Application of Cryocoolers to a Vintage Dilution Refrigerator

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ABSTRACT

A dilution refrigerator is required for 50mK detector operation of CDMS(Cryogenic Dark Matter Search). Besides shielding the dilution refrigerator itself, the liquid nitrogen shield and liquid helium bath in the refrigerator cool the detector cryostat heat shields and cool electronics, resulting in significant external heat loads at 80K and at 4K.

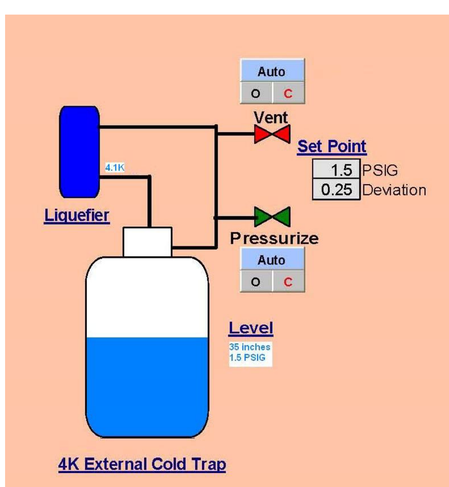
An Oxford Instruments Kelvinox 400 has served this role for ten years but required daily transfers of liquid nitrogen and liquid helium. Complicating the cryogen supply is the location 800 meters below ground in an RF shielded, class 10000 clean room at Soudan, MN.

Nitrogen and helium re-liquefiers using cryocoolers were installed outside the clean room and continuously condense room temperature gas and return the liquids to the dilution refrigerator through a transfer line. This paper will describe the design, installation, controls and performance of liquefaction systems.

External Cold Trap Re-Liquefier

- Cryomech PT415
- Custom lifting frame
- Thermo-siphon operation, manual adjustment
- Automatic helium gas venting and supply
- Heater controlled by pressure
- Liquid helium usage before installation 3.25 SL/M
- Liquid helium usage after installation, none

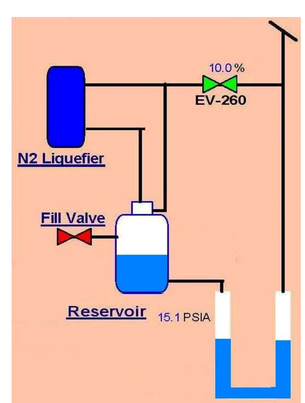
External Cold Trap Re-Liquefier



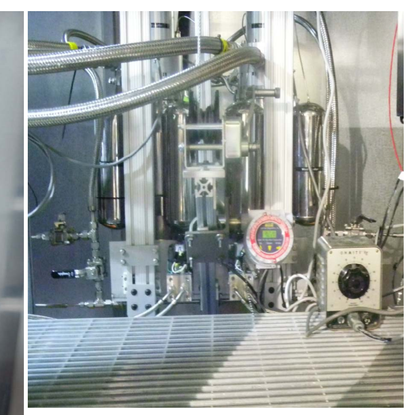
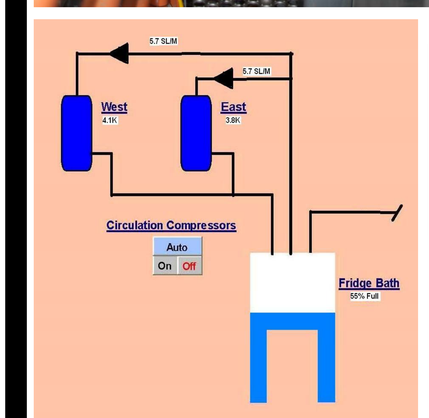
Dilution Ref. Nitrogen Re-Liquefier

- Cryomech AL 300
  - equipped with heat exchanger
  - electric cartridge heaters
  - temperature sensors
- Thermo-siphon operation, control valve adjustment
- 3.8 meter transfer line to DR
- Vacuum vessel by Ability Engineering
- Supported with rubber vibration isolation
- Liquid nitrogen usage before installation 15.6 SL/M
- Losses reduced to leakage
- Nitrogen gas makeup added

Nitrogen Re-liquefier



Dilution Refrigerator Helium Re-Liquefier Performance

- Two Cryomech PT-415's
- Custom lifting frame
- Forced flow with miniature, dry compressors
- 3.8 meter transfer line
  - Shielded with liquid nitrogen
  - Heat load 220 mW actual
- Liquid Helium usage before installation 10.0 SL/M
- Liquid Helium usage after installation, 2.4 SL/M
  - Improvement expected following improved insulation and shielding
  - This includes Pot usage of about 0.9 SL/M

Dilution Refrigerator Bath Re-Liquefier