Temperature Sensor Experiment

University of Illinois

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D. Errede/UIUC
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Purpose
Providing temperature information for cooling channel energy absorber undergoing testing in Mucool Test Area

Study properties of fiberoptic gauges at cryogenic temperatures.

History
Z. Conway, M. Haney, (D. Errede) got the experiment going, purchasing equipment, setting up cryostat, installing sensors.

Zack wrote the daq for our test setup and absorber testing in situ.

Jason Crnkovic, D. Errede, M. Haney studied the systematic errors associated with the test setup.

Gefei Qian has added some nice modifications to the daq and written a temperature conversion program whose algorithm looks better than Lakeshores.
Cooling Channel Lattice Cell
Includes UIUC
New MUCCOOL Test Facility

Fill & test absorbers
HP 201 MHz (& 805 MHz ?) Tests
Integrate components into a unit
Test in intense ionizing beam
Absorber Instrumentation

The absorber environment:

- The absorber will absorb 100-1000 Watts depending on beam intensity in cooling channel muon beam.

- The MTA will provide a 400 MeV proton beam of ~ $10^{12}$-$10^{13}$ protons/pulse @ 15 Hz to mimic the dE/dx deposition of a muon beam.

- The absorber sits inside a solenoid of 4 Tesla (~1.5 T at absorber in cooling channel design)

- The absorber is filled with liquid hydrogen thus operates at cryogenic temperature (14 –20K)

THUS the monitoring devices must be rad-hard, and able to operate in high magnetic fields and cryogenic temps.
Absorber Aluminum Window Pressure/Burst Testing
Cryogenic Testing of Temperature Gauges

Jason Crnkovic
2003 Summer REU Student at UIUC
8/8/2003
Figure 1: The apparatus

- **Keithley Switch**
- **218: sensor monitor OR**
- **Keithley multimeter**
- **332: cryostat temperature controller**

**amphenol connector:**
- Braid-shielded cable to 218 channels 1-4 (using channels 1 and 2) through the Keithley switch
- Connects to 218 channels 5, 6, 7, 8

**amphenol connector (pt06A-12-10S (sr) 0238):**
- To Edwards vacuum pump pressure gauge then valve (gas release)

**amp connectors**
- To allow connection through the Keithley switch.

**amphenol connector:**
- Connects to Edwards vacuum pump pressure gauge then valve (gas release)

**Liquid helium**

**4 windows**

**amphenol connector:**
- 3 twisted pairs: sample heater (+X) not connected at the moment
  - diode sense (+V)
  - diode excite (+I)

**to 332 Input B banana clips**

**to 332 Input A banana clips**

- Vapor heater (+X)
- Diode sense (+V)
- Diode excite (+I)
Sensors under consideration

Cernox  
Diagram found at:  
http://www.lakeshore.com/temp/sen/F017_00_00.pdf

Diode  
Diagram found at:  
http://www.lakeshore.com/temp/sen/F031_00_00.pdf

FISO Temperature Gauge  
Diagram found at:  
Temperature diode and resistive transducers
(experiment in Urbana)
Figure 2: Electronic Connections

Keithley switch

IEEE-488 Interface

amp

218

1-4 channels, experiment sample RTD

5-8 channels

IEEE-488 Interface

amp

332

2 twisted pairs
vapor diode excite sense

3 twisted pairs
sample heater + -X
" diode sense + -V
" diode excite + -I

2 twisted pairs
sample diode excite sense

3 twisted pairs
vapor heater + -X
" diode sense + -V
" diode excite + -I

Amphenol pt06A-12-10S (sr) 0238

navy green connector unconnected at the moment

braid shielded cable

2x amp connectors

to PC

3 amphenol connectors

to PC

3 twisted pairs
sample heater + -X
" diode sense + -V
" diode excite + -I

2 twisted pairs
vapor heater hi
" diode sense hi
" diode excite hi

to PC

2 twisted pairs
sample heater low
" diode sense low
" diode excite low

unconnected at the moment

amp

amp

amp
Figure 3: Sample Holder
\( I = 10.0001 \pm 0.0001 \ \mu \text{Amps} \)

\( R_{\text{wire}} \sim 15 \ \text{Ohms/m}, \quad \text{length/wire about } \frac{1}{2} \text{ meter} \)

Figure 4: Sensor Circuit Diagram
\[ I = 10.0001 \pm 0.0001 \, \mu\text{Amps} \]

\[ R_{\text{wire}} \sim 15 \, \text{Ohms/m}, \quad \text{length/wire about } \frac{1}{2} \text{ meter} \]

**Figure 5: Sensor Circuit Diagram**
We examined the voltages and resistances of all loops in the circuit, both as 4 wire and 2-wire resistance measurements, with the sensors in and out of the circuit. We reversed the current through the loops to look for current-direction independent potentials.

The temperature dependent potentials increase with an increase in temperature.

No significant effects were found under stable temperature conditions.
Data from Teststand using Cernox RTDs

Cernox 21265 and 27990 Resistance vs. Temperature

![Graph showing the resistance vs. temperature for Cernox 21265 and 27990.](image-url)

- **Cernox 21265**
- **Cernox 27990**
- **Temperature Sample Chamber**

**Resistance (Ohms)**: 597.5, 418.65, 336.5, 196.51, 166.91, 59.23

**Temperature (K)**: 0, 50, 100, 150, 200, 250, 300, 350
Status

The status of the commissioning of the Cernox is that the calibrated sensors work (+- 0.03K @ 20K) better than the specifications of our needs (+- 0.1K @ 20K).

The electronics (Lakeshore 218s) are not measuring resistances to within specifications (worse than 1% in the 100-1000 Ohm range). The Keithley multimeter (6 ½ digit precision, accuracy tested with high precision resistors; 100 & 1000 Ohms) that we bought demonstrates that the problem lies with the Lakeshore electronics.

One 218 has been sent back to Lakeshore for corrected calibration. All 218s demonstrate the same problem and will be sent back to Lakeshore.

The temperature sensor system is presently operational with the Keithleys and the simple daq provided by Keithley.

The Conway/Qian DAQ handles 218s, the IRM, the FISO fiber optic transducers, and the PCI-MIO-E16 ADC.
Conclusions

Recalibrate the 218s