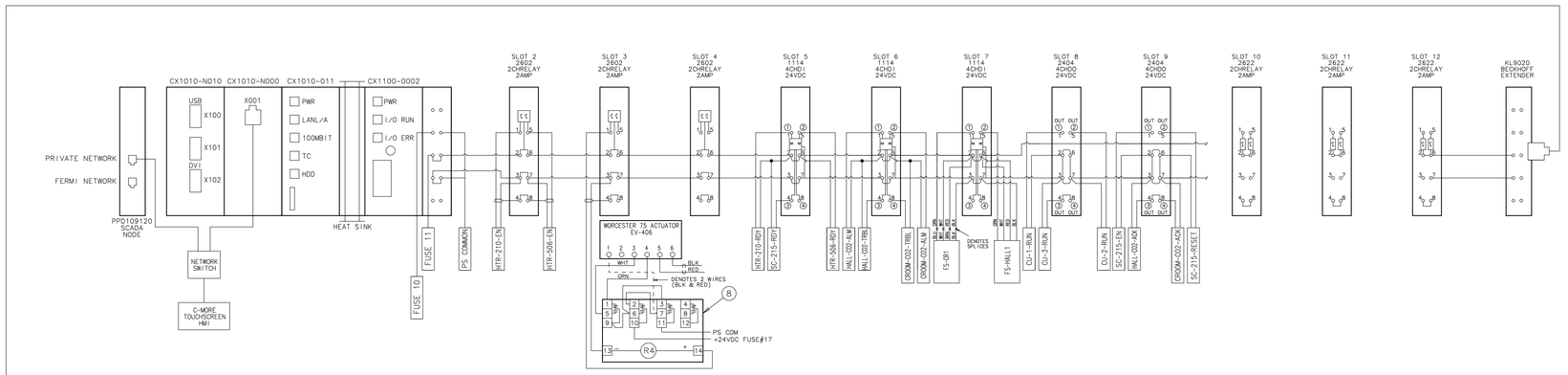
b. Documents

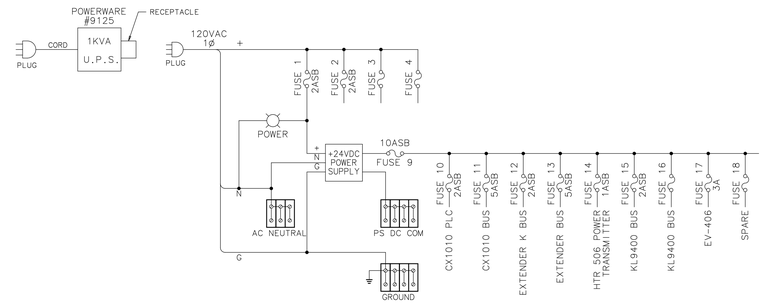
I. Electrical Design Standards for Electronics to be used in Experiment Apparatus at Fermilab

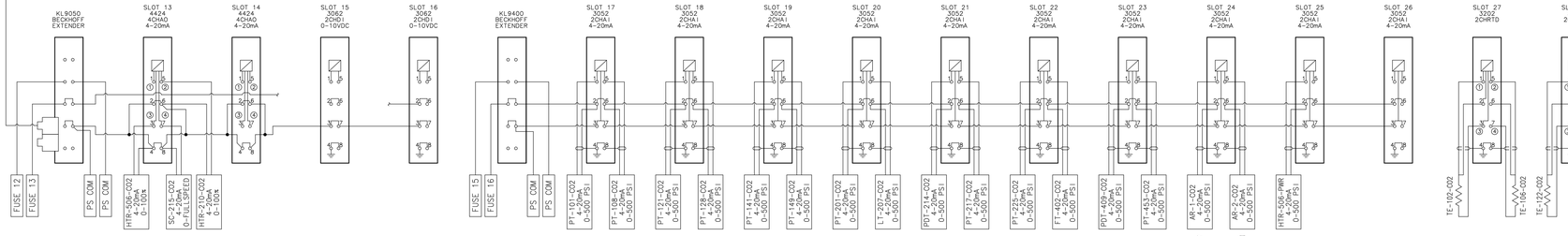
II. EED/Infrastructure Doc. No:H011228A

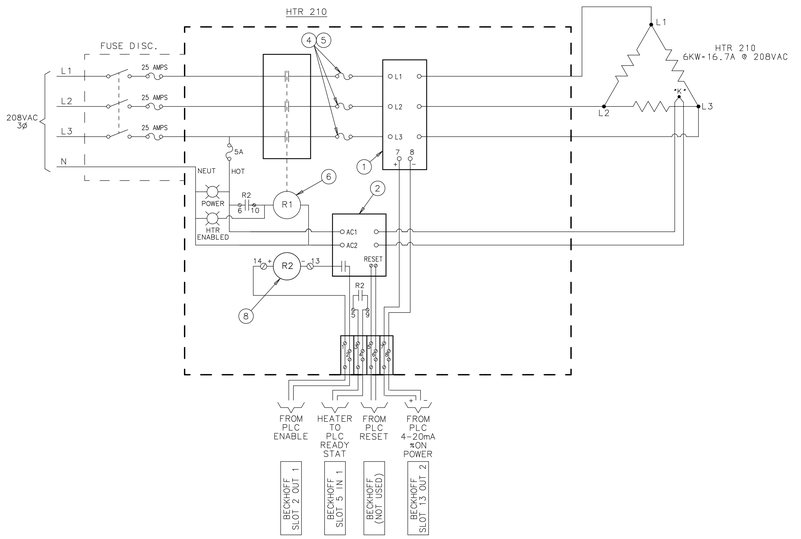
III. CO_2 Hazard Engineering Note - https://ppd-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1348

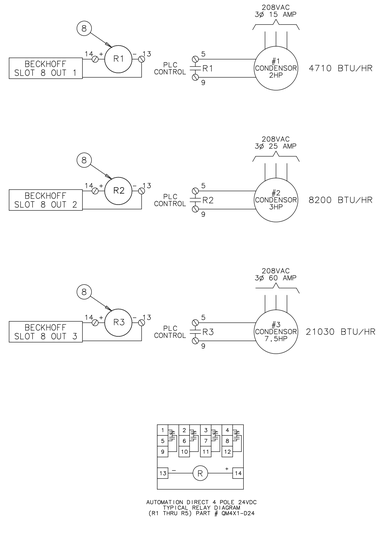
REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE

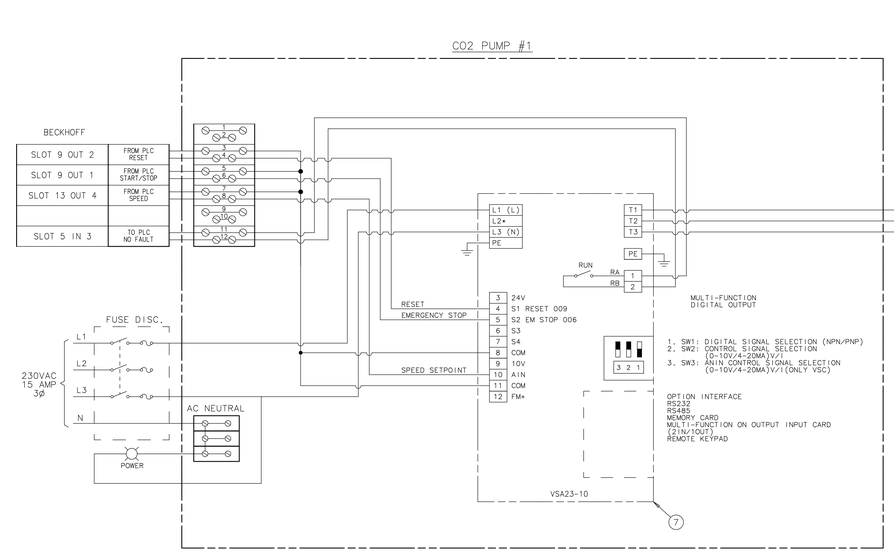


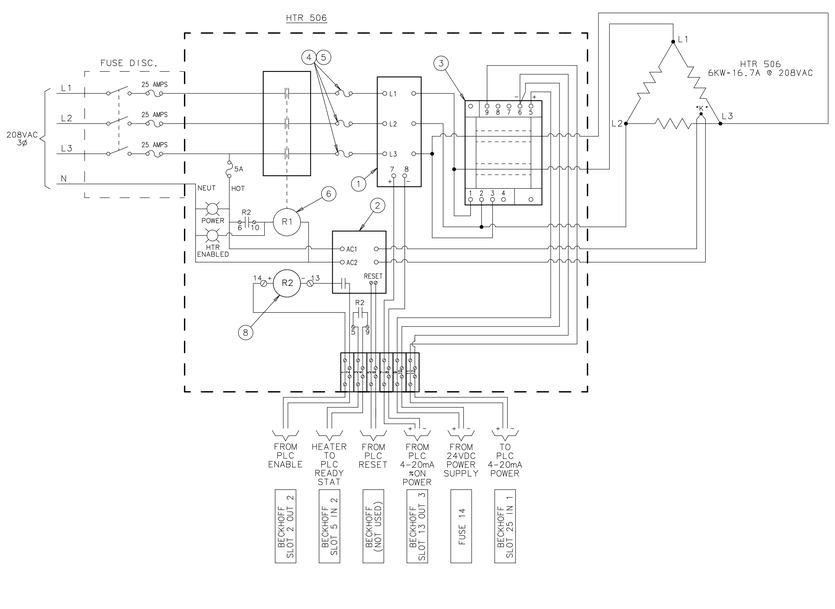


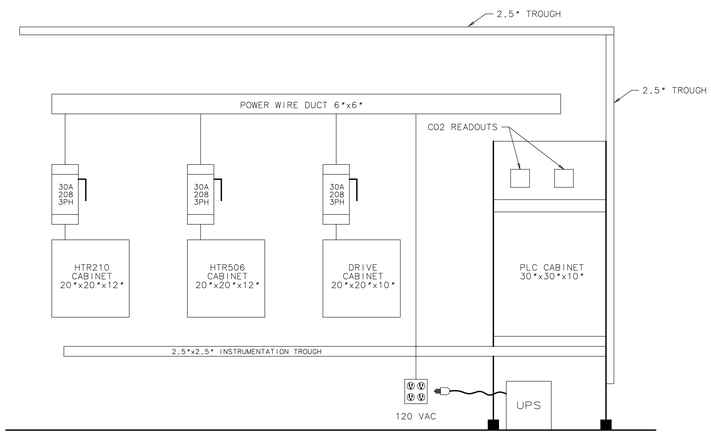












LOGIC TRUTH TABLE

DEVICE	DISCRIPTION	ON STATE	OFF STATE	COMMENTS
SLOT 2 OUT 1	HTR 210 HEATER ENABLE	ENABLED	DISABLED	
SLOT 2 OUT 2	HTR 506 HEATER ENABLE	ENABLED	DISABLED	
SLOT 3 OUT 1	EV406 OPEN/CLOSE	OPEN	CLOSED	
SLOT 5 IN 1	HTR 210 HEATER READY STAT	READY	TRIPPED	
SLOT 5 IN 2	HTR 506 HEATER READY STAT	READY	TRIPPED	
SLOT 5 IN 3	CO2 PUMP READY STAT	RUN	OFF	
SLOT 8 OUT 1	CONDENSING UNIT 1 ON/OFF CONTROL	RUN	OFF	
SLOT 8 OUT 2	CONDENSING UNIT 2 ON/OFF CONTROL	RUN	OFF	
SLOT 8 OUT 3	CONDENSING UNIT 3 ON/OFF CONTROL	RUN	OFF	
SLOT 9 OUT 1	CO2 PUMP READY ENABLE	ENABLED	DISABLED	
SLOT 9 OUT 2	CO2 PUMP RESET	RESETTING	STBY	

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
8	COML	AUTOMATION DIRECT 4 POLE 24VDC PART# QM4X1-D24	5
7	COML	EMOTRON VARIABLE AC MOTOR DRIVE MODEL #VSA23-10	1
6	COML	MAGNETIC CONTACTOR, 3 POLE, 40 AMP, 120V COIL, PART #MC2--3-40-120	2
5	COML	FUSE HOLDER, DIN-RAIL MOUNT, PART #17-5114	6
4	COML	FUSES FOR DIN-A-MITE (ITEM #1) 40 AMP, PART #17-8040 L2T	6
3	COML	TRANSDUCER, AC POWER, CR MAGNETICS, PART #CR6240	1
2	COML	LV SERIES LIMIT CONTROLS WATLOW, PART #LVC2LW 000 1000 A	2
1	COML	DIN-A-MITE CONTROL INPUT 4-20ma, 3ø, 3-CONT'D LEDS, 30AMP, WATLOW, PART #DC30-24F0-0000	2

PARTS LIST

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	D.MARKLEY	09-AUG-2010
	DRAWN	J.CATALANELLO	09-AUG-2010
± ± ±	CHECKED		
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2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. MAX. ALL MACH. SURFACES	USED ON		
5. DRAWING UNITS: U.S. INCH	MATERIAL		

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UNITED STATES DEPARTMENT OF ENERGY

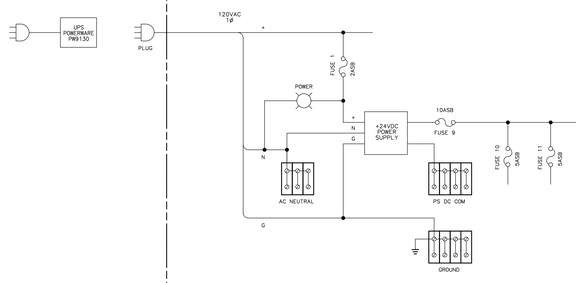
CMS/DETECTORS PIXEL CONTROL SYSTEM WIRING WIRING

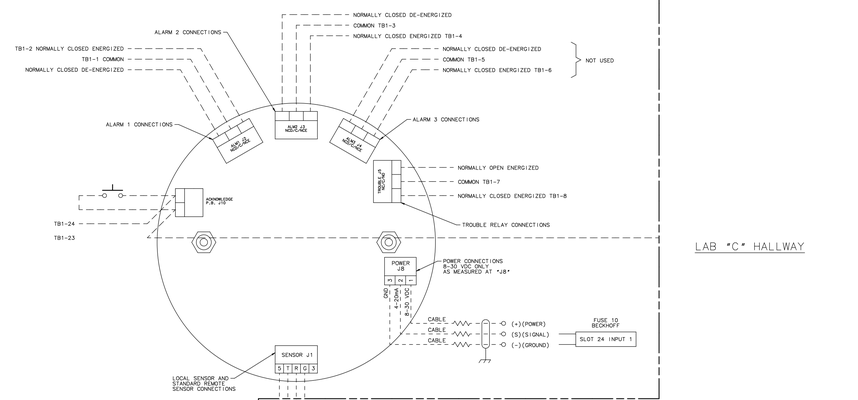
SCALE	DRAWING NUMBER	SHEET	REV
	9213.750-EE-486150	1 OF 2	

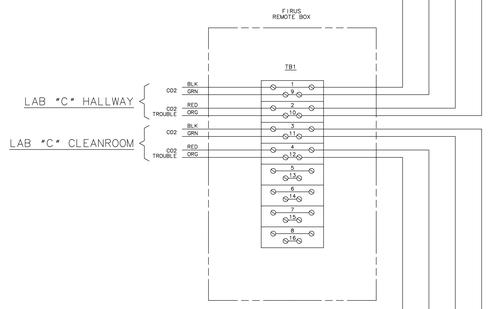
CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

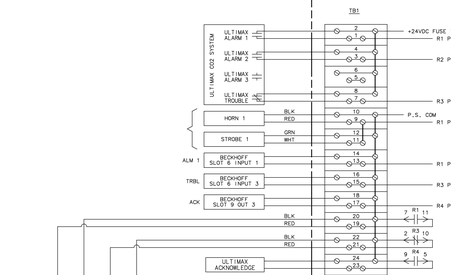
REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE

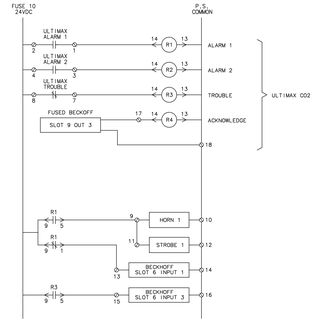
CO2 MONITOR SYSTEM
LAB "C" HALLWAY ENCLOSURE

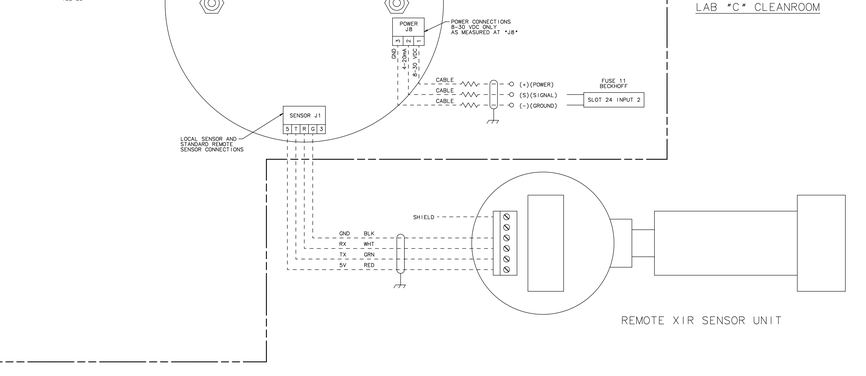


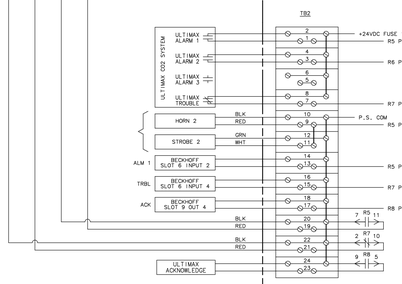


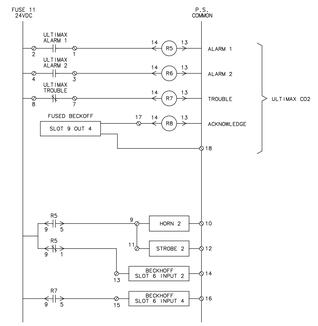




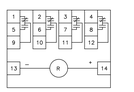








LOGIC TRUTH TABLE				
DEVICE	DISCRIPTION	ON STATE	OFF STATE	COMMENTS
R1, R5	CO2 ALARM 1	ALARM	NORMAL	TRIP POINT=2%
R2, R6	CO2 ALARM 2	ALARM	NORMAL	
	CO2 ALARM 3	ALARM	NORMAL	
R3, R7	CO2 TROUBLE	NORMAL	TROUBLE	
R4, R8	ACK ULTIMAX	ACK	RUN	



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	D.MARKLEY	09-AUG-2010
			DRAWN	J.CATALANELLO	09-AUG-2010
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES MAX.			APPROVED		
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3. DIMENSIONS BASED UPON ASME Y14.5M-1994					
4. MAX. ALL MACH. SURFACES			MATERIAL		
5. DRAWING UNITS: U.S.INCH					

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UNITED STATES DEPARTMENT OF ENERGY

CMS/DETECTORS
PIXEL
CONTROL SYSTEM WIRING WIRING

SCALE	DRAWING NUMBER	SHEET	REV
	9213.750-EE-486150	2 OF 2	

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