Operation-Readiness Clearance of the Magnet Rack for the SpinQuest Experiment at NM4

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Abstract

The SpinQuest experiment at NM4 requires superconducting magnet and the cryogenic system to polarize the target. The superconducting magnet is powered by Oxford-Instrument MercuryIPS that sit on the magnet rack. The magnet rack also houses several readout instruments from various sensors. This document describes all instruments in the magnet rack including the power requirement, cables and connections.

This document consist of five sections. The first section provides the introduction, scope and purposes of the document. The second section gives the layout and general description of the system. The third section provides the information for each instrument. Section four provides the summary of the power consumption. The cable connection to the target cave, Root pump and the communication cable connections are described in section five.

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1 Introduction, scope and purposes of the document

The polarized target is one of the critical system in the SpinQuest experiment at NM4. Many electronic instruments are required to polarize, maintain and measure the degree of polarization of the target. Those instruments are organized in several electronic racks: Magnet rack, NMR racks and slow control or target rack. Figure 1 shows the location of these racks, Root pumps and the target cave.

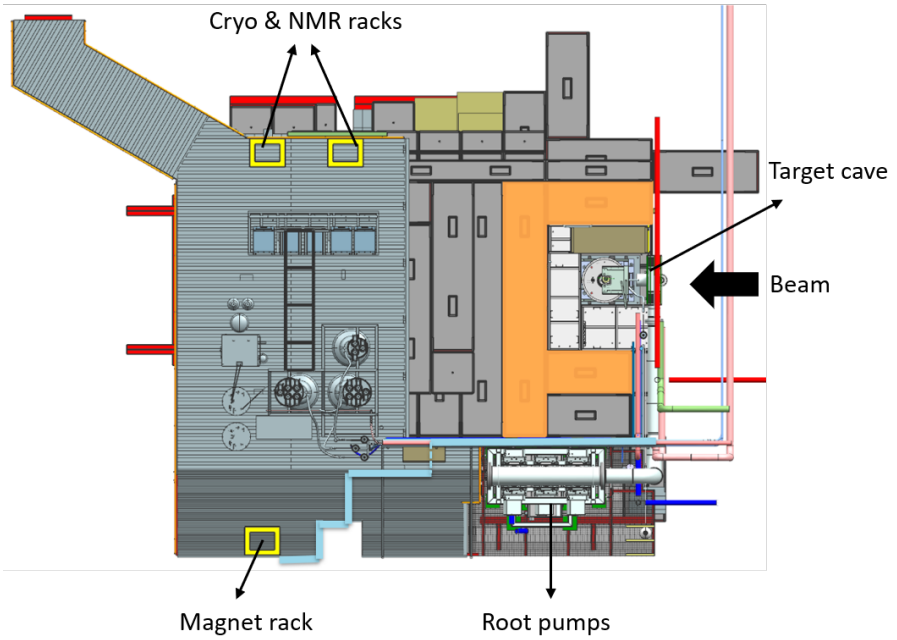

Figure 1: Top view of the cryo platform showing the location of the magnet rack, NMR rack, cryo or target (slow control) rack, root pumps and target cave.

This ORC document only provides the description of the magnet rack which include the layout, description for each instrument, power consumption and cable installation to the target cave. The NMR racks, target rack and other subsystem of the polarized target are described in separate documents.

There are 10 instruments that will be placed in the magnet rack. Some of the instruments are connected to the target and magnet dewar that is located in the target cave. Other instruments are connected to some sensors in the root pumps. The purpose of this document are:

1. To obtain permission to turn on the instruments for testing prior to the experiment.

2. To obtain permission to install the cables from the magnet rack to the target cave and root-pumps area.

3. To obtain permission to turn on all instruments during the experiment.

2 Layout and General Description of the System

The layout of the magnet-rack system is shown in figure 2 and 3. Some of the instruments require single-phase 208 VAC input. The power will be drawn from the 3-phase 208 VAC wall outlet. There is a power distribution unit (PDU) inside the rack which pick 1-phase 208 VAC from the 3-phase source. The instruments that sit on the magnet rack are

1. Power supply for the superconducting magnet. The superconducting magnet will be energized by Oxford-Instrument MercuryIPS. The power supply includes one master unit, and one slave unit, each of which are capable of providing up to 40 A of current, or 80 A in parallel. The master has a touch screen and allows control of the magnet current from this front panel, while the slave listens for commands from the master and has no way to control it directly.

2. Superconducting shim power supply. The Oxford instrument shim power supply model 2411 is designed for energizing superconducting shim coils. The supply deliver a maximum current of 20 A. In addition to the main magnet switch heater, a matrix of up to 10 superconducting switches can be addressed, so ten superconducting shim coils can be set to different currents.

3. Cryogenic environment controller. The Oxford instrument MercuryITC is a controller and read out sensors that measure the liquid Helium and liquid Nitrogen level.

4. Intelligent temperature monitor. The Oxford instrument ITM10 is a read-out device for the temperature sensors located on the superconducting coils.

5. Pressure sensor controller. Pfeiffer Vacuum MaxiGauge is a multi channel (6 port) of the pressure-sensor controller. The pressure sensors are located on the root pump.

6. Bench power supply. BK Precision 1550 is a bench power supply used to power a water flow sensor located on the root pump.

7. RS232-Ethernet converter. PK70EX-232CR is a multi port RS232 to Ethernet converter device. It take the input of the RS232 serial data from the Maxigauge, MercuryIPS, MercuryITC and ITM10 and convert them to Ethernet data.

8. USB-Ethernet converter. SILEX DS-510 is a multi port USB to Ethernet converter device. This device take the input from the shim power supply.

9. 208 VAC Power distribution unit. AC-power strip (PDU) Trip Lite PDU1230 will be used to power the MercuryIPS, ISS10, MercuryITC and ITM10. This power-distribution unit connect to 208 VAC wall outlet via a PDU which pick a single phase from the 3-phase source (see the layout of this PDU in figure 2)

10. 120 VAC Power distribution unit. AC-power strip (PDU) Cyclades PM10-L30A will be used to power The Maxigauge, BK Precision 1550, 12V PK70EX-232CR and SILEX DS-510. This power-distribution unit connect to 120 VAC wall outlet.

These instruments are described in detail in the next chapter.

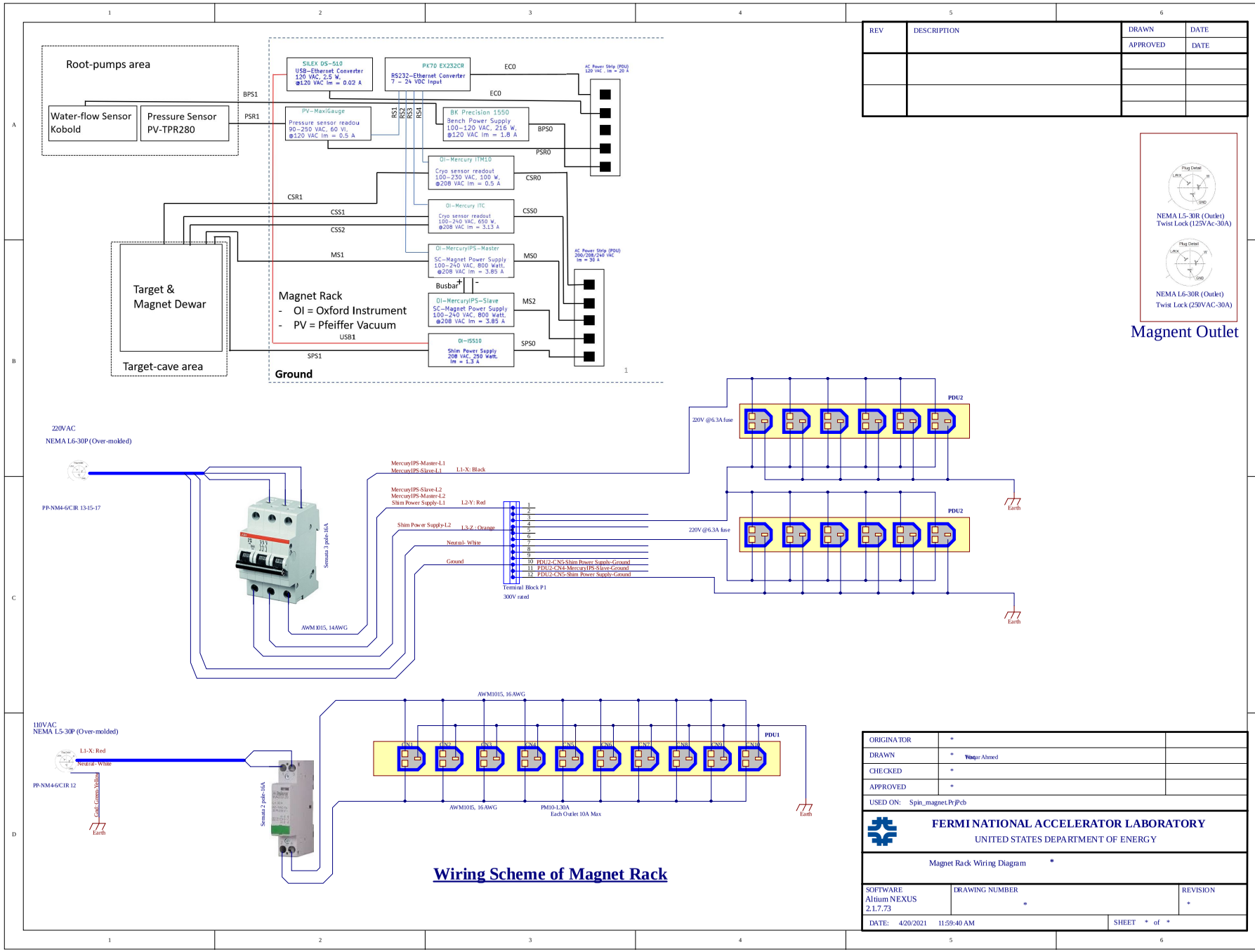

Figure 2: The layout and wiring scheme of the magnet-rack system.

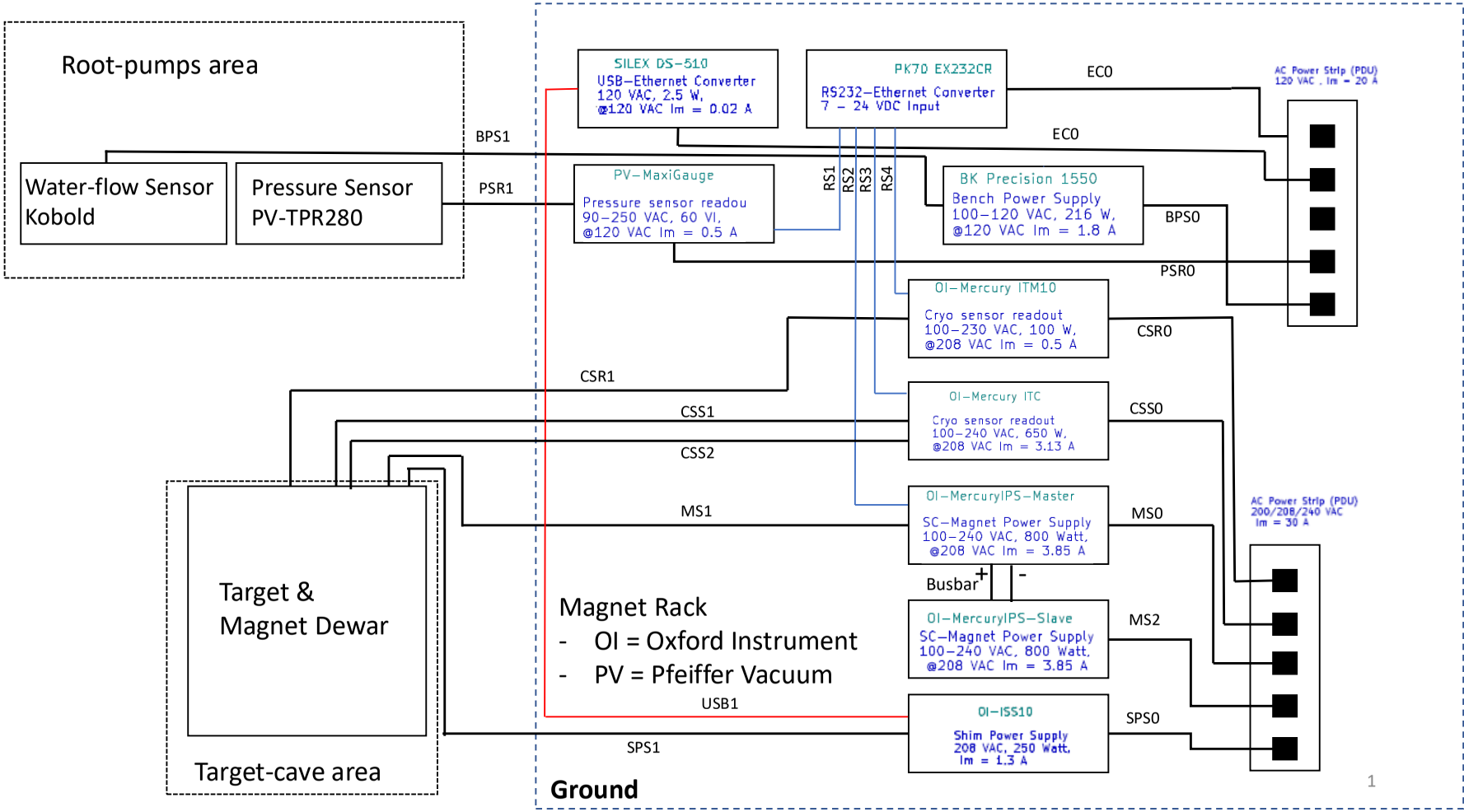

Figure 3: The layout and instruments housed in the magnet rack.

Cable	Description
EC0, PSR0,BPS0,SPS0, CSR0, CSS0, MS0, MS2	AC power cord
PSR1	Factory made sensor cable (Pfeiffer Vacuum, catalog number PT448252- T)
BPS1	AWG 18-gauge wire
MS1	Factory-made power cable (Eland cable: BS 638:PART 4 H.O.F.R 85 DEG.C 25 MM2 ELAND)
CSS1	Helium probe sensor cable (Oxford Inst. : 7-2-4C P46339 CNC6700 HE) with extension of AWM 2464 cable
CSS2	Nitrogen probe sensor cable (Oxford Inst. : 7-2-4C IEC60332.1 CNC6600 N2) with extension of AWM 2464 cable
USB1	USB cable
RS1,RS2, RS3, RS4	RS232 Cable

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Table 1: Description of the cables code shown in figure 3

3 Instruments

This section describes the instrument functionality, power requirements, cable and connections.

3.1 Power Supply for the Superconducting Magnet

Figure 4: MercuryIPS from Oxford Instrument.

- **factory:** Oxford Instrument.
- **Model:** MercuryIPS (Master and Slave).
- **Function:** Energize the superconducting magnet.
- **Power requirement:** 100-240 VAC, 800 Watt. At 208 VAC Maximum current is 3.85 A for both master and slave.
- **Cable and connections:** The MercuryIPS power the superconducting magnet via twisted pair and heavy gauge superconducting magnet power cables. The positive and negative terminals of the master and slave are connected via metal busbar. The master and slave also connected by the provided DB-9 female to male cable, which goes from the DB-9 'out' port on the master to the DB-9 'in' port on the slave. The master should then be connected via the DB-27 RS232 cable to the RS232-Ethernet converter (PK70EX-232CR). Both master and slave are powered from the AC power strip Trip Lite PDU1230.
- **Descriptions:** The master and slave units are capable of providing up to 40 A of DC current.

3.2 Cryogenic Environment Controller

- **factory:** Oxford Instrument.
- **Model:** MercuryITC.

Figure 5: MercuryITC from Oxford Instrument

- **Function:** Controller and read out of the liquid Helium and Nitrogen level sensors.
- **Power requirement:** 100-240 VAC, 650 Watt. At 208 VAC Maximum current is 3.13 A.
- **Cable and connections:** The MercuryITC connect the liquid helium level sensor via DB9 to 9 pin circular pin and the liquid nitrogen level via DB9 to 3 pin circular connection. The RS232 cable connects MercuryITC to RS232-Ethernet converter (PK70EX-232CR). The device are powered from the AC power strip Trip Lite PDU1230.

3.3 Superconducting shim power supply

Figure 6: 10-channels shim power supply from Oxford Instrument.

- **factory:** Oxford Instrument.
- **Model:** 2411.
- **Function:** power the superconducting shim coils.
- **Power requirement:** 208 VAC, 250 Watt. At 208 VAC Maximum current = 1.3 A.
- **Cable and connections:** The 10-channels shim power supply connect the shim coils via a factory-made power cable. The USB cable transport the serial data to USB-Ethernet converter (SILEX DS-510). The device are powered from the AC power strip Trip Lite PDU1230.

- **Descriptions:** The power supply deliver a maximum DC current of 20 A.

3.4 Intelligent Temperature Monitor

Figure 7: Intelligent temperature monitor (ITM10) from Oxford Instrument.

- **factory:** Oxford Instrument.
- **Model:** ITM10.
- **Function:** Read out the temperature sensor on the superconducting coils.
- **Power requirement:** 115-230 VAC, 100 Watt. At 208 VAC Maximum current is 0.5 A.
- **Cable and connections:** The ITM10 connect the temperature sensor via DB50 to 9 pin circular. The RS232 cable transport the serial data to RS232-Ethernet converter (PK70EX-232CR). The device are powered from the AC power strip Trip Lite PDU1230.

3.5 Pressure Sensor Controller

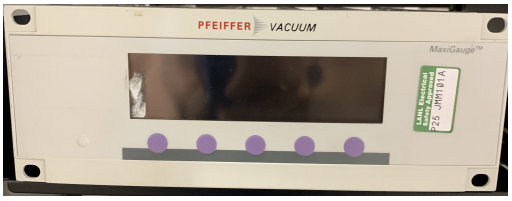

Figure 8: Multi channels Maxigauge pressure sensor read out from Pfeiffer Vacuum.

- **factory:** Pfeiffer Vacuum.
- **Model:** Maxigauge.
- **Function:** Read out the pressure sensor on the root pump.
- **Power requirement:** 90-250 VAC, 60 VA. At 120 VAC Maximum current is 0.5 A.

- **Cable and connections:** The Maxigauge connect the pressure sensor via factory made sensor cables. The RS232 cable transport the serial data to RS232-Ethernet converter (PK70EX-232CR). The device are powered from the AC power strip Cyclades PM10-L30A.

3.6 Bench Power Supply

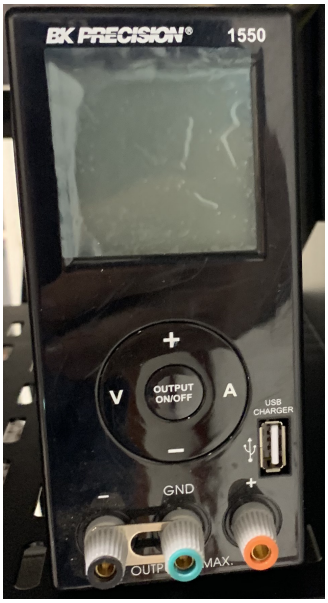

Figure 9: BK Precision 1550 power supply

- **factory:** BK Precision.
- **Model:** BK Precision 1550.
- **Function:** Provide DC supply to water flow sensor (Kobold) on root pump.
- **Power requirement:** 100-120 VAC, 216 Watt. At 120 VAC, maximum current of 1.8 A.
- **Cable and connections:** The supply power the water flow sensor via 12-AWG wire. The device are powered from the AC power strip Trip Lite PDUMH20.
- **Descriptions:** The power supply provide the output DC current of 0-3 A at adjustable voltage of 1-36 Volt DC.

Figure 10: RS232 to Ethernet converter from NetBurner PK70EX-232CR.

3.7 RS232-Ethernet Converter

- **factory:** NetBurner.
- **Model:** PK70EX-232CR.
- **Function:** NetBurner PK70EX-232CR is a multi ports RS232 to Ethernet converter.
- **Power requirement:** NetBurner PK70EX-232CR require 120 VAC input, with the maximum power of 6.03 Watt and maximum current of 0.19 A.
- **Cable and connections:** NetBurner PK70EX-232CR input RS232 cables from the Maxigauge, MercuryIPS, MercuryITC and ITM10 and output TCP/IP data via Ethernet cable to the control room. The device is powered from the AC power strip Cyclades PM10-L30A.

3.8 USB-Ethernet Converter

Figure 11: RS232 to Ethernet converter from SILEX.

- **factory:** SILEX.
- **Model:** SILEX DS-510.
- **Function:** SILEX DS-510 is a double ports USB to Ethernet converter.
- **Power requirement:** 120 VAC, 10 Watt. Maximum current is 0.4 A.
- **Cable and connections:** SILEX DS-510 input USB cables from the Shim power supply and output TCP/IP data via Ethernet cable to the control room. The device are powered from the AC power strip Cyclades PM10-L30A.

3.9 AC-Power Strip (PDU) Trip Lite PDU1230

Figure 12: AC-Powes Strip Trip Lite PDU1230.

- **factory:** Trip Lite.
- **Model:** Trip Lite PDU1230.
- **Function:** Single-phase power distribution unit.
- **Input voltage and current:** 208 VAC, Maximum input current of 30 A (agency de-rated to 24 A).
- **Total outlets:** 20.
- **Output voltage and Capacity:** 208 VAC with capacity of 5kW.
- **Overload protection:** Several 10 A and 15 A breakers.

3.10 AC-Power Strip (PDU) Cyclades PM10-L30A

Figure 13: AC-Powes Strip Cyclades PM10-L30A.

- **factory:** Emerson Electric Co.
- **Model:** Cyclades PM10-L30A.
- **Function:** Single-phase power distribution unit.
- **Input voltage and current:** 100-125 VAC, Maximum of 30 A (agency de-rated to 24 A).
- **Total outlets:** 10.
- **Output voltage and Capacity:** 100-125 VAC.
- **Overload protection:** 2 × 15 A circuit breakers.

4 Power Consumption Summary

The instruments described in previous section are powered from the 208 VAC wall outlet or 120 VAC wall outlet. Table 2 and 3 provide the summary of the power consumption and maximum current for all instruments.

Device	Power Consumption (W)	Maximum Current (A)
MercuryIPS – Master	800	3.85
MercuryIPS – Slave	800	3.85
Shim Power Supply	250	1.3
MercuryITC	650	3.13
ITM10	100	0.5
Total	**2.6 kW**	**12.63 A**

Table 2: List of instruments powered from the 208 VAC wall outlet.

Device	Power Consumption (W)	Maximum Current (A)
PV-MaxiGauge	60	0.5
BK Precession 1550	216	1.8
NetBurner PK70EX-232CR	6.03	0.19
SILEX-DS150	10	0.4
Total	**292.03**	**2.89**

Table 3: List of instruments powered from the 120 VAC wall outlet.

5 Cable Connection and Installation

5.1 Cable Connection to the Target Cave

There are four instruments in the magnet rack that connect to the magnet and sensors inside the magnet dewar which is located in target cave. Table 4 summaries the connections from instruments in the magnet rack to magnet dewar in the target cave.

Instrument	Cable & Connection	Diameter (Inch)
MercuryIPS – Master	Twisted pair and heavy gauge superconducting magnet power cables	1
ITM10	DB50 to 9 Pin circular sensor cable	0.6
Shim Power Supply	Shim-coils power cable (factory made)	1
MercuryITC	DB9 to 9 Pin circular sensor cable DB9 to 3 Pin circular sensor cable	0.3 0.3

Table 4: List of cables connecting instruments in the magnet rack to the target cave.

5.2 Cable Connection to the Root Pump

There are two instruments in the magnet rack that connect to the sensors on the root pump: MaxiGauge and BK Precision 1550. MaxiGauge connect to pressure sensors on root pump via factory-made sensor cables. The BK Precision 1550 provide power supply to water-flow sensor (Kobold) via 12-AWG wire. Both cables are installed using cable tray or flexible conduit at above minimum height requirement from FNAL (7 ft).

5.3 Communication cables and other connections

The instruments are remote-controlled from the counting house via serial communication. Most of the instruments transport the data via RS232 or USB cables which need to be converted to TCP/IP data using RS232/USB to Ethernet converter. Table 5 shows the summary of the communication cables and other connections.

Instrument	Communication cables or Other connections	Notes
MercuryIPS – Master	DB25 to DB9 (0.125 inch)	Connect to NetBurner PK70EX-232CR
	DB9 to DB9 (0.25 inch)	Connect to MercuryIPS Slave
	Flat metal busbar	Connect to MercuryIPS Slave
ITM10	DB50 to DB9 (0.125 inch)	Connect to NetBurner PK70EX-232CR
Shim Power Supply	USB cables (1/16 inch)	Connect to SILEX DS-510
MercuryITC	DB25 to DB9 (0.125 inch)	Connect to NetBurner PK70EX-232CR
MaxiGauge	DB9 to DB9 (0.25 inch)	Connect to NetBurner PK70EX-232CR

Table 5: List of communication cables and other connection in the magnet rack.