

4.2.13 Target Pile Air Cooling System

The purpose of the air cooling system is (1) to keep the pit floor and walls at approximately 12.8 °C, (2) to remove the following heat loads: beam heating - 158 kW, stripline - 2.4 kW, ambient - 3.4 kW, fan - 50 kW, (3) to dehumidify at a rate of 20 kilograms/hour at the 158 kW beam heating load, and (4) filter particulates from the airflow. The automatically controlled system is designed to provide 240 kW of cooling, and to circulate and filter 750 Nm³ of air per hour. The high efficiency particulate filters have a minimum removal efficiency of 99.97% with 0.3-micron size particles. The dehumidification rate is based on a leak exchange rate between the target hall and the target pile of 2.5% of the design airflow rate. The filters are installed in bag-in/bag-out housings.

The flow schematic is shown in **Figure 4.2-41 a & b**. It is discussed below, starting where the cooling airflow exits the target pile.

Temperature and humidity of the air exiting the target pile are monitored. Humidity of the target hall is also monitored.

Pressure drop across the particulate and high efficiency filter banks are individually monitored. High differential pressure across either bank will shutdown the fan. It is very important to change the filters at the specified pressure drops. In particular, the prefilter will come apart at high-pressure drops, and unload the particulates trapped in it. This will unnecessarily load the much more expensive high efficiency filters, most likely requiring that they be changed immediately.

The airflow is cooled after filtering. An automatically controlled air damper is installed in parallel with the evaporator coils. It will make moderate adjustments in the amount of air flowing to the evaporators to reduce the reheat duty. Air damper position can also be positioned manually. An electrically operated solenoid valve starts or stops the flow of high-pressure liquid refrigerant 22 to each evaporator coil based on the system heat load. Solenoid valve operation can be either automatic or manual. The full-open and full-closed state of each solenoid valve is monitored using limit switches. A self-operated, thermal expansion valve automatically controls flow of refrigerant 22 to each evaporator coil. Evaporator coil header pressure is used to automatically adjust condenser unit capacity to match the system heat load. Operating status of the condensing unit is monitored.

The single-speed fan boosts the airflow to operating pressure after cooling. Fan differential pressure is monitored. The particle beam will shutdown if fan differential pressure is too low. Fan inlet and outlet temperatures are monitored. The fan can be started and stopped in either the target hall or the power supply room.

The reheater heats the airflow to operating temperature when needed. Reheater operation can be either automatic or manual. The heating element is equipped with a high temperature switch to protect it from burning out. Temperature and humidity of the air entering the target pile are monitored. The particle beam will shutdown if supply air temperature to the target pile is high or low for too long.

Slow start, smart motor contactors energize the fan and refrigeration compressor motors. Each contactor will protect its motor from being damaged by current and voltage irregularities. Each motor winding has an internal high temperature switch that is included in the control logic to further protect the motor from damage.

A PLC, programmable logic controller, is used to automatically control the solenoid valves that start and stop high-pressure refrigerant flow to each evaporator coil. Control logic for the fan is hardwired. All monitoring instruments are wired to PLC input modules. The PLC transmits all monitored signals to Acnet via Ethernet. The signals will be displayed on Acnet parameter pages. Selected signals are included on alarm pages and on graphic displays.

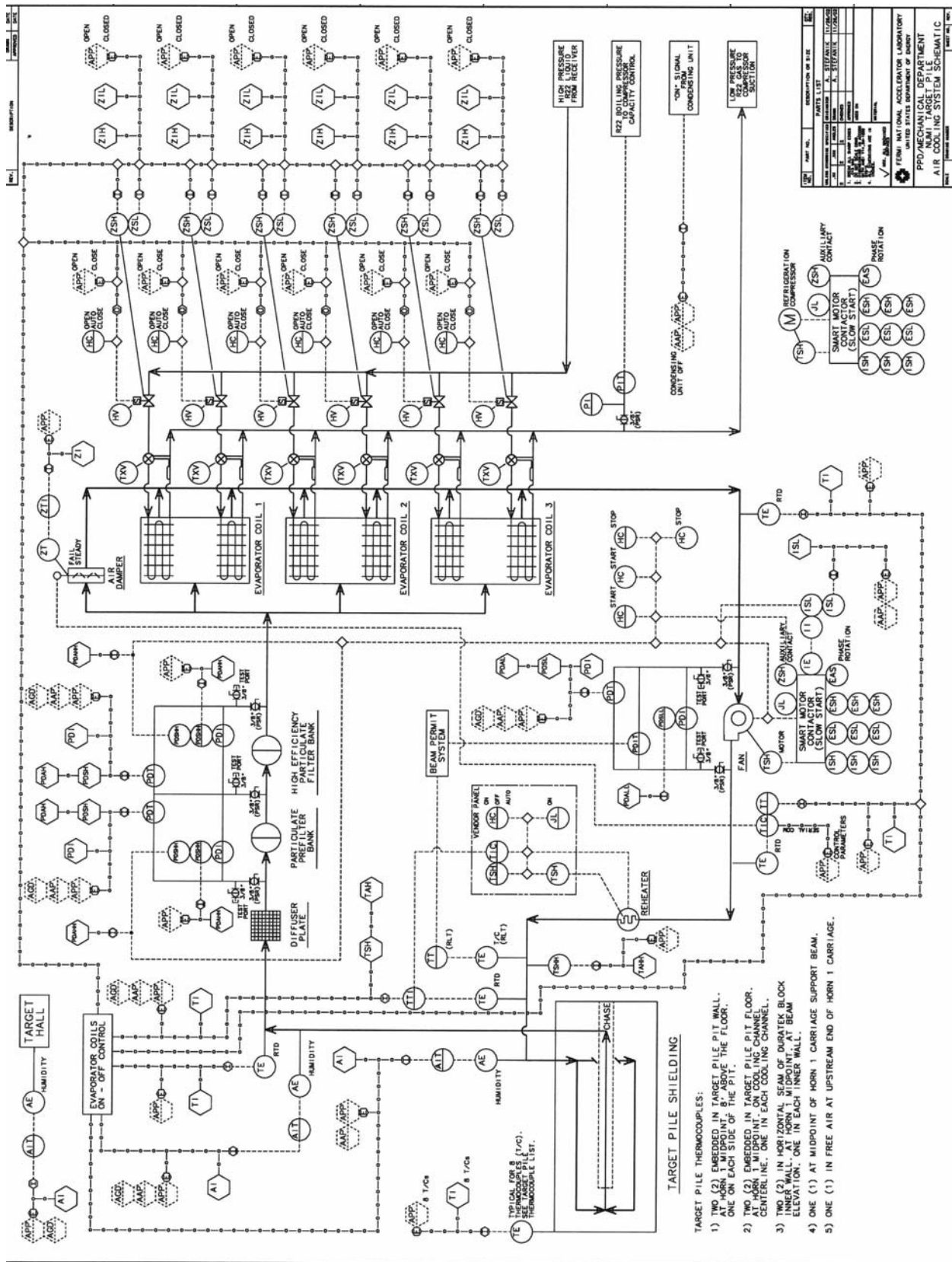
The instrument list is given in **Table 4.2-16.5a** and **Table 4.2-16.5b** .

BPS -> Beam Permit System; PSR -> Power Supply Room; PLC -> Programmable Logic Controller; WC -> Water Column										
TAG NO.	DESCRIPTION	LOCATION	UNITS	NORMAL OPERATING RANGE	NORMAL OPERATING VALUE	CALIBRATION RANGE	ACCURACY [+/-]	ANALOG SIGNAL	DISCRETE SIGNAL	MANUFACTURER
AE -	Analysis Element - Supply air relative humidity	Local	%	55 to 65	-	0 - 100				
AE -	Analysis Element - Return air relative humidity	Local	%	30 to 65	-	0 - 100				
AE -	Analysis Element - Target hall relative humidity	Local	%	50 to 100	-	0 - 100				
AIT -	Analysis Indicating Transmitter - Supply air relative humidity	PSR	%	55 to 65	-	0 - 100				
AIT -	Analysis Indicating Transmitter - Return air relative humidity	PSR	%	30 to 65	-	0 - 100				
AIT -	Analysis Indicating Transmitter - Target hall relative humidity	PSR	%	50 to 100	-	0 - 100				
HC -	Hand control, Open Auto Close - Evaporator #1 upper coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #1 lower coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #2 upper coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #2 lower coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #3 upper coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #3 lower coil	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Open Auto Close - Evaporator #4 upper coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Open Auto Close - Evaporator #4 lower coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Open Auto Close - Evaporator #2 upper coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Open Auto Close - Evaporator #2 lower coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Open Auto Close - Evaporator #3 upper coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Open Auto Close - Evaporator #3 lower coil	Acnet command to PLC	-	-	-	-	-	-	-	-
HC -	Hand control, Start - Fan	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Start - Fan	Local	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Stop - Fan	PSR	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, Stop - Fan	Local	-	-	-	-	-	-	0 to 110 VAC	
HC -	Hand control, On Off Auto - Reheater	PSR - Vendor panel	-	-	-	-	-	-	-	-
IE -	Current Element - Fan motor	Fan motor contactor	%	55 to 70	65	0 - 100		_ to _VDC	-	
ISL -	Current Switch Low - Fan motor (Fan "on" signal to software logic)	Fan motor contactor	%	0 - 100	25			-	0 to 24 VDC	
ISL -	Current Switch Low - Fan motor (Fan "on" signal to hardwired logic)	Fan motor contactor	%	0 - 100	25			-	0 to 24 VDC	
JL -	Power Light - Reheater on	PSR - Vendor panel	-	-	-	-	-	-	-	-
PDI -	Pressure Differential Indicator / Switch - Prefilter bank	PSR	inches WC	0.7 to 1.3	< 1.5	0 to 3	±2% FS	-	-	Dwyer
PDI -	Pressure Differential Indicator / Switch - High efficiency filter bank	PSR	inches WC	1.5 to 3	< 3	0 to 5	±2% FS	-	-	Dwyer
PDI -	Pressure Differential Indicator / Switch - Fan	PSR	inches WC	10 to 13	12	0 to 15	±2% FS	-	-	Dwyer
PDI -	Pressure Differential Transmitter - Fan	PSR	inches WC	10 to 13	12	0 to 20	1% FS	0 to 10 VDC	-	Orange Research
PDSHH -	Pressure Differential Switch High - Prefilter bank	PSR	inches WC	-	1.25	-	-	-	0 to 24 VDC	Dwyer
PDSHH -	Pressure Differential Switch High - High efficiency filter bank	PSR	inches WC	-	2.75	-	-	-	0 to 24 VDC	Dwyer
PDSHH -	Pressure Differential Switch High High - Prefilter bank	PSR	inches WC	-	1.5	-	-	-	0 to 24 VDC	Dwyer
PDSHH -	Pressure Differential Switch High High - High efficiency filter bank	PSR	inches WC	-	3	-	-	-	0 to 24 VDC	Dwyer
PDSLL -	Pressure Differential Switch Low Low - Fan	PSR	inches WC	-	8	-	-	-	0 to 24 VDC	Dwyer
PDT -	Pressure Differential Transmitter - Prefilter bank	PSR	inches WC	0.7 to 1.3	< 1.5	0 to 2.5	±0.25% FS	4 to 20 mA	-	Setra
PDT -	Pressure Differential Transmitter - High efficiency filter bank	PSR	inches WC	1.5 to 3	< 3	0 to 5	±0.25% FS	4 to 20 mA	-	Setra
PDT -	Pressure Differential Transmitter - Fan	PSR	inches WC	10 to 13	12	0 to 25	±0.25% FS	4 to 20 mA	-	Setra
PI -	Pressure Indicator - Evaporator coils	PSR	psig	58 to 69	61.75	0 to 100	±2% FS	-	-	Dwyer
PIT -	Pressure Transmitter - Evaporator coils	PSR	psig	58 to 69	61.75	0 to 100	±0.11% FS	4 to 20 mA	-	Setra
TE -	Temperature Element - Return air temperature from target pile	Local	°F	50 to 80	< 80	40 to 100	±0.5	-	-	Minco
TE -	Temperature Element - Supply air temperature to target pile	Local	°F	40 to 60	55	40 to 100	±0.5	-	-	Minco
TE -	Temperature Element - Fan inlet temperature	Local	°F	45 to 55	50	40 to 100	±0.5	-	-	Minco
TE -	Temperature Element - Fan discharge temperature	Local	°F	50 to 60	55	40 to 100	±0.5	-	-	Minco
TE -	Temperature Element - Target pile pit wall #1 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Target pile pit wall #2 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Target pile pit floor #1 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Target pile pit floor #2 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Durastak block inner wall #1 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Durastak block inner wall #2 @ hom 1 midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Hom 1 carriage support beam @ midpoint	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TE -	Temperature Element - Free air at upstream end of hom 1 carriage	Local	°F	50 to 60	55	40 to 100	±2	-	-	Omega
TIC -	Temperature Indicating Controller - Air damper	PSR	°F	50 to 60	55	40 to 100	-	4 to 20 mA	-	
TIC -	Temperature Indicating Controller - Reheater control	PSR - Vendor panel	°F	50 to 60	55	40 to 100	-	4 to 20 mA	-	
TSH -	Target pile supply air temperature high - Reheater control	PSR - Vendor panel	°F	50 to 65	65	-	-	-	-	
TSHH -	Heating element temperature high - Reheater control	PSR - Vendor panel	°F	-	-	-	-	-	-	
TSHH -	Target pile supply air temperature high high	Local	°F	50 to 70	70	-	-	-	0 to 24 VDC	
TT -	Temperature Transmitter - Fan discharge temperature	PSR	°F	50 to 60	55	40 to 100	-	4 to 20 mA	-	
TTI - -1	Temperature Transmitting Indicator - to PLC	PSR	°F	50 to 60	55	40 to 100	-	4 to 20 mA	-	
TTI - -2	Temperature Transmitting Indicator - to Reheater control	PSR	°F	50 to 60	55	40 to 100	-	4 to 20 mA	-	
ZSH -	Position Indicator - Fan contactor closed (auxiliary contact)	Motor contactor	-	-	-	-	-	-	0 to 110 VAC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSH -	Position Indicator - Solenoid valve HV-nnn open	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZSL -	Position Indicator - Solenoid valve HV-nnn closed	Local	-	-	-	-	-	-	0 to 24 VDC	
ZT -	Position Transmitter - Air damper	Local	%	-	-	0 to 100	-	4 to 20 mA	-	
ZTI -	Position Transmitting Indicator - Air damper	PSR	%	-	-	0 to 100	-	4 to 20 mA	-	
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-
Energize HV -	PLC logic output signal	PLC	-	-	-	-	-	-	0 to 110 VAC	-

Table 4.2-16.5a Air-cooling system instrument list – Part 1

TAG NO.	MODEL NUMBER	INSTRUMENT DESCRIPTION	CABLE	WIRED TO	PLC INPUT MODULES	PLC OUTPUT HARDWIRED TO	PLC OUTPUT MODULES	ACNET PARAMETER PAGE	ACNET GRAPHIC DISPLAY	ACNET ALARM SET POINT
AE-				AIT-	-	-	-	-	-	-
AE-				AIT-	-	-	-	-	-	-
AE-				AIT-	-	-	-	-	-	-
AIF-				PLC	AIM1 Ch 1	-	-	Yes	Yes	65
AIF-				PLC	AIM1 Ch 2	-	-	Yes	Yes	65
AIF-				PLC	AIM1 Ch 3	-	-	Yes	Yes	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
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HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
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HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				HV-	-	-	-	-	-	-
HC-				Fan motor contactor control circuit	-	-	-	-	-	-
HC-				Fan motor contactor control circuit	-	-	-	-	-	-
HC-				Fan motor contactor control circuit	-	-	-	-	-	-
HC-				Fan motor contactor control circuit	-	-	-	-	-	-
HC-				Vendor panel wiring	-	-	-	-	-	-
IE-				I-	-	-	-	-	-	-
ISL-	On II-			PLC	DMI1 Ch 1	-	-	Yes	-	-
ISL-	On II-			Fan motor contactor	-	-	-	-	-	-
JL-				Reheater vendor panel wiring	-	-	-	-	-	-
PDI-	Photohelic 3003MR	Differential pressure gauge with two switches	-	-	-	-	-	-	-	-
PDI-	Photohelic 3005MR	Differential pressure gauge with two switches	-	-	-	-	-	-	-	-
PDI-	Photohelic 3015MR	Differential pressure gauge with two switches	-	-	-	-	-	-	-	-
PDI-	20107 w/LCD Display	Beryllium copper diaphragm with inductive pickup	-	BPS	-	-	-	-	-	-
PDSSH-	On PDI-	Phototransistor actuated SPOT relay, 1.0 amp @30 vdc	-	PLC	DMI1 Ch 2	-	-	Yes	-	-
PDSSH-	On PDI-	Phototransistor actuated SPOT relay, 1.0 amp @30 vdc	-	PLC	DMI1 Ch 3	-	-	Yes	-	-
PDSSH-	On PDI-	Phototransistor actuated SPOT relay, 1.0 amp @30 vdc	-	PLC	DMI1 Ch 4	-	-	No	-	-
PDSSH-	On PDI-	Phototransistor actuated SPOT relay, 1.0 amp @30 vdc	-	PLC	DMI1 Ch 5	-	-	No	-	-
PDSSH-	On PDI-	Phototransistor actuated SPOT relay, 1.0 amp @30 vdc	-	PLC	DMI1 Ch 6	-	-	No	-	-
PDI-	C-264 Option 717	Variable capacitance	-	PLC	AMI Ch 4	-	-	Yes	Yes	1.25
PDI-	C-264 Option 717	Variable capacitance	-	PLC	AMI Ch 5	-	-	Yes	Yes	2.75
PDI-	C-264 Option 717	Variable capacitance	-	PLC	AMI Ch 6	-	-	Yes	Yes	8
PI-	Photohelic A3601DS	Pressure gauge with two switches	-	-	-	-	-	-	-	-
PIT-	C-204	Variable capacitance	-	Refrigerator compressor control	-	-	-	-	-	-
TE-	S457PEZ24	Bendable averaging RTD, 100 Ω at 0 °C	-	PLC	RTD IM1 Ch 1	-	-	Yes	No	-
TE-	S457PEZ12	Bendable averaging RTD, 100 Ω at 0 °C	-	TIC-	-	-	-	-	-	-
TE-	S457PEZ12	Bendable averaging RTD, 100 Ω at 0 °C	-	PLC	RTD IM1 Ch 2	-	-	Yes	No	-
TE-	S457PEZ12	Bendable averaging RTD, 100 Ω at 0 °C	-	TIC-	-	-	-	-	-	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 1	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 2	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 3	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 4	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 5	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 6	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 7	-	-	Yes	No	-
TE-		Omegaclad Type J - MgO insulation and metal sheath	-	PLC	TIC IM1 Ch 8	-	-	Yes	No	-
TIC-				Air damper positioner	-	-	-	-	-	-
TIC-				Reheater SCRs	-	-	-	-	-	-
TSH-				Reheater vendor panel wiring	-	-	-	-	-	-
TSHM-				Reheater vendor panel wiring	-	-	-	-	-	-
TSHM-				PLC	DMI1 Ch 7	-	-	Yes	-	-
TI-	On TIC-			PLC	AMI Ch 7	-	-	Yes	-	-
TI-	-1			PLC	AMI Ch 8	-	-	Yes	Yes	60
TI-	-2			Reheater vendor panel	-	-	-	-	-	-
ZSH-				Fan motor contactor control circuit	-	-	-	-	-	-
ZSH-				PLC	DMI1 Ch 8	-	-	Yes	-	-
ZSH-				PLC	DI2 Ch 1	-	-	Yes	-	-
ZSH-				PLC	DI2 Ch 2	-	-	Yes	-	-
ZSH-				PLC	DI2 Ch 3	-	-	Yes	-	-
ZSH-				PLC	DI2 Ch 4	-	-	Yes	-	-
ZSH-				PLC	DI2 Ch 5	-	-	Yes	-	-
ZSL-				PLC	DI2 Ch 6	-	-	Yes	-	-
ZSL-				PLC	DI2 Ch 7	-	-	Yes	-	-
ZSL-				PLC	DI2 Ch 8	-	-	Yes	-	-
ZSL-				PLC	DI3 Ch 1	-	-	Yes	-	-
ZSL-				PLC	DI3 Ch 2	-	-	Yes	-	-
ZSL-				PLC	DI3 Ch 3	-	-	Yes	-	-
ZTI-				ZTI-	-	-	-	-	-	-
ZTI-				PLC	DI3 Ch 4	-	-	Yes	-	-
Energize HV-				-	-	Solenoid valve to evap #1 upper coil	DOM1 Ch 1	-	-	-
Energize HV-				-	-	Solenoid valve to evap #1 lower coil	DOM1 Ch 2	-	-	-
Energize HV-				-	-	Solenoid valve to evap #2 upper coil	DOM1 Ch 3	-	-	-
Energize HV-				-	-	Solenoid valve to evap #2 lower coil	DOM1 Ch 4	-	-	-
Energize HV-				-	-	Solenoid valve to evap #3 upper coil	DOM1 Ch 5	-	-	-
Energize HV-				-	-	Solenoid valve to evap #3 lower coil	DOM1 Ch 6	-	-	-

Table 4.2-16.5b Air-cooling system instrument list – Part 2



PARTS LIST	
NO.	DESCRIPTION OR SIZE
1	...
...	...
...	...

FERMI NATIONAL ACCELERATOR LABORATORY
 PHYSICS DEPARTMENT
 N. 1000 UNIVERSITY AVENUE
 CHICAGO, ILLINOIS 60607
 AIR COOLING SYSTEM SCHEMATIC

Figure 4.2-41a: Air-cooling system flow schematic

LEGEND














	INSTRUMENT INSTALLED IN THE POWER SUPPLY ROOM
	LOCAL INSTRUMENT
	SOFTWARE FUNCTION ACCESSIBLE TO OPERATOR
	SOFTWARE FUNCTION NOT ACCESSIBLE TO OPERATOR
	ACNET PARAMETER PAGE
	ACNET ALARM PAGE
	ACNET GRAPHIC DISPLAY
	PLC INPUT
	PLC OUTPUT
	ETHERNET
	ELECTRICAL INSTRUMENTATION SIGNAL (mA OR VDC)
	PLC SOFTWARE LINK
	CONTROL INTERLOCK
T/C	THERMOCOUPLE
RTD	RESISTANCE TEMPERATURE DETECTOR

Figure 4.2-41b: Legend for Air-cooling system flow schematic