Cold & Lonely

The Role of Cryogenics, Vacuum Systems & Leak Detection in Big Science Projects

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Introduction

Cryogenics (T< 120 K),Vacuum (P< 1 Bar) and leak detection systems play a vital role in Big Science Facilities.

Cryogenics provides:

- Cooling of Superconducting Magnets and Superconducting Radiofrequency Cavities
- Production & storage of cold dense liquids for space propulsion (oxygen, hydrogen, methane), neutron moderation (hydrogen and solid methane) and particle detection (argon)
- Cooling of low noise electronics, infrared and x-ray sensors, bolometers and superconducting electronics and quantum computing devices
- Low temperature (down to < 1 K) sample environments
- Production of clean vacuum spaces via cryopumping
- Cooling of space simulation chambers
- Cryogenic distillation columns for nitrogen production and separation of hydrogen as part of the ITER Fuel cycle

Introduction

Vacuum Systems provide:

- Vacuum space for particle beams & associated experiments
- Vacuum insulation for cryogenic systems
- Vacuum for space simulation chambers
- Vacuum environment for material studies

Leak Detection is an enabling technology for both cryogenics and vacuum systems

- Leaks in vacuum systems can result in higher pressures and contamination of clean vacuum spaces
- Leaks in cryogenic systems can result in the loss of gases or liquids and in the freezing of air within the cryogenic systems resulting in blockages and system failure
  - Thus all vacuum and cryogenic systems must be leak tight to a high degree (generally must pass a test via a He Leak Detector)

Equipment & Services Required for Cryogenics & Vacuum Systems

This can be divided into 2 categories:

1) Unique, sophisticated equipment for the production and maintanance of cryogenic temperatures and vacuum.

- Examples: cryogenic refrigerators, small cryocoolers, dilution refrigerators, cryogenic instrumentation, storage dewars for cryogenic liquids, cryostats, turbopumps, He leak detectors, liquid and gaseous supplies (He, N_2, Ar)
- A relatively small number of firms provide these services and startups require significant investments in technology development and a steep learning curve

Equipment & Services Required for Cryogenics & Vacuum Systems

2) More standard industrial equipment that is vital for cryogenic and vacuum system construction and operation

- Examples: Room temperature piping, valves, flanges, seals, motors, cabling; warm gas storage systems; room temperature instrumentation and control systems; heat exchangers; water systems; cooling towers; welding services; rigging services
- This category of equipment often represents the larger physical space of cryogenic and vacuum systems
- Items in this category are frequently replaced in regular maintanence activities - ”long tail”

An Example from ESS

COLD

Warm

Procurement Estimates from Participating Institutions (details in follow on talks)

Institute	Estimated Procurements for Cryogenic Systems	Estimated Procurements for Vacuum Systems
CERN	>10 MCHF in the 2023–2027	>10 MCHF in the 2023–2027
ESA		
ESO	7 MEuros in 2023 - 2030	2 MEuros in 2023 - 2030
ESS	100 kEuros total for 2023 - 2027	0.5 MEuros in 2023 0.75 MEuros each year for 2024 - 2027
EXFEL	250 kEuro/year (2022-2026)(*) (*)(power, cold gases & major upgrades not included)	1.3MEuro/year (2022-2026) (*)(major upgrades not included)
FAIR	55 MEuros total for cryogenics, vacuum & leak detection over the next 5 to 6 years	
F4E	10s of millions of Euros between 2024 and 2030	10s of millions of Euros between 2024 and 2030
SKA		

Sources of Information

Professional Societies

- Cryogenics Society of Europe https://www.cryoeurope.org/
- British Cryogenics Council https://bcryo.org.uk/
- Cryogenic Society of America https://www.cryogenicsociety.org/
  - The CSA Buyers Guide provides an extensive listing of organizations and firms involved in cryogenics https://csabg.org/
- International Union for Vacuum Science, Technique and Applications https://iuvsta.org/

A short course on Cryogenic Engineering including slides and video presentations, may be found here: https://uspas.fnal.gov/materials/21onlineSBU/onlineSBU-Cryogenics.shtml

A short course from CERN on Vacuum for Particle Accelerators may be found here: https://cas.web.cern.ch/schools/glumslov-2017

Procurement information can typically be found on Large Facility websites or via the ILO

Summary

- Cryogenic and vacuum systems play important roles in Big Science Facilities
- Total estimated needs in these areas from participating facilities in the future is on the order of 100 MEuros
- Needs in these areas may be divided into very specialized equipment and more standard industrial equipment
  - The latter category frequently consitutes the bulk of purchases needed to maintain operating facilities
  - Operating facilites frequently have long lifetimes and thus ongoing procurement needs
- There are many resources available to learn about the procurements associated with cryogenic and vacuum systems.