Fermilab

DZERO SILICON COOLING SYSTEM

MONITORING, INTERLOCKS, & ALARMS

ENGINEERING NOTE
3823.112-EN-548

REVISION A
Nov 7, 2001

Fermilab
Dan Markley

Engineering Note 3823.112-EN-548 Outline

Revision A Highlights

Chart 1-Silicon System Relational External Interlock Chart

1. Silicon Power--Added Hardware Latch (Reset Button)
2. Silicon Cooling---Deleted Software Interlock Ave 88 RTD > -15C
3. Purge Air Isolation Valve--Added Hardware Latch (Reset Button)
4. Emergency Warm-up---GN2 Purge Backup Average Pressure> 700PSI
   ---Dumps all Chiller Power

Chart 2-Silicon System Computer Alarm Chart.—general update
Chart 3-Silicon System Auto-Dialer Alarm Chart .—general update
Appendix C-Drawings. —general update
What-If Analysis---Added to this EN Note
Note: Revision A, reflects all the Interlock changes created by doing the What-If analysis.

Abstract

This engineering note describes the Monitoring, Interlock, and Alarm systems used to operate the Dzero Silicon Cooling System and the Silicon Dry Air Purge System. The actual software programming is not included in this document, but the programming actions and interactions are included.

Introduction

Dzero has installed a two-piece Silicon Detector into the warm bore of the CC Calorimeter in late 2000 and early 2001. These two pieces are referred to the South half and the North half. Each half is powered by electronics that generates excess heat that must be removed. Removal of this heat is performed by a cooling system that circulates a glycol and water mixture from a chiller through the Silicon cooling system manifolds and back to the chiller. It is expected that the coolant will be chilled to –15° C.

The Silicon detector has a dry air purge system that provides a continuous purge of dry air with a dew point well below the operating temperature of the detector. The monitoring, interlock, and alarm systems also cover this dry air purge system.

The dry purge system and the cooling system for the Silicon detector have been added to what is commonly known as the Dzero Cryo Control System for monitoring, interlocks, and alarming.

The cooling system mechanical piping has been sized with all the proper safety and relief devices such that the monitoring and interlock system are <u>not</u> relied upon for personnel safety. All electrical loads have the proper overload protection.

The Silicon Detector power system has an extensive *internal* interlock protection scheme provided by its power supply and processor control and data acquisition electronics. This Engineering note describes the Silicon System's *external* interlocks provided by the cooling system, which are an added layer of protection.

Thirty RTD temperature sensors were installed throughout the VLPC fiber barrel structure in order to track the fiber barrel temperatures as the Silicon system is cooled down and its purge air flows are adjusted. These thirty temperature sensors are displayed on the Silicon computer graphics pictures. This I/O is included in Table 2-Cryo PLC Silicon I/O Map.

Systems Electrical Power

Dzero has backup electrical power provided by a diesel generator that starts automatically upon commercial power loss. The Silicon purge air compressors, the Silicon chiller cabinets, and the U.P.S. that supplies power to the Silicon cooling system control system are all on backup power. The Silicon cooling system monitoring and interlock system are powered by a U.P.S., which prevents power interruption to these control system.

Chillers

There are two chiller cabinets, they have been designated chiller #1 and chiller #2. They are commercial units which contain a coolant pump, a chiller compressor, and the associated motor controls to run and control the unit. The temperature control is a stand alone single loop controller with a relay output and it is mounted on the chiller cabinet.

The chiller cabinet motor controls have been modified for remote interlock control. The remote interlocks have been implemented using solid state relays. See attached electrical drawing for details.

There have been a few Temperature loop controller failures while the chiller units were operated at the Fermi SIDET facility. The relays contact outputs have failed by shorting together. This loop controller has been rewired for the Dzero installation in such a manor as to limit the stresses that have been causing these failures. The relay outputs no longer switch an inductive AC load, they have been rewired to switch a small DC non-inductive load, namely the input to a solid state relay.

Each chiller has two bypass key-switches built into the cabinet. One key switch overrides the external pump interlocks while the other key switch overrides the external cooling interlocks. These were installed for emergency and diagnostic reasons. The keys to these key-switches will be administratively controlled.

Monitoring

Current Process Control System Overview

The current process control system is based on a number of commercial Siemens Programmable Logic Controllers (PLC's) and is commonly referred to as the CRYO control system. These PLC's are capable of handling thousands of physical I/O through remote I/O bases. These remote I/O bases can have many types of modules installed in any of the slots for handling different types of field I/O. These PLC's are commercial computers which have many prewritten communication drivers available. Programming the PLC's is also done through commercial software. The Website http://dmacs-nt-server.fnal.gov/ may be visited for more information pertaining to this control system.

The operator interface is based on the commercial distributed control platform of Intellutions FIX32. FIX32 provides computer alarms, graphical pictures with real time values, operator security, and historical collection of data. The use of FIX32 originated at Dzero and is now commonly used throughout the Lab.

The Cryo Control System monitors and controls the Helium Refrigerator, LAR Calorimeters Cryo, Super conducting Solenoid cryo, Instrument Air, Vacuum, Building HVAC, WAMUS and Solenoid magnet power supplies, and the VLPC cryo.

Silicon Cooling System Integration into the current Process Control System

The Cryo control system was expanded with the addition of I/O base eleven on the South sidewalk and I/O bases seven, eight, and ten on the detector platform in order to pickup the physical field devices for the Silicon cooling system and dry purge air system.

The Silicon cooling system and dry purge air system logic programming were added to the PLC which has plenty of program capacity.

The Silicon cooling system and dry purge air system computer graphical pictures and database blocks were developed and added to the FIX32 system.

Silicon Cooling System Computer Security.

The Silicon Cooling System's computer security, along with all of Dzero's other process control system's computer security are provided by a combination of Intellution's FIX32 and Microsoft's NT Operating System Platform.

The computer system's infrastructure is controlled and protected by Microsoft's Windows NT Domain Controllers. This infrastructure includes domain user accounts, server file protection, Remote Access Services (RAS), and distributed networking. This is the "DMACS" domain at Fermilab. There are currently three domain controllers, two at Dzero and one at CDF. This domain is shared by many groups at Fermilab. The domain administrators control the domains user accounts and file privileges.

The process control system's security is provided by Intellutions's Fix32 and Fix Dynamics. This security is setup by the system developers who draw the pictures and build the databases. The system developers lay out their system based on a predefined set of rules. They then grant privileges to the users and operators who would need some control over these systems. These "privileges" are what allows some and denies others access to opening and closing a valve for instance.

Remote Process Control System access is provided by an NT RAS connection and Microsoft's NetMeeting. Remote access allows someone to view process data from home or elsewhere. The NT RAS security is provided by the NT domain controller, this security is essentially someone logging into the domain through a modem connection. NetMeeting allows someone to remotely take control of a workstations desktop. NetMeeting only allows an administrator to do this. The Process Control System security through NetMeeting is handled by NetMeeting, FIX32 or Dynamics, and the NT domain controllers. Other future remote access paths include the Internet i.e. a WebSite, however this is not well developed at this time.

DAQ system monitoring

The Dzero physics data acquisition and file system commonly referred to as the DZERO DAQ system will have access to the Silicon data along with all the other process control data. All the process data will be stored on a SCADA node dedicated to accessing and conditioning data just for the DAQ system. The DAQ programmers will be responsible for organizing a data polling list, then manipulating and storing the data in the physics file system. They may also choose to setup some sort of alarm system.

Interlocks

All interlock design and wiring practices use "failsafe" methods. That is a device must have positive feedback to its electronic circuits or it is considered "tripped". For example, a normally closed contact would be used on temperature switch in the field. This allows for a lost signal or a disconnected field device to generate a tripped condition. Discriminator modules are used in this system in order to convert an analog value into a discrete signal. These modules are all configured in their failsafe mode, which allows for loss of signal or transmitter failure to result in a tripped condition.

There is one exception to the failsafe practice in the Silicon Cooling System design. That is the control of the cooling circuit in the chiller cabinets. The chiller cooling control is called the Hot Bypass valve, when this valve is energized the chiller is not cooling. If the control signal is lost, the chiller would be forced into the cooling mode, since a solid state relay is used to control this circuit. I have countered this by using this same DC control voltage that controls the Hot Bypass control, to control the main chiller power solid state relay, therefore, if this DC control voltage were lost for any reason the entire chiller would shutdown.

Interlock Layers

The Silicon detector has two functional interlock layers. The primary power interlock system is embedded in the detector power supply and its control system. This system is capable of monitoring temperature and other parameters and shutting down individual channels and groups of channels. This system will be described in another paper.

The secondary interlock system is based around the cooling system parameters and referred to as the external interlock system. The external interlock system is designed to protect the Silicon detector from temperature and dew point limits.

External Interlocks See Appendix A, Chart #1 for a full relational list of external interlocks.

There are seven external interlock strings.

1. Silicon Detector Power Permit.

   This interlock is designed to protect the Silicon Detector from being powered up during unusual cooling system conditions, such as flow and temperature abnormalities.

   The Silicon Detector power is divided into 4 quadrants, the NW, NE, SE, and SW. Each quadrants main power is controlled by a Rack Monitor Interface(RMI). The cooling system provides a permit to each quadrant's RMI external input in the form of a relay contact.

   The North Silicon (NW and NE quadrants) Power interlock and the South Silicon (SW and SE quadrants) power interlock each have a key-switch override provided to bypass their respective interlock chain. The key-switches are located on the main interlock panel on the South Sidewalk. These keys will be administratively controlled.

   The hardware interlock inputs are: South Return Flow > 3 GPM, North Return Flow > 3 GPM, South Return Temp < 65F GPM, North Return Temp < 65F, PLC SUM(sum of the Software interlocks), Emergency Warm-up. The Software inputs to the interlock are Operator Command, Chiller Pump On, Ave of 88 temps > -15C.

   This interlock has a manual reset on the interlock panel.

2. Silicon Cooling System Pump Permit.

   This interlock is designed to protects the chiller coolant pumps from running dry and cavitating.

   The hardware interlock inputs are: Separator Tank Pressure, Separator Tank Level, Expansion Tank Level, Chiller Discharge Pressure, Chiller Suction Pressure, and Emergency Warm-up. This interlock has a manual reset on the interlock panel, to avoid an oscillating interlock condition. There are no Software inputs for this pump interlock string.

3. Silicon Cooling System refrigeration Permit.

   This interlock is designed to protect the Silicon detector from high dew points and low purge flows which could cause condensation and even frost inside the detector. The hardware interlock inputs are Purge Air Dew Pt High, S. Silicon Purge Flow(on platform), N. Silicon Purge Flow(on platform), PLC SUM(sum of the Software interlocks). There are no Software inputs for this cooling system interlock string.

4. Silicon Purge Air Compressor Isolation Valve Permit.

   This interlock is designed to protect the Silicon detector from high dew points originating in the Air compressor system due to such failures as air drier switching problems or tank blow-down problems. This interlock string has a manual reset button on the interlock panel to avoid an oscillating interlock condition. If this valve closes the backup air trailer system will automatically supply air to the Silicon purge system due to a cascading regulator system. The backup air trailer has been pressurized with dry air from the compressed air system at Dzero and should never be less than 1500 PSIG.

The hardware interlock input is: Purge air Dew point level. There are no Software inputs for the pump interlock string.

5. Silicon Expansion Tank GN2 Purge Valve Permit.

   This interlock is designed to protect the Silicon detector cooling pipes from excessive pressure should the expansion tank vent be blocked or plugged. This interlock string has a manual reset button on the interlock panel to avoid an oscillating interlock condition.

   The hardware interlock input is: Expansion Tank Pressure. There are no Software inputs for this interlock string.

6. Silicon Purge Air Isolation Valve Permit.

   This interlock is designed to isolate the air in case of a suspected fire and is a backup dewpoint interlock. This is tripped manually from a switch in the Dzero Main Control room or the Satellite control station in the Dzero front lobby and a second purge air dewpoint monitor. This interlock hardware has been set up in such a way that it could be triggered automatically from such devices as a Very Early Smoke Detection System (VESDA) in the future.

   The hardware interlock input is: Hand Switch and a spare unused input and purge air dewpoint monitor #2. There are no Software inputs for this interlock string.

   This interlock has a manual reset on the interlock panel.

7. Silicon System Emergency Warm-up.

   This interlock is designed to protect the Silicon Detector in the event of a cooling system failure or a purge air failure. When this interlock is tripped, it currently shutsdown any chiller pumps that may be running. This is interlock string was developed separately from the pump interlock in the event more actions were needed, such as a forced warm-up.

   There are no hardware inputs for this interlock string. The software inputs are: The ten sample dew-points around the detector < -20C, S. Silicon Purge Flow(on platform), N. Silicon Purge Flow(on platform), Low coolant temperature, High Coolant Temperature, and GN2 Purge Backup Pressure average > 700 PSIG.

Alarms

The Silicon cooling system may run attended or unattended by operators. The alarms have been picked, programmed, and configured to be consistent with the other systems that the control system runs and monitors.

Alarm Layers

Dzero incorporates a layered alarm strategy. There are typically three layers of alarms. The first is a computer alarm that notes when a parameter is slightly out of normal tolerance. The second is a computer alarm when a parameters is more than slightly out of tolerance. The third is an Auto-Dialer alarm when the parameter is at a point where immediate attention is necessary.

Computer Alarms

See Chart 1 for a complete list of Silicon computer alarms. Computer alarms are generated by the FIX32 software mentioned earlier in this paper. An operator with the correct security privileges may set the alarm thresholds and also acknowledge these alarms.

A computer alarm can be routed and filtered by any of many FIX32 nodes throughout Dzero and Fermilab. When a computer alarm occurs, all the FIX32 nodes that are set up to filter in the alarm area of a particular alarm will start beeping. This beeping will continue until the alarm condition is cleared and the alarm is acknowledged.

AutoDialer Alarms

See Chart 2 for a complete list of Silicon Auto-Dialer alarms. An operator with the correct security privileges may set the alarm thresholds and also acknowledge these alarms.

The Auto-Dialer alarm is generated by the PLC and a computer dedicated to running a software package called WIN911. This software package is capable of paging people's pagers with a numeric code as well as calling inside and outside the lab using the telephone system with a voice synthesized message. The Auto-Dialer is preprogrammed with a list of "experts" who can deal with the particular systems' problem that created the alarm. The Auto-Dialer will continue paging and calling people serially on this list until someone acknowledges the alarm or the alarm condition ceases.

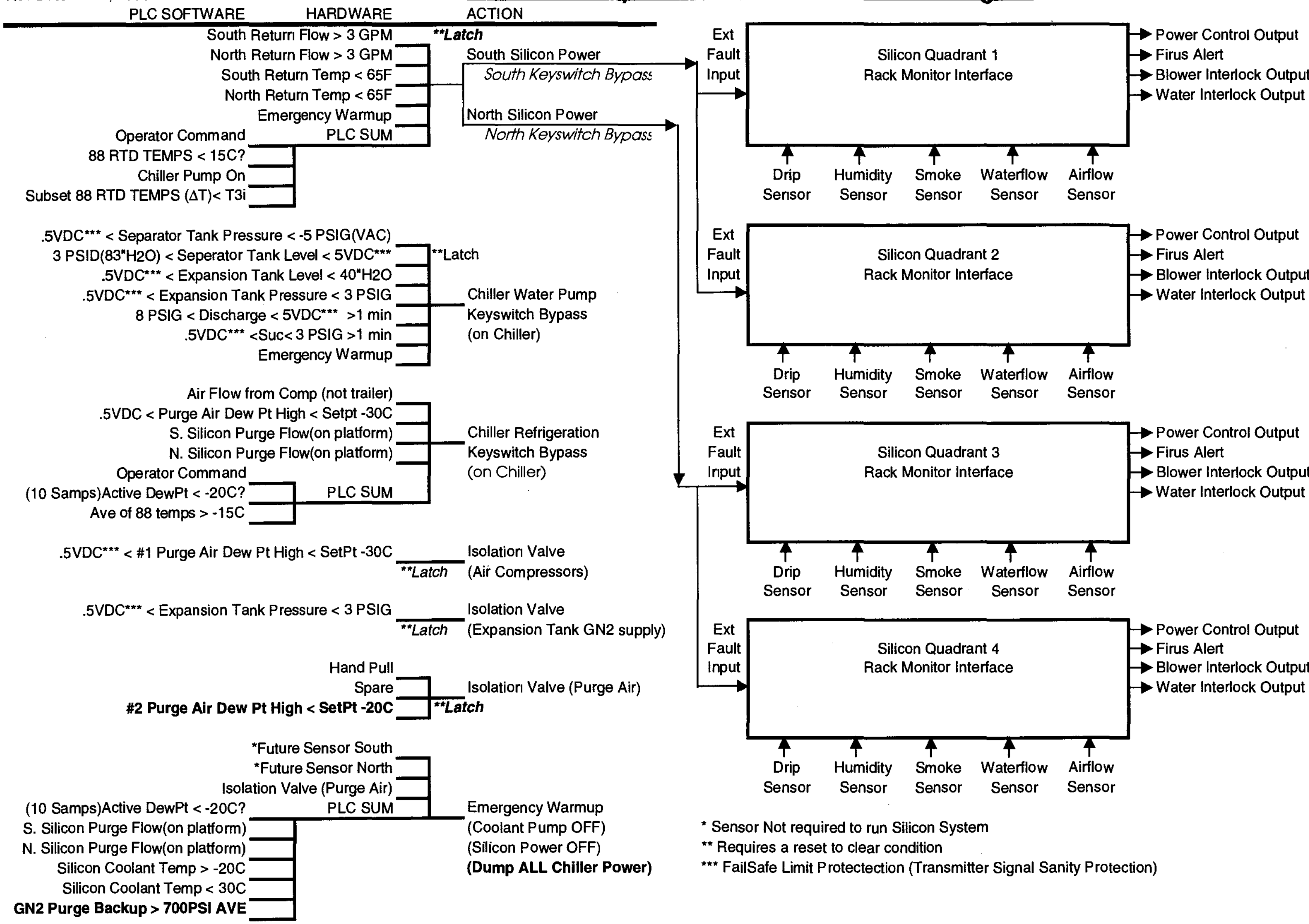
The Auto-Dialer is what really makes unattended operation possible at Dzero.

DAQ Alarms

All the PLC data from all process systems will be available to the programmers that program the Dzero DAQ system. Once this data is picked sorted the programmers will likely set up a set of alarms. This assumption is based on last run's experience. The infrastructure for this data transfer is well defined and in progress of being implemented. The data sets haven't been picked or defined yet, as of this EN Note.

Rev Date Mar 7, 2001

DZERO Silicon System----External Interlock Flow Diagram



* Sensor Not required to run Silicon System
** Requires a reset to clear condition
*** FailSafe Limit Protectection (Transmitter Signal Sanity Protection)

Chart 2-Silicon System Computer Alarm Chart.

Silicon Computer Alarm Page

Cooling System		Interlocks	
Equipment		1. Silicon Power	Intlk Broken
Chiller #1 Coolant Pump	OFF	2. Chiller Pump	Intlk Broken
Chiller #2 Coolant Pump	OFF	3. Chiller Cooling	Intlk Broken
Silicon S. Power Keyswitch	Bypassed	4. GN2 Purge Isolation Valve	Intlk Broken
Silicon N. Power Keyswitch	Bypassed	5. Comp Air Isolation Valve	Intlk Broken
Chiller #1 Pump Keyswitch	Bypassed	6. Purge Air Isolation Valve	Intlk Broken
Chiller #1 Cooling Keyswitch	Bypassed	7. Emergency Warmup	Intlk Broken
Chiller #2 Pump Keyswitch	Bypassed		
Chiller #2 Cooling Keyswitch	Bypassed		
Pressure		Air Purge System	
1. Suction Pressure	Hi/Low	1. East Compressor Status	OFF
2. Discharge Pressure	Hi/Low	2. West Compressor Status	OFF
3. Expansion Tank	Hi/Low	3. Tank Blowdown Status	Fail
4. Separator Tank	Hi/Low	4. Drier Status	Fail
Level		5. Room 215 Air Pressure	HI/Low
1. Expansion Tank	Hi/Low	6. Platform Air Pressure	HI/Low
2. Separator Tank	Hi/Low	7. Purge Dewpoint #1	HI
Flow		8. Purge Dewpoint #2	HI
1. Cooling Supply Flow	Hi/Low	9. Glycol Temperature	HI/Low
2. South Return Flow	Hi/Low	Sampled Dewpoints	
3. North Return Flow	Hi/Low	1	Hi
Temperature		2	Hi
1. Chiller Supply Temp	Hi/Low	3	Hi
2. South Return Temp	Hi/Low	4	Hi
3. North Return Temp	Hi/Low	5	Hi
4. Vacuum Jackets	Hi/Low	6	Hi
5. 88 RTD Temps	Hi/Low	7	Hi
Conductivity		8	Hi
1. Coolant Conductivity	Hi	9	Hi
Gas Nitrogen Purge Supply		10	Hi
1. GN2 NothWest Bank			
2. GN2 NorthEast Bank			
3. GN2 SouthWest Bank			
4. GN2 SouthEast Bank			

Computer Alarm Events

1. All View Nodes with Alarms enabled will beep
2. All View Node Alarm windows display alarm message
3. Alarms are logged to file.
4. Alarms can be filtered by Alarm area.
5. Only privileged personnel can acknowledge alarms

Chart 3-Silicon System Auto-Dialer Alarm Chart.

Silicon AutoDialer Alarm Page

Interlocks	
4001. Silicon Power	OFF
4002. Chiller Pump	OFF
4003. Chiller Cooling	OFF
4004. GN2 Purge Isolation Valve	Closed
4005. Compressor Air Isolation Valve	Closed
4006. Purge Air Isolation	Closed
4007. Emergency Warmup	Engaged
Air Purge System	
4008. East and West Compressor	OFF
4009. Platform Air Pressure	< X
4010. Drier	Fail
4011. Purge Dewpoint	Hi
4012. Glycol Temperature	Low
4013. Glycol Temperature	> X
4014. Dewpoint Sample	
1	> X
2	> X
3	> X
4	> X
5	> X
6	> X
7	> X
8	> X
9	> X
10	> X
4024. Ave GN2 Purge Cyl Supply PSIG	> X
4025. Air Separator Tank H2O Level	High

Numeric Message Displayed

9114***

Cooling System	
Equipment	
4015 Chiller #1 Coolant Pump	OFF
4016 Chiller #2 Coolant Pump	OFF
4017 keyswitches	
Silicon S. Power Keyswitch	Bypassed
Silicon N. Power Keyswitch	Bypassed
Chiller #1 Pump Keyswitch	Bypassed
Chiller #1 Cooling Keyswitch	Bypassed
Chiller #2 Pump Keyswitch	Bypassed
Chiller #2 Cooling Keyswitch	Bypassed
Level	
4018. Expansion Tank	> X
4019. Separator Tank	< X
Flow	
4020. Cooling System Flow	
Supply Flow	< X
South Return Flow	< X
North Return Flow	< X
Temperature	
4021. Coolant Temp	
Supply Temp	> X
Supply Temp	< X
South Return Temp	> X
North Return Temp	> X
4022. Vacuum Jackets	
Any Vac Jacket	< X
4023. 88 RTD Temps	
Any RTD Temp	< X
Any RTD Temp	> X

TABLE 1. SILICON COOLING SYSTEM INSTRUMENTATION LIST

				RANGE	MANUFACTURER	MODEL#
Platform Instruments						
Pressure						
	LT	5210	GL	0 - 100 "WC	Honeywell	STD924-E1A-00000-1C,ZS
	PT	5209	GL	0-5 PSIG	Honeywell	STD930-E1A-00000-1C,ZS
Temp						
	TE	5271	GL	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5272	GL	-50 to 230C	Omega	RTD-NTP-DUAL-72-E-MTP
	TE	5273	GL	-50 to 230C	Omega	RTD-NTP-DUAL-72-E-MTP
	TE	5274	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5275	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5276	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5277	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5278	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5279	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5280	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5281	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5282	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5283	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
Building Instruments						
Pressure						
	PT	5133	GL	-15 to 75 psig	Honeywell	STD930-E1A-00000-1C,ZS
	PT	5163	GL	-15 to 10 psig	Honeywell	STD930-E1A-00000-1C,ZS
	DPT	5321	GL	0-30 PSID	Honeywell	STD924-E1A-00000-1C,ZS
	PT	5320	GL	-15 to 5 PSIG	Honeywell	STD924-E1A-00000-1C,ZS
Flow						
	FT	5130	GL	.05-2 M/S	Kobold	KAL-7215
	FI	5144	GL	2.64 -26.4 GPM	Kobold	KSM-4060
	FT	5348	GL	.05-2 M/S	Kobold	KAL-7215
	FI	5359	GL	1.32-13.2 GPM	Kobold	KSM-4030
	FT	5349	GL	.05-2 M/S	Kobold	KAL-7215
	FI	5360	GL	1.32-13.2 GPM	Kobold	KSM-4030
	FS	5350	GL	.05-2 M/S	Burling	KAL-4215
	FS	5352	GL	.05-2 M/S	Burling	KAL-4215
Temp						
	TS	5351	GL	30F-140F	Burling	C-1S-531-N-180-10-07
	TS	5353	GL	30F-140F	Burling	C-1S-531-N-180-10-07
	TE	5131	GL	-50 to 230C	Omega	RTD-NTP-DUAL-72-E-MTP
	TE	5136	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5137	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5151	GL	-50 to 230C	Omega	RTD-NTP-DUAL-72-E-MTP
	TE	5334	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5335	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5332	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5333	V	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5358	GL	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD
	TE	5357	GL	-50 to 230 C	Omega	RTD-809 100ohm Pt RTD

Other

CM	5155	GL	0-10mSiemens	Omega	CDTX-680-10
				Omega	CDTX-681-A-S
PT	6231	I	0-200 PSIG	Omega	PX605-200GI
PT	6305	I	0-110 PSIG	Honeywell	STD930-E1A-00000-1C,ZS
FS	6205	I	1-90 fps	Omega	FST-321-P
FS	6305	I	1-90 fps	Omega	FST-321-P
FS	6306	I	1-90 fps	Omega	FST-321-P
EV	6206	I	0-240 PSIG	Omega	FSV-2103
			0-240 PSIG	Omega	FSV-2101

TABLE 2. CRYO PLC-SILICON I/O MAP

	SLOT/PT	I/O Type	Address	Description	Signal	Range
11	01/01	AI 4-20mA	WX1281	Pressure Transmitter after Flow Meter	4-20mA	-15 to 75 PSIG
11	01/02	AI 4-20mA	WX1282	Common Chiller Suction Pressure	4-20mA	-15 to 10 PSIG
11	01/03	AI 4-20mA	WX1283	Total Supply Flow	4-20mA	0-18.8 GPM
11	01/04	AI 4-20mA	WX1284	South Return Flow	4-20mA	0-12 GPM
11	01/05	AI 4-20mA	WX1285	North Return Flow	4-20mA	0-12 GPM
11	01/06	AI 4-20mA	WX1286	Separator Tank Level	4-20mA	0-30 PSID
11	01/07	AI 4-20mA	WX1287	Expansion Tank Level	4-20mA	0-100" WC
11	01/08	AI 4-20mA	WX1288	Expansion Tank Pressure	4-20mA	0-5 PSIG
11	02/01	AI 4-20 Ma	WX1289	Purge Air Supply Dewpoint	4-20mA	-120 to 80F
11	02/02	AI 4-20 mA	WX1290	Sample Air Dewpoint	4-20mA	
11	02/03	AI 4-20 mA	WX1291	Separator Tank Pressure	4-20mA	-15 to 5 PSIG
11	02/04	AI 4-20 mA	WX1292	Silicon Purge Air Pressure Room 215	4-20mA	0-200 PSIG
11	02/05	AI 4-20 mA	WX1293	Silicon Purge Air Pressure Platform	4-20mA	0-110 PSIG
11	02/06	AI 4-20 mA	WX1294	Silicon Conductivity	4-20mA	0-10 microSiemens
11	04/01	Discrete Out	Y1313	PLC Sum to Silicon Power Intlk Relay	24VDC	
11	04/02	Discrete Out	Y1314	Silicon Power PLC Permit Lamp	24VDC	
11	04/03	Discrete Out	Y1315	PLC Sum to Chiller Hot Bypass Intlk Relay	24VDC	
11	04/04	Discrete Out	Y1316	PLC Sum to Chiller Hot Bypass Intlk Lamp	24VDC	
11	04/05	Discrete Out	Y1317	PLC Sum to Emergency Warmup Intlk Relay	24VDC	
11	04/06	Discrete Out	Y1318	PLC Sum to Emergency Warmup Intlk Lamp	24VDC	
11	04/07	Discrete Out	Y1319	Silicon Chiller #1 Start-up	24VDC	
11	04/08	Discrete Out	Y1320	Silicon Chiller #2 Start-up	24VDC	
11	06/07	Discrete Out	Y1335	Silicon Dewpt Solenoid #1	24VDC	
11	06/08	Discrete Out	Y1336	Silicon Dewpt Solenoid #2	24VDC	
11	06/09	Discrete Out	Y1337	Silicon Dewpt Solenoid #3	24VDC	
11	06/10	Discrete Out	Y1338	Silicon Dewpt Solenoid #4	24VDC	
11	06/11	Discrete Out	Y1339	Silicon Dewpt Solenoid #5	24VDC	
11	06/12	Discrete Out	Y1340	Silicon Dewpt Solenoid #6	24VDC	
11	06/13	Discrete Out	Y1341	Silicon Dewpt Solenoid #7	24VDC	
11	06/14	Discrete Out	Y1342	Silicon Dewpt Solenoid #8	24VDC	
11	06/15	Discrete Out	Y1343	Silicon Dewpt Solenoid #9	24VDC	
11	06/16	Discrete Out	Y1344	Silicon Dewpt Solenoid #10	24VDC	
11	08/01	Discrete In	X1345	Silicon Power Interlock-South Return Flow	24VDC	
11	08/02	Discrete In	X1346	Silicon Power Interlock-North Return Flow	24VDC	
11	08/03	Discrete In	X1347	Silicon Power Interlock-South Return Temp	24VDC	
11	08/04	Discrete In	X1348	Silicon Power Interlock-North Return Temp	24VDC	
11	08/05	Discrete In	X1349	Silicon Power Interlock SUM	24VDC	
11	08/06	Discrete In	X1350	South Silicon Power Keyswitch Intlk Bypass	24VDC	
11	08/07	Discrete In	X1351	North Silicon Power Keyswitch Intlk Bypass	24VDC	
11	08/08	Discrete In	X1352	Chiller Pump Intlk-Seperator Tank Pressure	24VDC	
11	08/09	Discrete In	X1353	Chiller Pump Intlk-Seperator Tank Level	24VDC	
11	08/10	Discrete In	X1354	Chiller Pump Intlk-Expansion Tank Level	24VDC	
11	08/11	Discrete In	X1355	Chiller Pump Intlk-Expansion Tank Pressure	24VDC	
11	08/12	Discrete In	X1356	Chiller Pump Intlk-Discharge Pressure	24VDC	
11	08/13	Discrete In	X1357	Chiller Pump Intlk-Suction Pressure	24VDC	

e	SLOT/PT	I/O Type	Address	Description	Signal	Range
11	08/14	Discrete In	X1358	Chiller Pump Interlock SUM	24VDC	
11	08/15	Discrete In	X1359	Chiller Hot Bypass Intlk-Comp Air Flow	24VDC	
11	08/16	Discrete In	X1360	Chiller Hot Bypass Intlk-Purge Dew Point	24VDC	
11	09/01	Discrete In	X1361	Chiller Hot Bypass Intlk-South Purge Flow	24VDC	
11	09/02	Discrete In	X1362	Chiller Hot Bypass Intlk-North Purge Flow	24VDC	
11	09/03	Discrete In	X1363	Chiller Hot Bypass Intlk Sum	24VDC	
11	09/04	Discrete In	X1364	Comp Air Isolation Valve Intlk Sum	24VDC	
11	09/05	Discrete In	X1365	GN2 Purge Isolation Intlk Valve	24VDC	
11	09/06	Discrete In	X1366	Emergency Warmup Intlk Sum	24VDC	
11	09/07	Discrete In	X1367	Emergency Warmup-Spare 1	24VDC	
11	09/08	Discrete In	X1368	Emergency Warmup-Spare2	24VDC	
11	09/09	Discrete In	X1369	Chiller Pump #1 Status	24VDC	
11	09/10	Discrete In	X1370	Chiller Pump #2 Status	24VDC	
11	09/11	Discrete In	X1371	Purge Air Isolation Hand Pull	24VDC	
11	09/12	Discrete In	X1372	Purge Air Isolation Spare	24VDC	
11	09/13	Discrete In	X1373	Purge Air Isolation Sum	24VDC	
11	09/14	Discrete In	X1374	GN2 Flow Switch	24VDC	
11	10/01	Discrete In	X1377	Silicon Chiller # 1 Pump Bypass Keyswitch	24VDC	
11	10/02	Discrete In	X1378	Silicon Chiller # 1 Hot-Gas Bypass Keyswitch	24VDC	
11	10/03	Discrete In	X1379	Silicon Chiller # 1 Hot-Gas Bypass Solenoid	24VDC	
11	10/04	Discrete In	X1380	Silicon Chiller # 2 Pump Bypass Keyswitch	24VDC	
11	10/05	Discrete In	X1381	Silicon Chiller # 2 Hot-Gas Bypass Keyswitch	24VDC	
11	10/06	Discrete In	X1382	Silicon Chiller # 2 Hot-Gas Bypass Solenoid	24VDC	
11	11/01	RTD	WX1393	Chiller Combined Supply Temp.	100 Pt	
11	11/02	RTD	WX1394	Chiller Combined Supply "VJ" Temp	100 Pt	
11	11/03	RTD	WX1395	Chiller Combined Jumper "VJ" Temp	100 Pt	
11	11/04	RTD	WX1396	Chiller Combined Return Temp	100 Pt	
11	11/05	RTD	WX1397	North Det Return Jumper "VJ" Temp	100 Pt	
11	11/06	RTD	WX1398	South Det Return Jumper "VJ" Temp	100 Pt	
11	11/07	RTD	WX1399	North Det Return "VJ" Temp	100 Pt	
11	11/08	RTD	WX1400	South Det Return "VJ" Temp	100 Pt	
11	12/07	RTD	WX1407	South Glycol Return Temp	100 Pt	
11	12/08	RTD	WX1408	North Glycol Return Temp	100 Pt	
7	09/04	RTD	WX2636	North Silicon Supply line "VJ"	100 Pt	
7	09/05	RTD	WX2637	North Silicon Outlet line "VJ"	100 Pt	
7	09/06	RTD	WX2638	South Silicon Supply line "VJ"	100 Pt	
7	09/07	RTD	WX2639	South Silicon Outlet line "VJ" Close	100 Pt	
7	09/08	RTD	WX2640	South Silicon Outlet line "VJ"	100 Pt	
7	10/14	AI 4-20mA	WX2654	Silicon Vacuum of Coolant Supply Line	4-20mA	1mTorr-1000Torr
7	10/15	AI 4-20mA	WX2655	Silicon Vacuum of North Return Coolant Line	4-20mA	1mTorr-1000Torr
7	10/16	AI 4-20mA	WX2656	Silicon Vac of South Return Coolant Line	4-20mA	1mTorr-1000Torr
7	14/12	Discrete Out	Y2700	Silicon Vacuum Jacket Valve Coolant Supply	24VDC	ON=OPEN
7	14/13	Discrete Out	Y2701	Silicon Vac Jacket Valve N. Coolant Return	24VDC	ON=OPEN
7	14/14	Discrete Out	Y2702	Silicon Vac Jacket Valve S. Coolant Return	24VDC	ON=OPEN
8	10/01	RTD	WX2841	Silicon Expansion Tank Out Glycol Temp	100 Pt	

SLOT/PT		I/O Type	Address	Description	Signal	Range
8	10/02	RTD	WX2842	North Silicon Detector Out Glycol Temp	100 Pt	
8	10/03	RTD	WX2843	South Silicon Detector Out Glycol Temp	100 Pt	
8	10/04	RTD	WX2844	North Silicon Detector Out "VJ" Temp	100 Pt	
8	10/05	RTD	WX2845	South Silicon Detector Out "VJ" Temp	100 Pt	
8	10/06	RTD	WX2846	Silicon Expansion Tank "VJ" Temp	100 Pt	
8	10/07	RTD	WX2847	North Silicon Detector Out "VJ" Temp Close	100 Pt	
8	10/08	RTD	WX2848	Silicon Expansion Tank feed to Det "VJ"	100 Pt	
8	11/01	AI VOLTS	WX2849	Silicon -H-Disk 2 North - Slot # 4 Loc. Temp	0-5VDC	
8	11/02	AI VOLTS	WX2850	Silicon -H-Disk 2 North - Slot # 12 Loc. Temp	0-5VDC	
8	11/03	AI VOLTS	WX2851	Silicon -H-Disk 2 North - Slot # 16 Loc. Temp	0-5VDC	
8	11/04	AI VOLTS	WX2852	Silicon -H-Disk 2 North - Slot # 24 Loc. Temp	0-5VDC	
8	11/05	AI VOLTS	WX2853	Silicon -H-Disk 1 North - Slot # 4 Loc. Temp	0-5VDC	
8	11/06	AI VOLTS	WX2854	Silicon -H-Disk 1 North - Slot # 12 Loc. Temp	0-5VDC	
8	11/07	AI VOLTS	WX2855	Silicon -H-Disk 1 North - Slot # 16 Loc. Temp	0-5VDC	
8	11/08	AI VOLTS	WX2856	Silicon -H-Disk 1 North - Slot # 24 Loc. Temp	0-5VDC	
8	11/09	AI VOLTS	WX2857	Silicon -F-Disk 6 North - Slot # 1 Loc. Temp	0-5VDC	
8	11/10	AI VOLTS	WX2858	Silicon -F-Disk 6 North - Slot # 4 Loc. Temp	0-5VDC	
8	11/11	AI VOLTS	WX2859	Silicon -F-Disk 6 North - Slot # 7 Loc. Temp	0-5VDC	
8	11/12	AI VOLTS	WX2860	Silicon -F-Disk 6 North - Slot # 10 Loc. Temp	0-5VDC	
8	11/13	AI VOLTS	WX2861	Silicon -F-Disk 5 North - Slot # 2 Loc. Temp	0-5VDC	
8	11/14	AI VOLTS	WX2862	Silicon -F-Disk 5 North - Slot # 5 Loc. Temp	0-5VDC	
8	11/15	AI VOLTS	WX2863	Silicon -F-Disk 5 North - Slot # 8 Loc. Temp	0-5VDC	
8	11/16	AI VOLTS	WX2864	Silicon -F-Disk 5 North - Slot # 11 Loc. Temp	0-5VDC	
8	12/01	AI VOLTS	WX2865	Silicon -F-Disk 4 North - Slot # 3 Loc. Temp	0-5VDC	
8	12/02	AI VOLTS	WX2866	Silicon -F-Disk 4 North - Slot # 6 Loc. Temp	0-5VDC	
8	12/03	AI VOLTS	WX2867	Silicon -F-Disk 4 North - Slot # 9 Loc. Temp	0-5VDC	
8	12/04	AI VOLTS	WX2868	Silicon -F-Disk 4 North - Slot # 12 Loc. Temp	0-5VDC	
8	12/05	AI VOLTS	WX2869	Silicon -F-Disk 3 North - Slot # 2 Loc. Temp	0-5VDC	
8	12/06	AI VOLTS	WX2870	Silicon -F-Disk 3 North - Slot # 5 Loc. Temp	0-5VDC	
8	12/07	AI VOLTS	WX2871	Silicon -F-Disk 3 North - Slot # 8 Loc. Temp	0-5VDC	
8	12/08	AI VOLTS	WX2872	Silicon -F-Disk 3 North - Slot # 11 Loc. Temp	0-5VDC	
8	12/09	AI VOLTS	WX2873	Silicon -Barrel 3 North - Slot # 8-2 Loc. Temp	0-5VDC	
8	12/10	AI VOLTS	WX2874	Silicon -Barrel 3 North - Slot # 8-5 Loc. Temp	0-5VDC	
8	12/11	AI VOLTS	WX2875	Silicon -Barrel 3 North - Slot # 8-8 Loc. Temp	0-5VDC	
8	12/12	AI VOLTS	WX2876	Silicon -Barrel 3 North - Slot # 8-11 Loc. Temp	0-5VDC	
8	12/13	AI VOLTS	WX2877	Silicon -F-Disk 2 North - Slot # 2 Loc. Temp	0-5VDC	
8	12/14	AI VOLTS	WX2878	Silicon -F-Disk 2 North - Slot # 5 Loc. Temp	0-5VDC	
8	12/15	AI VOLTS	WX2879	Silicon -F-Disk 2 North - Slot # 8 Loc. Temp	0-5VDC	
8	12/16	AI VOLTS	WX2880	Silicon -F-Disk 2 North - Slot # 11 Loc. Temp	0-5VDC	
8	13/01	AI VOLTS	WX2881	Silicon -Barrel 2 North - Slot # 8-2 Loc. Temp	0-5VDC	
8	13/02	AI VOLTS	WX2882	Silicon -Barrel 2 North - Slot # 8-5 Loc. Temp	0-5VDC	
8	13/03	AI VOLTS	WX2883	Silicon -Barrel 2 North - Slot # 8-8 Loc. Temp	0-5VDC	
8	13/04	AI VOLTS	WX2884	Silicon-Barrel 2 North -Slot # 8-11 Loc. Temp	0-5VDC	
8	13/05	AI VOLTS	WX2885	Silicon -F-Disk 1 North - Slot # 2 Loc. Temp	0-5VDC	
8	13/06	AI VOLTS	WX2886	Silicon -F-Disk 1 North - Slot # 5 Loc. Temp	0-5VDC	
8	13/07	AI VOLTS	WX2887	Silicon -F-Disk 1 North - Slot # 8 Loc. Temp	0-5VDC	

e	SLOT/PT	I/O Type	Address	Description	Signal	Range
8	13/08	AI VOLTS	WX2888	Silicon -F-Disk 1 North - Slot # 11 Loc. Temp	0-5VDC	
8	13/09	AI VOLTS	WX2889	Silicon -Barriel 1 North -Slot # 8-2 Loc. Temp	0-5VDC	
8	13/10	AI VOLTS	WX2890	Silicon -Barriel 1 North- Slot # 8-5 Loc. Temp	0-5VDC	
8	13/11	AI VOLTS	WX2891	Silicon -Barriel 1 North- Slot # 8-8 Loc. Temp	0-5VDC	
8	13/12	AI VOLTS	WX2892	Silicon -Barriel 1 North-Slot # 8-11 Loc.Temp	0-5VDC	
8	13/13	AI VOLTS	WX2893	Silicon -H-Disk 2 South - Slot # 4 Loc. Temp	0-5VDC	
8	13/14	AI VOLTS	WX2894	Silicon -H-Disk 2 South - Slot # 12 Loc.Temp	0-5VDC	
8	13/15	AI VOLTS	WX2895	Silicon -H-Disk 2 South - Slot # 16 Loc.Temp	0-5VDC	
8	13/16	AI VOLTS	WX2896	Silicon -H-Disk 2 South - Slot # 24 Loc.Temp	0-5VDC	
8	14/01	AI VOLTS	WX2897	Silicon -H-Disk 1 South- Slot # 4 Loc. Temp	0-5VDC	
8	14/02	AI VOLTS	WX2898	Silicon -H-Disk 1 South - Slot # 12 Loc.Temp	0-5VDC	
8	14/03	AI VOLTS	WX2899	Silicon -H-Disk 1 South - Slot # 16 Loc.Temp	0-5VDC	
8	14/04	AI VOLTS	WX2900	Silicon -H-Disk 1 South - Slot # 24 Loc.Temp	0-5VDC	
8	14/05	AI VOLTS	WX2901	Silicon -F-Disk 6 South - Slot # 1 Loc. Temp	0-5VDC	
8	14/06	AI VOLTS	WX2902	Silicon -F-Disk 6 South - Slot # 4 Loc. Temp	0-5VDC	
8	14/07	AI VOLTS	WX2903	Silicon -F-Disk 6 South - Slot # 7 Loc. Temp	0-5VDC	
8	14/08	AI VOLTS	WX2904	Silicon -F-Disk 6 South - Slot # 10 Loc. Temp	0-5VDC	
8	14/09	AI VOLTS	WX2905	Silicon -F-Disk 5 South - Slot # 2 Loc. Temp	0-5VDC	
8	14/10	AI VOLTS	WX2906	Silicon -F-Disk 5 South - Slot # 5 Loc. Temp	0-5VDC	
8	14/11	AI VOLTS	WX2907	Silicon -F-Disk 5 South - Slot # 8 Loc. Temp	0-5VDC	
8	14/12	AI VOLTS	WX2908	Silicon -F-Disk 5 South - Slot # 11 Loc. Temp	0-5VDC	
8	14/13	AI VOLTS	WX2909	Silicon -F-Disk 4 South - Slot # 3 Loc. Temp	0-5VDC	
8	14/14	AI VOLTS	WX2910	Silicon -F-Disk 4 South - Slot # 6 Loc. Temp	0-5VDC	
8	14/15	AI VOLTS	WX2911	Silicon -F-Disk 4 South - Slot # 9 Loc. Temp	0-5VDC	
8	14/16	AI VOLTS	WX2912	Silicon -F-Disk 4 South - Slot # 12 Loc. Temp	0-5VDC	
8	15/01	AI VOLTS	WX2913	Silicon -F-Disk 3 South - Slot # 2 Loc. Temp	0-5VDC	
8	15/02	AI VOLTS	WX2914	Silicon -F-Disk 3 South - Slot # 5 Loc. Temp	0-5VDC	
8	15/03	AI VOLTS	WX2915	Silicon -F-Disk 3 South - Slot # 8 Loc. Temp	0-5VDC	
8	15/04	AI VOLTS	WX2916	Silicon -F-Disk 3 South - Slot # 11 Loc. Temp	0-5VDC	
8	15/05	AI VOLTS	WX2917	Silicon -Barrel 3 South - Slot # 8-2 Loc.Temp	0-5VDC	
8	15/06	AI VOLTS	WX2918	Silicon -Barrel 3 South - Slot # 8-5 Loc.Temp	0-5VDC	
8	15/07	AI VOLTS	WX2919	Silicon -Barrel 3 South - Slot # 8-8 Loc.Temp	0-5VDC	
8	15/08	AI VOLTS	WX2920	Silicon -Barrel 3 South -Slot # 8-11Loc.Temp	0-5VDC	
8	15/09	AI VOLTS	WX2921	Silicon -F-Disk 2 South - Slot # 2 Loc. Temp	0-5VDC	
8	15/10	AI VOLTS	WX2922	Silicon -F-Disk 2 South - Slot # 5 Loc. Temp	0-5VDC	
8	15/11	AI VOLTS	WX2923	Silicon -F-Disk 2 South - Slot # 8 Loc. Temp	0-5VDC	
8	15/12	AI VOLTS	WX2924	Silicon -F-Disk 2 South - Slot # 11 Loc. Temp	0-5VDC	
8	15/13	AI VOLTS	WX2925	Silicon -Barrel 2 South - Slot # 8-2 Loc.Temp	0-5VDC	
8	15/14	AI VOLTS	WX2926	Silicon -Barrel 2 South - Slot # 8-5 Loc.Temp	0-5VDC	
8	15/15	AI VOLTS	WX2927	Silicon -Barrel 2 South - Slot # 8-8 Loc.Temp	0-5VDC	
8	15/16	AI VOLTS	WX2928	Silicon -Barrel 2 South-Slot # 8-11 Loc.Temp	0-5VDC	
8	16/01	AI VOLTS	WX2929	Silicon -F-Disk 1 South - Slot # 2 Loc. Temp	0-5VDC	
8	16/02	AI VOLTS	WX2930	Silicon -F-Disk 1 South - Slot # 5 Loc. Temp	0-5VDC	
8	16/03	AI VOLTS	WX2931	Silicon -F-Disk 1 South - Slot # 8 Loc. Temp	0-5VDC	
8	16/04	AI VOLTS	WX2932	Silicon -F-Disk 1 South - Slot # 11 Loc. Temp	0-5VDC	
8	16/05	AI VOLTS	WX2933	Silicon -Barriel 1 South -Slot # 8-2 Loc.Temp	0-5VDC	

e	SLOT/PT	I/O Type	Address	Description	Signal	Range
8	16/06	AI VOLTS	WX2934	Silicon -Barriel 1 South -Slot # 8-5 Loc.Temp	0-5VDC	
8	16/07	AI VOLTS	WX2935	Silicon -Barriel 1 South -Slot # 8-8 Loc.Temp	0-5VDC	
8	16/08	AI VOLTS	WX2936	Silicon -Barriel 1 South Slot # 8-11 Loc.Temp	0-5VDC	
10	01/01	RTD	WX2145	Cylinder 3 South @ 1 O'Clock	100 Pt	
10	01/02	RTD	WX2146	Cylinder 3 South @ 4 O'Clock	100 Pt	
10	01/03	RTD	WX2147	Cylinder 3 South @ 5 O'Clock	100 Pt	
10	01/04	RTD	WX2148	Cylinder 3 South @ 7 O'Clock	100 Pt	
10	01/05	RTD	WX2149	Cylinder 3 South @ 8 O'Clock	100 Pt	
10	01/06	RTD	WX2150	Cylinder 3 South @ 10 O'Clock	100 Pt	
10	01/07	RTD	WX2151	Cylinder 1 South @ 1 O'Clock	100 Pt	
10	01/08	RTD	WX2152	Cylinder 1 Center @ 1 O'Clock	100 Pt	
10	02/01	RTD	WX2153	Cylinder 1 South @ 4 O'Clock	100 Pt	
10	02/02	RTD	WX2154	Cylinder 1 Center @ 4 O'Clock	100 Pt	
10	02/03	RTD	WX2155	Cylinder 1 South @ 5 O'Clock	100 Pt	
10	02/04	RTD	WX2156	Cylinder 1 Center @ 5 O'Clock	100 Pt	
10	02/05	RTD	WX2157	Cylinder 1 South @ 7 O'Clock	100 Pt	
10	02/06	RTD	WX2158	Cylinder 1 Center @ 7 O'Clock	100 Pt	
10	02/07	RTD	WX2159	Cylinder 1 South @ 8 O'Clock	100 Pt	
10	02/08	RTD	WX2160	Cylinder 1 Center @ 8 O'Clock	100 Pt	
10	03/01	RTD	WX2161	Cylinder 1 South @ 10 O'Clock	100 Pt	
10	03/02	RTD	WX2162	Cylinder 1 Center @ 10 O'Clock	100 Pt	
10	03/03	RTD	WX2163	Cylinder 1 North @ 1 O'Clock	100 Pt	
10	03/04	RTD	WX2164	Cylinder 3 North @ 1 O'Clock	100 Pt	
10	03/05	RTD	WX2165	Cylinder 1 North @ 4 O'Clock	100 Pt	
10	03/06	RTD	WX2166	Cylinder 3 North @ 4 O'Clock	100 Pt	
10	03/07	RTD	WX2167	Cylinder 1 North @ 5 O'Clock	100 Pt	
10	03/08	RTD	WX2168	Cylinder 3 North @ 5 O'Clock	100 Pt	
10	04/01	RTD	WX2169	Cylinder 1 North @ 7 O'Clock	100 Pt	
10	04/02	RTD	WX2170	Cylinder 3 North @ 7 O'Clock	100 Pt	
10	04/03	RTD	WX2171	Cylinder 1 North @ 8 O'Clock	100 Pt	
10	04/04	RTD	WX2172	Cylinder 3 North @ 8 O'Clock	100 Pt	
10	04/05	RTD	WX2173	Cylinder 1 North @ 10 O'Clock	100 Pt	
10	04/06	RTD	WX2174	Cylinder 3 North @ 10 O'Clock	100 Pt	
10	04/07	RTD	WX2175	South Silicon Internal Ambient RTD Upper	100 Pt	
10	04/08	RTD	WX2176	South Silicon Internal Ambient RTD Lower	100 Pt	
10	05/07	RTD	WX2183	North Silicon Internal Ambient RTD Upper	100 Pt	
10	05/08	RTD	WX2184	North Silicon Internal Ambient RTD Lower	100 Pt	

TABLE 3. HVAC PLC AIR COMPRESSOR I/O MAP

e	SLOT/PT	I/O Type	Address	Description	Signal	Range
1	10/09	DIS IN	X0097	EAST AIR COMP MOTOR STARTER	24VDC	
1	10/10	DIS IN	X0098	WEST AIR COMP MOTOR STARTER	24VDC	
1	10/11	DIS IN	X0099	I/A DRIER FAILURE	24VDC	
1	10/12	DIS IN	X0100	SEPARATER TANK BLOWDOWN FAIL	24VDC	
1	16/5	RTD	WX181	Drier Inlet	100 Pt	
1	16/6	RTD	WX182	Drier Heater Out	100 Pt	
1	16/7	RTD	WX183	Tower Out	100 Pt	
1	17/8	RTD	WX184	Drier Inlet	100 Pt	

What If Analysis of the Silicon Cooling and Dry Gas Interlock System

Revised Feb 5, 2001.

Any event leading to removal of a permit will be investigated before the permit is re-established to ensure that the cause is understood and corrective measures have been taken.

Action	Failure	Consequences	Comments
Remove permit for silicon power	What if the south coolant return flow sensor fails to detect a low flow condition?	None	This results in a low separator tank or a high expansion tank level trip, shutting down the chiller pump (hardware), causing a silicon power permit trip (hardware). In addition, the permit for silicon power will be removed based upon high south return temperature (hardware) provided the flow is not halted entirely. If the flow is sufficiently low, the interlock for low discharge pressure will be tripped. The permit for silicon power will be removed based upon high south coolant return temperature (hardware chain) before the silicon is damaged from over-temperature. Interlocked temperature measurements based upon RTD's on silicon devices (software chain) provide independent protection except for final hardware generation of the permit.
	What if the north coolant return flow sensor fails to detect a low flow condition?	None	This results in a low separator tank or a high expansion tank level trip, shutting down the chiller pump (hardware), causing a silicon power permit trip (hardware). In addition, the permit for silicon power will be removed based upon high south return temperature (hardware) provided the flow is not halted entirely. If the flow is sufficiently low, the interlock for low discharge pressure will be tripped. The permit for silicon power will be removed based upon high south coolant return temperature (hardware chain) before the silicon is damaged from over-temperature. Interlocked temperature measurements based upon RTD's on silicon devices (software chain) provide independent protection except for final hardware generation of the permit.
	What if the south coolant return temperature sensor fails to detect a high temperature condition?	None	Independent measurements of south and north return temperatures (hardware chain) ensure that, for single failures, one or the other temperature measurement will lead to removal of the silicon power permit if the coolant temperature is high. The interlock based upon south flow rate ensures that, if refrigeration is adequate, the silicon will be adequately cooled. Interlocked temperature measurements based upon RTD's on silicon devices (software chain) provide additional, independent protection.
	What if the north coolant return temperature sensor fails to detect a high temperature condition?	None	Independent measurements of south and north return temperatures (hardware chain) ensure that, for single failures, one or the other temperature measurement will lead to removal of the silicon power permit if the coolant temperature is high. The interlock based upon north flow rate ensures that, if refrigeration is adequate, the silicon will be adequately cooled. Interlocked temperature measurements based upon RTD's on silicon devices (software chain) provide additional, independent protection.

	What if an emergency warm-up is initiated but the emergency warm-up signal is not received by hardware in the silicon power permit chain?	None	Provided the emergency warm-up signal is received in the chiller water pump permit chain, the permit for silicon power will be removed based upon low return flow of coolant.
	What if a false emergency warm-up signal is generated?	None	Silicon will be warmed unnecessarily, an operational inconvenience. Even after irradiation of silicon, a warm-up of a day is acceptable
	What if a false PLC sum trip is generated?	None	Silicon will be warmed unnecessarily, an operational inconvenience. Even after irradiation of silicon, a warm-up of a day is acceptable
	What if the PLC sum trip fails to be generated?	None	Hardware interlocks will provide protection.
	What if the PLC software is corrupted so that no software permit is generated?	None	Hardware interlocks will provide protection.
	What if monitored devices in the hardware interlock chain fail?	None	The hardware interlocks are the primary devices to protect silicon from over-temperature. We believe that the level of protection provided is satisfactory. However, except for the final summation of trip conditions, independent protection is provided via PLC based monitoring of system conditions.
	What if silicon power is not removed when its permit is removed?	None	The likelihood of such a failure has been reviewed within D0. As the result of that review, an independent hardware permit chain will be added to the SMT Interlock and Control electronics to ensure that silicon power is removed when its permit is removed. The existing permit chain contains PLC's and will continue to be active. The new chain will provide an independent permit path with no PLC's. Both permits must be present for power supplies to be energized.

Action	Failure	Consequences	Comments
Remove permit to chiller water pump	What if the separator tank pressure is high and that is not detected?	None	The chiller water pump will be turned off via at least one of the following hardware interlock chains: high suction pressure, low separator tank level, high expansion tank level.
	What if the separator tank level is low and that is not detected?	Minor (possible chiller pump failure)	Eventually, the coolant level may drop sufficiently far that cooling is compromised. In that case, removal of the silicon power permit will protect the silicon (except for final permit generation, independent hardware and software chains). However, the chiller pump may be damaged by cavitation. A second chiller allows cooling to be re-established if repairs to the first chiller are needed.
	What if the expansion tank level is high and that is not detected?	None	Once coolant volume has been established for operation, high expansion tank level implies low separator tank level. A catch tank is provided for any overflow of the expansion tank. If significant flow into the catch tank occurs, the interlock on low separator tank level will be tripped (hardware chain).
	What if the expansion tank pressure is high and that is not detected?	None	A relief valve has been added to ensure that, even if the vent from the expansion tank is obstructed, the expansion tank will not be pressurized excessively.
	What if discharge pressure is low after 1 minute and that is not detected?	None	This interlock is provided to prevent the system from being run with an inadequately functioning pump or in the unlikely case that a line or other component has ruptured. Low discharge pressure implies high pump suction pressure, which is interlocked (hardware chain). If the cause is a leak or rupture, then the pump will trip on low separator tank level. The silicon will be protected from over-temperature by removal of its power permit A second chiller can be energized to provide cooling.
	What if pump suction pressure is high after 1 minute and that is not detected?	None	The pump permit will be removed based upon low discharge pressure (hardware). The silicon will be protected from over-temperature by removal of its power permit (except for final permit generation, independent hardware and software chains). A second chiller can be energized to provide cooling.
	What if a false emergency warm-up signal is generated?	None	Silicon will be warmed unnecessarily, an operational inconvenience. Even after irradiation of silicon, a warm-up of a day is acceptable
	What if an emergency warm-up is initiated but the relay in the chiller fails to turn off the chiller pump?	None	The chiller contactor will turn power off to both chiller cabinets. If the chiller pump continued to run, the effective time for warm-up would be increased.

	What if an emergency warm-up is initiated but the chiller contactor fails to turn off the chiller pumps?	None	Each chiller pumps' relay will turn power off to the respective pump. If the chiller pump continued to run, the effective time for warm-up would be increased.

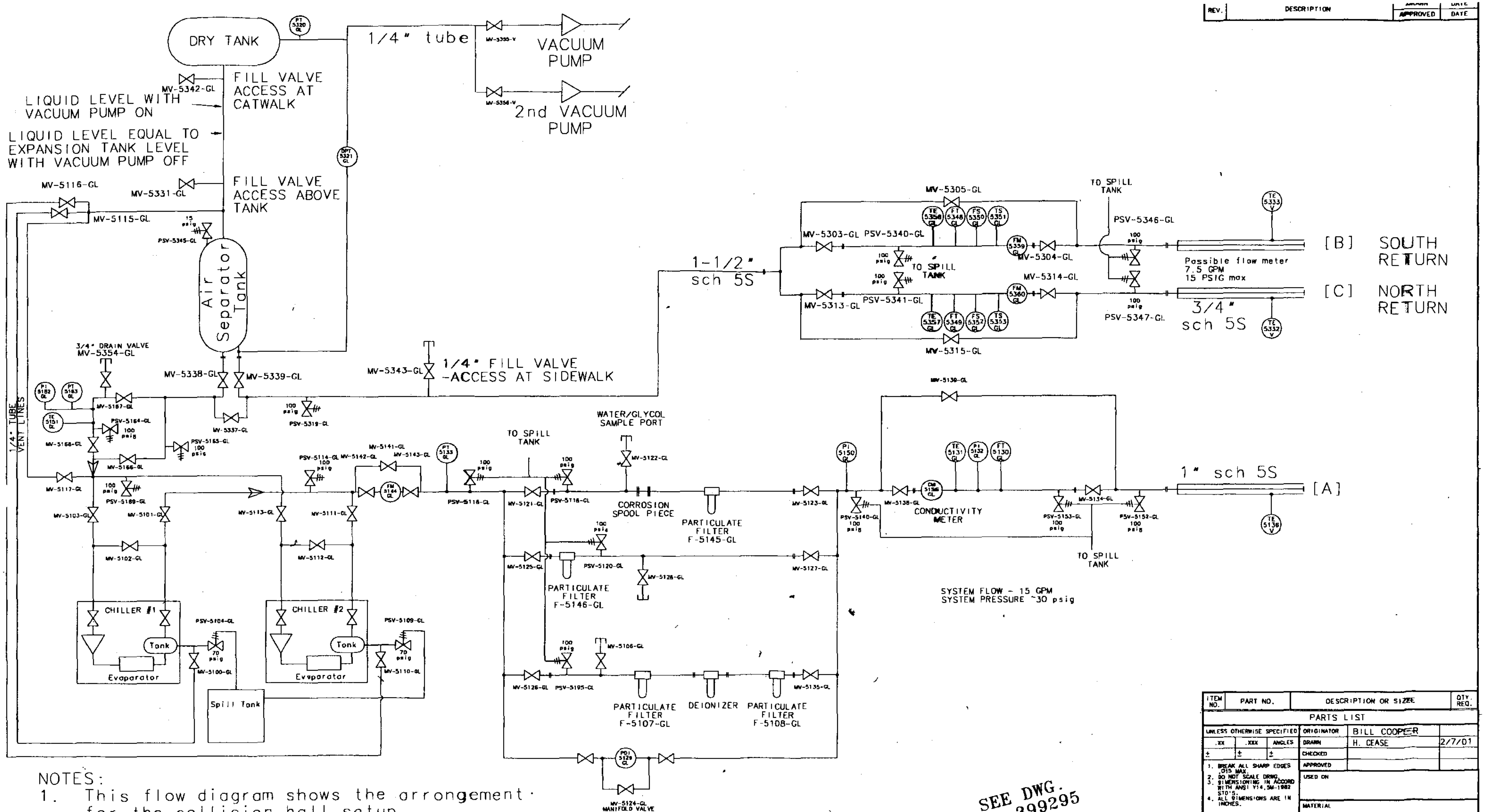
Action	Failure	Consequences	Comments
Remove permit for chiller refrigeration	What if switchover of airflow from the compressor to the trailer occurs and is not detected?	None	Air will be drawn from the trailer until it is exhausted. That will be detected as low north and south purge flows on the platform and the permit for chiller refrigeration will be removed (hardware chain). If the dew point of purge air is high, an independent trip of the chiller refrigeration will be generated (hardware chain). If the dew point sampling system detects high dew points (software chain), the chiller refrigeration permit will be removed. Finally, an emergency warm-up will be initiated based upon low north and south silicon purge flows (software chain).
	What if the dew point of purge air is high and that is not detected by the sensor in the air supply line?	None	The dew points at various locations in the apparatus are independently measured via a dew point sampling system, part of a PLC interlock chain. The chiller refrigeration permit would be removed via that chain. Multiple failures are implied.
	What if the south silicon air purge flow is low and that is not detected?	None	The permit for chiller refrigeration will be removed based upon low north silicon purge flow (hardware chain). An emergency warm-up will be initiated based upon low purge flow (software chain)
	What if the north silicon air purge flow is low and that is not detected?	None	The permit for chiller refrigeration will be removed based upon low south silicon purge flow (hardware chain). An emergency warm-up will be initiated based upon low purge flow (software chain)

Action	Failure	Consequences	Comments
Close isolation valve for the air compressors	What if high dew point is detected but the isolation valve for the air compressors fails to close?	None	Purge Air Dew point #2 sensor will close the Purge air isolation valve at a slightly higher dew point than sensor #1.

Action	Failure	Consequences	Comments
Close isolation valve for the Purge Air	What if high dew point is detected but purge air isolation valve fails to close.	None	Purge Air Dew point #1 sensor will close the Air compressor Isolation Valve.
	What if Hand Switch is triggered but purge air isolation valve fails to close.	None	Since this is an operator action, the operator will be able to shutdown the air by closing valves or shutting down compressors.

Action	Failure	Consequences	Comments
Close isolation valve on the expansion tank purge supply	What if high expansion tank pressure is detected but the isolation valve does not close?	None	A relief valve has been added to ensure that the expansion tank cannot be pressurized excessively.

Action	Failure	Consequences	Comments
Initiate emergency warm-up	What if the dew point sample system fails?	None	Chiller refrigeration is discontinued via a hardware chain if there is insufficient flow into the purge volumes or the dew point of the purge air is high. The isolation valve for airflow from the compressors is closed via a hardware chain if the purge air dew point is high. That hardware chain also initiates an emergency warm-up. The isolation valve can also be closed via a hand pull.
	What if the PLC chains to initiate an emergency warm-up based upon south silicon purge flow and north silicon purge flow fail?	None	Hardware interlocks discontinue chiller refrigeration. Hardware chains close the isolation valve for flow from the air compressors upon detection of high purge air dew point. Closing the isolation valve initiates an emergency warm-up. The isolation valve can also be closed via a hand pull.



NOTES:

1. This flow diagram shows the arrangement for the collision hall setup.
2. The assembly hall equipment is to be installed in the same fashion as the collision hall equipment.
3. All plumbing sizes are given as tubing OD unless otherwise noted.

CONNECTIONS [A] THROUGH [C] ARE MADE IN THE ASSEMBLY HALL

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

ORIGINATOR	BILL COOPER
DRAWN	H. CEASE 2/7/01
CHECKED	
APPROVED	
USED ON	
MATERIAL	

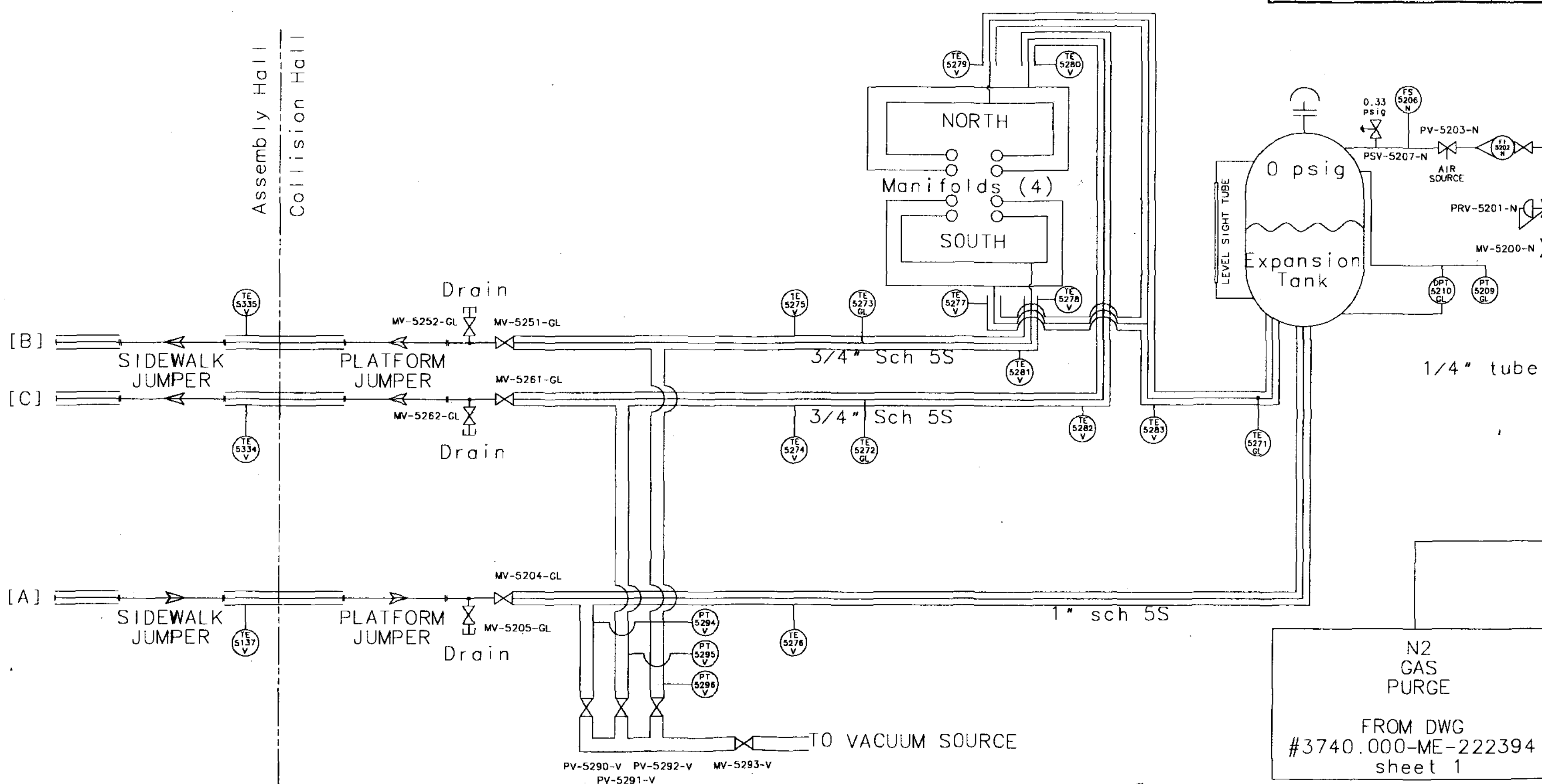
UNLESS OTHERWISE SPECIFIED
1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRWG.
3. DIMENSIONING IN ACCORD WITH ANSI Y14.5M-1982 STD'S.
4. ALL DIMENSIONS ARE IN INCHES.

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

DO DETECTOR UPGRADE
D-ZERO SILICON COOLING
P&ID LAYOUT

DRAWING NUMBER 3823.112-MD-900790 SHEET NO. 1 OF 2

Plotted by mateski on 07-Nov-2001 , File: 90079001__.pff



SEE DWG. MD-399295

CONNECTIONS [A] THROUGH [C] ARE MADE IN THE ASSEMBLY HALL

NOTES:

1. This flow diagram shows the arrangement for the collision hall setup.
2. The assembly hall equipment is to be installed in the same fashion as the collision hall equipment.
3. All plumbing sizes are given as tubing OD unless otherwise noted.

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED — ORIGINATOR: BILL COOPER; DRAWN: H. CEASE 1/31/01; CHECKED; APPROVED; USED ON; MATERIAL

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRWG.
3. DIMENSIONING IN ACCORD WITH ANSI Y14.5M-1982 STD'S.
4. ALL DIMENSIONS ARE IN INCHES.

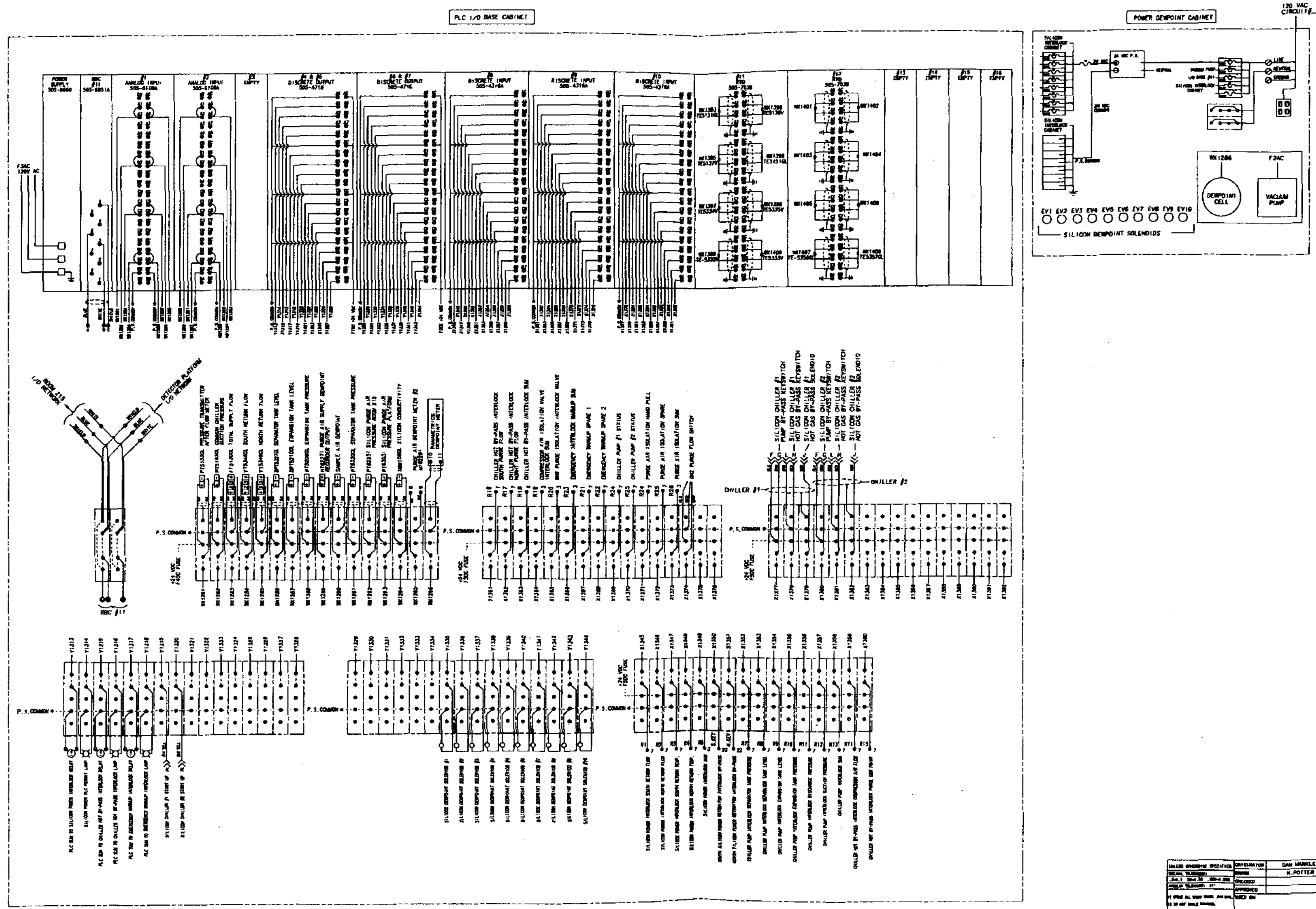
MAX. ALL MACHINED SURFACES

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D0 DETECTOR UPGRADE
D-ZERO SILICON COOLING
P&ID LAYOUT

SCALE | DRAWING NUMBER 3823.112-MD-900790 | SHEET NO. 2 OF 2 | REV.

REV	DESCRIPTION		
A	ADDED DEW MONITOR #2	D. FRIEND	3/13/01
B	ADDED DEW POINT METER AT WK1296	MATESKI	5/16/01



ORIGINATOR	DAN MARKLEY	08/21/00
DRAWN	K.POTTER	08/30/00
CHECKED		
APPROVED		

MATERIAL: SEE PARTS LIST ON PAGE 1 OF 2

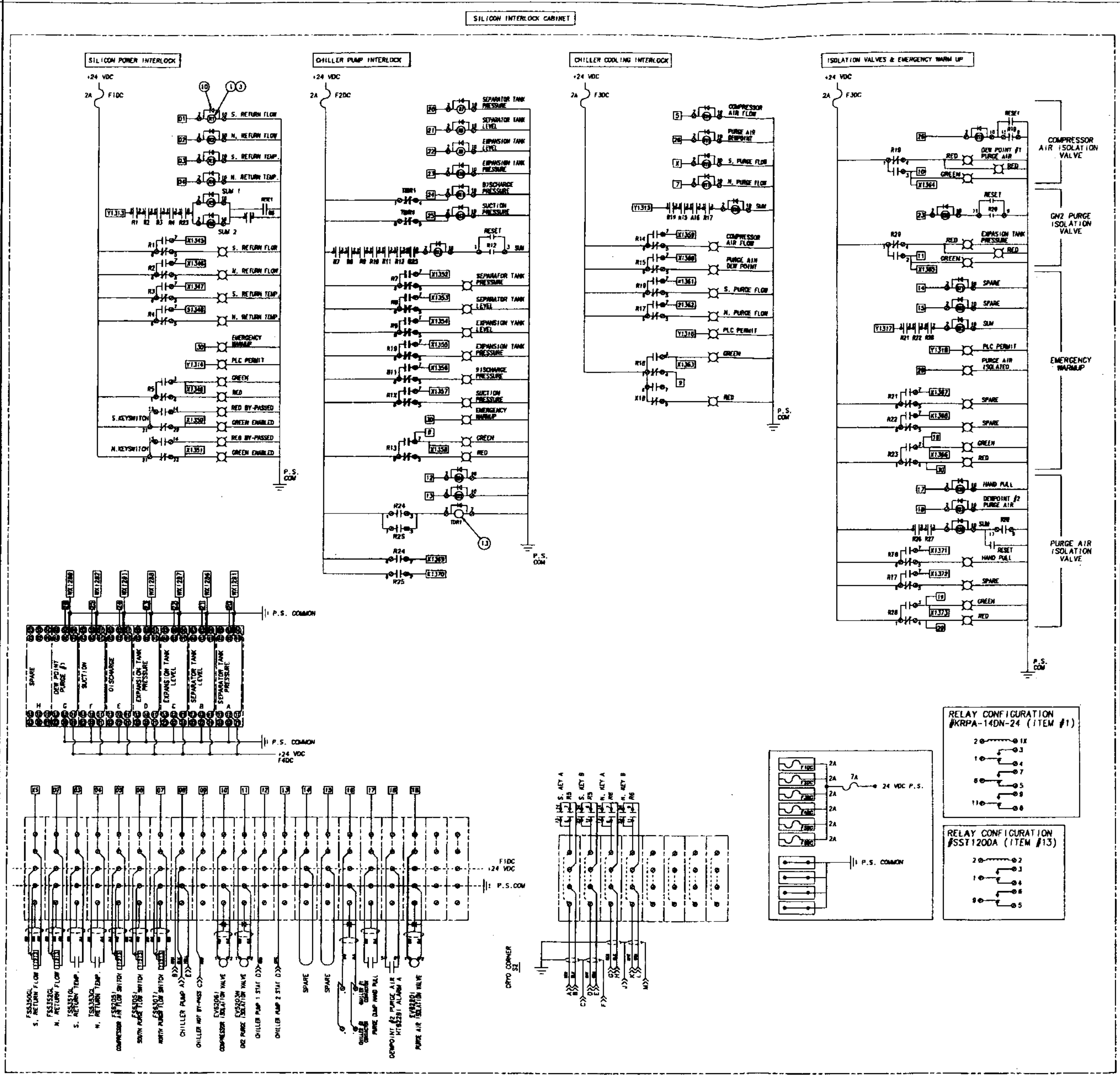
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D-ZERO SILICON COOLING SYSTEM INTERLOCK WIRING DIAGRAM

SCALE	DRAWING NUMBER	SHEET	REV
NO SCALE	3823.112-EE-330338	1 OF 4	B

CREATED WITH : MS2.1 GROUP: D0MS

Plotted by mateski on 07-Nov-2001 . File: 330338oh B.plt



INTERLOCK THRESHOLD SETTING TABLE

TAG	DESCRIPTION	MODULE #TRANSMITTER RANGE	LOW	HIGH	TGU TRIP POINTS LOW	HIGH	VOLTAGE SETTINGS LOW	HIGH
FSS350GL	SOUTH RETURN FLOW				3 GPM	------		
FSS352GL	NORTH RETURN FLOW				3 GPM	------		
TSS351GL	SOUTH RETURN TEMP		------	------	------	85F	------	------
TSS353GL	NORTH RETURN TEMP		------	------	------	85F	------	------
PTS320GL	SEPARATOR TANK PRESSURE	A	-15PSIG	5PSIG	-15PSIG	-5PSIG	.5VDC	3.0VDC
DPTS321GL	SEPARATOR TANK LEVEL	B	0 PSIG	30PSIG	10 PSIG	30 PSIG	2.33VDC	5VDC
DPTS210GL	EXPANSION TANK LEVEL	C	0" WC	100" WC	0" WC	40"H2O	.5VDC	2.8VDC
PTS209GL	EXPANSION TANK PRESSURE	D	9 PSIG	5 PSIG	0 PSIG	3PSIG	.5VDC	3.4VDC
PTS133GL	DISCHARGE	E	-10PSIG	75PSIG	8PSIG	75PSIG	1.33VDC	5VDC
PYS163GL	SUCTION	F	-10PSIG	18PSIG	-15PSIG	3PSIG	.5VDC	1.84VDC
HT68271	PURGE DEW POINT #1	G	-120F	80F	-120F	-22F	.5VDC	3.0VDC
HY68281	PURGE DEW POINT #2		-120F	20F	-----	-15F	-----	-----

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
13	COMM./STK.	THOMAS & BETTS #SST1200A TIME DELAY RELAY	1
12	COMM./STK.	#3" x 6"LG. CLOSE CONDUIT NIPPLE	2
11	COMM./STK.	# D2410 CRYDOM SOLID STATE RELAY	1
10	COMM./STK.	#1N4005 POWER DIODE	1
9	COMM./STK.	CHILLER CABINET #2	1
8	COMM./STK.	CHILLER CABINET 31	1
7	COMM./STK.	12 PIN BURNDY FEEDTHROUGH	1
6	COMM./STK.	#A-363012LP 36x30x12 HOFFMAN ENCLOSURE	1
5	COMM./STK.	#C-SD302412W 30x24x12 HOFFMAN ENCLOSURE	1
4	COMM./STK.	#A-242008LP 24x20x8 HOFFMAN ENCLOSURE	1
3	COMM./STK.	#101-8430-09-203 DIALIGHT LAMP SOCKET	1
2	COMM./STK.	#27E891 P&B 11 PIN RELAY SOCKET DIN RAIL MOUNT	1
1	COMM./STK.	#KRPA-14 DN-24 P&B 24 VDC RELAY	1

PARTS LIST

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	DAN MARKLEY	08/21/00
	DRAWN	K.POTTER	08/30/00
	CHECKED		
	APPROVED		
	USED ON		
	MATERIAL	SEE PARTS LIST	

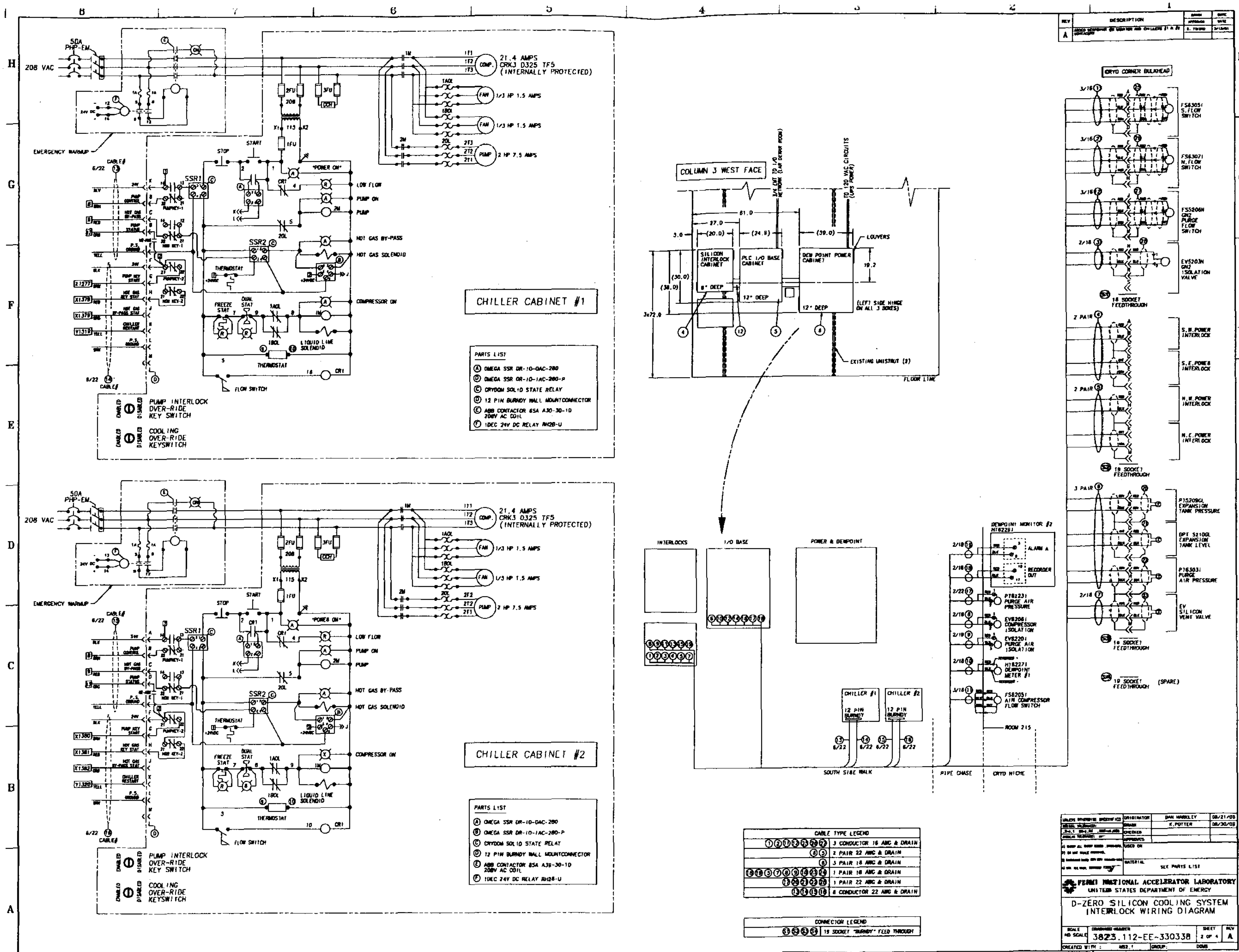
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D-ZERO SILICON COOLING SYSTEM INTERLOCK WIRING DIAGRAM

SCALE	DRAWING NUMBER	SHEET	REV
NO SCALE	3823.112-EE-330338	2 OF 4	A

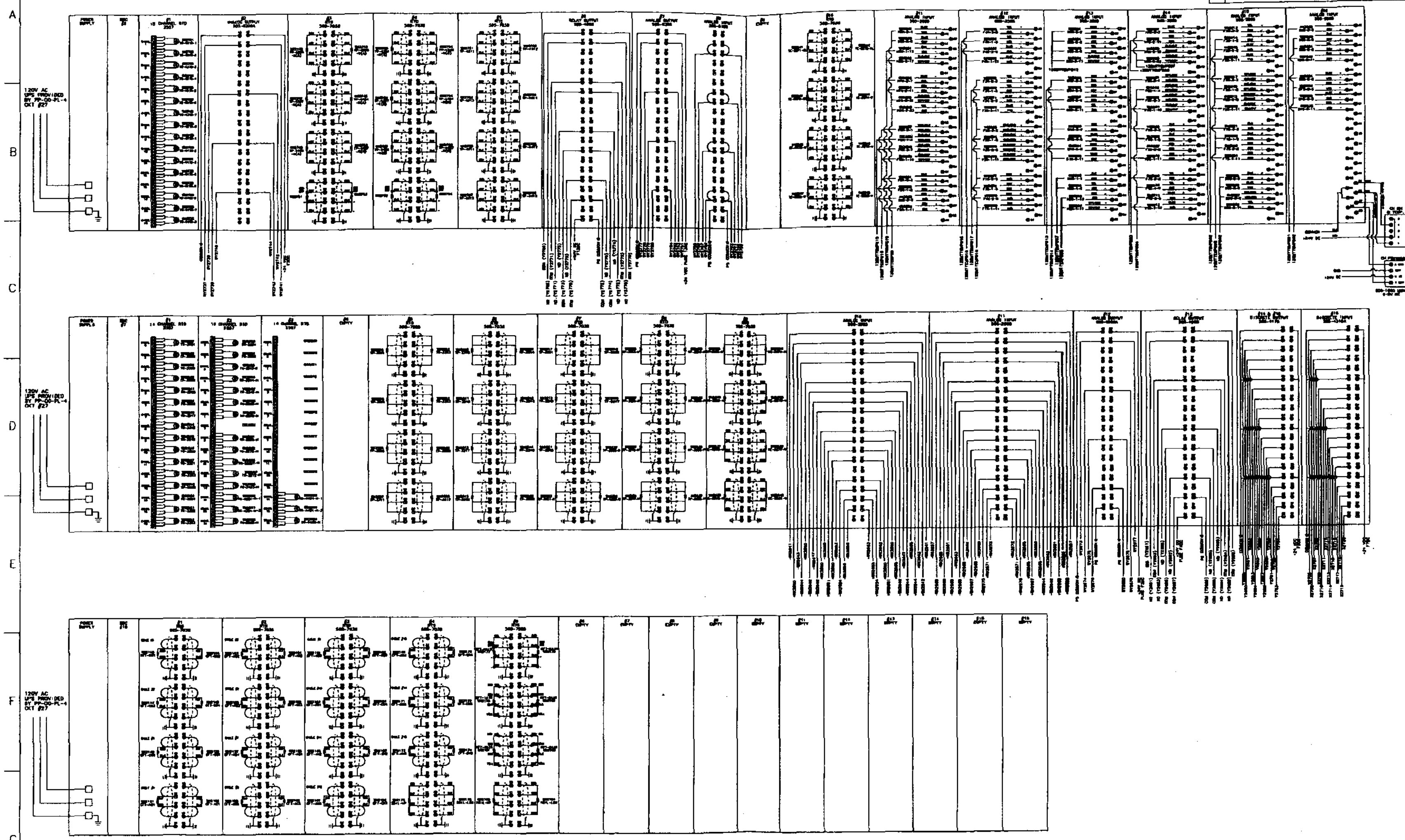
CREATED ON 2H : MS2.1 GROUP: D0MS

Plotted by mgleski on 07-Nov-2001 File: 330338OD_A.plt



Plotted by moteski on 07-Nov-2001 . File: 330338OD_A.pff

REV.	DESCRIPTION	DRAWN / APPROVED	DATE
C	[illegible]	[illegible]	[illegible]
A	ADDED SILICON DETECTOR INSTRUMENTATION	K. POTTER / B. MARKLEY	[illegible]
B	ADDED I/O BASE #10	K. POTTER / B. MARKLEY	[illegible]



NOTES:

2. TR-4XXX SERIES RTD WIRING DETAILS CAN BE FOUND IN ELECTRICAL DRAWING 3823.113-ED-330327 DO DETECTOR UPGRADE, FIBER TRACKER - VLPC CRYOSTATS, INSTRUMENTATION FEEDTHROUGH CONNECTORS.

1. TR-3XXX SERIES RTD WIRING DETAILS CAN BE FOUND IN ENGINEERING NOTE 3823.111-EN-474 DO CRYOGENIC SYSTEM, SUPERCONDUCTING SOLENOID PLATFORM I/O.

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

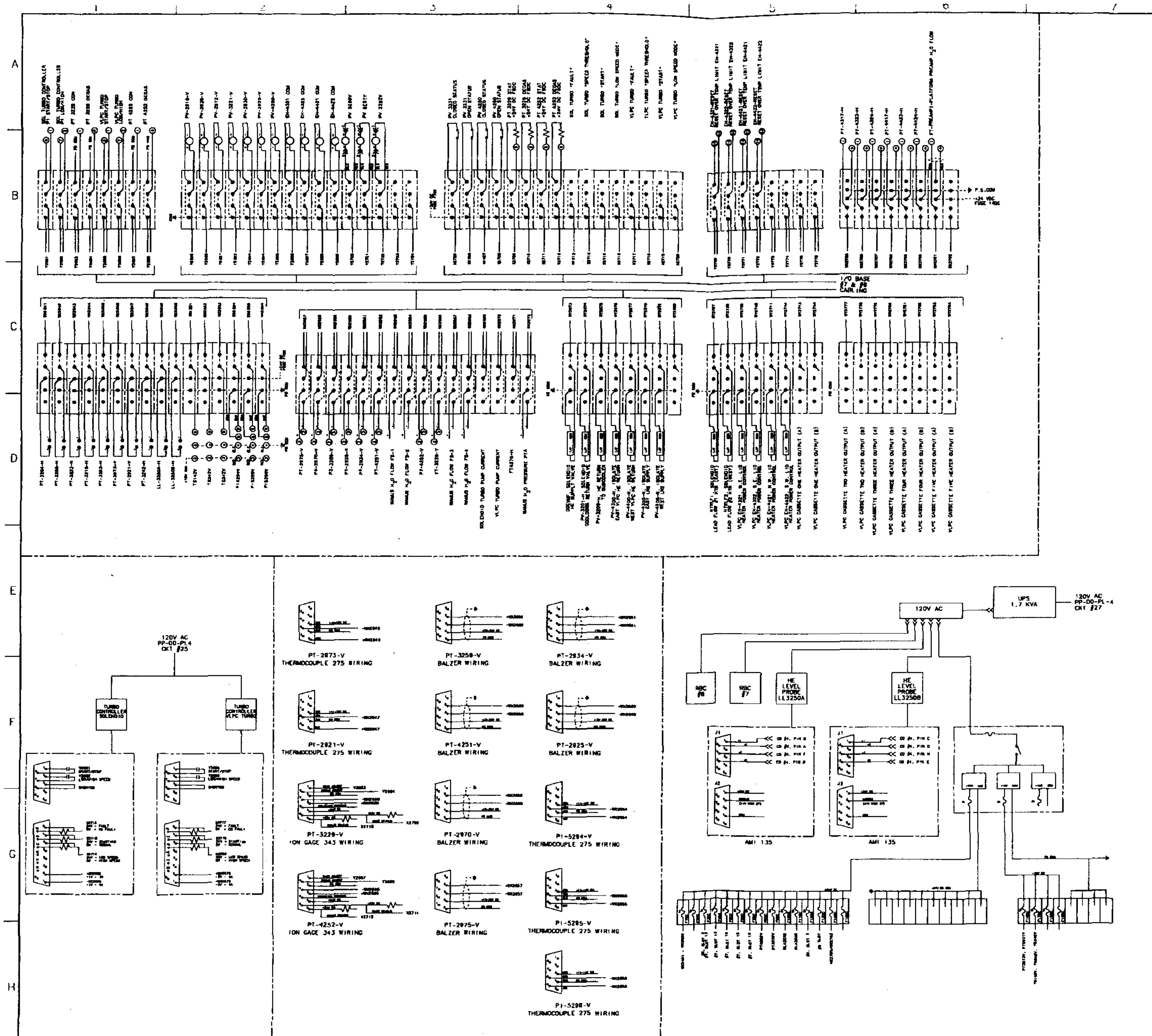
ORIGINATOR	B. MARKLEY 6/00
DRAWN	B. FRIEND 6/23/00

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

DZERO UPGRADE
CRYOGENIC CONTROL SYSTEM
I/O BASE #7, #8 & #10 WIRING DETAILS

SCALE	DRAWING NUMBER	SHEET NO.	REV.
NONE	3823.D00-EE-330328	1 OF 2	C

Plotted by mmleski on 07-Nov-2001 . File: 33032800 C.pff



REV.	DESCRIPTION	DRAWN / APPROVED	DATE
A	ADDED SILICON DETECTOR INSTRUMENTATION	S. POTTER	
		D. MARKLEY	
B	ADDED MORE SILICON DETECTOR INSTRUMENTATION.	MATESKI	
		S. MARKLEY	

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

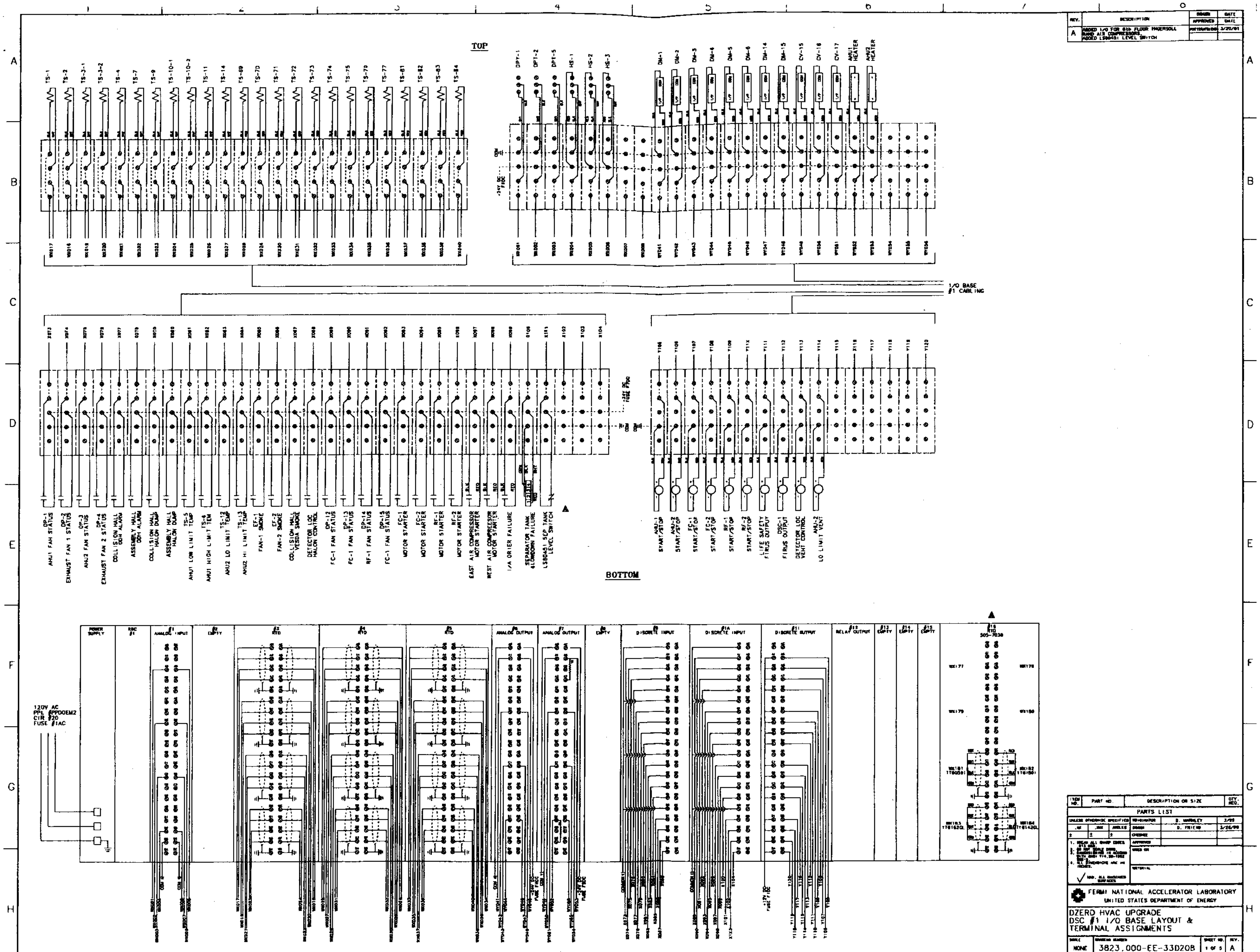
ORIGINATOR: D. MARKLEY
DRAWN: D. FRIEND

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

DZERO UPGRADE
CRYOGENIC CONTROL SYSTEM
I/O BASE #7 & #8 WIRING DETAILS

SCALE	DRAWING NUMBER	SHEET NO.	REV.
NONE	3823.000-EE-330328	2 OF 2	B

Plotted by mateski on 07-Nov-2001 . File: 330328D2 B.pff



Plotted by mmleski on 07-Nov-2001 , File: 33D208.pff