**S-AA-M-31**

# Cryogenic Target Handling System Operations Manual Volume IV–CTHS Description

# Chapter 3: Room 157 Overview

## Table of Contents

# Chapter 3
# Room 157 Overview

## 3.1 INTRODUCTION

Room 157 (Fig. 3.1-1) is located on the south side of the main lobby of LLE. The room houses the target-filling and characterization subsystems of the OMEGA Cryogenic Target Handling System and the Tritium Fill Station. This chapter introduces the room and provides details about supporting facilities that are not included in other chapters.

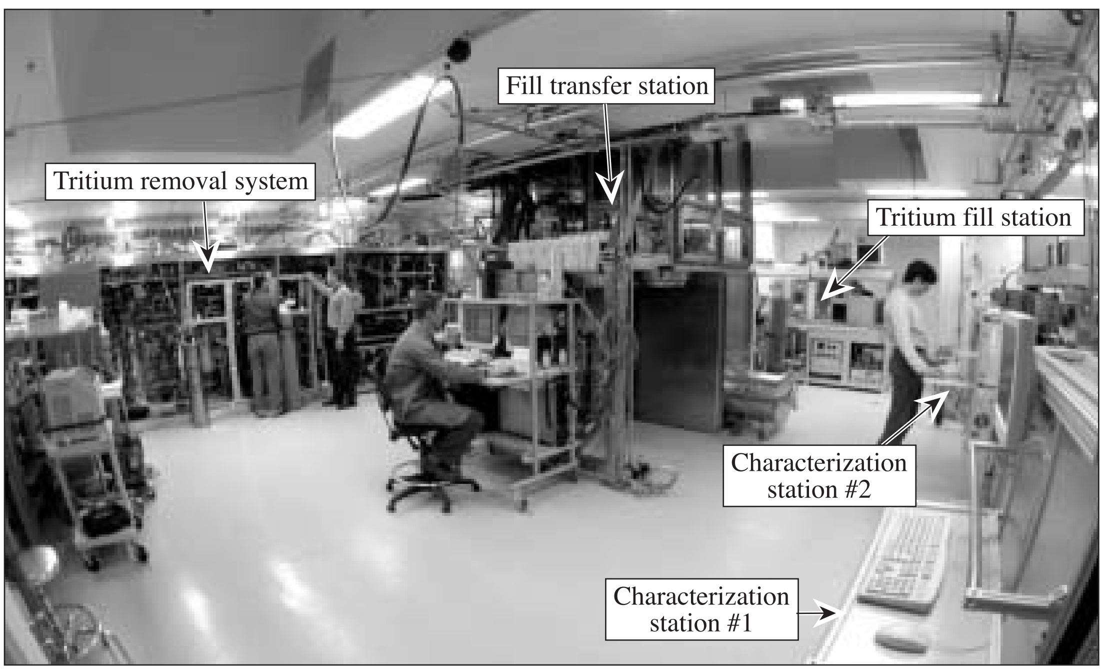


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Figure 3.1-1
Photograph of Room 157.

### 3.1.1 Floor Plan

The floor plan in Fig. 3.1-2 shows the major equipment in Room 157. The room is approximately 1250 sq ft and has a small anteroom for entry that is approximately 8 ft wide by 12 ft long. Two cutouts in the ceiling accommodate the FTS cryostat domes.

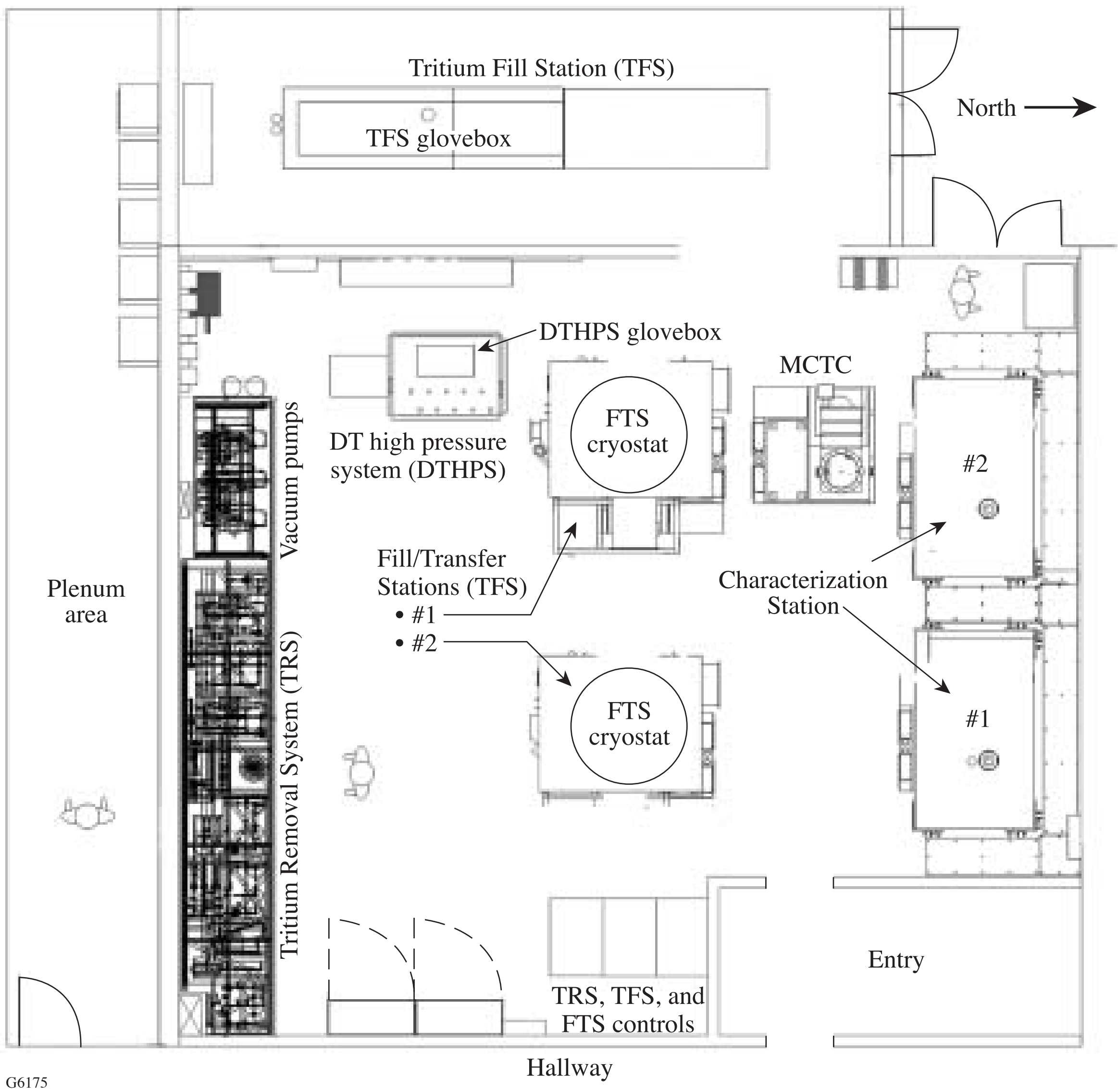


Figure 3.1-2
Room 157 floor plan.

### 3.1.2 Special Considerations for Tritium

Room 157 is used to prepare room-temperature and cryogenic targets filled with deuterium or a mixture of deuterium and tritium. The room has been constructed and is operated to ensure that it is isolated from the remainder of the LLE building in the event of a tritium release. The ceiling panels are made of nonporous metal and are caulked against their frame to make a leak-tight surface. The walls are painted with a nonporous paint. The floor is coated with a tough epoxy that forms a skirt around the wall to inhibit the spread of contamination and facilitate decontamination.

Normal entry into the room is made through a double-door passthrough on the east side. Only one of the double doors can be opened at a time. This maintains the negative pressure that is set up for the room in the HVAC system and prevents tritium gas from escaping in the event of a large release. Access is controlled by key card. Two other doors are for emergency exit only.

### 3.1.3 Major Equipment in Room 157

The major equipment items that are installed in Room 157 are discussed in detail in other chapters of the manual. They are as follows:

- the Tritium Fill Station (TFS)—Chap. 5,
- the DT High-Pressure System (DTHPS)—Chap. 6,
- the Fill and Transfer Stations (FTS)—Chap. 7,
- the Characterization Stations (CS)—Chap. 8, and
- the Room 157 Tritium Recovery System (TRS)—Chap. 12.

## 3.2 VACUUM MANIFOLD SUBSYSTEM

The Room 157 Vacuum Manifold Subsystem (VMS) was designed and built as a part of the Room 157 TRS. It is a flexible arrangement of valves, manifolds, and pumps that connects to all the vacuum volumes in the room. The VMS provides vacuum services to these "customer" volumes and delivers the exhausts to the remainder of the TRS. As illustrated in Fig. 3.2-1, the normal configuration of the VMS provides four separate, pumped manifolds that are used to service groups of customer volumes on the basis of their specific needs. (Figure 3.2-2 shows more details of the subsystem.)

The customer volumes can be simple plenums, such as a pass-through, or volumes, such as the interior of the FTS, that are maintained at high vacuum by a dedicated turbo pump. In the latter case, the VMS functions as the roughing and turbo backing system.

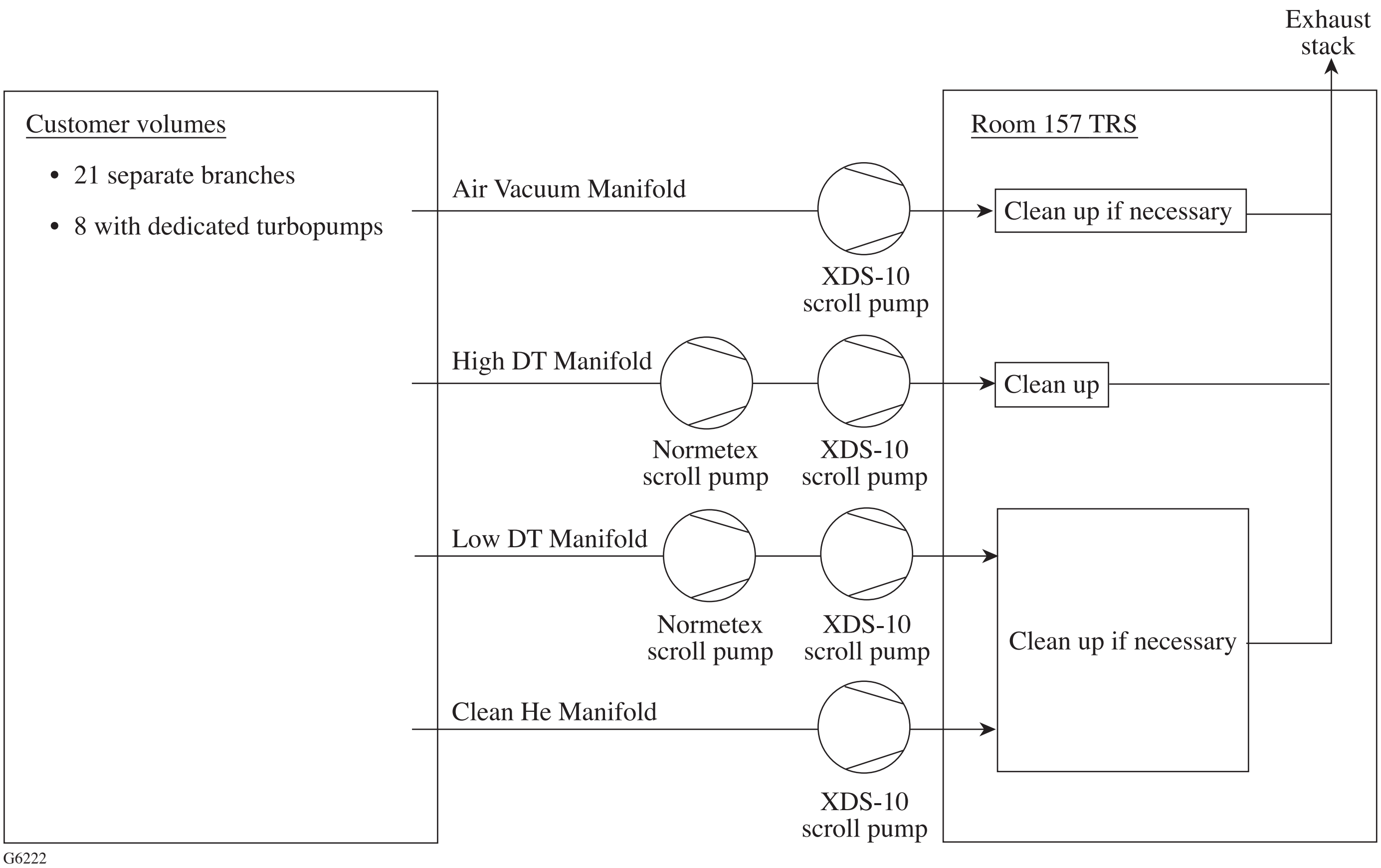


Figure 3.2-1
Simplified overview of the Vacuum Manifold Subsystem in its normal configuration.

The VMS helps to thermally isolate the components from the room-temperature environment so that cryogenic temperatures can be achieved by evacuating insulating volumes. Operating at high vacuum minimizes conduction and convection within enclosed spaces and greatly improves the performance of the insulation systems. A second reason that vacuum technology is critical to the CTHS is that much of the equipment is operated at temperatures that cause the primary constituents of air to condense and freeze. Air must be excluded from those regions to prevent a buildup of ice.

The Vacuum Manifold System is comprised of four vacuum manifolds that handle four different types of vacuum gas streams.

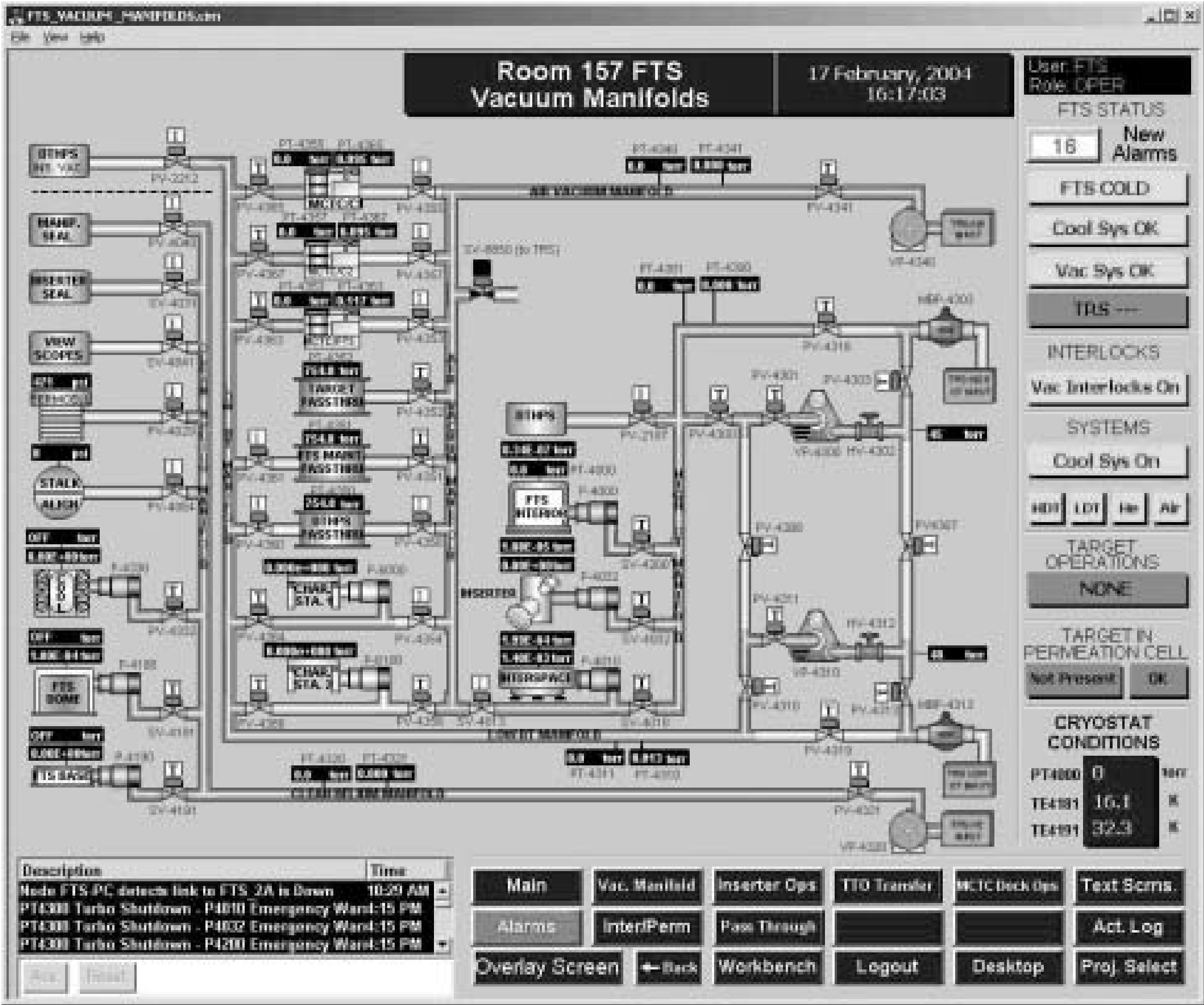


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Figure 3.2-2
Room 157 Vacuum Manifold.

*Air Vacuum Manifold*

This manifold is used to pump equipment that is exposed to room air in normal operation. It is connected to nearly every vacuum space. The exhaust gas streams are sent to the air vacuum cleanup system in the TRS.

*Clean Helium Manifold*

This manifold is used to maintain vacuum spaces not exposed to air or tritium. It is connected to the base, dome, and cooling module spaces as well as to several small pump-outs. These include the permeation cell sealing gas, stalk aligner, borescope, manipulator seal, and inserter rotary seal. The clean helium manifold is also used to pump out the helium recirculation system piping during maintenance. The clean helium stream will usually be discharged directly to stack; however, if tritium is detected in the stream, it is diverted to the TRS and processed before being discharged to the stack.

*Low-DT Manifold*

This manifold is used to maintain vacuum spaces that contain no air and are expected to experience only low levels of tritium. These include the MCTC's, the characterization station chambers, and all glovebox pass-through chambers.

*High-DT Manifold*

This manifold is used to maintain vacuum spaces that contain no air and are expected to experience significant levels of tritium. These spaces include the FTS inserter and interior spaces, the FTS-MCTC interspace, and the DTHPS process piping.

### 3.2.1 CTHS Vacuum Pumps

The four types of CTHS vacuum pumps are described below. These pumps are all "dry" pumps in that no sealants or lubricants are employed.

#### 3.2.1.1 Mekanor 9 cfm Normetex

These all-stainless-steel, dry scroll pumps from the French company Mekanor are hand-built pumps that feature extremely tight tolerances between the scroll and stator. These pumps require backing pumps since they cannot discharge to atmospheric pressure. The MB-601 pumps, below, are used in series with these pumps to provide backing. The Normetex pumps can achieve high vacuum ($4 \times 10^{-3}$ Torr). The maximum discharge rate is 9 scfm at 10 Torr.

#### 3.2.1.2 Senior Flexonics Metal Bellows MB-601

In these all-stainless-steel, dual-acting bellows pumps, a pair of stainless-steel bellows are compressed and expanded in synchronous fashion; metal reed valves control the flow of gas into and out of each bellows. These pumps can achieve about 60-Torr vacuum. The pumps can be plumbed in series for vacuum operation or in parallel for high throughput. The maximum flow rate that can be achieved by these pumps (plumbed in parallel) is about 5 cfm.

#### 3.2.1.3 BOC Edwards XDS-10

Like the Normetex pumps, these are also dry scroll pumps. Their safe operating range is much greater than that of the Normetex, but they cannot tolerate high levels of tritium owing to the presence of elastomers. The XDS pumps require no backing pump since they can operate at atmospheric outlet pressure. The maximum flow rate of these pumps is approximately 7 cfm.

#### 3.2.1.4 Edwards Turbo Pumps (EXT 250, EXT 250M, EXT 255H, EXT 70)

These all-stainless-steel, turbo-molecular pumps can achieve extremely high vacuum. They require a backing pump and have an upper operating suction pressure limit of 0.3 Torr. These pumps can generate vacuum down to about $1 \times 10^{-6}$ Torr. They are located directly adjacent to the vacuum spaces that they serve, rather than in the VMS pump enclosure, and have external controllers. These pumps may be found on the base, dome, cooling module, and interspace volumes on the FTS. They are also located on all MCTC's and on each Characterization Station. Several sizes of these pumps exist in the system.

### 3.2.2 Vacuum Manifold Operating Considerations

The three pumping configurations that exist in the VMS are diagrammed in Fig. 3.2-3. The major operating considerations for each are introduced in this section.

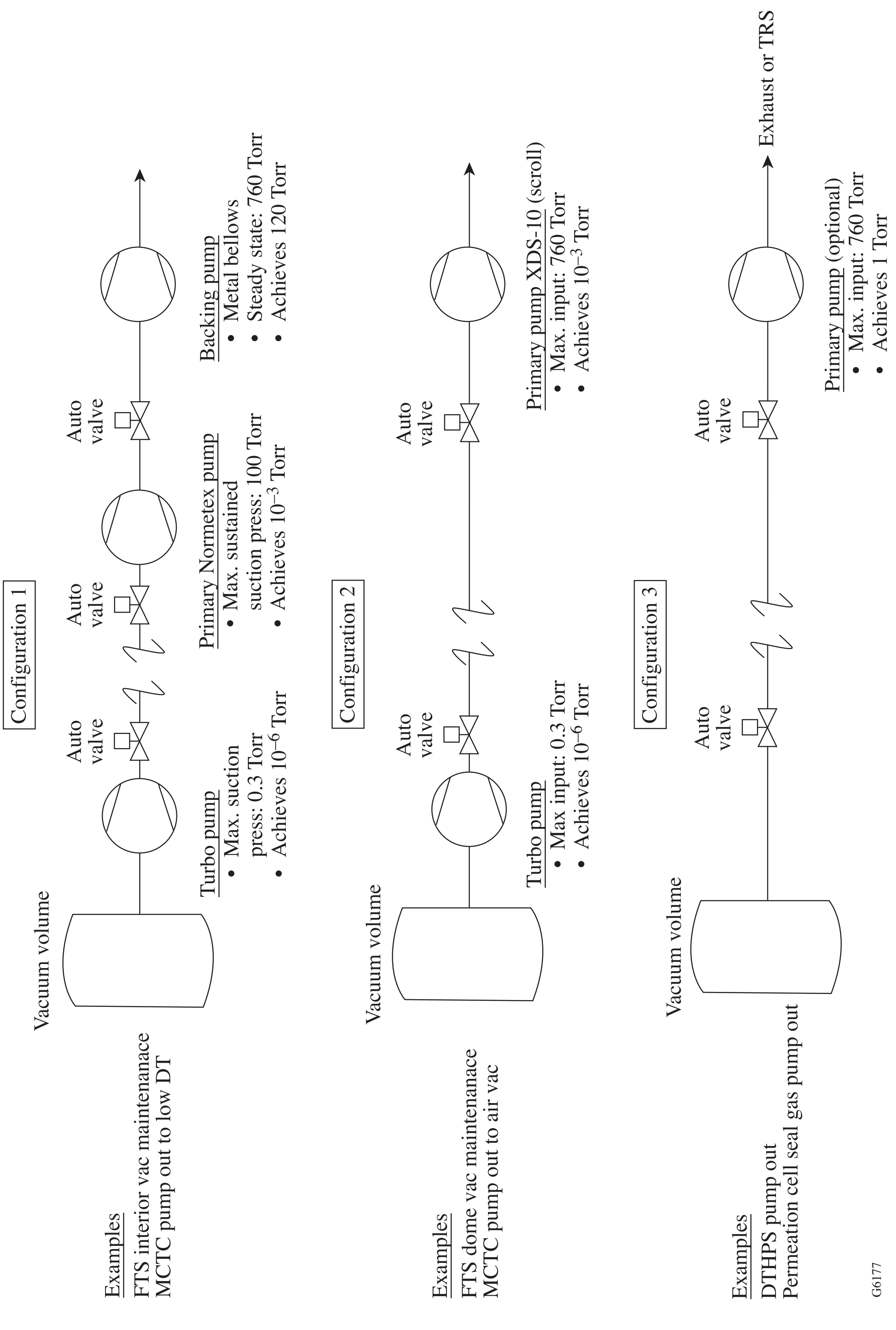


Figure 3.2-3
Three component configurations typical of those that make up the CTHS Vacuum Manifold.

*Configuration 1—Turbo Pump Backing with Normetex Scroll Pump*

In this configuration, high vacuum is established and maintained in the customer volume by operating three vacuum pumps in series. Figure 3.2-4 illustrates the overlapping operating ranges of the pumps and shows two limit parameters that are implemented in the PLC controls.

The metal bellows pump is turned on first to pump the upstream volume down from atmospheric pressure. The Roughing Limit (Rlimit) is set at the lower end of the bellows pump operating range within the upper end of the Normetex pump operating range. The Normetex pump is turned on when the pressure is below Rlimit. If Rlimit is set too high, the Normetex pump will overheat. If it is too low, the bellows pump will bottom out before the Normetex pump is started.

When the system is operating correctly, the Normetex pump will pump the upstream volume down into the operating range of the turbo pump that is close coupled to the customer volume. Backing Limit 1 (B1limit) is set at the lower end of the Normetex pump operating range within the upper end of turbo pump operating range. The turbo pump is turned on when the pressure is below B1limit. If B1limit is set too high, the turbo pump will overheat. If it is too low, the Normetex pump will bottom out before the turbo pump is started.

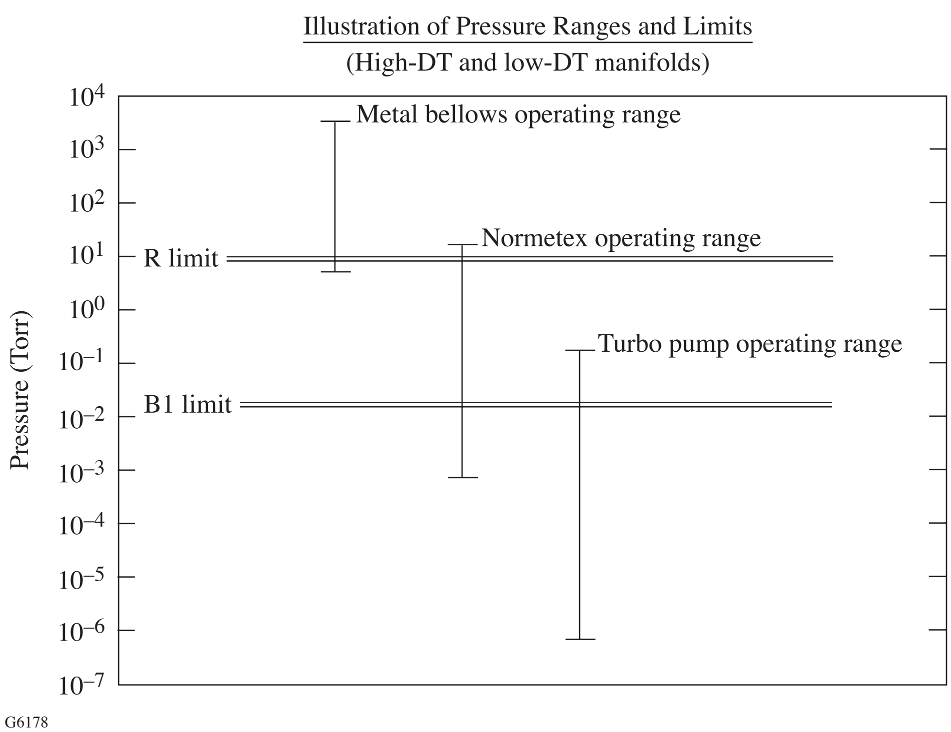


Figure 3.2-4
Vacuum Manifold Backing Limit 1.

*Configuration 2—Turbo Pump Backing with XDS-10 Scroll Pump*

In this configuration, high vacuum is established and maintained in the customer volume by its dedicated turbo pump and one of the scroll pumps. Figure 3.2-5 illustrates the overlapping operating ranges of the pumps and shows the limit parameter that is implemented in the PLC controls.

The metal bellows pump is turned on first to pump the upstream volume down from atmospheric pressure. Backing Limit 2 (B2limit) is set at the lower end of the XDS-10 scroll pump operating range within the upper end of the turbo pump operating range. The turbo pump is turned on when the pressure is below B2limit. If B2limit is set too high, the turbo pump will overheat. If it is too low, the scroll pump will bottom out before the turbo pump is started.

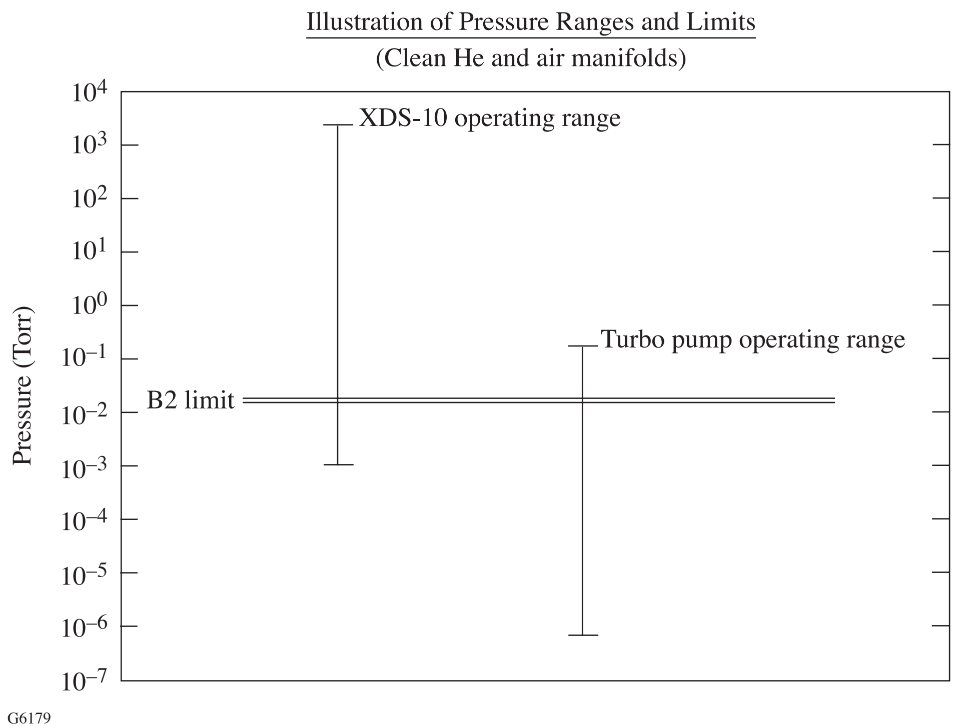


Figure 3.2-5
Vacuum Manifold Backing Limit 2.

*Configuration 3—Customer Volume Without a Dedicated Turbo Pump*

In this configuration, the required vacuum is established and maintained in the customer volume by one of the VMS vacuum pumps operating alone.

### 3.2.3 Pump Enclosure

Much of the CTHS Vacuum Manifold System for FTS#1 (including valves, pumps, and instrumentation) is located in the Room 157 TRS Pump Enclosure (Fig. 3.2-6). Gas from the CTHS equipment enters through four feedthroughs at the top of the enclosure. The effluent from the four manifold pumps is then directed through the left-side wall and into the remainder of the TRS .

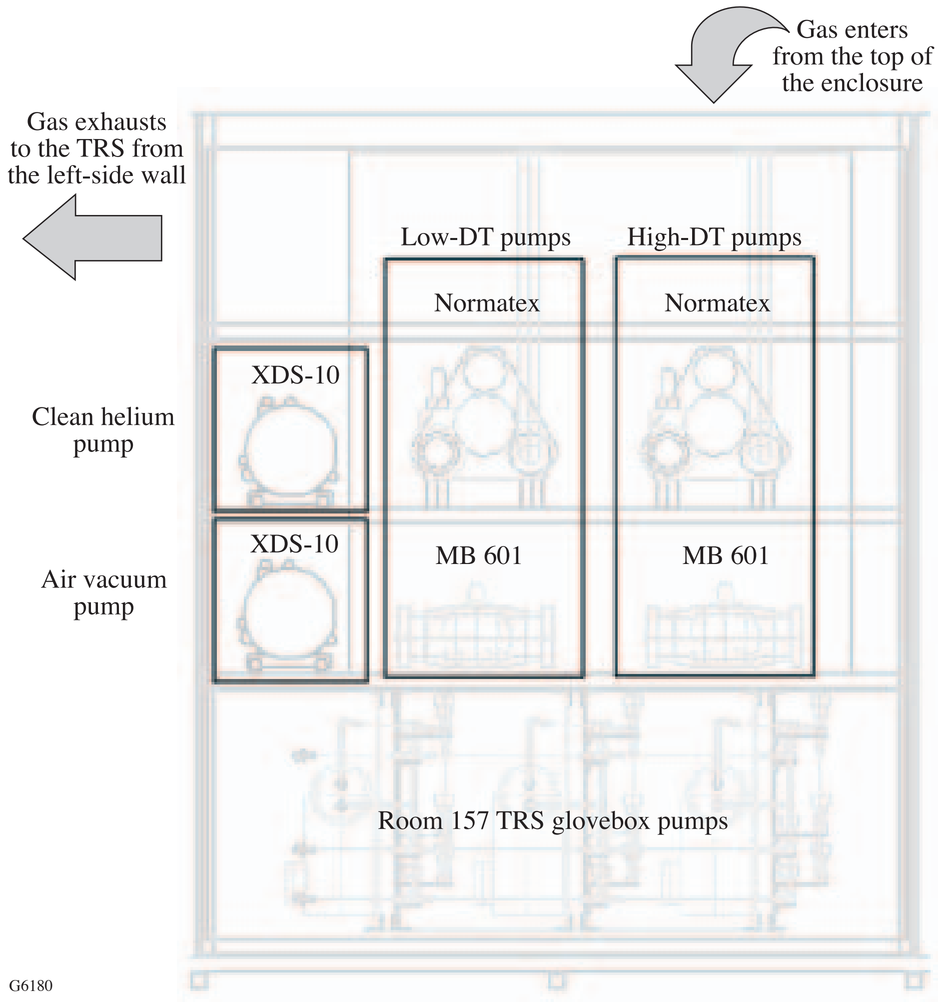


Figure 3.2-6
Pump Enclosure showing the location of the CTHS vacuum pumps.

## 3.3 LIQUID NITROGEN SUPPLY AND VENT SYSTEM

The FTS cryostats are cooled with liquid nitrogen ($LN_2$) provided by the LLE facility supply via a dedicated phase separator. Vacuum-insulated lines and valves distribute the $LN_2$ from the separator to the FTS elements. The cold, gaseous nitrogen produced by the element cooling process is carried away from the cold areas in a separate vacuum-insulated circuit. Insulation vacuum for this system is provided by a set of dedicated vacuum pumps.

### 3.3.1 Outside $LN_2$ Tank

A large 2500-gal $LN_2$ tank supplies $LN_2$ to Room 157 and other systems at LLE. The tank contains about a 3-day supply for the entire facility. The Room 157 equipment is connected via a $LN_2$ Phase Separator that is installed in the Plenum area.

### 3.3.2 $LN_2$ Phase Separator

Liquid nitrogen is supplied to Room 157 via the Vacuum Barrier Corp. Liquid Nitrogen Phase Separator. This separator is a 6.5-gal reservoir (Fig. 3.3-1) that provides liquid nitrogen to the supply lines via gravity feed. A separate controller maintains the level in the reservoir. The reservoir is vacuum

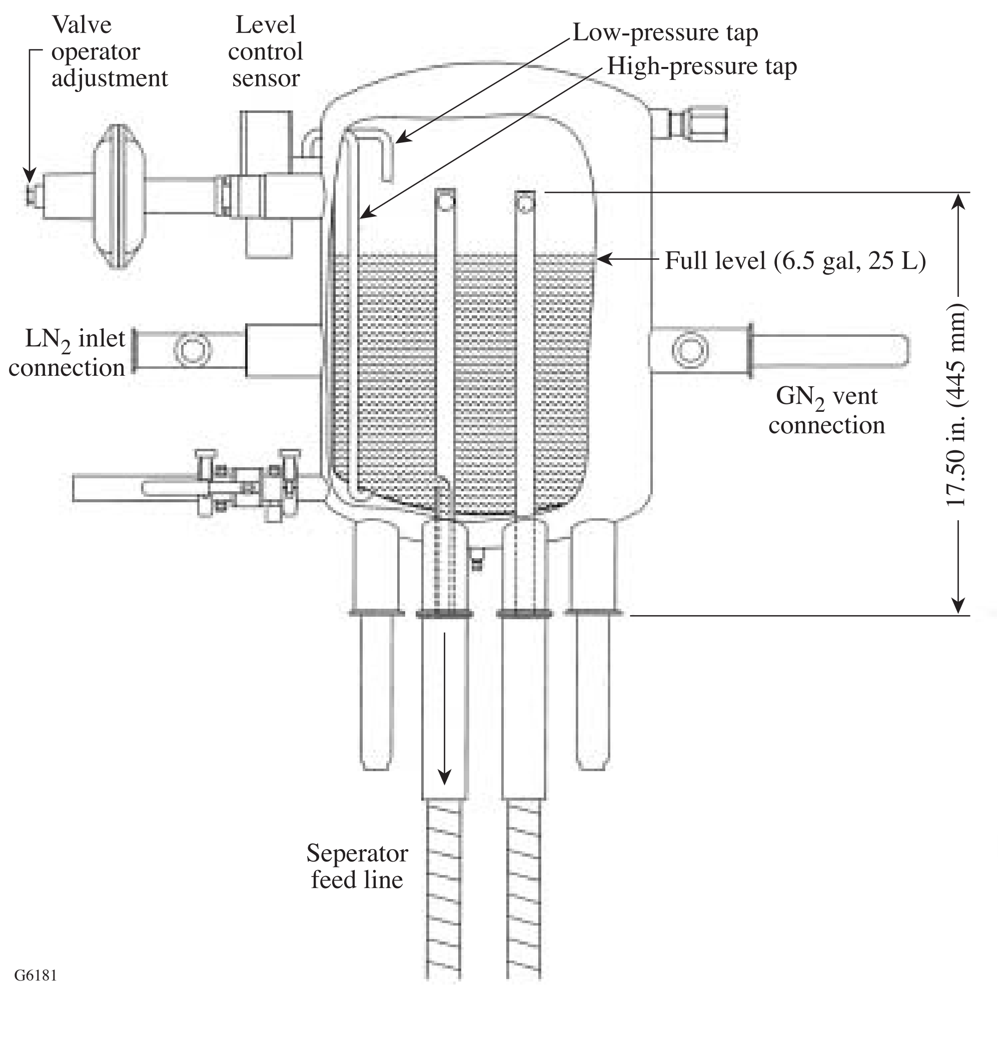


Figure 3.3-1
LN2 Phase Separator.

jacketed, and a vacuum is constantly maintained. Nitrogen vapor is automatically vented from the reservoir as it collects in the head space above the liquid. The separator is mounted near the ceiling of the Plenum area because of the need to have the reservoir as high as possible for gravity flow.

### 3.3.3 $LN_2$ Supply Hoses and Valves

The two hoses that supply the FTS are vacuum-insulated hoses from Vacuum Barrier Corporation. The type of hose employed, called SEMAFLEX, consists of a central tube through which $LN_2$ flows, surrounded by a vacuum shell. The SEMAFLEX lines terminate at vacuum-jacketed, pneumatically operated valves that control the flow of $LN_2$ into the base, dome, and cooling module.

These hoses pass $LN_2$ from the reservoir in the Plenum area through the wall into Room 157 and terminate at the (1) FTS base and dome, (2) FTS cooling module, (3) TRS cryocooler, and (4) TFS target storage.

### 3.3.4 $LN_2$ Vent System

The base, dome, and cooling module $LN_2$ reservoirs are vented via vacuum-insulated hoses. The vent hoses are connected to a manifold that discharges the nitrogen into a ceiling exhaust vent. At the end of the manifold, the tubing splits, sending flow to dual in-line heaters to warm the $LN_2$ up to room temperature prior to discharge. The controller is located on the wall in the southwest corner of the lab. Another heater on the vent line is used to maintain the temperature of an O-ring seal installed between the terminus of the vacuum insulated piping and the manifold. It is important to keep this O ring warm in order to maintain the vacuum in the supply/vent hose.

### 3.3.5 $LN_2$ System Vacuum Pumps

Two VBC-11 vacuum pumps (Fig. 3.3-2) are used to maintain the vacuum spaces within the supply and vent hoses at a pressure of about 10 Torr. If the $LN_2$ hoses lose vacuum, significant condensation will form on the outside of the hoses and fittings.

### 3.3.6 $LN_2$ Level Control within the FTS Cryostat

Individual level controllers from JC Controls maintain the level of $LN_2$ within the base, dome, and cooling module reservoirs. These devices employ a thermal conductivity probe that detects the presence of $LN_2$. The controller periodically (determined by a timer) opens the vacuum-jacketed coolant supply valve on the $LN_2$ fill line. The line stays open until the sensor detects that the reservoir space is full.

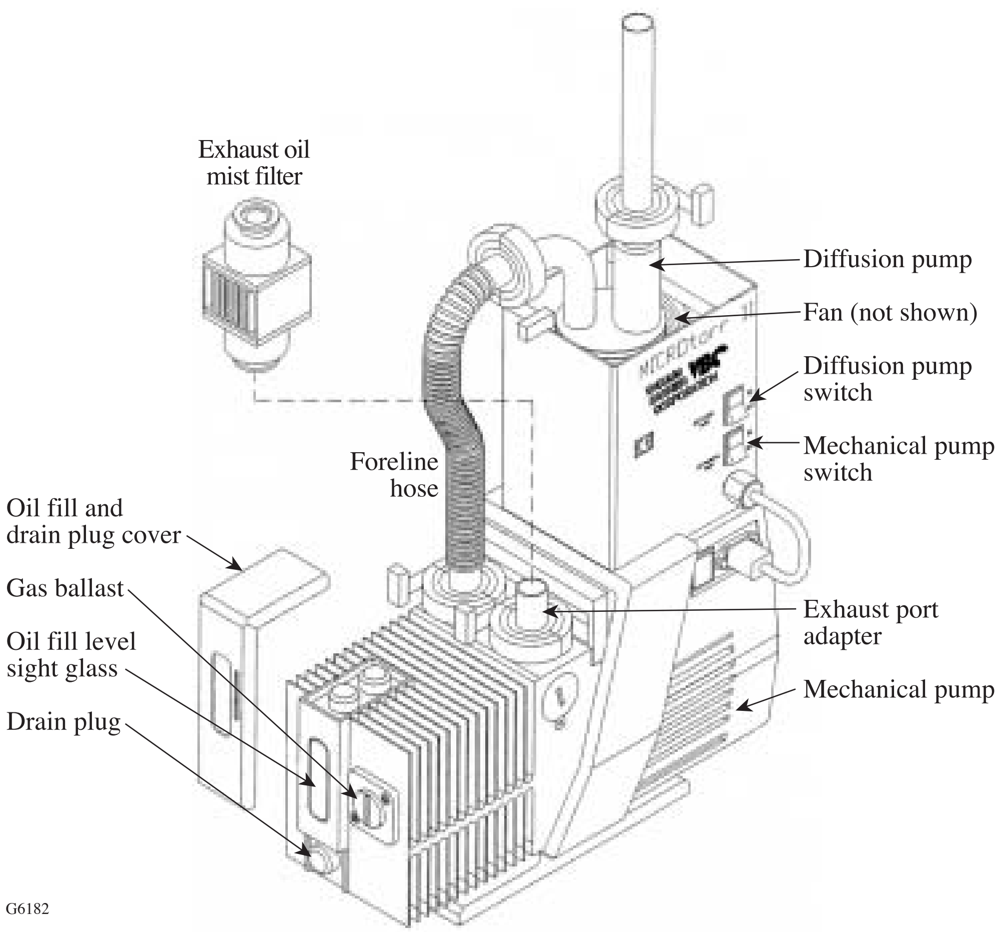


Figure 3.3-2
Vacuum Pump for use with the $LN_2$ supply system (Vacuum Barrier Corporation MICROtorr-11).

## 3.4 OTHER UTILITIES

### 3.4.1 Compressed Air System

An air compressor supplies dry, compressed 120-psig air to Room 157. The compressed air is used to supply the air castors that support the Moving Cryostat Transport Carts when they are moved between locations. Compressed air is available in the room (and outside in the hallway) through a compressed air line that is wound on a spooler. The spooler and power switch to control the compressor operation are located near the northwest corner of the room.

### 3.4.2 Helium and Nitrogen Gas Supply

*Helium Gas*

Four types of compressed helium are available in Room 157: high-pressure (6000-psig) helium for permeation cell sealing; ultrahigh-purity (99.9995%) helium for FTS exchange gas; 120-psig, high-purity (99.997%) helium for activating valves; and for glovebox gas.

The helium is supplied by an array of A-size bottles located outside Room 157 in the hallway leading to the west loading dock. Each type of helium supply has its own piping manifold mounted near the bottle to control pressure and flow.

*Nitrogen Gas*

In addition to serving as a source of liquid nitrogen, LLE's 2500-gal $LN_2$ station functions to vaporize the liquid and provide pure, dry, nitrogen gas for laboratory uses. The station provides Room 157 with 80-psig nitrogen.

### 3.4.3 Room HVAC System

The room is supplied with 2000 cfm of conditioned air by a duct off the main air supply conduit for the first floor of LLE. The air enters the room at three locations in the ceiling: two in the main room and one in the anteroom. The room is exhausted by a dedicated roof fan that provides approximately 2200 cfm of exhaust flow. The exhaust duct to the roof is above the area just south of the FTS and east of the DTHPS. The exhaust duct has two intakes: a vertical grill in the eastern "top hat" of the room and a horizontal grill between the two top hats.

For added safety, the room pressure is kept negative relative to areas outside the room and is monitored by a differential pressure manometer located in the double-door passthrough. Dampers in the air supply ducting are manually adjusted to maintain the negative pressure.

In addition to the room air supply and exhaust, a separate stand-alone room recirculating air cooling system is located in Room 157 to maintain room temperature.

### 3.4.4 Room Tritium Alarm System

A tritium monitor in the anteroom samples the room air continuously (via a pump). The Femto-Tech tritium monitor (Fig. 3.4-1) is comprised of an ion chamber for detection and a U24-D Control Unit for system control and display functions. This system measures tritium activity directly using an 1800-cc active-volume ion gauge capable of resolving tritium to $1 \times 10^{-7}$ $\mu$Ci/ml with an accuracy of ±5%. The ion gauge is not gamma-compensated. The system has low and high alarms set at 10 and 20 $\mu$Ci/M$^3$, respectively.

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Figure 3.4-1
The tritium monitor makes an audible alarm when the tritium concentration in the room exceeds 20 $\mu$Ci/m$^3$, the maximum limit allowable for workers to remain in the room.