SPIRE Test Facility Vacuum System Requirements

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1 Scope of the document

This document describes the requirements for the main vacuum system for the SPIRE calibration cryostat.

2 Reference Documents

	Title	Author	Reference	Date
RD 1	SPIRE Test Facility Requirements Specification	D.L. Smith	SPIRE-RAL-PRJ-000463 Issue 1.3	2-April-2001
RD 2	SPIRE Calibration Cryostat drawings	M. Harman	A1-KG0720-001 - Draft	6-April-2001

3 Introduction

The Rutherford Appleton Laboratory is playing a key role in the development of the SPIRE (Spectral and Photometric Imaging REceiver) instrument on the European Space Agency's (ESA) Herschel far infrared space telescope mission due to be launched in 2007. Herschel is part of ESA's Horizons 2000 programme and will be implemented with the collaboration of NASA. Herschel will utilise a super fluid helium cryostat similar to the technology used on the successful ISO mission and will have a lifetime of approximately 3 years.

Prior to the launch of SPIRE, several development models of the instrument will be built which will require testing & qualification in a terrestrial environment. Part of the test & qualification programme will commence in August 2000 at the Rutherford Appleton Laboratory and will require a cryostat to emulate the spacecraft cryogenic environment.

The SPIRE calibration cryogenic system performs a critical role providing the necessary cooling for a low noise receiver instrument. It is vital for successful operation of the instrument that the cryogenic system provides appropriate thermal cooling capacity and stability, mechanical robustness and a high degree of reliability. Furthermore be sufficiently simple to ensure minimum and straightforward instrument integration, operation and maintenance. Further details of the calibration facility requirements and the design concept are given in RD 1 and RD 2.

4 Operation

The cryostat has a requirement to be evacuated to a high level to ensure system efficiency. Before filling the cryogen tanks and cooling the system, the vacuum chamber must be evacuated to $<10^{-6}$mbar. The pumping system must be isolated from the main vacuum chamber by means of a gate valve before filling the cryogen tanks in order to prevent back flow of any lubricants into the main chamber. The gate valve will be re-opened during warm-up.

There will be an initial bakeout of the cryostat at 80ºC for 24 hours before the cryostat is used for instrument testing. It will not be possible to bake the system with the SPIRE instrument in position.

5 Flow Schematics

The following diagram shows the proposed layout of the vacuum system. The lambda point He bath pump system is shown for completeness only.

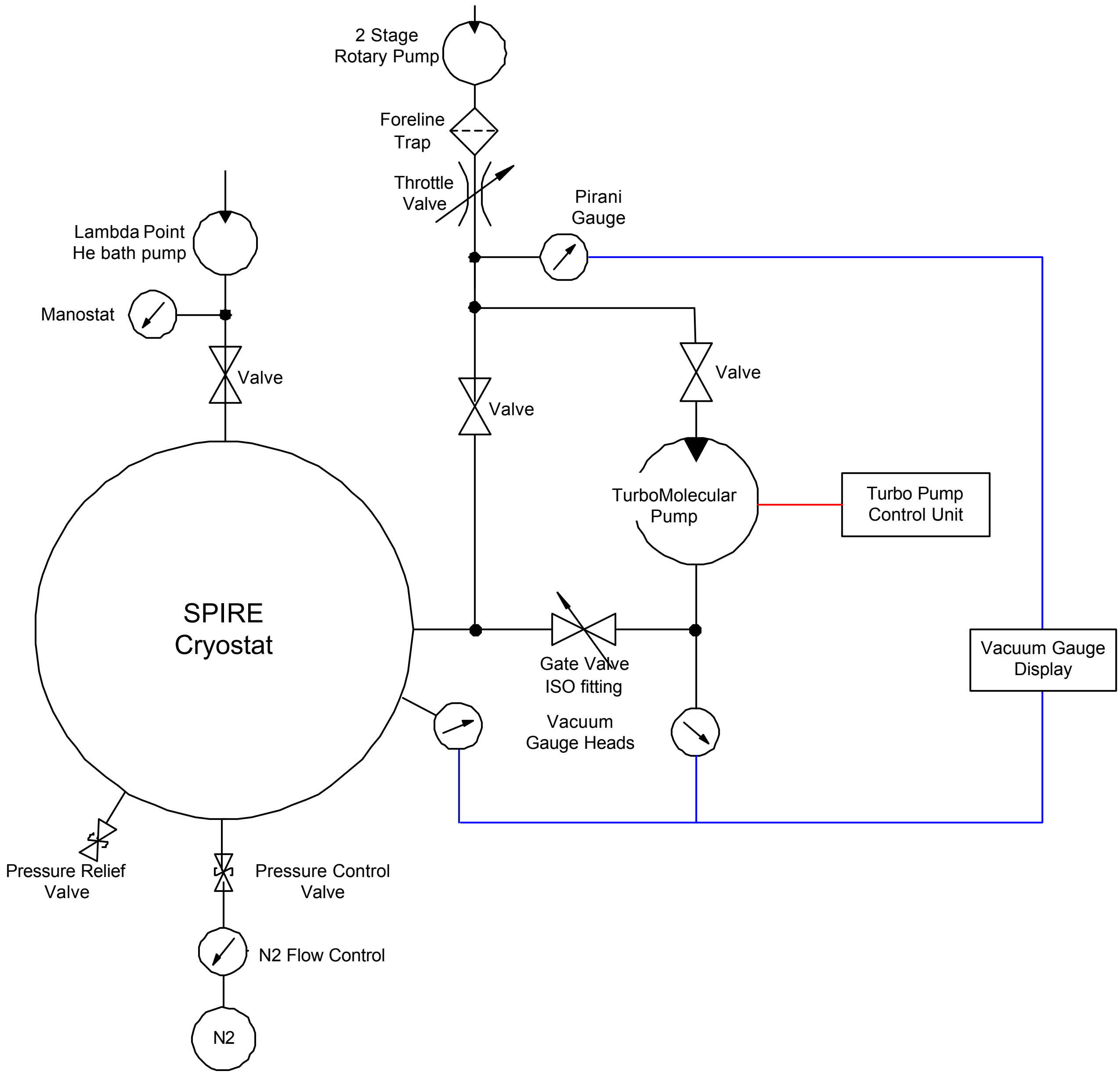

Figure 1: Proposed vacuum system for SPIRE calibration cryostat.

6 System Requirements

6.1 Vacuum level

A vacuum level of must be achieved in 1×10^{-6}mbar prior filling of any cryogen

6.2 Pumping time

The maximum pumping time shall be 24 hours.

6.3 Pumping speed

The maximum pumping rate shall be TBD $Lmin^{-1}$ between atm. and 10^{-1}mbar to protect the instrument filters. These rates also apply for back filling.

6.4 Bakeout

The main chamber & pumping line will be heated to 80°C maximum for 24 hours during cryostat commissioning only. Bakeout is not permitted with the SPIRE instrument in position.

6.5 Vacuum integrity

All vessels must be to leak tight & must not have a leak rate exceeding $<1x10^{-8}$mbar ls^{-1}.

The pumping system must have the ability to connect a mass spectrometer or Residual Gas Analyser without disassembly of the main pumping system.

6.6 Catastrophic vessel failure mode

An over pressure relief valve must be installed on the main vacuum chamber to prevent the chamber exceeding atmospheric pressure either during controlled let-up-to-air, or catastrophic failure of any vessels. The valve must conform to BS5500.

6.7 Vacuum connections

All Vacuum flange connections will be standard NW or ISO fittings.

6.8 Contaminants

The pumping system must be oil free if possible to prevent contamination of the optical surfaces. A fore-line trap will be installed between the 2-stage pump & the cryostat to prevent the back migration of oil vapour.

A gate valve will be installed between the pumping system and cryostat. The valve must be closed before filling the cryogen tanks in order to prevent back flow of any lubricants into the main chamber. The gate valve must automatically close in the event of a failure of the pumping system

A mass spectrometer will be installed during the cryostat commissioning to measure contaminant levels.

6.9 Electromagnetic Interference (EMI)

The SPIRE detectors measure total power and are therefore highly susceptible to any stray electromagnetic radiation. It is therefore essential that the vacuum system, including gauges, pumps, etc.. are isolated from the instrument during testing. This will probably mean that the vacuum system is shut down while the SPIRE instrument is operating.

6.10 Budget constraints

Where possible the most economic selection of components will be made providing this will not compromise the specified requirements and performance.

7 Component specification

A description of the vacuum system components is described bellow. Although all components are not described in detail in the absence of any specification items good vacuum practice will apply.

7.1 Roughing pump

The roughing pump will be of a 2 stage oil sealed rotary vane pump with a minimum pumping speed of approx. $80m^3\ h^{-1}$ The pump will be floor mounted locally to the cryostat on a stainless steel flexible tube. The flange mounting will be of the ISO or NW standard. The pump shall have an oil mist filter to process exhaust gasses. The pump will be suitable for UK power requirements.

7.2 Turbo Molecular pump and controller

The turbo molecular pump will be mounted onto the cryostat on a short manifold. The minimum pumping speed will be N_2 1600 ls^{-1}. This pump shall have > 10000 hours of maintenance free operation, typical of pumps having a magnetic levitating bearing system. The pump shall be oil free to prevent any contamination of the optical surfaces by hydrocarbons. The pump will have an inlet screen for protection. The pump & controller power supply is to be 50/60Hz - 200-240V suitable for UK power requirements. Pump to controller cable will be a minimum of 5m long.

7.3 Backing Pump

RAL will consider the most cost-effective solution that meets the overall system requirements.

7.4 Fore-line trap

The Fore-line or chemical trap is required to prevent the back migration of oil from the roughing pump into the cryostat during prolonged periods of pumping.

7.5 Valves

7.5.1 Gate valve

The valve on the cryostat main evacuation port will be a removable, though not necessarily, automatic gate valve. Ideally the valve should be connected to the turbo-pump control unit so that it can shut down in the event of a pump failure. The flange mounting will be consistent to the turbo molecular pump so as not to impair the pump performance. The valve seal materials may be of viton but must not have a leak rate exceeding $<1x10^{-8}$ mbar ls^{-1}.

7.5.2 Valves

The valves will be manually operated. The flange mounting will be of the ISO KF standard. The valve seal materials may be of viton but must not have a leak rate exceeding $<1x10^{-8}$mbar ls^{-1}.

7.5.3 Throttle valve

The valves indicated on the flow schematic might be 1 single unit, provided the throttle valve can both restrict flow & seal. This valve may be manually operated. The flange mounting will be of the ISO NW standard. The valve seal materials may be of viton but must not have a leak rate exceeding $<1x10^{-8}$mbar ls^{-1}.

7.5.4 Overpressure relief valve

An over pressure relief valve will be integral with the cryostat main vacuum vessel. The valve will activate only when the main vacuum chamber exceeds atmospheric pressure either during controlled let-up-to-air or catastrophic failure of any vessels

7.6 Vacuum measurement and control

7.6.1 Vacuum gauges

The gauge or gauges must have a pressure measurement range from atmosphere to 10^{-7}mbar**.** The flange mounting will be of the ISO KF standard. The vacuum gauges must be mounted in a vertical orientation with the connection to the vacuum base. The vacuum gauge must be compatible with the vacuum gauge display.

7.6.2 Vacuum gauge display

The vacuum gauge display or displays will be a suitable for panel or bench mounting. The displays will be required to have a 0-10v output for external monitoring. The displays will be suitable for UK power requirements. The gauge to display cables will be approx. 3m.

8 Acceptance Testing

8.1 Leak testing

The pumping system must have the capability to connect a mass spectrometer or Residual Gas Analyser to leak rates & monitor partial pressures of contaminants in the chamber during commissioning. This is not required for the actual calibration tests over pressure valve

8.2 Contaminate testing

The pumping system must have the capability to connect a mass spectrometer or Residual Gas Analyser to leak rates & monitor partial pressures of contaminants in the chamber during commissioning.