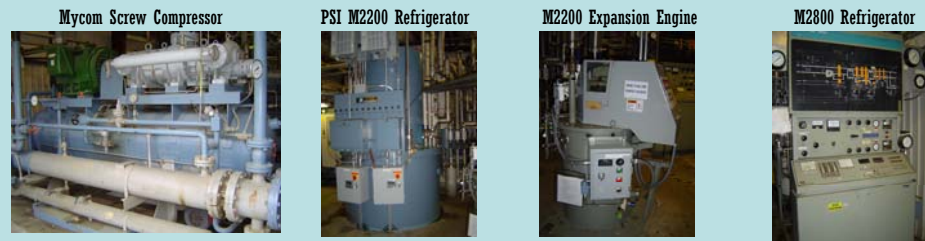


History of Jefferson Lab 2K and 4K Helium Cryogenics

12000 Jefferson Avenue, Newport News, Virginia, USA

1989



Plants: CTI M2800 Helium Refrigerator
KPS M2200 Helium Refrigerator
Helium Shield Refrigerator

Capacity: 200W at 4K, Sulzer Turbine Expanders (2)
750W at 4K, Reciprocating Expansion Engines (2)
800W at 35K, Reciprocating Expansion Engine (KPS)

Service: 4K primary supply with warm vacuum pumping to provide 2K for cryomodule and superconducting cavity testing
35K secondary supply for transfer line and cryomodule shield service

Commission Date: 1988, 4K ; 1989 2K
Service Duty: 24/7/365 Continuous Unattended

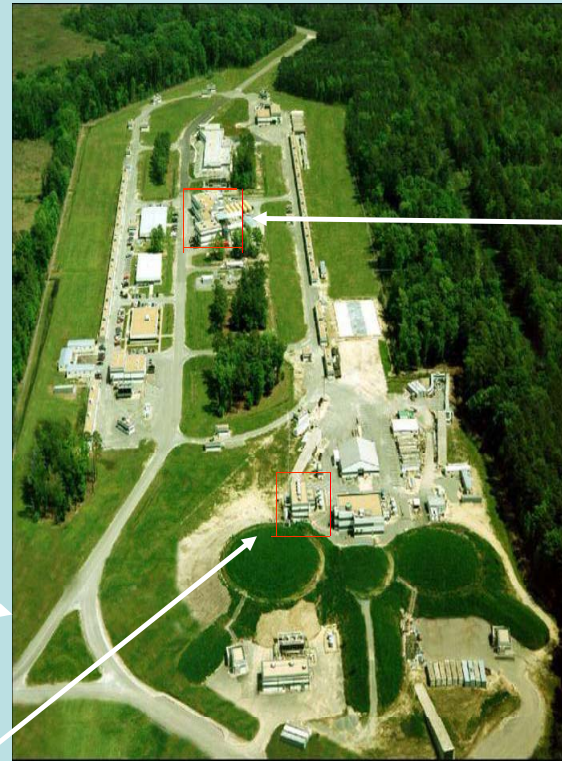
Operation Hours to Date: >120,000
Main Compressors: 3-400 HP Mycom Compound Screw Compressors

Control System: EPICS software, VME/CAMAC/Relay local hardware, Programming: JLab Cryogenics Group

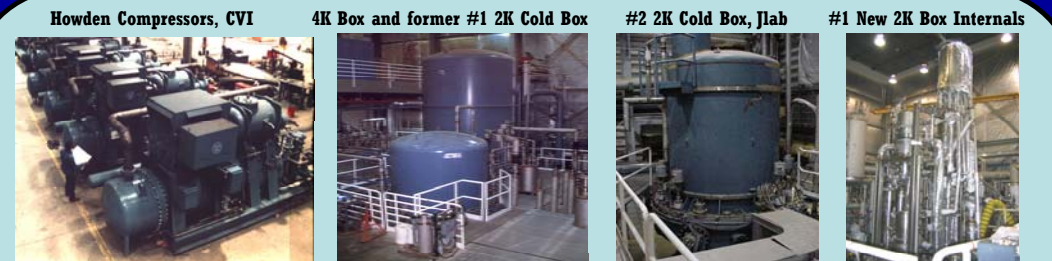
Cooling Water: 600 gal/min **Electric Power:** 0.8 MW, 480V **LN2 Precooling:** 30 gal/hour

CRYOGENIC TEST FACILITY (CTF)

Jefferson Lab Accelerator Site



1991/1994



Plant: Central Helium Liquefier **Capacity:** 12KW at 35K shield, 4.6KW at 2.1K primary, 10 g/s Liquefaction
Service: Maintains 45.5 super-conducting linac cryomodules at 2.1K (72,800 liquid liter inventory)
Provides shield circuit for linac cryomodules and transfer lines at 35K

Commission Date: 1991 (4K), 1994 (2K) **Service Duty:** 24/7/365 Continuous Unattended,
Operation Hours to Date: 112,000 **Main Compressors:** 3 x 600 HP 1st Stage, 3 x 2250 HP 2nd Stage Howden

Cold Compressors: Qty 2, 2K Cold Boxes (Primary and Redundant), 250 g/s 5 stage each, 0.039 atm to 1.1 atm

Cooling Water: 2300 gal/min **Electric Power:** 5.5 MW, 4160V **LN2 Precooling:** 330 gal/hour

Availability: 99% inclusive of all refrigerator, beam and experimental hall target recovery time

CENTRAL HELIUM LIQUEFIER (CHL)

1994



Plant: End Station Refrigerator **Capacity:** 1500W at 4.5K...or... 800W at 4K plus 1200W at 15K (variable combination possible)
Service: Provides 4K cooling of experimental hall spectrometer magnets and 4K/15K cryogenic experimental targets

Commission Date: 1978, LBL Escar Program **Service Duty:** 24/7/365 Continuous Unattended, computer controlled
1994, Jefferson Lab

Operation Hours to Date: <900 ESCAR **Main Compressors:** 1-200 HP 1st Stage, 2-1000 HP 2nd Stage : Sullair Oil Flooded Screw
94,000 JLab (one 2nd stage compressor is a spare)

Control System: EPICS software, VME/CAMAC/PLC local hardware **Programming:** JLab Cryogenics Group

Cooling Water: 450 gal/min **Electric Power:** 1.2 MW, 480/4160V **LN2 Precooling:** 40 gal/hour

Special Features: 80K charcoal beds added by JLab, JLab variable energy saving capacity control

Typical Plant Availability: 99.5% inclusive of experiment data recovery time

END STATION REFRIGERATOR (ESR)

BACKGROUND

The cryogenic systems at Jefferson Laboratory consist of six 2K and 4K helium refrigerators in three plant locations (CHL, ESR, CTF) in support of the laboratory's Continuous Electron Beam Accelerator, Free Electron Laser Facility, Cryomodule Test Facility, and the super-conducting magnets/targets of three Experimental Halls. These plants represent plants built as early as 1971 and appear much the same as they did during their construction but have been modified for the JLab applications and are very different from a technology point of view.

In the past, large scale helium cryogenic systems in the United States saw dramatic steps in both scale and technology with each passing commercial and experimental laboratory application. As the end user applications grew, so did the challenges of engineering cryogenic systems never attempted before. Many new technologies had to be developed to support the application. An early 1970s 300W refrigerator would have been very large machine. Then within a short time (mid-late 1970s) came the LANL M4000 (now at SLAC), 4K 1500W LBL Escar/FERMI refrigerators and the 3.5K ORNL plant. The large FERMI Big "L" 5KW 4K liquefiers of the 1980s moved the refrigerator "performance bar" up once again, becoming the world's largest. This was followed by the very large BNL Isabelle 3.5K refrigerator and the JLab 2K 4.6KW refrigerator depicted above. For the JLab 2K refrigerator the technology change from a previous 5 g/s plant (Torr-Supra) to 235 g/s using centrifugal cold compressors equipped with cryogenic cooled bearings and motor drives. With each new user application, new cryogenic technology had to be nurtured and developed in advance. JLab cryogenic senior staff engineers were fortunate to be part of the design of all of the plants listed above in their earlier industrial cryogenic careers and have seen the introduction of components as oil flooded screw compressors, silicon diode temperature sensors, turbine expanders, cold compressors, effective oil removal, contamination control, and the change from pneumatic to computer controls.

Since 1988 through the present day the JLab plants have under gone an evolution of further design change and technology enhancements. Building on the experiences of the past, these changes focus on system performance, efficiency and high reliability with an eye to future technology requirements. For JLab this has included the development of the "Ganni Helium Process Cycle" and "Improved Multipass LN2 Helium Precooling", as well as automated plant capacity control which varies the amount of utility used while matching the refrigeration produced to a varying load. All which was developed to meet the user needs of economy and performance.

As JLab plans to upgrade its current accelerator 6 GeV beam operations to 12 GeV, the need to double the current JLab 2K refrigeration CHL plant capacity will follow all of the past history of cryogenic helium plant design and operation.....better technology with economy and reliability.

1998



Plant: Standby Refrigerator **Capacity:** 12KW shield load at 35K plus 1850W at 4K primary load
Service: Provides 4K primary and 35K shield secondary refrigeration to maintain CEBAF cryomodules at 4K during scheduled accelerator or CHL maintenance or downtime periods.

Commission Date: 1998, 4K and 35K **Service Duty:** 24/7/365 Continuous Unattended

Operation Hours to Date: 1150 **Main Compressors:** 1-600 HP 1st Stage, 1-1750 HP 2nd Stage; Howden Screw

Control System: EPICS software, VME/CAMAC/PLC local hardware, Programming: JLab Cryogenics Group

Cooling Water: 600 gal/min **Electric Power:** 1.4 MW, 4160V **LN2 Precooling:** 100 gal/hour

STANDBY HELIUM REFRIGERATOR (SBR)

