

Operational Readiness Clearance for roots pumps in NM4

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1 Description

The system to be tested is a vacuum pump system for the E1039 experiment. The roots vacuum pumps are used to create a vacuum over the target helium volume which lowers the temperature of that volume to approximately 1K. The system consists of four large vacuum pumps connected in series, which are connected via a support manifold. The system will eventually be used to cause the liquid helium in a test chamber to reach a low enough vapor pressure such that the temperature of the helium, and thus the chamber, reach one degree Kelvin. The system was designed, manufactured, and purchased from Oerlikon Leybold Vacuum Inc.

1.1 Scope:

For the purposes of this document, the roots vacuum system extends from a large bore, pneumatic gate valve near the target cryostat, through the pump stack with the helium exhaust to the liquefaction system. A schematic of this system is shown in Figure 2. During normal operation, the roots system will pump 25 S.L.P.M. of helium boil off from the target at a pressure of 10^{-2} psi and exhaust this helium to the liquefaction plant at a pressure of 1.7 psi. The volume under vacuum described here is about $29 ft^3$.

The pumping assembly in NM4 consists of 3 roots booster pumps, RUVAC WH 7000 and 1 backing pump, Sogavak SV630. The RUVAC WH are Roots Boosters driven by water cooled hermetically sealed motors. The assembled pumpstack is $4' \times 10'$ in area and about 15' high and the total weight of the assembly is 2000 kg. This document contains information regarding the operational readiness of the pump stack.



Figure 1: Image of Root Pump Stack installed at NM4

2 Specifications of the pumps and instrumentation

There are two types of pumps in this pump stack, roots pumps and backing pump. Attached with this document are technical specification tables for the roots pumps and the rotary vane(backing) pump.

2.1 Roots pumps: Oerlikon RUVAC WH7000

These are the three roots booster pumps. These are manufactured by Oerlikon Leybold, the ones we use are model named: RUVAC WH7000. They operate at electrical power of 480V @ 34A. Following table outlines the technical specifications of the roots pumps as per the manual provided by the manufacturer.

Technical specifications for the RUVAC WH7000 and Sogavac SV630 are found in the accompanying documentation

2.2 Sogavac SV 630

Electrical power of the rotary vane pump: 1x 480V @ 29A The maximum pressure of the cooling water should be 6 bar. The pump must only be operated between 10 and 40C. Do not operate RUVAC WH pumps in connection with backing pumps where an ultimate pressure exceeding 10 bar is specified. This will prevent excessively high temperatures when the RUVAC is running idle.

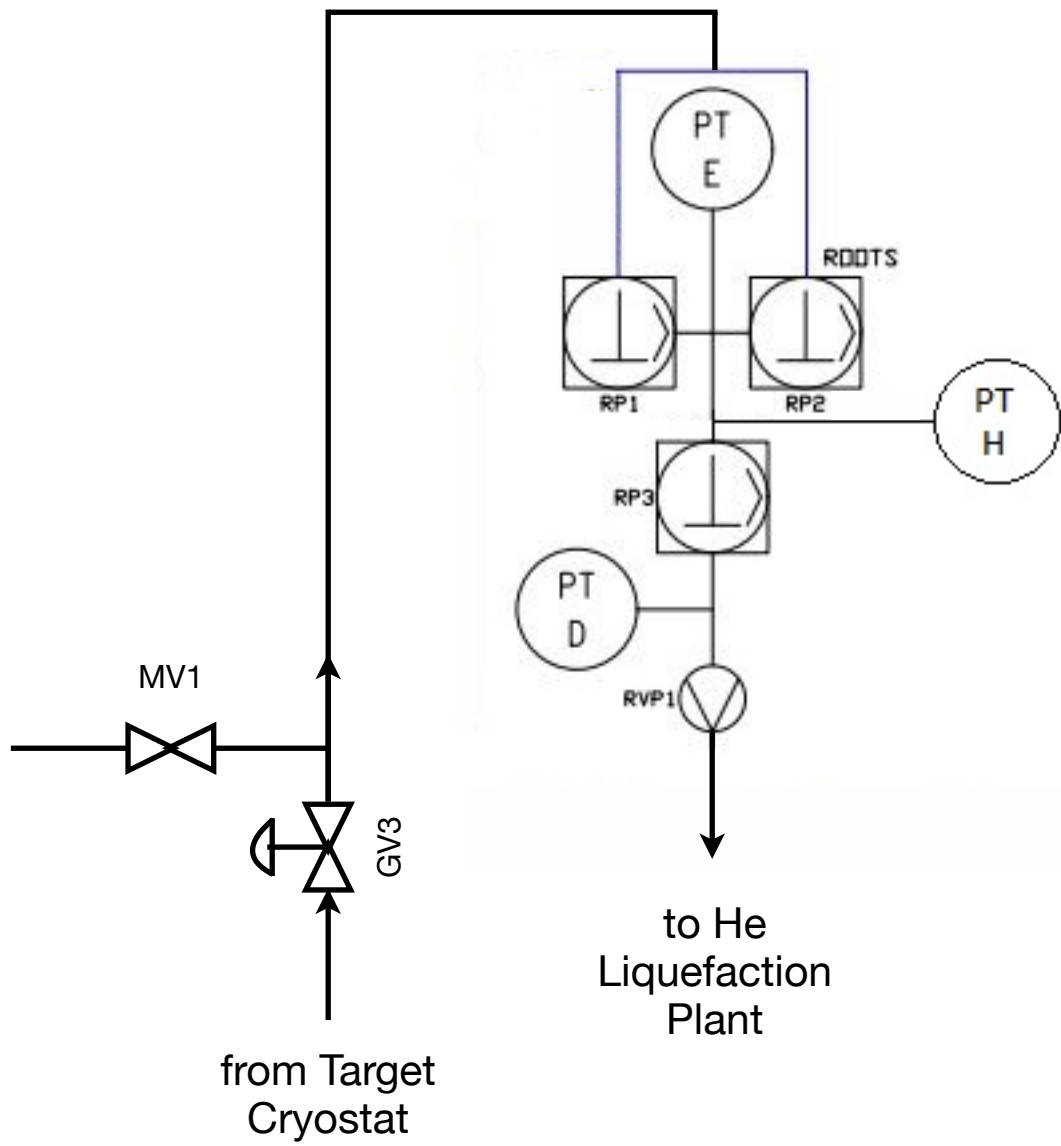


Figure 2: PID for root pump stack

2.3 Vacuum Volume

We used schedule 40 12" stainless steel(SS 304L) pipe held together with ISO K flanges and claw clamps for much of the run to the target. Bellows connect various sections of the pipe to allow for some motion between section of the vacuum pipe.

The valves used in the plumbing includes the large, pneumatic gate valve (GV-1) and the small manual valve (MV-3). The gate valve is manufactured by MDC and the model number is: LGV-10000V- P01(technical specifications can be found in the manual that is attached with the document). The manual valve is a Stainless steel Pfeiffer manual ball valve, DN 40 ISO-KF, 120VKZ040, attached is the manual for technical specification.

The support structure for the roots stack was designed and assembled by the pumps manufacturer Oerlekon Leybold for this installation.

3 Electrical Systems and Pump Control

The roots and rotary vane pumps draw their 3 phase 480V power from electrical panel (PHP-NM4-1) through a control cabinet. A wiring diagram for the AC power is presented in Figure 4.

3.1 AC

480 VAC and 200 amp, power source: PHP-NM4-1, wire size: AWG- , fuse or circuit breaker size. The 480V power is provided in the building from panel PHP-NM4-1(circuit number). 5 conductor 3 phase. The AC frequency is 60 Hz The panel for the 24DC sensors consists of connections for the following:

3.2 Sensor cable dimensions

3.3 DC:24 VDC Instrument spec sheets

The following sensors and transducers are part of the DC wiring system:

- DI 2000 vacuum transducer
- Kobold PSR 5115 flow switch
- M4 Oil Temp switch
- M4 Oil Level switch
- intempco MS25 Sanitary temp sensor
- M4 Anti suckback valve
- Ceravac transmitter CTR-100
- vacuum transducer: oerlikon DI2000

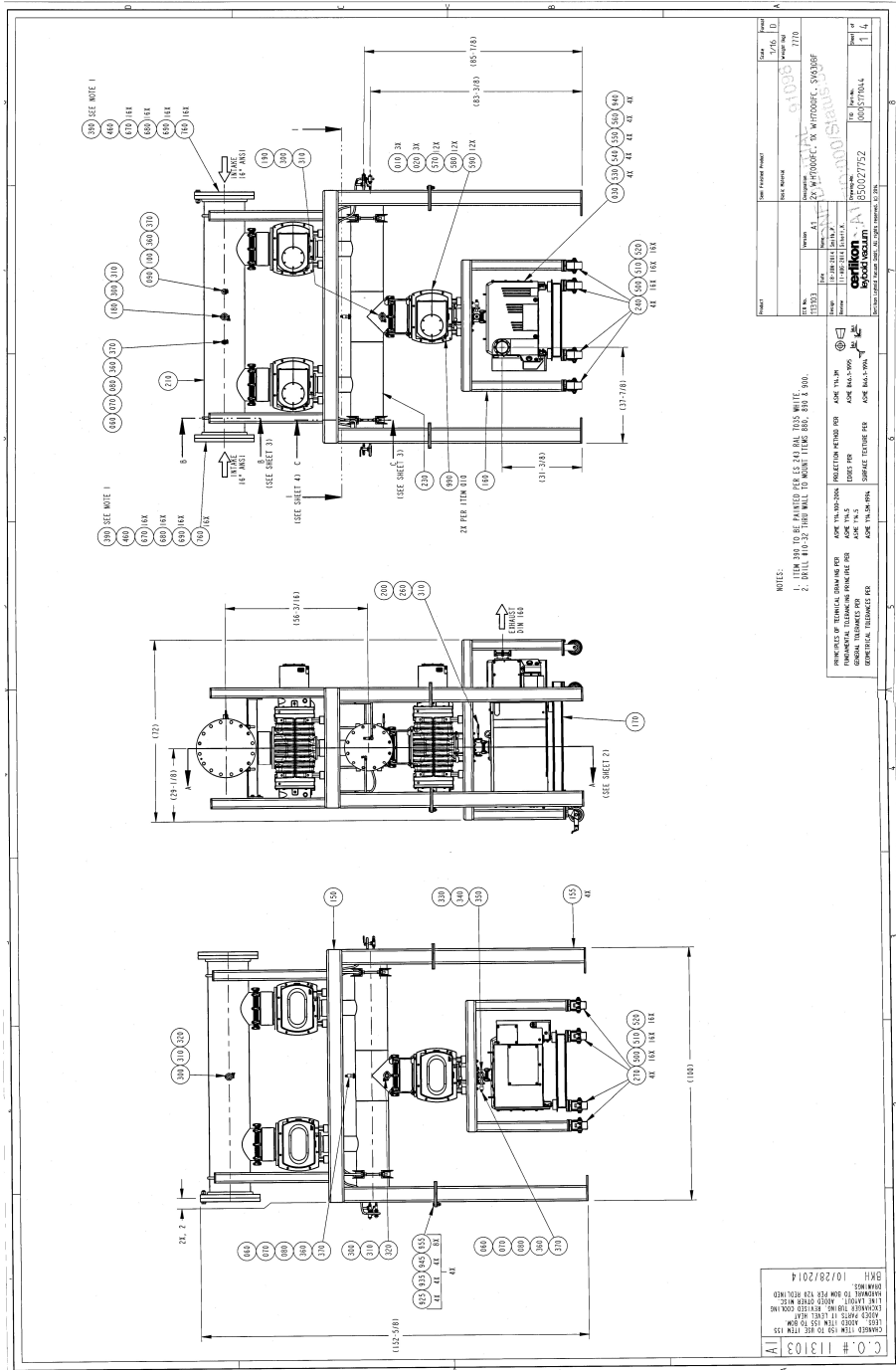


Figure 3: Pump stack dimensions

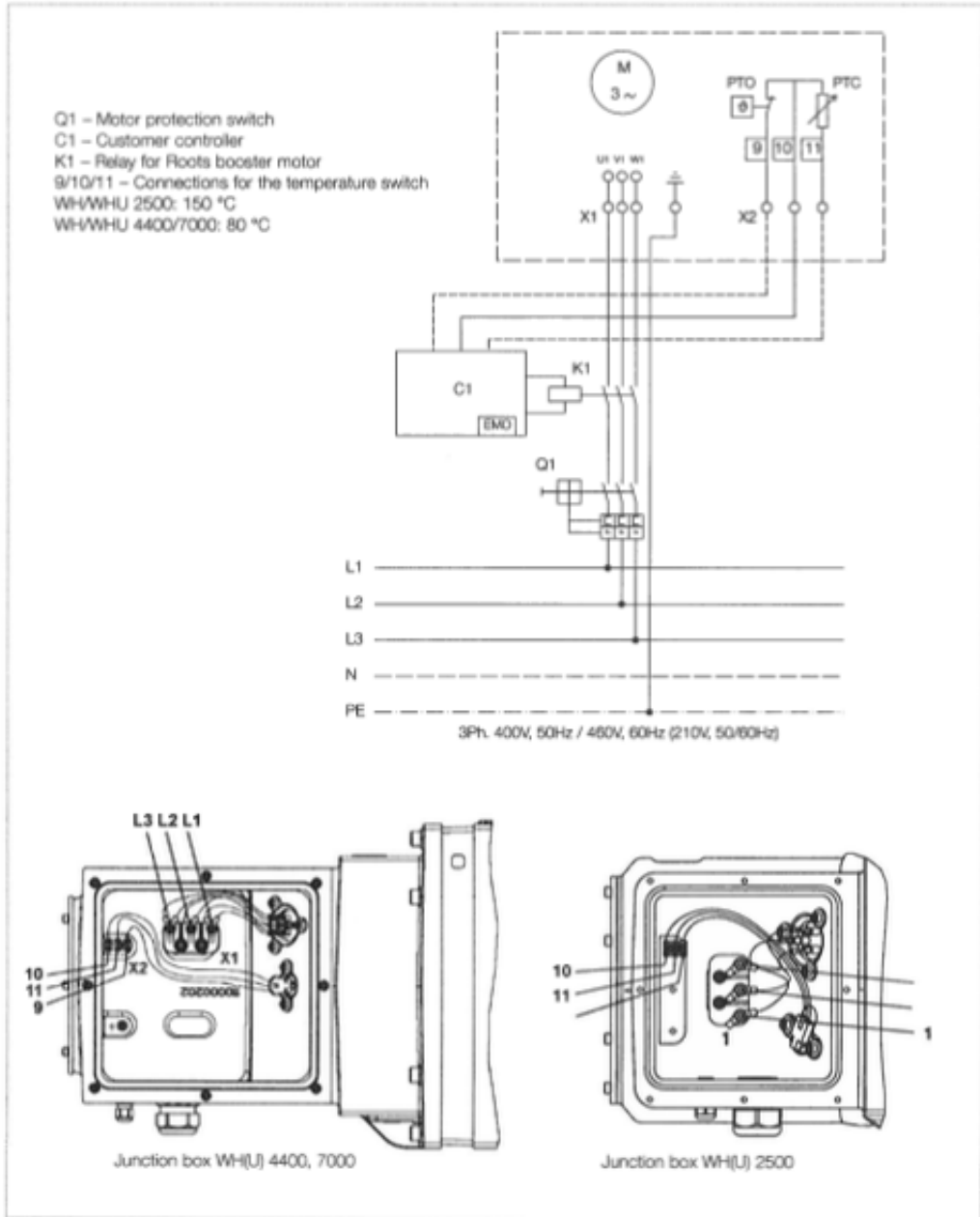


Fig. 3.8 Electrical connections for WH(U) 4400, 7000 and WH(U) 2500 without frequency converter

Figure 4: Wiring diagram for AC power supply to the roots

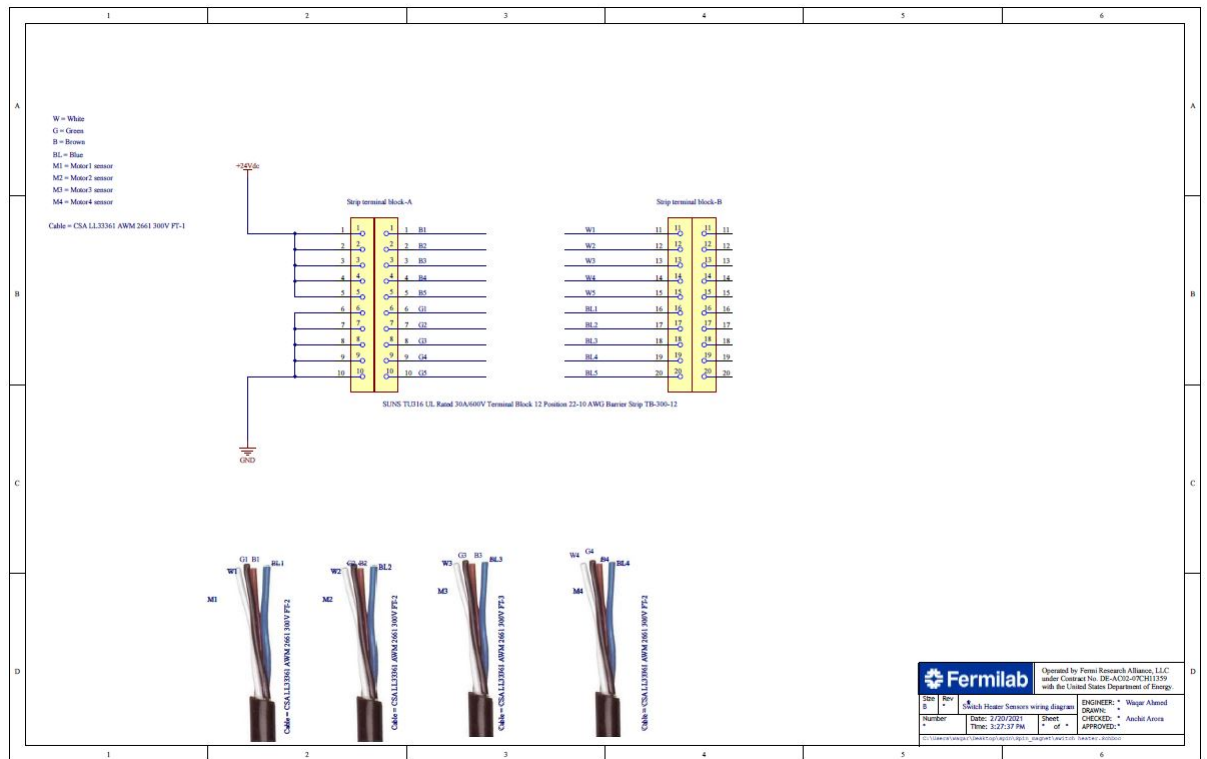


Figure 5: Switch heater wiring diagram

Roots Water Cooling P&ID

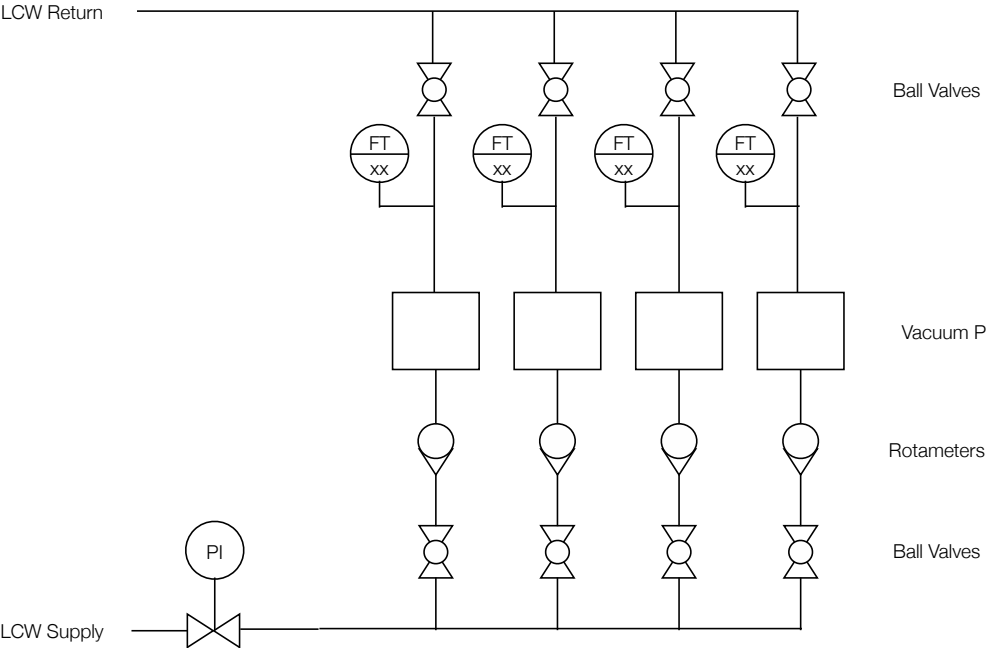


Figure 6: Low conductivity water PID



Figure 7: 24 VDC feedthrough panel

3.3.1 Wire Specification

The specification of wires connecting different sensors on the root pump stack to the 24 VDC panel is as follows:

- Wire gauge: 18 AWG
- Standard: AWM(Appliance wire material) 2661 22/4
- Make: INTEM PCO
- 4 conductor wire
- M2 micro female controller PT-100
- Untwisted pair cable

4 Piping and instrumentation diagram

Piping and instrumentation diagram indicating nominal flows and pressures for the water system is shown in figure 6 . The hose used for the connections is: 3/4" inner diameter polyurethane hose supply/return lines (only up to the water supply/return connections).

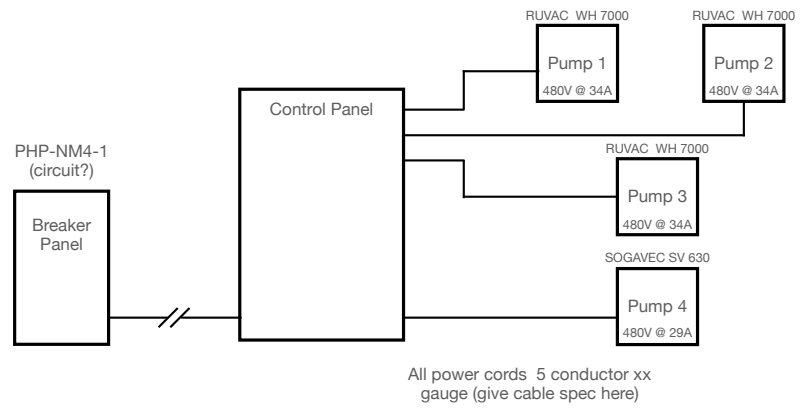


Figure 8: Roots AC Wiring Diagram

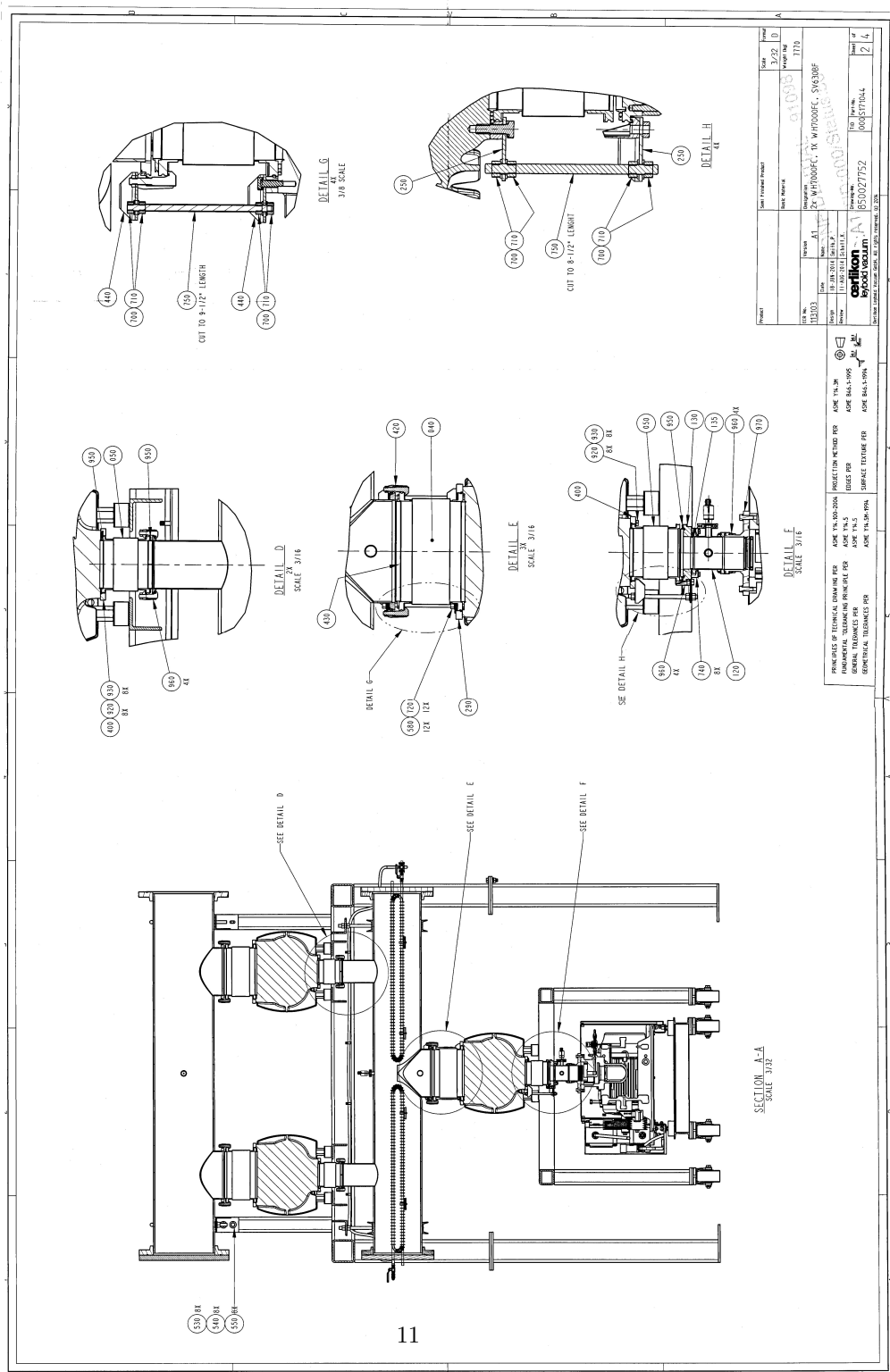


Figure 9: Schematic of the pumps stack

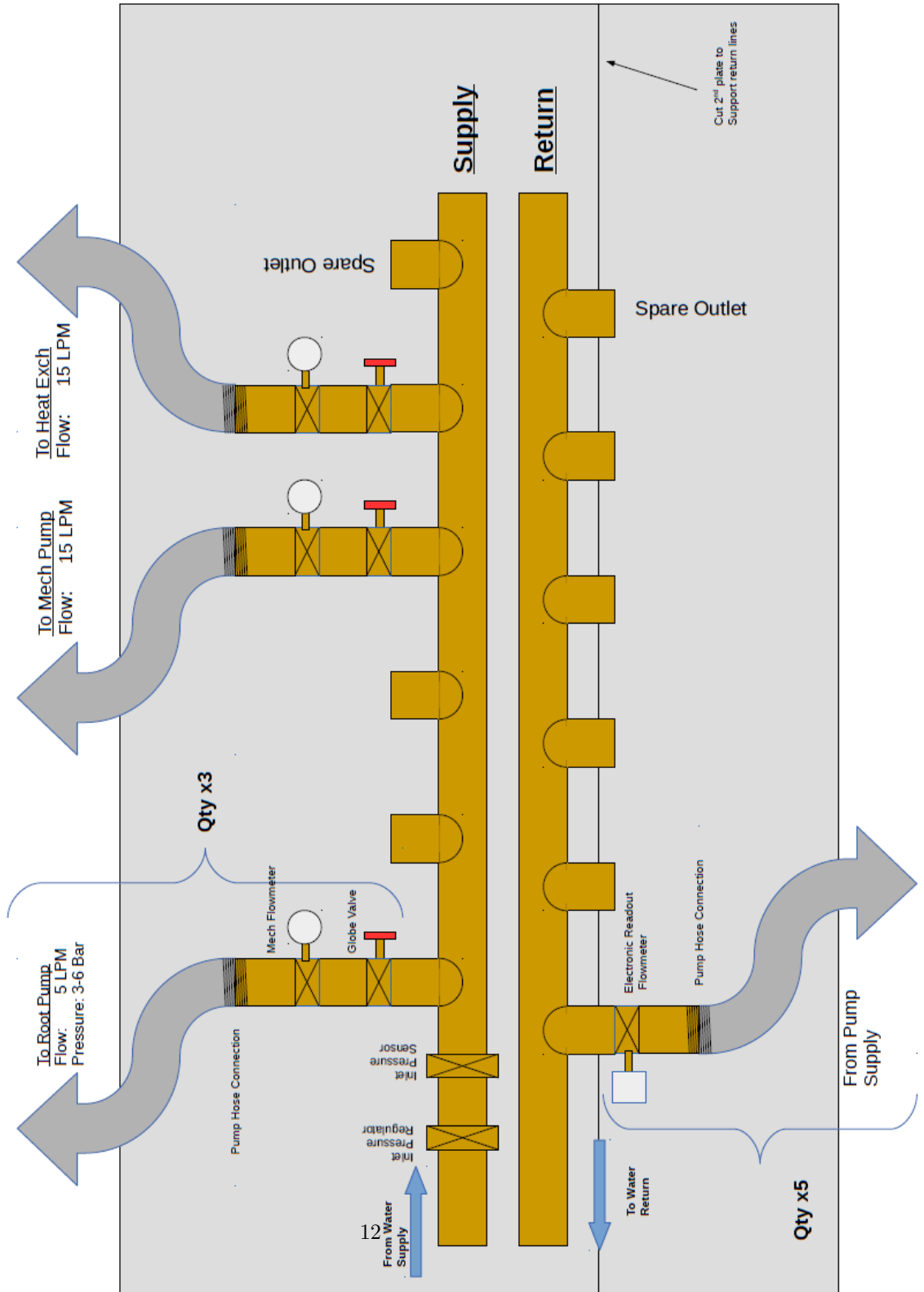


Figure 10: Water flow in and out of the pumps



Figure 11: Electrical control panel for roots power supply

Full Scale (FS) / Measurement range	1 Torr / 1×10^{-4} - 1 Torr	10 Torr / 1×10^{-3} - 10 Torr 100 Torr / 0.01 - 100 Torr 1000 Torr / 0.1 - 1000 Torr Pressure Units: 1 Torr = 1.33 mbar = 133 Pascal
Materials exposed to gases	ceramic (Al_2O_3), stainless steel 316, Vacon 70	ceramic (Al_2O_3), stainless steel 316, Vacon 70
Max. overrange pressure	2000 Torr for 1/10/100 Torr sensors, 3000 Torr for 1000 Torr sensors	2000 Torr for 1/10/100 Torr sensors, 3000 Torr for 1000 Torr sensors
Measurement uncertainty	0.2% of reading \pm temperature effect	0.2% of reading \pm temperature effect
Resolution	0.003% of FS for 0.1/1 Torr sensors	0.003% of FS for 10/100/1000 Torr sensors
Temperature effects		
Zero coefficient	%/ $^{\circ}C$	0.015 of Full scale
Span coefficient	%/ $^{\circ}C$	0.01 of reading
Response time	ms	≤ 30
Nominal temperatur range	$^{\circ}C$	+5 to +50
Supply voltage	V DC	+14 to +30
Power consumption	W	≤ 1
Signal Output	V	0 - 10; linear
Interface		0.26 (0.57)
Weight approx.	kg (lbs)	RS 232 C
Dead Volume	cm ³	6
Connection cable	see section "Connection Cable for active Sensors"	see section "Connection Cable for active Sensors"
Calibration	see section "Miscellaneous", para. "Oerikon Leybold Vacuum Calibration Service"	see section "Miscellaneous", para. "Oerikon Leybold Vacuum Calibration Service"

Figure 12: Ceravac Transmitter technical data

Piping and instrumentation diagram for the vacuum system is presented in SeaQuest-Doc-5834. SeaQuest-Doc-5834 contains the PID for the cryogenic system.

Water supply and return lines at 70psi and 4gpm are also needed. E1039 480V Vacuum Pump System 3 The second step is to provide power to the system. The system requires a 480VAC, 200 Amp power supply. Power is fed into an electrical box provided by the manufacturer. 480VAC lines will go from the electrical box to the four vacuum pumps to supply power to each individual pump. 24VDC Feedthrough panel wires exit the electrical box to various readout sensors on the system.

4.1 Pressure sensor

Ceravac CTR 100 used for absolute pressure measurement for gases. Pressure measurement is independent of the gas type. The aluminium oxide ceramics diaphragm of the CERAVAC sensors is capable of returning precisely to its initial position with respect to a certain pressure so that the measurements will be highly reproducible. Since the diaphragm is not impaired by overpressures or frequent pressure changes, no blocking valves will be required.

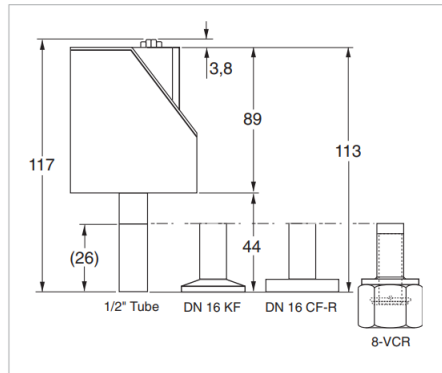


Figure 13: Ceravac CTR100 dimensions

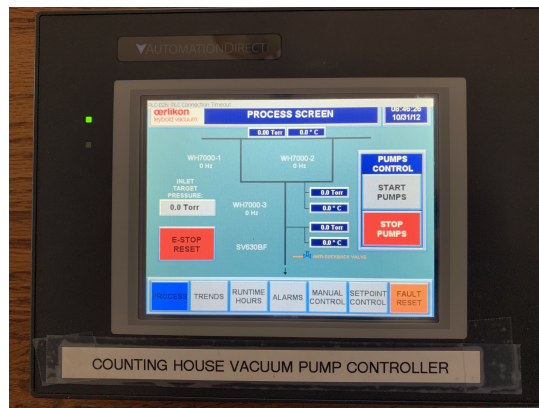


Figure 14: Counting house vacuum pump controller

4.2 Counting House Vacuum Pump Controller

Make: Automation Direct Surrounding Air temperature: 50 C Input :12-24V
 Max. 16W Class2 for use in pollution degree 2 environment communication:
 Ethernet/USB/RS485

4.3 Vacuum Transducer

The vacuum transducer is

4.4 Paddle type Flow switch

Model: Kobold PSMaterial: brass
 Maximum pressure: 1450PSIG
 Media Temperature

Measuring principle	piezo-resistive
Measuring range	2000 - 1 mbar (1500 - 1 Torr)
Max. overload	5 bar abs.
Uncertainty	0.25 % FS (linearity, hysteresis, reproducibility)
Reproducibility	0.05 % FS
TC* Zero	0.1 % FS/10K
TC* Sensitivity	0.15 % FS/10K
Materials in contact with media	stainl. steel 1.4305, Al ₂ O ₃ ceramic, FPM (DI2000, DU2000), EPDM (DI2001, DU2001)
Operating temperature	0 ... +60 °C
Storage temperature	-40...+70 °C
Response time	< 20 ms
Voltage supply	DI: 12 – 30 VDC (two-wire) DU: 14,5 - 30 VDC (four-wire)
Electrical connection	DI: 5m cable with diode plug, 7pin, male DU: 5m cable with plug type FCC68, 8pin
Output signal	DI: 4 - 20 mA, linear max. load in Ω : (supply voltage – 12V) / 0.02A DU: 2 - 10 VDC, linear
Dead volume	1.8 cm ³
Vacuum connection	small flange DN16 ISO KF with G1/4 female thread
Protection class	IP 54
Weight	DI: 260 g DU: 240 g

* Temperature coefficient

Figure 15: Vacuum Transducer technical data

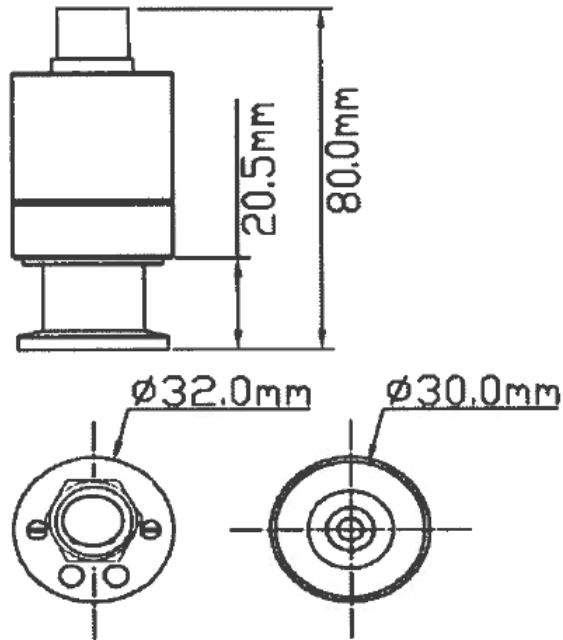


Figure 16: cross-section of vacuum transducer

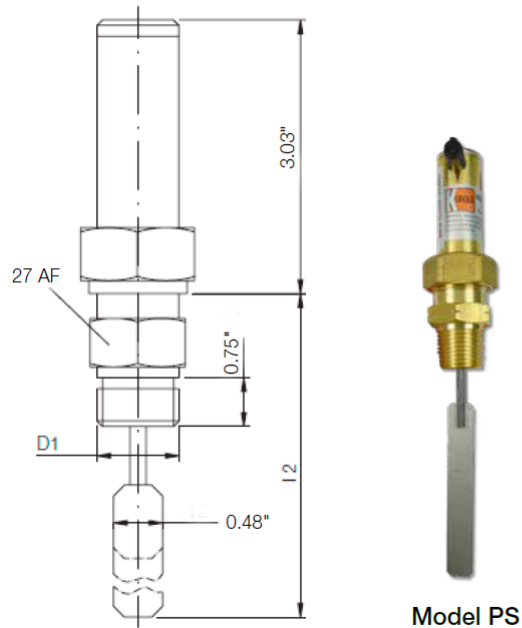


Figure 17: Flow switch

Max. Pressure

1-1/4" ... 1-1/2" = 360 PSIG

SS: 1/4" ... 1" = 3600 PSIG

1-1/4" ... 1-1/2" = 580 PSIG

Ingress Protection: IP 65

Mounting Orientation: Horizontal Flow Preferred

Max Flow Rate: 5x Switching Range, Increasing

Maximum Contact Ratings (cCSAus):

SPST Contact: 2A, 20 VAC, 0.18 A, 230 VAC, max. 40 W

SPDT Contact: 0.13 A, 150 VAC, 0.5 A, 40 VAC, max. 20 W

Cable: PVC Jacketed

Cable Length: Standard: 5 Ft. (1.5m), Optional (SPST only): 10, 15 or 21 Ft.

480VAC power has already been supplied to the electrical box at LANL, and approved by LANL electrical safety personnel. However, only the 24VDC readouts were tested at the LANL facility. FNAL electrical safety personnel will be needed to guide the 480VAC power supply connections in the NM4 area.

The system is controlled via an LED touch screen on the front of the electrical box, shown in Fig. 16. This panel is made by automation direct and the manual for the same is attached with this document. Electrical power: Roots: 3x 480V @ 34A Rotary Vane pump: 1x 480V @ 29A

Water Cooling: 3 liters/min @ 5 C to 35 C
Water supplied by FNAL low conductivity water system.

Hazard ID Checklist

Flammables (Gases or Liquids)		Gases		Hazardous Chemicals		Other Hazardous /Toxic Materials	
Type:		Type:			Cyanide plating materials	List any other hazardous/toxic materials planned for use:	
Flow rate:		Flow rate:			Hydrofluoric Acid		
Capacity:		Capacity:			Methane		
Radioactive Sources		Metals of Concern			photographic developers		
	Permanent Installation		Beryllium (Be)		PolyChlorinated Biphenyls (PCBs)		
	Temporary Use		Lithium (Li)		Scintillation Oil		
Type:			Mercury (Hg)		Triethylamine (TEA)		
Strength:			Lead (Pb)		Tri-Methylamino Ethyl (TMAE)		
Nuclear Materials*			Tungsten (W)		Other: (Activated Water?)		
Name:			Uranium (U)				
Weight:			Other:	Lasers			
Mechanical Structures		Electrical Equipment			Permanent installation		
	Lifting Devices		Cryo/Electrical devices		Temporary installation		
	Motion Controllers		Capacitor Banks		Alignment		
	Scaffolding/ Elevated Platforms		High Voltage/High Amperage		Calibration		
	Other:		Exposed Equipment over 50 V	Type:			
			Non-commercial/Non-PREP	Wattage:			
			Modified Commercial/PREP	MFR Class:			
Vacuum Vessels		Pressure Vessels		Cryogenics			
Inside Diameter:		Inside Diameter:			Inert cryogenic liquids		
Operating Pressure:		Operating Pressure:			Hydrogen cryo liquids		
Window Material:		Window Material:			Other cryo liquids		
Window Thickness:		Window Thickness:					

Figure 19: Hazard ID checklist