NIST Center for Neutron Research

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

Navneet Gill

CHRNS Center for High Resolution Neutron Scattering NIST

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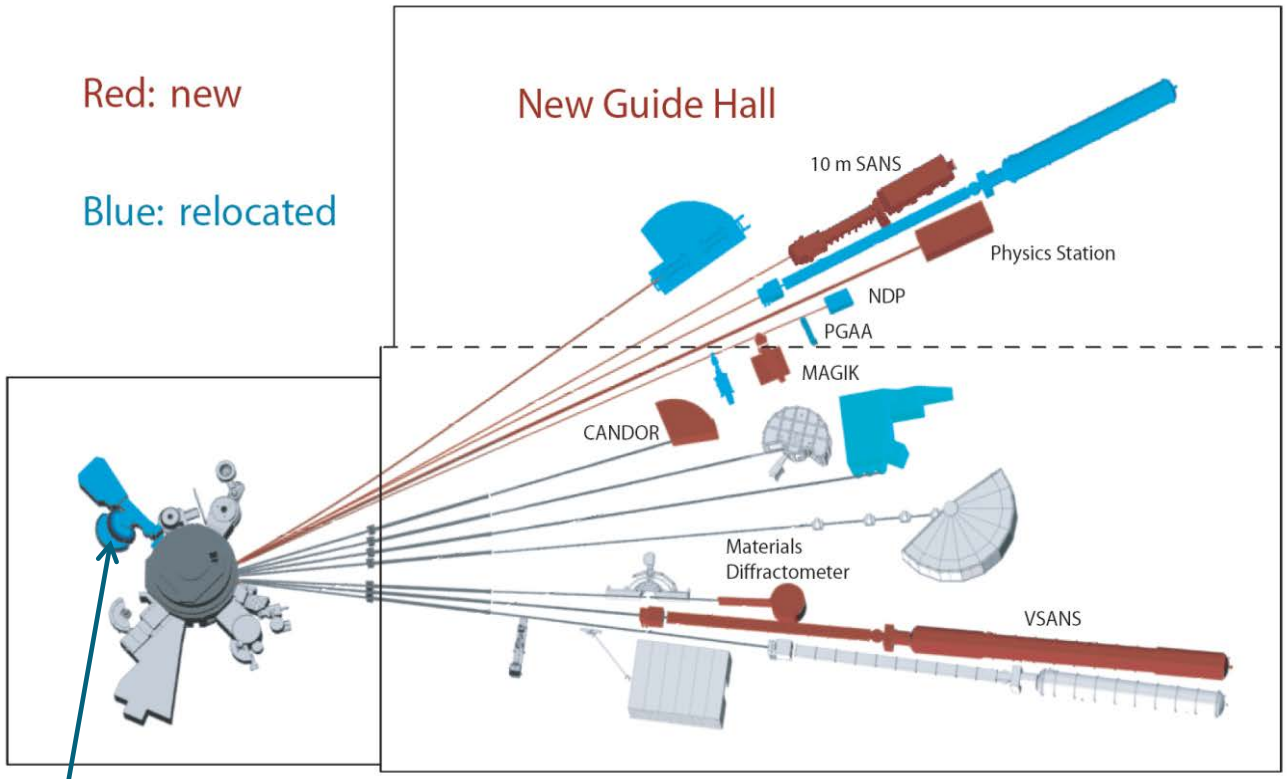
NIST National Institute of Standards and Technology U.S. Department of Commerce

Expansion of Cold Neutron Facilities



MACS* moved to BT-9 to make room for new guides.
***Multi-Axis Crystal Spectrometer**

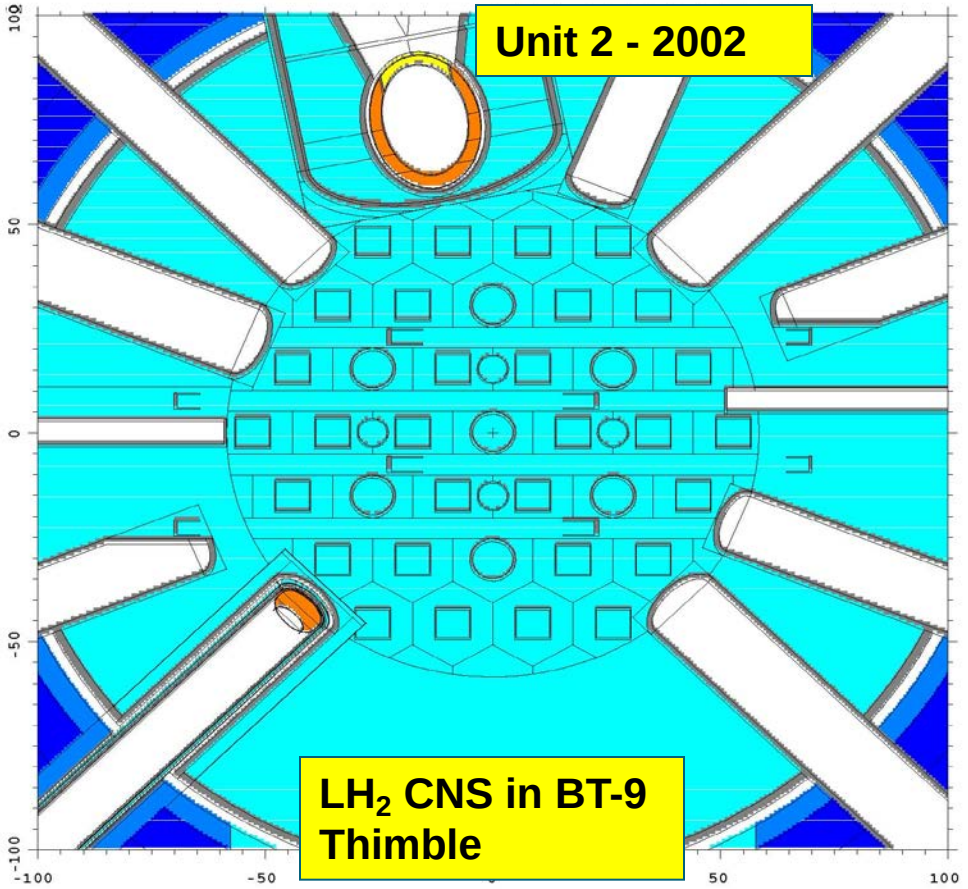
Five-year plan funded by America Competes Act ~$100 M

5 new guides, at least 6 instruments

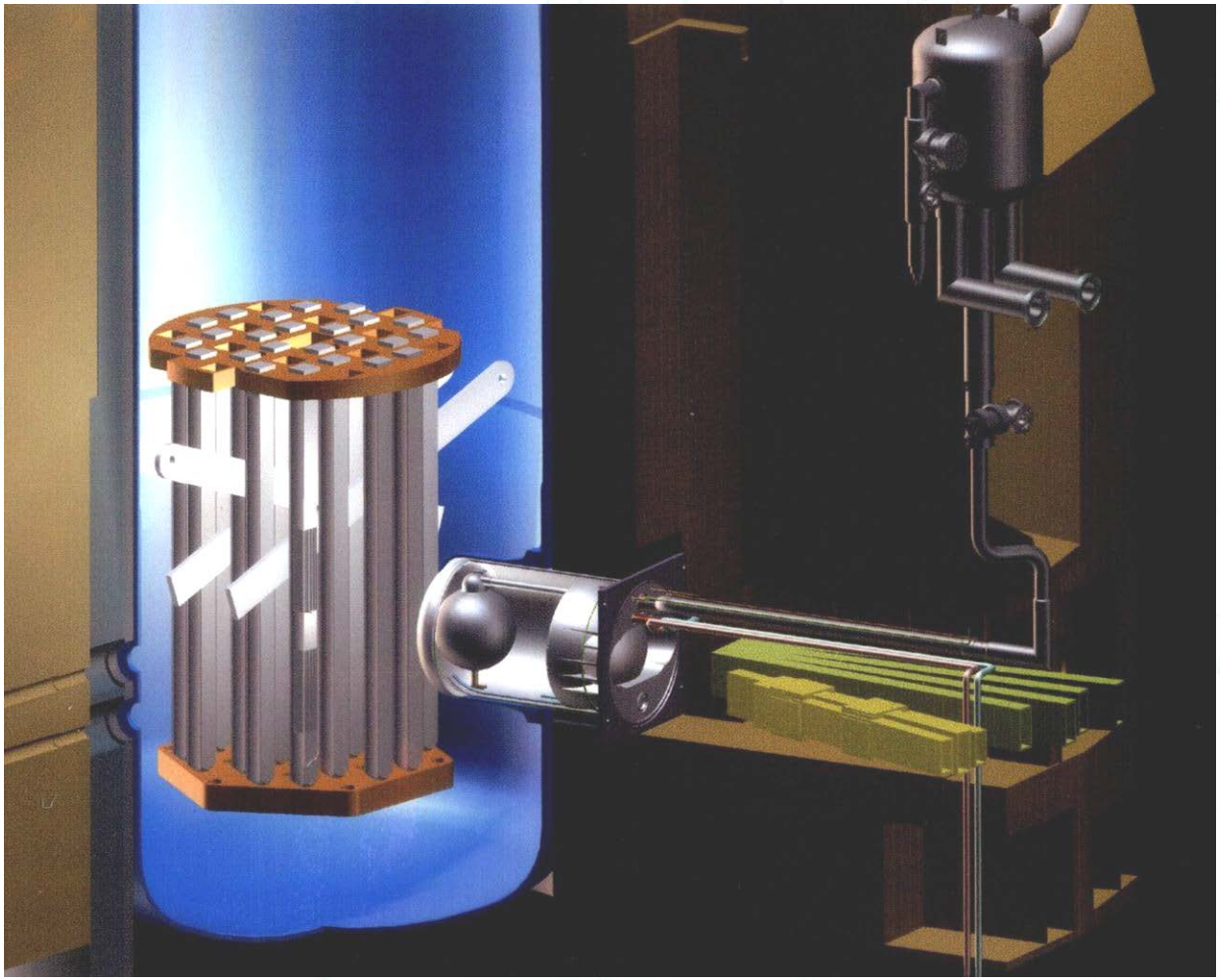
New guide hall nearly doubles space

A Second LH_2 Source is Needed for MACS

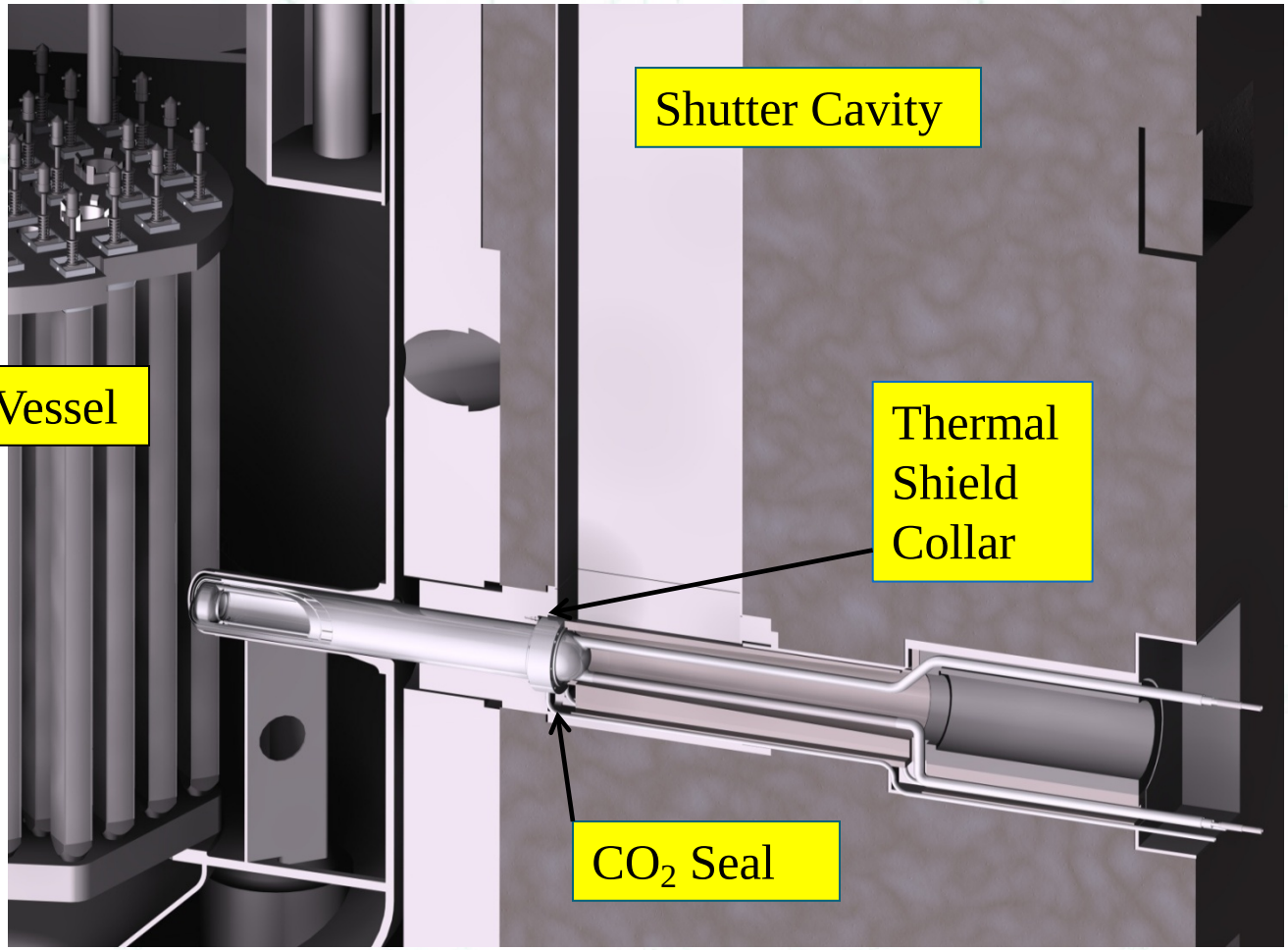
- Liquid H_2 allows neutrons to scatter and come to a lower temperature
- Original cold source has 32 cm OD major axis and 24 cm OD minor axis, 5 L volume, 2-3cm thick
- “Peewee” has an 11 cm ID, and a 0.5 L volume, 4.5cm thick.



The condenser is located outside the reactor, 2 meters above the source

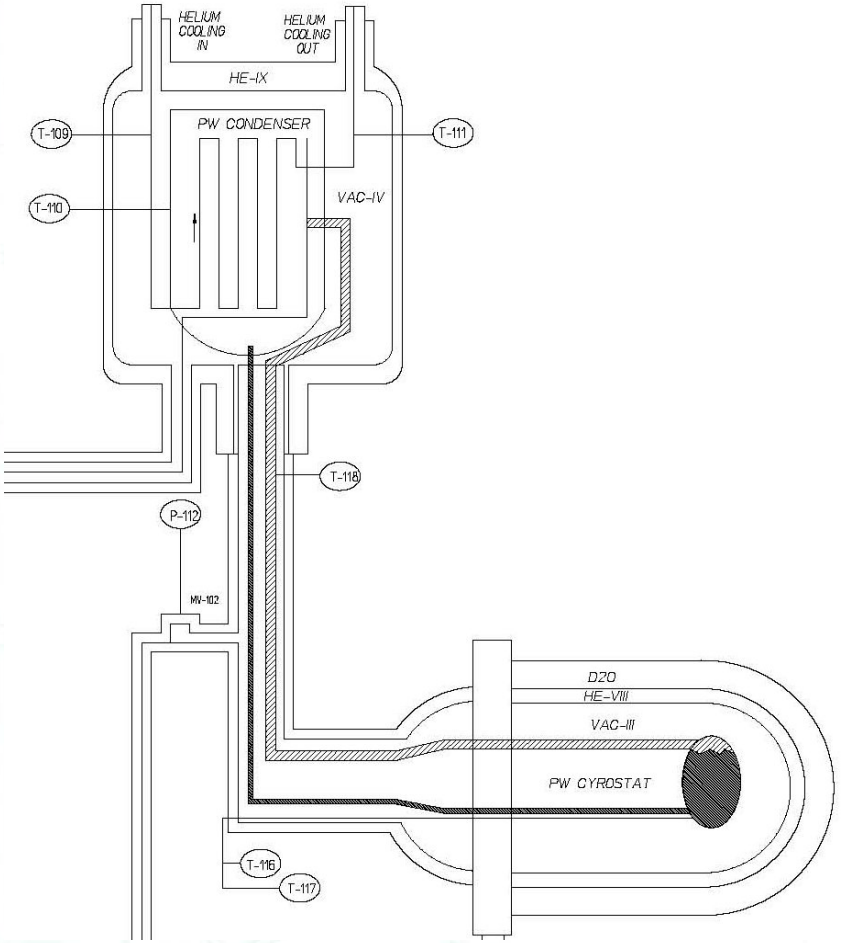


Installation of the Cryostat Assembly in the BT-9 Beam Port



Thermo Siphon

Peewee has been designed to create a simple thermo siphon that should result in mostly liquid hydrogen in the moderator vessel



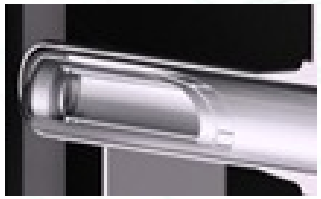
Cold Neutron Source (CNS)

- Cold LH_2 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.

Cold Neutron Source (CNS)

- 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

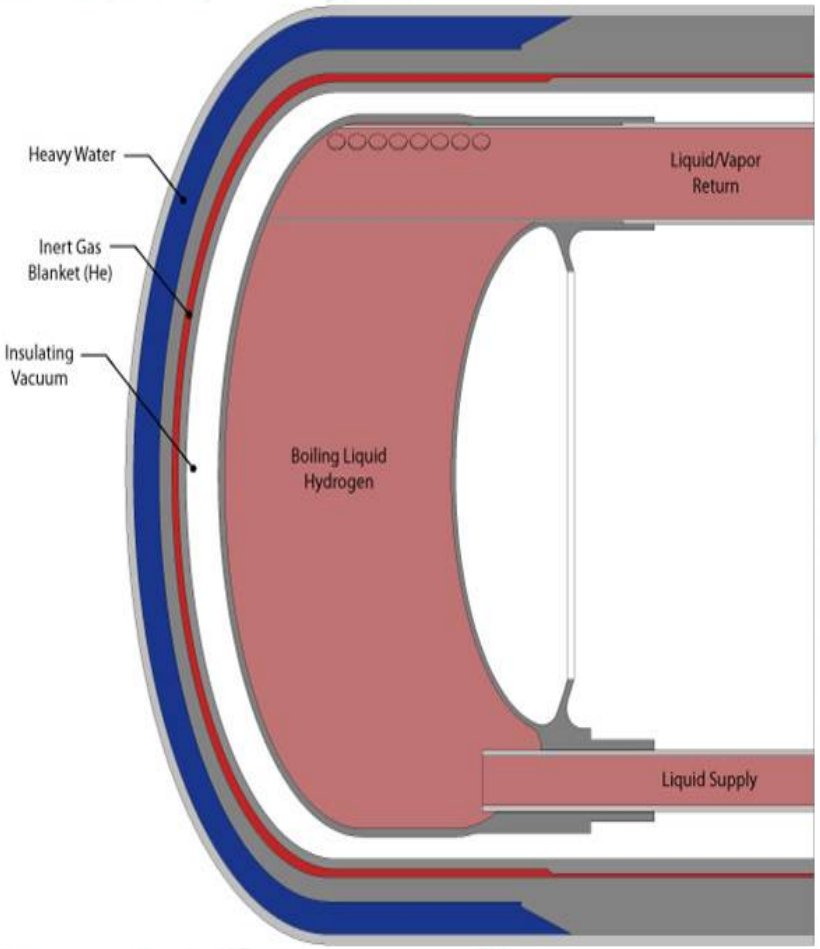
Structure of the BT-9 Cold Source

D_2O Temperature: 310-320K

Helium Pressure: 120-130 kPa

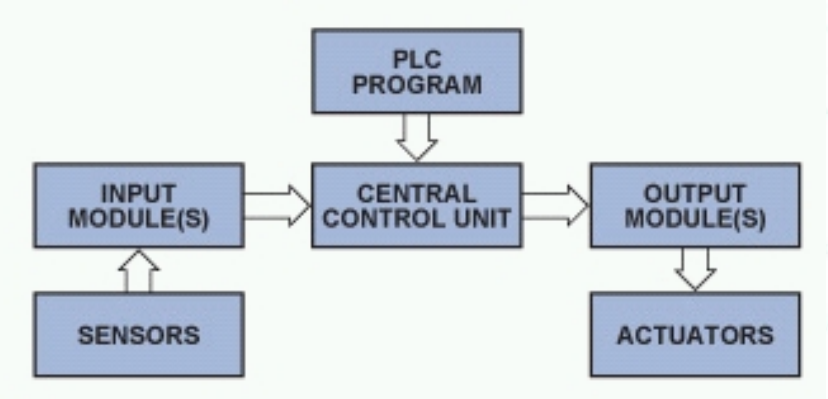
Vacuum: $\leq 10^{-6}$ Torr

Liquid H_2: 20.4 K at 1 atm



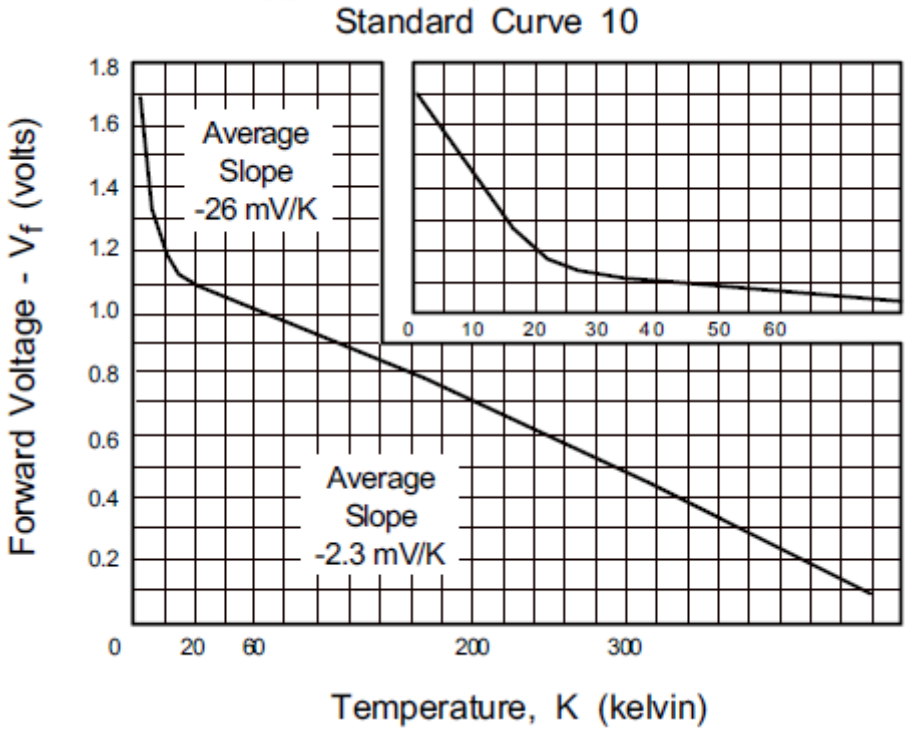
Automation and Control System

- 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



Temperature Response Curve

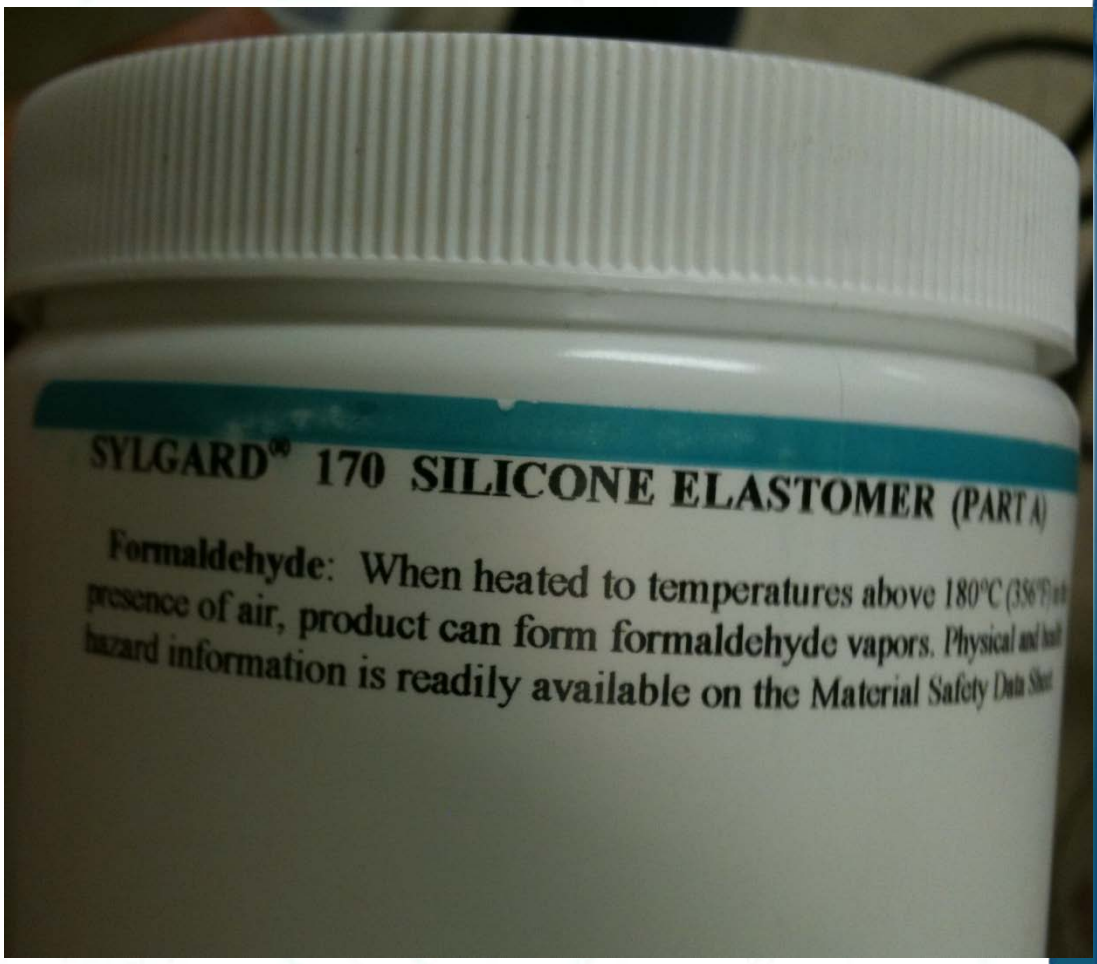
- The silicon diode was connected to a transmitter which operates in a 0-325K range by generating a signal that is 0-10V
- Accuracy of the DT670 diode is ±12 mK at low temperatures



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 $5*10^{-6}$ Torr $\pm$ 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

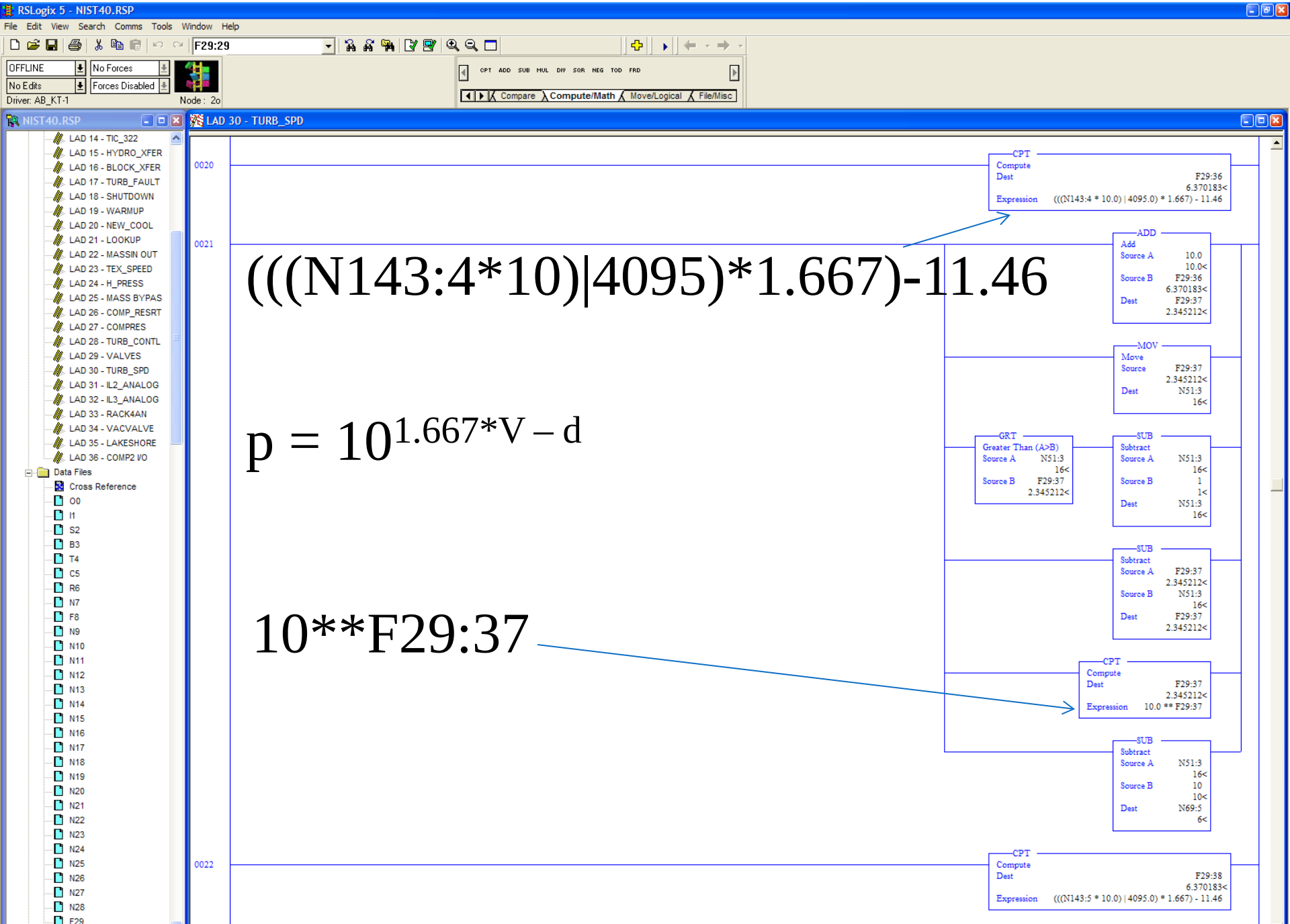


Sylgard 170 Silicone elastomer helps in protecting against environmental attack.

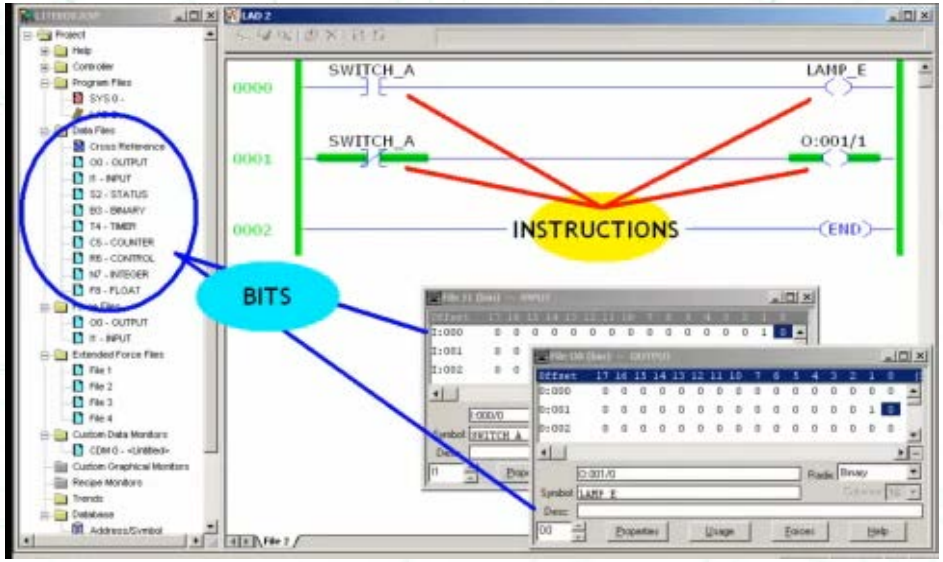
PLC Input Modules

- 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

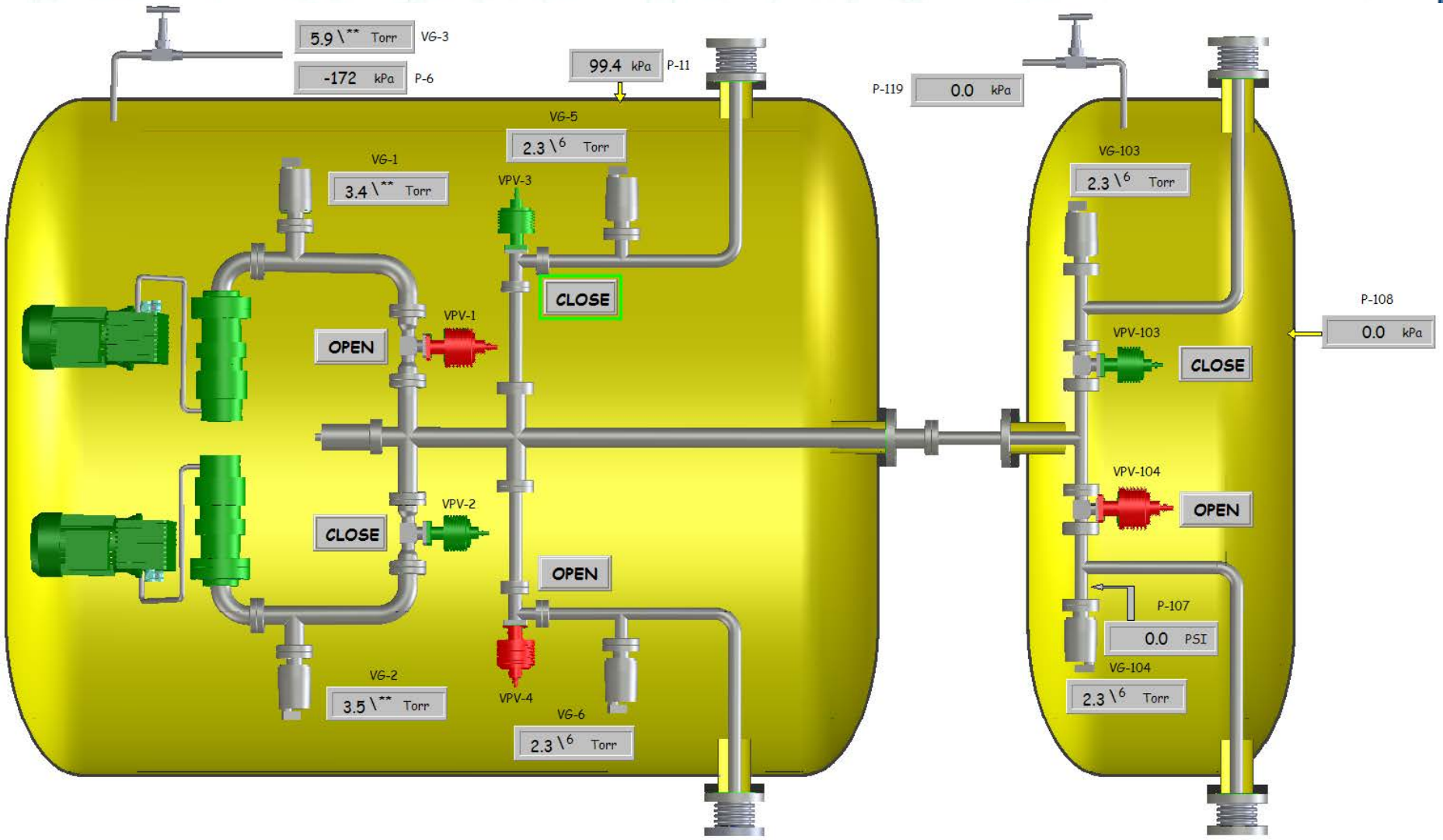

RSLogix 5 - NIST40.RSP
File Edit View Search Comms Tools Window Help
F29:29
OFFLINE
No Forces
No Edits
Forces Disabled
Driver: AB_KT-1
Node : 2o
Compare Compute/Math Move/Logical File/Misc
NIST40.RSP
LAD 14 - TIC_322
LAD 15 - HYDRO_XFER
LAD 16 - BLOCK_XFER
LAD 17 - TURB_FAULT
LAD 18 - SHUTDOWN
LAD 19 - WARMUP
LAD 20 - NEW_COOL
LAD 21 - LOOKUP
LAD 22 - MASSIN OUT
LAD 23 - TEX_SPEED
LAD 24 - H_PRESS
LAD 25 - MASS BYPAS
LAD 26 - COMP_RESRT
LAD 27 - COMPRES
LAD 28 - TURB_CONTL
LAD 29 - VALVES
LAD 30 - TURB_SPD
LAD 31 - IL2_ANALOG
LAD 32 - IL3_ANALOG
LAD 33 - RACK4AN
LAD 34 - VACVALVE
LAD 35 - LAKESHORE
LAD 36 - COMP2 I/O
Data Files
Cross Reference
O0
I1
S2
B3
T4
C5
R6
N7
F8
N9
N10
N11
N12
N13
N14
N15
N16
N17
N18
N19
N20
N21
N22
N23
N24
N25
N26
N27
N28
F29
LAD 30 - TURB_SPD
0020
0021
0022
CPT
Compute
Dest F29:36 6.370183<
Expression (((N143:4 * 10.0) | 4095.0) * 1.667) - 11.46
ADD
Add
Source A 10.0 10.0<
Source B F29:36 6.370183<
Dest F29:37 2.345212<
MOV
Move
Source F29:37 2.345212<
Dest N51:3 16<
GRT
Greater Than (A>B)
Source A N51:3 16<
Source B F29:37 2.345212<
SUB
Subtract
Source A N51:3 16<
Source B 1 1<
Dest N51:3 16<
SUB
Subtract
Source A F29:37 2.345212<
Source B N51:3 16<
Dest F29:37 2.345212<
CPT
Compute
Dest F29:37 2.345212<
Expression 10.0 ** F29:37
SUB
Subtract
Source A N51:3 16<
Source B 10 10<
Dest N69:5 6<
CPT
Compute
Dest F29:38 6.370183<
Expression (((N143:5 * 10.0) | 4095.0) * 1.667) - 11.46
(((N143:4*10)|4095)*1.667)-11.46
p = 10^1.667*V – d
10**F29:37

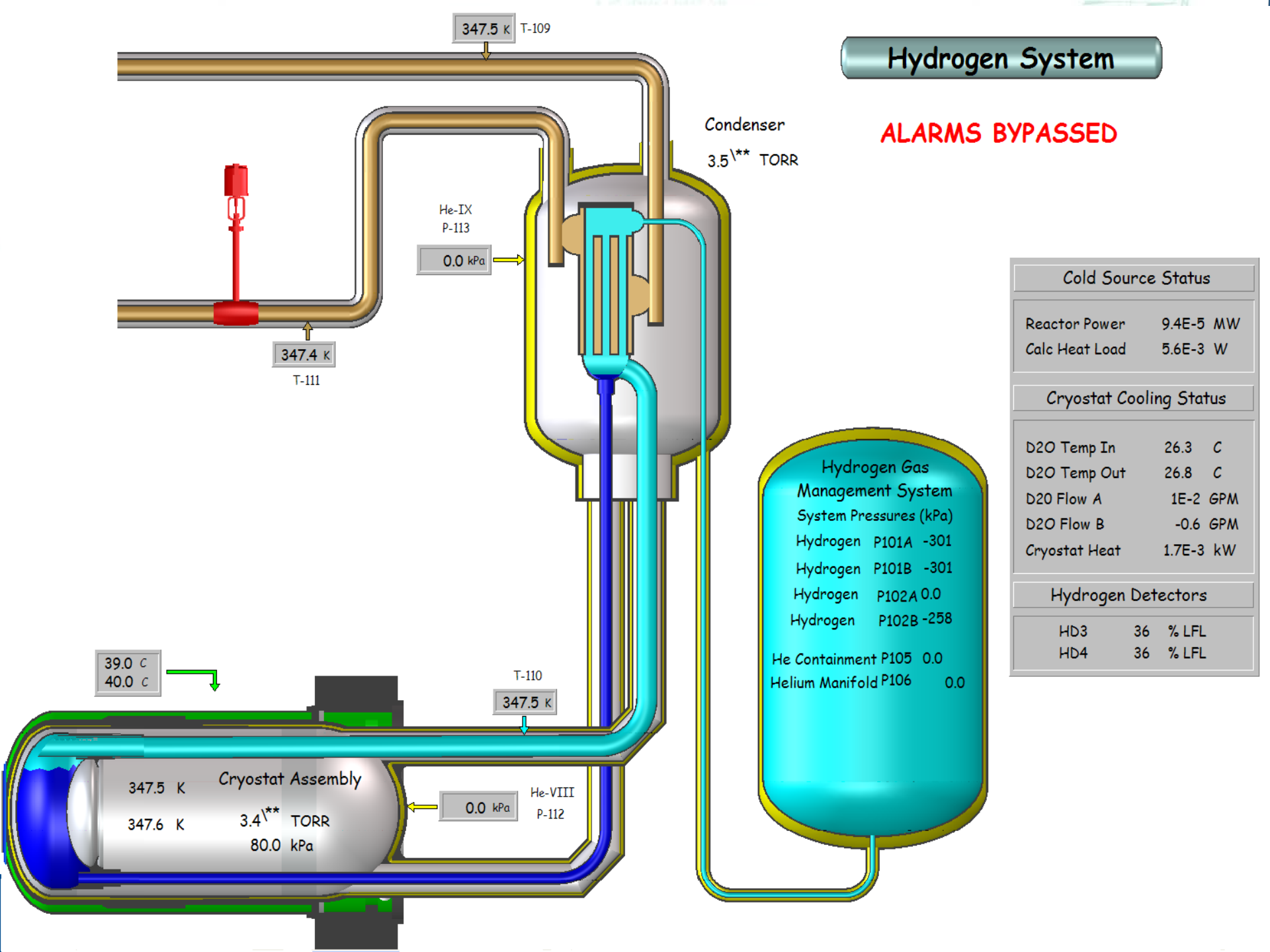
Ladder Logic Addressing



- 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.

Peewee Vacuum System




Hydrogen System
ALARMS BYPASSED
347.5 K
T-109
Condenser
3.5** TORR
He-IX
P-113
0.0 kPa
347.4 K
T-111
Hydrogen Gas Management System
System Pressures (kPa)
Hydrogen P101A -301
Hydrogen P101B -301
Hydrogen P102A 0.0
Hydrogen P102B -258
He Containment P105 0.0
Helium Manifold P106 0.0
Cold Source Status
Reactor Power 9.4E-5 MW
Calc Heat Load 5.6E-3 W
Cryostat Cooling Status
D2O Temp In 26.3 C
D2O Temp Out 26.8 C
D20 Flow A 1E-2 GPM
D2O Flow B -0.6 GPM
Cryostat Heat 1.7E-3 kW
Hydrogen Detectors
HD3 36 % LFL
HD4 36 % LFL
39.0 C
40.0 C
T-110
347.5 K
347.5 K
Cryostat Assembly
347.6 K
3.4** TORR
80.0 kPa
0.0 kPa
He-VIII
P-112

Thanks to the Sponsors!

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Questions?