Instrument Design for the Accelerator Cryogenic System in the DALS Project

ICEC/ICMC

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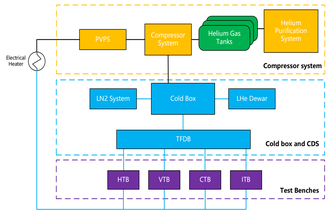
Introduction

DALS (Dalian Advanced Light Source) Test Facility

- The DALS project aims to construct a High repetition rate free electron laser (FEL) based on CW SRF accelerator (1.0 GeV)
- The DALS Test facility aims to test key components of DALS, which consists of four testbenches for cavity test, cryomodule test and beam test

Cryogenic Control System

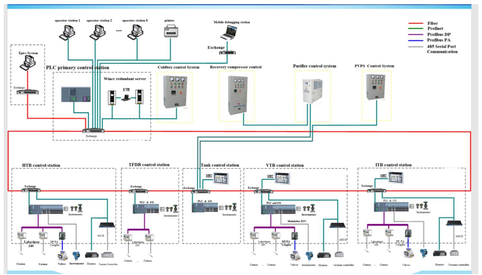
- The cryogenic system consists of 1 cryoplant, helium storage system, vacuum pump system, recovery and purification system and cryogenic distribution system (CDS) including four testbenches as cooling target.
- Cooling targets: Horizontal Testbench (HTB), Vertical Testbench (VTB), Injector Testbench (ITB), Cryogenic Testbench (CTB).
- Sensors used in the cryogenic systems: temperature sensors, pressure sensors, flow meters, Superconducting liquid level meter, heaters and purity meter.



DALS Test Facility Cryogenic System Diagram

Rules for using and selecting sensors：

- Suitable range and accuracy；
- Long-term stability；
- Redundancy and backup for the important position;
- On-line calibration;
- Easy to repair and replace;
- Correct installation method;
- Heat sink for the sensors lead inside the thermostat.



Network Structure of Cryogenic Control System

- The entire control network uses optical fiber ring network to ensure the stability of the control system；
- Some valves are used in the accelerator tunnel, because the impact of radiation, so the Profibus PA communication protocol is selected.

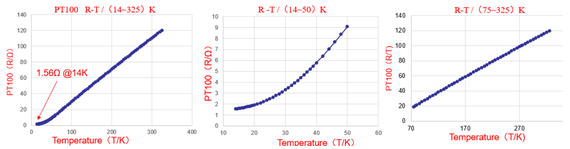
Temperature Measurement

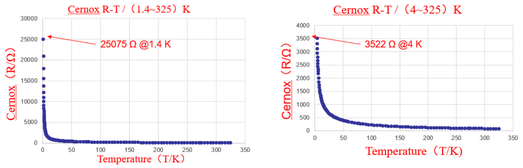
PT100： Resistance changes with temperature

Four-wire resistance measurement；

Stable Sensitivity, (about 0.39 Ω /℃, 75 K ~325 K);

Easy to measure, using AI card.





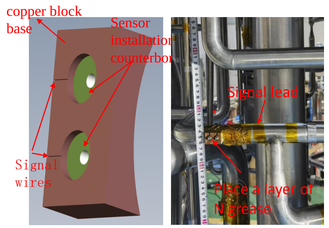
Cernox： Resistance changes with temperature

Four-wire resistance measurement；

Thin film sensor, Coating process, low heat capacity;

Each sensor has a unique curve;

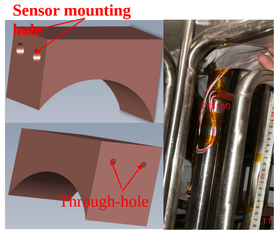
In low-temperature region, high sensitivity and quick response.



Two Sensors, CU package, 1 use & 1 backup；

The signal lead must be protected in a insulation tube;

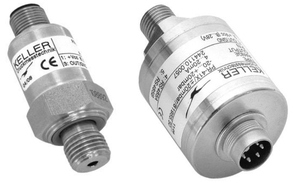
Heat sink at the insulation tape on the tube.



Heat sink , N grease；

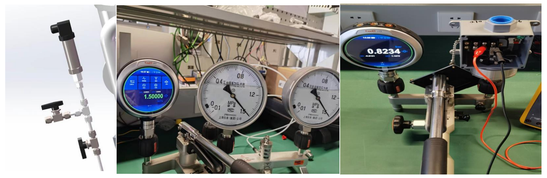
Through hole to prevent holding Pressrue；

Pressure Measurement



Piezoresistive Pressure Transmitter: Cheap price, stable performance, wide range, wide application, but low accuracy;

Capacitive Pressure Transmitter: Adjustable range, high accuracy, high sensitivity but expensive.

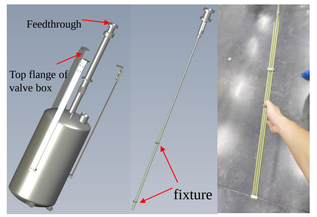


- Each pressure transmitter installation should be reserved for calibration port, usually close the valve, open the valve during calibration;
- The pressure gauge should be calibrated before installation;
- The pressure switch should be adjusted to the appropriate operating value before installation;

Liquid Level Measurement

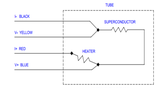
Superconducting liquid level sensor

sensor current:	75 mA (4 K)； 57 mA (2 K)
sensor resistance:	11.6 Ω/in. @ 20 K；13.7 Ω/in. @ 300 K
Voltage (Sensitivity)	0.87 V/in. (4 K)；0.66 V/in. (2 K)



Before installing the LHe level sensor, the status of the sensor should be checked at room temperature.

Inspection Method: measure the resistance between each wires.



- ●red-blue：~5Ω，heating
- ●yellow-black：~0.7Ω， wire resistance
- ●yellow-blue=black-blue：13.7Ω × Active Length(inch)

Fix the liquid level sensor on the support rod and insert it into the phase separator along the guide pipe.

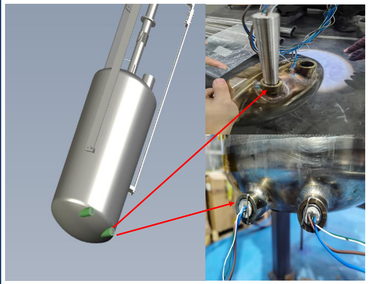
The guide pipe and top flange are sealed by welding.

Feedthrough, CF flange, CW35.

The liquid level sensor and support rod are fixed with fixtures.

Heaters

Heating rod, Bottom of phase separator



- Using stycast ® 2850-FT epoxy resin adhesive to increase thermal conduction;
- Real time monitoring of heater temperature, to protect the heater;
- Choose a Feedthrough with a higher rated current;
- The pipe size is processed according to the size of the heater.

Pipe Heater, Verify the flow rate inside the pipeline

- Select copper tube based on the diameter of the pipeline;
- Throw the copper tube out of the middle, and make a groove on tube and insert the heater into the groove;
- Press the surface of the copper tube flat；
- Using indium sheet to increase thermal conductivity;
- The outside is fastened with iron bands.

Conclusions

- This paper describes the selection and working principle of the temperature sensor, superconducting level meter, pressure sensor, pipe heater and other instruments used in the accelerator cryogenic system.
- This paper focuses on the installation process and calibration methods of these sensors.
- The engineering experience for the use of instruments will contribute to similar accelerator cryogenic systems in the future.