Cryogenic Environmental Process Instrumentation for New Beam Tube #9 (BT-9) Cold Source at the Center for Neutron Research (NCNR)

Navneet Gill

08-03-2011
Expansion of Cold Neutron Facilities

Five-year plan funded by America Competes Act
~$100 M

5 new guides, at least 6 instruments

New guide hall nearly doubles space

MACS* moved to BT-9 to make room for new guides.
*Multi-Axis Crystal Spectrometer
A Second LH$_2$ Source is Needed for MACS

- Liquid H$_2$ allows neutrons to scatter and come to a lower temperature
- Original cold source has 32 cm OD major axis and 24 cm OD minor axis, 5 L volume, 2-3 cm thick
- “Peewee” has an 11 cm ID, and a 0.5 L volume, 4.5 cm thick.
The condenser is located outside the reactor, 2 meters above the source.
Installation of the Cryostat Assembly in the BT-9 Beam Port

- LH₂ Vessel
- Shutter Cavity
- Thermal Shield Collar
- CO₂ Seal
Peewee has been designed to create a simple thermo siphon that should result in mostly liquid hydrogen in the moderator vessel.
Cold Neutron Source (CNS)

- Cold LH₂ moderator at 20K must be used to lower the neutron energies.
- Neutron wavelengths become longer.
- BT-9 Peewee CNS being installed for the MACS instrument.
- 5 new guides being installed for the guide hall expansion.
Thermal neutrons in the reactor are in the 20-400 meV energy range.

Neutrons have to be slowed down to acquire longer wavelengths.

- Thermal Neutrons: 25 meV and 1.2 Å
- Cold Neutrons: 5 meV and 4 Å
SURF Project

- Measuring and automating control of environmental variables in a cryogenic environment

- Successfully configuring and programming Programmable Logic Controller (PLC) system and the software

- Installation of a PLC processor and create a functional ladder logic program for vacuum and temperature data acquisition at the BT-9 cold neutron source at the NIST reactor

- Human Machine Interface Display for the operation/control by operator
D$_2$O Temperature: 310-320K
Helium Pressure: 120-130 kPa
Vacuum: ≤ 10$^{-6}$ Torr
Liquid H$_2$: 20.4 K at 1 atm
Automation and Control System

- Sensor (silicon diode, vacuum gauge, etc) generates an electrical signal that is sent to an input module
- The signal is processed by the control unit and an output is sent and any required actions are performed
The silicon diode was connected to a transmitter which operates in a 0-325K range by generating a signal that is 0-10V.

Accuracy of the DT670 diode is ±12 mK at low temperatures.
Vacuum Gauge Technology

- Pirani Gauge with a tungsten wire filament. Higher pressure means that more molecules colliding with the wire and thus lowering the wire temperature.
- Wire temperature directly linked to the resistance of the wire and thus generates an electrical signal.
- Can measure down to $5 \times 10^{-6}$ Torr ± 30%
- Need for vacuum (no transfer of heat through molecular motion, no motion of molecules) $>10^{-8}$ Torr at about 20K
Vacuum gauges were drifting in the helium environment, Potting necessary to reduce affect of the helium environment
Sylgard 170 Silicone elastomer helps in protecting against environmental attack.
Different modules were used depending on the type of application.

Applications varied between both analog and digital signals

Analog was used for temperature and vacuum measurement

Digital electronics were used to toggle bits between 0 and 1 to control a solenoid valve
PLC Rack Example
$$(((N143:4*10)|4095)*1.667)-11.46$$

$$p = 10^{1.667}V - d$$

$$10^{**F29:37}$$
Ladder Logic Addressing

- Each of the addresses in the PLC program has a specific bit that changes in value between 0 and 1 for digital signals and others values for analog signals.
Thanks to the Sponsors!

- The Center for High Resolution Neutron Scattering National Science Foundation program allowed for the grants that sponsored the SURF program.
Thanks to Mike Middleton, Cold Source Reactor Engineering, and SURF Directors for all the help!
Questions?