GE Medical Systems

# Technical Publications

## Direction 2231934

**Revision 6**

# GE 0.7T Open*Speed* Magnet and Cryogens Subsystem



**Operating Documentation**

# DAMAGE IN TRANSPORTATION

All packages should be closely examined at time of delivery. If damage is apparent, have notation "**damage in shipment**" written on **all** copies of the freight or express bill **before** delivery is accepted or "signed for" by a General Electric representative or a hospital receiving agent. Whether noted or concealed, damage **MUST** be reported to the carrier **immediately** upon discovery, or in any event, within **14** days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this **14** day period.

Immediately complete **"Damage Loss Claim Form"** after damage is found. Form is available via MS Exchange Mail at **Outlook/Public Folder/All Public Folders/Medical Systems/!Global Initiatives/Information Management/Forms/Common Forms/Damage Loss Claim Form.** Send completed form to e-mail address listed on form.

For more information about the Transportation Claim Procedure, access the GE Medical Systems Intranet and enter the following URL address: **ftp://3.87.40.2/ globepro/qualsys/Docs/190016MF.PDF**

REV 0, 11/17/2000

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**WARNING**

- **THIS SERVICE MANUAL IS AVAILABLE IN ENGLISH ONLY.**
- **IF A CUSTOMER'S SERVICE PROVIDER REQUIRES A LANGUAGE OTHER THAN ENGLISH, IT IS THE CUSTOMER'S RESPONSIBILITY TO PROVIDE TRANSLATION SERVICES.**
- **DO NOT ATTEMPT TO SERVICE THE EQUIPMENT UNLESS THIS SERVICE MANUAL HAS BEEN CONSULTED AND IS UNDERSTOOD.**
- **FAILURE TO HEED THIS WARNING MAY RESULT IN INJURY TO THE SERVICE PROVIDER, OPERATOR OR PATIENT FROM ELECTRIC SHOCK, MECHANICAL OR OTHER HAZARDS.**

**AVERTISSEMENT**

- **CE MANUEL DE MAINTENANCE N'EST DISPONIBLE QU'EN ANGLAIS.**
- **SI LE TECHNICIEN DU CLIENT A BESOIN DE CE MANUEL DANS UNE AUTRE LANGUE QUE L'ANGLAIS, C'EST AU CLIENT QU'IL INCOMBE DE LE FAIRE TRADUIRE.**
- **NE PAS TENTER D'INTERVENTION SUR LES ÉQUIPEMENTS TANT QUE LE MANUEL SERVICE N'A PAS ÉTÉ CONSULTÉ ET COMPRIS.**
- **LE NON-RESPECT DE CET AVERTISSEMENT PEUT ENTRAÎNER CHEZ LE TECHNICIEN, L'OPÉRATEUR OU LE PATIENT DES BLESSURES DUES À DES DANGERS ÉLECTRIQUES, MÉCANIQUES OU AUTRES.**

**WARNUNG**

- **DIESES KUNDENDIENST-HANDBUCH EXISTIERT NUR IN ENGLISCHER SPRACHE.**
- **FALLS EIN FREMDER KUNDENDIENST EINE ANDERE SPRACHE BENÖTIGT, IST ES AUFGABE DES KUNDEN FÜR EINE ENTSPRECHENDE ÜBERSETZUNG ZU SORGEN.**
- **VERSUCHEN SIE NICHT, DAS GERÄT ZU REPARIEREN, BEVOR DIESES KUNDENDIENST-HANDBUCH NICHT ZU RATE GEZOGEN UND VERSTANDEN WURDE.**
- **WIRD DIESE WARNUNG NICHT BEACHTET, SO KANN ES ZU VERLETZUNGEN DES KUNDENDIENSTTECHNIKERS, DES BEDIENERS ODER DES PATIENTEN DURCH ELEKTRISCHE SCHLÄGE, MECHANISCHE ODER SONSTIGE GEFAHREN KOMMEN.**

**AVISO**

- **ESTE MANUAL DE SERVICIO SÓLO EXISTE EN INGLÉS.**
- **SI ALGÚN PROVEEDOR DE SERVICIOS AJENO A GEMS SOLICITA UN IDIOMA QUE NO SEA EL INGLÉS, ES RESPONSABILIDAD DEL CLIENTE OFRECER UN SERVICIO DE TRADUCCIÓN.**
- **NO SE DEBERÁ DAR SERVICIO TÉCNICO AL EQUIPO, SIN HABER CONSULTADO Y COMPRENDIDO ESTE MANUAL DE SERVICIO.**
- **LA NO OBSERVANCIA DEL PRESENTE AVISO PUEDE DAR LUGAR A QUE EL PROVEEDOR DE SERVICIOS, EL OPERADOR O EL PACIENTE SUFRAN LESIONES PROVOCADAS POR CAUSAS ELÉCTRICAS, MECÁNICAS O DE OTRA NATURALEZA.**

**ATENÇÃO**

- **ESTE MANUAL DE ASSISTÊNCIA TÉCNICA SÓ SE ENCONTRA DISPONÍVEL EM INGLÊS.**
- **SE QUALQUER OUTRO SERVIÇO DE ASSISTÊNCIA TÉCNICA, QUE NÃO A GEMS, SOLICITAR ESTES MANUAIS NOUTRO IDIOMA, É DA RESPONSABILIDADE DO CLIENTE FORNECER OS SERVIÇOS DE TRADUÇÃO.**
- **NÃO TENTE REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.**
- **O NÃO CUMPRIMENTO DESTE AVISO PODE POR EM PERIGO A SEGURANÇA DO TÉCNICO, OPERADOR OU PACIENTE DEVIDO A‘ CHOQUES ELÉTRICOS, MECÂNICOS OU OUTROS.**

**AVVERTENZA**

- **IL PRESENTE MANUALE DI MANUTENZIONE È DISPONIBILE SOLTANTO IN INGLESE.**
- **SE UN ADDETTO ALLA MANUTENZIONE ESTERNO ALLA GEMS RICHIEDE IL MANUALE IN UNA LINGUA DIVERSA, IL CLIENTE È TENUTO A PROVVEDERE DIRETTAMENTE ALLA TRADUZIONE.**
- **SI PROCEDA ALLA MANUTENZIONE DELL’APPARECCHIATURA SOLO DOPO AVER CONSULTATO IL PRESENTE MANUALE ED AVERNE COMPRESO IL CONTENUTO.**
- **NON TENERE CONTO DELLA PRESENTE AVVERTENZA POTREBBE FAR COMPIERE OPERAZIONI DA CUI DERIVINO LESIONI ALL’ADDETTO ALLA MANUTENZIONE, ALL’UTILIZZATORE ED AL PAZIENTE PER FOLGORAZIONE ELETTRICA, PER URTI MECCANICI OD ALTRI RISCHI.**

**警告**

・このサービスマニュアルには英語版しかありません。
・ＧＥＭＳ以外でサービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
・このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないで下さい。
・この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

**注意:**

- 本维修手册仅存有英文本。
- 非 GEMS 公司的维修员要求非英文本的维修手册时，客户需自行负责翻译。
- 未详细阅读和完全了解本手册之前，不得进行维修。
- 忽略本注意事项会对维修员，操作员或病人造成触电，机械伤害或其他伤害。

# SAFETY ALERT USAGE

**CAUTION**

**“A ’CAUTION’” Safety Alert is “used to identify conditions or actions for which a potential hazard may exist which will or can cause minor personal injury or property damage if the instructions are ignored.”***

**WARNING!**

**“A ’WARNING’” SAFETY ALERT IS “USED TO IDENTIFY CONDITIONS OR ACTIONS FOR WHICH A SPECIFIC HAZARD IS KNOWN TO EXIST WHICH MAY CAUSE SEVERE PERSONAL INJURY, DEATH OR SUBSTANTIAL PROPERTY DAMAGE IF THE INSTRUCTIONS ARE IGNORED.”***

**DANGER!!**

**“A ’DANGER’” SAFETY ALERT IS “USED TO IDENTIFY CONDITIONS OR ACTIONS FOR WHICH A SPECIFIC HAZARD IS KNOWN TO EXIST WHICH WILL CAUSE SEVERE PERSONAL INJURY OR SUBSTANTIAL PROPERTY DAMAGE IF THE INSTRUCTIONS ARE IGNORED.”***

* Direction 46–015099, MR Style Guide.

# DIRECTION 2231934 APPLICATION

Direction 2231934 covers the set-up, commissioning and service of GE Superconducting Magnet Model 0.7T Open*Speed*.

This magnet has superconducting coils immersed in a liquid helium vessel which is surrounded by an insulating cryostat. The coils are ramped to a field strength of 0.7 Tesla at a nominal, continuous coil current of 760 amperes. Once the magnet is ramped, no external power is required to maintain the field.

The magnet is used in Magnetic Resonance Imaging ( MRI ) systems and is designated as Class I equipment per IEC ( International Electrical Code ) Standard 60601. MR system components and connections are covered in the MR Systems ( Signa ) Pre-Installation manual.

# REVISION HISTORY

| REV | DATE | PCN | PRIMARY REASON FOR CHANGE |
|---|---|---|---|
| A | Feb. 9, 2000 | | A Release |
| B | Apr. 14, 2000 | | |
| 0 | Aug. 25, 2000 | | |
| 1 | Nov. 29, 2000 | | Addition of Safety Warnings and Safety Requirements list; new Vent Matrix |
| 2 | March 29, 2001 | | Safety refinements; Shim procedure deleted in favor of separate Shimming document; updating Renewal Parts |
| 3 | May 30, 2001 | | Switch to standardized MR safety section 2301164PRE; clarify Burst Disc rating / orientation; clarify V2 & V3 LHe Fill settings; added RENEWAL PARTS, Section 4-17A |
| 4 | Sept. 25, 2001 | | Changed helium levels in Helium Precool / Fill and Ramp Fill; new Recondenser Deicing subsection; new Bypass Unit, Two-Stage Coldhead and One-Stage Coldhead replacement procedures; updated RENEWAL PARTS |
| 5 | March 27, 2002 | 188979 | Switch to Burst Disc 2319285-2; revised RuO Temperature Monitor ( 2171219 ) and RuO Sensor Checks sections; new Universal Fixed-Site Service Platform ( 2319156 ); Two-Stage Coldhead and One-Stage Coldhead replacement includes revised Universal Coldhead Replacement Tool Kit ( 2300306 ); new Preparation for Site Removal section; RENEWAL PARTS, Section 2-1 covers both Rev. 3 and Rev. 4 of Magnet Assembly 2244211; miscellaneous revisions to match same material in other manuals. |
| 6 | August 29, 2002 | 229046 | New Safety Alert Usage and Direction 2231934 application pages at manual front; added Magnet Siting, Installation & Commissioning Flow Chart & Check List to INTRODUCTIONS, Section 1; added grounding and jumper cables and adjusted fill level requirements in Ramp/Fill and Rampdown; added part numbers to Burst Disc assembly illustrations; updated gas FlexLine installation / routing, connections and replacement; updated RENEWAL PARTS. |

# LIST OF EFFECTIVE PAGES



* In Revision 2 the content of these sections was replaced with a note referring the reader to *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure, where the latest Shimming material is located.

** In Revision 3 INTRODUCTION, Section 5, Safety Considerations was replaced by 2301164PRE, MR Magnet – Safety Requirements, in a new SAFETY REQUIREMENTS tab.

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SECTION PAGE

## SAFETY REQUIREMENTS



## INTRODUCTION

# SET-UP AND CALIBRATION

## SET-UP AND CALIBRATION ( continued )



* In Revision 2 these sections were deleted from this manual as they are covered in *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure.

# FUNCTIONAL CHECKS

# REPLACEMENT / MAINTENANCE

## REPLACEMENT / MAINTENANCE ( continued )

## REPLACEMENT / MAINTENANCE ( continued )



## SCHEMATICS / INTERCONNECTS

# RENEWAL PARTS

# RENEWAL PARTS ( continued )

# DATA SHEETS

# MR MAGNET — SAFETY REQUIREMENTS

## 1 MAGNET SAFETY

### 1-1 Magnetic Field Considerations

The Magnetic Resonance Imaging ( MRI ) System utilizes a magnet, which can have a field strength several thousand times greater than that of the earth's magnetic field. The magnetic field surrounding the magnet is called the fringe field, and it extends from the magnet's iso-center in all dimensions. The fringe field may present a hazard to personnel and equipment within the immediate area. Therefore, magnetic field precautions must be applied to the floors above and below the magnet, as well as to the surrounding space on the same level.

To minimize the risk to personnel and equipment when the magnet is at field, follow the precautions listed below:

1. Post "WARNING" signs, part number 46-255326P1, outside the 5 gauss zone alerting personnel with cardiac pacemakers, neurostimulators and other biostimulation devices of the effect of the magnetic field on these devices. See Illustration 1. Post these signs two days prior to the activation of the magnet for maximum impact.
2. Post "SECURITY ZONE" signs, part number 46-255325P1, outside the exam room to alert personnel of the high magnetic field and not to bring ferromagnetic objects into the exam room. See Illustration 2.
3. Set up the "AUTHORIZED PERSONNEL" signs, part number 2289812, at the entrance(s) to the magnet room prior to the start of magnet service procedures. See Illustration 3.
4. Notify responsible personnel two days prior to the activation of the magnet to allow for preparatory actions to be accomplished.
5. Do not bring ferromagnetic objects ( including TOOLS, pens, tape measures, and vacuum pumps ) into the exam room when the magnet is at field unless otherwise called for in the service documentation. Do not bring large metal objects near the outside walls of the exam room.
6. Use only nonmagnetic cylinders, nonmagnetic cylinder carts, and Dewars when transferring cryogens into an energized superconducting magnet.
7. Do not take self-winding watches, magnetically coded credit cards, magnetic recording heads, magnetic tapes or cameras near the magnet when it is at field.

## 1-1 Magnetic Field Considerations ( continued )

**Note**

The Local GE Field Service Operation will provide the signs in the primary local languages. The highly visible ( orange, black & white ) security and warning signs are available from GE under the following catalog numbers:

- E8819AA MR Warning Sign Kit ( 2 security signs, 10 exclusion signs ) in English
- E8819A One MR Security Warning Sign, in English.
- E8819B One MR Exclusion Warning Sign, in English.
- E8819C One MR Security Warning Sign, in Spanish.
- E8819D One MR security Warning Sign, in French.
- E8819BA MR Warning Label Kit ( Peel-Off Back )
- 2289812 Authorized Personnel Warning Sign, in English.

## 1-1 Magnetic Field Considerations ( continued )


**MAGNETIC FIELD WARNING SIGN ( 46-255326P1 )**
ILLUSTRATION 1

## 1-1 Magnetic Field Considerations ( continued )


**MAGNETIC FIELD SECURITY ZONE SIGN ( 46-255325P1 )**
ILLUSTRATION 2

## 1-1 Magnetic Field Considerations ( continued )


**MAGNETIC FIELD SECURITY ZONE SIGN ( 2289812 )**
ILLUSTRATION 3

## 1-2 Emergency Situations

### Description

The Magnet technology used on MR Systems may vary from one product design to another. There are 3 basic magnet technologies used by suppliers today: 1) Superconducting Magnets, 2) Permanent Magnets, and 3) Resistive Magnets. Each magnet technology will have emergency response processes unique to that design. For example, If a person is pinned to the magnet by a ferromagnetic object or that object has become attached to the magnet then the Magnet technology will dictate the appropriate action to be taken. Therefore, go to the appropriate Magnet section in this document and refer to the First Aid / Emergency Situations subsection for specific actions. Revision 1 of this document addresses designs relating to Superconducting Magnets. The sections for Permanent Magnets and Resistive Magnets will be included in a future update of this document.

# 2 SUPERCONDUCTING MAGNETS

## 2-1 Introduction

Superconducting magnets contain cryogenic liquids ( liquid helium = -452°F, -269°C; liquid nitrogen = -320°F, -196°C ) and generate a three-dimensional magnetic field several times the strength of the earth's magnetic field. These conditions require safety precautions to be taken to prevent serious injury ( cryogenic burns, asphyxiation, explosion, fire, shock, ferromagnetic projectiles or other magnetic field effects ).

The safety precautions / requirements contained in the following sections must be reviewed, understood and implemented prior to performing any service on a Superconducting Magnet. Make sure that all magnet service is performed by trained / authorized personnel and all safety equipment is in place.

All persons working with cryogenic liquids should understand the following:

- Nature and properties of liquid and gaseous helium and nitrogen
- Specific instructions on the equipment and clothing
- Use and care of protective equipment and clothing
- Safety and first aid
- Handling emergency situations such as leaks, spills and fires

## 2-2 Cryogen Safety Requirements

### 2-2-1 Site Precautions

The Field Service Engineer is responsible to make sure the following items are in compliance:

- Review all service processes to be performed on the magnet with the facility safety officer or with the local authorities ( i.e. fire department, safety council, etc. ) and obtain any required permits prior to magnet commissioning and servicing.
- Magnet room venting shall be installed, tested, and operating in conformance with site planning requirements.
- A portable floor fan and exhaust duct shall be used to remove the cold nitrogen gas that stratifies at floor level, from the room to the outside, during nitrogen pre-cool.
- The magnet shall be vented in conformance with the site planning requirements. Magnet plumbing and vent system shall be inspected for leaks during magnet installation.
- The door into the magnet room must be secured in the open position prior to any service action that will result in the handling or release of cryogens from the magnet. The ceiling hatch and rear door shall be secured in the open position if in a mobile van.
- Any service actions which release large quantities of cryogenic gas shall have provisions for exhausting the gas through the magnet vent system.

### 2-2-1 Site Precautions ( continued )

- Make sure a second person ( GE, contractor, or hospital personnel trained in these safety requirements ) is present in the area during magnet service in case of emergency.
- A working phone line accessing an outside line shall be available in case of an emergency.
- Set up “Authorized Personnel Only” signs outside the magnet room door(s) prior to any magnet servicing.
- Make sure an Oxygen Monitoring device is calibrated and operating properly before beginning any magnet service.
- Always maintain a clear exit path no less than 28 inches wide.

### 2-2-2 Equipment Handling Precautions

- Do not bring any ferromagnetic equipment, Dewars or cylinders into the magnet room when the magnet is ramped. They will become dangerous projectiles in the presence of the magnetic field.
- Helium gas cylinders are pressurized to 2400 psi. Secure each helium cylinder before removing the protective cap and open the main valve very slowly to prevent any possibility of a fatal release of explosive gas. Make sure gas cylinders are stored in an upright secured position.
- Firmly hold the unattached end of the gas hose during a purge to prevent hose’s “whipping“ motion.
- Keep Dewars in the vertical position at all times. Dewars should have wheels mounted at the base for transport. If wheels are not present, use a low platform dolly, which fully encompasses the Dewar’s base for moving. Do not slide or roll Dewars. Use a suitable hand truck to move gas cylinders.
- Store Dewars in a well ventilated area as outlined in the room ventilation pre-installation manual.
- Make sure that safety relief valves and regulators are operating properly.
- Check all equipment, Dewars, and gas cylinders for leaks.
- Make sure the transportation route for Dewars and gas cylinders is clear of obstacles and restrictions.

### 2-2-3 Cryogen Handling Precautions

- Contact of liquid cryogens or their vapors with the eyes can cause severe frostbite even when contact is too brief to affect the skin. Always wear safety glasses and face shield when handling cryogens.
- Never allow any unprotected part of the body to touch cold magnet plumbing.
- Protective clothing ( long sleeve shirt, long pants, protective apron / jacket ) and dry, non-absorbent insulated gloves shall be worn when handling or being exposed to cryogens, to prevent cold burns from contact with the cryogenic liquid or gas.
- Make sure a calibrated, functioning oxygen monitor is installed in the magnet room in conformance with site requirements or place a functioning portable oxygen monitor in the magnet room and cryogen storage area. The position of the $O_2$ monitor sensor should be at a level that corresponds to the cryogen product being stored or dispensed ( i.e., for liquid helium the sensor should be near the ceiling; for liquid nitrogen the sensor should be near the floor ).
- Smoking is prohibited in the magnet room and around cryogens. Liquid cryogens can liquefy atmospheric oxygen producing a highly enriched oxygen liquid.
- When pluming a stinger, always point the stinger toward the ceiling and away from the face at a 45-degree angle.
- Do not bring more than 1000 liters or 2 Dewars ( whichever is less ) of cryogens into the magnet room.

### 2-2-4 Magnet Servicing Precautions

- **RAMP MAGNET DOWN TO ZERO FIELD** prior to any service requiring opening / exposure to the helium vessel and / or cryogenic gas / liquid, except for the removal of fill and ramp lead port caps, to prevent the possibility of a magnet quench and rapid expulsion of cryogenic helium gas and liquid.
- Make sure non-ferromagnetic fiber or composition safety shoes are worn in the magnet room.
- Observe helium vessel pressure gauge and vent the magnet down to < 0.5 psi before removing ramp / fill port caps or loosening component resulting in the release of cryogenic helium gas and liquid.
- Never allow a helium Dewar to empty during a magnet fill, resulting in a magnet quench from the introduction of warm helium gas.
- Wear proper personal protective equipment ( PPE ).
- Use caution when inserting ramp leads or a shim lead into a ramped magnet to prevent a quench.

### 2-2-5 First Aid / Emergency Situations

- Notify proper emergency responders.
- Do not make any rescue attempts until the environment has been verified as being safe for normal occupancy, then move persons suffering from a lack of oxygen immediately to an area with normal atmosphere and seek medical assistance.
- Use large volumes of tepid water, within the temperature range of 105°F ( 41°C ) to 115°F ( 46°C ), to flush frostbitten or cold burn areas and get medical attention immediately. Notify the physician that this is a cold burn.
- In case of a magnet cryogenic vent failure during a quench stay near the floor where the oxygen will be and immediately exit the magnet room.
- If a ferromagnetic object has become attached to the magnet and cannot be safely removed by two people, the magnet will have to be ramped down.

## 2-3 Magnet Field Safety Requirements

### 2-3-1 Site Precautions

The magnet will create a fringe field that may present a hazard to other personnel working or visiting near the MR Suite. Make sure these precautions are followed to minimize risk to personnel.

- Post warning signs outside the 5-gauss zone, including areas above and below the magnet room, prior to ramping the magnet to warn personnel with cardiac pacemakers, neurostimulators, steel plates or other conditions affected by a magnetic field not to proceed into the area.
- Post “Ramped Magnet” warning sign at magnet room entrance prior to ramping the magnet.
- Notify site administration before ramping the magnet.
- Remove all ferromagnetic material from the magnet room that is not properly installed on the system.
- Prior to ramping the magnet make sure that the Magnet Rundown Unit ( MRU ) is operating properly.
- Do not bring any ferromagnetic tools / objects into the magnet room when the magnet is ramped unless specifically called for in the service documentation.
- Do not loosen any ferromagnetic components on a ramped magnet unless specifically called for in the service documentation.
- Wear leather gloves when opening or closing the coldhead motor shield.
- Use caution when opening or closing the top half of the coldhead motor shield. Never put your hand or fingers between the motor shield and mounting bracket.

### 2-3-2 Ramping Precautions

A superconducting magnet at field is a high-energy storage device capable of discharging rapidly ( quenching ), creating a high voltage across the main leads. Make sure the following precautions are observed when ramping a superconducting magnet.

- When working with the main lead connections that are installed into a ramped magnet do not touch both main lead extensions at the same time or allow them to come in contact with one another.
- Allow main lead extensions to cool before fully inserting them into a ramped magnet to prevent any possibility of a quench.
- Make sure the power supply has passed all functional checks and the input power cable is disconnected before connecting it to the main power leads.
- Make sure the final magnet "parking" current and voltage polarity has been recorded and will be available if a rampdown is required. An incorrect polarity connection will result in a magnet quench.
- Use the appropriate hold-down tool to properly secure ramp leads to the magnet.

### 2-3-3 Emergency Rampdown of Magnet

- Make sure the Magnet Rundown Unit ( MRU ) has been installed in conformance with the GE magnet service manual, the batteries have been charged for 24 hours and the MRU has passed the functional checks in conformance with the supplier manual before ramping the magnet.
- Make sure the rampdown methods covered in the introduction of the GE magnet service manual are fully understood by field service engineers involved with the MR equipment.
- Hospital personal involved with the MR equipment should be familiar with the equipment operator's manual and Magnet Rundown Unit operation.

## 2-4 Magnet & Cryogens Service Safety Requirements

TABLE 1
**SERVICE PROCEDURE SAFETY REQUIREMENTS**

| Safety Requirement | Service Procedure ( X = Required Item For Procedure ) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Detransiting Magnet & Vacuum** | **Conversion to Operating Configuration** | **Venting Installation** | **Nitrogen Precool / Purge** | **Helium Precool / Warm-Up** | **Helium Fill / Top-Off** | **Magnet Ramping** | **Magnet S/C Shim** | **Magnet P-Shim** | **Burst Disk / Plumbing Component Replacement** | **Magnet / Recondenser De-Icing** | **Shim Lead Replacement** | **Baffle / Instrumentation Lead Replacement** | **Cryocooler Service** |
| 1. Cryogenic vent system installed per requirements. | – | – | – | X | X | X | X | X | – | X | X | X | X | X |
| 2. Special permits obtained, if required by local authorities, for use of inert gasses / cryogens during magnet commissioning and service procedures. | X | X | – | X | X | X | X | – | X | X | X | X | X | X |
| 3. Mobile van ceiling hatch secured open. | X | X | X | X | X | X | X | X | – | X | X | X | X | X |
| 4. Room ventilation fan tested and running ( room exhaust at ceiling ). | – | X | X | – | X | X | X | X | – | X | X | X | X | X |
| 5. Room ventilation fan tested and running ( room exhaust at floor ). | – | – | – | X | – | – | – | – | – | – | – | – | – | – |
| 6. Vent magnet and inspect exhaust. | X | X | X | X | X | X | X | X | – | – | X | X | X | X |
| 7. Second person on site and trained in safety. practices for procedure being performed. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 8. Fully functional land-line telephone ( with emergency response numbers clearly posted beside it ) in known and immediately available location near Magnet Room. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 9. Magnet Room doors secured open to assist in room ventilation. Ensure cross ventilation to outside or other large volume non-workspace. | X | X | X | X | X | X | X | X | – | X | X | X | X | X |
| 10. $O_2$ Monitor on site, tested and functional for both visual and audible alarms, whenever cryogens are being stored or dispensed. Portable device 2287000 for magnets up to and including 3.0T. | X | X | X | X | X | X | X | X | – | X | X | X | X | X |
| 11. Cryogen Safety Kit ( 46-271137G1 ) on site for use. Kit includes cryogen gloves, face shield and goggles. | X | X | X | X | X | X | X | X | – | X | X | X | X | X |
| 12. Nonferrous safety shoes. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

## 2-4 Magnet & Cryogens Service Safety Requirements ( continued )

TABLE 1 ( CONTINUED )
**SERVICE PROCEDURE SAFETY REQUIREMENTS**

| | Service Procedure ( X = Required Item For Procedure ) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Safety Requirement | Detransiting Magnet & Vacuum | Conversion to Operating Configuration | Venting Installation | Nitrogen Precool / Purge | Helium Precool / Warm-Up | Helium Fill / Top-Off | Magnet Ramping | Magnet S/C Shim | Magnet P-Shim | Burst Disk / Plumbing Component Replacement | Magnet / Recondenser De-Icing | Shim Lead Replacement | Baffle / Instrumentation Lead Replacement | Cryocooler Service |
| 13. Secure area and display signs alerting of intended process. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 14. Verify dewar transportation path is clear. | - | - | - | X | X | X | X | - | - | - | - | - | - | - |
| 15. Dewars stored in a ventilated area. | - | - | - | X | X | X | X | X | - | - | - | - | - | - |
| 16. Not-in-use gas cylinders secured to wall with protective cap in place. | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 17. Before removing protective cap on gas cylinder, secure to wall or nonmagnetic cart. | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 18. Move gas cylinders / Dewars without wheels using hand trucks designed for purpose. ( Nonmagnetic gas cylinder cart: 46-306717G1 ) | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 19. Keep gas cylinders / Dewars in upright position at all times. | X | - | - | X | X | X | X | X | X | - | - | - | - | - |
| 20. Keep ferromagnetic equipment / objects out of magnet room when magnet is ramped. | - | - | - | - | - | X | X | X | X | X | X | X | X | X |
| 21. Use only nonmagnetic tools in the magnet room when the magnet is ramped ( 46-320273G4 ). | - | - | - | - | - | X | X | X | X | X | X | X | X | X |
| 22. Wear long-sleeve shirt and apron designed for cryogenic servicing. | - | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 23. Inspect all pressure regulators for proper functioning. | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 24. Inspect all pressure relief valves and ensure proper configuration to achieve recommended pressure ( e.g., 20 psi ). | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 25. Inspect all valves and fittings for leaks. | X | - | - | X | X | X | X | X | - | X | X | X | X | X |
| 26. MRU installed and tested prior to magnet ramp. | - | - | - | - | - | - | X | X | X | X | X | X | X | X |
| 27. Post “Ramped Magnet” warning signs included in kit 46-258770G4. | - | - | - | - | - | - | X | - | - | - | - | - | - | - |

## 2-4 Magnet & Cryogens Service Safety Requirements ( continued )

TABLE 1 ( CONTINUED )
**SERVICE PROCEDURE SAFETY REQUIREMENTS**

| | Service Procedure ( X = Required Item For Procedure ) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Safety Requirement** | **Detransiting Magnet & Vacuum** | **Conversion to Operating Configuration** | **Venting Installation** | **Nitrogen Precool / Purge** | **Helium Precool / Warm-Up** | **Helium Fill / Top-Off** | **Magnet Ramping** | **Magnet S/C Shim** | **Magnet P-Shim** | **Burst Disk / Plumbing Component Replacement** | **Magnet / Recondenser De-Icing** | **Shim Lead Replacement** | **Baffle / Instrumentation Lead Replacement** | **Cryocooler Service** |
| 28. Post “Authorized Personnel Only” signs ( 2289812 ) at entrance to MR suite. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 29. Notify Hospital Administrator when magnet is ramping. | - | - | - | - | - | - | X | - | - | - | - | - | - | - |
| 30. Remove all ferromagnetic material from Magnet Room before ramping or shimming magnet. | - | - | - | - | - | X | X | X | X | - | - | - | - | - |
| 31. Use only single Dewar connection ( i.e., no daisy-chain connections ) | - | - | - | X | X | X | X | X | - | - | - | - | - | - |
| 32. Identify and label Dewars as “full” or “empty”; label Dewar storage area. | - | - | - | X | X | X | X | - | - | - | - | - | - | - |
| 33. Remove frost from valve operators on magnet after each Dewar change. | - | - | - | X | X | X | X | - | - | - | - | - | - | - |
| 34. Notify hospital engineering personnel prior to use of any equipment ( i.e., heat guns, propane torches, welding equipment, etc. ) that could set off the fire alarm system. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 35. Identify and understand the properties and operation of the site’s fire suppression system ( i.e., water sprinkler, halon, $CO_2$, etc. ) and how to respond to alarms. | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 36. Reduce magnet helium vessel pressure to 0.2 psig before performing service. | - | X | - | - | - | X | X | X | - | X | X | X | X | - |
| 37. Use product-defined tools and personal protective equipment ( such as gloves, goggles and protective clothing ) when removing or installing passive shim material / assemblies. | - | - | - | - | - | - | - | - | X | - | - | - | - | - |

## 2-5 Buddy System Requirements & Certification

The Buddy System ( second person on site ) is required whenever service is performed on the superconducting magnet subsystem. It is critical that a "Buddy" is always present to ensure your safety. A "Buddy" is more than just a second person that is "around" while you are working. A "Buddy" is someone who will maintain communication with you at all times and sound the alarm in case of an emergency and may even assist in performing the service procedure, if qualified.

All individuals selected to perform the task of either "Work Assistant" or "Work Observer" must comply with the prerequisite training and complete the certification form located in Section 2-5-1, Worker Certification / Agreement Form. A signed copy of the certification must remain on file at the customer site.

### 2-5-1 Worker Certification / Agreement Form

## IMPORTANT !!!

**All individuals selected to perform the task of either "Work Assistant" or "Work Observer" must comply with the prerequisite training and complete the certification. Do not allow a person to function as a buddy ( second person ) until ALL the MANDATORY requirements are completed for the category being performed.**

**Instructions:** Table 2 is to be completed by the individual that is being certified to function as either a Work Assistant or Work Observer.

TABLE 2
**SECOND PERSON – BUDDY REQUIREMENTS**

| Safety Requirment | Work Assistant | Work Observer | Initialed by Second Person When Complete | Comments |
|---|---|---|---|---|
| 1. Must have completed all required EHS training. | MANDATORY | | | |
| 2. Completed and have on file the medical clearance form "Magnetic Resonance Employee Questionnaire For Metallic Foreign Body and Electronic Devices," available from the GEMS Medical department. | MANDATORY | MANDATORY | | |
| 3. Must have completed the magnet and cryogen safety training portion of MR 508, Principles of MRI, or MR 512, Magnet & Cryogen Safety ( CD-ROM ). | MANDATORY | MANDATORY | | |
| 4. Must know how to wear the proper PPE for the procedure being performed as described in the service documentation and/or demonstrated by the Site FE performing the qualification process. | MANDATORY | | | |
| 5. Needs to be a FE, GE employee, or magnet-knowledgeable person. | MANDATORY | | | |
| 6. Know how to evacuate the area ( Emergency escape route ) as demonstrated by the primary FE | MANDATORY | MANDATORY | | |
| 7. Know how to notify emergency responders as per site emergency process. | MANDATORY | MANDATORY | | |
| 8. Will not attempt a rescue until the atmosphere is determined safe by use of a calibrated instrument designed for measuring atmospheric air quality. | MANDATORY | MANDATORY | | |
| 9. Know how to control and operate the valves on the gas cylinders / regulators and cryogenic Dewars. | MANDATORY | | | |

## 2-5-1 Worker Certification / Agreement Form ( continued )

TABLE 2 ( CONTINUED )
**SECOND PERSON – BUDDY REQUIREMENTS**

| Safety Requirment | Work Assistant | Work Observer | Initialed by Second Person When Complete | Comments |
|---|---|---|---|---|
| 10. Know how to terminate the cryogen transfil operation on both the Dewars and the magnet in the event of a problem. | MANDATORY | | | |
| 11. Know how and when to perform an emergency run down procedure as defined in the service documentation. | MANDATORY | MANDATORY | | |
| 12. Know how and when to initiate 'Emergency OFF' as defined in the service documentation. | MANDATORY | MANDATORY | | |
| 13. Know how to respond to an oxygen monitor alarm. | MANDATORY | MANDATORY | | |
| 14. Know what to do during a quench. | MANDATORY | MANDATORY | | |
| 15. Know the physical changes or indicators of working in an oxygen deficient atmosphere. | MANDATORY | MANDATORY | | **Your buddy MUST:**<br>• Listen for changes in your voice; it will be higher than usual when working with helium.<br>• Watch for physical indicators; you may begin staggering or slur your speech when working with nitrogen.<br>• Notify the emergency response team when necessary. |
| 16. Identify and understand the properties and operation of the site's fire suppression system ( i.e., water sprinkler, halon, $CO_2$, etc. ) and how to respond to alarms. | MANDATORY | MANDATORY | | |

### 2-5-1 Worker Certification / Agreement Form ( continued )

**Instructions:** Table 3 is to be completed by the Field Engineer responsible to perform any of the listed service procedures. He or she must certify the capabilities of the “Second Person,” either by interview or training, and initial the appropriate “Assistant” or “Observer” column to show they have been certified.

TABLE 3
**SECOND PERSON - SERVICE PROCEDURE CERTIFICATION**

| Service Procedure | Assistant (FE initials required if meets certification) | Observer (FE initials required if meets certification) |
|---|---|---|
| 1. Detransit Magnet | | |
| 2. Conversion to Operating Configuration | | |
| 3. Venting Installation | | |
| 4. Nitrogen Precool / Purge | | |
| 5. Helium Precool / Warm Up | | |
| 6. Helium Fill / Top-Off | | |
| 7. Magnet Ramping | | |
| 8. Magnet P-Shim | | |
| 9. Magnet S/C Shim | | |
| 10. Burst Disk / Plumbing Component Replacement | | |
| 11. Magnet / Recondensor De-Icing | | |
| 12. Shim Lead Replacement | | |
| 13. Baffle / Instrumentation Lead Replacement | | |
| 14. Cryocooler Service | | |
| 15. Other [ ] | | |
| 16. Other [ ] | | |

## 2-5-1 Worker Certification / Agreement Form ( continued )

### Certification Agreement

I understand and will comply with the MR Buddy System Requirements.

| (Print) Name of Buddy | Signature | Date |
|---|---|---|

I certify the person above meets or exceeds the MR Buddy System Requirements for the selected category / procedures.

| (Print) Name of FE | Signature | Date |
|---|---|---|

**The primary Field Engineer must keep the completed forms on site.**

# REVISION HISTORY

| REV | DATE | PCN # | AUTHOR | PRIMARY REASONS FOR CHANGE |
|---|---|---|---|---|
| 0 | May 10, 2001 | | P. Senski | Initial Document Release |
| 1 | Oct. 23, 2001 | 224297 | P. senski | Added clarification of $O_2$ sensor position under fourth bullet in Sec. 2-3.<br>Made the following revisions to Table 1:<br>1. Reversed order of column headers for Magnet S/C Shim and Magnet P-Shim only.<br>2. Corrected required item errors for line item 1.<br>3. Corrected required item errors for column 1.<br>4. Changed content of safety requirement line item 10.<br>5. Added new requirement line items 36 and 37. |
| | | | | |
| | | | | |
| | | | | |

# INTRODUCTION

## TABLE OF CONTENTS

# SECTION 1 – DOCUMENTATION ORGANIZATION

## IMPORTANT !!!

The most recent version of this manual is available at the MR Service Engineering web site:

`http://3.87.118.28/optec3/common/mangets/magnets.htm#magnet%20 manuals`

### 1-1 SYSTEM DOCUMENTATION ORGANIZATION

Signa Service Manuals have been divided into an Installation Manual, a System Manual, a Subsystem Manual, a Renewal Parts Manual, and a Mobile System Manual. The Installation Manual contains hardware installation instructions and acts as an overall steering document to guide you through installation set-up and adjustment procedures in the other manuals. The System Manual contains all system level procedures, and the Subsystem Manual contain subsystem level procedures. The Option / Upgrade Installation Manual contains instructions for installing Signa options and a tabbed division which serves as a holding place for individual upgrade directions.

**Note**

All electrical installations preliminary to positioning the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations, and testing shall be performed by qualified GE Medical Systems personnel. The products involved and the accompanying electrical installations are highly sophisticated; special engineering competence is required. In performing all electrical work on these products, GE will use its own specially trained field engineers. All of GE's electrical work on these products will comply with the requirements of the applicable electrical codes. The purchaser of GE equipment shall only utilize qualified personnel ( i.e., GE's field engineers, personnel of third-party service companies with equivalent training, or licensed electricians ) to perform electrical servicing on the equipment.

### 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS

**Note**

Direction 2231934, *GE 0.7T OpenSpeed Magnet and Cryogens Subsystem Manual,* covers the 0.7T Open*Speed* magnet system models shown in Table 1-1.

TABLE 1-1
**MAGNET MODEL / ASSEMBLY NUMBERS**

| MAGNET MODEL NUMBER | MAGNET ASSEMBLY NUMBER |
|---|---|
| 2228679 | 2244211 |

## 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS ( continued )

### INTRODUCTION

Documentation organization, system and component identification and safety considerations are in this section.

### SET UP AND CALIBRATION PROCEDURES

Magnet system installation, commissioning, adjustment, and calibration procedures are in this section. Procedures from supplier manuals are referenced where applicable.

**Note**

The sequence of Magnet Commissioning procedures is shown in Illustration 1-1. An overview of the entire Siting, Installation and Commissioning process is shown in Table 1-2.

### FUNCTIONAL CHECKS

Procedures for performing subsystem checks are in this section, such as procedures done for diagnostics and periodic maintenance. Magnet resistance values and guideline tables are provided in this section.

### REPLACEMENT / MAINTENANCE

Procedures and illustrations for subsystem maintenance and component replacement are in this section.

### SCHEMATICS / INTERCONNECTS

A cable Interconnect diagram for the system, schematics for all nonsupplier subsystem circuits and power supply controls, meters and Indicators are in this section.

### RENEWAL PARTS

Renewal part identification and exploded views for the Magnet / Cryogen Subsystem and GE Part Number Reference Tables for supplier renewal parts are in this section.

### DATA SHEETS

Contains logs, charts and tables for helium fill, ramping, shimming and pressure / temperature records.

## 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS ( continued )

**Note**

All schematics / circuit diagrams, component parts lists, descriptions, adjustments / calibrations and other information necessary for the field service of this magnet system are contained within Direction 2231934 and referenced supplier manuals.

**CAUTION**

**In accordance with International Standard, IEC 601-1, the manufacturer is not responsible for any consequences caused by unauthorized modification of this type B Equipment.**

**All procedures covered in this manual, other than the indicator lamp checks on the Magnet Rundown Unit, should be performed by a General Electric authorized service representative.**

**DANGER!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, INCLUDED IN THIS MANUAL.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT THE CRYOSTAT DOWN TO < 0.5 PSIG THROUGH VENT VALVE V2 BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

## 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS ( continued )

TABLE 1-2
**MAGNET SITING, INSTALLATION & COMMISSIONING**
**FLOW CHART & CHECK LIST**

**SITING & INSTALLATION**

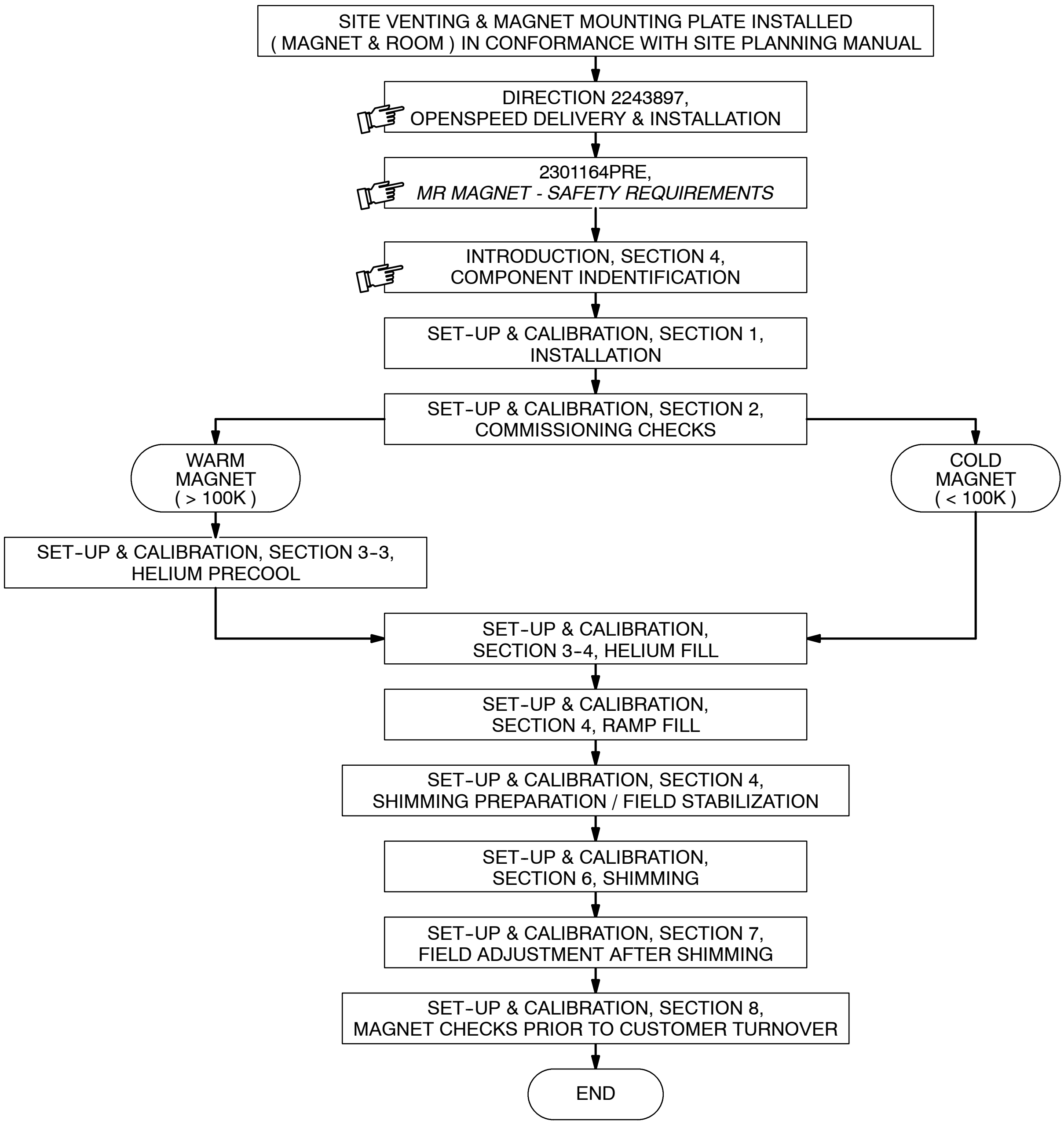
| RESPONSIBILITY | FUNCTION | REFERENCE DOCUMENT | COMPLETE |
|---|---|---|---|
| GE INSTALLATION SPECIALIST & SHIELD ROOM VENDOR | MAGNET ROOM REQUIREMENTS:<br>• SAFETY ( EXHAUST & VENTING )<br>• MAGNET ANCHORING<br>• POWER & COOLING<br>• MOUNTING PLATE INSTALLED ( IF REQUIRED ) | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION<br>DIRECTION 2268297, OPENSPEED MOUNTING PLATE INSTALLATION | ☐ |
| GE INSTALLATION SPECIALIST | PREINSTALLATION CHECK LIST COMPLETED | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| GE FIELD ENGINEER & RIGGER | SITE DELIVERY REVIEW:<br>• ACCESS & ROUTE<br>• CLEARANCES | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| RIGGER | MAGNET DELIVERY | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| GE FIELD ENGINEER | MAGNET COMPONENT CHECKS:<br>• PHYSICAL & ELECTRICAL | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| RIGGER | MOVE MAGNET TO MR SUITE | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| RIGGER | LEVELING & BOLTING DOWN MAGNET | DIRECTION 2243897, OPENSPEED DELIVERY & INSTALLATION | ☐ |
| | CONTINUE WITH "COMMISSIONING" PHASE | | |

## 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS ( continued )

TABLE 1-2 ( CONTINUED )
**MAGNET SITING, INSTALLATION & COMMISSIONING**
**FLOW CHART & CHECK LIST**

| **COMMISSIONING** | | | |
|---|---|---|---|
| **RESPONSIBILITY** | **FUNCTION** | **REFERENCE DOCUMENT** | **COMPLETE** |
| | FROM "SITING & INSTALLATION" PHASE | | |
| GE FIELD ENGINEER | MR MAGNET SAFETY DOCUMENT 2301164PRE REVIEW & COMPLIANCE | DIRECTION 2231934, SAFETY REQUIREMENTS TAB | ☐ |
| GE FIELD ENGINEER | MAGNET CONVERSION TO OPERATING CONFIGURATION AND IMMEDIATE VENT INSTALLATION | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | MAGNET SYSTEM COMPONENTS INSTALLATION & FUNCTIONAL CHECKS:<br>• CRYOCOOLER<br>• MRU<br>• MAGNET MONITOR | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | MAGNET COMMISSIONING CHECKS | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | CONNECT MAGNET MONITOR | DIRECTION 2230681, GEMS MAGNET MONITORING HARDWARE ( SHEM ) INSTALLATION | ☐ |
| GE FIELD ENGINEER | MAGNET PRECOOL & FILL | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | RAMP MAGNET | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | SHIM MAGNET | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| GE FIELD ENGINEER | MAIN FIELD ADJUSTMENT A/R | DIRECTION 2231934, SET-UP AND CALIBRATION TAB | ☐ |
| | HAND OFF TO SYSTEMS CALIBRATION | | |

## 1-2 SUBSYSTEM MANUAL ( DIRECTION 2231934 ) ORGANIZATION / CONTENTS ( continued )



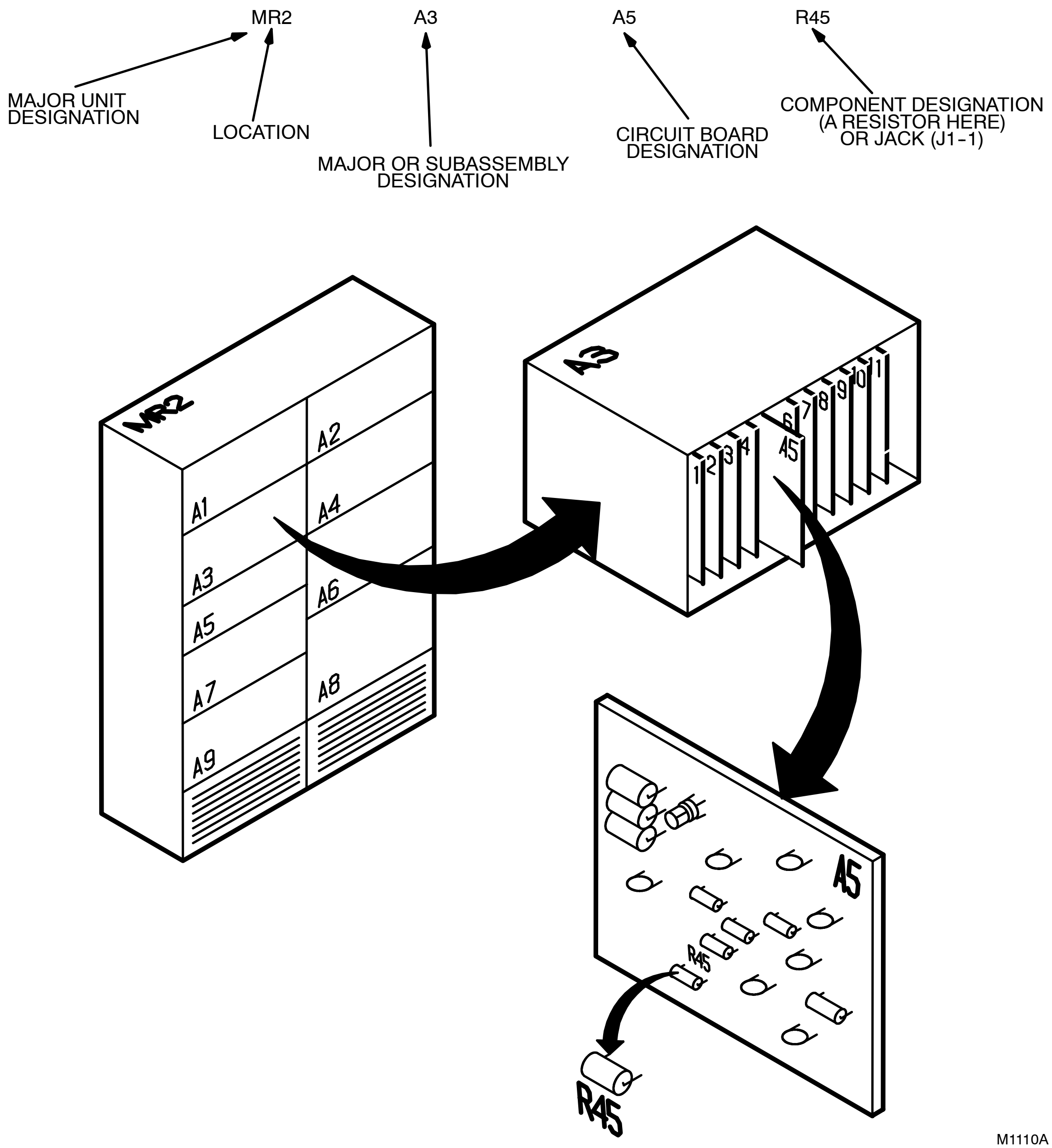

**MAGNET COMMISSIONING FLOW DIAGRAM**
ILLUSTRATION 1-1

# SECTION 2 – VENDOR MANUAL MATRIX

| EQUIPMENT | VENDOR | GE MANUAL NUMBER<br>( VENDOR MANUAL NUMBER ) | GE MODEL NUMBER<br>( VENDOR MODEL NUMBER ) |
|---|---|---|---|
| CRYOCOOLER AND SHIELDCOOLER COLDHEADS AND COMPRESSOR | SUMITOMO HEAVY INDUSTRIES, LTD. | 2262271<br>( CD32ZZ–055B ) | 2218465<br>( RDK–408 4K COLDHEAD ) |
| | | | 2244334<br>( RDK–400 SINGLE–STAGE COLDHEAD ) |
| | | | 2188440–2<br>( CSW–71D WATER–COOLED, HIGH VOLTAGE COMPRESSOR ) |
| | | | 2266223<br>( BY–PASS UNIT ) |
| MAIN POWER SUPPLY CABINET<br>( SERVICE TOOL ) | ELECTRONICS MEASUREMENTS INC. ( EMI ) | 46–294439P6<br>( 83–452–010 ) | 46–260776G4<br>( EMI MODEL 452–62–2 ) |
| MAGNET RUNDOWN UNIT | AMERICAN MAGNETICS INC. ( AMI ) | SERVICE:<br>46–318393 | 46–294231G1<br>( GE–MRU ) |
| | | OPERATION:<br>46–318394 | |
| MAGNET MONITOR UNIT | ADVANTEK | OPERATION:<br>2229090–100 | 2209000 |
| | | HARDWARE INSTALLATION:<br>2261116 | |

# SECTION 3 – EXPLANATION OF DESIGNATOR SYSTEM

The Component Designator System identifies all system components consistently throughout this manual. See Illustration 3-1 for an explanation of the system.

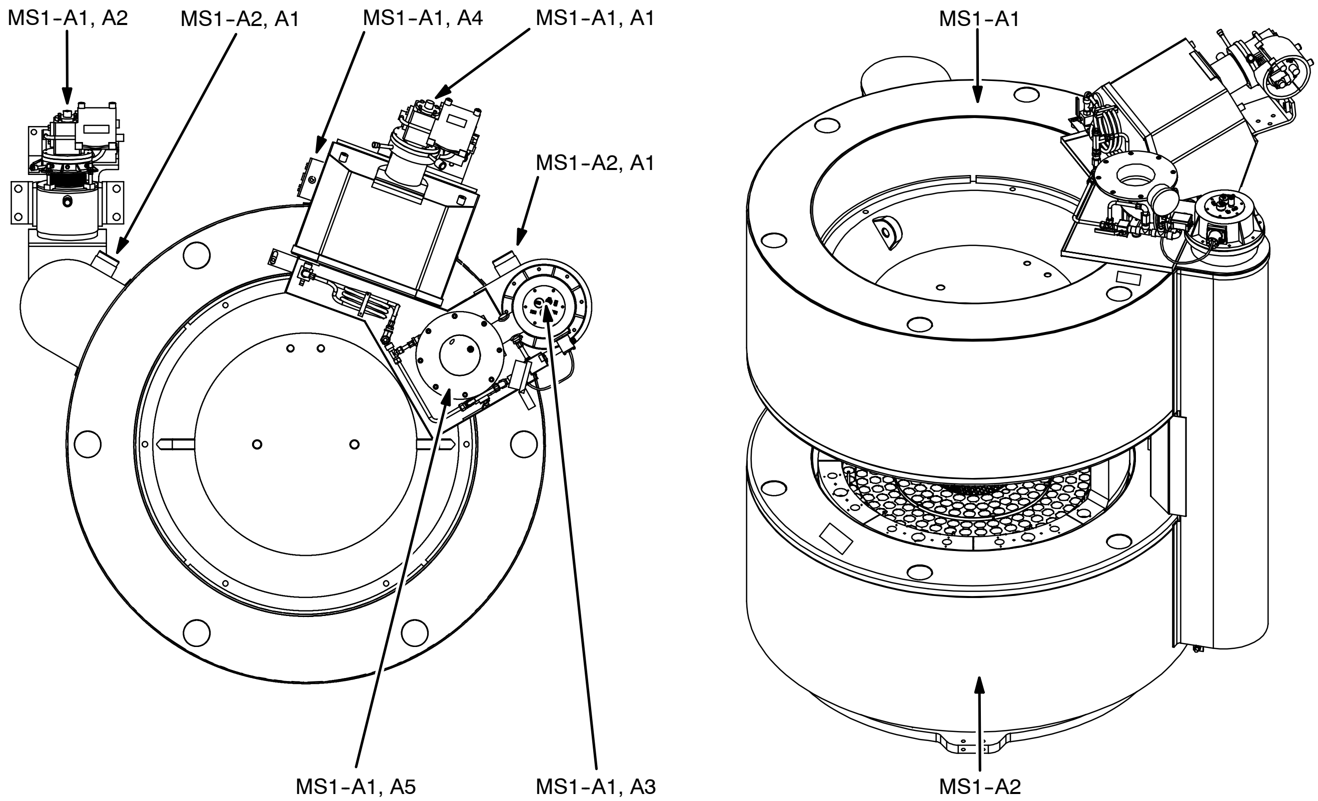



**COMPONENT DESIGNATOR SYSTEM**
ILLUSTRATION 3-1

# SECTION 4 – COMPONENT IDENTIFICATION

This manual covers the major components shown in Illustrations 4–1 through 4–4.

### MS1 Open*Speed* Superconducting Magnet / Cryostat

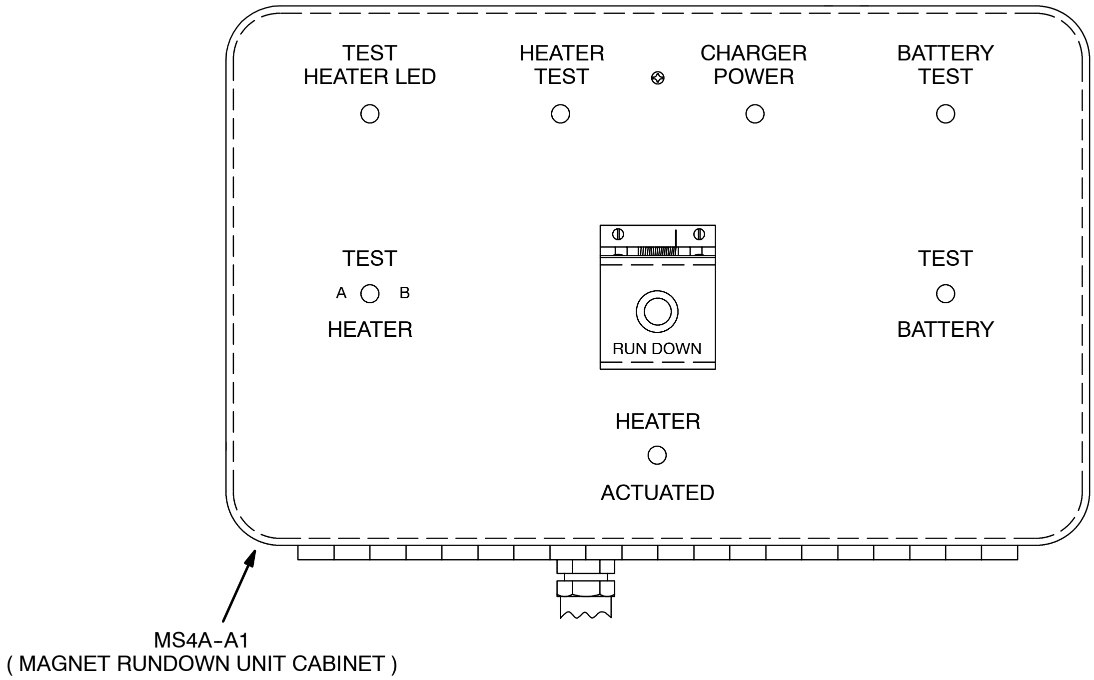



| DESIGNATOR | DESCRIPTION |
|---|---|
| MS1–A1 | TOP CRYOSTAT |
| MS1–A1,A1 | CRYOCOOLER COLDHEAD |
| MS1–A1,A2 | SHIELDCOOLER COLDHEAD |
| MS1–A1,A3 | SERVICE TURRET |
| MS1–A1,A4 | INSTRUMENTATION BOX |
| MS1–A1, A5 | HELIUM VENT |
| MS1–A2 | BOTTOM CRYOSTAT |
| MS1–A2,A1 | VACUUM PORT |

**OPEN*SPEED* MAGNET / CRYOSTAT COMPONENT DESIGNATIONS**
ILLUSTRATION 4–1

## SECTION 4 – COMPONENT INDENTIFICATION ( continued )

### MS4 Magnet Rundown Unit ( MRU )

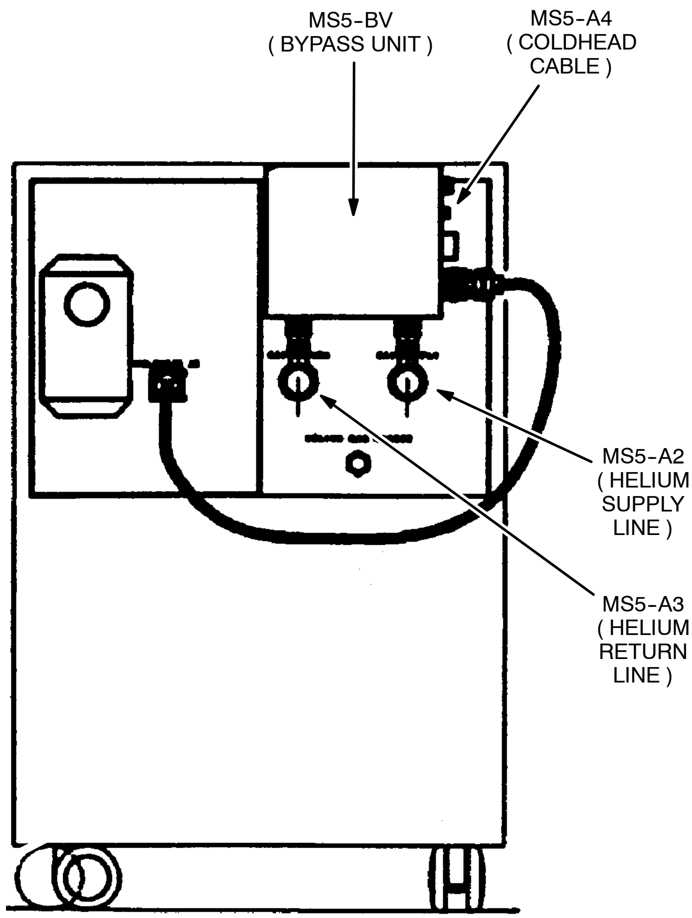



| DESIGNATOR | DESCRIPTION |
|---|---|
| MS4–A1 | MAGNET RUNDOWN UNIT |
| MS4–A2 | MAGNET RUNDOWN UNIT CABLE |

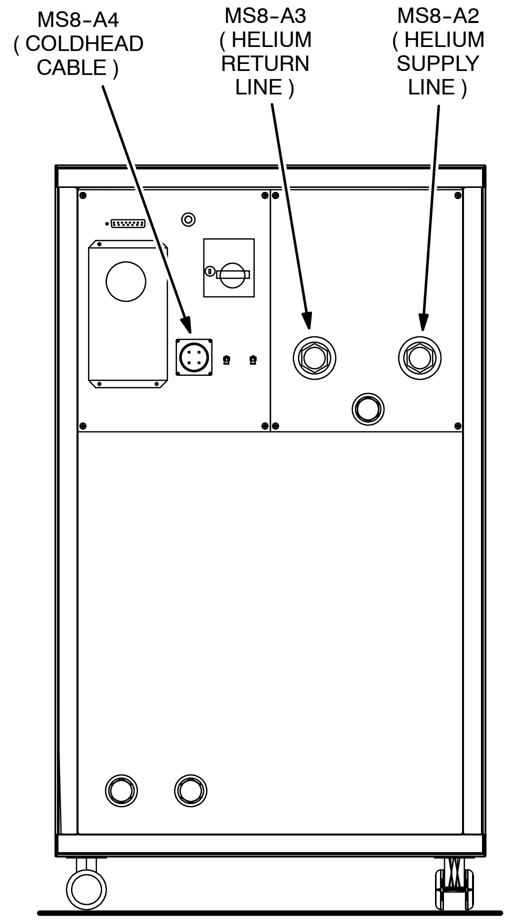
**MAGNET RUNDOWN UNIT ( MRU ) COMPONENT DESIGNATIONS**
ILLUSTRATION 4–2

## SECTION 4 – COMPONENT INDENTIFICATION ( continued )

### MS5 / MS8 Cryocooler Compressor




**MS5 ( COMPRESSOR )**



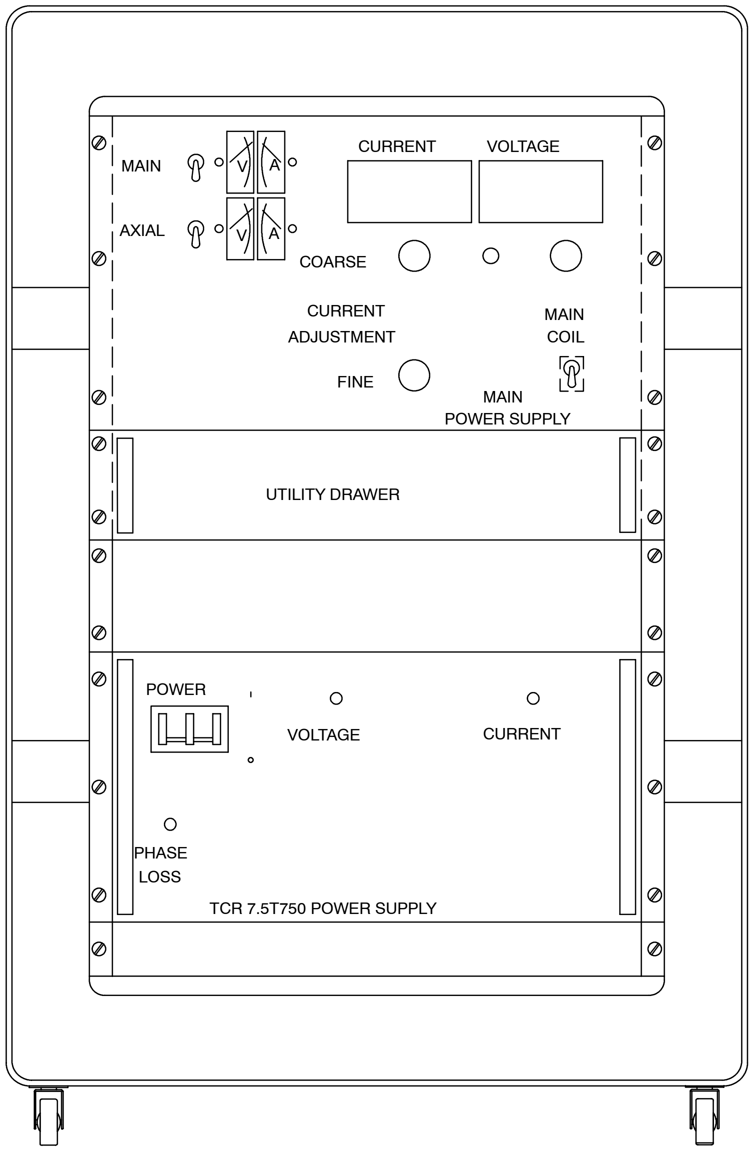

**MS8 ( COMPRESSOR )**

| DESIGNATOR | DESCRIPTION |
|---|---|
| MS5 | COMPRESSOR FOR CRYOCOOLER / RECONDENSER |
| MS8 | COMPRESSOR FOR SHIELDCOOLER |

**CRYOCOOLER COMPRESSOR COMPONENT DESIGNATIONS**
ILLUSTRATION 4-3

## SECTION 4 – COMPONENT INDENTIFICATION ( continued )

### MS7 Magnet Service Power Supply Cabinet




**MS6 MAGNET SERVICE POWER SUPPLY CABINET – SERVICE TOOL**
**( NOT PART OF PRODUCT )**
ILLUSTRATION 4-4

# SECTION 5 – SAFETY CONSIDERATIONS

**Note**

This material is now covered in 2301164PRE, *MR Magnet – Safety Requirements*, reproduced in this manual's SAFETY REQUIREMENTS tab.

# SET-UP AND CALIBRATION

## TABLE OF CONTENTS

SECTION PAGE

# TABLE OF CONTENTS ( continued )



* In Revision 2 these sections were deleted from this manual as they are covered in *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure.

# SECTION 1 - MAGNET SYSTEM INSTALLATION

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**WARNING!**

- **MAKE SURE BOTH MAGNET AND ROOM VENTING SYSTEMS ARE INSTALLED IN THE MAGNET ROOM IN CONFORMANCE WITH THE APPLICABLE PREINSTALLATION MANUAL ( ROOM VENTILATION AND CRYOGENIC VENTING ) PRIOR TO BRINGING THE MAGNET INTO THE ROOM. LARGE QUANTITIES OF GASEOUS HELIUM ARE DISCHARGED FROM THE MAGNET DURING INSTALLATION AND COMMISSIONING ACTIVITIES, WHICH WILL REQUIRE EXHAUSTING TO PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM.**
- **DO NOT STAND ON TOP OF MAGNET! INJURY MAY RESULT FROM FALLING. PERFORM ALL SERVICE ACTIONS REQUIRING ACCESS TO TOP OF MAGNET FROM THE PLATFORM LADDER ( 22656565 ) SUPPLIED WITH MAGNET.**

**SECTION 1 – MAGNET SYSTEM INSTALLATION ( continued )**

## IMPORTANT !!!

Procedures for moving magnet into magnet room and bolting magnet in place are covered in *GE 0.7T OpenSpeed Magnet Delivery and Installation Manual* ( Direction 2243897 ), Sections 5 and 6. The magnet must be bolted in its permanent location before commencing with this section. Review INTRODUCTION, Sections 4, Component Identification, and the SAFETY REQUIREMENTS tab of this manual before initiating the installation.

A helium gas cylinder, regulator, gas hose and heat gun should be available at the site to use in case any ice / frost needs to be cleared in the magnet. Helium gas will be required later during cryogen fill.

## 1–1 CONVERSION TO OPERATING CONFIGURATION

### Introduction

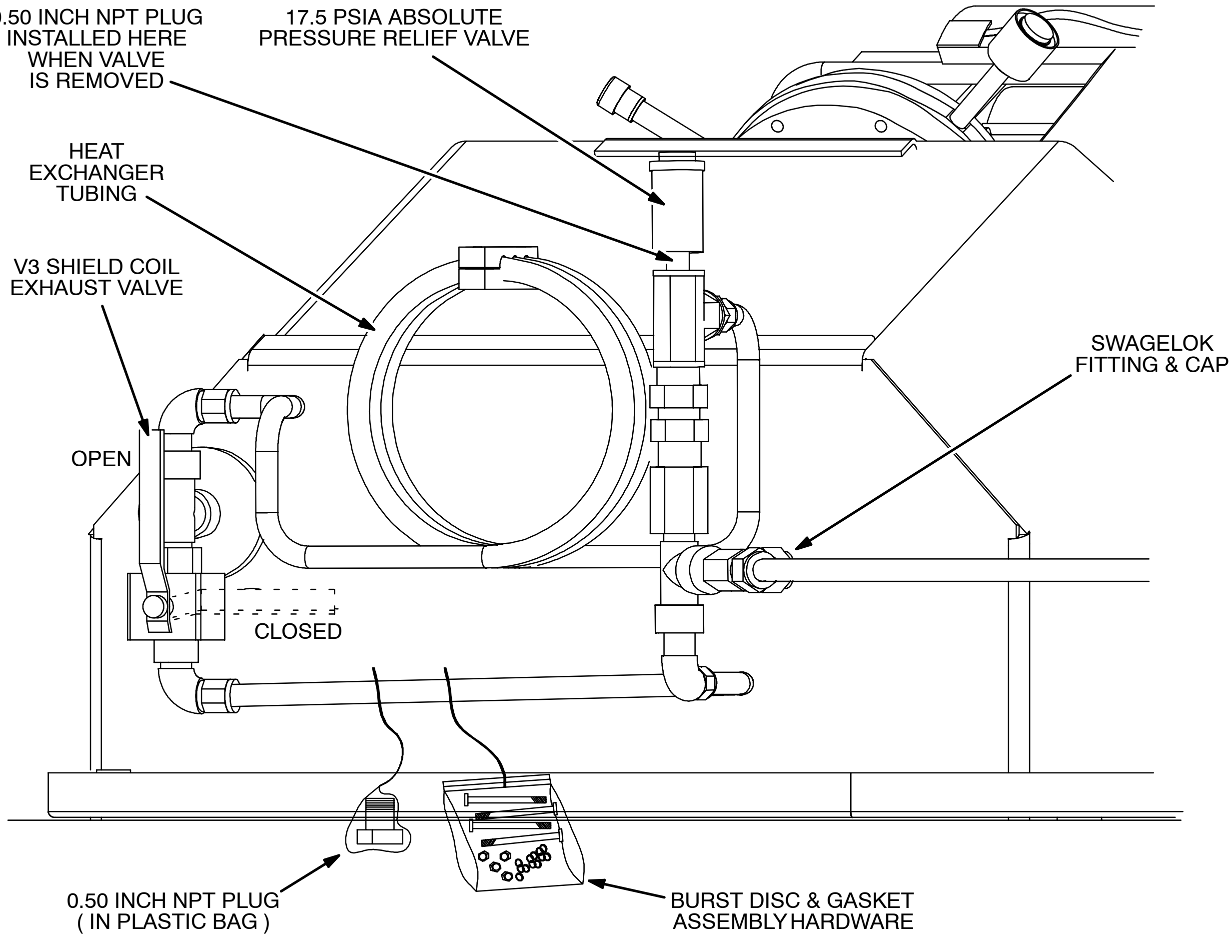
The magnet arrives at the installation site in a shipping configuration and requires the actions covered in this procedure to convert it to the operating configuration. Ground shipments ( over land or sea ) are made with all helium vent plumbing installed on the magnet. Air shipments are made with the following ( see Illustrations 1–1, 1–2 and 1–3 ):

- Vent Adapter removed.
- Blanking Plate with 4 relief valves installed in place of the Burst Disk.
- .50 inch ( 12.7 mm ) Plumbing Plug in a plastic bag.
- 17.5 psia Relief Valve installed at the termination of shield vent plumbing and heat exchanger tubing.

**Note**

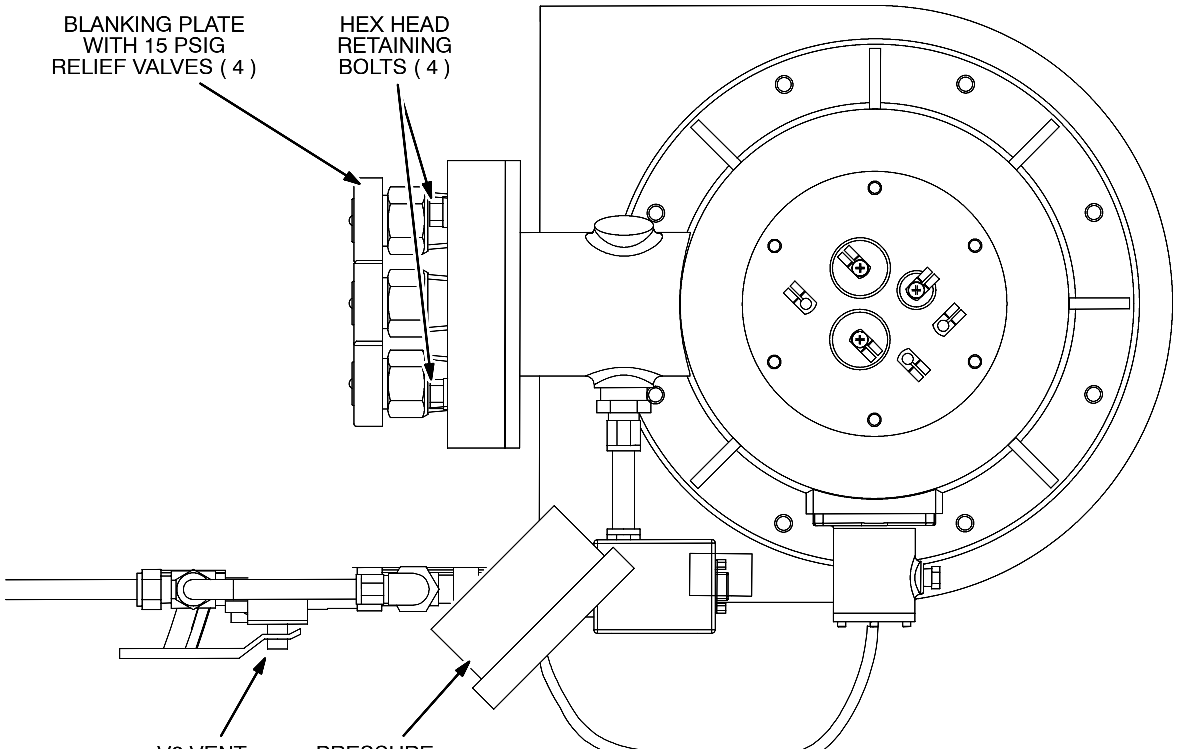
Conversion to operating configuration is performed from the Universal Service Ladder / Platform 2319156. See Section 1–8 for assembly and adjustment instructions.

## 1-1 CONVERSION TO OPERATING CONFIGURATION ( continued )

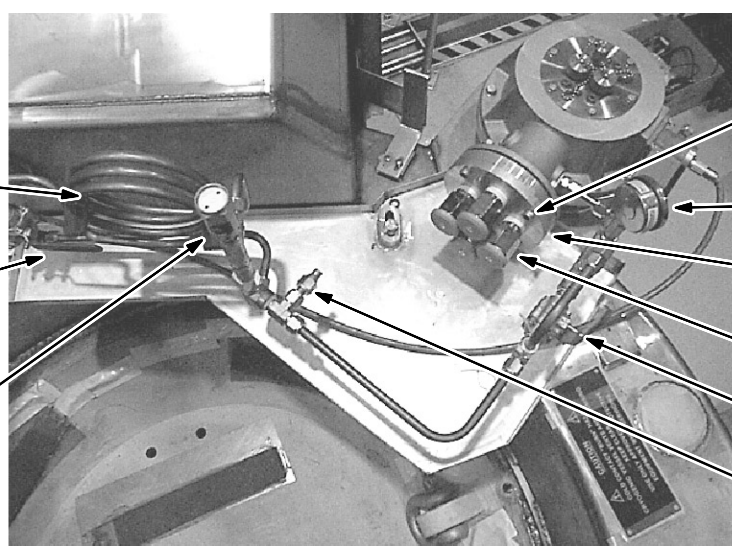



**MAGNET AIR SHIPMENT CONFIGURATION**
ILLUSTRATION 1-1

## 1-1 CONVERSION TO OPERATING CONFIGURATION ( continued )




**VALVE, BLANKING PLATE, BOLT LOCATIONS**
ILLUSTRATION 1-2




**AIR SHIP VENT ADAPTER & PLUMBING CONFIGURATION**
ILLUSTRATION 1-3

## 1-1 CONVERSION TO OPERATING CONFIGURATION ( continued )

### Procedure

1. Record the Cryostat Pressure Gauge reading in the DATA SHEETS, Section 1, Magnet Temperature / Pressure Data. See Illustration 1-1, 1-2 and 1-3.

**Note**

**Steps 2 through 15 are not performed for ground shipped magnets**. Perform these steps only for air shipped magnets with the Vent Adapter Plumbing and Burst Disc removed.

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY MEASURES CONTAINED IN *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, INCLUDED WITH THIS MANUAL.**

**RAPID EXHAUSTING OF COLD HELIUM GAS WILL BE ENCOUNTERED WHEN REPLACING THE HELIUM VENT PLUMBING AND BURST DISC. WEAR NONABSORBENT GLOVES, GOGGLES, LONG SLEEVE SHIRT AND LONG PANTS WHEN PERFORMING THESE OPERATIONS.**

**MAKE SURE NO PERSON IS NEAR THE PLUME PATH WHEN HELIUM VENT VALVE V2 IS OPENED.**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT THE CRYOSTAT DOWN TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE V2 BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

2. Remove the Swagelok fitting, if present, and slowly open Vent Valve V2. Allow the cryostat to exhaust until the pressure, indicated on the pressure gauge on top of the magnet ( or on the digital meter of the pressure controller or magnet monitor ), is < 0.5 psig. Close V2. See Illustrations 1-1 and 1-3.

3. Remove the 17.5 psia pressure relief valve from Shield Vent Plumbing / Heat Exchanger Tubing and immediately install a 0.50 inch NPT plug in its place. See Illustrations 1-1 and 1-3.

4. Unpack the 12 psig Burst Disc from its container, located in the Venting Hardware Kit, and inspect it for visible damage ( nicks and scratches ). Make sure the Burst Disc is part number 2319285-2 and its rating plate is marked 12 psig.

## 1-1 CONVERSION TO OPERATING CONFIGURATION (continued)

**CAUTION**

**Perform Steps 5 through 10 rapidly to prevent condensation and icing within the vertical stack. Six bolts are attached to the vent plumbing in a plastic bag. These are used to attach the Vent Adapter and Burst Disc / Gasket Assembly.**

**Note**

Make sure the Belleville washers are present and that the orientation of the washers is maintained when they are reinstalled.

5. Hold the Blanking Plate and Flange Disc and loosen / remove the four hex head retaining bolts securing the four 15 psi relief valves and the Blanking Plate to the Stack Flange Exhaust. See Illustrations 1-2 and 1-3.

6. Remove the Blanking Plate with the four 15 psig relief valves.

**CAUTION**

**Be careful when removing the Blanking Plate and inserting the new Burst Disc so as not to dislodge the o-ring in the Plenum Flange or scratch the sealing surface of the flange. Make sure the captured Burst Disc flange is assembled to the Vent Adapter.**

**Note**

See Illustration 1-5 for Steps 7 through 12.

7. Install the 4 inch ( 101 mm ) o-ring ( 46-281101P8 ), located in the Venting Hardware Kit, in the groove of the Vent Adapter.

8. Install the captured burst disc flange on the vent adapter using the bolts in plastic bag.

9. Install Burst Disc 2319285-2 ( with the Garlok gasket facing the Vent Adapter ) in conformance with REPLACEMENT / MAINTENANCE, Section 6, Burst Disc Replacement. See Illustration 1-4. Use bolts provided in plastic bag.

10. Tighten all six bolts until Belleville washers are flattened.

**Note**

Loosening of magnet exhaust plumbing may be required for the Swagelok fitting connection.

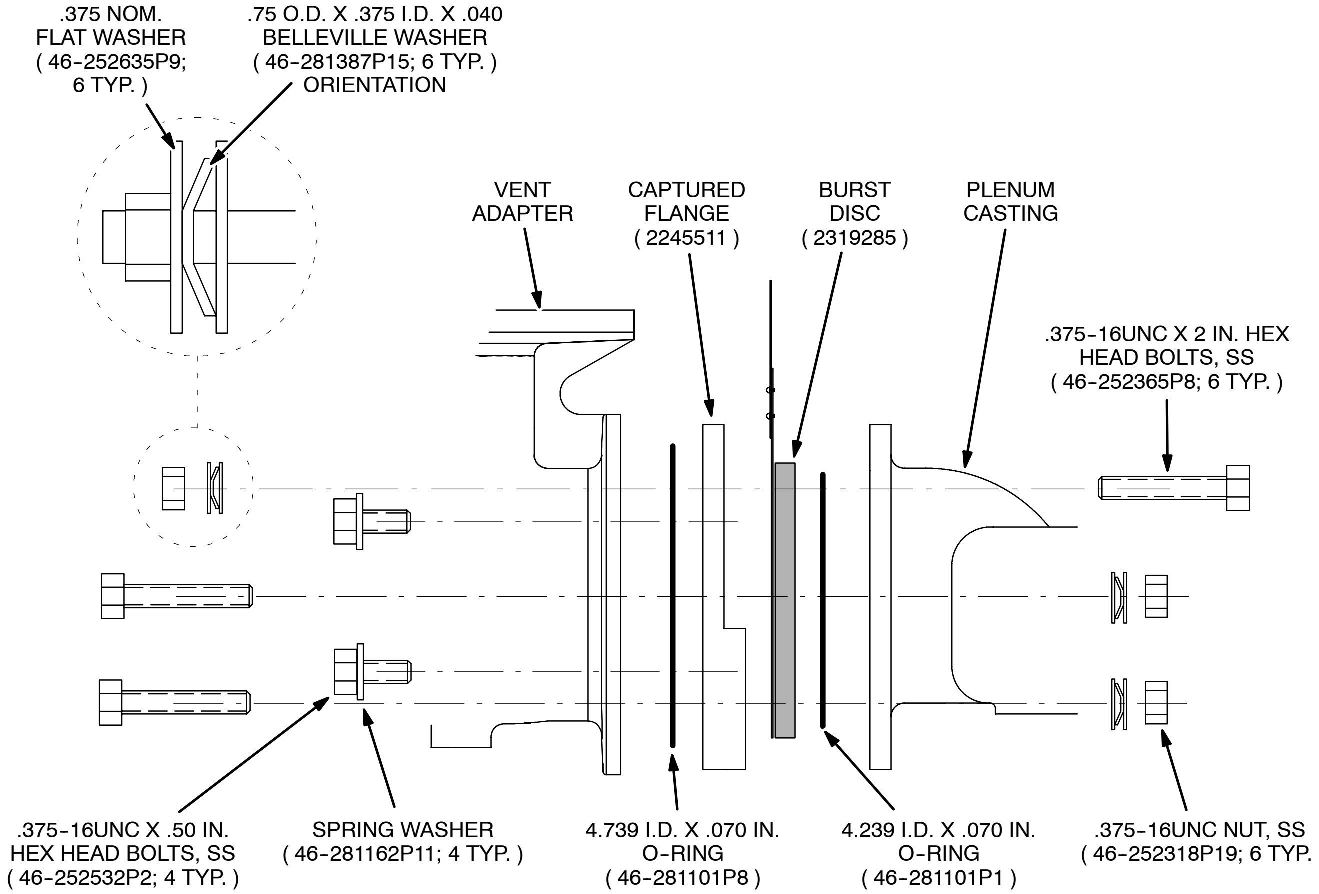
11. Assemble the vent plumbing as follows ( see Illustration 1-5 ):

    a. Reconnect the plumbing at Connection Point 1 ( male connector ).

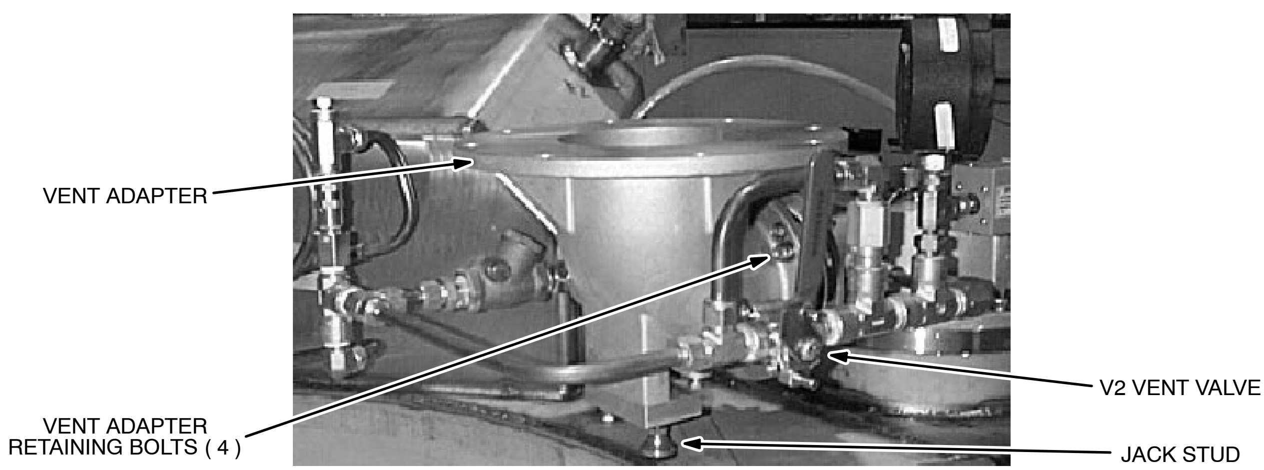
    b. Connect the check valve plumbing subassembly to the Vent Adapter at Connection Point 2 ( .75 inch MNPT ).

    c. Make sure check valve is oriented as shown.

## 1-1 CONVERSION TO OPERATING CONFIGURATION (continued)




**HELIUM VESSEL BURST DISC ASSEMBLY**
ILLUSTRATION 1-4




**VENT ADAPTER & PLUMBING CONNECTIONS**
ILLUSTRATION 1-5

### 1-1 CONVERSION TO OPERATING CONFIGURATION (continued)

12. Tighten and leak-check all plumbing joints after connecting.

13. Adjust the Jack Stud at base of Vent Adapter so it is in contact with the cryostat.

14. Pack and return the 17.5 psia and 15 psig Relief Valves and the Blanking Plate to:

GE MAGNET SYSTEMS
3001 W. RADIO DRIVE
FLORENCE, SOUTH CAROLINA 29501
ATTN: MATERIALS GROUP

**WARNING!**

**MAGNET LIFTING SHACKELS, JACKING RAILS, MOUNTING BRACKETS AND HARDWARE ARE MADE OF FERROUS MATERIALS AND MUST BE REMOVED FROM MAGNET ROOM BEFORE RAMPING.**

15. Remove the magnet lifting shackels, jacking rails, mounting brackets and hardware from the Magnet Support Ring and store onsite. Inform the customer of storage requirements. Notify the customer that the jacking rails, mounting brackets and hardware are part of the magnet and need to be stored in an accessible place for future use.

## 1-2 VENTING INSTALLATION

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**WARNING!**

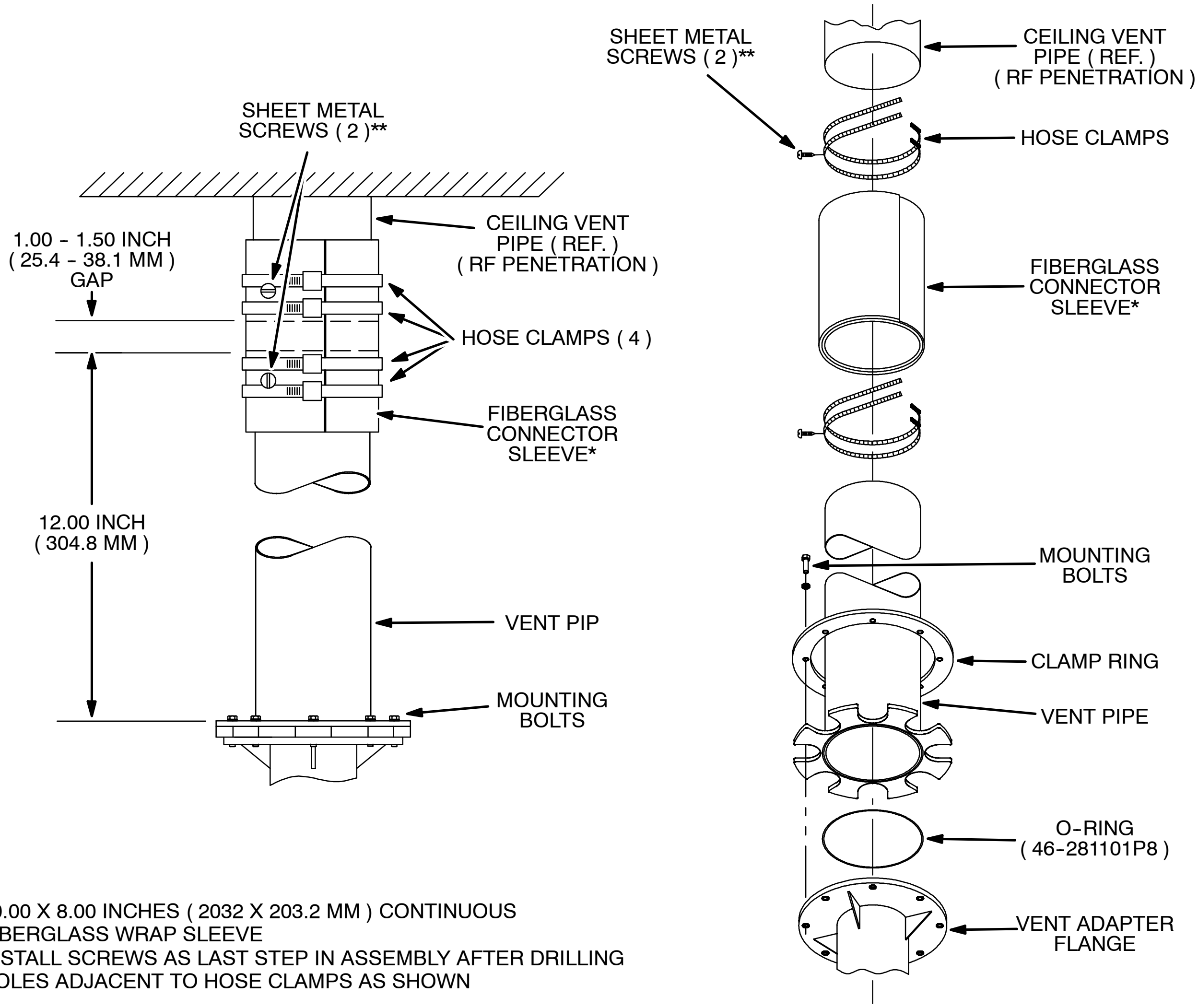
**MAKE SURE THE EXHAUST DUCT EXIT HAS RESTRICTED ACCESS TO WITHIN 10 FEET ( 3 METERS ) OF THE VENT ADAPTER TO AVOID BURNS FROM COLD EXHAUST GAS.**

**PROTECT THE VENTILATION EXHAUST OPENING FROM INGRESS OF RAIN, SNOW OR DEBRIS THAT COULD BLOCK THE EXHAUST SYSTEM.**

**MAKE SURE THE PRESSURE DROP IN THE VENT SYSTEM DOES NOT EXCEED 12 PSI ( 92.7 KPA ) FROM THE VENT ADAPTER TO THE EXIT AT THE OUTSIDE OF THE BUILDING. THIS WILL PREVENT ANY POSSIBLE DAMAGE TO THE MAGNET AND VENT SYSTEM DURING A QUENCH.**

1. Assemble the Helium Vent Kit ( 46-281866G1 ) between the Magnet Vent Adapter and the Outside Vent to the "RF Penetration" point. Cut the Vent Pipe to the required length. Use the clamps and connector provided in the kit to connect the vent to the Outside Vent at the "RF Penetration" point. See Illustration 1-6.

## 1-2 VENTING INSTALLATION ( continued )




* 80.00 X 8.00 INCHES ( 2032 X 203.2 MM ) CONTINUOUS FIBERGLASS WRAP SLEEVE
** INSTALL SCREWS AS LAST STEP IN ASSEMBLY AFTER DRILLING HOLES ADJACENT TO HOSE CLAMPS AS SHOWN

**HELIUM VENT KIT ASSEMBLY**
ILLUSTRATION 1-6

**CAUTION**

**Insulate the vent pipe within the magnet room if there horizontal sections that could collect condensation and drip on personnel.**

2. Make sure that the pressure drop in the Vent System does not exceed 12 psi from the Vent Adapter or 9 psi from the “RF Penetration” point to the exit at the outside the building. Use Table 1-1 to compute the pressure drop in the system.

## 1-2 VENTING INSTALLATION ( continued )

3. Inspect the Vent System for integrity and blockages prior to connecting it to the Magnet.

4. Connect the Vent to the Vent Adapter of the Magnet using the Clamps and Gasket provided.

TABLE 1-1
**CRYOGENIC VENT SYSTEM PRESSURE DROP MATRIX FOR 0.7T MAGNET**
**( THIS TABLE MUST BE USED FOR CRYOGENIC VENT SYSTEM DESIGN )**

| INSIDE DIAMETER OF VENT PIPE | CRYOGENIC VENT SYSTEM PRESSURE DROP MATRIX FOR A 0.7 TESLA MAGNET | | PRESSURE DROP PER ELBOW USED ANYWHERE WITHIN A 20 FT VENT SEGMENT | | | |
|---|---|---|---|---|---|---|
| | DISTANCE OF VENT SYSTEMCOMPONENT FROM MAGNET | PRESSURE DROP FOR STRAIGHT VENT PIPE WITH SMOOTH INSIDE SURFACE | STANDARD SWEEP 45° ELBOW | STANDARD SWEEP 90° ELBOW | LONG SWEEP 45° ELBOW | LONG SWEEP 90° ELBOW |
| in. (mm) | ft (m) | psi/ft (KPa/m) | psi (KPa) | psi (KPa) | psi (KPa) | psi (KPa) |
| 8 | 0- 20 ( 0.0- 6.1) | 0.003 (0.021) | 0.031 (0.21) | 0.062 (0.43) | 0.015 (0.10) | 0.044 (0.30) |
| | 20- 40 ( 6.1-12.2) | 0.0075 (0.052) | 0.075 (0.52) | 0.15 (1.03) | 0.036 (0.25) | 0.10 (0.67) |
| (203.2) | 40- 60 (12.2-18.3) | 0.012 (0.083) | 0.125 (0.86) | 0.25 (1.38) | 0.059 (0.41) | 0.17 (1.17) |
| | 60- 80 (18.3-24.4) | 0.018 (0.124) | 0.179 (1.23) | 0.36 (2.48) | 0.086 (0.59) | 0.25 (1.72) |
| | 80-100 (24.4-30.5) | 0.024 (0.17) | 0.237 (1.63) | 0.47 (3.24) | 0.11 (0.76) | 0.33 (2.28) |
| 10 | 0- 20 ( 0.0- 6.1) | 0.0011 (0.0076) | 0.013 (0.09) | 0.028 (0.19) | 0.006 (0.041) | 0.023 (0.16) |
| | 20- 40 ( 6.1-12.2) | 0.0026 (0.018) | 0.031 (0.21) | 0.067 (0.46) | 0.016 (0.11) | 0.055 (0.38) |
| (254.0) | 40- 60 (12.2-18.3) | 0.0043 (0.03) | 0.052 (0.36) | 0.11 (0.76) | 0.026 (0.18) | 0.093 (0.64) |
| | 60- 80 (18.3-24.4) | 0.0062 (0.043) | 0.075 (0.52) | 0.16 (1.10) | 0.037 (0.26) | 0.13 (0.90) |
| | 80-100 (24.4-30.5) | 0.0082 (0.057) | 0.099 (0.68) | 0.21 (1.45) | 0.049 (0.34) | 0.18 (1.24) |
| 12 | 0- 20 ( 0.0- 6.1) | 0.00045 (0.0031) | 0.007 (0.048) | 0.014 (0.097) | 0.003 (0.021) | 0.009 (0.062) |
| | 20- 40 ( 6.1-12.2) | 0.0011 (0.0076) | 0.016 (0.11) | 0.034 (0.23) | 0.008 (0.055) | 0.021 (0.14) |
| | 40- 60 (12.2-18.3) | 0.0018 (0.0124) | 0.027 (0.19) | 0.056 (0.39) | 0.013 (0.090) | 0.036 (0.25) |
| (304.8) | 60- 80 (18.3-24.4) | 0.0026 (0.018) | 0.039 (0.27) | 0.081 (0.56) | 0.018 (0.124) | 0.052 (0.36) |
| | 80-100 (24.4-30.5) | 0.0035 (0.024) | 0.052 (0.36) | 0.11 (0.76) | 0.024 (0.165) | 0.069 (0.48) |
| | 100-120 (30.5-36.6) | 0.0043 (0.030) | | 0.14 (0.97) | | 0.087 (0.60) |
| | 120-140 (36.6-42.7) | 0.0053 (0.037) | | 0.16 (1.10) | | 0.105 (0.72) |
| | 140-160 (42.7-48.8) | 0.0062 (0.043) | | 0.19 (1.31) | | 0.125 (0.862) |

Note 1 : Elbows with angles greater than 90° must not be used.

Note 2 : The table data is based on the following:
a. Initial flow conditions at magnet interface
b. Gas temperature starting at 4.5 Kelvin (-452° F or -268° C ).
c. Helium gas flow rate of 750 cubic feet per minute ( 21.0 cubic meters per minute ) @ 1.77 atm, saturated vapor.

**Note**

If the total pressure drop calculated exceeds the maximum specified pressure drop of 12 psi, then large diameters for some of the vent line sections would have to be selected and the total pressure drop recalculated until it is less than 12 psi.

## 1-3 SYSTEM LEAK TEST

Cryostat pressure can increase up to 7.5 psig during operation, thereby increasing any leakages. A leak will slowly deplete the helium supply, possibly causing cryopumping, icing and interfere with the operation of the Recondenser.

It is important to identify and eliminate any leak at installation, after the magnet has been converted to its operating condition.

1. Allow the cryostat to build pressure prior to operating the Cryocooler Coldhead.

**Note**

Commercial HVAC leak detector fluids can be used to determine small leaks in the helium plumbing and venting. Some examples available through HVAC distributors are:

- Bird Dog Quart Spray ( p/n DOG-1Q ) *or*
- Big Blue ( p/n Rt100S / Rt100G )

2. When the cryostat pressure reaches 4 psig, check the following areas for leaks using a "Snoop" or leak detector liquid:
   - All plumbing joints
   - Vertical Turret and Instrumentation Lead cover
   - Ramp Lead and Fill Port caps
   - Burst Disc 360 degree contact around the Plenum
   - Pressure gauge and relief valves
   - Shim Lead collar / cap
3. Disconnect 7.5 and 10.0 psig relief valves at the exhaust side. Check for leak using a small balloon. Replace any leaking relief valves.
4. Repair any leaks found prior to commissioning the magnet.

## 1-4 CRYOCOOLER INSTALLATION AND CHECK OUT

### Introduction

The Cryocooler comes with a Coldhead already installed on the magnet and a separate Compressor unit, which will be located in the SCC cabinet in the equipment room. A power cable and gas supply and return lines connect the two units. Locate and read the vendor manual(s) supplied with your system to become thoroughly familiar with the configuration, site requirements and procedures for the system supplied prior to installation. Compressor installation instructions are covered in the Compressor vendor manual. Compressor location and cable routing is shown in Direction 2241391, *Signa OpenSpeed Pre-installation Manual*. A Bypass Unit is supplied for the Cryocooler Compressor. This unit is connected directly to the Compressor. The Cryocooler interconnect diagram is shown in SCHEMATICS / INTERCONNECTS, Section 1.

### 1-4-1 Cryocooler Compressor Installation

1. Unpack and install the Compressor in conformance with the vendor service manual. Note any visible damage and notify the shipper.
2. Position the Cryocooler Compressor in the equipment room to the right of the SCC Cabinet ( as viewed facing the cabinet's front ). Refer to Direction 2241391, *Signa OpenSpeed Pre-installation Manual*.
3. Insert the Cryocooler Compressor into the bottom right section of the SCC Cabinet using the rails provided with the cabinet.
4. Connect the input power cable in conformance with the vendor manual and local electrical code.

## IMPORTANT !!!

The Magnet Monitor must be installed shortly after the Cryocoolers are powered on. If the Cryocoolers are turned on without the pressure control from the magnet monitor, helium vessel pressure could go subatmospheric, which can cause icing in the Service Turret.

**CAUTION**

**Do NOT connect the Flex Lines until system Gas Pressure Check is performed in Section 1-4-2, to prevent line contamination.**

### 1-4-2 System Gas Pressure Check

## IMPORTANT !!!

***DO NOT OVER PRESSURIZE THE COMPRESSOR!*** Over pressurizing the Compressor can prevent the Compressor bypass valve from closing after the restart of a warm Compressor. This condition will severely degrade Compressor capacity during operation, resulting in cryostat pressure increase and helium loss.

Proper static gas pressure for the Cryocooler Compressor is given in Table 1-2. Check the static pressure reading on the Compressor Pressure Gauge. If the pressure is not within specification use the following procedures to adjust the pressure to specification.

TABLE 1-2
**COMPRESSOR STATIC GAS PRESSURES**

| | STATIC GAS PRESSURE AT 20°C ( 68°F ) | | |
|---|---|---|---|
| | MPa | KGF / $CM^2G$ | PSIG |
| CRYOCOOLER COMPRESSOR | 1.60 - 1.65 | 16.3 - 16.8 | 232 - 239 |
| SHIELD COOLER COMPRESSOR | 1.45 - 1.50 | 14.8 - 15.3 | 210 - 217 |

**Note**

Static pressure is effected by ambient temperature. Small variances will occur with temperature variances around 70° F.

### 1-4-2-1 Increasing Gas Pressure

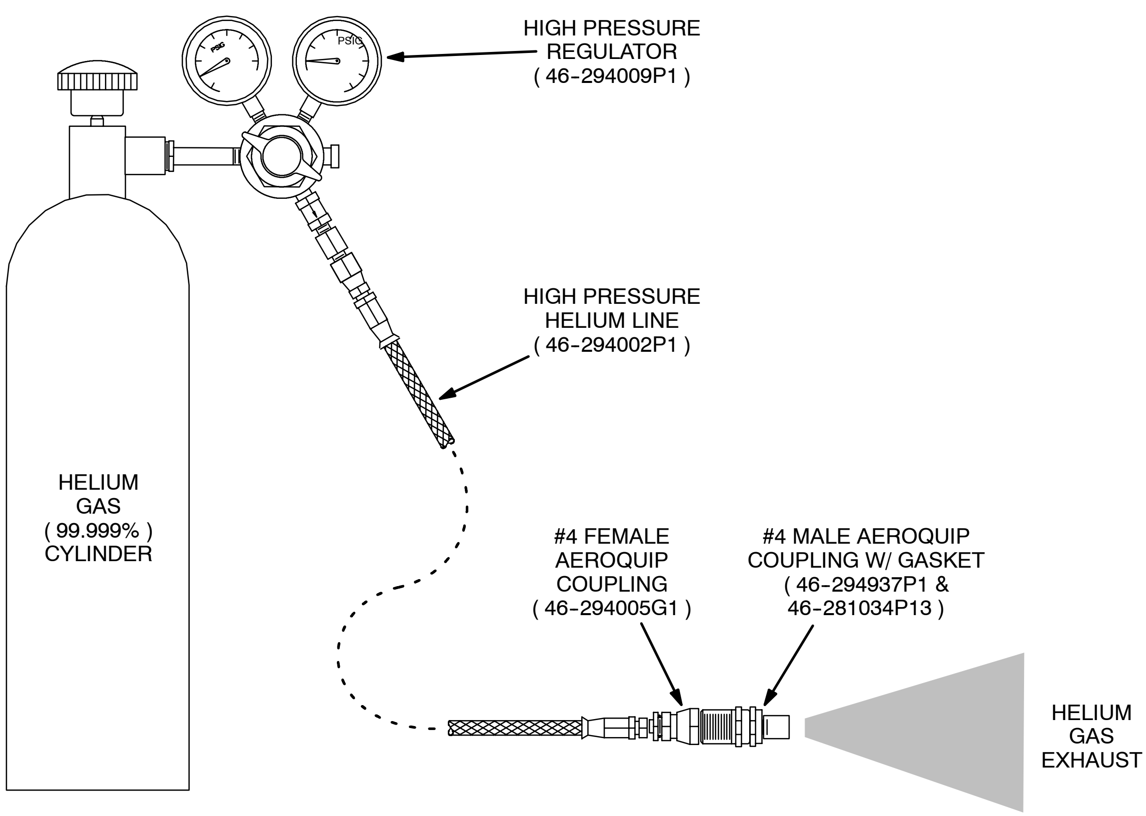
**CAUTION**

**The following procedure purges air out of the regulator and connecting lines before the line is connected to a new cylinder of certified 99.999% helium gas.**

**Note**

Use the Shield Cooler Installation / Maintenance Kit ( 46-281088G3 ) to perform all necessary maintenance to Cryocooler Systems.

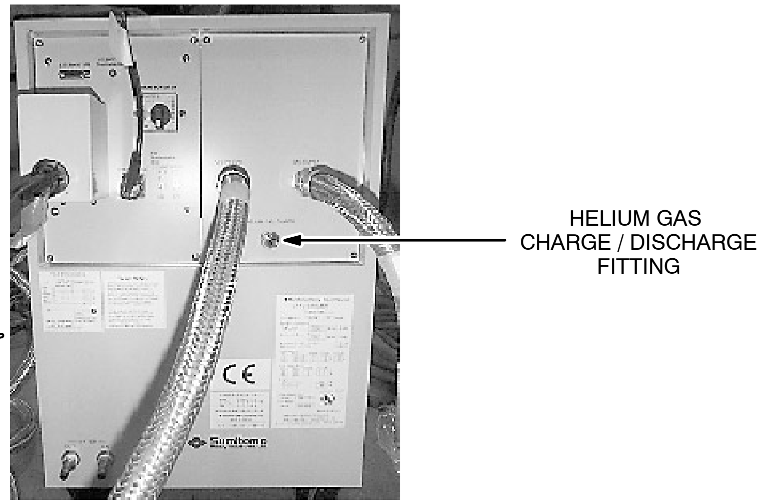
1. Obtain a cylinder of 99.999% Helium Gas.
2. Loosely attach the high pressure regulator ( 46-294009P1 ) to the gas cylinder per the following steps.
   a. Thread in the screw that connects the regulator to the Helium bottle about 2 turns.
   b. Turn regulator handle fully clockwise to open the regulator.
   c. Open Helium bottle, and immediately tighten the regulator to the Helium bottle.
   d. Close the regulator valve by turning the handle counterclockwise.
3. Attach high pressure helium line ( 46-294002P1 ) to regulator at shut off valve. See Illustration 1-7.




**SET-UP FOR COMPRESSOR CHARGING**
ILLUSTRATION 1-7

### 1-4-2-1 Increasing Gas Pressure ( continued )

4. Attach a #4 female Aeroquip coupling ( 46-294005G1 ) to the end of the high pressure charging line. See Illustration 1-8.




**CHARGE / DISCHARGE FITTING LOCATION**
ILLUSTRATION 1-8

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSI.**

5. Attach a #4 male Aeroquip coupling ( 46-294937P1 ) with Gasket ( 46-281034P13 ) to the #4 female Aeroquip coupling. Hand tighten the fittings together. This will open the Helium circuit to allow the charging assembly to be purged.

6. Establish gas flow through the Helium line and fittings by slowly opening the main valve on the gas cylinder and tightening the male fitting into the female Aeroquip.

7. Allow Helium to purge out the assembly for 2 minutes.

8. Remove the male Aeroquip fitting coupling from the female coupling.

9. Close the regulator. Shut off Compressor power to let the supply and return line pressures equalize in the Compressor.

10. Fully open the valve on the cylinder.

11. Adjust the regulator control valve to achieve a pressure of approximately 200 psig.

#### 1-4-2-1 Increasing Gas Pressure ( continued )

12. Attach the purged charging line assembly with the female Aeroquip coupling to the charging fitting on the front of the Compressor. See Illustration 1-8.
13. Increase Compressor Helium pressure by adjusting the regulator until the Compressor's high side gauge reads in the Cryocooler Compressor range specified in Table 1-2.
14. If too much Helium gas has been added, refer to Section 1-4-2-3, Decreasing Gas Pressure, to lower the Helium pressure.

#### 1-4-2-2 Disconnection and Storage of Hoses and Regulator

1. Remove the Aeroquip coupling from the Compressor. Restore Compressor power.
2. Close the regulator.
3. Attach a high pressure hose and #4 female Aeroquip fitting to the #4 male Aeroquip fitting until the Helium circuit is opened and gas is flowing.
4. Allow the high pressure line and Aeroquip to depressurize.
5. Remove the #4 male Aeroquip fitting and the #4 female Aeroquip fitting from the high pressure charging line.
6. Remove the high pressure charging line from the regulator.
7. Close the valve on the Helium cylinder. Bleed off pressure from the regulator.
8. Remove the regulator from the Helium bottle.
9. Store all Shield Cooler Installation / Maintenance Kit ( 46-281088G2 ) equipment in the carrying case.

#### 1-4-2-3 Decreasing Gas Pressure

1. Remove the protective cap from the Compressor's front panel fitting.
2. Make sure a #4 female Aeroquip coupling ( 46-294005G1 ) and a #4 male Aeroquip coupling ( 46-294937P1 ) are connected to the hose. See Illustration 1-7.

**Note**

Use the Shield Cooler Installation / Maintenance Kit ( 46-281088G2 ) to perform all necessary maintenance to Cryocooler Systems.

3. Slowly tighten the fittings until you hear gas escaping.
4. When the pressure reaches the Cryocooler pressure specified in Table 1-2, immediately unscrew the fittings and hose to prevent further gas removal.
5. Replace the protective cap on the Compressor's front panel fitting.

### 1-4-3 Bypass Unit Installation

The Compressor Bypass Unit is installed directly onto the Cryocooler Compressor and provides an alternate path for the helium gas flow when the Coldhead is cycled off while the Compressor running.

The unit is approximately 2 pounds ( 1 KG ) in weight and is supported on the Compressor by the Aeroquip fitting connections.

**WARNING!**

**BEFORE STARTING BYPASS UNIT INSTALLATION AND BEFORE CONNECTING OR DISCONNECTING THE JUNCTION CABLE AND COLDHEAD POWER CABLE, MAKE SURE NO POWER IS APPLIED TO THE COMPRESSOR UNIT. FAILING TO OBSERVE THIS PRECAUTION MAY RESULT IN ELECTRICAL SHOCK.**

**SEALED INSIDE THE BYPASS UNIT IS HIGH PRESSURE HELIUM GAS. DAMAGE TO THE UNIT MAY CAUSE GAS TO EXCAPE, POTENTIALLY EXPLOSIVELY. HANDLE WITH EXTREME CARE.**

**CAUTION**

**Before connecting the flexlines, make sure to check the flat rubber gasket of the Bypass Unit's self-seal coupling for dirt or dust and to see whether it is attached correctly. Connecting the flexlines with that flat rubber gasket seated abnormally may cause gas to escape.**

**Do not mismatch the Bypass Unit's "SUPPLY" and "RETURN" connection and the flexlines. Misconnecting the gas line may prevent Cryocooler from operating properly.**

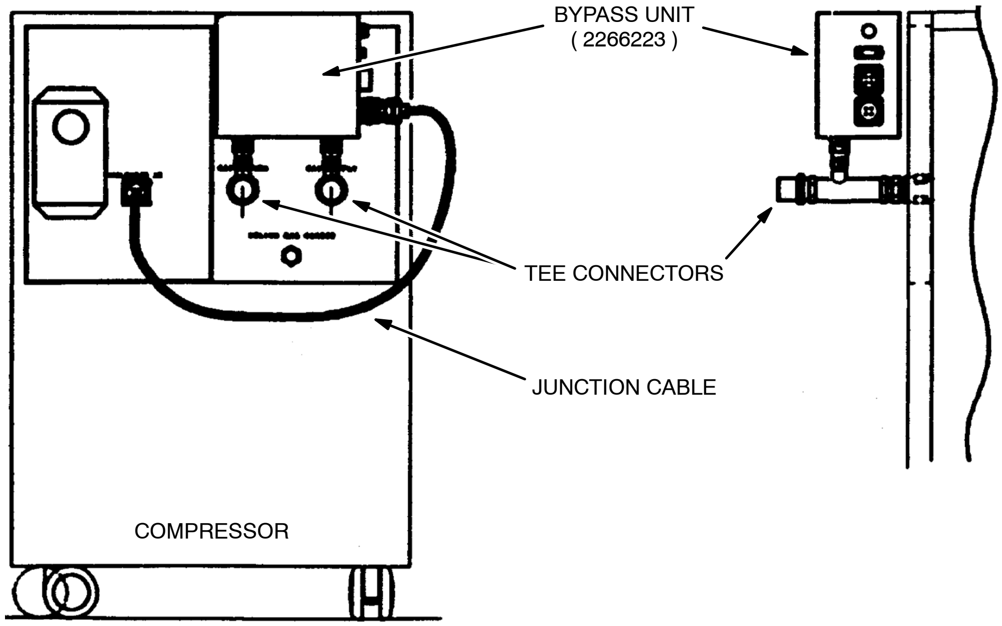
**IMPORTANT !!!**

When connecting Bypass Unit and flexlines, make sure the unit is oriented properly in conformance with Illustration 1-9.

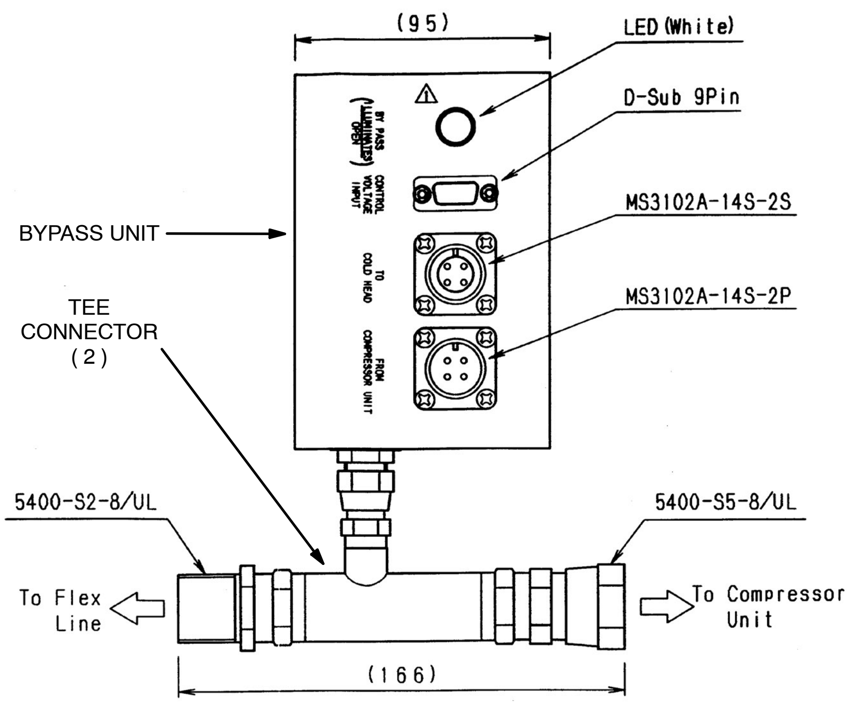
Tighten the self-sealing coupling nut by hand for the first turn and finally tighten it firmly. Be careful not to tighten it excessively.

1. Remove all protective caps of the self-sealing connectors.
2. Check the flat rubber gaskets on all self-sealing connectors to make sure they are being clean and properly positioned.
3. Connect the both supply and return tee connectors to the Compressor unit. See Illustrations 1-9 and 1-10.
4. Connect the Bypass Unit. See Illustrations 1-9 and 1-10.
5. Connect the Junction Cable between Compressor unit and Bypass Unit. See Illustration 1-9.

### 1-4-3 Bypass Unit Installation ( continued )




**BYPASS UNIT ATTACHED TO COMPRESSOR**
ILLUSTRATION 1-9




**BYPASS UNIT CONNECTIONS**
ILLUSTRATION 1-10

### 1-4-3 Bypass Unit Installation ( continued )

6. The following connections can now made to the Bypass Unit, in conformance with Sections 1-4-5 and 1-4-7, to complete the interconnections of the Cryocooler assembly:
   - Return and supply gas lines.
   - Coldhead power cable
   - Control voltage input cable from the MR system.

### 1-4-4 Cooling

#### 1-4-4-1 Water Supply Connection ( for water-cooled Compressor - for SCC cabinet )

1. Verify that the cooling water supply meets all specification requirements in the supplier service manual.
2. Check hose lengths. Hoses must be long enough to allow attached Compressor to be pulled to in front of SCC Cabinet for troubleshooting purposes. Replace with long enough hoses if needed.
3. Connect the water supply hose to the cooling water inlet connection. Secure with a worm drive screw type hose clamp.
4. Similarly connect the water return hose to the cooling water outlet connection of the Compressor.

#### 1-4-4-2 Air Space ( for air-cooled Compressor )

1. Turn on the cooling water supply and operate the Compressor at least 30 minutes to make sure that cooling water is sufficient and that the Compressor is operating properly.
2. Check the system for water leaks.
3. Verify that minimum air space shown in the supplier manual for the Compressor is met.
4. Verify that the temperature requirement called out in the vendor manual will be met.

**WARNING!**

**ANTIFREEZE IS POISONOUS TO AQUATIC, ANIMAL AND HUMAN LIFE. BECAUSE OF ITS SWEETNESS, ANIMALS MAY BE DRAWN TO IT. CONSEQUENTLY IT IS CLASSIFIED AS HAZARDOUS BOTH FOR SHIPMENT AND AS A WASTE. THEREFORE, IT MAY NOT BE SHIPPED BY UNTRAINED PEOPLE. CRYOCOOLER COMPRESSORS WHICH CONTAIN ANTIFREEZE MUST BE DRAINED BEFORE BEING RETURNED TO THE SUPPLIER. MAKE ARRANGEMENTS WITH THE HOSPITAL MAINTENANCE DEPARTMENT FOR DISPOSAL.**

### 1-4-5 Cryocooler Gas Line Installation

**IMPORTANT !!!**

Helium gas lines and Coldhead power cables are marked with two run numbers. One is for Cryocooler applications and one is for Shield Cooler applications.

Before installing the Coldhead gas lines and power cable, mark out with a black pen the run number on the label at each end of the line / cable that does not apply. See Table 1-3.

TABLE 1-3
**COLDHEAD GAS LINES / POWER CABLE RUN NUMBERS**

| APPLICATION | GAS SUPPLY LINE | GAS RETURN LINE | COLDHEAD PENETRATION PANEL POWER CABLE | COMPRESSOR PENETRATION PANEL POWER CABLE |
|---|---|---|---|---|
| CRYOCOOLER | 621 | 622 | 624 | 623 |
| SHIELD COOLER | 625 | 626 | 628 | 627 |

#### 1-4-5-1 Gas Line Routing and Shielding

**CAUTION**

**When routing gas lines make sure all slack is coiled within the equipment room to prevent white pixel generation in images and that all curvatures / coils in the gas lines have radii greater than 12 inches ( 300 mm ) to prevent bending force on Aeroquip fittings and strain / “chirping” noise on the line.**

1. Feed gas supply line through designated 55 mm ( 2.17 inch ) port hole in Penetration Panel. Install line into cable trough in conformance with site planning requirements. Position line to reach Coldhead connection at the magnet and Compressor connection in the equipment room.
2. Repeat Step 1 using the other available port for the return line.
3. Adjust the slack on the helium supply and return flexlines for the most suitable length on both sides of the Penetration Panel. Loosely coil excess line length in the equipment room.

### 1-4-5-1 Gas Line Routing and Shielding ( continued )

**Note**

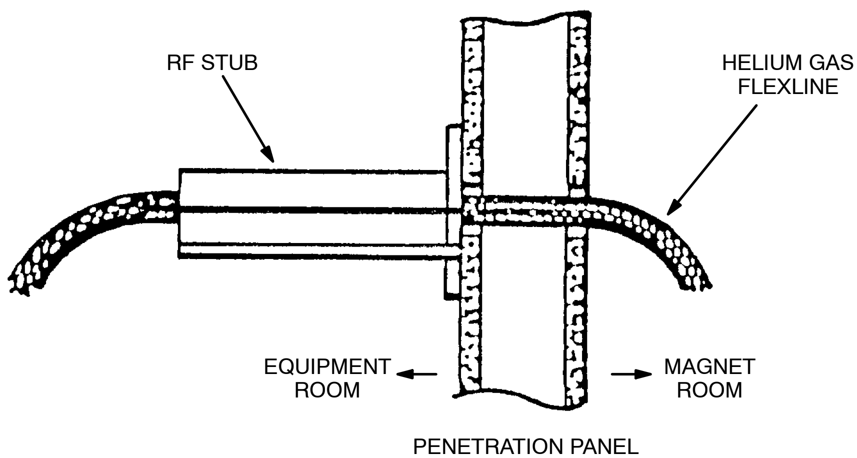
RF shielding of the flexlines as they pass through the Penetration Panel is performed from the equipment room side of the Penetration Panel. Use the following procedure for both the helium supply and return lines. See Illustration 1-11.

4. Install RF shielding around each gas line as it passes through the Penetration Panel:

   a. Position half of the RF Stub Assembly ( 46-260860G1 ) underneath the helium supply line, with the flange end oriented toward the Penetration Panel. See Illustration 1-11.

**Note**

Make sure RF Stub Assembly is clean ( bright copper appearance ). Wire brush surface as required, to effect clean surface.




**RF STUB ASSEMBLY MOUNTING**
ILLUSTRATION 1-11

   b. Secure the flange of the RF Stub Assembly to the Penetration Panel with four screws, aligning the flange holes with the holes In the Penetration Panel.

   c. Insert bronze wool ( 46-318068P1 ) around the helium supply line ( top and bottom ) over the length of the RF Penetration Stub.

   d. Position the other half of the RF Stub Assembly over the helium supply line, with the flange oriented toward the Penetration Panel and align it over the lower 1/2.

   e. Secure the flange of the top half of the RF Penetration Stub Assembly to the Penetration Panel with four screws, aligning the flange holes with holes in the Penetration Panel.

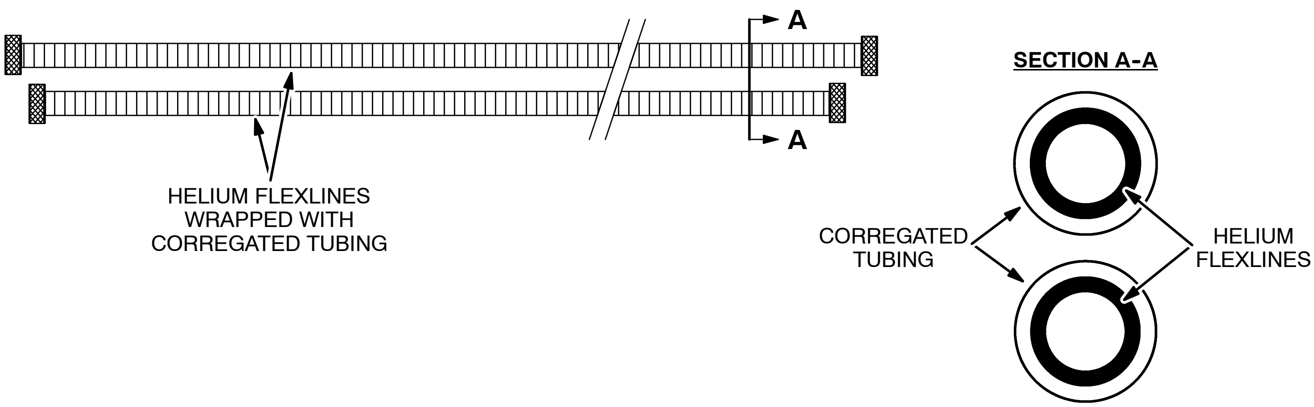
   a. Repeat Steps 4a and 4e for the Helium return line.

#### 1-4-5-1 Gas Line Routing and Shielding ( continued )

5. Cover both lines completely with Corregated Plastic Tubing ( 2251611 ) from the Penetration Panel where the lines exit the magnet room to the helium line fittings at the Coldhead. See Illustration 1-12.

**Note**

Corregated plastic tubing is used to isolate helium gas lines from each other and from ground to prevent spike noise.




**HELIUM LINE CASING INSULATION**
ILLUSTRATION 1-12

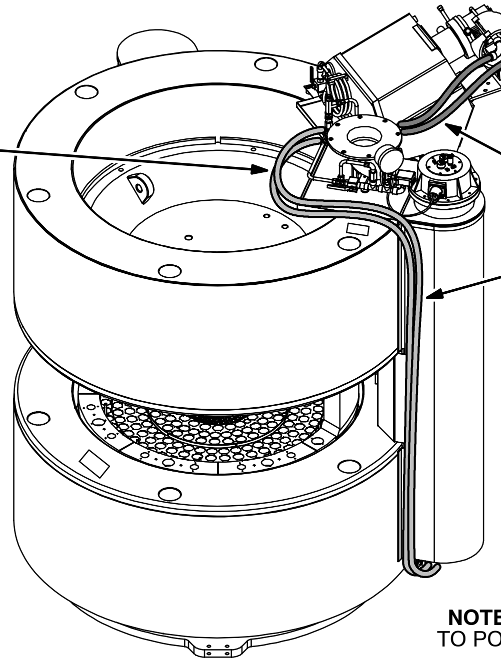
#### 1-4-5-2 Flexible Gas Line Connections

**CAUTION**

**When routing gas lines make sure all slack is coiled within the equipment room to prevent white pixel generation in images and that all curvatures / coils in the gas lines have radii greater than 12 inches ( 300 mm ) to prevent bending force on Aeroquip fittings and strain / "chirping" noise on the line.**

1. Route supply and return lines around the bottom of the magnet on the right side ( facing from the front of magnet ). Route the lines up along vertical posts and route around the vent adapter to the Coldhead in a wide arc to prevent kinking. See Illustration 1-13.

**1-4-5-2 Flexible Gas Line Connections ( continued )**




**FLEXIBLE GAS LINE STRAIN RELIEF AND ROUTING AT MAGNET**
ILLUSTRATION 1-13

**WARNING!**

**DO NOT PUT ANY BENDING FORCE ON THE AEROQUIP FITTINGS DURING HELIUM FLEX-LINE CONNECTING / DISCONNECTING. A BENDING FORCE WILL CREATE DIFFICULTY IN THE RAPID THREAD ENGAGEMENT / DISENGAGEMENT REQUIRED TO PREVENT HELIUM LOSS AND CONTAMINATION. IT CAN ALSO RESULT IN BENDING OR LEAKING OF THE AEROQUIP STEMS. SUPPORT THE GAS LINES TO PREVENT A BENDING FORCE WHEN CONNECTING / DISCONNECTING TO THE COLDHEAD AT THE TOP OF THE MAGNET.**

**Note**

See REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections, for proper connection of flexlines.

2. Connect right-angle flexline connectors ( 2273967 and 2273967-2 ) to the supply and return fittings on the Coldhead.

#### 1-4-5-2 Flexible Gas Line Connections ( continued )

**CAUTION**

**The order and technique are important when connecting helium flexlines to prevent inoperative Coldheads and system contamination. Read and follow the procedure in the vendor manual provided with the Compressor. Make sure lines are connected in the sequence given in Step 3. Gas back pressure may prevent the Coldhead from starting if gas lines are connected in the reverse sequence.**

3. Connect gas return line ( green mark ) to Bypass Unit. Connect gas supply line ( yellow mark ) to Bypass Unit. Connect gas return line ( green mark ) first, then connect the gas supply line ( yellow mark ) to the right-angle flexline connectors on the Coldhead.
4. Observe the readings of the Compressor pressure gauges. If they are constant, then a leak is not suspected.
   - If the readings are above specification, then vent down as described in SET-UP AND CALIBRATION, Section 1-4-2, System Gas Pressure Check.

**IMPORTANT !!!**

**DO NOT OVER PRESSURIZE THE COMPRESSOR!** Over pressurizing the Compressor can prevent the Compressor bypass valve from closing after the restart of a warm the Compressor. This condition will severely degrade Compressor capacity during operation, resulting in cryostat pressure increase and helium loss.

   - If the pressure readings are below the Cryocooler specification shown in Table 1-2, then increase the helium gas charge in the complete system by supplying helium gas through the supply fitting on the Compressor as described in SET-UP AND CALIBRATION, Section 1-4-2, System Gas Pressure Check. Also see Section 1-4-6, Leak Test.

### 1-4-6 Leak Test

1. After increasing helium charge, if the pressure continues to drop, remove the lines from the Compressor in conformance with REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections.

**Note**

Lines suspected of leaking may be tested using the regulator, charging line and manifold.

2. Connect the regulator, charging line and manifold and purge as previously described in SET-UP AND CALIBRATION, Section 1-4-2-1, Increasing Gas Pressure.
3. Connect one of the flexlines to the appropriate fitting on the manifold and pressurize to approximately 100 psig.
4. Reduce the supply pressure using the regulator control and observe whether the pressure is maintained on the manifold pressure gauge. If the pressure drops, then that line may have a gas leak.

### 1-4-6 Leak Test ( continued )

5. Maintain 100 psig with the regulator and check the line with a liquid soap solution or a commercial leak testing solution such as Leak-Tec.

6. If the line has a leak, then notify Magnet Systems to obtain a replacement.

7. Repeat the above procedure for the other gas line.

**Note**

If the Compressor pressure gauge readings had dropped and stayed constant, then the charge may have just been low and the system will be recharged.

### 1-4-7 Cryocooler Electrical Cable Connections

**IMPORTANT !!!**

Helium gas lines and Coldhead power cables are marked with two run numbers. One is for Cryocooler applications and one is for Shield Cooler applications.

Before installing the Coldhead gas lines and power cable, remove the run number label at each end of the line / cable that does not apply. See Table 1-4.

Do NOT cut through the power cable insulation when removing nonapplicable run number label.

TABLE 1-4
**COLDHEAD GAS LINES / POWER CABLE RUN NUMBERS**

| APPLICATION | GAS SUPPLY LINE | GAS RETURN LINE | COLDHEAD PENETRATION PANEL POWER CABLE | COMPRESSOR PENETRATION PANEL POWER CABLE |
|---|---|---|---|---|
| CRYOCOOLER | 621 | 622 | 624 | 623 |
| SHIELD COOLER | 625 | 626 | 628 | 627 |

1. Connect Coldhead power cables ( Run 623 and 624 ) as shown in Illustration 1-14 when the Penetration Panel is installed.

**Note**

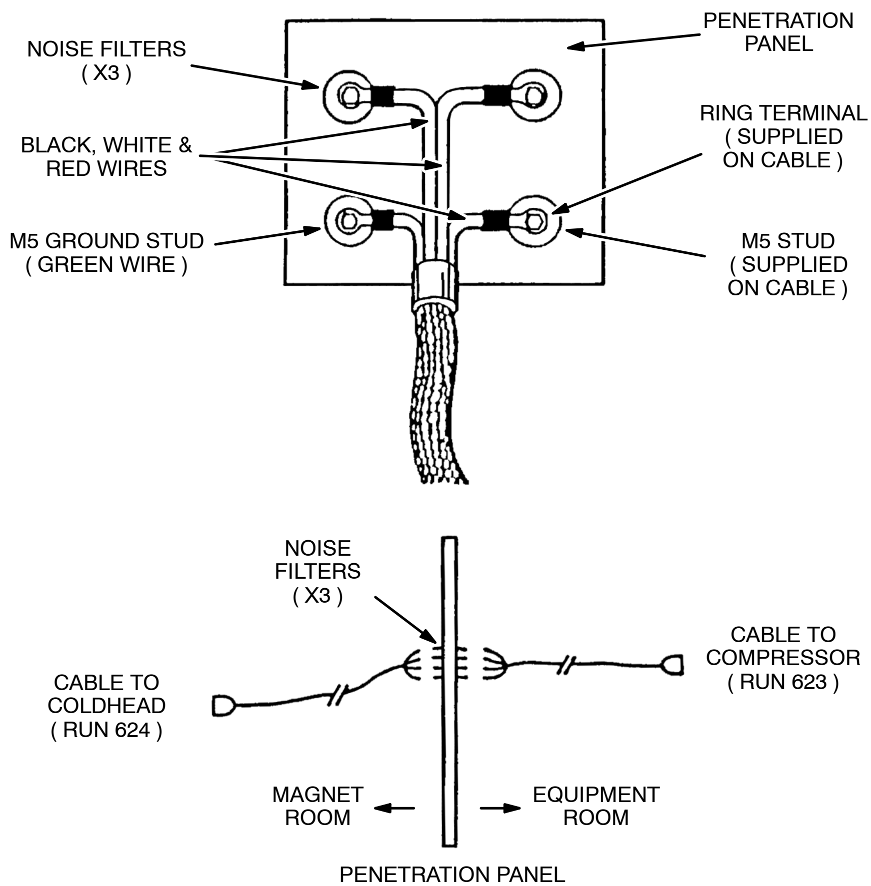
Power cables supplied from the factory may be connected to a terminal block to facilitate Cryocooler operation prior to Penetration Panel installation. If terminal block is not present, connect the ring terminals via screws or terminal block ( same wire color ) to allow Cryocooler to operate prior to Penetration Panel installation.

2. Connect Coldhead cable ( Run 623 ) to the Bypass Unit. Connect Coldhead cable ( Run 624 ) to the Coldhead. See SCHEMATICS / INTERCONNECTS, Illustration 1-2, Magnet Cryocooler Interconnect Diagram.

### 1-4-7 Cryocooler Electrical Cable Connections ( continued )

**CAUTION**

**Make sure that the wire code ( color and number ) is properly matched on the noise filter studs on both sides of the Penetration Panel to prevent improper operation or damage.**




**CRYOCOOLER ELECTRICAL CABLE CONNECTIONS**
ILLUSTRATION 1-14

### 1-4-8 Cryocooler Operation

1. Turn on the main power.
2. Turn on the Compressor power switch. The Coldhead motor should begin operating.
3. Perform Cryocooler checks covered in the vendor manual.

### 1-4-9 Monitoring Cryocooler Temperatures

#### Introduction

The RuO Temperature Monitor ( 2171219; included in Magnet Tool Kit 2183710 ) is used to monitor the second stage Coldhead RuO temperature and the temperature of the mating surface on the Recondenser during installation and troubleshooting of the Coldhead.

**Note**

Magnet Monitor 2209000 can be used to monitor cooldown and temperature trends but does not give accurate temperature readings at 4.2K.

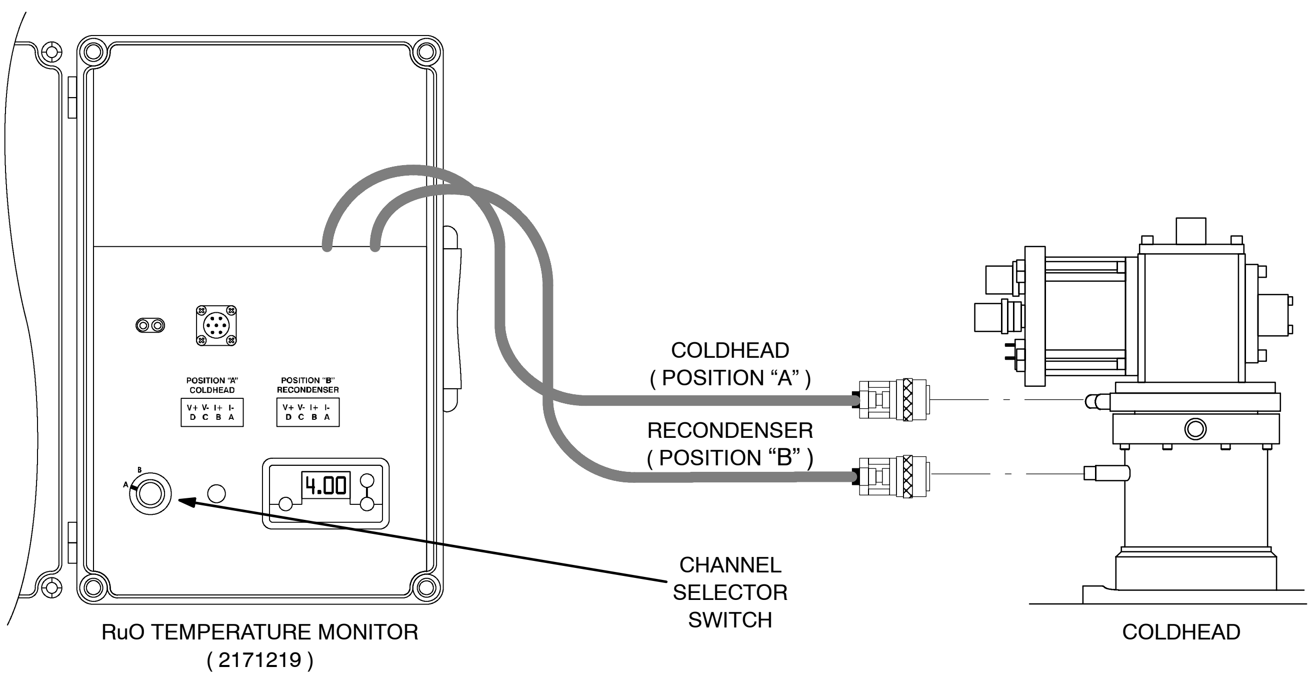
Second stage Coldhead temperature is monitored indirectly during operation by monitoring the silicone diode temperature of the Recondenser at the system monitor cabinet.

First stage Coldhead temperature is monitored indirectly by monitoring the silicone diode Coldhead Sleeve temperature at the system monitor cabinet.

#### Procedure

1. Connect the test plug to temperature monitor's cables to confirm calibration.

2. Connect temperature monitor's cables to magnet connectors as shown in Illustration 1-15.




**RuO TEMPERATURE MONITOR ( 2171219 ) CONNECTIONS**
ILLUSTRATION 1-15

### 1-4-9 Monitoring Cryocooler Temperatures ( continued )

3. Set the Channel Selector Switch to the desired channel ( A or B ), and depress the button to read the temperature on that channel.

4. Make sure the first and second stage Coldhead temperatures are cooling down.

### 1-4-10 Setting Coldhead Tension

**Note**

Check the tightness of the mounting bolts in conformance with the following procedure, to make sure that sufficient contact is made at the first and second stage heat stations when the Cryocooler Coldhead cools down during magnet installation or after it has been shut off for a considerable length of time ( week[s] ).

1. Monitor the Coldhead first and second stage temperatures in conformance with SET-UP AND CALIBRATION, Section 1-4-9, Monitoring Cryocooler Temperatures, until equilibrium temperatures are reached ( temperature stabilized ).

2. During cooldown, check the Coldhead mounting bolts. Make sure they are hand tight. If not, hand tighten.

3. When Coldhead temperatures have stabilized, check if Belleville washer gap settings are within the specified range of 0.003 - 0.005 inch ( 0.08 - 0.13 mm ). See Illustration 1-16.

4. If Belleville washer gaps are greater than 0.005 inch ( 0.13 mm ), tighten the Coldhead bolts in the staggered bolt pattern, shown in Illustration 1-16, until even gaps within specification are set for all bolts. Make sure that an even gap is maintained between the transition and sleeve flanges around the full circumference.

5. Make sure the final temperatures read on the Portable Temperature Monitor are within the following limits:

   Recondenser: < 4.4K
   $\Delta$ T [ Recondenser ( B position ) - Coldhead ( A position ) ]: $\leq$ 0.1K

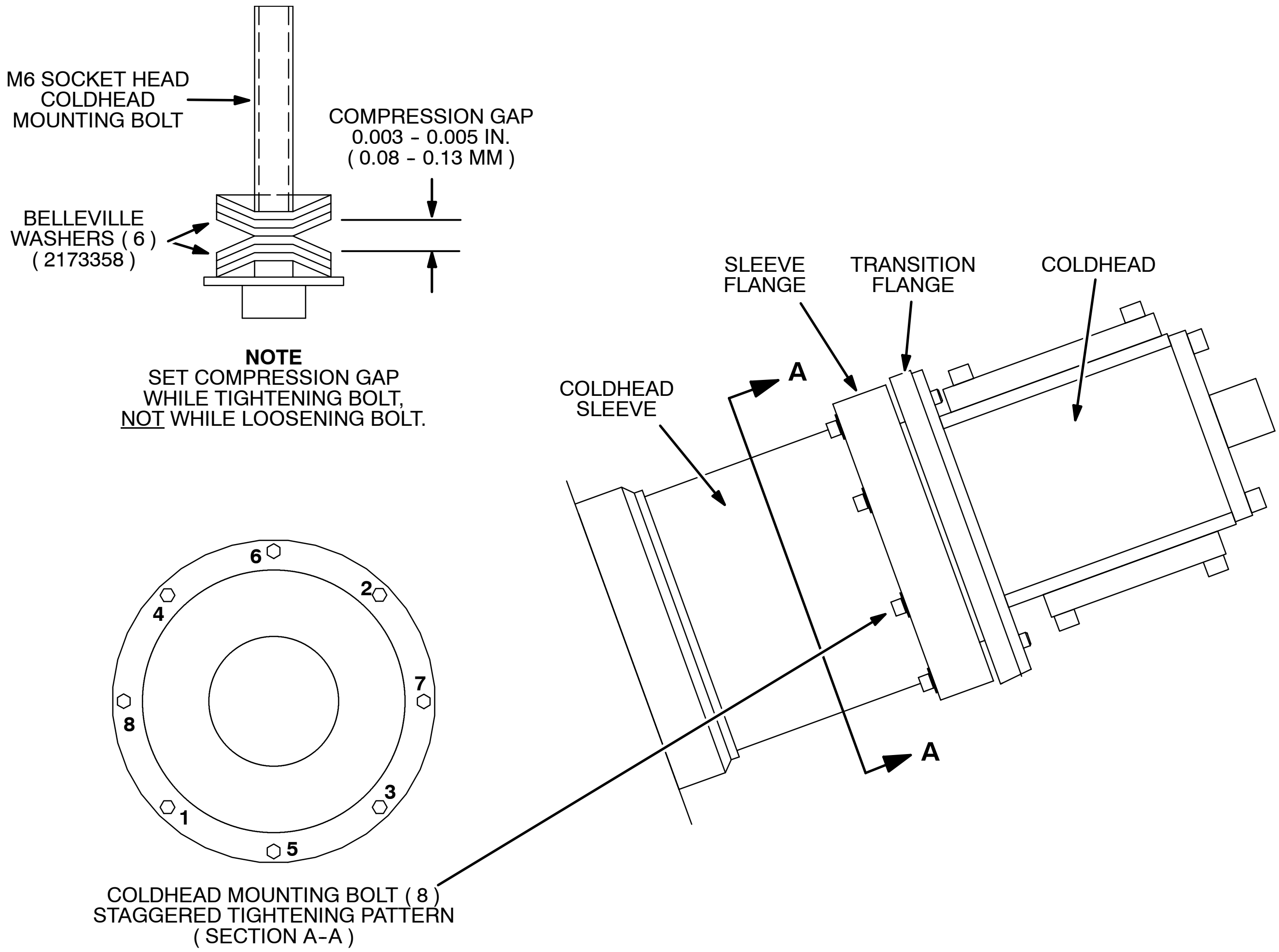
   Note

   Second stage Coldhead RuO temperature may show a small oscillation ( 0.0K - 0.2K ) on the temperature monitor. This is a result of the displacer motion inside the second stage and the sampling rate of the monitor. Record the average temperature for all checks.

   Second stage temperarure = ( $T_{max}$ + $T_{min}$ ) / 2

6. If temperature limits are exceeded, perform procedure in REPLACEMENT / MAINTENANCE, Section 9-6, Coldhead Interface Adjustment.

### 1-4-10 Setting Cold Head Tension ( continued )




**COLDHEAD MOUNTING BOLT GAP SETTING**
ILLUSTRATION 1-16

## 1-5 SHIELD COOLER INSTALLATION AND CHECK OUT

### Introduction

The Shield Cooler comes with a Coldhead already installed on the magnet and a separate Compressor unit, which will be located in the SCC cabinet in the equipment room. A power cable and gas supply and return lines connect the two units. Locate and read the vendor manual(s) supplied with your system to become thoroughly familiar with the configuration, site requirements and procedures for the system supplied prior to installation. Compressor installation instructions are covered in the vendor manual. The Shieldcooler Interconnect Diagram is shown in SCHEMATICS / INTERCONNECTS, Page 1-3.

### 1-5-1 Shield Cooler Compressor Installation

1. Unpack and install the Compressor in conformance with the vendor service manual. Note any visible damage and notify the shipper.
2. Position the Shield Cooler Compressor inside the left side of the SCC Cabinet ( as viewed facing the cabinet's front ). Refer to Direction 2241391, *Signa OpenSpeed Pre-installation Manual*.
3. Insert the Shield Cooler Compressor into the bottom left section of the SCC Cabinet using the rails provided with the cabinet.
4. Connect the input power cable in conformance with the vendor manual and local electrical code.

## IMPORTANT !!!

The Magnet Monitor must be installed shortly after the Cryocoolers are powered on. If the Cryocoolers are turned on without the pressure control from the magnet monitor, helium vessel pressure could go subatmospheric, which can cause icing in the Service Turret.

**CAUTION**

**Do NOT connect the Flex Lines until System Gas Pressure Check is performed in Section 1-5-2 to prevent line contamination.**

### 1-5-2 System Gas Pressure Check

## IMPORTANT !!!

**DO NOT OVER PRESSURIZE THE COMPRESSOR!** Over pressurizing the Compressor can prevent the Compressor bypass valve from closing after the restart of a warm Compressor. This condition will severely degrade Compressor capacity during operation, resulting in cryostat pressure increase and helium loss.

Proper static gas pressure for the Shield Cooler Compressor is shown in Table 1-5. Check the static pressure reading on the Compressor pressure gauge. If the pressure is not within specification use the following procedures to adjust the pressure to specification.

TABLE 1-5
**COMPRESSOR STATIC GAS PRESSURES**

| | STATIC GAS PRESSURE AT 20°C ( 68°F ) | | |
|---|---|---|---|
| | MPa | KGF / $CM^2G$ | PSIG |
| CRYOCOOLER COMPRESSOR | 1.60 - 1.65 | 16.3 - 16.8 | 232 - 239 |
| SHIELD COOLER COMPRESSOR | 1.45 - 1.50 | 14.8 - 15.3 | 210 - 217 |

**Note**
Static pressure is effected by ambient temperature. Small variances will occur with temperature variances around 70° F.

#### 1-5-2-1 Increasing Gas Pressure

**CAUTION**

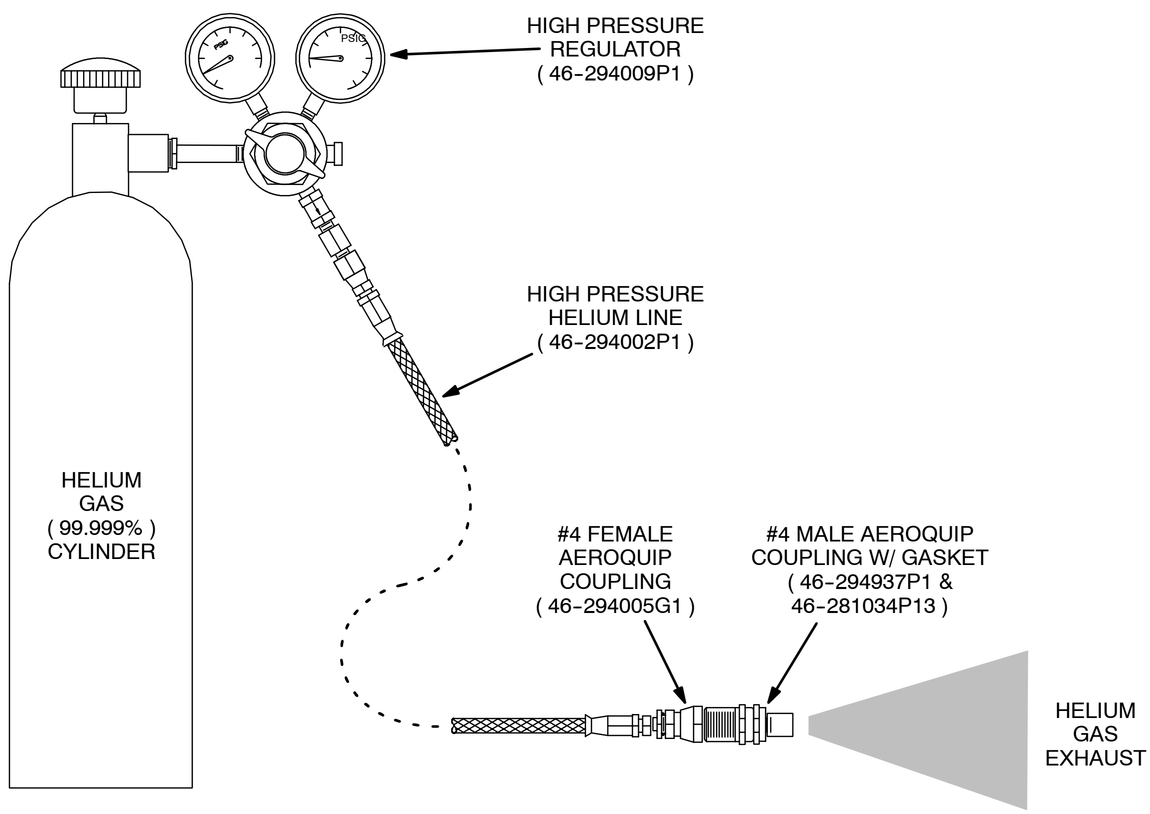
**The following procedure purges air out of the regulator and connecting lines before the line is connected to a new cylinder of certified 99.999% helium gas.**

**Note**
Use the Shield Cooler Installation / Maintenance Kit ( 46-281088G2 ) to perform all necessary maintenance to Shield Cooler Systems.

1. Obtain a cylinder of 99.999% Helium gas.

### 1-5-2-1 Increasing Gas Pressure ( continued )

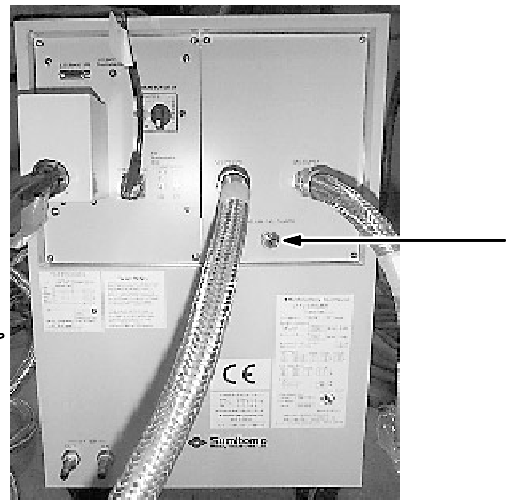
2. Loosely attach the high pressure regulator ( 46-294009P1 ) to the gas cylinder per the following steps.
   a. Thread in the screw that connects the regulator to the Helium bottle about 2 turns.
   b. Turn regulator handle fully clockwise to open the regulator.
   c. Open Helium bottle, and immediately tighten the regulator to the Helium bottle.
   d. Close the regulator valve by turning the handle counterclockwise.
3. Attach the high pressure helium line ( 46-294002P1 ) to the regulator at the shut-off valve. See Illustration 1-17.




**SET-UP FOR COMPRESSOR CHARGING**
ILLUSTRATION 1-17

### 1-5-2-1 Increasing Gas Pressure ( continued )

4. Attach a #4 female Aeroquip coupling ( 46-294005G1 ) to the end of the high pressure charging line. See Illustration 1-18.




**CHARGE / DISCHARGE FITTING LOCATION**
ILLUSTRATION 1-18

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSI.**

5. Attach a #4 male Aeroquip coupling ( 46-294937P1 ) with Gasket (46-281034P13 ) to the #4 female Aeroquip coupling. Hand tighten the fittings together. This will open the helium circuit to allow the charging assembly to be purged.
6. Establish gas flow through the helium line and fittings by slowly opening the main valve on the gas cylinder and tightening the male fitting into the female Aeroquip.
7. Allow helium to purge out the assembly for 2 minutes.
8. Remove the male Aeroquip fitting coupling from the female coupling.
9. Close the regulator. Shut off Compressor power to let the supply and return line pressures equalize in the Compressor.
10. Fully open the valve on the cylinder.
11. Adjust the regulator control valve to achieve a pressure of approximately 200 psig.

### 1-5-2-1 Increasing Gas Pressure ( continued )

12. Attach the purged charging line assembly with the female Aeroquip coupling to the charging fitting on the front of the Compressor. See Illustration 1-18.
13. Increase Compressor helium pressure by adjusting the regulator until Compressor's high side gauge reads in the Shield Cooler Compressor range specified in Table 1-5.
14. If too much helium gas has been added, refer to Section 1-5-2-3, Decreasing Shield Cooler Gas Pressure, to lower the helium pressure.

### 1-5-2-2 Disconnection and Stowage of Hoses and Regulator

1. Remove the Aeroquip coupling from the Compressor. Restore Compressor power.
2. Close the regulator.
3. Attach a high pressure hose and #4 female Aeroquip fitting to the #4 male Aeroquip fitting until the helium circuit is opened and gas is flowing.
4. Allow the high pressure line and Aeroquip fittings to depressurize.
5. Remove the #4 male Aeroquip fitting and the #4 female Aeroquip fitting from the high pressure charging line.
6. Remove the high pressure charging line from the regulator.
7. Close the valve on the helium cylinder. Bleed off pressure from the regulator.
8. Remove the regulator from the helium bottle.
9. Store all Shield Cooler Installation / Maintenance Kit ( 46-281088G2 ) equipment in the carrying case.

### 1-5-2-3 Decreasing Gas Pressure

1. Remove the protective cap from the Compressor's front panel fitting.
2. Make sure a #4 female Aeroquip coupling ( 46-294005G1 ) and a #4 male Aeroquip coupling ( 46-294937P1 ) are connected to the hose. See Illustration 1-17.

**Note**

Use the Shieldcooler Installation / Maintenance Kit ( 46-281088G2 ) to perform all necessary maintenance to Shield Cooler systems.

3. Slowly tighten the fitting until you hear gas escaping.
4. When the pressure reaches the Shield Cooler pressure specified in Table 1-5, immediately unscrew the fittings and hose to prevent further gas removal.
5. Replace the protective cap on the Compressor's front panel fitting.

### 1-5-3 Cooling

#### 1-5-3-1 Water Supply Connection ( for water-cooled Compressor - for SCC cabinet )

1. Verify that the cooling water supply meets all specification requirements in the vendor service manual.
2. Check hose lengths. Hoses must be long enough to allow the attached Compressor to be pulled to in front of the SCC Cabinet for troubleshooting purposes. Replace with long enough hoses if needed.
3. Connect the water supply hose to the cooling water inlet connection. Secure with a worm drive screw-type hose clamp.
4. Similarly connect the water return hose to the cooling water outlet connection of the Compressor.
5. Turn on the cooling water supply and operate the Compressor at least 30 minutes to make sure that cooling water is sufficient and that the Compressor is operating properly.
6. Check the system for water leaks.

#### 1-5-3-2 Air Space ( for air-cooled Compressor )

1. Verify that minimum air space shown in the vendor manual is met.
2. Verify that temperature requuirement called out in the vendor manual will be met.

**WARNING!**

**ANTIFREEZE IS POISONOUS TO AQUATIC, ANIMAL AND HUMAN LIFE. BECAUSE OF ITS SWEETNESS, ANIMALS MAY BE DRAWN TO IT. CONSEQUENTLY IT IS CLASSIFIED AS HAZARDOUS BOTH FOR SHIPMENT AND AS A WASTE. THEREFORE, IT MAY NOT BE SHIPPED BY UNTRAINED PEOPLE. SHIELD COOLER COMPRESSORS WHICH CONTAIN ANTIFREEZE MUST BE DRAINED BEFORE BEING RETURNED TO THE SUPPLIER. MAKE ARRANGEMENTS WITH THE HOSPITAL MAINTENANCE DEPARTMENT FOR DISPOSAL.**

### 1-5-4 Shield Cooler Gas Line Installation

**IMPORTANT !!!**

Helium gas lines and Coldhead power cables are marked with two run numbers. One is for Cryocooler applications and one is for Shield Cooler applications.

Before installing the Coldhead gas lines and power cable, mark out with a black pen the run number on the label at each end of the line / cable that does not apply. See Table 1-3.

## 1-5-4 Shield Cooler Gas Line Installation ( continued )

TABLE 1-6
**COLDHEAD GAS LINES / POWER CABLE RUN NUMBERS**

| APPLICATION | GAS SUPPLY LINE | GAS RETURN LINE | COLDHEAD PENETRATION PANEL POWER CABLE | COMPRESSOR PENETRATION PANEL POWER CABLE |
|---|---|---|---|---|
| CRYOCOOLER | 621 | 622 | 624 | 623 |
| SHIELDCOOLER | 625 | 626 | 628 | 627 |

### 1-5-4-1 Gas Line Routing and Shielding

**CAUTION**

**Make sure that the gasline has sufficient slack at both ends and any excess length is not coiled with a radius less than 12 inches ( 305 mm ) to prevent any bending force on the Aeroquip fitting and any strain or "chirping" noise at the line.**

1. Feed the gas supply line through the designated 55 mm ( 2.17 inch ) port hole in the Penetration Panel. Install the line into cable trough in conformance with site planning requirements. Position the line to reach Coldhead connection at the magnet and the Compressor connection in the equipment room.
2. Repeat Step 1 using the other available port for the return line.
3. Adjust the slack on the helium supply and return flexlines for the most suitable length on both sides of the Penetration Panel. Loosely coil excess line length in the equipment room.

   **Note**
   RF shielding of the flexlines as they pass through the Penetration Panel is performed from the equipment room side of the Penetration Panel. Use the following procedure for both the helium supply and return lines. See Illustration 1-11.

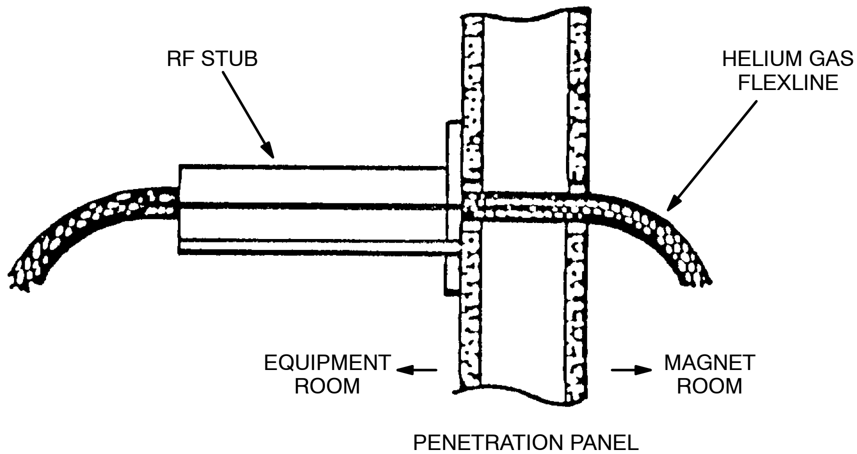
4. Install RF shielding around each gas line as it passes through the Penetration Panel:
   a. Position half of the RF Stub Assembly ( 46-260860G1 ) underneath the helium supply line, with the flange end oriented toward the Penetration Panel. See Illustration 1-11.

      **Note**
      Make sure RF Stub Assembly is clean ( bright copper appearance ). Wire brush surface as required, to effect clean surface.

   b. Secure the flange of the RF Stub Assembly to the Penetration Panel with four screws, aligning the flange holes with the holes In the Penetration Panel.

### 1-5-4-1 Gas Line Routing and Shielding ( continued )

4. ( continued )




**RF STUB ASSEMBLY MOUNTING**
ILLUSTRATION 1-19

c. Insert bronze wool ( 46-318068P1 ) around the helium supply line ( top and bottom ) over the length of the RF Penetration Stub.

d. Position the other half of the RF Stub Assembly over the helium supply line, with the flange oriented toward the Penetration Panel and align it over the lower 1/2.

e. Secure the flange of the top half of the RF Penetration Stub Assembly to the Penetration Panel with four screws, aligning the flange holes with holes in the Penetration Panel.

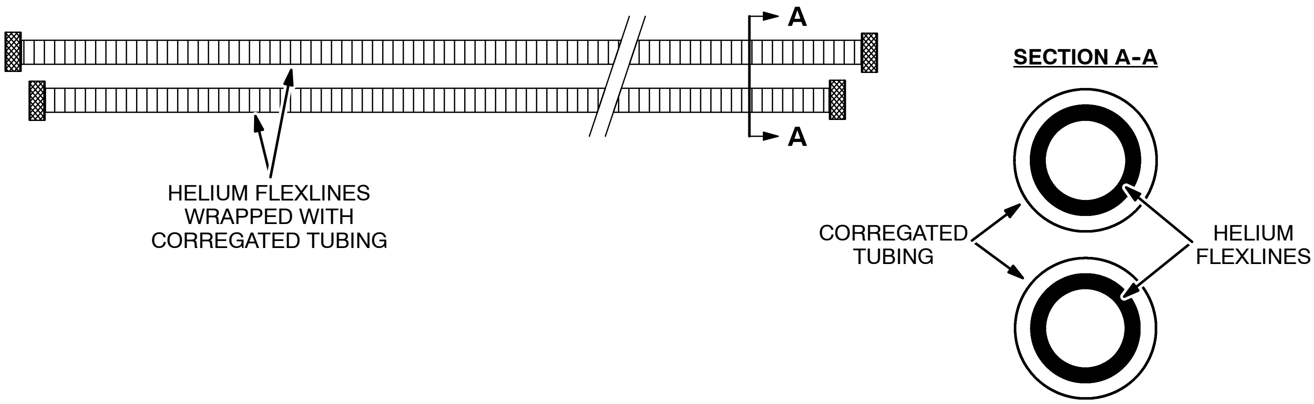
b. Repeat Steps 4a and 4e for the Helium return line.

5. Cover both lines completely with Corregated Plastic Tubing ( 2251611 ) from the Penetration Panel where the lines exit the magnet room to the helium line fittings at the Coldhead. See Illustration 1-12.

**Note**

Corregated plastic tubing is used to isolate helium gas lines from each other and from ground to prevent spike noise.

### 1-5-4-1 Gas Line Routing and Shielding ( continued )




**HELIUM LINE CASING INSULATION**
ILLUSTRATION 1-20

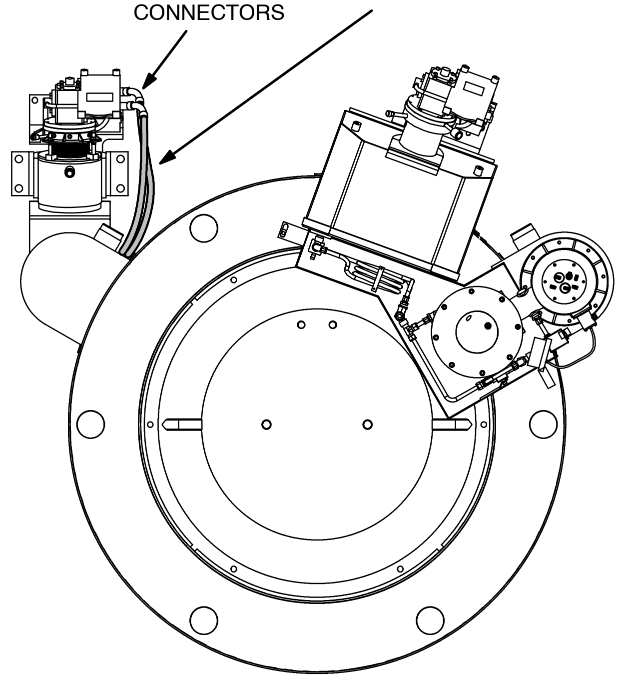
### 1-5-4-2 Flexible Gas Line Connections

**CAUTION**

**When routing gas lines make sure all slack is coiled within the equipment room to prevent white pixel generation in images and that all curvatures / coils in the gas lines have radii greater than 12 inches ( 300 mm ) to prevent bending force on Aeroquip fittings and strain / “chirping” noise on the line.**

1. Route the supply and return lines through cable troughs in the floor and magnet feet and over to the Coldhead. See Illustration1-21.

### 1-5-4-2 Flexible Gas Line Connections ( continued )




**FLEXIBLE GAS LINE STRAIN RELIEF AND ROUTING AT MAGNET**
ILLUSTRATION 1-21

**WARNING!**

**DO NOT PUT ANY BENDING FORCE ON THE AEROQUIP FITTINGS DURING HELIUM FLEXLINE CONNECTING / DISCONNECTING. A BENDING FORCE WILL CREATE DIFFICULTY IN THE RAPID THREAD ENGAGEMENT / DISENGAGEMENT REQUIRED TO PREVENT HELIUM LOSS AND CONTAMINATION. IT CAN ALSO RESULT IN BENDING OR LEAKING OF THE AEROQUIP STEMS. SUPPORT THE GAS LINES TO PREVENT A BENDING FORCE WHEN CONNECTING / DISCONNECTING TO THE COLDHEAD AT THE TOP OF THE MAGNET.**

**Note**
See REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections, for proper connection of flexlines.

2. Connect the right-angle flexline connectors ( 2273967 and 2273967-2 ) to the supply and return fittings on the Coldhead.

#### 1-5-4-2 Flexible Gas Line Connections ( continued )

**CAUTION**

**The order and technique are important when connecting helium flexlines to prevent inoperative Coldheads and system contamination. Read and follow the procedure in the vendor manual provided with the Compressor. Make sure lines are connected in the sequence given in Step 3. Gas back pressure may prevent the Coldhead from starting if gas lines are connected in the reverse sequence.**

3. Connect the gas return line ( green mark ) first, and then connect the gas supply line ( yellow mark ) to the Compressor. Connect the gas return line ( green mark ) first, and then connect the gas supply line ( yellow mark ) to the right-angle flexline connectors on the Coldhead.

4. Observe the readings of the Compressor pressure gauges. It they are constant, then a leak is not suspected.

   - If the readings are above specification, then vent down as described In SET-UP AND CALIBRATION, Section 1-5-2, System Gas Pressure Check.

**IMPORTANT !!!**

**DO NOT OVER PRESSURIZE THE COMPRESSOR!** Over pressurizing the Compressor can prevent the Compressor bypass valve from closing after the restart of a warm Compressor. This condition will severely degrade Compressor capacity during operation, resulting in cryostat pressure increase and helium loss.

   - If the pressure readings are below the Shield Cooler specification shown in Table 1-5, then increase the helium gas charge in the complete system by supplying helium gas through the supply fitting on the Compressor as described in SET-UP AND CALIBRATION. Section 1-5-2, System Gas Pressure Check. Also see Section 1-5-5, Leak Test.

### 1-5-5 Leak Test

1. After increasing helium charge, if the pressure continues to drop, remove the lines from the Compressor in conformance with REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections.

**Note**

If the lines are suspected to have a leak, they may be tested using the regulator, charging line and manifold.

2. Connect the regulator, charging line and manifold and purge as previously described in SET-UP AND CALIBRATION, Section 1-5-2, System Gas Pressure Check.

3. Connect one of the flexlines to the appropriate fitting on the manifold and pressurize to approximately 100 psig.

4. Reduce the supply pressure using the regulator control and observe whether the pressure is maintained on the manifold pressure gauge. If the pressure drops, then that line may have a gas leak.

### 1-5-5 Leak Test ( continued )

5. Maintain 100 psig with the regulator and check the line with a liquid soap solution or a commercial leak testing solution such as Leak-Tec.

6. If the line has a leak, then notify Magnet Systems to obtain a replacement.

7. Repeat the above procedure for the other gas line.

**Note**

If the Compressor pressure gauge readings had dropped and stayed constant then the charge may have just been low and the system will be recharged.

### 1-5-6 Shieldcooler Electrical Cable Connections

## IMPORTANT !!!

Helium gas lines and Coldhead power cables are marked with two run numbers. One is for Cryocooler applications and one is for Shield Cooler applications.

Before installing the Coldhead gas lines and power cable, remove the run number label at each end of the line / cable that does not apply. See Table 1-7.

Do NOT cut through the power cable insulation when removing the nonapplicable run number label.

TABLE 1-7
**COLDHEAD GAS LINES / POWER CABLE RUN NUMBERS**

| APPLICATION | GAS SUPPLY LINE | GAS RETURN LINE | COLDHEAD PENETRATION PANEL POWER CABLE | COMPRESSOR PENETRATION PANEL POWER CABLE |
|---|---|---|---|---|
| CRYOCOOLER | 621 | 622 | 624 | 623 |
| SHIELDCOOLER | 625 | 626 | 628 | 627 |

1. Connect Coldhead power cables ( Run 627 and 628 ) as shown in Illustration 1-22 when the Penetration Panel is installed.

**Note**

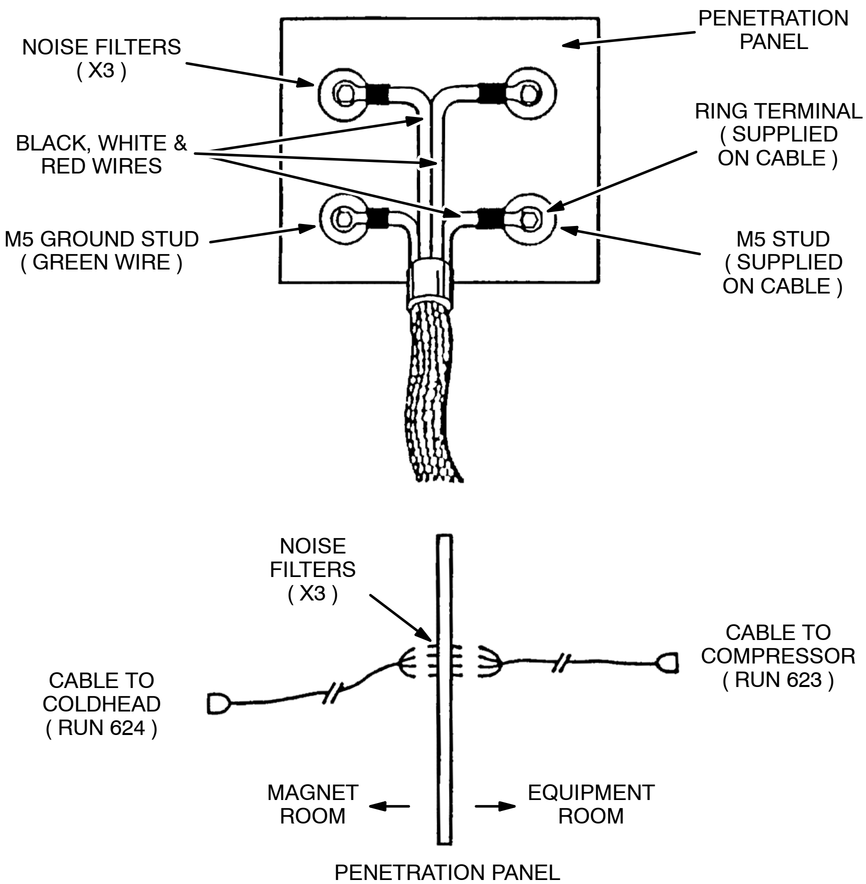
Power cables supplied from the factory may be connected to a terminal block to facilitate Cryocooler operation prior to Penetration Panel installation. If terminal block is not present, connect the ring terminals via screws or terminal block ( same wire color ) to allow Cryocooler to operate prior to Penetration Panel installation.

2. Connect Coldhead cable ( Run 627 ) to the Compressor. Connect Coldhead cable ( Run 628 ) to the Coldhead. See SCHEMATICS / INTERCONNECTS, Illustration 1-3, Magnet Shieldcooler Interconnect Diagram.

### 1-5-6 Shieldcooler Electrical Cable Connections ( continued )

**CAUTION**

**Make sure that the wire code ( color and number ) is properly matched on the noise filter studs on both sides of the Penetration Panel to prevent improper operation or damage.**




**SHIELDCOOLER ELECTRICAL CABLE CONNECTIONS**
ILLUSTRATION 1-22

### 1-5-7 Shieldcooler Functional Checks

1. Perform shieldcooler functional checks covered in the supplier manual.

### 1-5-8 Shieldcooler Operation

1. Turn on the main power.
2. Turn on the Compressor power switch. The Coldhead motor should begin operating.

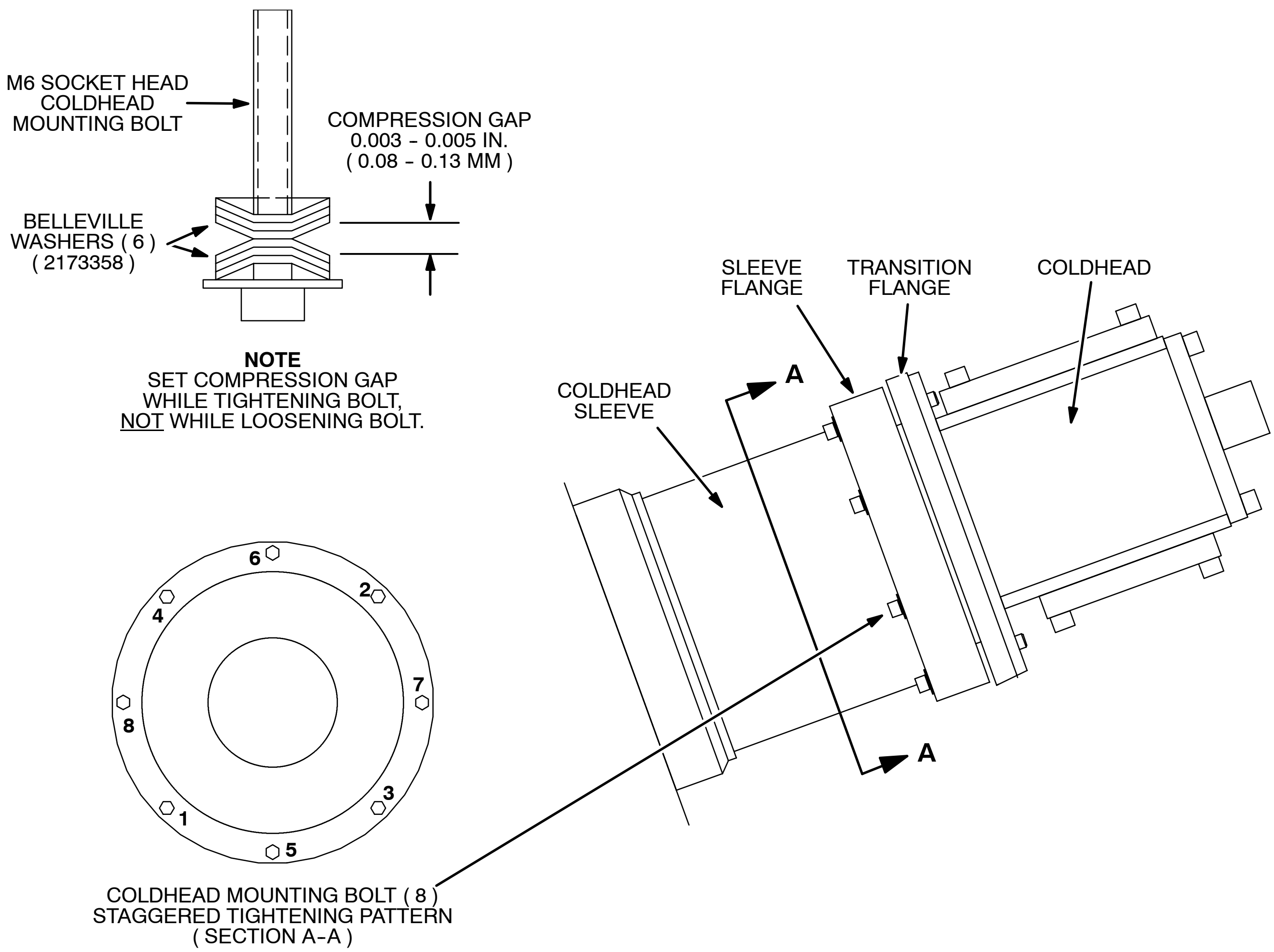
### 1-5-9 Setting Coldhead Tension

**Note**

Check the tightness of the mounting bolts in conformance with the following procedure, to make sure that sufficient contact is made at the heat station when the Shieldcooler Coldhead cools down during magnet installation or after it has been shut off for weeks.

1. Monitor the Coldhead first stage temperature in conformance with SET-UP AND CALIBRATION, Section 1-4-9, Monitoring Cryocooler Temperatures, until equilibrium temperatures are reached ( temperature stabilized ).
2. During cooldown check Coldhead mounting bolt tightness. Make sure they are hand tight. If not, hand tighten.
3. When Coldhead temperatures have stabilized, check if Belleville washer gap settings are within the specified range of 0.003 - 0.005 inches ( 0.08 - 0.13 mm ). See Illustration 1-23.
4. If Belleville washer gaps are greater than 0.005 inches ( 0.13 mm ), tighten the Coldhead bolts in the staggered bolt pattern, shown in Illustration 1-23, until even gaps within specification are set for all bolts. Make sure that an even gap is maintained between the transition and sleeve flanges around the full circumference.

### 1-5-9 Setting Coldhead Tension ( continued )




**COLDHEAD MOUNTING BOLT GAP SETTING**
ILLUSTRATION 1-23

## 1-6 MAGNET RUNDOWN UNIT ( MRU ) INSTALLATION

**WARNING!**

**DO NOT CONNECT 'P2' TO 'J2' LESS THAN 3 MINUTES AFTER THE MRU RECEIVED AC POWER OR THE RUN DOWN BUTTON WAS ACTIVATED. A MAGNET QUENCH MAY RESULT.**

1. Install and inspect the MRU in conformance to the supplier service manual included with the unit.

## 1-6 MAGNET RUNDOWN UNIT (MRU) INSTALLATION ( continued )

2. Batteries are installed and fully charged before leaving the factory. The charge should be verified according to the supplier service manual.

**Note**
MRUs are shipped strapped for 115V AC at 50-60 Hz. Refer to supplier manual for local requirements.

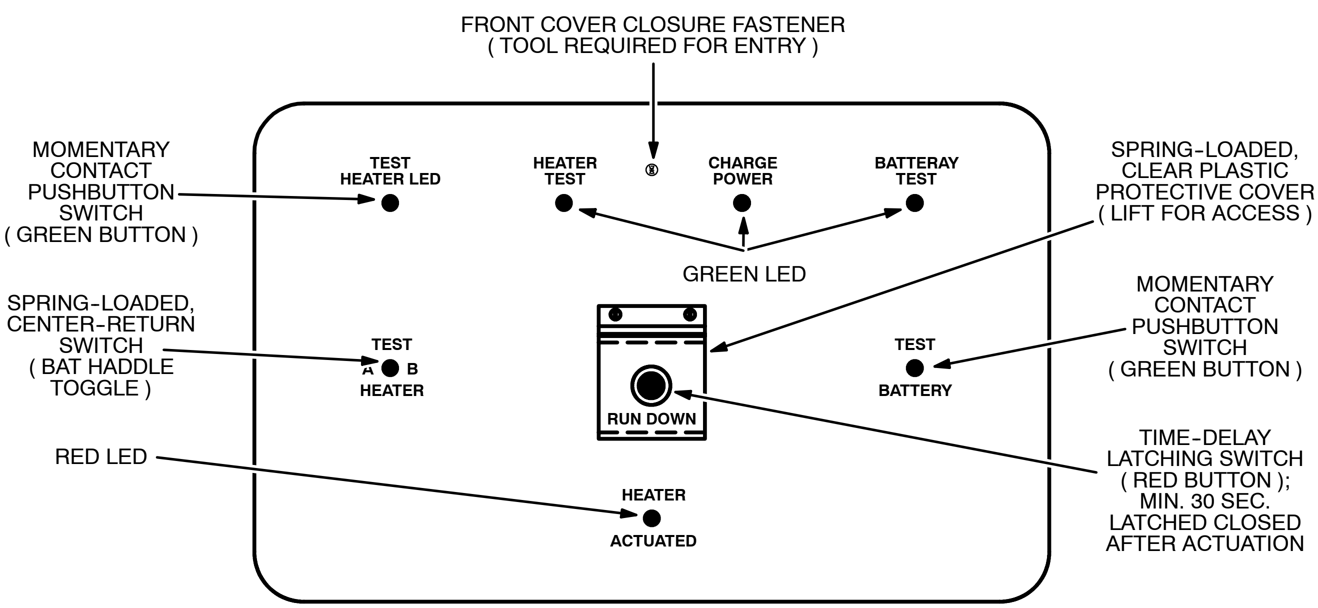
3. Perform all adjustments and functional checks in conformance to the supplier service manual.

**CAUTION**

**The MRU Cable is a shielded cable with the shield terminated at only the MRU end. It is essential that the cable be properly connected.**

**WARNING!**

**CHARGE THE MRU'S BATTERIES FOR 24 HOURS AND MAKE SURE THE RED "RUN DOWN" SWITCH IS NOT PUSHED IN BEFORE PERFORMING STEP 5 BELOW. SEE ILLUSTRATION 1-24.**

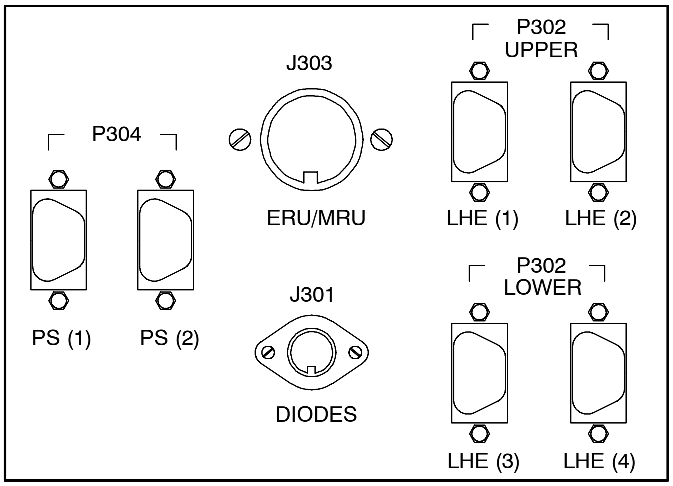



**MRU FRONT PANEL LAYOUT, LABELING & CONTROL FUNCTIONAL DESCRIPTIONS**
ILLUSTRATION 1-24

## 1-6 MAGNET RUNDOWN UNIT (MRU) INSTALLATION ( continued )

4. Connect the Lemo Connector ( P2 ) on the MRU Cable to J2, located behind the MRU's front cover. Close and fasten the MRU cover.

5. Connect the P303 connector on the MRU Cable to J303 on the Magnet Harness Terminal Box. The MRU is now operable. See Illustration 1-25 for the location of J303. The wiring diagram shown in SCHEMATICS / INTERCONNECTS, Illustration 1-1.




**MAGNET HARNESS TERMINAL BOX**
ILLUSTRATION 1-25

6. Verify that the Instrumentation Lead Assembly connector is mated on the top of the magnet.

**WARNING!**

**EXTREME CAUTION MUST BE TAKEN WHILE PERFORMING THE FOLLOWING FUNCTIONAL CHECKS AS INADVERTENTLY ACTIVATING THE "RUN DOWN" SWITCH WILL QUENCH THE MAGNET.**

7. Perform functional checks in conformance with the supplier service manual.

## 1-7 MAGNET MONITOR INSTALLATION

1. Connect Magnet Monitor cabling to magnet in conformance with Magnet Monitor installation manual.

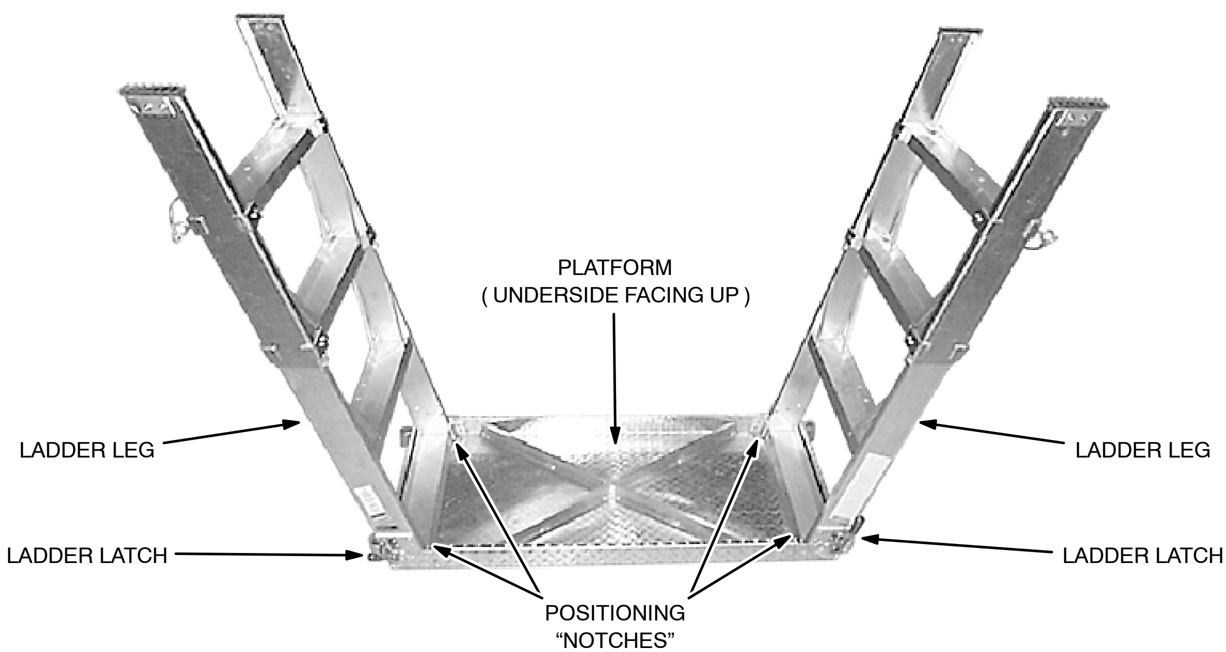
## 1-8 UNIVERSAL SERVICE LADDER / PLATFORM ( 2319156 ) SET-UP

The Universal Service Ladder / Platform ( 2319156 ) provides a 24 x 45 inch ( 610 x 1143 mm ) working platform that can hold 500 pounds ( 226 Kg ) at platform heights of either 40 or 50 inch ( 1016 or 1270 mm ).

**CAUTION**

**Wear leather gloves while assembling, adjusting or disassembling the Universal Service Ladder / Platform to protect against scratches and to keep your hands clean.**

1. Position the ladder components in an open area about 6 feet ( 1800 mm ) square.
2. Lay the platform section on the floor with its underside facing up as in Illustration 1-26.
3. Insert one ladder leg in each positioning notch as in Illustration 1-26.




**POSITIONING LADDER LEG SECTIONS TO PLATFORM UNDERSIDE**
ILLUSTRATION 1-26

4. Securely latch both ladder latches of each ladder leg to the platform. See Illustration 1-27.

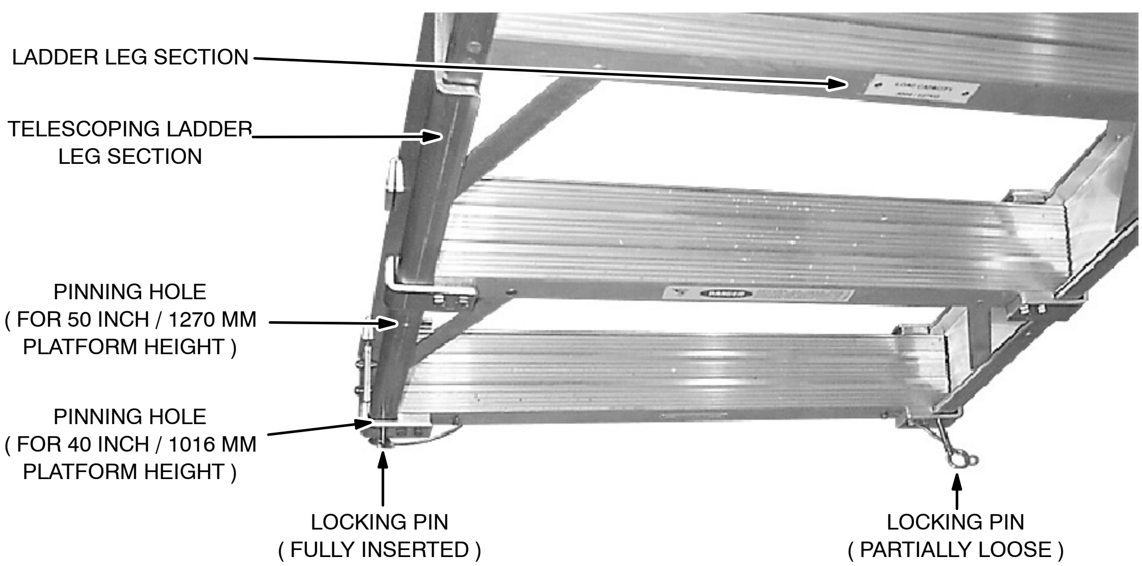
## 1-8 UNIVERSAL SERVICE LADDER / PLATFORM ( 2319156 ) SET-UP ( continued )


**LADDER LEG SECTION LATCHES**
ILLUSTRATION 1-27

5. Adjust both telescoping sections of each ladder leg for the platform height required. Pinning the telescoping sections fully retracted yields a 40 inch ( 1016 mm ) platform height, while fully extended yields a 50 inch ( 1270 mm ) platform height. See Illustration 1-28.

**Note**

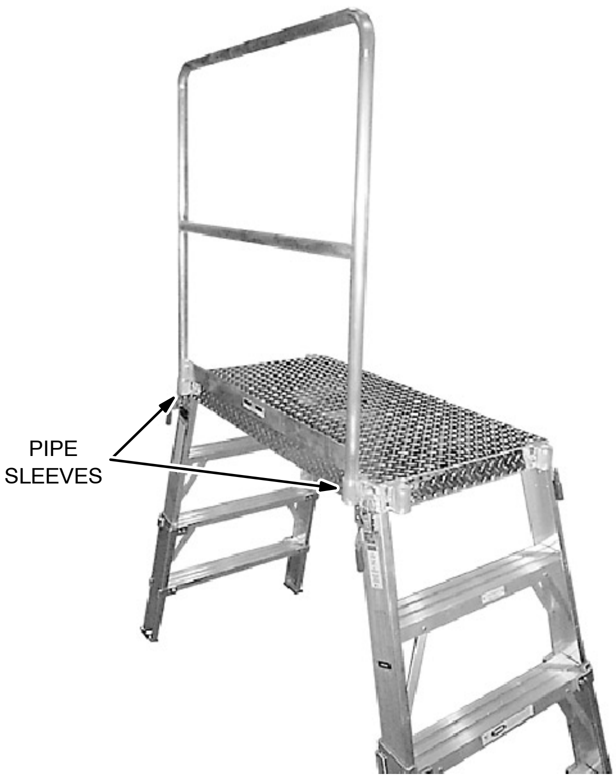
Although platform height can be set while the ladder / platform is upright or on its side, setting platform height while the platform is face down is easiest. Do not reset the height of an upright platform while weight is on it.



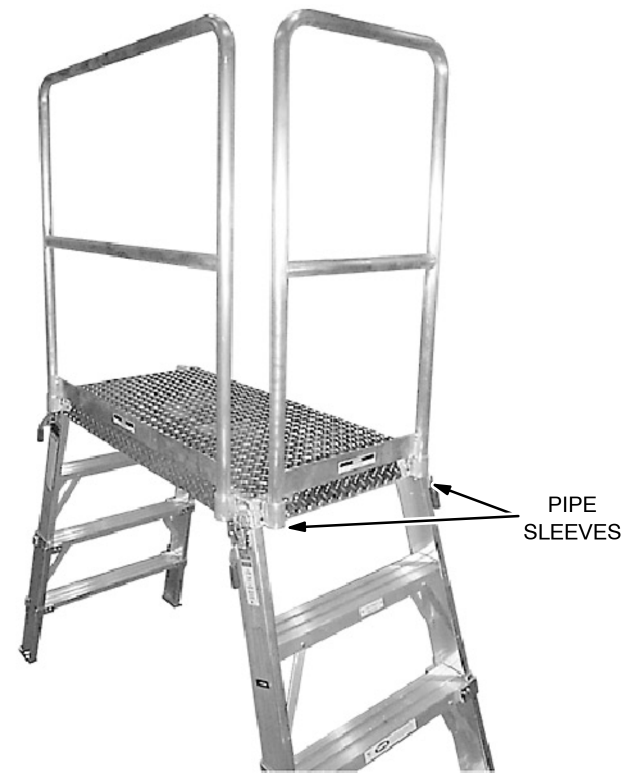

**LADDER LEG TELESCOPING SECTIONS & LOCKING PINS**
ILLUSTRATION 1-28

## 1-8 UNIVERSAL SERVICE LADDER / PLATFORM ( 2319156 ) SET-UP ( continued )

6. Carefully flip the assembled platform and ladder legs upright.
7. Insert the long safety rail section in the pipe sleeves on the platform's long edge. See Illustration 1-29.
8. Insert the short safety rail section in the pipe sleeves on the platform short edge that will not be needed as a ladder. See Illustration 1-29.




**STEP 7. LONG SAFETY RAIL TO LONG PLATFORM EDGE**




**STEP 8. SHORT SAFETY RAIL TO UNUSED SHORT PLATFORM EDGE**

**INSTALLING THE SAFETY RAIL**
ILLUSTRATION 1-29

# SECTION 2 – MAGNET COMMISSIONING CHECKS

Refer to FUNCTIONAL CHECKS, Section 1, for Commissioning Guidelines.

## 2–1 MAGNET ELECTRICAL CHECK

Perform electrical checks called out in FUNCTIONAL CHECKS, Section 5, Magnet Electrical Checks.

## 2–2 CRYOSTAT TEMPERATURE CHECK & COOLING / FILLING REQUIREMENTS

This Section describes the procedures and equipment used to establish the magnet temperature inside the Helium Vessel. It is essential to establish this temperature in order to determine the cooldown and liquid helium filling requirements prior to magnet commissioning.

The GE Magnet is equipped with two sensors requiring a 10 microampere current source with a stability of +0.005%. The Magnet Assembly is inside of the Helium Vessel. See Table 2–1.

TABLE 2–1
**MAGNET TEMPERATURE SENSORS**

| CONNECTOR | PIN OUTS | LOCATION |
|---|---|---|
| J301 | 1, 2 | UPPER MAGNET CARTRIDGE IRON RING |
| J301 | 3, 4 | LOWER MAGNET CARTRIDGE IRON RING |

**CAUTION**

**Magnet temperature sensors are designed to be driven by a 10 microampere source; some ohmmeters exceed this rating. Do not use any sensing or troubleshooting equipment which exceeds 10 microamperes. A Voltmeter can also be used to troubleshoot the sensor circuit.**

### 2–2–1 Use of Lakeshore 208 Thermometer Kit ( 46–301477G2 ) or Low Cost Shield Temperature Diode Box ( 46–317543G2 )

1. Use the equipment referenced below to establish the cryostat temperature.
2. Connect the temperature monitoring equipment to the diode connector on the Magnet Connector Assembly ( MS1–A3, A1 ) in conformance with Illustration 2–1.

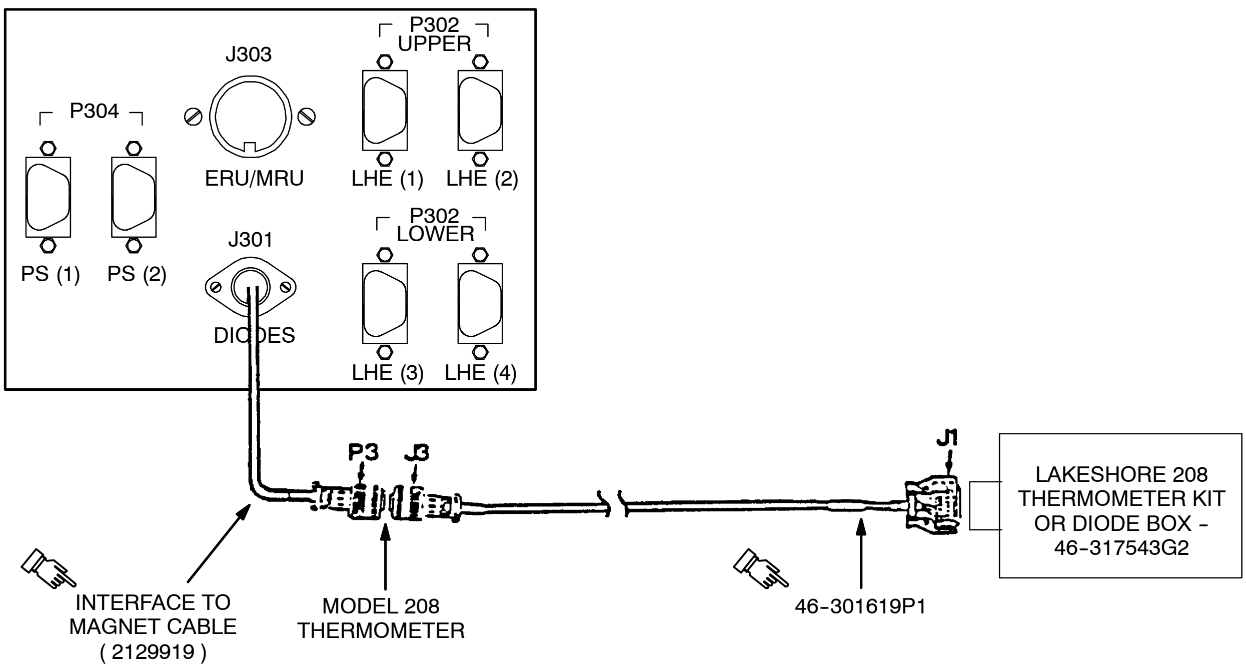
### 2-2-1 Use of Lakeshore 208 Thermometer Kit ( 46-301477G2 ) or Low Cost Shield Temperature Diode Box ( 46-317543G2 ) ( continued )

3. Select the diode to be monitored as shown in Table 2-2.

TABLE 2-2
**HELIUM VESSEL TEMPERATURE MONITOR DIODES**

| STAGE | 208 THERMOMETER KIT |
|---|---|
| DIODE 1 | SELECT CHANNEL #1 |
| DIODE 2 | SELECT CHANNEL #2 |

4. Use Curve 10 ( DT470 ). Refer to supplier's operations manual for proper setup and operation.




**CRYOSTAT TEMPERATURE MEASUREMENT SET-UP**
ILLUSTRATION 2-1

**Note**
A SHORTED sensor circuit will cause the meter to display a reading of approximately 400K; an OPEN sensor circuit will cause the meter display to flash. Check for problems with the instrumentation box connector and external wiring before ruling the temperature sensing diode as being defective.

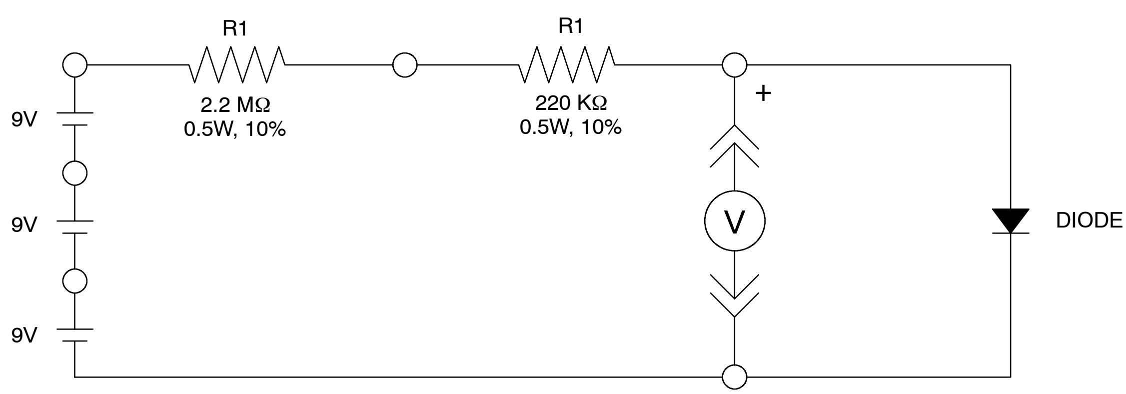
### 2-2-2 Diode Temperature Sensing Circuit

**Description**

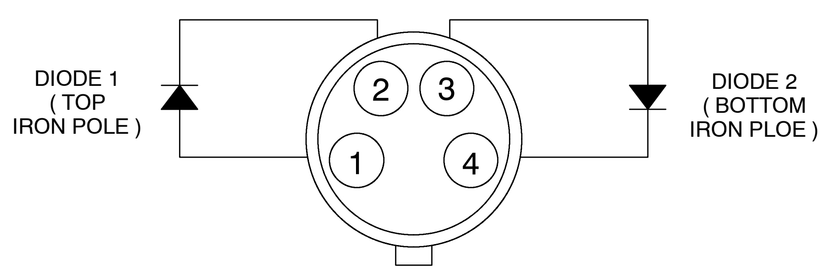
If the Lakeshore 208 Thermometer Kit or Low Cost Temperature Diode Box are not available, the following temperature sensing circuit can be fabricated from commonly available components for temperature measurements.

**Procedure**

1. Assemble three 9 VDC Batteries and a series resistance of 2.4 to 2.7 Megohms, as depicted in Illustration 2-2. Adjust resistance as required to obtain 10 ± 1 μA current.
2. Connect a Digital Voltmeter ( DVM ) across the diode with the polarity shown in Illustration 2-2. See Illustration 2-3 for the pin polarities at the J4 Connector.
3. Record the voltage reading on the DVM and determine the temperature readings from Illustration 2-4 and 2-5.




**TEMPERATURE SENSING CIRCUIT**
ILLUSTRATION 2-2

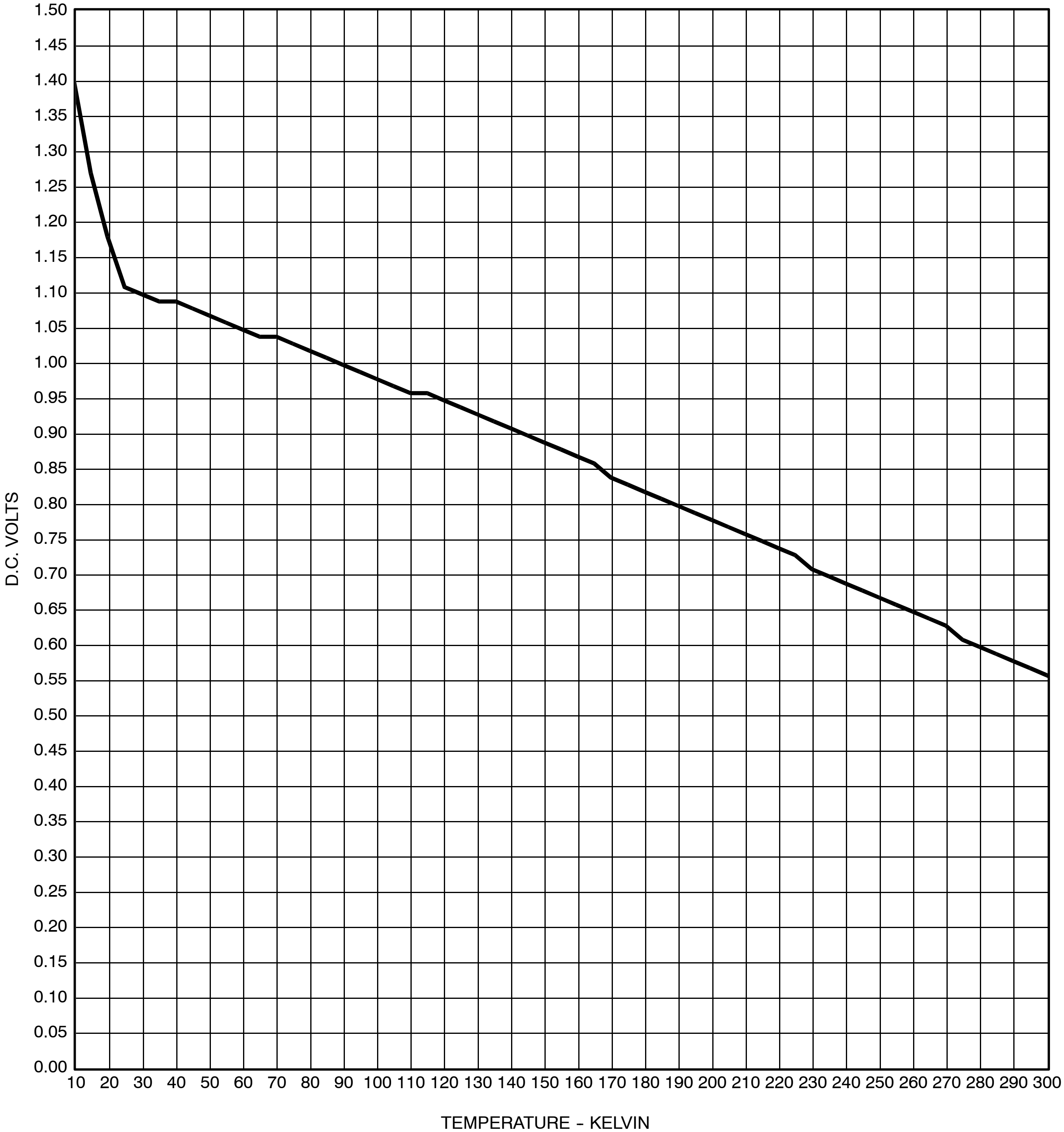



**DIODE POLARITIES**
ILLUSTRATION 2-3

### 2-2-2 Diode Temperature Sensing Circuit ( continued )


**SI410 DIODE VOLTAGE TO TEMPERATURE CONVERSION**
ILLUSTRATION 2-4

## 2-2-2 Diode Temperature Sensing Circuit ( continued )




**SI410 DIODE VOLTAGE TO TEMPERATURE CONVERSION**
ILLUSTRATION 2-5

### 2-2-3 Cryostat Cooling / Cryogen Filling Requirements

1. Record the Diode Temperatures. See SET-UP AND CALIBRATION, Section 2-2-1.

J301U Diode 1 ____________________________

J301L Diode 1 ____________________________

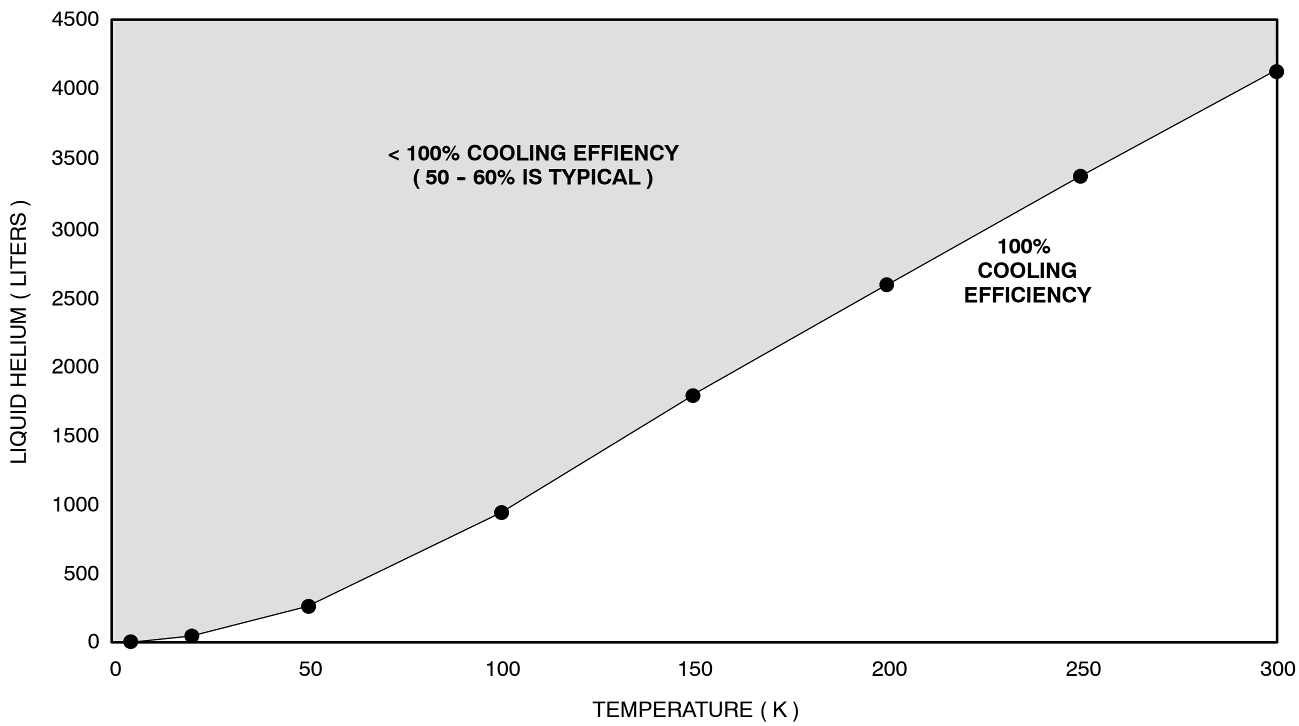
**CAUTION**

**Magnet temperature checks are performed during installation to determine the Cryostat Cooling / Cryogen Filling requirements prior to ramping. Make sure the indicated procedures, based upon diode temperatures, are followed.**

2. Determine the approximate liquid volume required using Illustration 2-6 as a guideline. Divide the liquid helium volume by an efficiency factor typical for your equipment and process to determine the actual liquid helium volume required.

**Note**

Illustration 2-6 shows helium cooling that's 100% efficient. A typical range for transfer / cooling efficiency is 50 - 60% and is dependent on a number of process and equipment factors.




**LIQUID HELIUM REQUIRED TO COOLDOWN TO 4.2K, AS A FUNCTION OF INITIAL MAGNET TEMPERATURE**
ILLUSTRATION 2-6

## 2-2-3 Cryostat Cooling / Cryogen Filling Requirements ( continued )

3. The magnet has an approximate capacity of 370 liters liquid helium. Make sure sufficient helium Dewars and gas cylinders are available for liquid helium precool and fill based upon Steps 2 and 3.

TABLE 2-3
**TEMPERATURE REQUIREMENTS**

| DIODE TEMPERATURES ( ANY OF 2 DIODES ) | CRYOSTAT COOLING / CRYOGEN FILLING REQUIREMENTS ( MANUAL SECTIONS ) |
|---|---|
| > 100 K | SECTION 3-3, LIQUID HELIUM PRECOOL |
| < 100 K | SECTION 3-4, LIQUID HELIUM FILL |

# SECTION 3 – HELIUM PRECOOL AND FILL

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

### Introduction

Helium precool and fill are performed with the same apparatus and set–up.

**Liquid nitrogen is NOT used for precool** to prevent the possibility of it being trapped in the magnet's internal plumbing and forming ice plugs during helium precool and fill.

Liquid helium transfer pressure for precool is approximately 3 – 4 psig versus 1 – 2 psig for liquid helium fill. Specific pressures and conditions are called out in the procedure.

Perform liquid helium precool and fill during magnet commissioning. Helium fill is also performed when liquid helium is depleted to the minimum level indicated in the table.

| Emergency Fill Level | Minimum Ramp Level |
|---|---|
| 60% ( Top Vessel ) | 92% at 1.0 psig ( Top Vessel ) |

Helium fills must be performed only as "bottom fills" using the indicated equipment. A bottom fill evenly distributes the liquid helium into both top and bottom vessels and prevents the occurrence of warm gas contacting the top bucking coil.

Review SAFETY REQUIREMENTS, *2301164PRE, MR Magnet – Safety Requirements*, before starting these procedures.

## 3-1 EQUIPMENT

### Bottom Fill Equipment

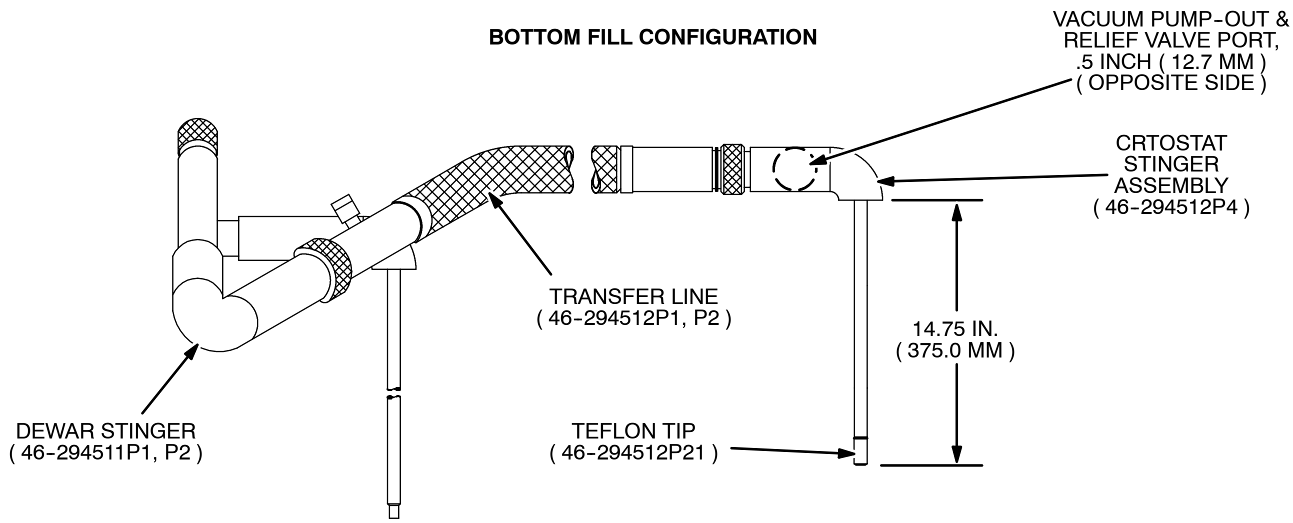
- 14.75 inch ( 375 mm ) Liquid Helium Cryostat Stinger Assembly ( 46-294512P4 )
- Liquid Helium Transfer Line ( 46-294512P1 for 12 feet [ 3658 mm ] or 46-294512P2 for 8 feet [ 2438 mm ] )
- 250 liter / 500 liter Dewar Stinger Assembly ( 46-294511P1 / P2, 2 required for multiple Dewar fills )
- Required helium Dewars and gas cylinders determined in Section 2-2-3, Cryostat Cooling / Cryogen Filling Requirements.

**Note**
A teflon tip is installed on each cryostat stinger and stinger extension to protect the threads.

### Other Equipment

- Regulator Kit ( 46-306734G1 )
- Hose Assembly ( 46-271135P16 )
- Safety Face Shield Kit ( 46-271137G1 )
- Nonmagnetic Tools
- Compression Fitting ( with retaining ring and o-ring ) ( 46-318619P1, 46-260272P1, 46-260340P9 )
- Heat Gun ( TC402274 )
- Lakeshore Thermometer Kit ( 46-301477G2 ), Low Cost Shield Temperature Diode Box ( 46-317543G2 ) or equivalent temperature monitor.

Select proper Dewar stinger lengths to be used during the fill. Refer to Illustration 3-1 for appropriate stinger configuration.




**VACUUM JACKETED HELIUM TRANSFER LINE AND DEWAR STINGER ASSEMBLY**
ILLUSTRATION 3-1

## 3-2 PREPARATION

**WARNING!**

**MAKE SURE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY MEASURES CONTAINED IN *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, INCLUDED WITH THIS MANUAL.**

**NEVER BRING HELIUM DEWARS, OR GAS CYLINDERS THAT ARE MADE FROM FERROMAGNETIC MATERIAL INTO THE EXAM ROOM. FERROMAGNETIC OBJECTS WILL BECOME DANGEROUS PROJECTILES IN A STRONG MAGNETIC FIELD. MAKE SURE ALL EQUIPMENT AND TOOLS USED IN THE EXAM ROOM ARE NON-FERROMAGNETIC.**

**SKIN CONTACT WITH LIQUID CRYOGENS WILL CAUSE BURNS. WEAR PROTECTIVE CLOTHING, GLOVES ( NONABSORBENT MATERIAL ) AND GOGGLES WHEN TRANSFERRING CRYOGENS.**

**SMOKING IS PROHIBITED IN THE EXAM AND CRYOGEN STORAGE ROOMS. LIQUID CRYOGENS CAN LIQUIFY ATMOSPHERIC OXYGEN THUS PRODUCING A HIGHLY ENRICHED OXYGEN LIQUID.**

**CAUTION**

**Make sure the Magnet Monitor's Cryogen Level Meter has been calibrated. Calibration should be done yearly and recorded in the Planned Maintenance Report in the Site Log. A calibrated Cryogen Level Meter is required to accurately determine helium fill level and efficiency.**

**If precooling the magnet, make sure the magnet diode monitoring equipment ( Lakeshore Thermometer Kit 46-301477G2, Low Cost Shield Temperature Diode Box 46-317543G2 or equivalent temperature monitor ) is connected and functional.**

**Make sure 1) the Compressor for the Two-Stage Cryocooler Coldhead is turned OFF before starting this procedure to prevent ice formation in the Recondenser and 2) the Compressor for the Single-Stage Shield Cooler Coldhead is turned ON to assist in shield cooling.**

**Make sure to use the Service Platform ( 2256565 ) for cryogen fills to access the fill port and vacuum vessel.**

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSI.**

### 3-2 PREPARATION ( continued )

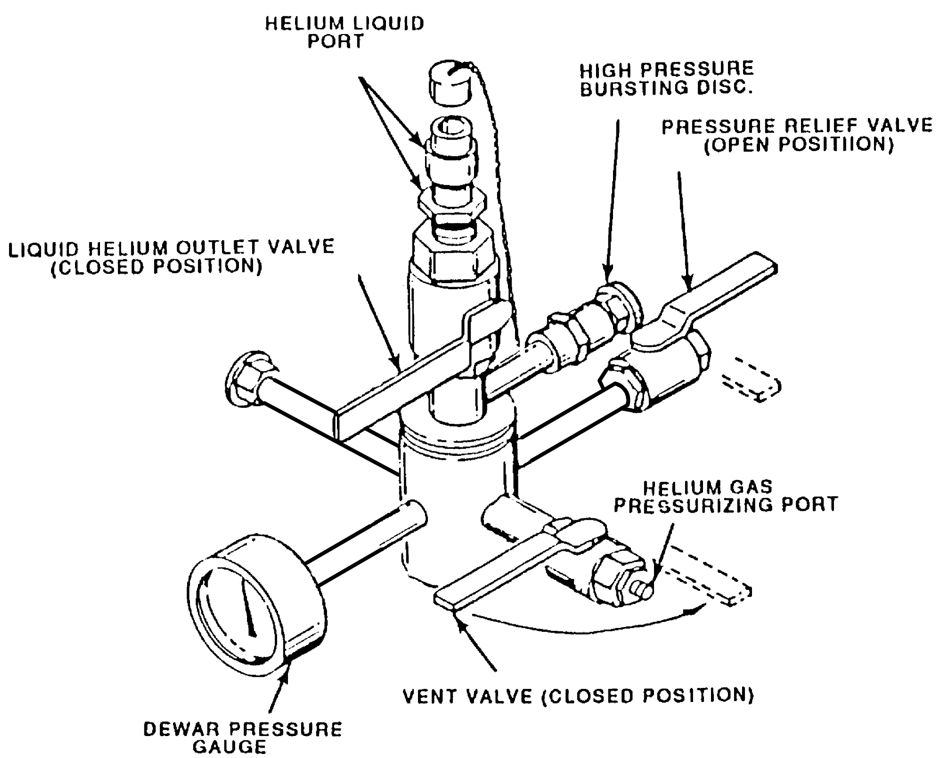
**Note**

Refer to DATA SHEETS, Section 4, Volumetric Conversion of Liquid Helium Level, to determine approximate quantity of liquid helium required to fill the cryostat. An empty and partially warmed cryostat will require an additional quantity of liquid helium as determined in SET-UP AND CALIBRATION, Section 2-2-3, Cryostat Cooling / Cryogen Filling Requirements, to cool the cryostat down to the 4.3K temperature where liquid helium will begin to collect in the cryostat.

**CAUTION**

**Do NOT use liquid nitrogen to cool the magnet as nitrogen ice blocks could occur in the internal plumbing.**

1. Obtain required quantity of full liquid helium dewars. Check Dewar pressure gauge. If pressure is above 1 psig, slowly open Dewar vent valve and reduce Dewar pressure to 1 psig. See Illustration 3-2.




**DEWAR CONNECTIONS**
ILLUSTRATION 3-2

### 3-2 PREPARATION ( continued )

**WARNING!**

**IF DEWAR PRESSURE DOES NOT VENT DOWN TO 1 PSIG, VERIFY THAT THE DEWAR PRESSURE RELIEF VALVE IS LEFT IN THE OPEN POSITION. CONTACT THE CRYOGEN SUPPLIER IMMEDIATELY.**

**Note**

The Dewar pressure relief valve is normally open during shipping and storage to prevent excessive build up of pressure in the Dewar. Therefore, always reopen pressure relief valve after using Dewar.

2. Obtain one full 135 SCF aluminum cylinder of helium gas for every 500 liters of liquid helium required ( for example, two 250-liter Dewars of liquid helium ).

**WARNING!**

**SECURE CYLINDER, ON GAS BOTTLE CART, BEFORE REMOVING PROTECTIVE VALVE CAP TO PREVENT CYLINDER FROM FALLING, WHICH COULD RESULT IN SHEARING VALVE OUTLET AND CAUSING HAZARDOUS HIGH PRESSURE GAS RELEASE.**

3. Connect standard GHe Cylinder Regulator and Hose Assembly to the valve outlet ( CGA 580 ) on GHe cylinder.
4. Make sure the regulator's adjusting handle is fully backed out, then slowly open GHe cylinder valve.
5. Observe the regulator's high pressure gauge. Make sure indicated pressure is approximately 2000 psig indicating full cylinder.
6. Record the Cryostat Pressure Gauge reading in DATA SHEETS, Section 1, Magnet Temperature / Pressure Data.
7. Connect magnet diode temperature monitoring equipment to the bottom diode connector. Verify that the equipment is functional.
8. Read and record the Magnet Cartridge temperature in conformance with SET-UP AND CALIBRATION, Section 2-2, Cryostat Temperature Check & Cooling / Filling Requirements.
   - If the Magnet Cartridge temperature is > 100K, precool the magnet in conformance with Section 3-3, Precool.
   - If the Magnet Cartridge temperature is < 100K, fill the magnet with liquid helium in conformance with Section 3-4, Liquid Helium Fill.

## 3-3 PRECOOL

**Note**

Use this procedure only when the Magnet Cartridge temperature is > 100K. Perform Section 3-4, Liquid Helium fill, when the Magnet Cartridge is < 100K.

1. Re-evacuate the cryostat in conformance with REPLACEMENT / MAINTENANCE, Section 4.

**Note**

See Illustration 3-3 for Steps 2 through 10.

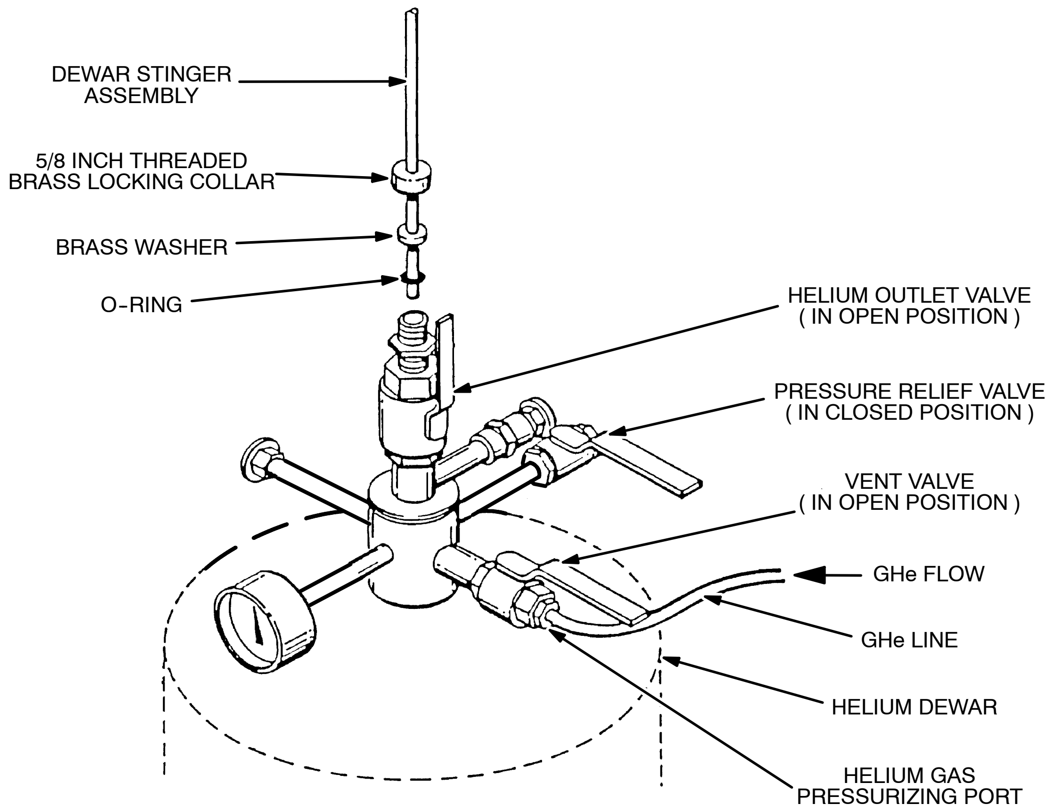
2. Verify that the Dewar LHe outlet valve is in the closed position.
3. Remove the 1/2 inch cap and adapters, exposing the 5/8 inch brass locking collar.
4. Loosen the 5/8 inch locking collar.
5. Verify that the Dewar pressure relief valve is in the open position. See Illustration 3-3.
6. Make sure the valve on the Dewar Stinger Assembly is closed. Insert the Dewar Stinger Assembly thru the 5/8 inch locking collar until stinger tip contacts the helium outlet valve. See Illustration 3-3.
7. Open the helium outlet valve.
8. Slowly insert Dewar Stinger Assembly into Dewar until stinger tip contacts liquid helium ( indicated by a pressure increase on the Dewar's pressure gauge and the expulsion of gas from the pressure relief valve port ).
9. Continue to insert Dewar Stinger Assembly at a rate that maintains a maximum 5 psig reading on the Dewar pressure gauge.
10. When the Dewar Stinger Assembly contacts the bottom of Dewar, raise the Stinger Assembly 1 inch and securely tighten the 5/8 inch threaded locking collar.

**Note**

If ceiling height prohibits insertion of Dewar Stinger Assembly into Dewar, Dewar must be moved to an area with a higher ceiling height and transported back into the magnet room.

11. When Dewar pressure stabilizes at 5 psig, close the pressure relief valve.
12. Attach the Cryostat Stinger Assembly onto the helium transfer line.

**3-3 PRECOOL ( continued )**




**HELIUM DEWAR CONNECTIONS**
ILLUSTRATION 3-3

**WARNING!**

**FIRMLY HOLD UNATTACHED END OF HOSE WHILE PURGING REGULATOR AND GAS LINE ASSEMBLY TO PREVENT WHIPPING MOTION.**

**Note**

Steps 13 and 14 will provide a helium-rich environment for connecting the helium gas line to the helium gas pressurizing port.

13. Purge the GHe Regulator and Gas Line Assembly by alternately turning the regulator handle fully in and out 3 times. Upon completion of purge, back the regulator out until minimal flow is felt exiting the Gas Line Assembly.
14. Open LHe Dewar's vent valve to allow a small amount of gas flow.
15. Attach the purged Gas Line Assembly to the LHe Dewar's helium gas pressurizing port. See Illustration 3-3.
16. Back out the regulator handle all the way.

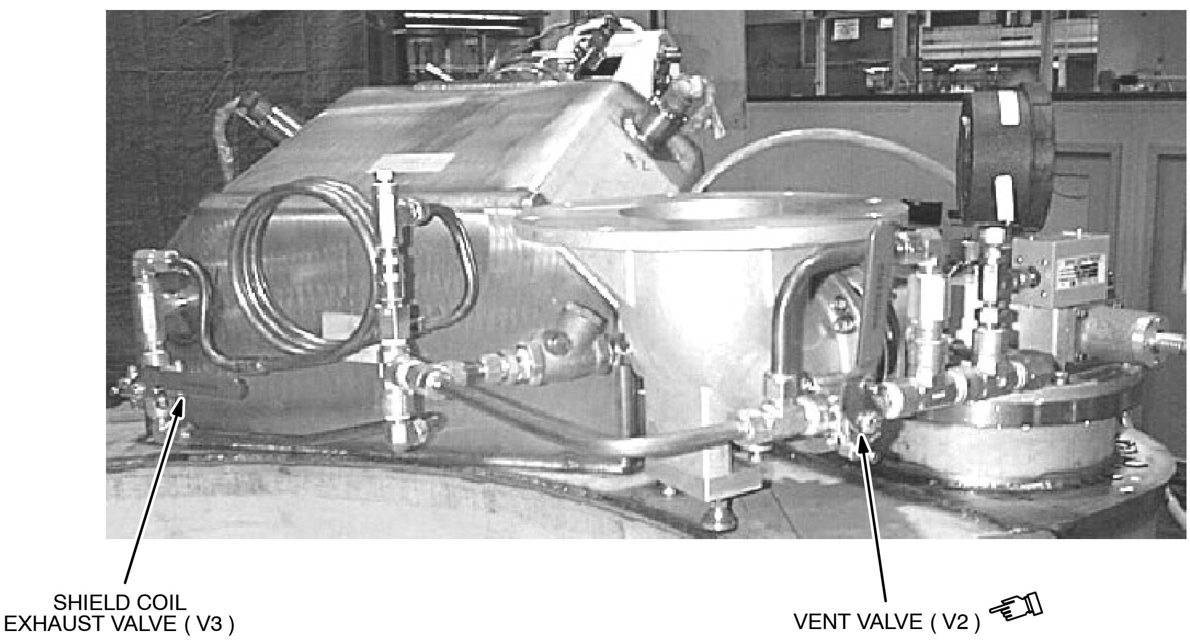
### 3-3 PRECOOL ( continued )

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.25 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.25 PSIG.**

**OBSERVE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN CRYOSTAT TO < 1 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO THE RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

17. Fully open the Shield Coil Exhaust Valve ( V3 ) on the magnet. Vent magnet cryostat pressure below 1 psig. See Illustration 3-4.




**VALVE LOCATIONS**
ILLUSTRATION 3-4

18. Partially open the Dewar Stinger Assembly's valve allowing liquid helium to purge and precool the Transfer Line Assembly until a liquid plume is observed exiting the assembly, allowing Dewar pressure to go down to < 3 psig before continuing.

19. With the plume present, uncap the Fill Port ( V1 ), fully insert the Cryostat Stinger Assembly, and then securely tighten the V1 Fill Port's compression fitting.

## 3-3 PRECOOL ( continued )

**CAUTION**

**Make sure the Stinger is fully inserted to prevent helium escaping from top of internal fill tube. A 14.75 inch ( 374.7 mm ) Stinger should sit flush against the compression fitting.**

20. Fully open Dewar Stinger Assembly's valve.

**Note**

If gas is observed escaping from the compression fitting on Fill Port V1 or on the helium Dewar, use a heat gun to warm the compression fitting and recheck the compression fitting tightness.

21. Open the Vent Valve at the Dewar's helium gas pressurizing port.
22. Verify that the GHe cylinder's Valve is fully open and adjust the GHe cylinder's regulator to obtain a Dewar pressure which is 1.5 psig above the cryostat pressure during precool, but do not set Dewar pressure above 5 psig.
23. Transfer helium at 3-4 psig Dewar pressure.
24. Monitor the magnet diode temperatures.
25. Monitor Dewar transfer for one or more of the following to determine when the Dewar is empty.
    a. Monitor the magnet pressure gauge for an increase in pressure.
    b. Listen for a whistling sound coming from the transfer line, indicating the Dewar is empty. Depending on equipment and conditions, the whistle may not always be heard.
    c. Monitor the Dewar pressure gauge for a decrease in pressure. ( A decrease in pressure could be caused by an empty gas cylinder as well. )
26. When changing helium Dewars, close the Dewar Stinger Assembly's valve, close the GHe cylinder's valve, close the Dewar vent valve, and open the Dewar pressure relief valve.
27. Change helium Dewars in conformance with Section 3-5, Changing Helium Dewars, before continuing with this procedure.
28. Read the Magnet Cartridge temperature in conformance with SET-UP AND CALIBRATION, Section 2-2, Cryostat Temperature Check & Cooling / Filling Requirements. When the temperature of the bottom magnet diode reaches 80K, close valve V3 and immediately open valve V2 fully. Adjust Dewar pressure to 2.5 - 3.0 psig.
29. Go to Step 21 of Section 3-4, Liquid Helium Fill.

### 3-4 LIQUID HELIUM FILL

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

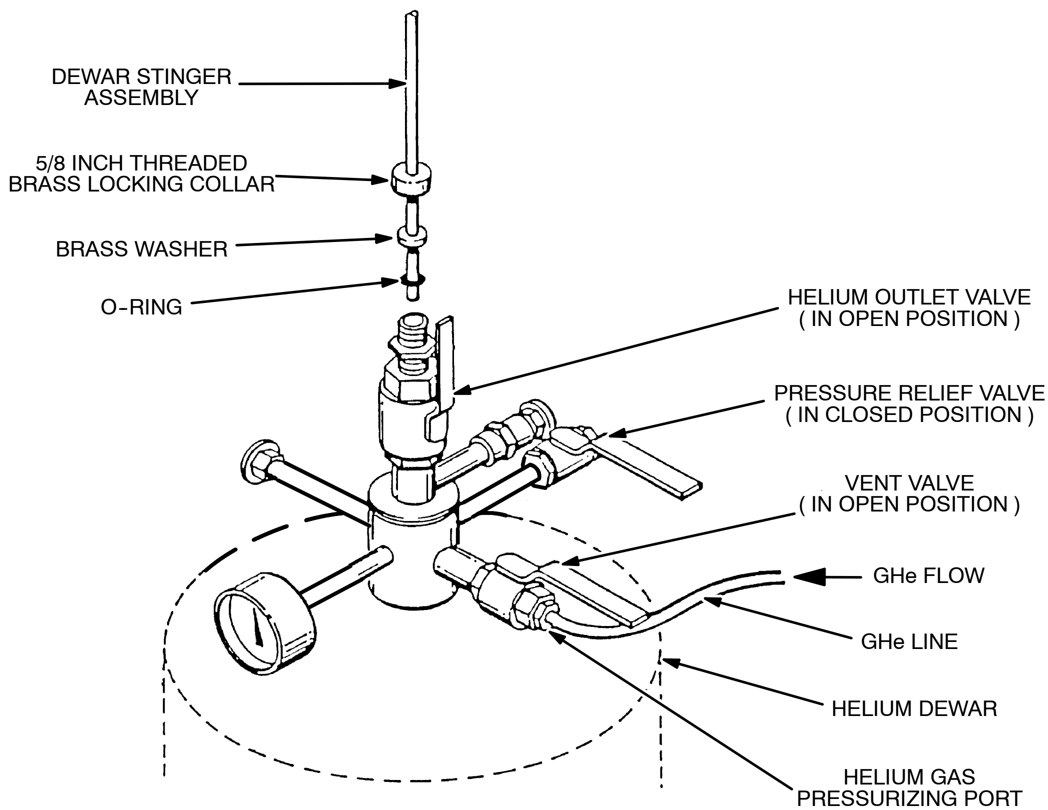
- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF <u>2301164PRE, MR MAGNET – SAFETY REQUIREMENTS</u>, INCLUDED IN THIS MANUAL.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN THE <u>2301164PRE, MR MAGNET – SAFETY REQUIREMENTS, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS</u>, INCLUDED IN THIS MANUAL.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH <u>2301164PRE, MR MAGNET – SAFETY REQUIREMENTS, SECTION 2-4, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION</u>.**

**Note**

Perform Steps 1 – 20 only when the Magnet Cartridge temperature < 100K. Perform Section 3-3, Precool, when the Magnet Cartridge temperature is > 100K.

1. Put the Magnet Monitor into the "Fill" position using the key.
2. Verify that the Dewar's liquid helium outlet valve is in the closed position. See Illustration 3-5.
3. Remove the 1/2 inch cap and adapters, exposing the 5/8 inch brass locking collar.
4. Loosen the 5/8 inch locking collar.
5. Verify that the pressure relief valve is in the open position. See Illustration 3-5.
6. Make sure the Dewar Stinger Assembly's valve is closed. Insert the Dewar Stinger Assembly thru the 5/8 inch locking collar until the stinger tip contacts the helium outlet valve. See Illustration 3-5.
7. Open the helium outlet valve.
8. Slowly insert Dewar Stinger Assembly into Dewar until the stinger tip contacts liquid helium ( indicated by a pressure increase on the Dewar's pressure gauge and the expulsion of gas from the pressure relief valve port ).
9. Continue to insert the Dewar Stinger Assembly at a rate that maintains a maximum 5 psig reading on the Dewar's pressure gauge.

## 3-4 LIQUID HELIUM FILL ( continued )




**HELIUM DEWAR CONNECTIONS**
ILLUSTRATION 3-5

10. When the Dewar Stinger Assembly contacts the bottom of the Dewar, raise the Stinger Assembly 1 inch and securely tighten the 5/8 inch threaded locking collar.

**Note**

If ceiling height prohibits insertion of Dewar Stinger Assembly into Dewar, Dewar must be moved to an area with higher ceiling height and transported back into the magnet room.

11. When Dewar pressure stabilizes below 5 psig, close the pressure relief valve.

12. Attach the Cryostat Stinger Assembly onto the helium transfer line.

### 3-4 LIQUID HELIUM FILL ( continued )

**WARNING!**

**FIRMLY HOLD UNATTACHED END OF HOSE WHILE PURGING REGULATOR AND GAS LINE ASSEMBLY TO PREVENT WHIPPING MOTION.**

**Note**

Steps 13 and 14 will provide a helium-rich environment for connecting the helium gas line to the Dewar helium gas pressurizing port to minimize contamination.

13. Purge the GHe Regulator and Gas Line Assembly by alternately turning the regulator handle fully in and out 3 times. Upon completion of purge, back the regulator out until minimal flow is felt exiting the Gas Line Assembly.
14. Open the helium Dewar's vent valve to allow a small amount of gas flow.
15. Attach the purged Gas Line Assembly to the LHe Dewar's helium gas pressurizing port. See Illustration 3-5.
16. Back out the regulator handle all the way.

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG.**

**OBSERVE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN CRYOSTAT TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

17. Open the magnet's helium vent valve ( V2 ) and vent the magnet cryostat pressure to 1 psig. Set valves V2 and V3 ( shown in Illustration 3-4 ) as shown Table 3-1:

TABLE 3-1
**V2 AND V3 VALVE POSITIONS DURING HELIUM FILL**

| PROCEDURE | HELIUM LEVEL ( TOP VESSEL ) | VALVE V2 POSITION | VALVE V3 POSITION |
|---|---|---|---|
| FILL | 0 - 70 % | OPEN | CLOSED |
| | 70 - 90 % | CLOSED | OPEN |
| RAMP / FILL | | CLOSED | OPEN |

### 3-4 LIQUID HELIUM FILL ( continued )

**CAUTION**

**Make sure the Fill Stinger has been properly plumed before inserting into a ramped magnet to prevent gas from entering the magnet and causing a quench.**

18. Partially open the Dewar Stinger Assembly's valve allowing liquid helium to purge and precool the Transfer Line Assembly until a liquid plume is observed exiting the assembly, allowing Dewar pressure to go down to < 3 psig before continuing.
19. With plume present, uncap fill port ( V1 ), fully insert the Cryostat Stinger Assembly, and then securely tighten the V1 Fill Port's compression fitting.

**CAUTION**

**Make sure the Stinger is fully inserted ( Stinger neck contacting the compression fitting ) to prevent helium escaping from top of internal fill tube.**

20. Fully open the Dewar Stinger Assembly's valve.

**Note**

If gas is observed escaping from the compression fitting on Fill Port V1 or on the helium Dewar, use a heat gun to warm the compression fitting and recheck the compression fitting tightness.

21. Open the vent valve at the Dewar's Helium Gas Pressurizing Port.
22. Verify that the GHe cylinder's valve is fully open and adjust the GHe cylinder's regulator to obtain a Dewar pressure which results in 1.0 psig at the cryostat.

### 3-4 LIQUID HELIUM FILL ( continued )

**CAUTION**

**Cryostat pressure is approximately 1 psig during helium fill. Make sure the cryostat pressure does not exceed 1.5 psig during fill. If pressures exceeding 1.5 psig exist on cryostat pressure gauge, stop the fill immediately and check fill equipment for loss of vacuum, high Dewar pressure, etc.**

**If frost is detected on the transfer line, indicating a soft line, stop the fill immediately ( as if the Dewar is empty ) to avoid a magnet quench.**

**Note**

Helium Vent Port V2 should be frosting up, indicating there is no restriction in the venting circuit.

23. Check the Helium Level Monitor for increase in the helium level. Then monitor cryogen level readings during fill process once every minute for the first five minutes and once every three minutes after the initial five minute interval.

**CAUTION**

**If the Helium Level Meter is not increasing, check the magnet and fill equipment for frosting or blockage. If it is decreasing, stop the fill immediately and contact service.**

**WARNING!**

**DO NOT ALLOW AN EMPTY DEWAR TO BLOW WARM HELIUM GAS INTO RAMPED MAGNET AS A QUENCH COULD OCCUR.**

### 3-4 LIQUID HELIUM FILL ( continued )

24. Monitor the Dewar transfer for one or more of the following to prevent blowing helium gas into the helium vessel. Immediately close the Dewar Stinger if any of these symptoms are observed and change Dewars in conformance with Section 3-5.

    a. Monitor the magnet pressure gauge for an increase in pressure.

    b. Listen for a whistling sound coming from the transfer line indicating the Dewar is empty. Depending on equipment and conditions, the whistle may not always be heard.

    c. Monitor the percent change on the LHe Meter. Stop the transfill when there is no positive ( increasing ) change in the meter reading.

25. Record information for each Dewar on DATA SHEETS, Sections 2, Liquid Helium Refill Log, or 3, Helium Fill Data.

26. When the helium volume in the top helium vessel = 70%, open valve V3 and immediately close valve V2. See Table 3-1.

**Note**

Valve V3 must be open to fill the top helium vessel from 70% full to 90% full.

27. When the top helium vessel is 90% full, or when changing helium Dewars, close the Dewar Stinger Assembly's valve, close the GHe cylinder's valve, close the Dewar's vent valve, and open the Dewar's pressure relief valve.

28. Close valve V3.

29. If additional Dewars are required, change helium Dewars in conformance with Section 3-5, Changing Helium Dewars, before continuing with this procedure.

**CAUTION**

**Fill the Top Helium Vessel only to the 90 - 92% level. Fill levels beyond 92% can result in magnet over-pressurization.**

30. When fill is complete, remove the Cryostat Stinger from the Fill Port ( V1 ) and immediately replace the Fill Port Cap.

**Note**

A heat gun may be required to remove frost from the V1 Fill Port Assembly before removing the Stinger.

31. Tighten the compression fitting at V1 to prevent a leak from occurring.

32. Disconnect the Helium Transfer Line Assembly from the helium Dewar Stinger Assembly.

33. Make sure the helium Dewar is under 1 psi, then remove the helium Dewar Stinger Assembly from the Dewar.

34. Close the GHe cylinder's valve.

35. Disconnect the GHe line from the Dewar's Helium Gas Pressurizing Port.

### 3-4 LIQUID HELIUM FILL ( continued )

36. Back off the pressure regulator adjusting handle ( CCW ) on the helium gas cylinder until no resistance is felt.

37. Verify following Dewar configuration.

| | |
|---|---|
| Liquid Helium Outlet Valve | closed |
| Helium Vent Valve | closed |
| Pressure Relief Valve | open |

Replace all adapters on the liquid helium valve outlet.

38. Remove GHe cylinder regulator from helium gas cylinder and install protective valve cap on cylinder.

39. Check and record cryogen level meter and cryostat pressure readings.

40. Put the magnet monitor into operational mode by turning key switch to the “ON” position.

41. Remove the GHe cylinder’s regulator from the cylinder and install a protective valve cap on the cylinder.

42. Check and record cryogen level meter and cryostat pressure readings.

### 3-5 CHANGING HELIUM DEWARS

**CAUTION**

**Always remove the Cryostat Stinger from the Fill Port and start the Fill Procedure over again when changing helium Dewars with the magnet at field. This is done to avoid the possibility of introducing helium gas from the helium transfer line into the magnet, thereby causing a magnet quench.**

1. Close the helium vent valves ( V2 / V3 ) on the magnet.

2. Remove the Stinger and cap the fill port ( V1 ).

**Note**

If 99.999% Helium Gas is used, the purity of the gas remaining in the cylinder will degrade as a result of this process ( i.e., the purity of the remaining gas will be something less than 99.999% ).

3. Obtain a full liquid helium Dewar. Check Dewar pressure gauge. If pressure is above 1 psig, slowly open Dewar’s Vent Valve and reduce Dewar pressure to 1 psig. See Illustration 3-5.

**3-5 CHANGING HELIUM DEWARS ( continued )**

**WARNING!**

**IF DEWAR PRESSURE DOES NOT VENT DOWN TO 0.5 PSIG, VERIFY THAT THE DEWAR PRESSURE RELIEF VALVE IS LEFT IN THE OPEN POSITION. CONTACT CRYOGEN SUPPLIER IMMEDIATELY.**

**Note**

The Pressure Relief Valve is normally open during shipping and storage to prevent excessive build-up of pressure in the Dewar. Therefore, always leave Pressure Relief Valve open after using a Dewar.

4. Observe the GHe cylinder regulator's high pressure gauge. Make sure the indicated pressure is at least 1000 psig, indicating sufficient gas volume for transferring a full 250-liter helium Dewar.

**WARNING!**

**SECURE THE CYLINDER BEFORE REMOVING PROTECTIVE VALVE CAP TO PREVENT CYLINDER FROM FALLING, WHICH COULD RESULT IN SHEARING THE VALVE OUTLET AND CAUSING HAZARDOUS HIGH PRESSURE GAS RELEASE.**

5. If a new GHe aluminum cylinder is required in Step 4, connect a standard GHe Regulator and Hose Assembly to the valve outlet ( CGA 580 ) on the GHe cylinder.
6. Make sure the regulator adjusting handle is backed fully out, then slowly open the GHe cylinder valve.
7. Refer to Section 3-1, Equipment, for appropriate equipment.
8. Observe the cryostat pressure gauge and vent, temporarily opening the helium vent valve as required to keep pressure below 0.5 psig.
9. Verify that the helium outlet valve is closed on the full Dewar.
10. Loosen the 5/8 inch locking collar on the full Dewar.
11. Remove the 1/2 inch cap and adapters, exposing the 5/8 inch brass locking collar.
12. Verify that the pressure relief valve is in the open position.
13. Verify that the Dewar Stinger Assembly's valve is in the closed position. Disconnect the Helium Transfer Line from the Dewar Stinger Assembly.
14. Remove the Dewar Stinger Assembly from the empty Dewar.
15. Wipe off frost or moisture on the Dewar Stinger and insert the Dewar Stinger Assembly thru the 5/8 inch locking collar until stinger tip contacts the helium outlet valve in the full Dewar. See Illustration 3-5.

### 3-5 CHANGING HELIUM DEWARS ( continued )

16. Insert the Dewar Stinger Assembly through the 5/8 inch locking collar until the stinger tip contacts the helium outlet valve.

17. Open the helium outlet valve.

18. Slowly insert Dewar Stinger Assembly into Dewar until the stinger tip contacts liquid helium ( indicated by a pressure increase on the dewar pressure gauge and expulsion of gas from the pressure relief valve port ).

19. Continue to insert the Dewar Stinger Assembly at a rate that maintains a maximum 5 psig reading on the Dewar's pressure gauge.

20. When the Dewar Stinger Assembly contacts bottom of the Dewar, raise the Stinger Assembly 1 inch and securely tighten the 5/8 inch threaded locking collar.

**Note**

If ceiling height prohibits insertion of the Dewar Stinger Assembly into the Dewar, the Dewar must be moved to an area with higher ceiling height and transported back into the magnet room.

21. When Dewar pressure stabilizes at 5 psig, close the pressure relief valve.

22. Attach the helium transfer line to the Dewar Stinger Assembly.

**WARNING!**

**FIRMLY HOLD UNATTACHED END OF HOSE WHILE PURGING REGULATOR AND GAS LINE ASSEMBLY TO PREVENT WHIPPING MOTION.**

23. Disconnect the GHe line from the empty Dewar. Purge the GHe cylinder's Regulator and Gas Line Assembly by alternately turning the regulator's handle fully in and out 3 times. Upon completion of the purge, back the regulator out until a minimal flow is felt exiting the Gas Line Assembly.

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER <u>VERY</u> SLOWLY. GAS IS AT 2400 PSI.**

24. Slightly open helium gas Vent Valve very slowly to allow for helium gas flow from the Dewar.

25. Attach the purged Gas Line Assembly to the Dewar's Helium Gas Pressurizing Port. Fully back out the regulator's adjusting handle.

26. Attach the Cryostat Stinger to the transfer line.

**3-5 CHANGING HELIUM DEWARS ( continued )**

27. Prepare the empty Dewar as follows:

| | |
|---|---|
| Liquid Helium Outlet Valve | closed |
| Helium Vent Valve | closed |
| Pressure Relief Valve | open |

Replace all adapters on the liquid helium valve outlet.

28. Continue with:

a. Section 3-3, Precool, Step 17

b. Section 3-4, Liquid Helium Fill, Step 16

c. Section 4-1, Helium Fill During Ramp - Person 2, Step 1

## 3-6 CHANGING HELIUM GAS BOTTLES

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSI.**

**WARNING!**

**HELIUM GAS BOTTLE CAPS ARE FERROUS AND MUST BE REMOVED BEFORE BRINGING BOTTLE INTO MAGNET ROOM AS THEY CAN BECOME DANGEROUS PROJECTILES IN A MAGNETIC FIELD.**

**Note**

Change the helium gas bottle when bottle pressure drops below 5 psig. Approximately one 235 SCF helium gas bottle is needed to pressurize a 500 liter liquid helium dewar.

1. Close the Dewar vent valve and remove the gas hose.

2. Close the main valve and regulator on the helium gas bottle.

3. Bring a full helium gas bottle into the magnet room and reconnect the regulator and hoses.

4. Purge the hose before reconnecting to the Dewar.

# SECTION 4 - RAMP FILL

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL “WORK ASSISTANTS” OR “WORK OBSERVERS” COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 4-1 INTRODUCTION

The Main and Bucking Coils of the GE 0.7T Open*Speed* Magnet are in a horizontal plane to generate a vertical magnetic field. Because of this configuration, it is essential that the magnet helium level remain between 95% and 98% during the ramp to be in contact with the Top Bucking Coil. Failure to maintain this condition will result in a cooling loss of the Top Bucking Coil and could result in a quench.

The ramp / fill procedure maintains the required helium level during the ramp through the controlled replenishment of liquid helium to compensate for loss through the Main Leads and Vent Valve V3.

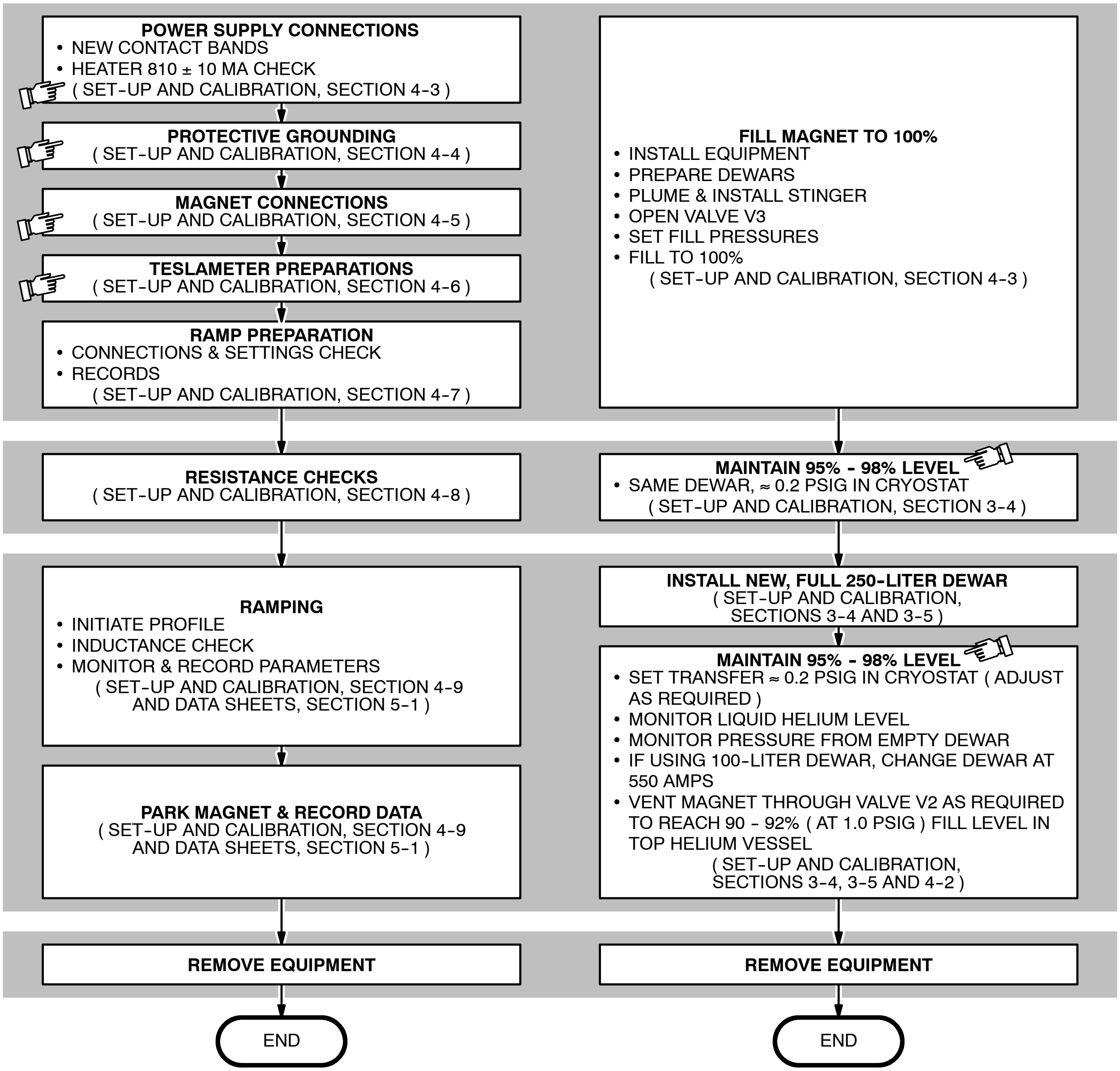
Because of the complexity and simultaneous tasks of the ramp / fill procedure, two trained and certified persons are required. Person 1 performs the ramp while person 2 simultaneously performs the fill.

Before starting these procedures, review and fully understand all superconducting magnet portions of *2301164PRE, MR Magnet - Safety Requirements*, found in the SAFETY REQUIREMENTS tab of this manual. Fully comply with that document’s Section 2-4, Magnet & Cryogen Service Safety Requirements. Have all “Work Assistants” or “Work Observers” comply with that document’s Section 2-4, Buddy System Requirements & Certification.

Illustration 4-1 highlights the tasks and sequence for each person. Table 4-1 outlines the ramp / fill process steps. Complete DATA SHEETS, Table 5-2, Magnet Ramp / Fill Profile, for both magnet ramp up and ramp down.

## 4-1 INTRODUCTION ( continued )

**PERSON 1 – RAMP TASKS** **PERSON 2 – FILL TASKS**




**RAMP / FILL PROCESS**
ILLUSTRATION 4-1

## 4-1 INTRODUCTION ( continued )

TABLE 4-1
**RAMP / FILL PROCESS STEPS**

| **Prerequisites** |
|---|
| • Magnet Heaters must be stabilized.<br>• Perform Power Supply checks to verify functional ramp supply.<br>• Magnet Monitor must be functional and put into “FILL” mode. |
| **The process** |
| • Vent magnet down to .5 psig.<br>• If the Upper Vessel helium level is < 80%, top off the magnet to at least 95%. Valve V3 should be open when helium level is greater than 70%.<br>• If the Upper Vessel helium level is > 80%, proceed to next step.<br>• Install Protective Grounding Circuit.<br>• Insert the Main Lead Extensions.<br>• Install the Hold-down Tool, but do not fully tighten.<br>• Insert the fill line Stinger and begin filling the magnet.<br>• Tighten the Hold-Down Tool.<br>• When the Upper Vessel helium level is > 90%, do resistance checks.<br>• When the resistance checks pass, change to a new 250-liter Dewar.<br>• Park magnet at 29.791 MHz. This will account for the frequency drop when the supply is ramped down and the frequency increase when the magnet is shimmed. Specification for 0.7T Open*Speed* Magnet is 29.803 MHz ± 10 KHz.<br>• Replace Power Supply Jumper Cable before removing the Main Lead Extensions.<br>• After the supply is turned off, continue to fill while removing the Hold-Down Tool and Main Lead Extensions. This will give a higher helium level for magnet turnover to the customer. Hold-Down Tool and Main Lead Extensions should be removed quickly.<br>• Put the Magnet Monitor back into normal operating mode. |

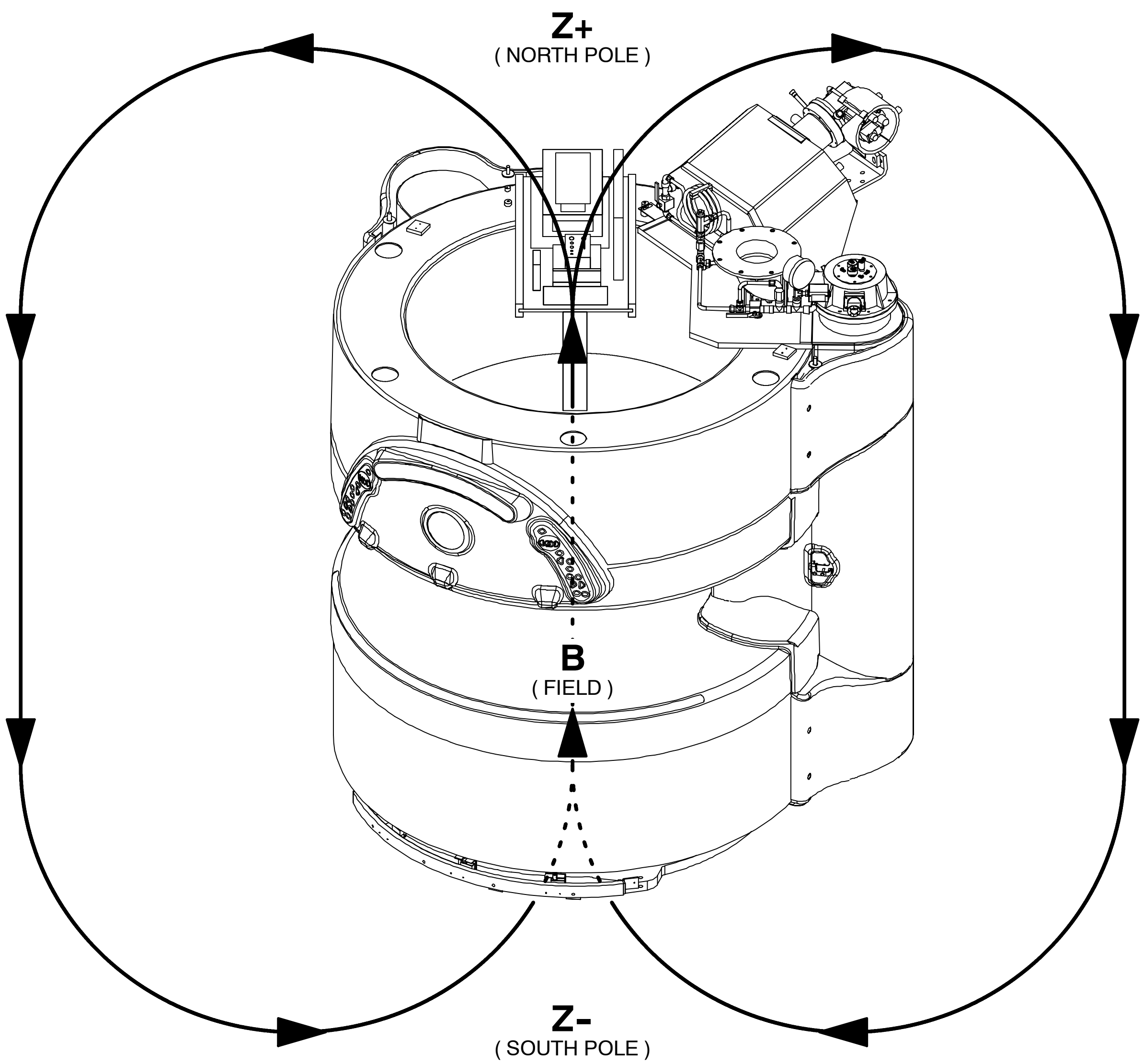
## IMPORTANT !!!

It is **essential** that the following conditions are met to prevent a 250-liter helium Dewar from running dry during the ramp. Approximately 150 liters of helium will be used under these conditions.

- Follow the ramp profile. Do not allow the ramp voltage to decay during each step of the ramp.
- Make sure contact resistance ( < 150 mV @ 750 amps ) is well within limits to minimize internal heat generation.
- Connect a new 250-liter helium dewar after resistance checks ( at start of ramp ).
- Maintain a helium level of 95% - 98% in the Top Helium Vessel during the ramp. Vessel pressure should be between 0.35 psig and 0.6 psig to maintain this helium level.
- Verify that magnet Temperature Control Units ( TCU’s ) have stabilized for at least 6 hours at a temperature of 28°C.

**Note:**
The field polarity of a normally ramped magnet is shown in Illustration 4-2.

## 4-1 INTRODUCTION ( continued )




**FIELD POLARITY OF A NORMALLY RAMPED MAGNET**
ILLUSTRATION 4-2

## 4-1 INTRODUCTION ( continued )

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM.**

**SECURE THE MAGNET ROOM DOORS IN THE OPEN POSITION BEFORE CHANGING MAGNETIC FIELD.**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## 4-2 HELIUM FILL DURING RAMP - PERSON 2

**CAUTION**

**Continuously observe the magnet vessel pressure and upper vessel helium level during the ramp / fill process. A portable helium meter should be used.**

**Note**

Portable Helium Meter 2270571 is calibrated for the GE 0.7T Open*Speed* magnet. However, any helium meter calibrated for a LCC or Florence-manufactured magnet can be used if the meter level is not allowed to drop below 97% during the ramp / fill process.

1. Open Valve V2 ( identified in Illustration 4-3 ) and vent the magnet down to < 0.5 psig. Close V2.

**CAUTION**

**Shield the pump-out port on the transfill line from cold helium gas that can harden the pump-out port o-ring and cause the line to go "soft."**

2. Assemble the equipment, a new Dewar and cylinder of helium gas. Plume and insert the Stinger after the Main Lead Extensions and Hold-Down Tool are installed.

### 4-2 HELIUM FILL DURING RAMP - PERSON 2 ( continued )

3. Open Shield Vent Valve V3, identified in Illustration 4-3. Fill the magnet to 100% in conformance with SET-UP AND CALIBRATION, Section 3-4, Helium Precool And Fill.

**Note**

Leave Valve V3 open sufficiently to maintain 0.2 psig helium transfer pressure during the entire ramping procedure to prevent pressure build-up.

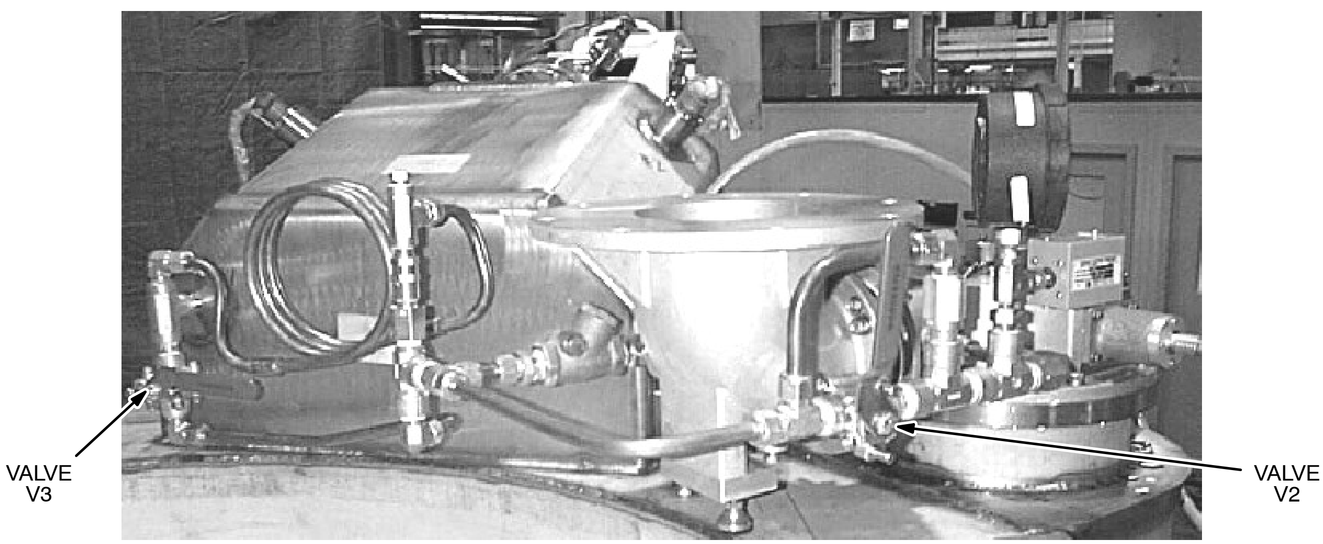
4. Maintain a 95 - 98% helium level during resistance checks. Nominal Cryostat pressure is 0.5 psig for maintaining this helium level.

5. Change to a new, full 250-liter Dewar at the start of ramp in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.

## IMPORTANT !!!

It is essential that the magnet is at 98% liquid helium level and a full 250-liter dewar is installed at the start of the ramp to prevent the Dewar from running dry during the ramp.

6. Adjust pressure from a helium gas cylinder connected to the Dewar and then to the Cryostat to produce a ~ 0.5 psig Cryostat pressure. Make minor adjustments to Dewar pressure as required to maintain between 95 - 98% liquid helium level during ramp.




**V2 AND V3 VALVE LOCATIONS**
ILLUSTRATION 4-3

## 4-2 HELIUM FILL DURING RAMP - PERSON 2 ( continued )

**CAUTION**

**Always maintain a positive pressure differential between the Dewar and the Cryostat to prevent any backflow of helium into the Dewar.**

**WARNING!**

**ALLOWING A HELIUM DEWAR TO EMPTY DURING RAMPING WILL CAUSE WARM GAS TO ENTER THE MAGNET AND CAUSE A QUENCH. CONTINUOUSLY MONITOR THE DEWAR AND MAGNET FOR A "WHISTLING" SOUND AND MAGNET PRESSURE FOR AN INCREASE; THESE INDICATE THE DEWAR IS EMPTY. WHEN AN EMPTY DEWAR IS SUSPECTED, IMMEDIATELY SHUT OFF THE DEWAR STINGER AND DISCONTINUE THE RAMP UP, MAINTAINING A CONSTANT RAMP CURRENT.**

7. Continuously monitor the magnet for a noticeable pressure increase and the Dewar Stinger for a whistling sound indicating that the Dewar is empty. If the Dewar is empty, have Person 1 park the magnet, turn the Power Supply off and change Dewars in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.

8. Once the magnet is ramped and parked, close V3. Then Open Valve V2 and vent the magnet as required to reach a 90% fill level in the Top Helium Vessel.

**CAUTION**

**Fill the Top Helium Vessel only to the 90 - 92% level. Fill levels beyond 92% can result in magnet over-pressurization.**

9. Immediately discontinue helium transfer. Remove all helium fill equipment in conformance with SET-UP AND CALIBRATION, Section 3-4, Liquid Helium Fill.

## 4-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1

### Introduction

At least once a year calibrate the Ramp Power Supply in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5-1000-2-D-1236 Main Power Supply Calibration / Check.

Make sure the Ramp Power Supply is installed and checked out in conformance with the vendor manual supplied with the unit before making any Power Supply connections to the magnet. See INTRODUCTION, Section 2, Vendor Manual Matrix for vendor manual numbers.

SCHEMATICS / INTERCONNECTS, Section 1-1, Magnet Interconnect Diagram, shows the cable numbers and interconnect patterns covered in this Section.

The Main Coil Power Cables, Switch Heater Cables and Voltage Sense Leads are provided as part of the Ramp Cart / Cable Kit ( 1000 Amp ) 2180589.

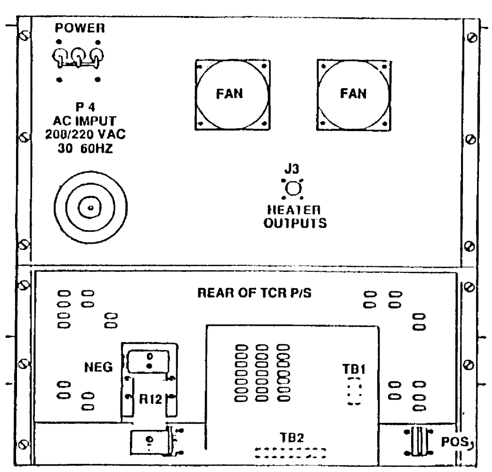
Use Main Lead Extensions 46-294204G1 from Magnet Ramping Equipment Kit 46-260703G6.

### Procedure

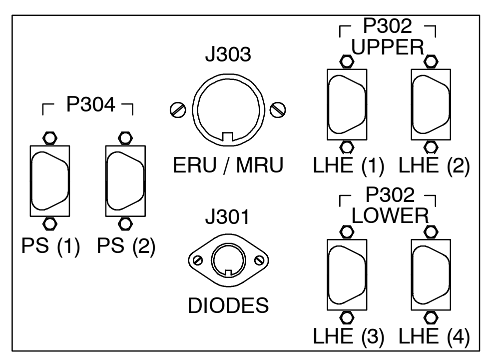
1. Verify that input power to the Main Coil Power Supply is disconnected.
2. Connect “P3” on Switch Heater Cable 46-281667G1 to Heater Outputs “J3” on the rear of the Main Coil Power Supply Cabinet ( MS6-A1 ). See Illustration 4-4.

**Note**

The magnet incorporates a “B0 Coil” to decrease moving-metal sensitivity of the magnet field. The B0 Coil Heater is energized through the Ramp Power Supply’s Axial Shim Heater Circuit. The Ramp Power Supply’s Axial Shim Heater must remain on throughout the Rampdown procedure in order to quench the B0 Coil field.




**POWER SUPPLY ( REAR )**




**CONNECTOR PANEL**

**MAGNET POWER SUPPLY OUTPUT CONNECTIONS AND MAGNET CONNECTOR PANEL**
ILLUSTRATION 4-4

## 4-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1 ( continued )

3. Connect "J304" on the Switch Heater Cable to "P304" on the Magnet Connector Assembly ( MS1-A3, A1 ). See Illustration 4-4.

**Note**

Make sure the nuts installed in Steps 4 and 6 below are tightened sufficiently to prevent a high resistance contact. Connect the red cables to the Positive ( + ) Buss Bar and the black cables to the Negative ( - ) Buss Bar on the Main Power Supply. For magnets ramped with normal polarity make sure the red ( + ) cables are connected to the "+" Magnet Ramp Port and the black ( - ) cables are connected to the "-" Magnet Ramp Port.

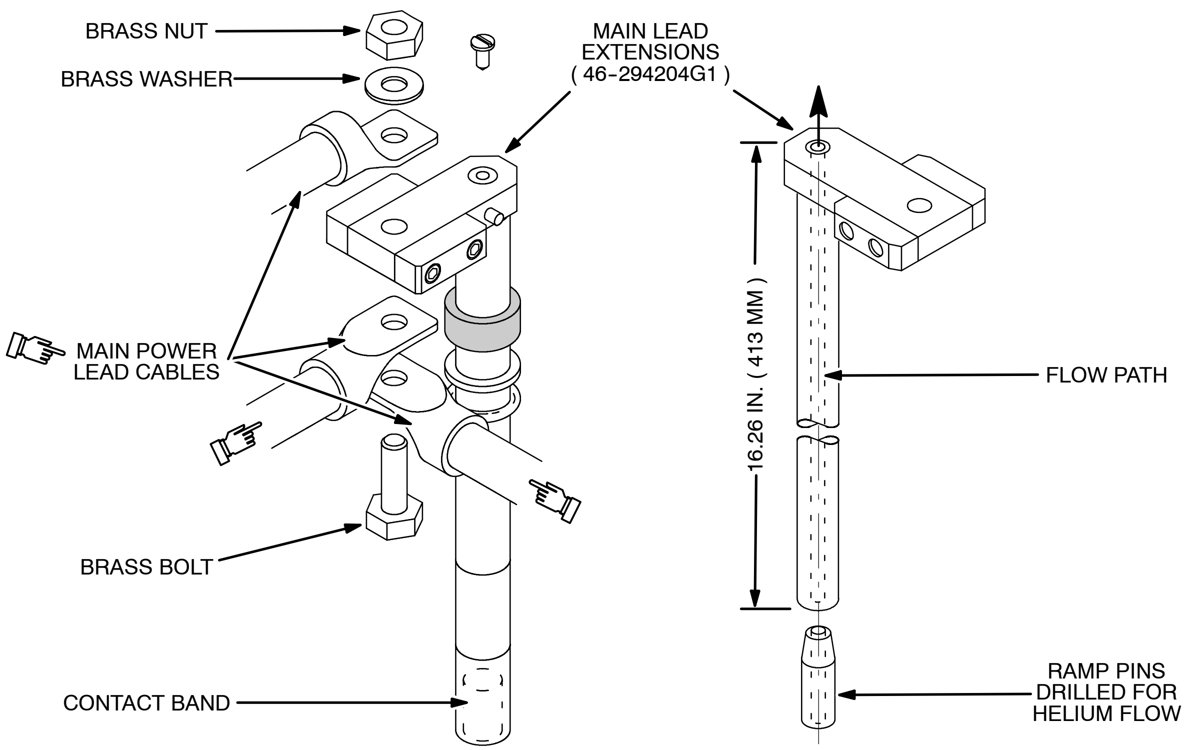
4. Connect the Main Coil Power Cables ( "+" Red: 46-260723G1; "-" Black: 46-260723G2 ) to the Main Power Supply Buss Bars with the .375 inch brass nuts, bolts and washers provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ).

**Note**

Three pairs of Main Coil Power Cables must be used when ramping the GE 0.7T Open*Speed* magnet.

5. Replace the Contact Bands on the Main Lead Extension ( 46-294204G1 ) according to REPLACEMENT / MAINTENANCE, Section 12, Main Lead Extension Contact Band Replacement. Make sure the Gas Flow Holes are not blocked.

6. Connect the other end of the Main Power Cables to the Main Lead Extensions with the brass nuts, bolts and washers provided. See Illustrations 4-5 and 4-10.




**HARDWARE MOUNTING ON MAIN LEAD EXTENSIONS**
ILLUSTRATION 4-5

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1

**WARNING!**

**MAKE SURE THE POWER SUPPLY IS ALWAYS COMPLETELY GROUNDED IN CONFORMANCE WITH THE FOLLOWING PROCEDURE BEFORE INSERTING OR EXTRACTING ANY MAIN LEAD EXTENSION TO THE MAGNET ( DURING RAMP UP, RAMP DOWN OR REPARKING MAGNET ). GROUNDING WILL PREVENT THE REMOTE POSSIBILITY OF A HIGH VOLTAGE BETWEEN THE MAIN LEAD EXTENSION AND THE CRYOSTAT GROUND IF AN UNLIKELY QUENCH AND ARC / SHORT TO THE CRYOSTAT OCCUR WHEN THE MAIN LEAD EXTENSION IS INSERTED / EXTRACTED.**

**IMPORTANT !!!**

Requirements during ramping:

- Always install the Pre-Ramp Protective Grounding Circuit and verify Main Lead Extension grounding to Cryostat ground before inserting or extracting any Main Lead Extension.
- Once the Main Lead Extensions are inserted, disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non-absorbant leather gloves with NO holes / tears. This removes the short across the power supply and enables magnet ramping up / down.
- Once the magnet is parked and the power supply turned off — but before removing the Main Lead Extensions — reconnect the Power Supply Jumper Cable's twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. This re-establishes full power supply grounding.
- After ramping up / down, when the power supply has been turned off and the Main Lead Extensions have been extracted, remove the Power Supply Jumper and Grounding Cables.

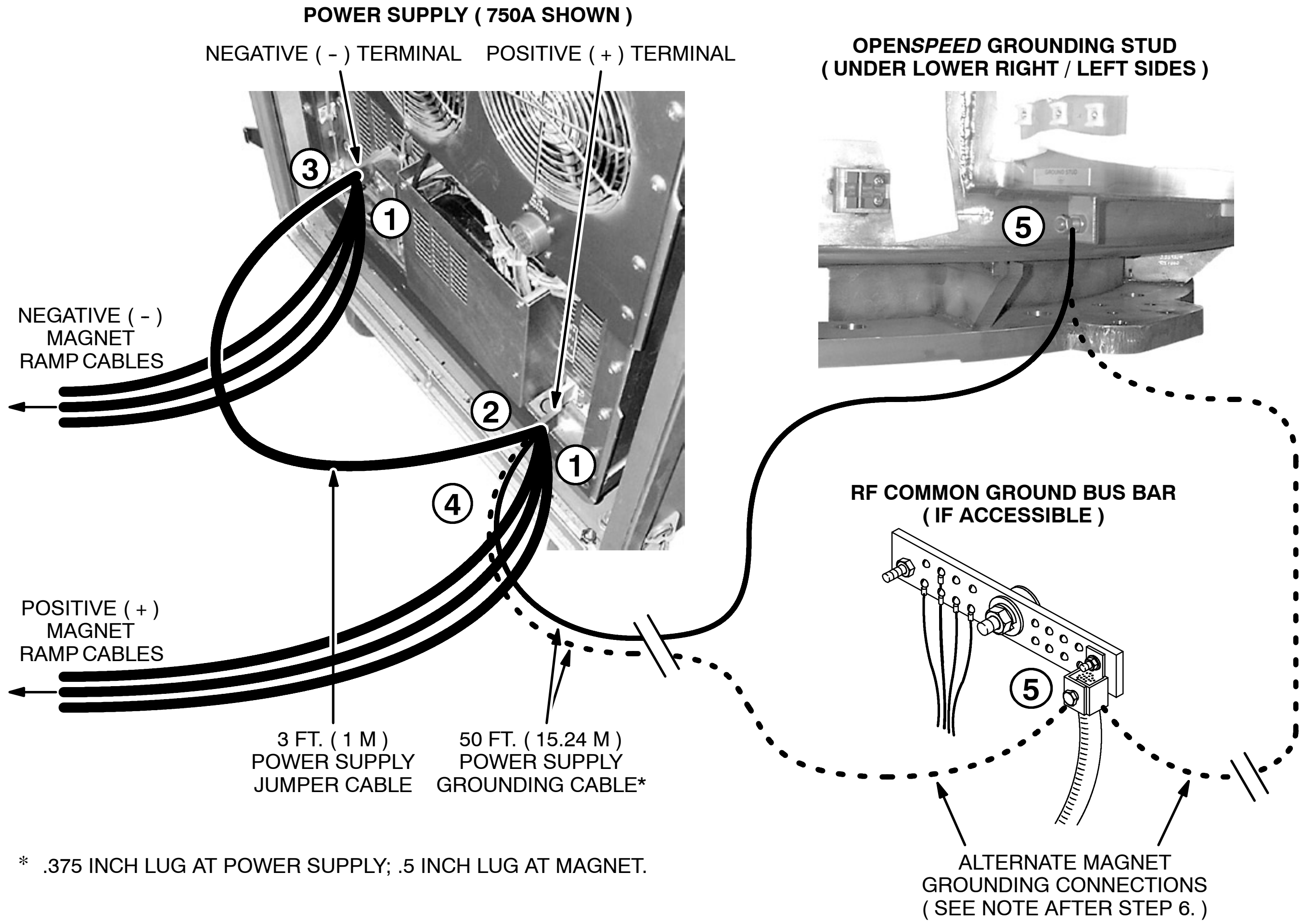
### Equipment

- .375-16 x 1.75 inch Brass Screws, Washers and Nuts ( 2 )
- 3 ft. ( 1 M ) Power Supply Jumper Cable
- 50 ft. ( 15.24 M ) Power Supply Grounding Cable

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

### Procedure

1. Connect the Magnet Ramp Leads to the Ramp Power Supply in the standard configuration and using the .375-16 x 1.75 inch brass screws, washers and nuts. See Illustration 4-6, label "1".

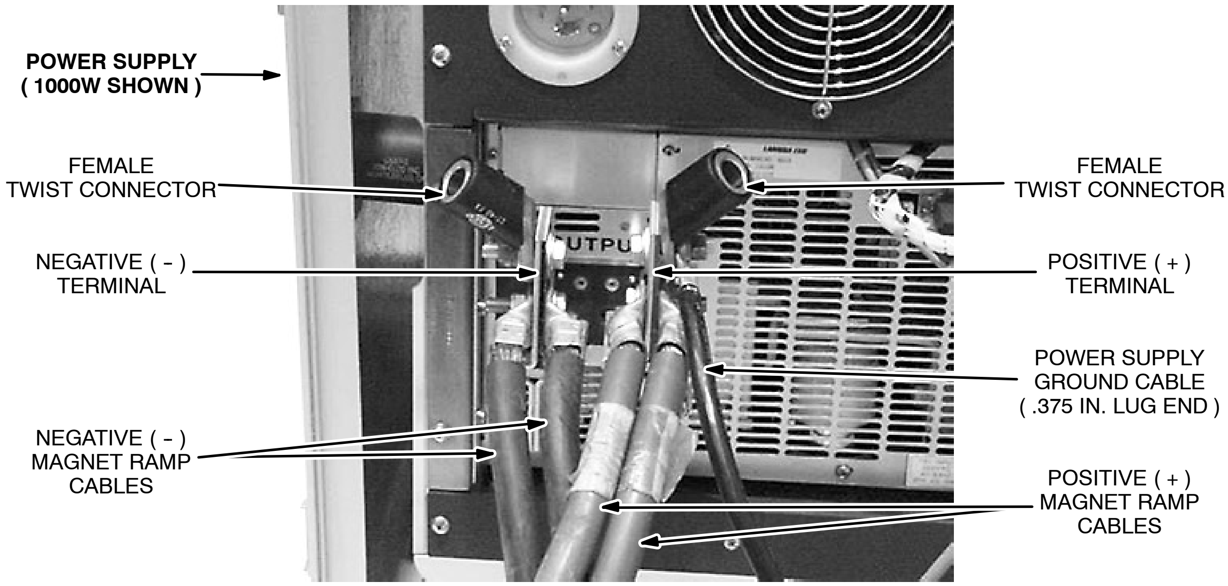



* .375 INCH LUG AT POWER SUPPLY; .5 INCH LUG AT MAGNET.

**PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS**
ILLUSTRATION 4-6

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

2. Disconnect the female twist connector lugs from the 3 ft. ( 1 M ) Power Supply Jumper Cable and then connect the lugs to the positive ( + ) and negative ( - ) power supply output terminals. See Illustration 4-7.

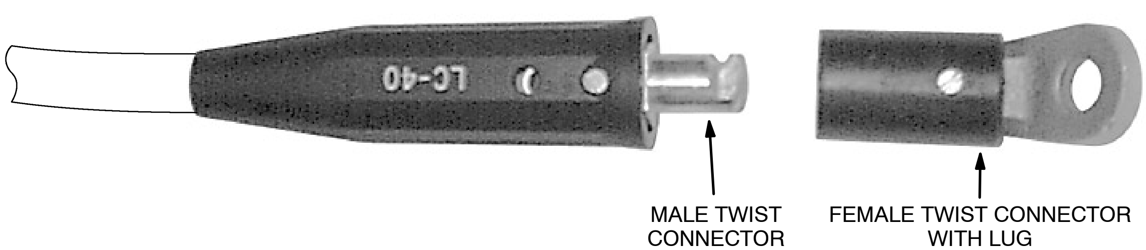



**FEMALE TWIST CONNECTORS ATTACHED TO POWER SUPPLY OUTPUT TERMINALS**
ILLUSTRATION 4-7

3. Connect one twist connector lug ( shown in Illustration 4-8 ) of the Power Supply Jumper Cable to the power supply's positive ( + ) terminal. Make sure the twist connector is fully engaged. See Illustration 4-6, label "2".

4. Connect the other twist connector lug( shown in Illustration 4-8 ) of the Jumper Cable to the power supply's negative ( - ) terminal. Make sure the twist connector is fully engaged. See Illustration 4-6, label "3".

5. Connect the .375 inch ( 9.5 mm ) lug of the 50 foot ( 15.24 M ) Power Supply Grounding Cable to the power supply's positive ( + ) terminal. See Illustration 4-6, label "4".




**TWIST CONNECTOR ON POWER SUPPLY JUMPER CABLE**
ILLUSTRATION 4-8

### 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

6. Connect the Grounding Cable's .5 inch ( 12.7 mm ) lug to the magnet's grounding lug. See Illustration 4-6, label "5".

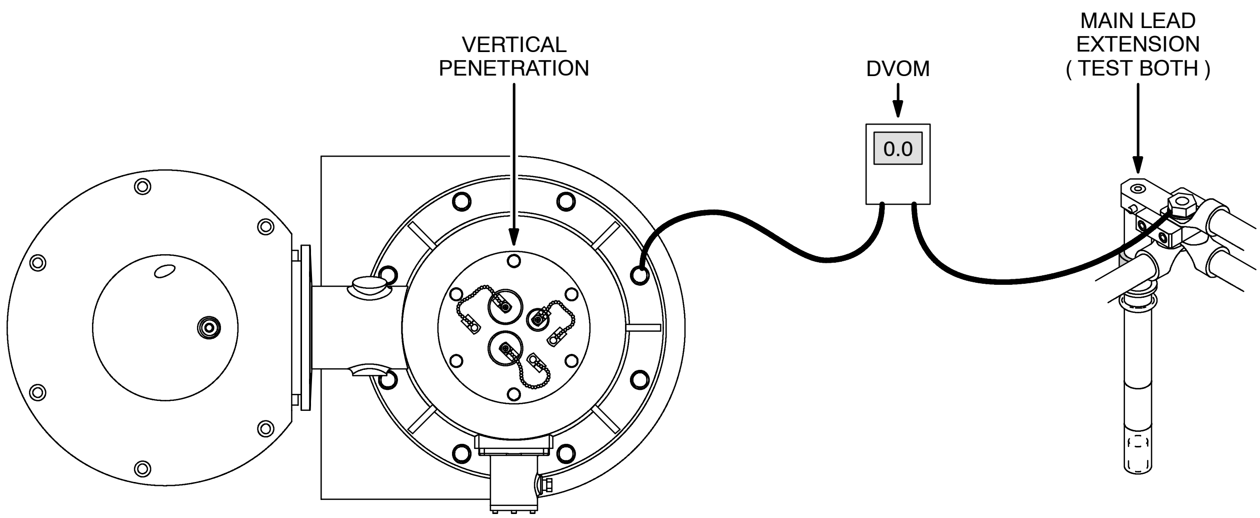
**Note**

If the magnet's grounding cable is connected to the RF Common Bus Bar at the Penetration Panel, the 50 foot ( 15.24 M ) Power Supply Grounding Cable can be connected between the power supply and the magnet or PDU ground wire clamp on the RF Common Bus Bar if more convenient. If the magnet is not grounded to the Penetration Panel, the Grounding Cable **must** be connected to the Cryostat Grounding Stud. See Illustration 4-6.

**CAUTION**

**Make sure there is a common ground ( resistance = 0 ohms ) between the Vacuum Vessel and the Main Lead Extension connections.**

7. Verify that the resistance between the Vacuum Vessel at the Vertical Penetration and each Main Lead Extension connection is zero ohms as read on a DVOM. See Illustration 4-9.



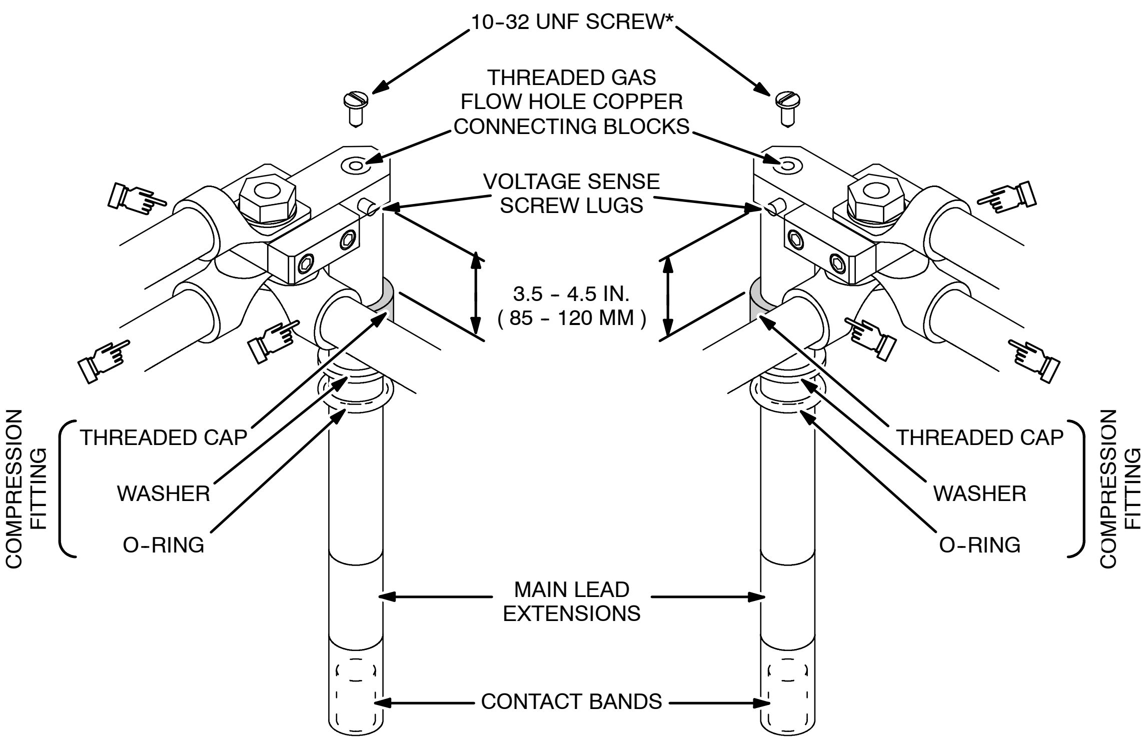

**VACUUM VESSEL TO MAIN LEAD EXTENSION RESISTANCE CHECK**
ILLUSTRATION 4-9

## 4-5 MAGNET CONNECTIONS - PERSON 1

1. Remove the threaded caps, washers and o-rings ( 46-294104P1, 46-294105P1, and 46-260389P1 ) from the plastic bag provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ) and mount them on the Main Lead Extensions. See Illustration 4-10.

**WARNING!**

**DO NOT LEAVE THE VENT SCREWS IN THE GAS FLOW HOLES FOR "DVM" CONNECTION SCREWS. THIS MAY CAUSE A QUENCH.**




* USED TO TEMPORARILY STOP GAS FLOW. REMOVE PRIOR TO RAMPING.

**COMPRESSION FITTING MOUNTING ON MAIN LEAD EXTENSIONS**
ILLUSTRATION 4-10

## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

2. Place the end of the Main Power Cables on the Service Turret ( MSI-A3, A3 ). Allow about 3 feet ( 900 mm ) of slack.

3. Ty-wrap the cables at convenient locations on top of the magnet to avoid cable movement during ramping.

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM. REVIEW AND FOLLOW <u>SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*</u>.**

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE, ALLOWING THE INTERNAL CRYOSTAT PRESSURE TO BUILD UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT THE CRYOSTAT DOWN TO < 0.5 PSIG THROUGH CRYOSTAT VENT VALVE V2 BEFORE EITHER REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

4. Check the Cryostat Pressure Gauge. If the pressure is above 0.5 psig, slowly open Helium Vent Valve V2 and allow pressure to drop to 0.5 psig. Then close valve V2.

### 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

5. Remove the cap on one Main Lead Extension receptacle located on the magnet Vertical Penetration. Make sure the gasket inside the cap does not get lost.
6. Immediately insert one Main Lead Extension into the open receptacle with 85 - 120 mm ( 3.5 - 4.5 inches ) of Main Lead Extension exposed. Loosely tighten the compression fitting.

**CAUTION**

**Make sure the Gas Flow Holes in the Main Lead Extensions are not blocked ( i.e., the 10-32 screws have been removed ) and that gaseous helium is exiting through the holes. Blocked holes prevent heat dissipation and result in high contact resistance.**

7. Repeat Steps 5 and 6 for the second Main Lead Extension.

**Note**

The Main Lead Extensions will depress approximately 1 inch ( 25 mm ) from the point of contact to the fully engaged position. A firm contact will be felt when fully engaged. Do not rotate the Main Lead Extensions excessively when in the engaged position as internal contact wear could result.

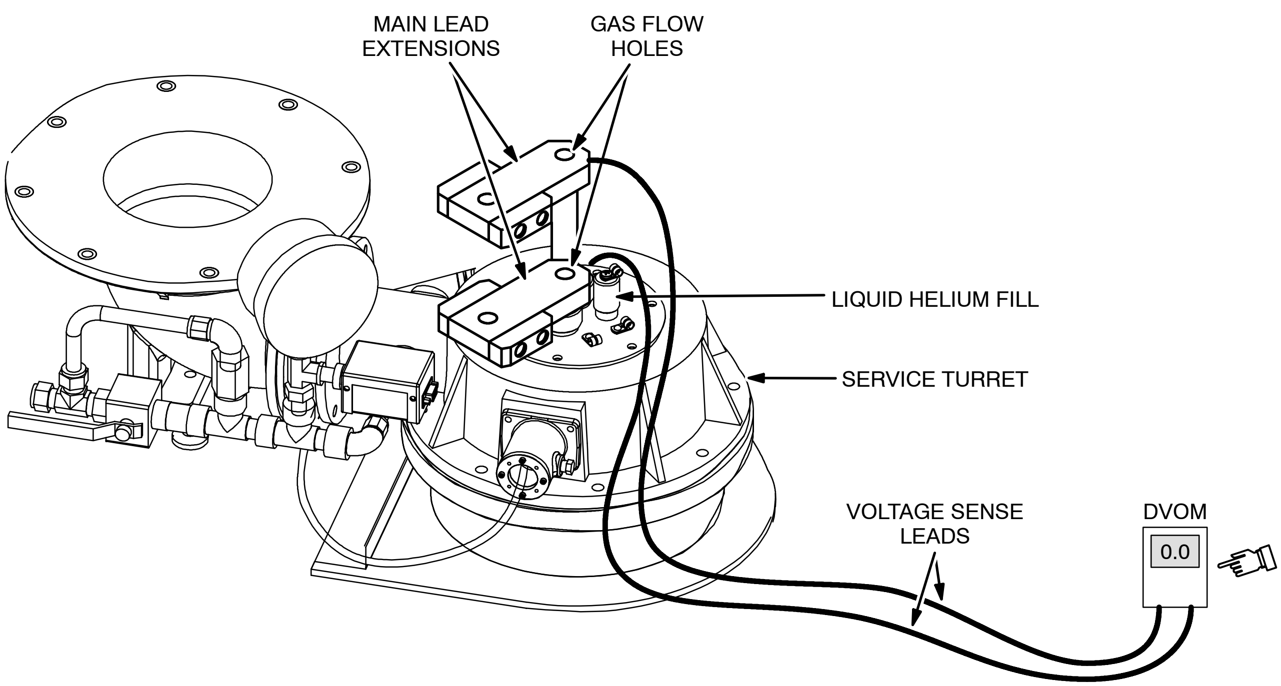
## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

8. When the Main Lead Extensions are sufficiently cooled, loosen the compression fittings and fully engage the Main Lead Extensions. Loosely tighten the compression fittings.

**WARNING!**

**CONNECTION POLARITIES MUST BE NOTED AND RECORDED IN DATA SHEETS, SECTION 5, MAGNET RAMPING & PARKING CURRENT LOG, TO PREVENT THE POSSIBILITY OF MIS-WIRING AND A RESULTANT QUENCH DURING FUTURE MAGNET RAMPING.**

9. Connect the Voltage Sense Leads to the Main Lead Extensions by clamping the spade lugs on the Voltage Sense Leads to the Main Lead Extensions with the screw lugs provided on the Lead Buss Bar. Terminate the other end of the Voltage Sense Leads to a DVM or DVOM placed near the Main Coil Power Supply. See Illustration 4-11.




**MAIN COIL AND VOLT SENSE LEAD CONNECTIONS**
ILLUSTRATION 4-11

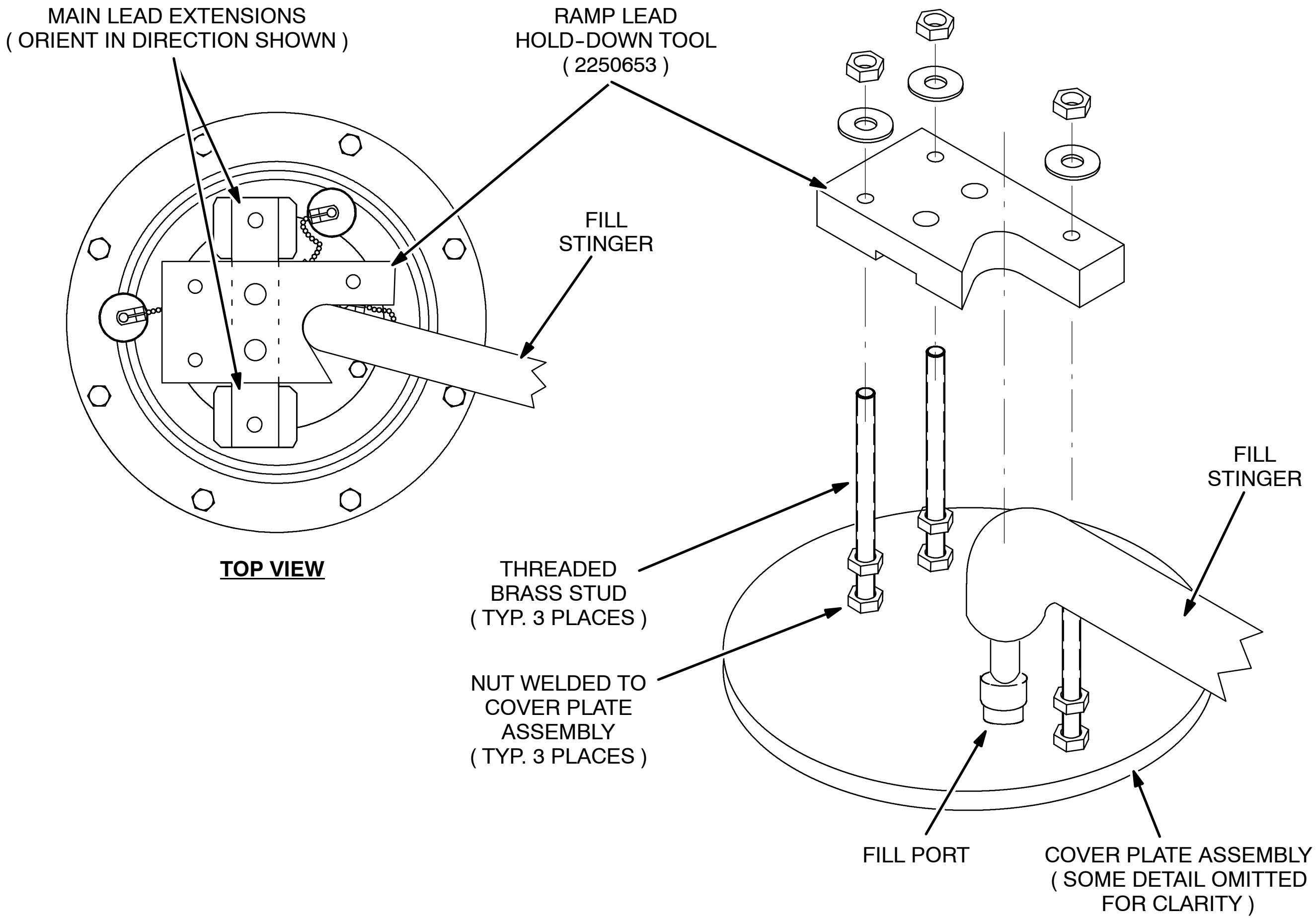
10. Insert three threaded brass studs into the nuts on the Vertical Penetration Cover Plate. See Illustration 4-12.

11. Install the Ramp Lead Hold-Down Tool ( 2250653 ). Make sure it is oriented properly, as shown in Illustration 4-12.

**Note**

The Ramp Lead Hold-Down Tool, contained in the magnet collector, will minimize Lead Extension motion and help obtain good contact resistance.

## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )




**RAMP LEAD HOLD-DOWN TOOL**
ILLUSTRATION 4-12

12. Thread and tighten the top nuts to hold the tool in place.

13. Hand tighten the Ramp Port compression nuts.

**CAUTION**

**Make sure the Gas Flow Holes of the Main Lead Extensions are not blocked ( i.e., the 10-32 screws have been removed ) and that gaseous helium is exiting through the holes before ramping. Blocked holes prevent heat dissipation and result in high contact resistance.**

## 4-6 TESLAMETER / PROBE SET-UP AND ADJUSTMENT - PERSON 1

### 4-6-1 Set-Up

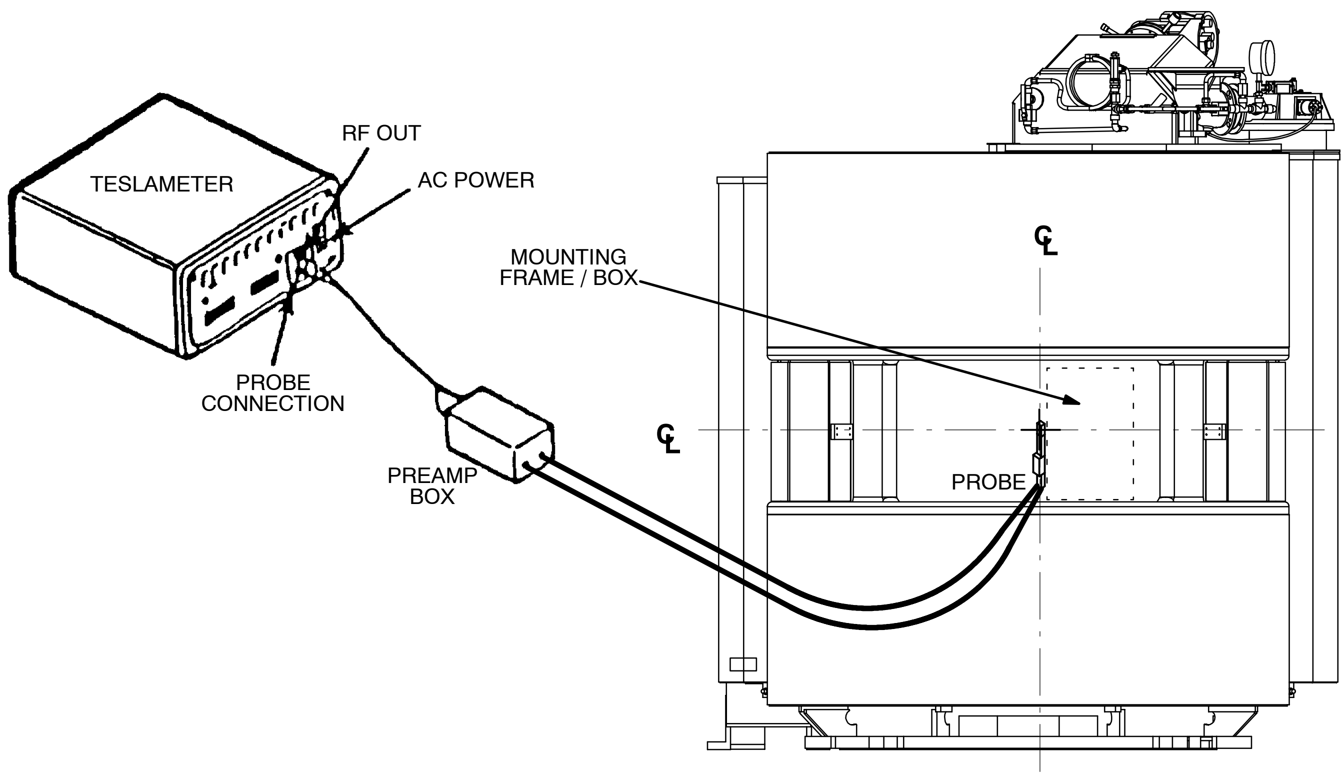
1. Mount and center the #4 Probe ( 0.35T - 1.05T ) in the magnet using a cardboard / wood box or a frame made from non-ferromagnetic material. See Illustration 4-13.

**Note**

Centering the Probe between enclosure surfaces will give sufficiently accurate magnet field strength readings for ramping purposes.

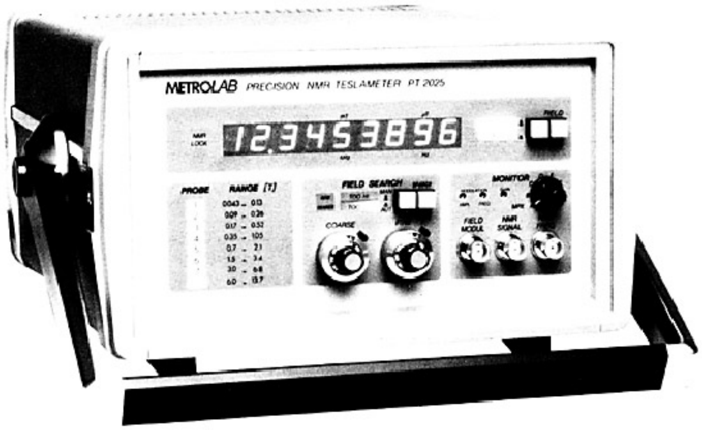
2. Connect the Preamp Box to the two Teslameter Probe inputs: the white Preamp Box wire to the Teslameter Probe left jack and the black Preamp Box wire to the right, lacing connector end of the Probe. See Illustration 4-13.

3. Turn on AC Power to the meter. The meter's rear view is shown in Illustrations 4-13 and 4-14.

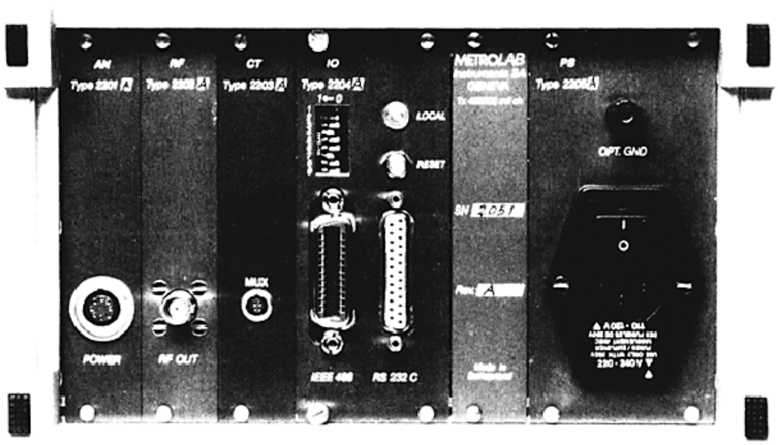



**PROBE SET-UP AND TESLAMETER INTERCONNECTIONS**
ILLUSTRATION 4-13

### 4-6-1 Set-Up ( continued )




FRONT VIEW




REAR VIEW

**TESLAMETER**
ILLUSTRATION 4-14

4. Pull the Lock / Manual Switch and set in the “MANUAL” position.

**CAUTION**

**If the “Lock / Manual” Switch is not in the “MANUAL” position at the start of field search during Ramping, the Teslameter’s sweep will be in the ±5,000 gauss range and the system could lock onto the mechanical oscillation harmonic produced by the Cryocooler Coldhead, resulting in an erroneous reading.**

5. Set the Coarse and Fine Control Knobs fully counterclockwise ( CCW ).

### 4-6-1 Set-Up ( continued )

6. Pull the “Freq / Field” Switch and set to the “FIELD” position. The Teslameter is now set up and ready to start monitoring the field when ramping commences.

**Note**
The Teslameter will not “lock in” on a probe signal until magnetic field is approximately 4000 Gauss.

### 4-6-2 Teslameter Adjustment ( Ramp Up )

1. Once ramping has started, monitor the power supply’s Current Meter until an indication of approximately 450 amps is approached. At this time, start monitoring the Teslameter.

2. As the developing field approaches the adjustable limit of the Teslameter probe ( approximately 4000 gauss ), the “NO STROBE SIGNAL” LED will start blinking. Watch for when this LED goes out.

3. When the “NO STROBE SIGNAL” LED is out, change the Lock / Manual Switch to the “LOCK” position. See Illustration 4-14.

**Note**
If the signal does not lock in, change the position of the Probe Modulation switch.

4. As the field continues to increase, note when the “HI” LED to the right of the Coarse Control Knob begins to light. Turn the Coarse Control Knob clockwise ( towards the lighted LED ) until the LED is extinguished.

**Note**
As the magnetic field increases, the probe sample resonant frequency will increase above the range setting of the Teslameter. Therefore, increase the setting of the Coarse Control Knob periodically to keep the Teslameter locked on the probe sample.

**Note**
The Fine Control Knob does not function when the Lock / Manual Switch is in the “LOCKED” position.

### 4-6-3 Teslameter Re-Sync

If the Teslameter should go out of sync while ramping the magnet up ( or down ), it can be resynchronized by the following procedure.

**Manual Re-Sync**

1. Reposition the Lock / Manual Switch to “MANUAL.”

**Note**
The “NO STROBE” Signal will be on, and the “LO” / “HI” LEDs will be oscillating, indicating search mode.

2. Note the present Current reading on the Main Power Supply’s Current Meter.

### 4-6-3 Teslameter Re-Sync ( continued )

**Manual Re-Sync ( continued )**

3. Multiply the Current read from the Main Power Supply's Current Meter by 6.85 ( approximately 6.85 gauss / amp ) and reset the meter at the resultant gauss level.
4. Slowly start increasing ( if ramping up ) the Coarse and / or Fine Control Knob while monitoring the "NO STROBE SIGNAL" LED.
5. Once the LED extinguishes, quickly place the Lock / Manual Switch to the "LOCK" position. The meter will now be in sync.

**Note**

If the "HI" LED is lit, the Coarse Control Knob will have to be turned in the "HI" direction until the LED goes out. Repeat this adjustment as required until the parking field is reached.

**Manual Re-Sync Using an Oscilloscope**

An Oscilloscope can be set up near the Teslameter to display and trigger on the "FIELD MODULATION" Signal from a jack on the Teslameter front panel. Adjust the time base to display one or two ramp wave forms. On the second channel, display the NMR Signal from the front panel of the Teslameter.

1. Leave the Teslameter in the "LOCKED" position.
2. Slowly turn the Coarse Control Knob in the direction the field is going ( i.e., if ramping up, turn the control knob up to the higher numbers ).
3. As the meter is approaching the actual field, the baseline of the "FID" Display will start to wander. Once the meter is in range of the field, the "FID" will appear on the Oscilloscope Trace as the meter "locks on."
4. When "locked on" the "NO STROBE SIGNAL" LED will be unlit. Readjust the Coarse Control Knob slightly in the direction of the lighted "LO" / "HI" LED until that LED goes out.
5. Maintain tracking through end of ramp sequence.

## 4-7 RAMPING PREPARATION - PERSON 1

**WARNING!**

**THE FOLLOWING REQUIRED SAFETY ACTIONS MUST BE TAKEN PRIOR TO RAMPING THE MAGNET:**

- **MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **NOTIFY SITE ADMINISTRATION BEFORE RAMPING THE MAGNET THAT ALL MAGNETIC SAFETY PRECAUTIONS MUST BE TAKEN.**
- **POST WARNING SIGNS OUTSIDE THE 5-GAUSS ZONE TO ALERT PERSONNEL WITH CARDIAC PACEMAKERS, NEUROSTIMULATORS AND OTHER BIOSTIMULATION DEVICES NOT TO PROCEED INTO THE DESIGNATED AREA. POST THESE SIGNS ON THE MAGNET ROOM LEVEL AS WELL AS AREAS BELOW THE MAGNET TO WHICH THE 5 GAUSS ZONE EXTENDS. SEE SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **POST "RAMPED MAGNET" AND "AUTHORIZED PERSONNEL ONLY" WARNING SIGNS AT MAGNET ROOM ENTRANCE AND AT MR SUITE ENTRANCE, RESPECTIVELY, PRIOR TO RAMPING THE MAGNET. WARNINGS ARE TO ALERT PERSONNEL THAT NO FERROMAGNETIC MATERIAL OR INDIVIDUALS WITH CARDIAC PACEMAKERS, NEUROSTIMULATORS OR STEEL PLATES ARE ALLOWED IN THE MAGNET ROOM WHEN THE MAGNET IS RAMPED.**
- **REMOVE ALL LOOSE FERROMAGNETIC MATERIAL FROM THE MAGNET ROOM. PULL THE POWER SUPPLIES AS FAR AWAY FROM THE MAGNET AS THE CABLES AND SITE GEOMETRY ALLOW. METAL OBJECTS CAN BECOME DANGEROUS PROJECTILES IN A MAGNETIC FIELD. MAKE SURE THE MAGNET LIFTING SHACKLE, JACKING RAIL AND MOUNTING BRACKETS HAVE BEEN REMOVED FROM AND STORED OUTSIDE THE MAGNET ROOM.**
- **MAKE SURE THE MAGNET RUNDOWN UNIT IS INSTALLED AND OPERATIONAL TO ENABLE THE MAGNETIC FIELD TO BE QUICKLY DISCHARGED IN CASE OF AN EMERGENCY. SEE SET-UP AND CALIBRATION, SECTION 1-6.**
- **DO NOT WEAR STEEL-TOED SAFETY SHOES NEAR A RAMPED MAGNET. USE A FIBER / COMPOSITION TYPE SAFETY SHOE.**

## 4-7 RAMPING PREPARATION - PERSON 1 ( continued )

1. Set up the field monitoring equipment, Probe and Teslameter in conformance with SET-UP CALIBRATION, Section 4-6, Teslameter / Probe Set-Up And Adjustment. Make sure the Probe is positioned at the center of the magnet.
2. Make sure the Magnet Power Supply is installed, checked and adjusted in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5-1000-2-D-1236 Main Power Supply Calibration / Check. Verify that the Heater 1 Main Power Supply is set for 810 ± 10 mA.
3. Make sure the Input Power Cable for the Power Supply is disconnected.
4. Make sure the Ramp Power Supply is connected to the magnet in conformance with SET-UP AND CALIBRATION, Sections 4-3, 4-4 and 4-5. Also make sure the Ramp Lead Hold-Down Tool is firmly in place and cooling gas is exiting from Main Lead Extensions.
5. Record the Main Coil connection polarity in DATA SHEETS, Table 4.
6. Set Heater 1 Main and Heater 2 Shim Axial Switches to the “OFF” position. Set the Current Adjust and Voltage Adjust Controls to zero ( full CCW ).
7. Connect the Input Power Cable to the Service Main Power Supply.
8. Make sure a Digital Voltmeter ( DVM ) is connected to the end of the Voltage Sense Leads and terminated at the power supply. The Voltmeter will measure voltage across the Lead Extensions of the magnet.
9. Make sure DATA SHEETS, Table 5-2, Magnet Ramp / Fill Profile, is filled out. Readings should be recorded at 3 minute intervals.
10. Disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 4-7 and 4-8.

**Note**

Resistance measurements cannot be made and the magnet cannot be ramped with the Power Supply Jumper Cable connected.

## 4-8 RESISTANCE CHECKS - PERSON 1

**Note**
CCW = counterclockwise -----> decrease
CW = clockwise -----> increase

1. Make sure the Current Adjust and Voltage Adjust Controls on the Main Power Supply are off ( full CCW ). Turn on input power to the Power Supply.

2. Set Heater 2 Shim Axial Switch to the "I" ( on ) position to enable power supply output.

3. Set the Voltage Adjust Control to "400" ( 4 turns counterclockwise from zero ). This will set a maximum limit of 3 V ( ~ 0.75 V / turn ) for the power supply output.

4. Observe the Main Power Supply Ammeter and slowly turn the Current Adjust Control counterclockwise to set 750A current through the Main Power Leads, Lead Extensions and persistent Main Switch.

5. Record the voltage reading on the Digital Voltmeter ( DVM ): ________________ mV.

   - A voltage reading < 50 mV indicates the Power Supply Jumper Cable is still in place.
   - A 50 - 150 mV reading indicates acceptable internal contact resistance of the Lead Extensions.
   - If the voltage reading is > 150 mV, turn the Current Adjust Contol off ( full CCW ), turn off the Power Supply Input Power and reseat the Lead Extensions on the top of the magnet.

6. Repeat Steps 1 through 5 if the Lead Extensions were reseated. Repeated readings > 150 mV indicate the need to replace the Lead Extension Contact Bands. See REPLACEMENT / MAINTENANCE, Section 12. Upon passing the internal resistance check, continue with Step 7.

7. Set the Toggle Switch on the Power Supply Voltmeter to the "Main Power Supply" position.

8. Read the voltage across the Power Supply Output Lugs. A Power Supply output voltage of 2.1 V or less at 750A indicates acceptable system resistance. If the voltage exceeds 2.1V during the test:

   a. Turn the Current Adjust Control off ( full CCW ).

   b. Turn off the input power.

   c. Check and retighten the bolts securing the Main Power Cables to the Power Supply and Lead Extensions.

   d. Turn the Power Supply back on.

   e. Repeat Step 8.

9. Upon passing Step 8, turn the Current Adjust and Voltage Adjust Controls to zero ( full CCW ) and continue with Section 1-9, Ramping - Person 1.

## 4-9 RAMPING - PERSON 1

**WARNING!**

**MAKE SURE THE MAGNET IS 98% FULL OF LIQUID HELIUM AND A FULL 250-LITER OR LARGER DEWAR OF LIQUID HELIUM IS CONNECTED TO THE TRANSFER LINE BEFORE RAMPING TO PREVENT THE LIQUID HELIUM LEVEL FROM DROPPING DURING RAMPING TO A LEVEL WHERE A QUENCH MAY OCCUR.**

**A RAMPING VOLTAGE IN EXCESS OF 2.5V ACROSS THE MAIN COIL OF THE MAGNET COULD CAUSE THE MAGNET TO QUENCH.**

**IF A QUENCH OCCURS DURING RAMPING, IMMEDIATELY TURN "VOLTAGE ADJUST" AND "CURRENT ADJUST" CONTROLS ON THE MAIN COIL POWER SUPPLY TO ZERO ( FULLY CCW ). A QUENCH IS A RAPID DISCHARGE OF THE MAGNETIC FIELD WHICH WILL RESULT IN THE RAPID GENERATION AND EXPULSION OF HELIUM GAS, RUPTURING THE BURST DISC IN THE VENT SYSTEM.**

**IMPORTANT !!!**

To prevent a quench if a Dewar should run empty, Person 2 shuts off helium flow and performs the following:

a. Park the magnet at the present setting ( Steps 8 - 16 of this section ).
b. Record the parking current and frequency in DATA SHEETS, Table 5-1.
c. Wait for Dewar change, Stinger plume and Stinger insertion into Fill Port V1.
d. Turn power supply on ( heaters off ) and set parking current in power supply.
e. Turn on the Main Axial Shim Heaters.
f. Continue the ramp.

1. Make sure:
   - A new 250-liter Dewar is installed;
   - A 98% liquid helium level is being maintained;
   - The power supply's Current and Voltage Adjust Controls are set to zero ( full CCW ); and
   - The Axial Switch set to "I" ( on ).
2. Engage the Set Point Button ( depress and hold until the current is set ) and set the Current Adjust Controls for a reading of 800A.
3. Leave the Current Adjust Controls at setting in Step 2. Turn the power supply's Voltmeter Select Switch to the "Main Coil" position.

## 4-9 RAMPING - PERSON 1 ( continued )

4. Set the Heater 1 Main Switch to "I" ( on ) and wait 3 minutes. Make sure gas flow is visible from Lead Extensions.

5. Ramp the magnet in conformance with Table 4-2 as follows:

   a. Slowly turn the power supply's Voltage Adjust Control to obtain the Main Coil ( Ramp ) Voltage value shown in the table, starting with 2.50 volts.

   b. Allow the voltage to decay over the current interval shown in the table.

   c. Monitor the power supply's Current Meter. When the limit of the current range for the voltage setting is reached, slowly turn the Voltage Adjust Control to obtain the Main Coil Voltage for the next range.

6. When the Main Coil ( Ramp ) Current reaches 200 amps, estimate the system inductance by measuring current change over a 10-second ramping interval:

$$L_{(\text{ inductance })} = 10 \times \text{Voltage} / \text{Current Change}$$

**Note:**
this method will give inaccurate values of inductance when the current is less than 200 amps.

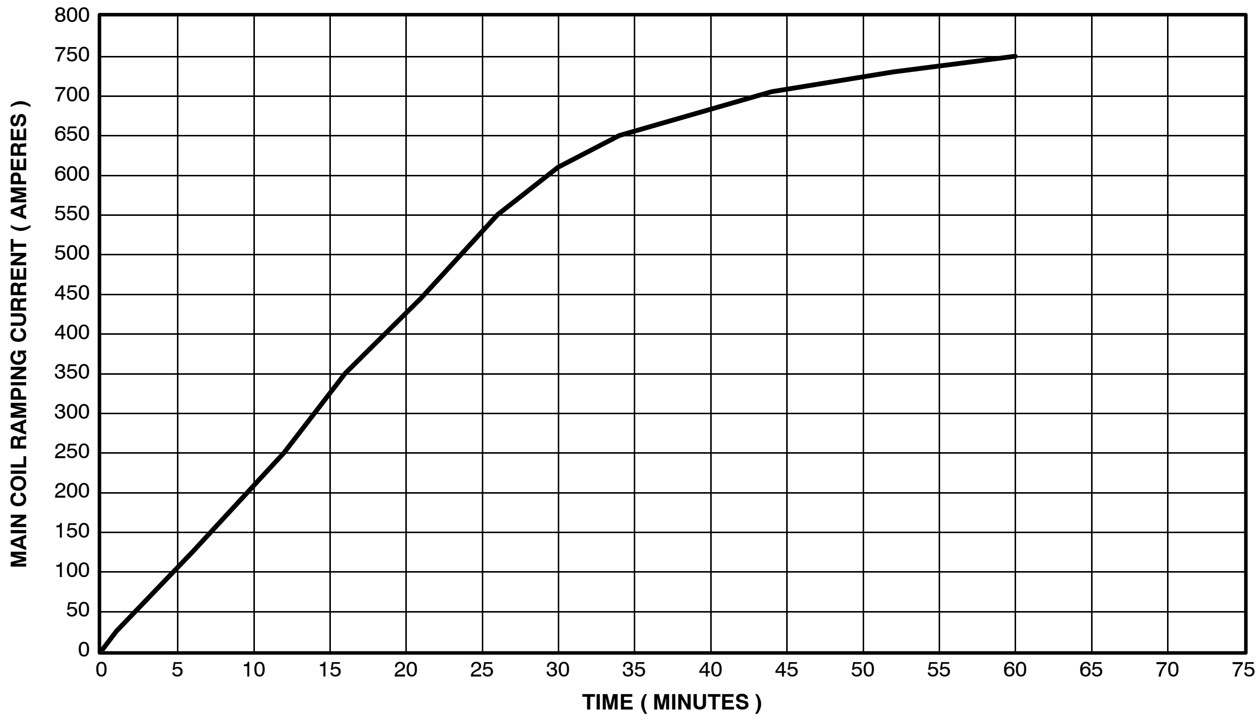
7. If the inductance ( L ) is outside the range of 5.3 - 5.5 henries, discontinue ramping, measure the main coil resistance in conformance with FUNCTIONAL CHECKS, Section 5, and contact your regional Magnet Team Engineer.

TABLE 4-2
**MAIN COIL RAMP CURRENT VERSUS VOLTAGE**

| "STAGE" | MAIN COIL ( RAMP ) VOLTAGE ( VOLTS ) | MAIN COIL ( RAMP ) CURRENT RANGE ( AMPS ) |
|---|---|---|
| 1 | 2.50 | 0 - 100 |
| 2 | 2.30 | 100 - 200 |
| 3 | 2.10 | 200 - 300 |
| 4 | 1.90 | 300 - 400 |
| 5 | 1.70 | 400 - 500 |
| 6 | 1.50 | 500 - 550 |
| 7 | 1.30 | 550 - 600 |
| 8 | 1.00 | 600 - 625 |
| 9 | 0.80 | 625 - 650 |
| 10 | 0.60 | 650 - 675 |
| 11 | 0.50 | 675 - 700 |
| 12 | 0.40 | 700 - 720 |
| 13 | 0.35 | 720 - 750 |
| 14 | 0.30 | 750 - PARKING AMPS |
| 15 | 0.00 | PARKING AMPS |

**Note**
Illustration 4-15, Magnet Ramping Profile, plots typical Main Coil ramping currents over time.

## 4-9 RAMPING - PERSON 1 ( continued )




**MAGNET RAMPING PROFILE**
ILLUSTRATION 4-15

8. As the magnet field approaches the desired parking frequency ( 29.800 - 29.802 MHz ), adjust the Main Coil driving voltage to 0.00 V.

**Note**

The ramping field in step 9 was chosen at the low end of the allowable range because passive shimming will increase the field frequency. The system specification for frequency is 29.793 MHz to 29.813 MHz

9. Check the Teslameter and adjust the Voltage Control as required to bring magnetic field to 29.802 - 29.803 MHz. This will account for the decrease in field after dialing the ramp supply down and the increase in field caused by passive shimming.

## 4-9 RAMPING - PERSON 1 ( continued )

**CAUTION**

**Observe the voltage displayed on the power supply Voltmeter ( toggle switch in “Main Coil” position ). When the switch goes “persistent” ( zero resistance ), the voltage across the magnet terminals will drop to approximately 0.00 V. This sudden voltage drop indicates that the switch has gone into the persistent mode. Make sure the switch is in the persistent mode before adjusting the voltage / current controls to prevent magnet rampdown to zero.**

10. Maintain the final current setting until the Main Switch goes into the “persistent” mode.
11. Set Heater 1 Main Switch to “O” ( off ). Wait a minimum of 7 minutes for the switch to fully cool and go “persistent”.

**WARNING!**

**MAKE SURE THE CONNECTION POLARITY AND FINAL RAMPING CURRENT ARE RECORDED IN DATA SHEETS, TABLE 5-1. THIS INFORMATION IS ESSENTIAL FOR LATER CHANGING OF THE MAGNETIC FIELD. THE MAIN POWER SUPPLY MUST BE SET TO THE SAME CURRENT AND POLARITY IN THE MAIN COILS TO AVOID A QUENCH WHEN TURNING ON THE MAIN SWITCH HEATER.**

12. Record the final ramping ( parking ) current and lead extension voltage / polarity values at which the switch went “persistent” in DATA SHEETS, Table 5-1, Magnet Ramping / Parking Current Log.
13. After the switch goes “persistent”, slowly turn the power supply Voltage Adjust Control to zero over a one minute period ( full CCW ). Make sure voltage reading remains at zero.
14. Gradually turn the Current Adjust Control to zero ( over a one minute period ).
15. Set Heater 2 Shim Axial Switch to its “O” ( off ) position.
16. Turn off the Ramp Power Supply.
17. Disconnect the Input Power Cable from the Main Power Supply.
18. Reconnect the Power Supply Jumper Cable’s twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 4-6 and 4-8.

## 4-9 RAMPING - PERSON 1 ( continued )

19. Remove the Ramp Lead Hold-Down Tool and replace the bolts on Lead Assembly Mounting Plate.

20. Make sure the magnet is at 100% helium fill level.

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

21. After parking the magnet and disconnecting the Main Power Supply, plug and remove one Main Extension Lead at a time in the following sequence.

    a. Open Valve V2 to de-pressurize the cryostat to 0.50 psig. Close V2.

    b. Install the screw into the flow hole of only one Main Lead Extension at a time. See Illustration 4-16.

    c. Remove all ice around the Main Lead Port compression nut on the Main Lead Extension that is being removed ( i.e. the Main Lead Extension that has the flow hole plugged in Step 21b ).

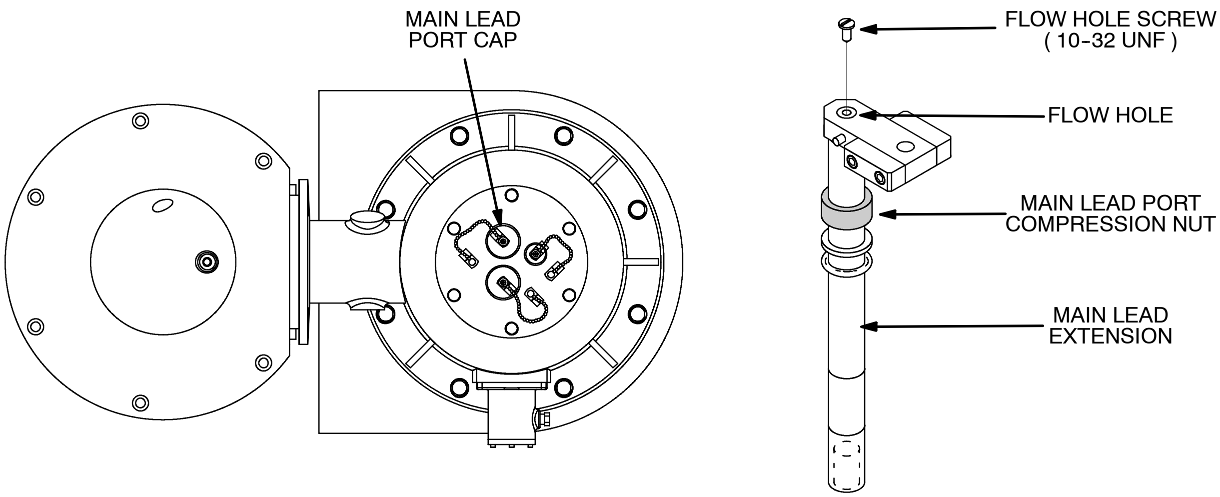
    d. Unscrew the Main Lead Port compression nut and remove the Main Lead Extension from the magnet. Immediately replace the cap onto the Main Lead Port.

    e. Repeat these steps ( a - d ) for the other Main Lead Extension.

## 4-9 RAMPING - PERSON 1 ( continued )

22. Remove the Power Supply Jumper and Grounding Cables.

23. Keep the Field Probe centered in magnet and proceed to SET-UP AND CALIBRATION, Section 5, Shimming Preparation / Field Stabilization.




**MAIN LEAD EXTENSION AND MAIN LEAD PORT COMPRESSION NUT**
ILLUSTRATION 4-16

# SECTION 5 - SHIMMING PREPARATION / FIELD STABILIZATION

### Description

The following preparations are **REQUIRED** prior to shimming the magnet. Allow main field drift to stabilize at 0.1 ppm/hr ( 2.98 Hz/hr ).

### Procedure

**CAUTION**

**Moving articles or equipment within the magnet room may affect field readings.**

1. Maintain probe setting at the physical center of the magnet after ramping.
2. Make sure the magnet is thermally stable ( i.e., the Temperature Control Units have remained at a temperature of 28°C for at least 6 hours ).

**Note**
Wait one hour before performing the following steps.

3. Monitor the magnetic field's center frequency at one hour intervals until the magnet has stabilized within 0.04 ppm/hr ( i.e., the frequency change between hourly readings is within 11.92 Hz ).
4. Make sure the stabilized magnet frequency is within center frequency requirements of 29.789 - 29.816 MHz when no passive shims are installed in the magnet. If passive shims are installed in the magnet, the stabilized frequency should be 29.793 - 29.813 MHz.

**Note**
Induced current must be removed from the B0 Coil before shimming the magnet. The B0 Coil Power Supply Kit ( 2141701 ) is used to quench the induced currents in the B0 Coil Circuit. The B0 Coil Power Supply is switchable from 115 to 230 VAC.

5. Connect the B0 Coil Power Supply output cable to P304-1 on the magnet connector box. Then connect the B0 Coil Power Supply input cable between the power supply and voltage source. Make sure the red switch underneath the power supply matches the input source ( i.e. 115 or 230 VAC ).
6. Depress the B0 Coil Power Supply spring-loaded switch and hold for one minute. The LED will light to indicate power supply is supplying output current.
7. Allow three minutes for the magnet to recover before taking field map.
8. Begin magnet shimming in accordance with *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure. Continue with this manual when finished shimming.

# SECTION 6 – SHIMMING

**Note**

Section 6, Shimming, has been deleted from this manual as it is now covered in *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure.

# SECTION 7 – FIELD MAP CHARACTERISTICS

**Note**

Section 7, Field Map Characteristics, has been deleted from this manual as it is now covered in *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure.

# SECTION 8 – SHIM TIPS AND TROUBLESHOOTING

**Note**

Section 8, Shim Tips and Troubleshooting, has been deleted from this manual as it is now covered in *Signa OpenSpeed Service Methods CDROM* ( 2250758 ), System Procedures, Setup & Calibration Section, 0.7T Passive Shim Procedure.

# SECTION 9 - FIELD ADJUSTMENT AFTER SHIMMING

### Description

This section gives the procedure for “fine tuning” the magnet if the bandwidth is out of range, not within 29.790 – 29.810 KHz. This range was chosen so as to provide a buffer for negative magnet field drift.

**WARNING!**

**A SUPERCONDUCTING MAGNET IS AN ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY DURING A QUENCH AND CREATING A VOLTAGE OF 100V OR MORE ACROSS THE MAIN LEADS AND EXTENSIONS.**

**MAKE SURE INPUT POWER TO THE MAIN POWER SUPPLY IS DISCONNECTED WHEN CONNECTING MAIN POWER LEADS AND THAT THE POSITIVE AND NEGATIVE POWER LUGS DO NOT MAKE CONTACT.**

### Procedure

1. Install the field probe at the center of the magnet. Make sure the Magnetometer displays the field or frequency at the center of the magnet. See SET-UP AND CALIBRATION, Section 4-4, Teslameter / Probe Set-Up and Adjustment.
2. If the resultant field is outside of the bandwidth shown above, use the procedure in REPLACEMENT / MAINTENANCE, Section 1, Magnet Field Adjustment / Rampdown ( Field Decrease to Zero ) to adjust the required field.

# SECTION 10 – MAGNET CHECKS PRIOR TO CUSTOMER TURNOVER

### Description

It is important to establish that the stabilized temperature, pressure and helium level of the magnet are well within the specified limits prior to turning it over to the customer.

This will establish that the parameters, critical to zero boil–off, are acceptable and that no problem or condition exists that will require service shortly after turnover or result in the depletion of helium.

### Procedure

1. Allow the magnet to stabilize for 24 hours after commissioning ( cryocooler operating, ramped, shimmed and field stabilized ).
2. Check helium level. Make sure helium level is a minimum of 90% top vessel / 100% bottom vessel. If helium level is below 90%, fill magnet with liquid helium and allow to stabilize for 24 hours before continuing with magnet checks.
3. Leak check all cryostat and plumbing components. Repair any leaks.
   - All plumbing joints
   - Vertical Turret and instrumentation lead cover
   - Ramp Lead and fill port caps
   - Burst Disc 360 degree contact around plenum
   - Pressure gauge and relief valves
4. Perform all functional checks identified in FUNCTIONAL CHECKS, Section 1–2, Magnet Temperature / Pressure Checks. Troubleshoot and repair any problems and repeat checks. Note the tighter pressure for customer turnover.
5. Prior to customer turnover make sure that the vessel pressure is oscillating between 0.9 psi and 1.1 psi per magnet monitor.
   - If pressure is below 1.0 psig, troubleshoot magnet monitor magnet heater.
   - If pressure is greater than 4.0 psig, repeat Step 4.
6. Make sure the magnet monitor is connected, functioning properly and is incorporated into the Online Center monitoring system.

## IMPORTANT !!!

Magnet pressure and temperature parameters must be continually monitored on the zero boil–off magnet to detect and repair problems before helium boil–off occurs ( pressure > 7.5 psig ).

# FUNCTIONAL CHECKS

## TABLE OF CONTENTS

# SECTION 1 – MAGNET FUNCTIONAL CHECKS

## 1-1 COMMISSIONING AND OPERATING GUIDELINES

Commissioning and operating guideliness for the magnet system are provided in Table 1-1, Magnet Commissioning / Operating Guidelines. Checking and maintaining the guideline conditions will make sure the optimum magnet commissioning and operation is achieved.

TABLE 1-1
**MAGNET COMMISSIONING / OPERATING GUIDELINES**

| ELEMENT | GUIDELINE | CHECK / SETTING REQUIREMENTS |
|---|---|---|
| MAIN FIELD | 29.790 – 29.810 MHZ | AFTER RAMPING & SHIMMING OR WHEN OUT OF GRADIENT AMPLIFIER BANDWIDTH. |
| DRIFT | < 0.1 PPM ( 2.98HZ ) / HR ( 12 HRS AFTER RAMP ) | BEFORE PASSIVE SHIMMING WITH STABILIZED TEMPERATURE CONTROL UNIT |
| HOMOGENEITY | 14 PPM @ 40 CM DSV | AFTER SHIMMING, ENVIRONMENT CHANGES OR IMAGE DEGRADATION. |
| MAIN POWER SUPPLY | 815 MA ± 5 MAIN HEATER<br>HEATER PASS VENDOR MANUAL CHECKS | BEFORE RAMPING UP / DOWN. |
| RAMPING CIRCUIT VOLTAGE RESISTANCE CHECK | < 2.1 V TOTAL @750 A<br>< 150MV RAMP LEADS @ 750 A | BEFORE RAMPING UP / DOWN |
| MAIN HEATER RESISTANCE | 20.5 – 25.0 OHMS | AT START OF COMMISSIONING |
| RAMP LEAD PREP. | NEW CONTACT BANDS<br>GAS FLOW OUT TOPHOLES | BEFORE RAMPING UP / DOWN |
| VENTING | PRESSURE DROP CALC. ≤ 17 PSIG | AT MAGNET INSTALLATION |
| STABILIZED CRYOSTAT PRESSURE | 0.9 TO 1.1 PSIG<br><br>< 5.0 PSIG | AFTER INSTALLATION, VENTING, COLDHEAD CHANGE, OPERATION |
| CRYOCOOLER SECOND STAGE INTERFACE TO RECONDENSER | $\Delta$ T ≤ 0.1K | AT INSTALLATION AND AFTER COLDHEAD CHANGE |
| VESSEL HELIUM ( LHE ) LEVEL AT 1.0 PSIG | <u>TOP</u> <u>BOTTOM</u><br>95% 100%<br>90% 100%<br>20% 50% | <br>MINIMUM RAMPING LEVEL<br>MINIMUM FOR CUSTOMER TURNOVER<br>MINIMUM OPERATING LEVEL |
| FILL CONDITIONS | CRYOSTAT < 1.0 PSIG<br>DEWAR < 2 PSIG<br>V2 OPEN | HELIUM ( LHE ) FILL / REFILL |

## 1-2 MAGNET TEMPERATURE / PRESSURE CHECKS

1. Check the magnet sensors referenced in Table 1-2, Magnet Temperature / Pressure Checks. See SET-UP AND CALIBRATION, Section 1-4-9, Monitoring Cryocooler Temperatures.

**Note**

Second stage Coldhead RuO temperature may show a small oscillation ( ~ 0.1K ) on the temperature monitor. This is a result of the displacer motion inside the second stage and the sampling rate of the monitor. Record the average temperature for all checks.

Second stage temperarure = ( $T_{max}$ + $T_{min}$ ) / 2

2. Record data in DATA SHEETS, Table 8-1, Magnet Temperature / Pressure Data.

3. Compare data with allowable ranges in Table 1-2, Magnet Temperature / Pressure Checks.

TABLE 1-2
**MAGNET TEMPERATURE / PRESSURE CHECKS**

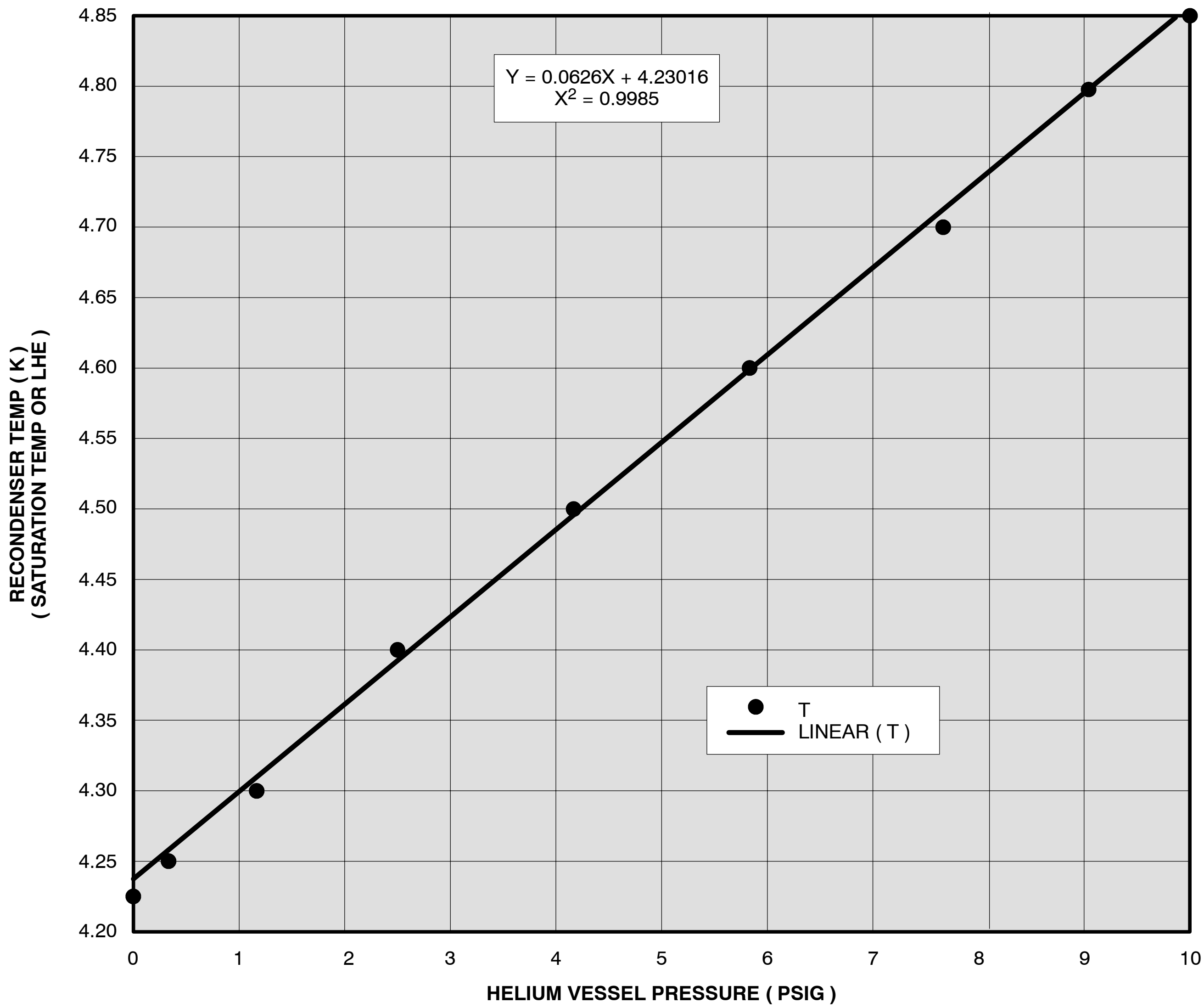
| PARAMETER CHECK | SENSOR LOCATION | ALLOWABLE RANGE | |
|---|---|---|---|
| | | MINIMUM | MAXIMUM |
| CRYOCOOLER SECOND STAGE TEMPERATURE | RuO SENSOR ON COLDHEAD SECOND STAGE | > 3.8 K | < 4.5 K |
| Δ TEMPERATURE ( COLDHEAD - RECONDENSER ) | COLDHEAD SECOND STAGE RuO - RECONDENSER RuO | > 0.0 K | ≤ 0.1 K |
| RECONDENSER TEMPERATURE | RuO ON RECONDENSER | > 3.8 K | < 4.6 K |
| SHIELD TEMPERATURE @ CRYOCOOLER | SILICONE DIODE ON SLEEVE | | < 45 K |
| HELIUM PRESSURE | PRESSURE TRANSDUCER AT TURRET | > 0.9 PSIG | < 5.0 PSIG |
| SHIELD TEMPERATURE @ SHIELDCOOLER | SILICONE DIODE ON SLEEVE | | < 45 K |

4. Use FUNCTIONAL CHECKS, Section 2, Magnet Helium Loss Troubleshooting Guide, to troubleshoot and resolve any values outside of the allowable range.

**Note**

Equilibrium state of Recondenser temperature ( helium saturation temperature ) vs. helium vessel pressure is shown in Illustration 1-1.

## 1-2 MAGNET TEMPERATURE / PRESSURE CHECKS ( continued )




**APPROXIMATE RECONDENSER TEMPERATURE VS. HELIUM VESSEL PRESSURE**
ILLUSTRATION 1-1

# SECTION 2 – MAGNET HELIUM LOSS TROUBLESHOOTING GUIDE

**Introduction**

Helium loss on a “zero boil-off” magnet should be insignificant, not measurable over a period of months. If significant helium loss is suspected, make sure the following are determined to define and quantify the suspected loss before proceeding with this troubleshooting guide.

- The Cryocooler may be turned off during certain scan sequences. Make sure the allowable duty cycle limits for the Cryocooler being off, shown below, are not exceeded. Base evaluation on Compressor hour meter, clock time and magnet monitoring data. Values are based on the continuous running of the single stage Shieldcooler.

  If the allowable Cryocooler off time has been exceeded, check magnet pressure profile to determine if relief valve has been opened, causing helium loss.

- Make sure the magnet is in a stabilized operating mode, not setting from a service action ( fill, ramp / fill, etc. ).

- Make sure two sets of data have been taken over 2 days to 2 weeks, depending on leak rate, with known, calibrated instrumentation.

If a quantified helium loss is established which is not a result of exceeding the allowable Cryocooler duty cycle, use the following troubleshooting guide to determine the root cause(s) of the problem.

## 2-1 PREPARATION

1. Make sure the equipment listed below is available at the site before starting this procedure to enable all required actions to be taken. Compressor and gas lines are not necessary at the site, but they should be available on an emergency order if required.
   - Coldhead Extraction / Insertion Kit ( 2262686 )
   - Coldhead Holding Tool ( 2214919 )
   - Copper Heat Exchanger Coils ( for clearing ice in the vertical penetration )
   - Lexan Purge Cover Plate ( 2174214 )
   - Field Vacuum Pump Kit ( 46-294047G1 )
   - Cryocooler Maintenance Kit ( 46-281088G3 )
   - Non-Magnetic Coldhead Wrench Kit ( 46-294804G1 )
   - Complete O-Ring supply in Magnet Spares Kit ( 46-294744G5 )
   - Transition Flange O-Ring ( 46-281247P1 )
   - Helium and Nitrogen Gas
   - Helium Gas Tube
   - Snoop or Leak Detector
   - Portable Temperature Monitor ( 2171219 )
   - M10 Metric Allen Wrench ( 46-320470P10 )
   - Aluminum Tape ( 46-260802P1 )
   - Heat Gun
   - Flashlight

## 2-1 PREPARATION ( continued )

2. Record the following temperature and pressure data. Use Portable Temperature Monitor ( 2171219 ) or magnet monitor to obtain the required temperature accuracy with the RuO sensors.

**Note**

Coldhead second stage RuO temperatures may show a small oscillation ( ≈ 0.1K ) on the temperature monitor. This is a result of displacer motion inside the Coldhead Sleeve and the sampling rate of the temperature monitor. Record the average temperature for all readings ( $T_{min} + T_{max}$ ) / 2.

- Recondenser temperature ____________________ ( Allowable range: > 3.9K, but < 4.6K )
- Coldhead second stage temperature ____________________ ( Allowable range: < 4.5K )
- Coldhead first stage temperature ____________________ ( Allowable range: < 45K )
- Magnet pressure ____________________ ( Allowable range: > 1.0 psig, but < 5.0 psig )

3. If any of the values recorded in Step 2 are outside the allowable range, go to Section 2-2, Temperature / Pressure Troubleshooting. Values above the allowable range will result in helium loss through the 7.5 psig relief valve.

   If the values are within the allowable range and helium loss is occurring, go to Section 2-3, Leak Troubleshooting.

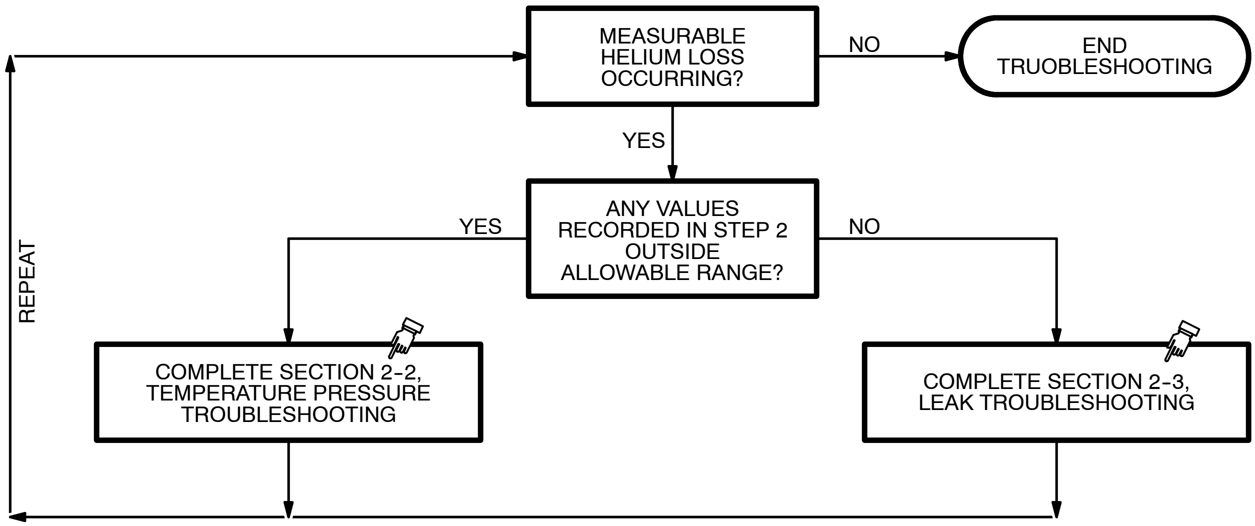
## IMPORTANT !!!

Follow the temperature / pressure troubleshooting procedure in the sequence shown to minimize the need for Coldhead removal / replacement.

4. Review the following tips before starting the troubleshooting procedure:

   - Use the LHe saturation temperature graph to estimate the equilibrium pressure for the Recondenser temperature. See Illustration 2-2.
   - Helium loss existing from the start of installation is an indication of an initial site, installation, magnet or Cryocooler condition and does not indicate a sleeve vacuum, capacity or helium loss problem in the Cryocooler over time.
   - If the temperature / pressure point on the graph in Illustration 2-1 is above or below the line on the saturation curve, the helium vessel may not have fully stabilized or the reading may be in error. Long stabilization times ( days ) can result from power or water outage conditions.
   - If the stabilized temperature / pressure point falls below the saturation curve, icing up of the Recondenser is indicated.
   - The combination of a number of small out of specification conditions can have a significant composite impact on temperature and pressure.

## 2-1 PREPARATION ( continued )

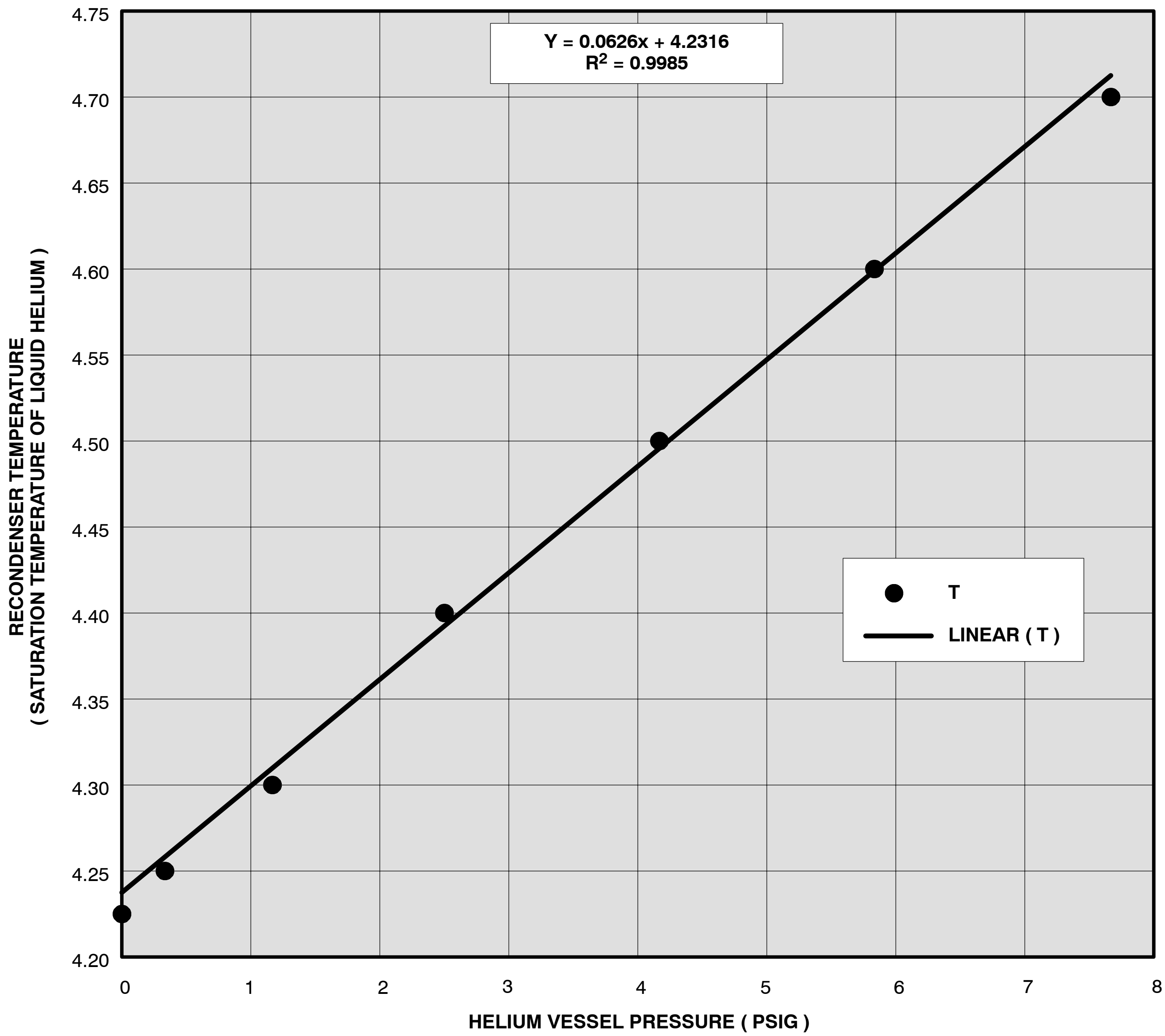



**TROUBLESHOOTING FLOW DIAGRAM**
ILLUSTRATION 2-1

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN THE CRYOSTAT TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

## 2-1 PREPARATION ( continued )




**APPROXIMATE RECONDENSER TEMPERATURE VS. HELIUM VESSEL PRESSURE**
ILLUSTRATION 2-2

## 2-2 TEMPERATURE / PRESSURE TROUBLESHOOTING

Refer to Tables 2-1 through 2-4.

## 2-2 TEMPERATURE / PRESSURE TROUBLESHOOTING ( continued )

TABLE 2-1
**MAGNET TROUBLESHOOTING GUIDE FOR HIGH PRESSURE / TEMPERATURES, SITE & INSTRUMENT PROBLEMS**

MAGNET SERIAL NO.______________________________ SITE ENGINEER:________________________________________
LOCATION:______________________________________ PHONE NUMBER:________________________________________

| AREA / POSSIBLE CAUSE | CHECKS / RESULTS | CORRECTIVE ACTION |
|---|---|---|
| **SITE:** | | |
| 1. High ambient room temperature | 1. Temp. < 28C / 82F<br>( Use Temp. Recorder 1 week )<br>Results__________________________________ | REPORT ANY DISCREPANCIES TO SITE MANAGEMENT FOR IMMEDIATE CORRECTION! |
| 2. Compressor space too small ( air cooled ) | 2. Requirements in SHI manual CVSA-71A, page 18<br>Results__________________________________ | |
| 3. Wrong Compressor input power ( k4 ) ( LCC ) | 3. 200 vac ± 5%; 3-phase delta; 25+ amp service<br>Requirement in in SHI manual CVSA-71D, page 4<br>Results__________________________________ | |
| 4. Site power interruption | 4. Check Compressor clock hours vs. elapsed time<br>Results__________________________________ | |
| 5. Compressor water ( water cooled ) | 5. Continuous water supply<br>Requirement in in SHI manual CVSA-71D, page 4<br>Results__________________________________<br>( SHI manual = GE Direction 2210552 ) | |
| **INSTRUMENTS:** | | |
| 1. Accuracy | Take 2 sets of temperature / pressure readings per manual procedure. Check SET-UP AND CALIBRATION, Section 1-4-9, Monitoring Cryocooler Temperatures | Retake any suspect reading(s) with new equipment. |

## 2-2 TEMPERATURE / PRESSURE TROUBLESHOOTING ( continued )

TABLE 2-2
**MAGNET TROUBLESHOOTING GUIDE FOR HIGH PRESSURE / TEMPERATURES, TWO STAGE CRYOCOOLER PROBLEMS**

MAGNET SERIAL NO.______________________ SITE ENGINEER:______________________
LOCATION:______________________ PHONE NUMBER:______________________

| AREA / POSSIBLE CAUSE | CHECKS / RESULTS | CORRECTIVE ACTION |
|---|---|---|
| Reference: SHI SRDK Cryocooler Service manual ( GE Direction 2210552 ) | | |
| **TWO STAGE CRYOCOOLER:** | | |
| 1. Serial numbers | 1. Record Serial numbers<br>Coldhead:______________<br>Compressor:______________ | |
| 2. Compressore pressure | 2. 16.5 KPA / 235 psig static /<br>23.5 KPA / 330 psig supply<br>Results______________ | 2. Fill / bleed with 99.999% helium as required. Recheck for pressure loss. |
| 3. Helium leaks | 3. Check gas line connections if pressure low<br>Results______________ | 3. Disconnect, check o-rings, reconnect, fill system with 99.999% helium. Check Aeroquip fittings for leaks. |
| 4. Dirty Air Filter | 4. Check air filter<br>Results______________ | 4. Clean. |
| 5. Bypass Unit not functioning; Solenoid stuck open / closed | 5a. Bypass light on Compressor lit for normal operation<br>Results______________<br>5b. Light on Bypass Unit lit in Bypass Operating Mode<br>Results______________<br>5c. Pressure pulsing in Normal Mode; steady in Bypass Mode<br>Results______________ | 5. Check for proper installation of Bypass Unit ( SET-UP AND CALIBRATION, Section 1-4-3 );<br>Bleed, run, re-fill Compressor as required ( SET-UP AND CALIBRATION, Section 1-4-2 );<br>Replace Bypass Unit if problem continues ( REPLACEMENT / MAINTENANC, Section 14 ). |
| 6. Restricted gas flow | 6. Gas line connections fully tightened<br>Results______________ | 6. Tighten gas line connections as required. Check Aeroquip fittings for leaks. |
| 7. Coldhead power | 7. 200 VAC ± 5%, 3-phase at Coldhead pins<br>Results______________ | 7. Check all cable connections and output power at the Compressor connector ( fuses ). |
| 8. Coldhead run in reverse<br>( 1st stage: 90K )<br>( 2nd stage: 15K ) | 8. Check wiring at Penetration Panel & proper cable numbers<br>Results______________ | 8. Correct miswiring at the Penetration Panel ( color match on each filter ); replace wrong cable numbers. |
| 9. Coldhead / Absorber life | 9. Coldhead < 10,000 hours<br>Absorber < 20,000 hours<br>Results______________ | 9. Replace Absorber ( 2172241 ) as required. |
| 10. Bent / Damaged Coldhead | 10. Check for bend / damage when removed<br>Results______________ | 10. Replace Coldhead if damaged. Refer to REPLACEMENT / MAINTENANCE, Section 9, Two-Stage Cryocooler Coldhead Replacement |
| 11. Gas line connection | 11. Yellow = supply; green = return; return first<br>Results______________ | 11. Make sure colors are correct & return line is connected first to prevent blocked rotary valve. |
| 12. Coldhead contamination | 12. Check for contamination signs ( knocking noise, oil on fittings, temperature shutdowns, leaks )<br>Results______________ | 12. Purge Coldhead of gas contamination. Check for oil contamination. Replace full Cryocooler System if contaminated. |

## 2-2 TEMPERATURE / PRESSURE TROUBLESHOOTING ( continued )

TABLE 2-3
**MAGNET TROUBLESHOOTING GUIDE FOR HIGH PRESSURE / TEMPERATURES, SINGLE STAGE SHIELDCOOLER PROBLEMS**

MAGNET SERIAL NO.________________ SITE ENGINEER:________________
LOCATION:________________ PHONE NUMBER:________________

| AREA / POSSIBLE CAUSE | CHECKS / RESULTS | CORRECTIVE ACTION |
|---|---|---|
| Reference: SHI SRDK Cryocooler Service manual ( GE Direction 2210552 ) | | |
| **SINGLE STAGE SHIELDCOOLER:** | | |
| 1. Serial numbers | 1. Record Serial numbers<br>Coldhead:________<br>Compressor:________ | |
| 2. Compressore pressure | 2. 15.5 KPA / 235 psig static /<br>23.5 KPA / 330 psig supply<br>Results________ | 2. Fill / bleed with 99.999% helium as required. Recheck for pressure loss. |
| 3. Helium leaks | 3. Check gas line connections if pressure low<br>Results________ | 3. Disconnect, check o-rings, reconnect, fill system with 99.999% helium. Check Aeroquip fittings for leaks. |
| 4. Dirty Air Filter | 4. Check air filter<br>Results________ | 4. Clean. |
| 5. Bypass Solenoid stuck open | 5. Bypass light lit for normal operation<br>Results________ | 5. Bleed, run, re-fill Compressor; replace Compressor if light still not lit. |
| 6. Restricted gas flow | 6. Gas line connections fully tightened<br>Results________ | 6. Tighten gas line connections as required. Check Aeroquip fittings for leaks. |
| 7. Coldhead power | 7. 200 VAC ± 5%, 3-phase at Coldhead pins<br>Results________ | 7. Check all cable connections and output power at the Compressor connector ( fuses ). |
| 8. Coldhead run in reverse ( 1st stage: 90K ) | 8. Check wiring at Penetration Panel & proper cable numbers<br>Results________ | 8. Correct miswiring at the Penetration Panel ( color match on each filter ); replace wrong cable numbers. |
| 9. Coldhead / Absorber life | 9. Coldhead < 10,000 hours<br>Absorber < 20,000 hours<br>Results________ | 9. Replace Absorber ( 2172241 ) as required. |
| 10. Bent / Damaged Coldhead | 10. Check for bend / damage when removed<br>Results________ | 10. Replace Coldhead if damaged. Refer to REPLACEMENT / MAINTENANCE, Section 10, One-Stage Shieldcooler Coldhead Replacement |
| 11. Gas line connection | 11. Yellow = supply; green = return; return first<br>Results________ | 11. Make sure colors are correct & return line is connected first to prevent blocked rotary valve. |
| 12. Coldhead contamination | 12. Check for contamination signs ( knocking noise, oil on fittings, temperature shutdowns, leaks )<br>Results________ | 12. Purge Coldhead of gas contamination. Check for oil contamination. Replace full Cryocooler System if contaminated. |

## 2-2 TEMPERATURE / PRESSURE TROUBLESHOOTING ( continued )

TABLE 2-4
**MAGNET TROUBLESHOOTING GUIDE FOR HIGH PRESSURE / TEMPERATURES, MAGNET & COLDHEAD INTERFACE PROBLEMS**

MAGNET SERIAL NO.______________________ SITE ENGINEER:______________________
LOCATION:______________________ PHONE NUMBER:______________________

| AREA / POSSIBLE CAUSE | CHECKS / RESULTS | CORRECTIVE ACTION |
|---|---|---|
| **MAGNET:** | | |
| 1. Magnet Monitor Heater | 1. Verify that the heater turns on at 0.9 psig and turns off at 1.0 psig<br>Results______________ | 1. Make sure the heater circuit is repaired if on. |
| 2. Magnet thermal short | 2. Visually check for “sweating” cold spots<br>Results______________ | 2. Report evidence otf thermal shorts to “OLC.” |
| 3. Leak / helium contamination in Coldhead Sleeve vacuum | 3. Reinstall Coldhead with nitrogen purge<br>Results______________ | 3. Reinstall in conformance with REPLACEMANT / MAINTENANCE, Section 12, Two-Stage Cryocooler Coldhead Replacement. |
| 4. Recondenser ice block | 4. Check Recondenser temperature for ≥ 4.0K<br>Results______________ | 4. If Recondenser temp. < 4.0K, clear ice block in Recondenser lines ( REPLACEMENT / MAINTENANCE, Section 2, Ice Removal ). |
| 5. Shim Lead ( LCC ) | 5. Check that the Shim Lead is retracted<br>Results______________ | 5. Fully retract & lock Shim Lead if not fully retracted. |
| 6. Ice in Vertical Penetration | 6. Ramp down magnet for visual check of ice in vertical stack if cryopumping is suspected<br>Results______________ | 6. Clean out ice to eliminate thermal short |
| **COLDHEAD INTERFACE:** | | |
| 1. Recondenser minus 2nd Stage ( RuO ): _____K<br>Coldhead 2nd Stage ( RuO ): _____K | 1. < 0.2K ΔT difference ( 0.1K ΔT typical )<br>Results______________ | 1. Check / set Coldhead Belleville washer gap. If ΔT > 0.2K or Sleeve > 45K, remove / replace in conformance with REPLACEMANT / MAINTENANCE procedure. |
| 2. 1st Stage Sleeve ( SI-410 diode ) _____K | 2. < 45K stabilized ( typical < 40K )<br>Results______________ | 2. If Sleeve > 45K, remove / replace in conformance with REPLACEMANT / MAINTENANCE procedure. |
| 3. Flange Gap | 3. Check that flange gap is even within 0.06 in. ( 1.6 mm ) around 360° circumference. Adjust | 3. Tighten Belleville washers to 0.003 in. ( 0.076 mm ) gap.<br>If ΔT > 0.2K or Sleeve > 45K, remove / replace in conformance with REPLACEMANT / MAINTENANCE procedure. |

## 2-3 LEAK TROUBLESHOOTING

### Description

Operation of the magnet with internal helium pressure up to 7.5 psig increases the potential of helium leaks. A number of small helium leaks will have a significant effect on boiloff and result in the measurable loss of helium over time.

Major helium leaks will de-pressurize the helium vessel and can result in cryopumping and icing inside the vessel.

### Procedure

1. Allow the helium vessel to build pressure by adjusting vessel pressure on magnet monitor to 4 psig.

**Note**

Commercial leak detector fluids, available in the HVAC industry, can be used to determine small leaks in the helium plumbing and venting. Some examples available through HVAC distributors are:

- Bird Dog Quart Spray ( p/n DOG-1Q ) or
- Big Blue ( p/n Rt100S / Rt100G )

2. When pressure > 3.9 psig, check the following areas for leaks with "Snoop" or a leak detector. Repair and test any leaks found.
   - All external plumbing joints
   - Vertical turret and instrumentation lead cover
   - Plenum interface
   - Ramp lead and fillport caps
   - Pressure gauge / transducer

**Note**

Replacement Burst Bisc and o-rings are contained in the spare parts kit. See RENEWAL PARTS, Section 3-5, Field Spare Parts Kit 46-294232G4.

3. Remove the outlet plumbing ( vent adapter side ) for the 7.5 psig relief valve and 10 psig bypass valve if present.

4. Attach a small balloon tightly to the exhaust side of the 7.5 psig relief valve and 10 psig bypass valve. Observe any expansion of the balloon from leaking helium gas. Replace any valve that has suspected leaks and retest new valve for leaks. Valve part numbers shown in RENEWAL PARTS, Section 2-1.

**Note**

Make sure the Magnet Monitor master alarm is disabled for 12 hours during leak troubleshooting.

## 2-3 LEAK TROUBLESHOOTING ( continued )

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS STEP. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING STEP 5 AND TO PREVENT OXYGEN DISPLACEMENT INSIDE THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**WEAR PROTECTIVE CLOTHING, NONABSORBENT GLOVES AND GOGGLES WHEN REPLACING THE BURST DISC ON COLD VENT SYSTEM.**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD TO PREVENT ANY POSSIBILITY OF A QUENCH.**

5. Remove the Vent Adapter.
6. Check the Burst Disc for cracks or significant leaks around the gasket. Ramp the magnet down and replace any cracked or leaking Burst Disc.

**IMPORTANT !!!**

Small ( micro ) bubbles may appear between the gasket and flange. This is normal for this gasket material. Make sure Belleville washers are flattened and leaks ( continuous bubbles over 0.08 inch or 2 mm diameter ) do not exist.

# SECTION 3 - RuO SENSOR CHECKS

## 3-1 USING RuO TEMPERATURE MONITOR 2171219

**Note**

RuO Temperature Monitor readings will increase slightly if the meter is cold. For best results the meter should be at or near room temperature.

1. Verify basic performance:

   a. Attach either cable to the CAL receptacle located in the upper left side of the monitor.

   b. Press the “Push To Read” button. The reading should be 3.95K to 4.05K.

   c. Repeat Steps 1a and 1b for the other cable.

**CAUTION**

**The RuO Temperaturee Monitor contains ferrous material. Keep the meter away from the magnet bore.**

2. Place the RuO Temperature Monitor near the magnet on the left hand side.

3. Run the two cables up to the Coldhead box and attach the cables as shown in Illustrations 3-1 and 3-2. Make sure the cables are straight between the monitor and the magnet. Coiled cable can effect accuracy of the readings.

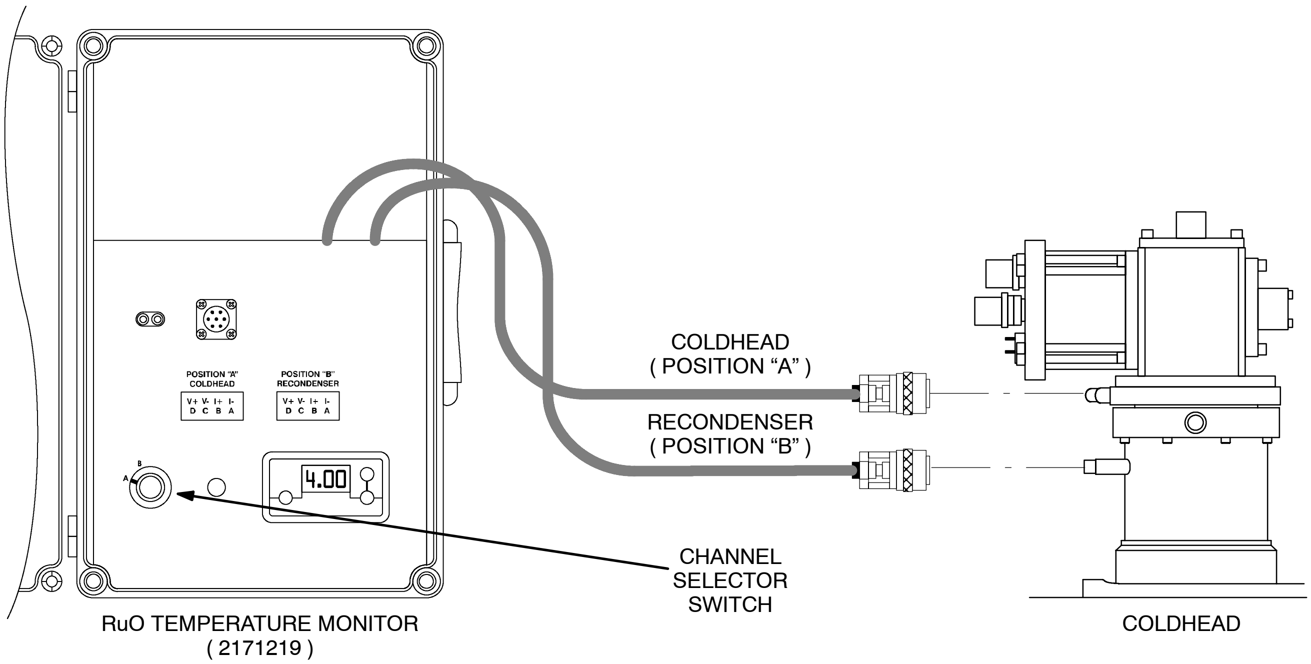
4. Rotate the switch on the RuO Temperature Monitor in the “Recondenser” position. Depress the “Push To Read” button, and let the readings stabilize for 10 seconds. Record the reading.

5. Place the switch in the “Coldhead” position. Depress the “Push To Read” button, and let the readings stabilize for 10 seconds. Since this reading will vary slightly, record the average of the high and low readings.

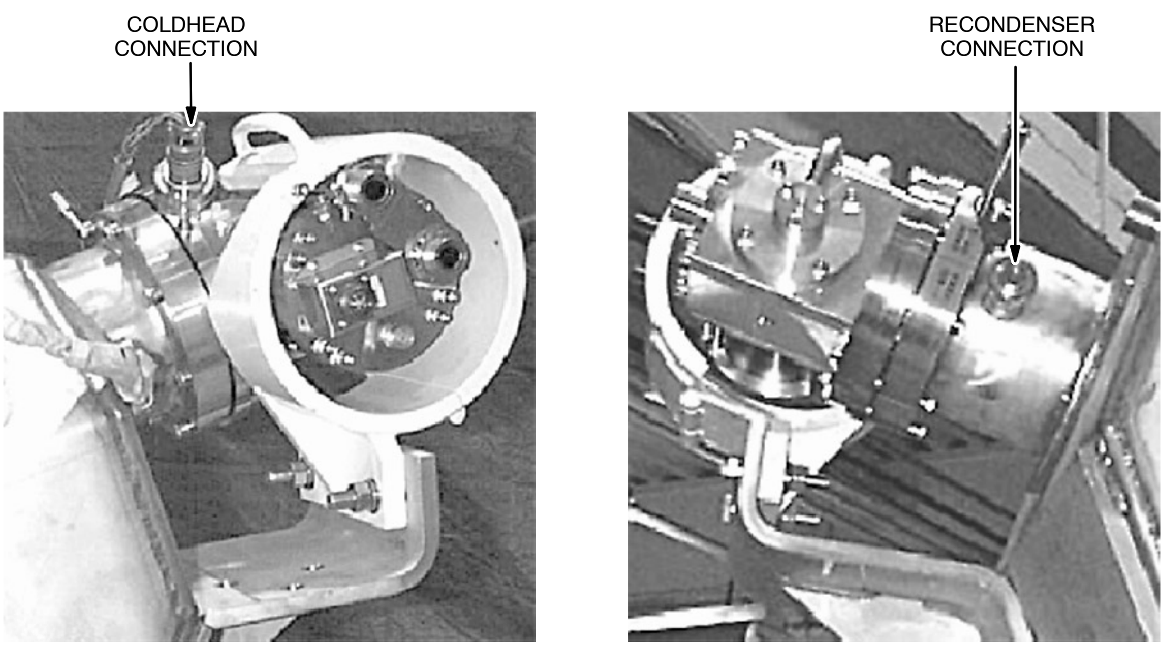
**Note**

If readings are not within the normal range, check battery output by connecting a DVM across the red and black terminals on the top of the RuO Temperature Monitor. Battery output should be above 8 VDC. When sampling voltage will drop about .7 VDC

## 3-1 USING RuO TEMPERATURE MONITOR 2171219 ( continued )



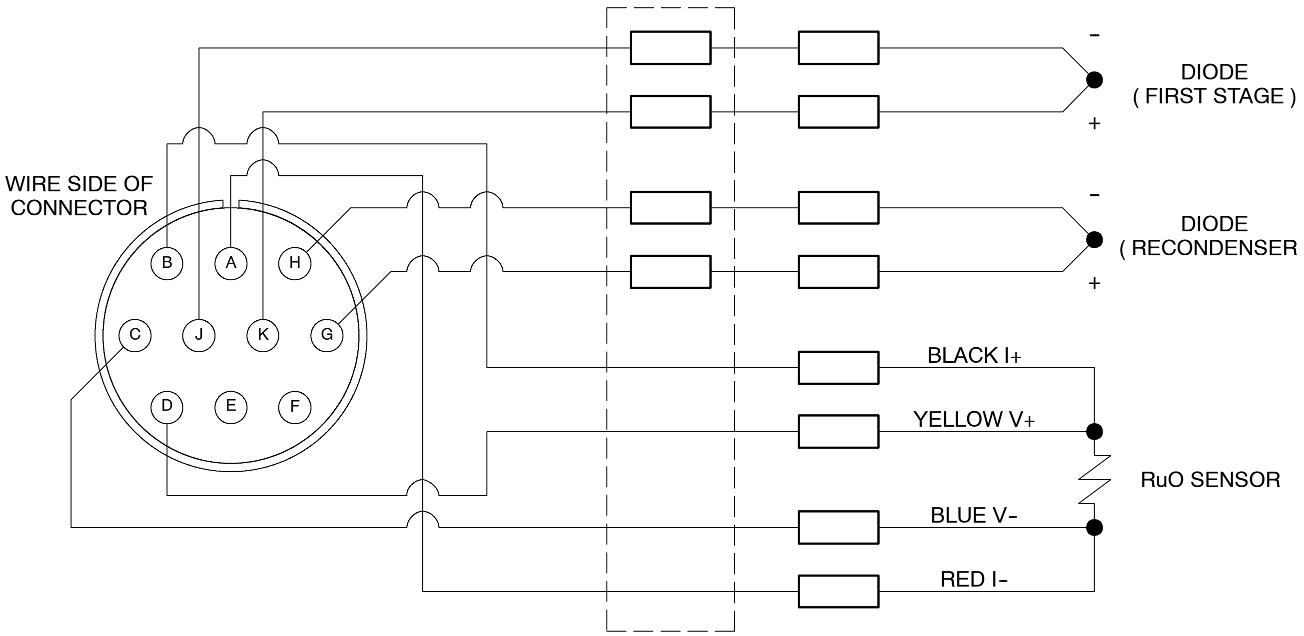

**RuO TEMPERATURE MONITOR ( 2171219 ) CONNECTIONS**
ILLUSTRATION 3-1




**RUO HEATER CONNECTIONS**
ILLUSTRATION 3-2

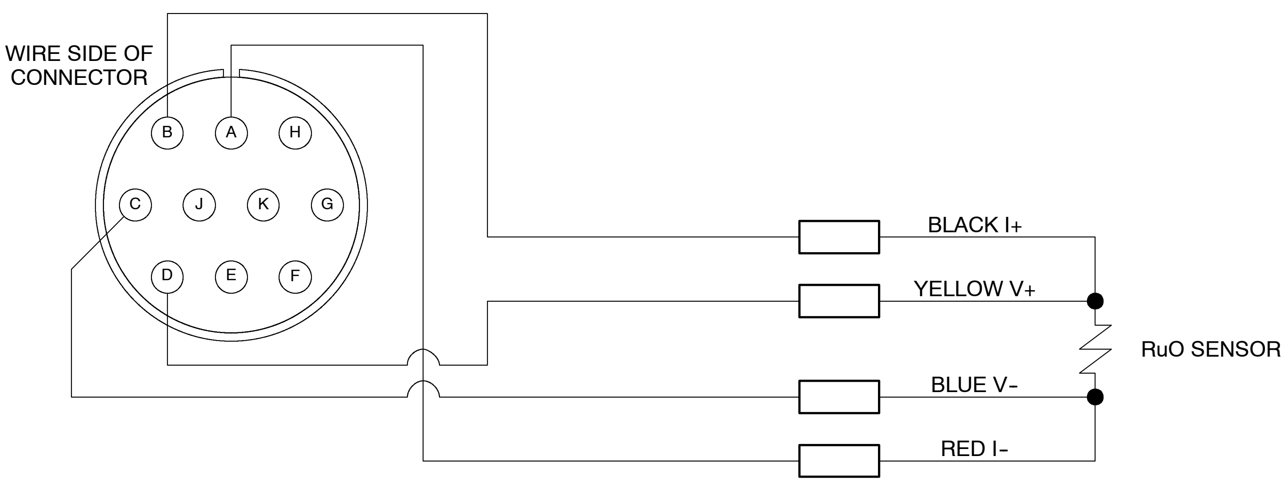
## 3-2 USING A DIGITAL VOLTMETER ( DVM )

1. Use a DVM with 10 microamp or less current supply to minimize $I^2R$ heating of the RuO. Connect to the appropriate contacts shown in Illustration 3-3. RuO locations are shown on Illustration 3-4.



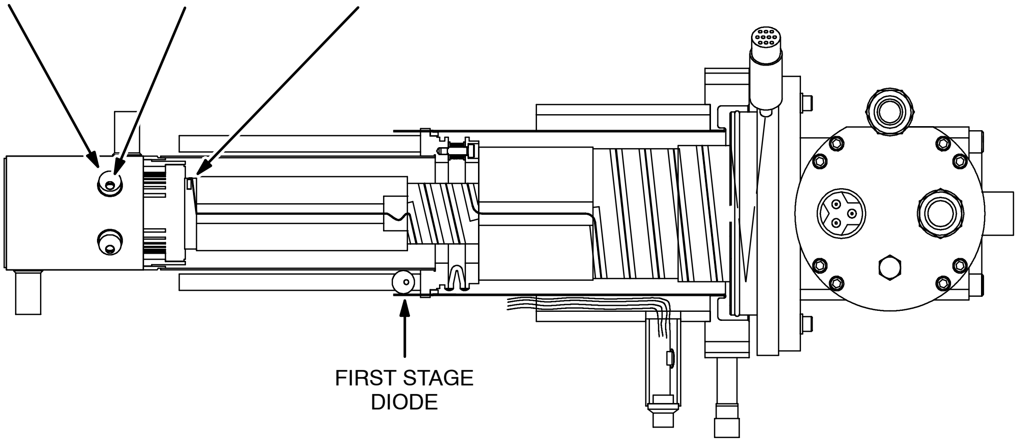

**Recondenser Vacuum Sleeve Wiring Diagram**

**Coldhead Transition Flange Wiring Diagram**




**RuO CIRCUIT AND PINOUTS**
ILLUSTRATION 3-3

## 3-2 USING A DIGITAL VOLTMETER ( DVM ) ( continued )




**RuO SENSOR / DIODE LOCATIONS**
ILLUSTRATION 3-4

2. Check for isolation of contacts A, B, C and D to cryostat ground.

3. Check resistance between contacts A, C ______ and B, D ______ . This is the resistance of the phosphor bronze wire loop to the RuO.

**Note**

Phosphor bronze wire has a resistance of 1.08 ohm / foot @ 300 K and 0.87 ohm / foot @ 4.2 K. Wire loop resistances are generally in the range of 25 – 75 ohms. Low resistance readings ( < 20 ohms ) may indicate a short in the wire loop or at the connector. Infinite resistance indicates an open circuit.

4. Check resistance between A, B _________ and C, D _________ .

5. Calculate RuO resistance:

RuO ohms = [ ohms ( A, B ) + ohms ( C, D ) ] / 2 – [ ohms ( A, C ) + ohms ( B, D ) ] / 2

RuO resistance should be in the range of 1,450 – 1,325 ohms for a unit with liquid helium at a pressure of 3 psig or less.

**Note**

Significant differences between readings in Step 3 or Step 4 or out of the specified range in Step 5 indicate a resistance short or open problem. A fully open sensor will read “000K,” a fully shorted sensor will read “300K” on the portable temperature monitor.

# SECTION 4 – MAGNETIC FIELD STABILITY

### Description

The following check is made to determine the "uncompensated" main field drift of the magnet. Compensated drift is also performed in the factory and requires a very tightly controlled environment. Contact the factory through the GE Magnet and Cryogenic ( MAC ) field specialist if compensated drift information is required.

### Procedure

**CAUTION**

**Moving equipment may effect the field readings. Verify that magnet temperature is stable with temperature control units. All output should read 28° C ± 0.1° C.**

1. Post signs indicating a magnetic drift test is in progress. Do not move or rearrange any articles or equipment in or near the magnet room during the test.
2. Assemble the probe and Teslameter using the procedure in SET–UP AND CALIBRATION, Section 4–4, Teslameter / Probe Set–Up and Adjustment.
3. Set the Teslameter switch to "NMR Frequency ( Hz )" and allow the Teslameter to stabilize within a 10 Hz band.

**Note**
Induced current must be removed from the B0 coil to measure uncompensated drift. The B0 Coil Power Supply Kit ( 2141701 ) is used to quench the induced currents in the B0 coil circuit. The B0 Coil Power Supply is switchable from 115 / 230 VAC.

4. Connect B0 Coil Power Supply output cable to P304–1 on the magnet connector box.
5. Connect the B0 Coil Power Supply input cable between the power supply and voltage source. Make sure red switch underneath the power supply matches the input source ( i.e., 115 or 230 VAC ).
6. Depress the spring–loaded switch on the B0 Coil Power Supply and hold for one minute. The LED will light to indicate power supply is supplying output current.
7. Allow three minutes for the magnet to recover before taking a field map.
8. Repeat Steps 4 through 6 after 24 hours. Record this frequency as "Frequency 2" in DATA SHEETS, Table 5–3.

**SECTION 4 – MAGNETIC FIELD STABILITY ( continued )**

9. Calculate the main field drift rate by using the following formula:

$$\text{Drift Rate (ppm/hr)} = \frac{(\text{Freq 1} - \text{Freq 2}) \times 10^6}{(\text{Freq 1}) \times (24)}$$

For the Initial drift rate use: Freq 1 = Initial reading
Freq 2 = reading after 24 hours

10. If the drift rate is greater than 3.0 Hz / hr, drift rate is outside guidelines; contact your the MAC Team representative or the regional service engineer. High drift rates will require frequent field adjustment and reshimming.

**Note**

The Teslameter has a resolution of ± 5 Hz; therefore, a month or more may be required to establish a significant frequency difference ( drift rate ).

# SECTION 5 – MAGNET ELECTRICAL CHECKS

This section provides "go" – "no go" tests for internal magnet circuitry faults.

**WARNING!**

**ELECTRICAL CHECKS CAN ONLY BE PERFORMED WITH THE MAIN COILS RAMPED DOWN ( 0 AMPS ). DO NOT MAKE CONTACT AT ANY CONNECTOR WITH COILS RAMPED UP. HIGH VOLTAGE COULD EXIST ACROSS CONNECTIONS DURING A QUENCH.**

**Note**
Resistance Table 5–1 is for cold superconducting coils ( 4.2K ).

1. Locate the Connector Pins using Table 5–1 and SCHEMATICS / INTERCONNECTS, Illustration 1–1.
2. Use a digital meter to measure the resistance across the identified Connector Pins.
3. Measure the resistances and record them in Table 5–1, comparing them to acceptable range.
4. Report any problems to your "MAC" Team Leader or Online Support Center.

TABLE 5–1
**MAGNET CIRCUITS RESISTANCE CHECKS COLD ( 4K )**

| FUNCTION | CONNECTOR | PIN # | RESISTANCE ( OHMS ) | |
|---|---|---|---|---|
| | INSTRUMENT CONNECTOR BOX | + – | TYPICAL RANGE | MEASURED |
| MAIN COILS | | | | |
| | P304–1 | 1 – 5 | 1 – 4 | |
| | P304–2 | 1 – 5 | 1 – 4 | |
| MAIN COIL SWITCH HEATERS | | | | |
| 1 | P304–1 | 2 – 6 | 21 – 25 | |
| 2 | P304–2 | 2 – 6 | 21 – 25 | |
| B0 COIL SWITCH HEATERS | | | | |
| 1 | P304–1 | 4 – 9 | 8 – 12 | |
| 2 | P304–2 | 4 – 9 | 8 – 12 | |
| MRU HEATER | | | | |
| 1 | J303 | 1 – 2 | 21 – 25 | |
| 2 | J303 | 3 – 4 | 21 – 25 | |
| NOTE: SOME EXCEPTIONS MAY OCCUR IN SERIAL NUMBERS DUE TO REWORK. | | | | |

# SECTION 6 – MAGNET RUNDOWN UNIT ( MRU )

**WARNING!**

**PERFORM THE FOLLOWING CHECKS AT WEEKLY INTERVALS. IN THE EVENT OF ANY FAILURES, IMMEDIATELY CONTACT YOUR GENERAL ELECTRIC SERVICE REPRESENTATIVE.**

**WARNING!**

**DO NOT CONNECT 'P2' TO 'J2' <u>LESS THAN 3 MINUTES</u> AFTER THE MRU RECEIVED AC POWER <u>OR</u> THE "RUNDOWN" BUTTON WAS ACTIVATED. A MAGNET QUENCH MAY RESULT.**

**MRU Checks**

1. Verify that the green "Charger Power" LED is lit.
2. Depress the "Test Battery" switch. The green "Battery" LED should light.
3. Place the "Test Heater" switch in "A" position. The green "Heater" LED should light.
4. Place the "Test Heater" switch in "B" position. The green "Heater" LED should light. If the "Heater" LED does not light, depress the "Test Heater" LED switch to verify that the LED is functioning.

See FUNCTIONAL CHECKS, Section 5, Magnet Electrical Checks, for checking continuity / resistance of the Main Switch Heaters.

# SECTION 7 - MAGNET QUENCHES

### Introduction

The following checks and operations have significant benefit in the prevention of and recovery from magnet quenches.

## 7-1 QUENCH PREVENTION

### 7-1-1 Before / During Ramping

1. Make sure the Cryocooler / Shieldcooler are functioning properly before ramping the magnet.
2. Make sure the Magnet Monitor is installed and functional before ramping the magnet.
3. Verify that the magnet is between 98 and 100% full of helium during the entire ramp / fill procedure.
4. Install new Contact Bands on the Ramp Lead Extensions
5. Make sure the power supply has been checked out in conformance with the supplier manual.
6. Make sure the magnet has passed the resistance checks.
7. Monitor helium Dewars continually for any signs of emptying.

### 7-1-2 Magnet Operation

1. Make sure the Magnet Monitor has been installed, calibrated and remains completely functional at all times during the magnet's operation.
2. Monitor critical performance parameters continually during magnet operation.
3. "Top off" the magnet helium level as often as practical at magnet service calls. Never allow the magnet to drop to a 60% helium level.
4. Maintain power to the Cryocooler, Shieldcooler and associated Chiller at all times. Emergency bac-up power is recommended for these components.
5. Fill the magnet in strict conformance with SET-UP AND CALIBRATION, Section 3, Ramp Fill. Never allow a helium Dewar to empty and blow gas into the magnet.
6. Do not insert any warm objects through the ports of the magnet's vertical penetration.
7. Check the magnet for pressure, leaks and temperatures in conformance with this manual at each service call.
8. Perform a magnet rampdown, if required, in strict conformance with REPLACEMENT / MAINTENANCE, Section 1, Magnet Field Adjustment / Rampdown ( Field Decrease To Zero ). Allow the magnet's Lead Extensions to cool before fully inserting them into a ramped magnet.

## 7-2 QUENCH RECOVERY

1. Turn off the Cryocooler immediately to prevent ice formation in the Recondenser.
2. Make sure a spare Burst Disc is available in the Field Spare Parts Kit at all times.
3. Service a quenched magnet as soon as possible!
4. Clean out any ice or debris from the Baffle Tree in the Vertical Penetration and replace the Burst Disc immediately in conformance with this manual.
5. Refill the magnet as soon as possible. If an immediate refill is not possible, maintain a positive pressure inside the magnet by using a helium gas bottle attached to a 1/2 inch ( 12.7 mm ) copper tube inserted into the fill port.
6. When the magnet is re-filled and / or under pressure, check all plumbing joints, valves and the Burst Disc for leaks.
7. Check the vent system and magnet Pressure Gauge for damage; repair or replace any damaged components.
8. Complete a magnet quench report at the ON Line Center.
9. Make sure all checks and operations have been completed in conformance with Section 7-1-1 of this procedure before / during ramping of the magnet.

# SECTION 8 - ESS7.5-1000-2-D-1236
# MAIN POWER SUPPLY CALIBRATION / CHECK

### Description

All ESS7.5-1000-2-D-1236 power supplies should be checked in conformance with this procedure at least once a year or whenever a fault condition is suspected.

### Equipment

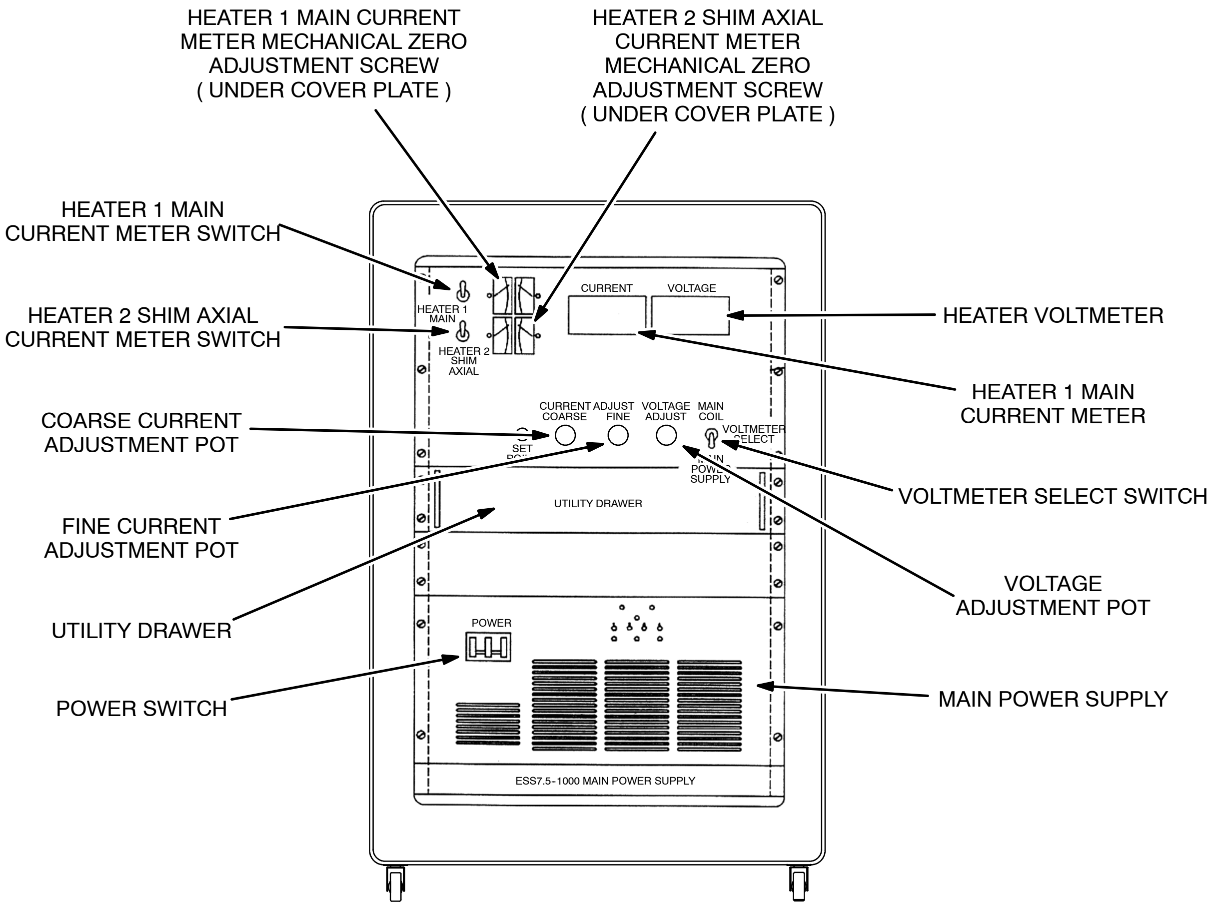
- 4 1/2 Digit True RMS Voltmeter ( Fluke 87 or equivalent )
- Oscilloscope
- Set of Ramping Cables ( 3 each )
- Power Supply Checkout Kit ( 2101360 )
- Non-Metallic Tuning Tool

**Note**
Use 3 each ( red and black ) ramp cables when testing power supply to 1,000 amps.

### 8-1 HEATER CURRENT METER ZERO CALIBRATION

1. Disconnect the input power cable from the power supply under test.
2. Remove the cover plates from the meter's Mechanical Zero Adjustment Screw ( located adjacent to each meter ). See Illustration 8-1.
3. Set the "Heater 1 Main" and "Heater 2 Shim Axial" switches to "O" ( off ). See Illustration 8-1.
4. Adjust each meter's Mechanical Zero Adjustment Screw as required to position the meter's indicator needle at "O" ( zero ).
5. Replace the cover plates.

## 8-1 HEATER CURRENT METER ZERO CALIBRATION ( continued )

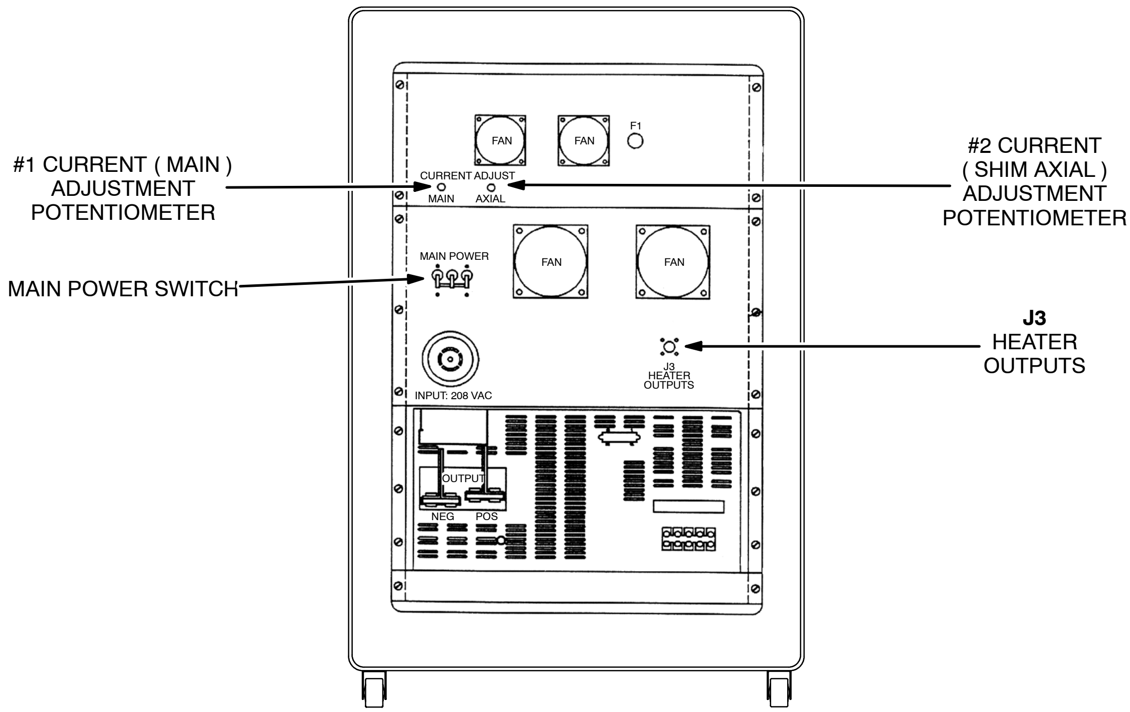



**1000 AMP SUPERCONDUCTING MAIN COIL SERVICE POWER SUPPLY CABINET, FRONT SIDE**
ILLUSTRATION 8-1

## 8-2 HEATER CALIBRATION

1. Disconnect the input power cable from the power supply under test.
2. Connect the P3 test connector to J3, located on the power supply' rear side. See Illustration 8-2.
3. Pull out the power supply's Utility Drawer. See Illustration 8-1.
4. Remove the eight screws mounting the Control Panel to the power supply. Place the Control Panel face down on the Utility Drawer to expose the panel's component side.
5. Connect an external digital voltmeter ( DVM ), set to "DC Volts," to the Heater 1 Main Standoffs. These standoffs are located on the Control Panel's component side. Use the set of standoffs nearest the voltmeter for the heater. See Illustration 8-3.
6. Connect 208 VAC to the AC input connector. Set both the "Main Power" ( Illustration 8-2 ) and the "Power On" ( Illustration 8-1 ) switches to "ON."

## 8-2 HEATER CALIBRATION ( continued )




**1000 AMP SUPERCONDUCTING MAIN COIL SERVICE POWER SUPPLY CABINET, REAR SIDE**
ILLUSTRATION 8-2

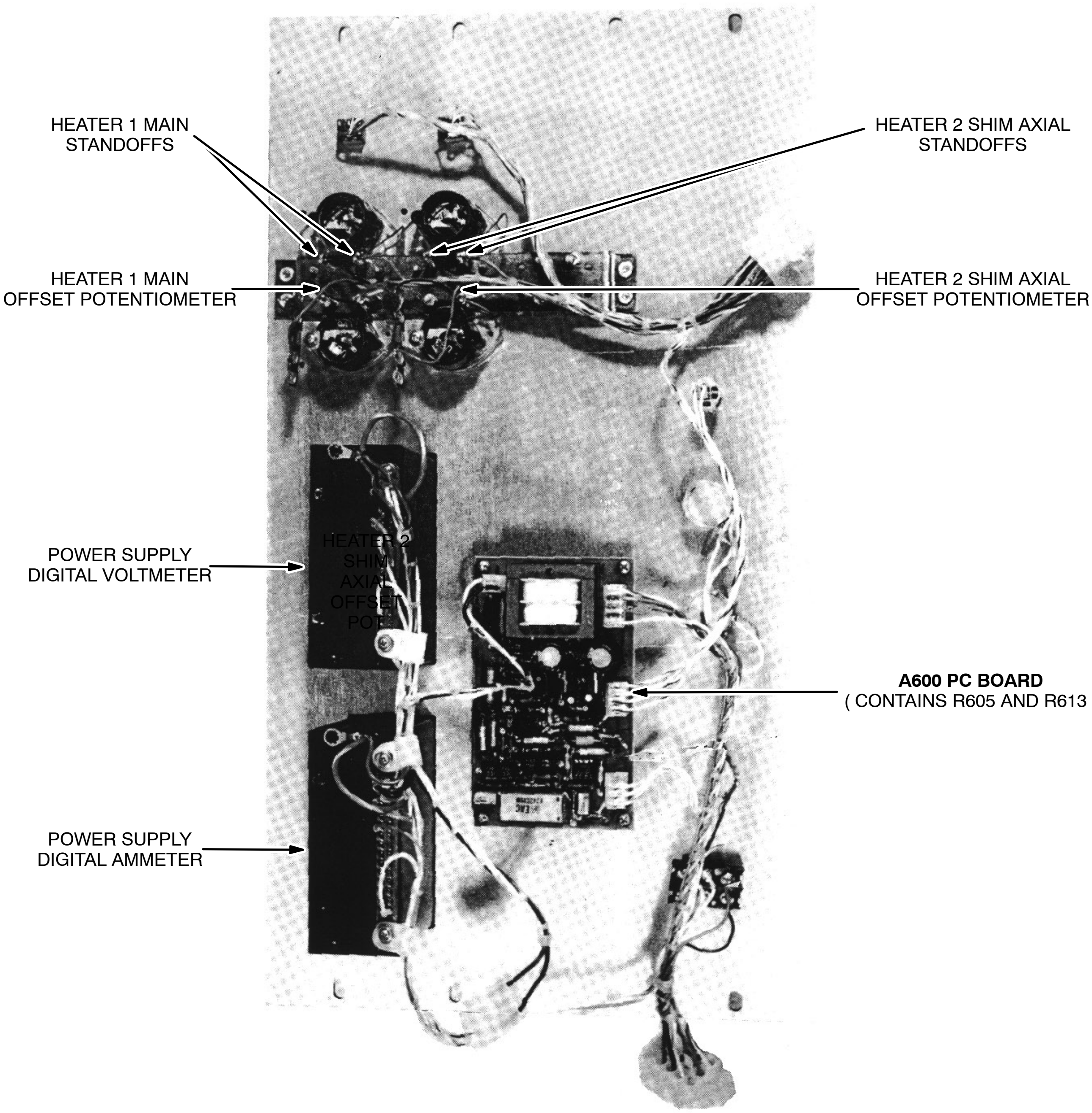
7. Set the “Heater 1 Main” switch to “I” ( on ).
8. Adjust the #1 Current Adjustment potentiometer, located on rear of power supply ( Illustration 8-2 ), as required to produce a 24.3 VDC indication on the external voltmeter.
9. Adjust the Heater 1 Main Meter Offset Potentiometer, located on the Control Panel as shown in Illustration 8-3, until the Heater 1 Main Current Meter ( Illustration 8-1 ) reads 810 mA DC.
10. Set “Heater 2 Shim Axial” switch to “I” ( on ).
11. Connect an external DVM set to “DC Volts” to the Heater 2 Shim Axial Standoffs located on the component side of the Control Panel. See Illustration 8-3.
12. Adjust #2 Current Adjustment potentiometer, located on rear of power supply ( Illustration 8-2 ), as required for 24.3 VDC indication on the external voltmeter.
13. Adjust the Heater 2 Shim Axial Meter Offset Potentiometer, located on the Control Panel as shown in Illustration 8-3, until the Heater 2 Shim Axial Current Meter ( Illustration 8-1 ) reads 810 mA DC.
14. Set both heater switches to “O” ( off ).
15. Set the “Main Power” and “Power On” switches to “OFF.”

## 8-2 HEATER CALIBRATION ( continued )

16. Reinstall the Control Panel.

**Note**

The Control Panel will have to removed later on in this procedure. It is only necessary to replace a couple of the Control Panel mounting screws at this time.




**REAR VIEW CONTROL PANEL**
ILLUSTRATION 8-3

## 8-3 VOLTAGE CALIBRATION

**Note**

Voltage Calibration and the Voltage Adjust Potentiometer Noise Test are to be performed under a “no load” condition ( i.e., the ramp cables are not connected together ).

1. Turn off the power supply; then disconnect the power supply input power cable.
2. Make sure the P3 test connector is connected to J3 located on the rear of the power supply. See Illustration 8-2.
3. Set the DVM to its “DC Volts” scale.
4. Connect the DVM to the positive ( + ) and negative ( - ) terminals of the power supply.
5. Adjust the Voltage Adjustment Potentiometer to minimum ( full CCW ), and the Coarse and Fine Current Adjust Potentiometers to maximum ( full CW ). See Illustration 8-1.

**DANGER!!**

**FATAL ELECTRIC SHOCK HAZARD!! WITH THE TB2 ACCESS COVER PLATE REMOVED, 208 VAC 3 PHASE ON TB1 IS EXPOSED. BE EXTREMELY CAREFUL NOT TO COME INTO CONTACT WITH TB1.**

6. Connect the power supply’s Power Input Cable to the power supply.
7. Set the “Main Power” ( Illustration 8-2 ) and “Power On” ( Illustration 8-1 ) switches to “ON.”
8. Set the “Heater 1 Main” and “Heater 2 Shim Axial“ switches to “I” ( on ). See Illustration 8-1.

**Note**

The ideal DVM reading in Step 9 is 7.5 Volts. Voltages lower than 7.5 volts could increase ramp up time. Voltages greater than 8.0 Volts could damage output capacitors. If the voltage is outside the range indicated in Step 9, return the power supply for repair.

9. Adjust the Voltage Adjustment Potentiometer to maximum ( full CW ). The DVM should display within the range of 7.0 - 8.0 VDC. See Illustration 8-1.
10. Adjust the Coarse Current Adjustment Potentiometer to minimum ( full CCW ). See Illustration 8-1.

## 8-3 VOLTAGE CALIBRATION ( continued )

**Note**

The adjustment in Step 11, below, is a Step Function. The DVM reading will not vary continuously as R605 is adjusted. The function of R605 is to set the threshold at which no voltage is available at the power supply output when the Current Adjustment controls ( located in Illustration 8-1 and shown enlarged in Illustration 8-4 ) are set to minimum. If R605 is adjusted much beyond the threshold point, there will be a delay between the point at which the Current Adjustment controls are adjusted from minimum until there is a noticeable power supplycurrent output.

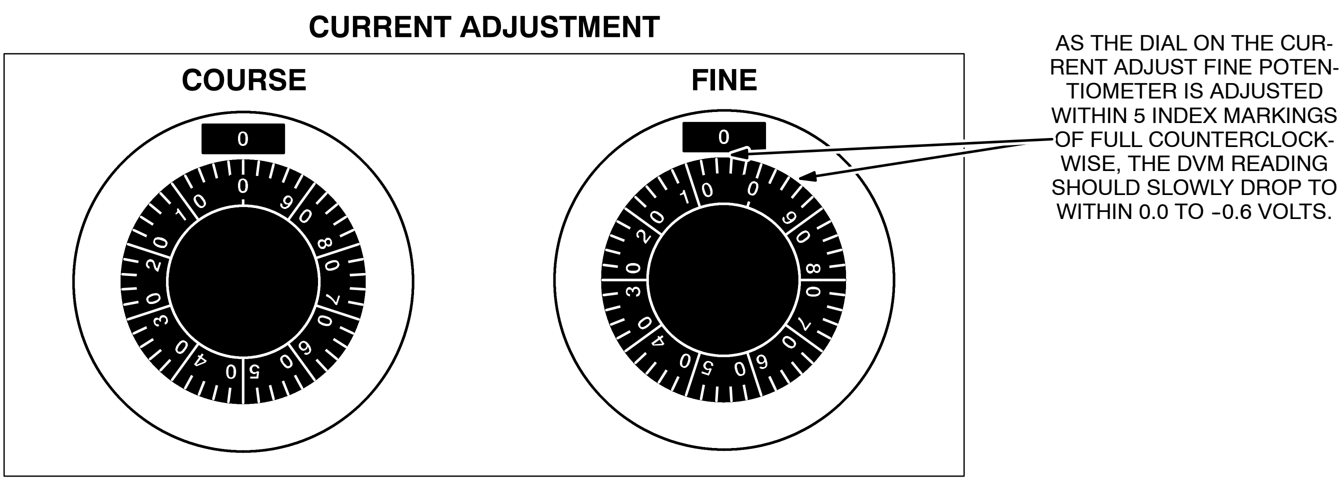
**Note**

It takes approximately 2 minutes for the DVM reading, in Step 11, to decay to a value between 0.0 and -0.6 Volts. A few trials adjusting the Fine Current Adjustment Potentiometer must be done to insure the power supply output voltage drops and rises as the Fine Current Adjustment Potentiometer is adjusted in and out of the range shown in Illustration 8-4.

**Note**

The Fine Current Adjustment Potentiometer is very sensitive.

11. Adjust the Fine Current Adjustment Potentiometer to minimum ( full CCW ). As the Fine Current Adjustment Potentiometer is adjusted to within 5 index markings from full counterclockwise, as shown in Illustration 8-4, the DVM reading should drop to between 0.0 VDC and -0.6 VDC. If necessary, adjust potentiometer R605, located on the A600 PC board behind the power supply's Control Panel, to the point at which the DVM drop occurs. See Illustration 8-3.




**CURRENT ADJUST POTENTIOMETERS**
ILLUSTRATION 8-4

12. Adjust the Fine Current Adjustment Potentiometer in and out of the range shown in Illustration 8-4 to insure proper adjustment of R605.

13. Reinstall the control panel if removed in Step 10.

**Note**

The Control Panel will have to removed later on in this procedure. It is only necessary to replace a couple of the Control Panel mounting screws at this time.

## 8-4 VOLTAGE ADJUST POTENTIOMETER NOISE TEST

### Description

The Voltage Adjustment Potentiometer is checked under a "no load" condition. Make sure the Ramp Leads are disconnected for this test. Test Plug J3 needs to be connected.

### Procedure

1. Disconnect the input power cable from Main Coil Power Supply.
2. Measure the resistance, using an Ohmmeter, from the Negative Buss Bar to any point on the power supply chassis. The resistance will increase, to well within the Megohm range, as the output capacitor is being charged by the Ohmmeter. Send the power supply to the repair facility if the resistance check indicates a shorted or leaky output capacitor.
3. Connect Oscilloscope X1 probe to the Oscilloscope.
4. Connect the X1 probe's ground lead to the negative output terminal buss bar. Connect the signal lead to the positive output terminal.
5. Set the Oscilloscope's "Time Base" control to 5 msec/div ( X1 Probe ).
6. Set the Oscilloscope's "Volt / Div" to 100 mV/div.
7. Set the input coupling to AC.
8. Connect the input power to Oscilloscope and turn on the Oscilloscope's power switch.
9. Connect the input power to the Main Coil Power Supply and turn on all power supply breaker switches.

**Note**

The Oscilloscope beam will move upward and downward as the Voltage Adjustment Control is adjusted.

10. Adjust the Voltage Adjustment Potentiometer through its full range of operation while observing the Oscilloscope. The signal should be free from spikes. A bad potentiometer will intermittently display large spikes as the potentiometer is adjusted through its full range. See Illustration 8-5 for an example of a bad potentiometer.

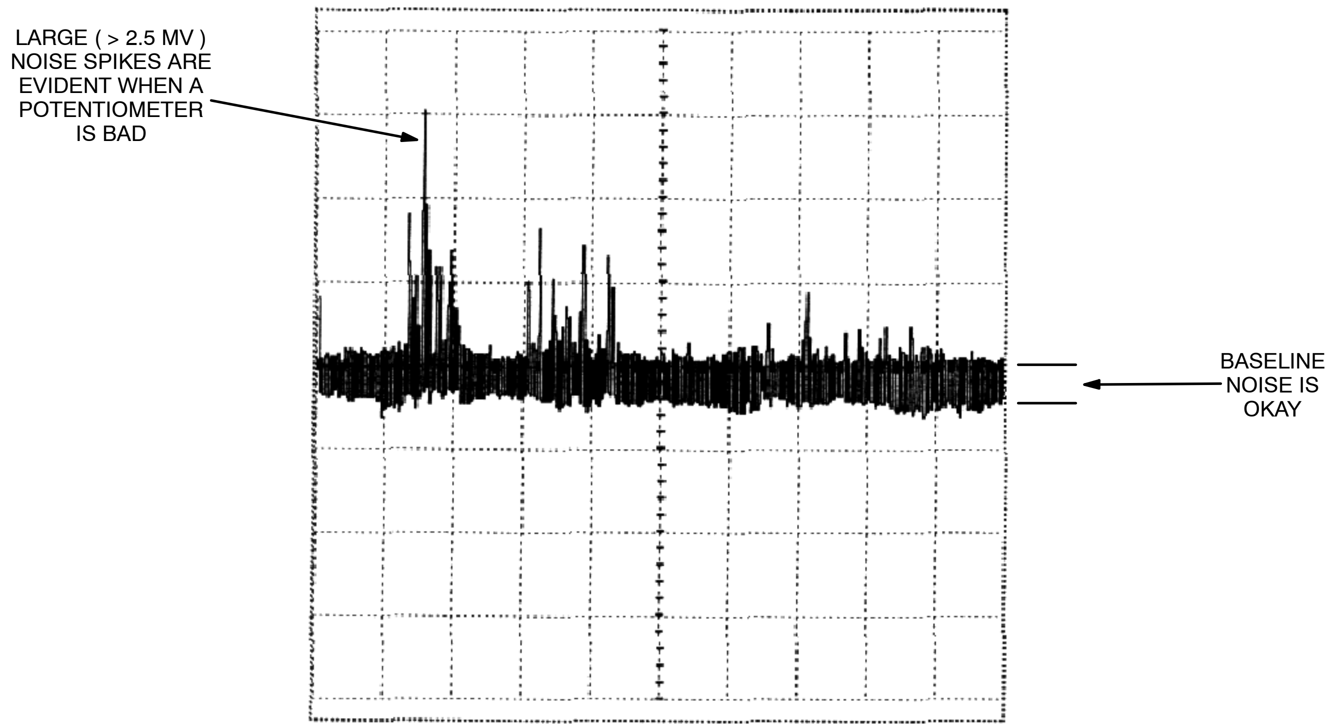
**Note**

A storage-type Oscilloscope, if properly used, will greatly aid in determining if a potentiometer is excessively noisy.

**Note**

Spikes seen riding on the baseline at regular intervals are caused by switching circuits in the main power module. Do not confuse these spikes as potentiometer noise. Make the probe and ground lengths as short as possible to isolate noise spikes less than a volt.

## 8-4 VOLTAGE ADJUST POTENTIOMETER NOISE TEST ( continued )




**POTENTIOMETER NOISE**
ILLUSTRATION 8-5

11. If the potentiometer fails this test, turn off and disconnect the power supply's input power and replace the pot. The Voltage Adjustment Potentiometer is a 5K, 10-turn pot.

**Note**

The 1,000 amp Power Supply ( 46-260776G4 ) has oil filled pots. They are designed to eliminate wire corrosion and resultant noise.

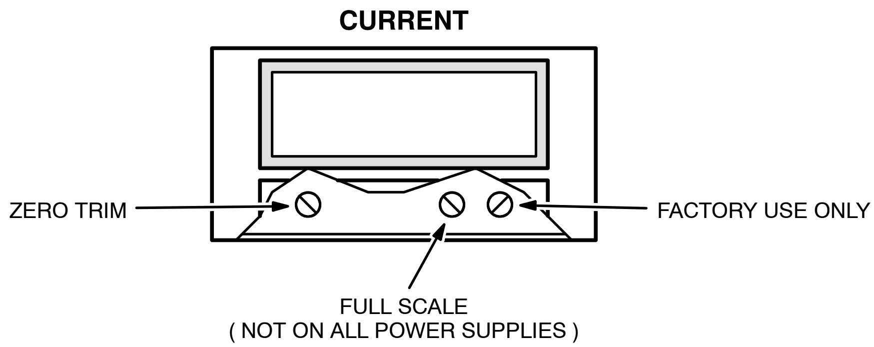
## 8-5 CURRENT CALIBRATION AND CURRENT POT NOISE CHECK

### Description

The External Current Shunt ( 2101358) should be replaced or calibrated at least once a year. If dropped, it could be forced out of tolerance and should be replaced. The resistance tolerance of the Shunt is ± 0.1%. This means the power supply output, at rated current, could be 750 ± 0.75 amps. The DVM used in the following section should be a 4 1/2 digit Digital Voltmeter ( DVM ) Fluke 87 or equivalent.

### Procedure

1. Connect the Oscilloscope power cable to an AC outlet and turn on Oscilloscope power.
2. Connect the P3 test connector to J3, located on the rear of the power supply as shown in Illustration 8-2.
3. Set the "Main Power" ( Illustration 8-2 ) and "Power On" ( Illustration 8-1 ) switches to "ON."
4. Set the "Heater 1 Main" and "Heater 2 Shim Axial" toggle switches to "I" ( on ). See Illustration 8-1.
5. Adjust the "Current Adjust" and "Voltage Adjust" potentiometers to minimum ( full CCW ). See Illustration 8-1.
6. Remove the "snap on" cover plate from the power supply's digital Current Meter. See Illustrations 8-1 and 8-6.




**POWER SUPPLY CURRENT METER ADJUSTMENT POTS**
ILLUSTRATION 8-6

**Note**
Step 7 must be performed with no load ( i.e., ramp cables disconnected ).

7. Adjust the Current Meter's Zero Trim Potentiometer, located under the meter's cover plate at the meter's lower left corner, to 000.0 Amps. See Illustration 8-6.

## 8-5 CURRENT CALIBRATION AND CURRENT POT NOISE CHECK ( continued )

**CAUTION**

**Heat in excess of 60 watts could be present at the junction between the Ramp Cable and the 1000 amp 100mV Current Shunt if the cables in Steps 11 and 12 are not tightly connected to the Current Shunt.**

**Because of the high current capacity of the power supply, rings and other jewelry should not be worn during this section of the checkout procedure as a potential burn hazard exists.**

**Place Cthe urrent Shunt on brick or ceramic material to avoid heat damage to tile or carpet.**

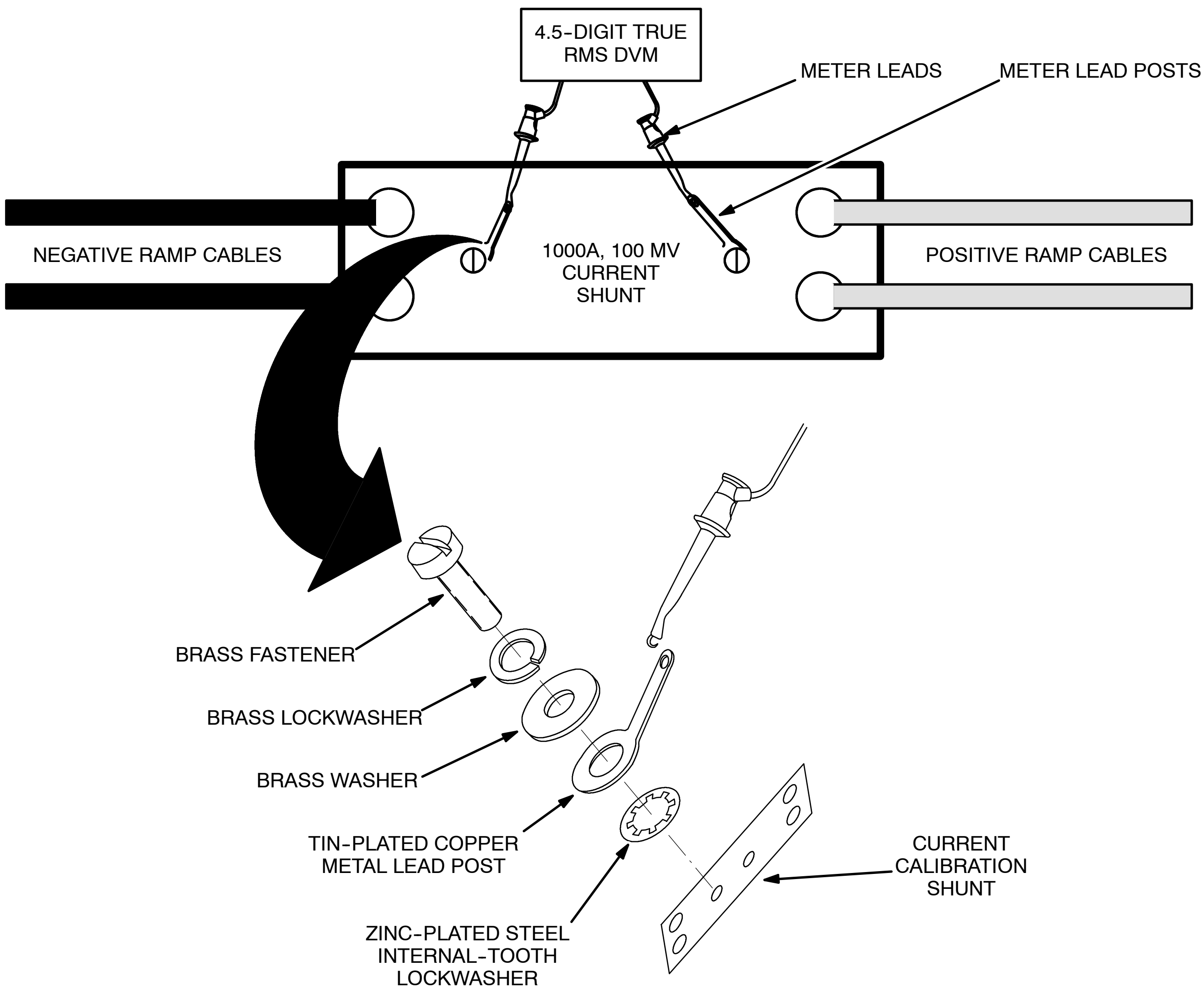
8. Set the “Heater 1 Main” and “Heater 2 Shim Axial” toggle switches to “O” ( off ). See Illustration 8-1.
9. Set the “Main Power” ( Illustration 8-2 ) and “Power On” ( Illustration 8-1 ) switches to “OFF.”
10. Connect the positive ( + ) and negative ( - ) Ramp Cables to the magnet power supply’s Output Buss Bars.
11. Tightly bolt the other end of the Positive ( + ) Ramp Cables to one side of the 1000 amp 100mV Current Shunt. See Illustration 8-7.
12. Tightly bolt the other end of the Negative ( - ) Ramp Cables to the other side of the 1000 amp 100mV Current Shunt.
13. Set the “Heater 1 Main” and “Heater 2 Shim Axial” toggle switches to “I” ( on ). See Illustration 8-1.
14. Adjust the “Voltage Control Potentiometer” to maximum ( full CW ). Make sure both “Current Adjustment Potentiometers” are set to minimum ( full CCW ).

**Note**

Erroneous readings will result in Steps 24 through 26 below, if the Meter Lead Post Fasteners are not tight. All materials used for the Meter Lead Posts, fasteners and washers were chosen to avoid the possibility of thermocouple action.

15. Install the Meter Lead Posts, fasteners and washers to the External Current Shunt as shown in Illustration 8-7. Make sure the Meter Lead Post fasteners are tight.
16. Connect a 4 1/2 digit “True RMS” Digital Voltmeter ( DVM ) to the Meter Lead Posts on the Current Calibration Shunt. See Illustration 8-7.
17. Set the DVM to read “DC millivolts.”
18. Connect the Oscilloscope X1 probe’s ground lead to the Negative Output Terminal Buss Bar and the signal lead to the Positive Output Terminal.
19. Set the Oscilloscope’s “Time Base“ control to 5 msec/div.
20. Set the Oscilloscope’s “Volt / Div“ to 100 mV / div.

## 8-5 CURRENT CALIBRATION AND CURRENT POT NOISE CHECK ( continued )




**CURRENT SHUNT CONNECTIONS**
ILLUSTRATION 8-7

21. Set the input coupling to “AC.”
22. Set the power supply’s “Main Power” ( Illustration 8-2 ) and “Power On” ( Illustration 8-1 ) switches to “ON.”
23. Set the “Heater 1 Main” and “Heater 2 Shim Axial” toggle switches to “I” ( on ). See Illustration 8-1.

**Note**

Each millivolt increment on the DVM corresponds to 10 amps. Make sure the meter used in this procedure is capable of reading to three decimal places.

24. Adjust the Current Adjustment controls to maximum ( full CW ). The external DVM should indicate a minimum of 80.0 mVDC. If this voltage is low, the power supply’s maximum rated current ( 800 amps ) will not be achievable, and the power supply should be returned for repair. Returned power supplies should have a written description of the problem.

## 8-5 CURRENT CALIBRATION AND CURRENT POT NOISE CHECK ( continued )

25. Adjust the Fine and Coarse Current Adjustment controls to obtain a reading of 80.0 mVDC on the external DVM. This corresponds to a power supply output of 800 amps. Adjust R613, located on the A600 board, to display a reading of 800 amps on the power supply's Current Meter. If a reading of 800 amps cannot be achieved, perform Step 26 below.

**Note**

Perform Step 26 only if a reading of 800 amps on the power supply's Current Meter cannot be achieved by adjusting R613.

26. Adjust power supply Current Meter "Full Scale" Trim Pot for 800 Amps. See Illustration 8-6.
27. Adjust the Current Adjustment Potentiometers through the full range of operation while observing the Oscilloscope. The signal should be free from spikes. See Illustration 8-5 for an example of a bad pot.
28. If either potentiometer fails this test, turn off and disconnect the power supply's input power and replace the pot. The Current Adjustment Potentiometer is a 5K, 10-turn pot. The Fine Current Adjustment Potentiometer is a 100 ohm, 10-turn pot. Extra potentiometers are included in the Power Supply Checkout Kit ( 2101360 ).
29. Adjust all Current and Voltage Adjustment potentiometers to minimum ( full CCW ).
30. Set the "Heater 1 Main" and "Heater 2 Shim Axial" toggle switches to "O" ( off ). See Illustration 8-1.
31. Set the "Main Power" ( Illustration 8-2 ) and "Power On" ( Illustration 8-1 ) switches to "OFF."
32. Reinstall the power supply's Control Panel.

# SECTION 9 – HEATER / RTD CONNECTOR BOX RESISTANCE CHECKS

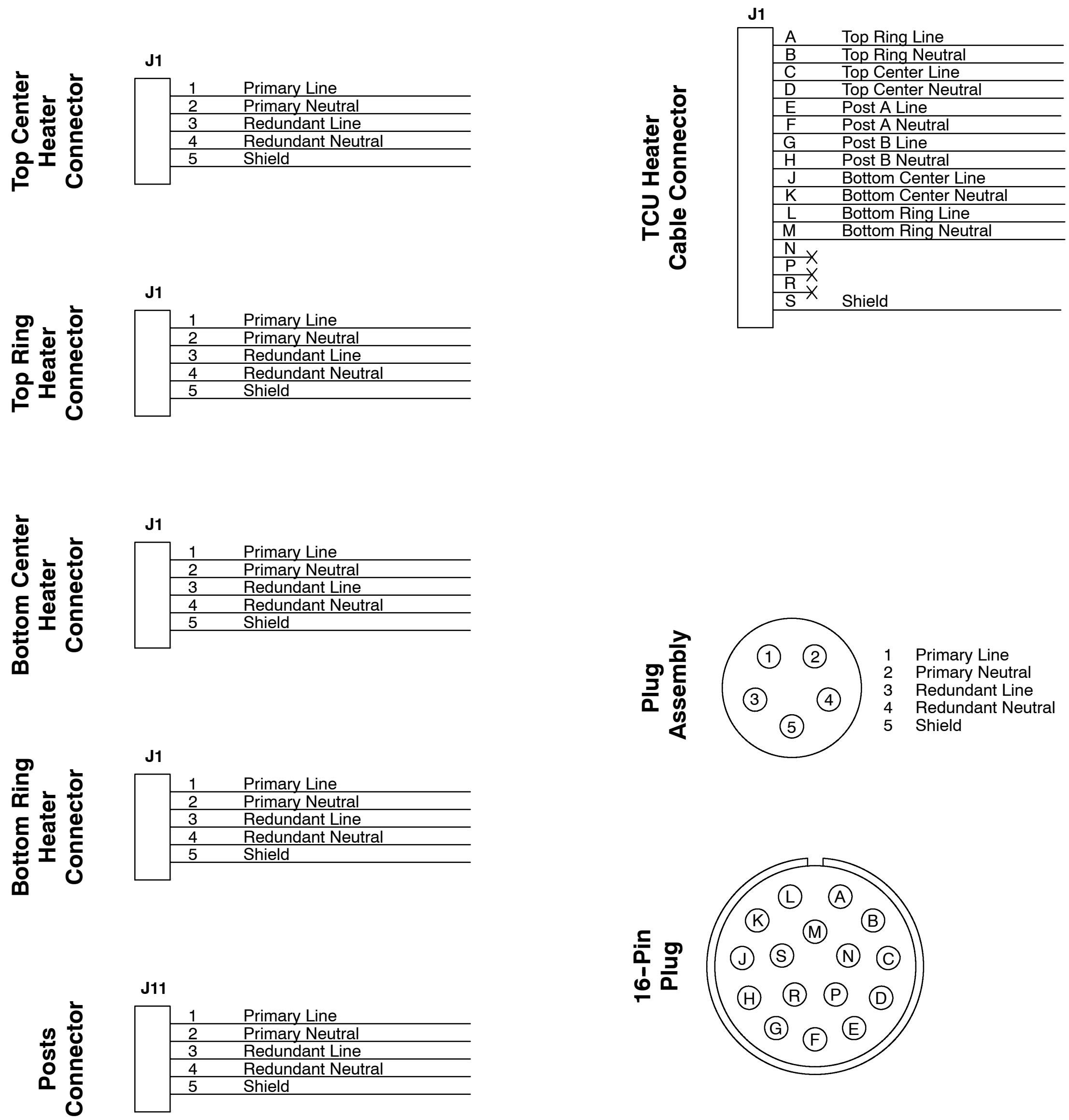
## 9-1 HEATER RESISTANCE CHECKS

**Note:**
Following table applies to both primary and redundant circuits with connectors attached to Heater / RTD Connector Box. Resistance values apply at room temperature ( 70 Deg, F ). Temperature fluctuations will cause resistance values to change.

TABLE 9-1
**HEATER RESISTANCE CHECKS**

| HEATER | CONNECTOR | PINS | RESISTANCE VALUE – OHMS |
|---|---|---|---|
| POSTS CONNECTOR ( POST A & POST B ) | J10 | 1 – 2 | 190 – 200 |
| | | 3 – 4 | |
| BOTTOM RING HEATER CONNECTOR | J1 | 1 – 2 | 45.6 – 52.0 |
| | | 3 – 4 | |
| BOTTOM CENTER HEATER CONNECTOR | J1 | 1 – 2 | 91.2 – 103.0 |
| | | 3 – 4 | |
| TOP RING HEATER CONNECTOR | J1 | 1 – 2 | 45.6 – 52.0 |
| | | 3 – 4 | |
| TOP CENTER HEATER CONNECTOR | J1 | 1 – 2 | 91.2 – 103.0 |
| | | 3 – 4 | |
| TCU HEATER CABLE CONNECTOR | J1 | A – B | 45.6 – 50.4 |
| | | C – D | 91.2 – 100.8 |
| | | E – F | |
| | | G – H | |
| | | J – K | |
| | | L – M | 45.6 – 50.4 |

## 9-1 HEATER RESISTANCE CHECKS ( continued )




**HEATER RESISTANCE CHECKS**
ILLUSTRATION 9-1

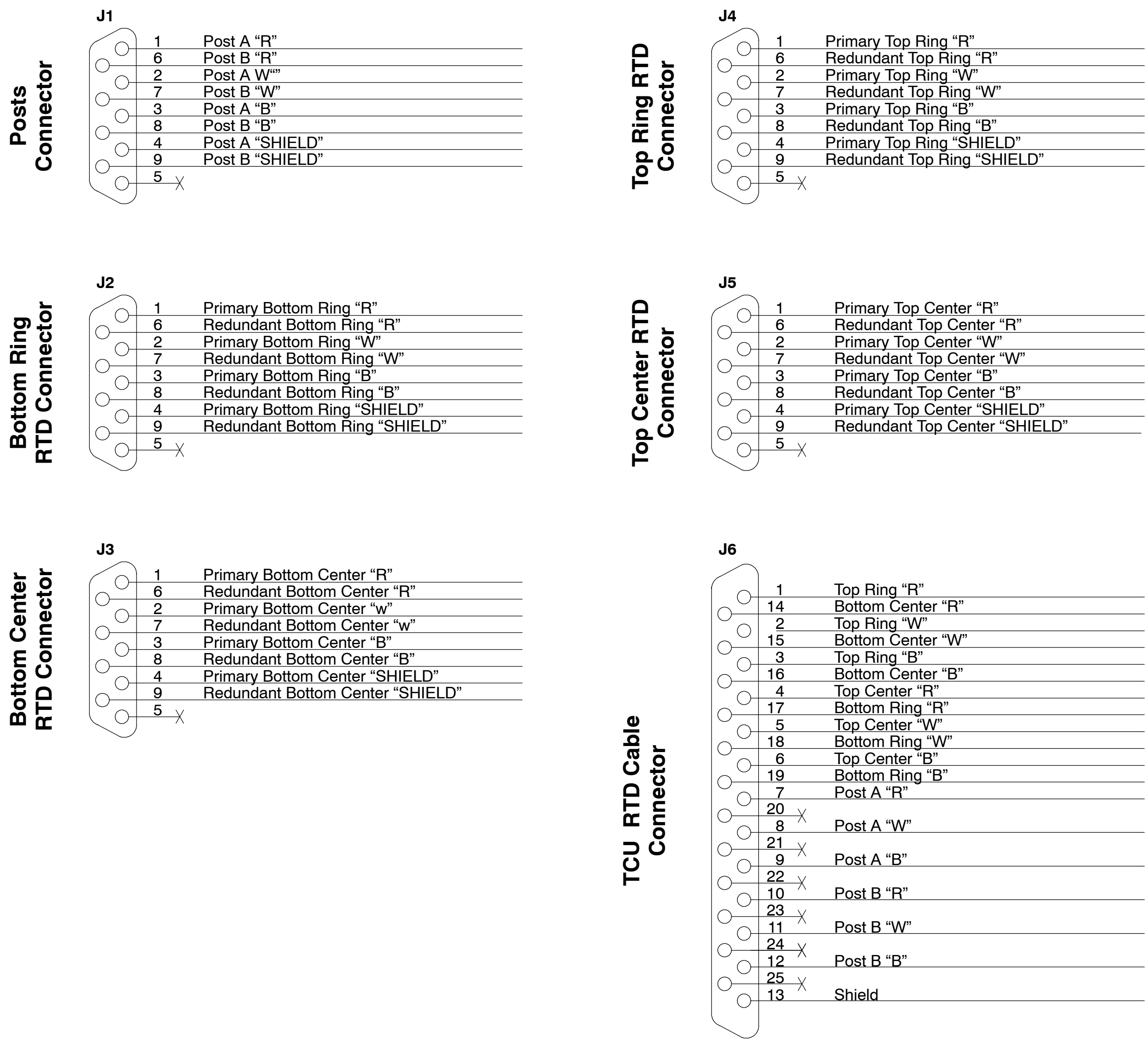
## 9-2 RTD RESISTANCE CHECKS

**Note:**
Following table applies to both primary and redundant circuits with connectors attached to Heater / RTD Connector Box. Resistance values apply at room temperature ( 70 Deg, F ). Temperature fluctuations will cause resistance values to change.

TABLE 9-2
**RTD RESISTANCE CHECKS**

| RTD | CONNECTOR | PINS | RESISTANCE VALUE - OHMS |
|---|---|---|---|
| POSTS CONNECTOR | J1 | 1 - 2 | 108 - 110 |
| | | 6 - 7 | |
| BOTTOM RING RTD CONNECTOR | J2 | 1 - 2 | |
| | | 6 - 7 | |
| BOTTOM CENTER RTD CONNECTOR | J3 | 1 - 2 | |
| | | 6 - 7 | |
| TOP RING RTD CONNECTOR | J4 | 1 - 2 | |
| | | 6 - 7 | |
| TOP CENTER RTD CONNECTOR | J5 | 1 - 2 | |
| | | 6 - 7 | |
| TCU RTD CABLE CONNECTOR | J6 | 1 - 2 | |
| | | 4 - 5 | |
| | | 7 - 8 | |
| | | 10 - 11 | |
| | | 14 - 15 | |
| | | 17 - 18 | |

## 9-2 RTD RESISTANCE CHECKS ( continued )




**RTD RESISTANCE CHECKS**
ILLUSTRATION 9-2

# REPLACEMENT / MAINTENANCE

## TABLE OF CONTENTS

# TABLE OF CONTENTS ( continued )

# TABLE OF CONTENTS ( continued )

# SECTION 1 – MAGNET FIELD ADJUSTMENT / RAMPDOWN ( FIELD DECREASE TO ZERO )

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 1–1 INTRODUCTION

The Main and Bucking Coils of the GE 0.7T Open*Speed* magnet are in a horizontal plane to generate a vertical magnetic field. Because of this configuration, it is essential that the magnet helium level remain between 95% and 98% during magnet field adjustment / rampdown so that helium stays in contact with the Top Bucking Coil. Failure to maintain this condition will result in a cooling loss of the Top Bucking Coil and could result in a quench.

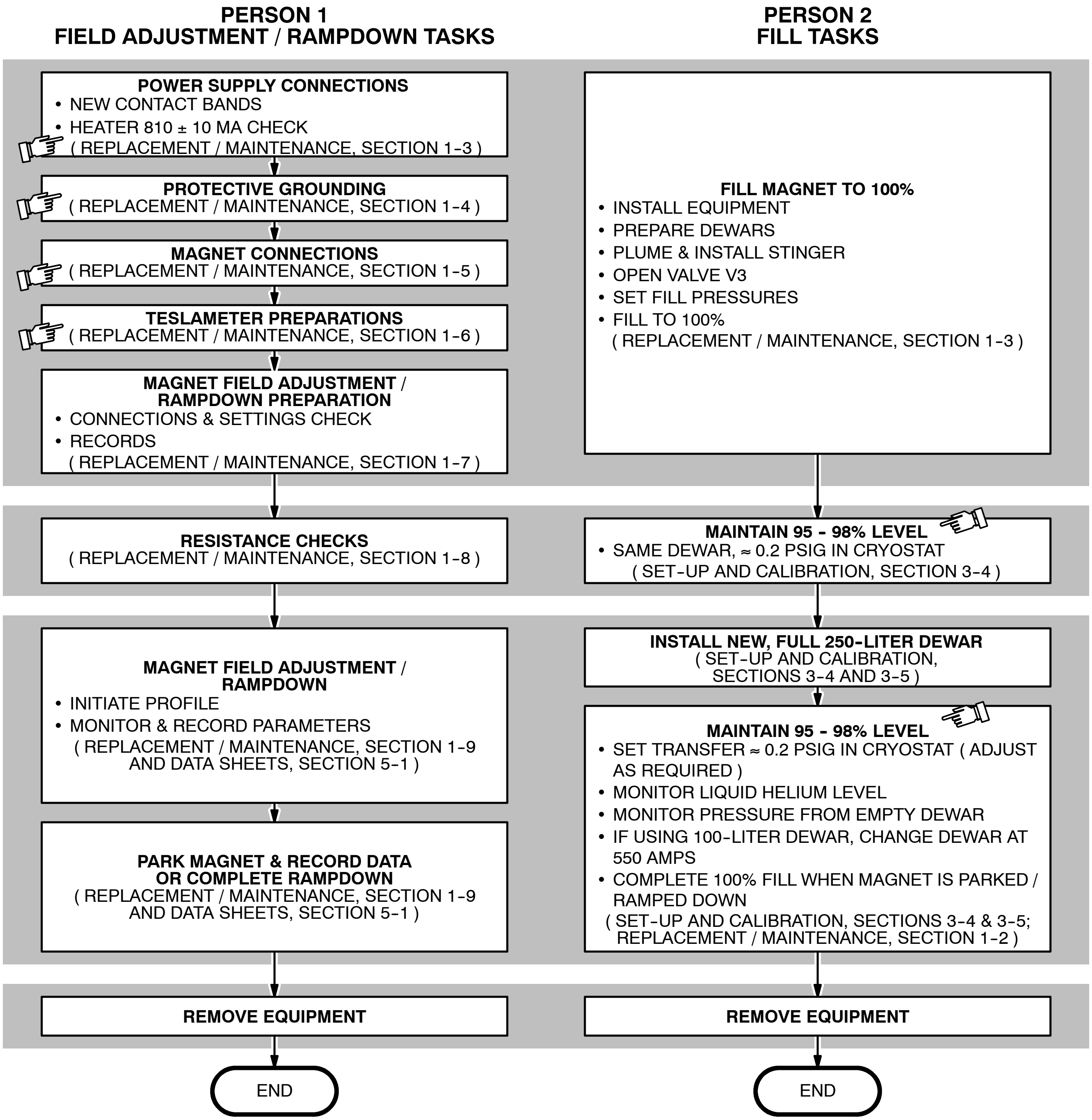
This procedure maintains the required helium level during magnet field adjustment / rampdown through the controlled replenishment of liquid helium to compensate for loss through the Ramp Leads and Vent Valve V3.

Because of the complexity and simultaneous tasks of magnet field adjustment / rampdown, two trained and certified persons are required to perform the steps. Person 1 performs the magnet field adjustment / rampdown while person 2 simultaneously performs the fill.

Before starting these procedures, review and fully understand all superconducting magnet portions of *2301164PRE, MR Magnet - Safety Requirements*, found in the SAFETY REQUIREMENTS tab of this manual. Fully comply with that document's Section 2–4, Magnet & Cryogen Service Safety Requirements. Have all "Work Assistants" or "Work Observers" comply with that document's Section 2–4, Buddy System Requirements & Certification.

Illustration 1–1 outlines the tasks and sequence for each person. Table 1–1 outlines the field adjustment / rampdown process steps. Complete DATA SHEETS, Table 5–2, Magnet Ramp / Fill Profile, for both ramp up and ramp down.

## 1-1 INTRODUCTION ( continued )




**FIELD ADJUSTMENT / RAMPDOWN / FILL PROCESS**
ILLUSTRATION 1-1

## 1-1 INTRODUCTION ( continued )

TABLE 1-1
**RAMP / FILL PROCESS STEPS**

| **Prerequisites** |
|---|
| • Magnet Heaters must be stabilized.<br>• Perform Power Supply checks to verify functional ramp supply.<br>• Magnet Monitor must be functional and put into “FILL” mode. |
| **The process** |
| • Vent magnet down to .5 psi.<br>• If the Upper Vessel helium level is < 80%, top off the magnet to at least 95%. Valve V3 should be open when helium level is greater than 70%.<br>• If the Upper Vessel helium level is > 80%, proceed to next step.<br>• Install Protective Grounding Circuit.<br>• Insert the Main Lead Extensions.<br>• Install the Hold-down Tool, but do not fully tighten.<br>• Insert the fill line Stinger and begin filling the magnet.<br>• Tighten the Hold-Down Tool.<br>• When the Upper Vessel helium level is > 90%, do resistance checks.<br>• When the resistance checks pass, change to a new 250-liter Dewar.<br>• Park magnet at 29.791 MHz. This will account for the frequency drop when the supply is ramped down and the frequency increase when the magnet is shimmed. Specification for 0.7T Open*Speed* Magnet is 29.803 MHz ± 10 KHz.<br>• Replace Power Supply Jumper Cable before removing the Main Lead Extensions.<br>• After the supply is turned off, continue to fill while removing the Hold-Down Tool and Main Lead Extensions. This will give a higher helium level for magnet turnover to the customer. Hold-Down Tool and Main Lead Extensions should be removed quickly.<br>• Put the Magnet Monitor back into normal operating mode. |

## IMPORTANT !!!

It is **essential** that the following conditions are met to prevent a 250-liter helium Dewar from running dry during rampdown. Approximately 150 liters of helium will be used under these conditions.

- Follow the rampdown profile. Do not allow the ramp voltage to decay during each step of the ramp.
- Make sure contact resistance ( < 150 mV @ 750 amps ) is well within limits to minimize internal heat generation.
- Connect a new 250-liter helium Dewar after resistance checks ( at the start of the magnet field adjustment / rampdown ).
- Maintain helium level of 95 – 98% during the fill. Vessel pressure should be between 0.2 – 0.4 psig to maintain this helium level.

## 1-1 INTRODUCTION ( continued )

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM.**

**SECURE THE MAGNET ROOM DOORS IN THE OPEN POSITION BEFORE CHANGING MAGNETIC FIELD.**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## 1-2 HELIUM FILL DURING FIELD ADJUSTMENT / RAMPDOWN - PERSON 2

**CAUTION**

**Make sure the fill Stinger has been properly plumed ( venting liquid helium ) before inserting into a ramped magnet to prevent any gas from entering the magnet and causing a quench.**

1. Open Vent Valve V2 and vent magnet down to < 0.5 psig. Close V2. See Illustration 1-2.
2. If the helium level in the upper vessel is less than 90%, top the magnet to 90%.

**CAUTION**

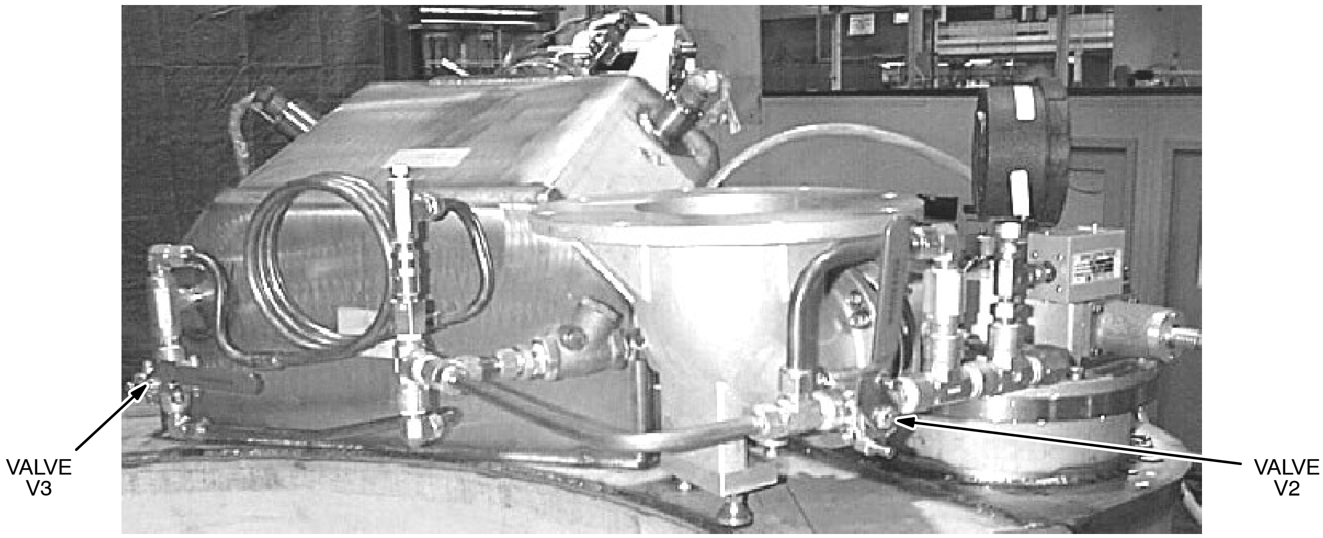
**Shield the pump-out port on the transfill line from cold helium gas that can harden the pump-out port o-ring and cause the line to go "soft."**

3. Assemble the equipment and a new Dewar. Plume and insert the Stinger after the Ramp Lead Extensions and Hold-Down Fixture are installed.
4. Open Shield Coil Vent Valve V3. See Illustration 1-2. Fill the magnet to 98% in conformance with SET-UP AND CALIBRATION, Section 3-4, Helium Fill.

**Note**

Leave Valve V3 open sufficiently to maintain 0.2 psig helium transfer pressure during the entire ramping procedure to prevent pressure build-up.

## 1-2 HELIUM FILL DURING FIELD ADJUSTMENT / RAMPDOWN - PERSON 2 ( continued )




**V2 AND V3 VALVE LOCATIONS**
ILLUSTRATION 1-2

5. Maintain a 95 - 98% helium level during resistance checks. Nominal cryostat pressure is 0.5 psig for maintaining this helium level.

6. Change to new, full 250 liter Dewar at the start of magnet field adjustment / rampdown in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Dewars.

### IMPORTANT !!!

It is **essential** that the magnet is at 98% liquid helium level and a new / full 250-liter Dewar is installed at the start of the ramp procedure to prevent the Dewar from running dry during the ramp.

7. Adjust Dewar pressure to produce ~ 0.5 psig cryostat pressure. Make minor adjustments to Dewar pressure as required to maintain between 95 - 98% liquid helium level during ramp.

## 1-2 HELIUM FILL DURING FIELD ADJUSTMENT / RAMPDOWN - PERSON 2 ( continued )

**CAUTION**

**Always maintain a positive pressure differential between the Dewar and the Cryostat to prevent any backflow of helium into the Dewar.**

**WARNING!**

**ALLOWING A HELIUM DEWAR TO EMPTY DURING RAMPING WILL CAUSE WARM GAS TO ENTER THE MAGNET AND CAUSE A QUENCH. CONTINUOUSLY MONITOR THE DEWAR AND MAGNET FOR A "WHISTLING" SOUND AND MAGNET PRESSURE FOR AN INCREASE; THESE INDICATE THE DEWAR IS EMPTY. WHEN AN EMPTY DEWAR IS SUSPECTED, IMMEDIATELY SHUT OFF THE DEWAR STINGER AND DISCONTINUE THE RAMP, MAINTAINING A CONSTANT RAMP CURRENT.**

8. Continuously monitor the magnet for a noticeable pressure increase and the Dewar Stinger for a whistling sound indicating that the Dewar is empty. If the Dewar is empty, immediately shut off the Dewar Stinger and change Dewars in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.

9. Once the magnet is ramped down and parked, make sure the magnet is at 90% helium fill level in the Top Helium Vessel. Then close V3 and immediately discontinue helium transfer. Remove the helium fill equipment in conformance with SET-UP AND CALIBRATION, Section 3-4, Liquid Helium Fill.

## 1-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1

### Introduction

At least once a year calibrate the Ramp Power Supply in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5-1000-2-D-1236 Main Power Supply Calibration / Check.

Make sure the Power Supply Cabinet is installed and checked out in conformance with the vendor manual supplied with the unit before making any power supply connections to the magnet. See INTRODUCTION, Section 2, Vendor Manual Matrix, for supplier manual numbers.

SCHEMATICS / INTERCONNECTS, Section 1-1, Magnet Interconnect Diagram, shows the cable numbers and interconnect patterns covered in this Section.

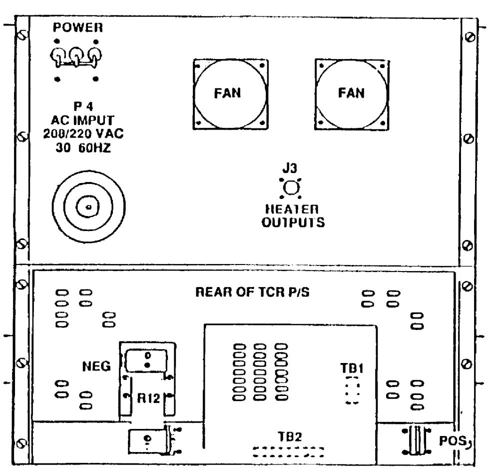
The Main Coil Power Cables, Switch Heater Cables and Voltage Sense Leads are provided as part of the Ramp Cart / Cable Kit ( 1000 Amp ) 2180589.

Use Main Lead Extensions 46-294204G1 from the Magnet Ramping Equipment Kit 46-260703G6.

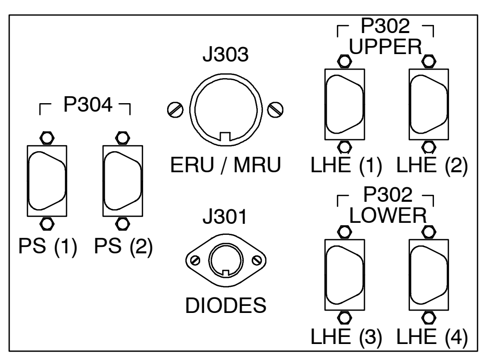
### Procedure

1. Verify that the input power to the Main Coil Power Supply is disconnected.
2. Connect "P3" on Switch Heater Cable 46-281667G1 to Heater Outputs "J3" on the rear of the Main Coil Power Supply Cabinet ( MS6-A1 ). See Illustration 1-3.

**Note:**
This magnet incorporates a "B0 Coil" to decrease moving-metal sensitivity of the magnet field. The B0 Coil Heater is energized through the Ramp Power Supply's Axial Shim Heater Circuit. The Ramp Power Supply's Axial Shim Heater must remain on throughout the field adjustment / rampdown procedure in order to quench the B0 Coil field.




**POWER SUPPLY ( REAR )**




**CONNECTOR PANEL**

**MAGNET POWER SUPPLY OUTPUT CONNECTIONS AND MAGNET CONNECTOR PANEL**
ILLUSTRATION 1-3

## 1-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1 ( continued )

3. Connect “J304” on the Switch Heater Cable to “P304” on the Magnet Connector Assembly ( MS1-A3, A1 ). See Illustration 1-3.

**Note**

Make sure the nuts installed in Steps 4 and 6 below are tightened sufficiently to prevent a high resistance contact. Connect the red cables to the Positive ( + ) Buss Bar and the black cables to the Negative ( - ) Buss Bar on the Main Power Supply. For magnets ramped with normal polarity make sure the red ( + ) cables are connected to the “+” Magnet Ramp Port and the black ( - ) cables are connected to the “-” Magnet Ramp Port.

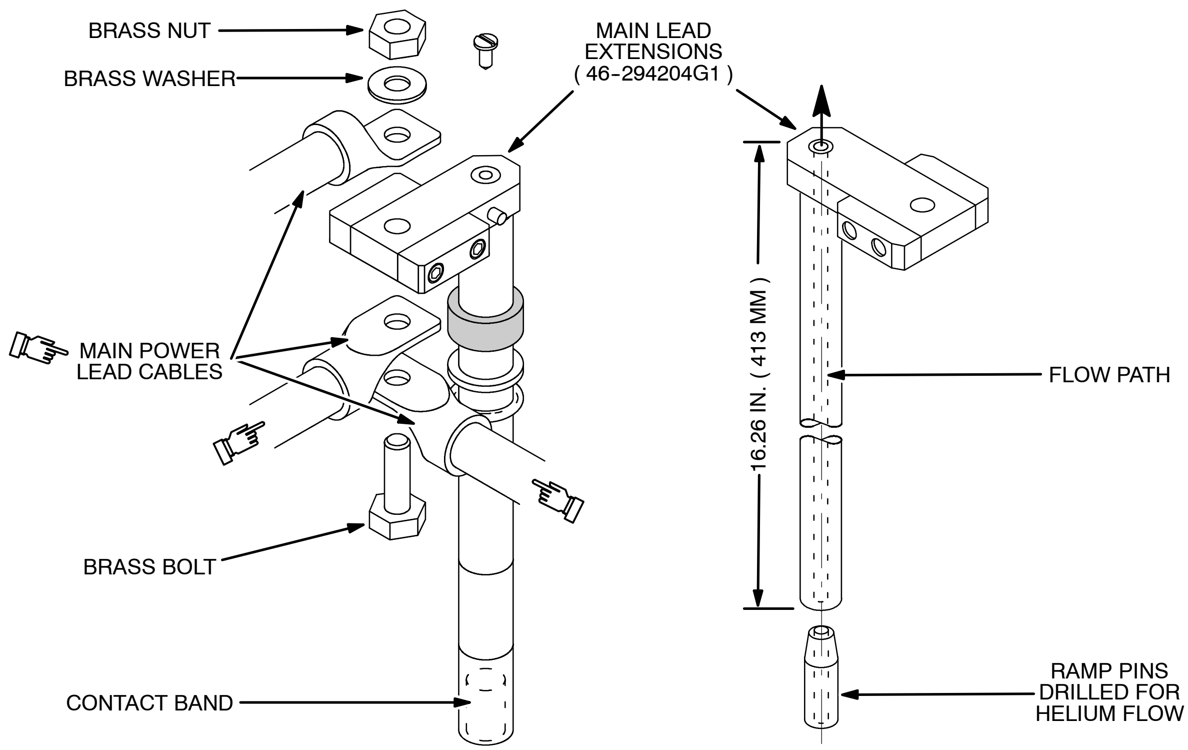
4. Connect the Main Coil Power Cables ( “+” Red: 46-260723G1; “-” Black: 46-260723G2 ) to the Main Power Supply Buss Bars with the .375 inch brass nuts bolts and washers provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ).

**Note**

Three pairs of Main Coil Power Cables must be used when ramping the GE 0.7T Open*Speed* magnet.

5. Replace the Contact Bands on Main Lead Extension ( 46-294204G1 ) according to REPLACEMENT / MAINTENANCE, Section 12, Main Lead Extension Contact Band Replacement. Make sure the Gas Flow Holes are not blocked.

6. Connect the other end of the Main Power Cables to the Main Ramp Lead Extensions with the brass nuts, bolts and washers provided. See Illustrations 1-4 and 1-9.




**HARDWARE MOUNTING ON RAMP LEAD EXTENSIONS**
ILLUSTRATION 1-4

## 1-4 PRE-RAMPDOWN PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1

**WARNING!**

**MAKE SURE THE POWER SUPPLY IS ALWAYS COMPLETELY GROUNDED IN CONFORMANCE WITH THE FOLLOWING PROCEDURE BEFORE INSERTING OR EXTRACTING ANY MAIN LEAD EXTENSION TO THE MAGNET ( DURING RAMP UP, RAMP DOWN OR REPARKING MAGNET ). GROUNDING WILL PREVENT THE REMOTE POSSIBILITY OF A HIGH VOLTAGE BETWEEN THE MAIN LEAD EXTENSION AND THE CRYOSTAT GROUND IF AN UNLIKELY QUENCH AND ARC / SHORT TO THE CRYOSTAT OCCUR WHEN THE MAIN LEAD EXTENSION IS INSERTED / EXTRACTED.**

**IMPORTANT !!!**

Requirements during ramping:

- Always install the Pre-Ramp Protective Grounding Circuit and verify Main Lead Extension grounding to Cryostat ground before inserting or extracting any Main Lead Extension.
- Once the Main Lead Extensions are inserted, disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non-absorbant leather gloves with NO holes / tears. This removes the short across the power supply and enables magnet ramping up / down.
- Once the magnet is parked and the power supply turned off — but before removing the Main Lead Extensions — reconnect the Power Supply Jumper Cable's twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. This re-establishes full power supply grounding.
- After ramping up / down, when the power supply has been turned off and the Main Lead Extensions have been extracted, remove the Power Supply Jumper and Grounding Cables.

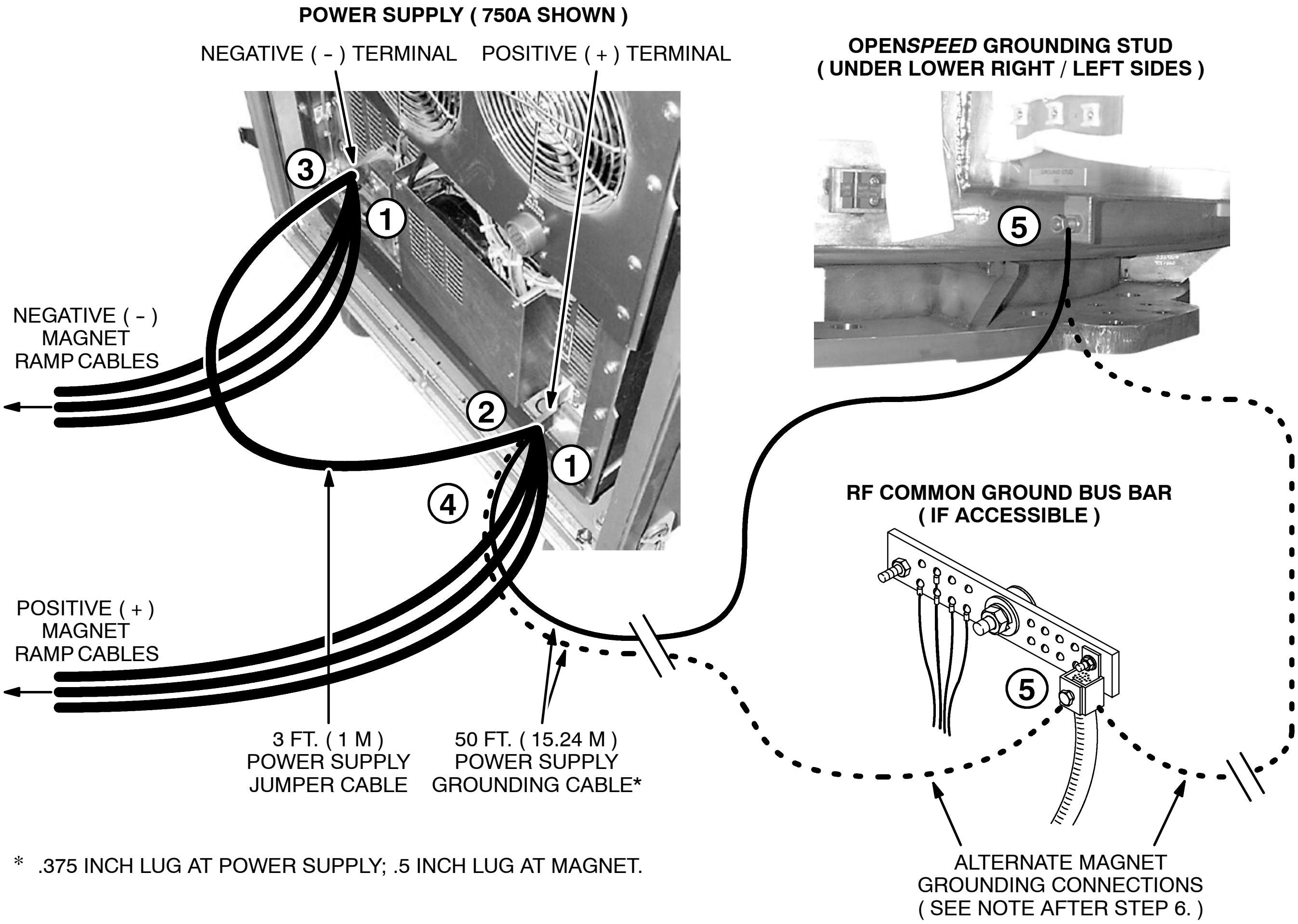
**Equipment**

- .375-16 x 1.75 inch Brass Screws, Washers and Nuts ( 2 )
- 3 ft. ( 1 M ) Power Supply Jumper Cable
- 50 ft. ( 15.24 M ) Power Supply Grounding Cable

## 1-4 PRE-RAMPDOWN PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

### Procedure

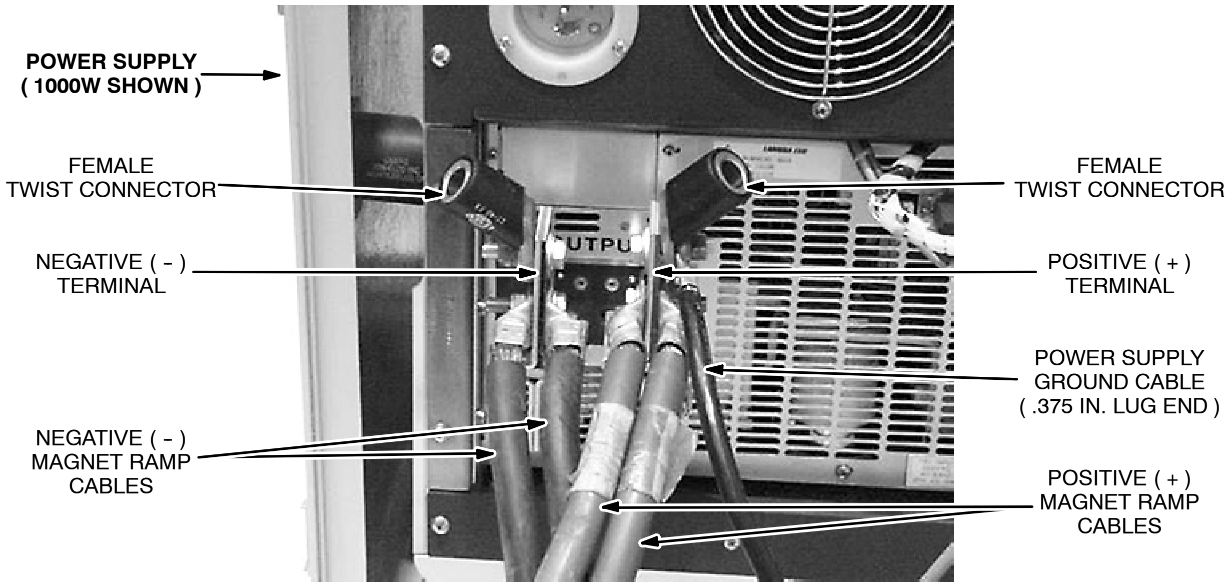
1. Connect the Magnet Ramp Leads to the Ramp Power Supply in the standard configuration and using the .375-16 x 1.75 inch brass screws, washers and nuts. See Illustration 1-5, label “1”.




**PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS**
ILLUSTRATION 1-5

## 1-4 PRE-RAMPDOWN PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

2. Disconnect the female twist connector lugs from the 3 ft. ( 1 M ) Power Supply Jumper Cable and then connect the lugs to the positive ( + ) and negative ( - ) power supply output terminals. See Illustration 1-6.

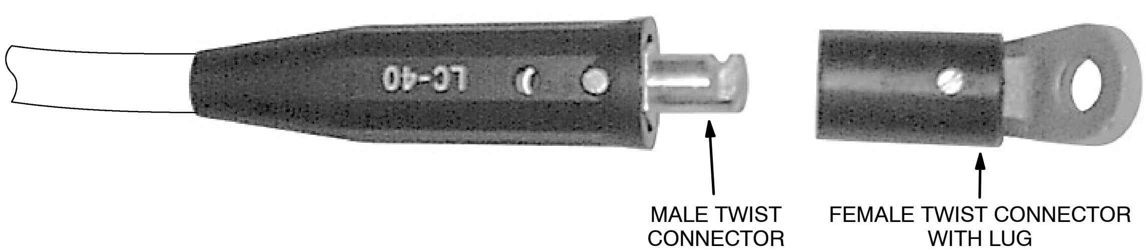



**FEMALE TWIST CONNECTORS ATTACHED TO POWER SUPPLY OUTPUT TERMINALS**
ILLUSTRATION 1-6

3. Connect one twist connector lug ( shown in Illustration 1-7 ) of the Power Supply Jumper Cable to the power supply's positive ( + ) terminal. Make sure the twist connector is fully engaged. See Illustration 1-5, label "2".

4. Connect the other twist connector lug( shown in Illustration 1-7 ) of the Jumper Cable to the power supply's negative ( - ) terminal. Make sure the twist connector is fully engaged. See Illustration 1-5, label "3".

5. Connect the .375 inch ( 9.5 mm ) lug of the 50 foot ( 15.24 M ) Power Supply Grounding Cable to the power supply's positive ( + ) terminal. See Illustration 1-5, label "4".




**TWIST CONNECTOR ON POWER SUPPLY JUMPER CABLE**
ILLUSTRATION 1-7

## 1-4 PRE-RAMPDOWN PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

6. Connect the Grounding Cable's .5 inch ( 12.7 mm ) lug to the magnet's grounding lug. See Illustration 1-5, label "5".

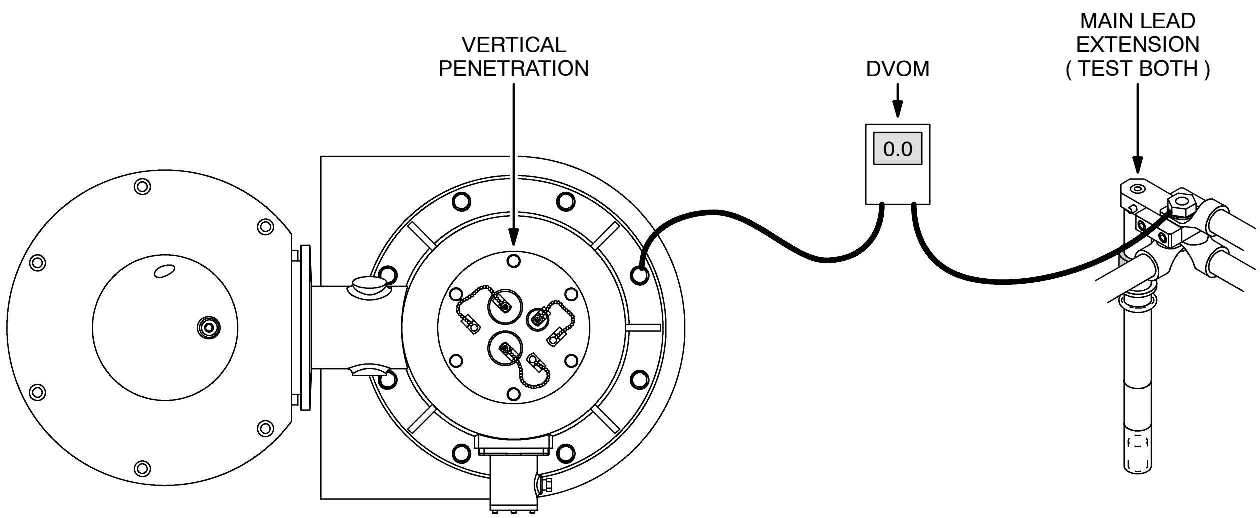
**Note**

If the magnet's grounding cable is connected to the RF Common Bus Bar at the Penetration Panel, the 50 foot ( 15.24 M ) Power Supply Grounding Cable can be connected between the power supply and the magnet or PDU ground wire clamp on the RF Common Bus Bar if more convenient. If the magnet is not grounded to the Penetration Panel, the Grounding Cable **must** be connected to the Cryostat Grounding Stud. See Illustration 1-5.

**CAUTION**

**Make sure there is a common ground ( resistance = 0 ohms ) between the Vacuum Vessel and the Main Lead Extension connections.**

7. Verify that the resistance between the Vacuum Vessel at the Vertical Penetration and each Main Lead Extension connection is zero ohms as read on a DVOM. See Illustration 1-8.



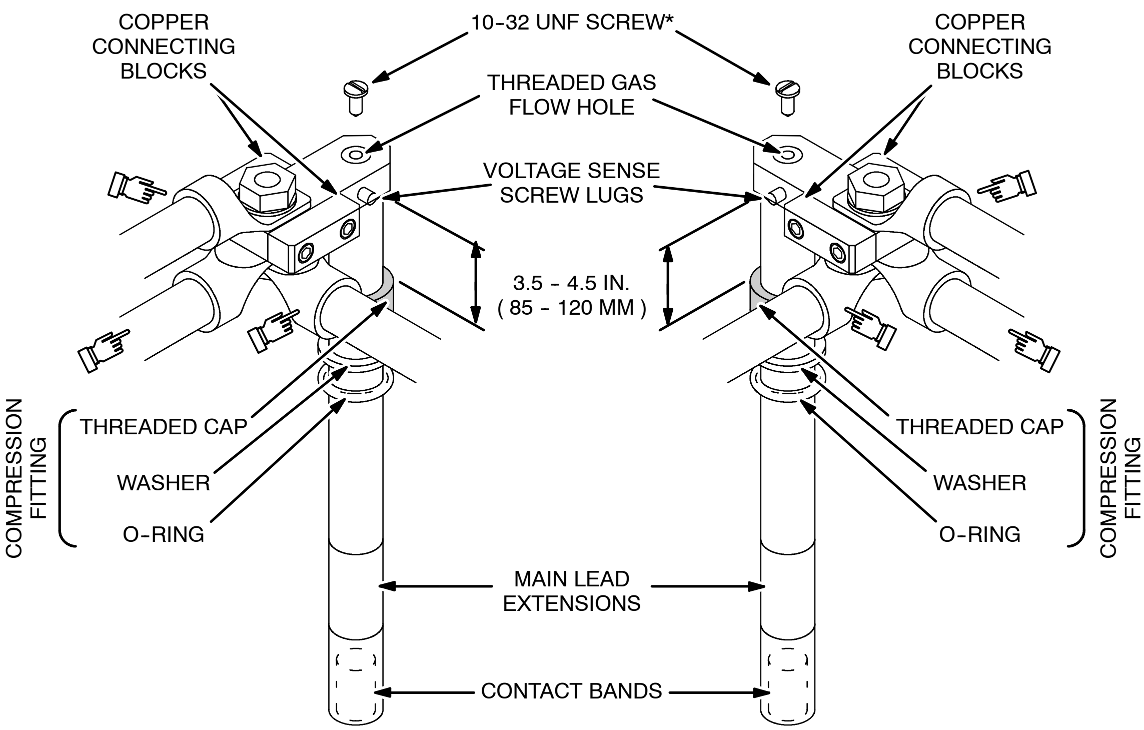

**VACUUM VESSEL TO MAIN LEAD EXTENSION RESISTANCE CHECK**
ILLUSTRATION 1-8

### 1-5 MAGNET CONNECTIONS - PERSON 1

1. Remove the threaded caps, washers and o-rings ( 46-294104P1, 46-294105P1, and 46-260389P1 ) from the plastic bag provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ) and mount them on the Main Lead Extensions. See Illustration 1-9.

**WARNING!**

**DO NOT LEAVE THE VENT SCREWS IN THE GAS FLOW HOLES FOR "DVM" CONNECTION SCREWS. THIS MAY CAUSE A QUENCH.**




* USED TO TEMPORARILY STOP GAS FLOW. REMOVE PRIOR TO RAMPING.

**COMPRESSION FITTING MOUNTING ON MAIN LEAD EXTENSIONS**
ILLUSTRATION 1-9

## 1-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

2. Place the end of the Main Power Cables on the Service Turret ( MSI-A3, A3 ). Allow about 3 feet ( 900 mm ) of slack.

3. Ty-wrap the cables at convenient locations on top of the magnet to avoid cable movement during ramping down.

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**WAIT FOR THE LEAD EXTENSIONS TO COOL SUFFICIENTLY ( A FOG OR WATER VAPOR FORMS AROUND THE LEAD EXTENSIONS ) BEFORE FULLY ENGAGING THEM, TO PREVENT THE RISK OF QUENCHING THE MAGNET.**

**CONNECTION POLARITIES MUST BE THE SAME AS IN DATA SHEETS, SECTION 5, MAGNET RAMPING & PARKING CURRENT LOG, TO PREVENT THE POSSIBILITY OF MISWIRING AND A RESULTANT QUENCH DURING FUTURE RAMPING OF THE MAGNET.**

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE, ALLOWING THE INTERNAL CRYOSTAT PRESSURE TO BUILD UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT THE CRYOSTAT DOWN TO $< 0.5$ PSIG THROUGH CRYOSTAT VENT VALVE V2 BEFORE EITHER REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

4. Check the Cryostat Pressure Gauge. If the pressure is above 0.5 psig, slowly open Helium Vent Valve V2 and allow pressure to drop to 0.5 psig. Then close Valve V2.

## 1-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

**CAUTION**

**To avoid the possibility of a quench, do not insert the Main Lead Extensions into the magnet unless the helium level is at 98% and then insert them slowly, with the 10-32 screws removed from Gas Flow Holes, to cool the Main Lead Extensions before insertion. Make sure gas is exiting Gas Flow Holes.**

5. Verify that the cryostat pressure is < 0.5 psig.
6. Remove the cap on one Main Lead Extension receptacle located on the Vertical Penetration. Make sure the gasket inside the cap does not get lost.

**CAUTION**

**Make sure the Gas Flow Holes in the Main Lead Extensions are not blocked and that gaseous helium is exiting through the holes. Blocked holes prevent heat dissipation and result in high contact resistance.**

7. Insert one Main Lead Extension into the open receptacle slowly enough to allow the Lead Extension to cool during insertion.

## 1-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

8. Continue inserting the Lead Extension until 85 - 120 mm ( 3.5 - 4.5 inches ) is left exposed, then loosely tighten the compression fitting.

9. Repeat Steps 6 - 8 for the second Main Lead Extension.

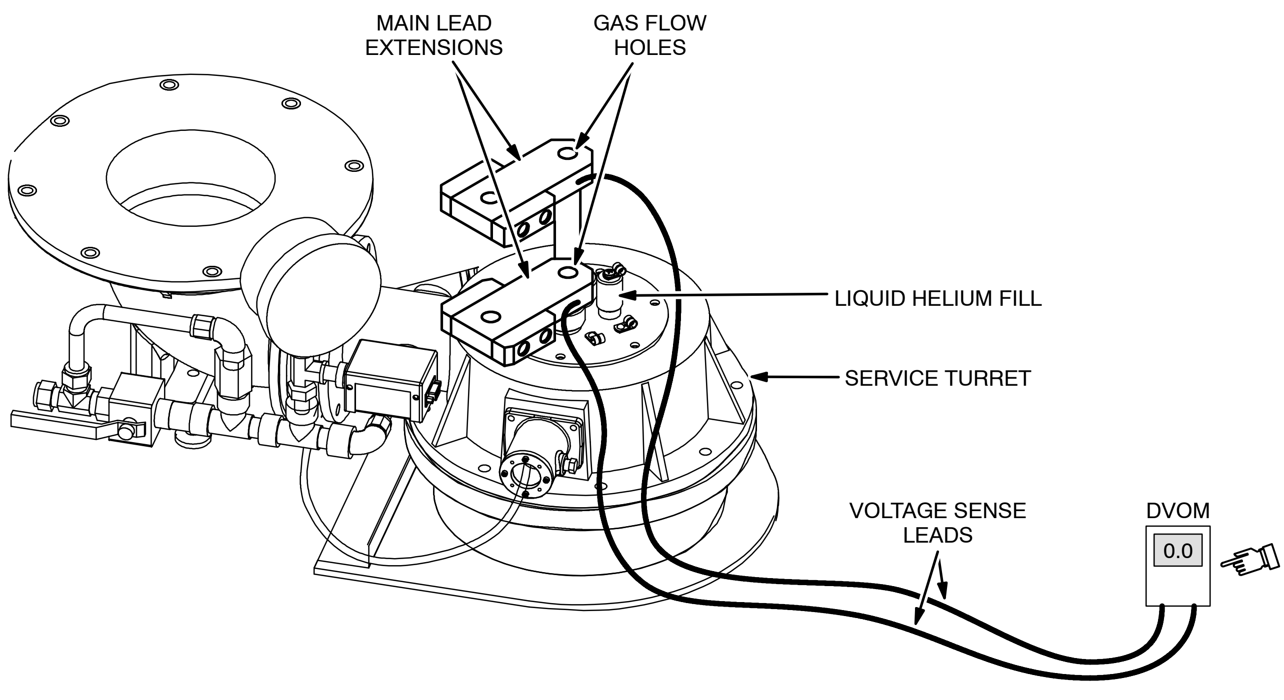
**Note**

The Main Lead Extensions will depress approximately 1 inch ( 25 mm ) from the point of contact to the fully engaged position. A firm contact will be felt when fully engaged. Do not rotate the Main Lead Extensions excessively when in the engaged position as internal contact wear could result.

10. When the Main Lead Extensions are sufficiently cooled, loosen the compression fittings and fully engage the Main Lead Extensions. Loosely tighten the compression fittings.

11. Retrieve the magnet polarity from DATA SHEETS, Section 5, Magnet Ramping & Parking Log.

12. Connect the Voltage Sense Leads to the Main Lead Extensions by clamping the spade lugs on the Voltage Sense Leads to the Main Lead Extensions with the screw lugs provided on the Lead Buss Bar. Terminate the other end of Voltage Sense Leads to a DVM or VOM placed near the Main Coil Power Supply. See Illustration 1-10.



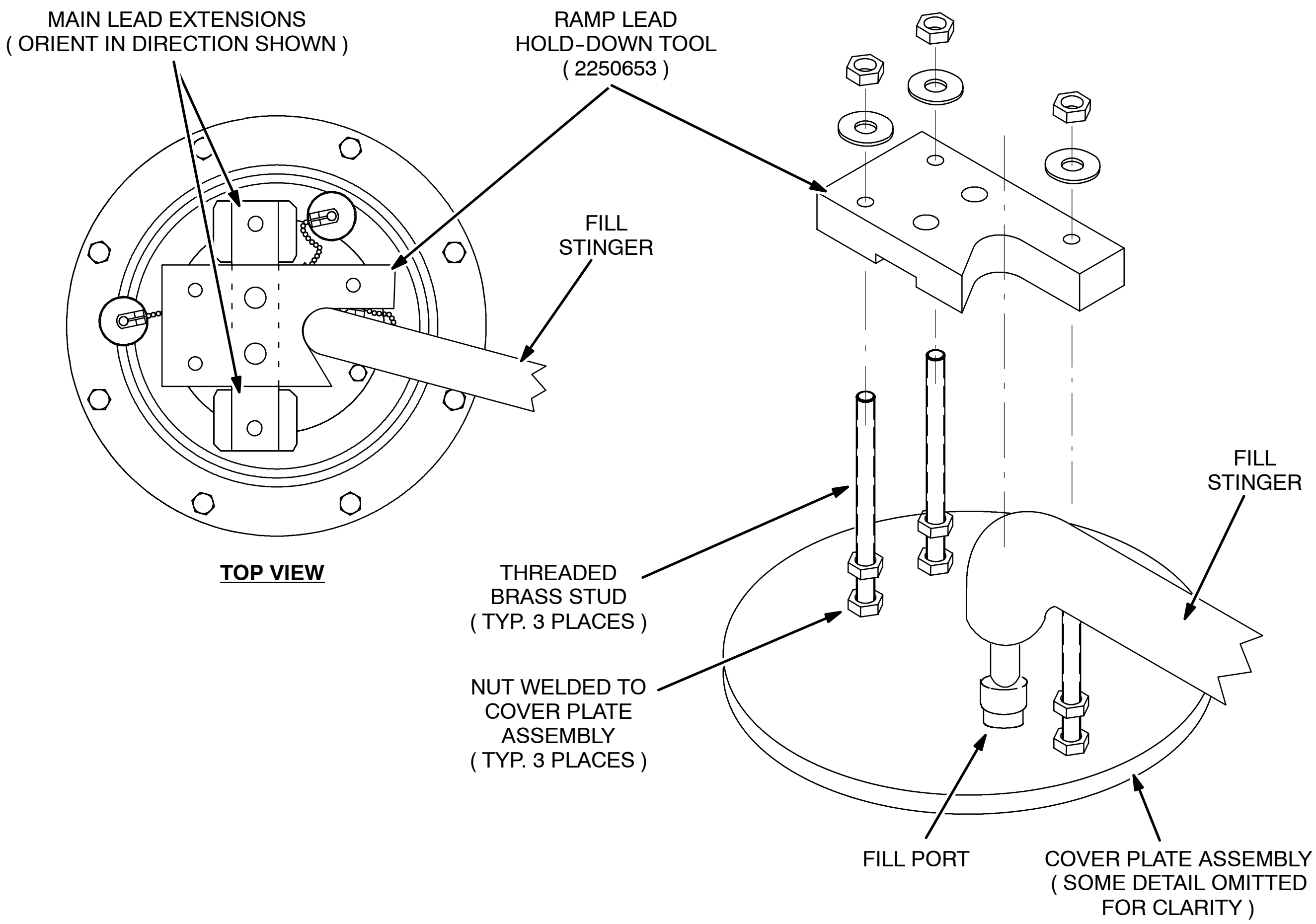

**MAIN COIL AND VOLT SENSE LEAD CONNECTIONS**
ILLUSTRATION 1-10

13. Insert three threaded brass studs into the nuts on the Vertical Penetration Cover Plate. See Illustration 1-11.

14. Install the Ramp Lead Hold-Down Tool ( 2250653 ). Make sure it is oriented properly, as shown in Illustration 1-11, to minimize Ramp Lead motion and help obtain good contact resistance.

## 1-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

15. Thread and tighten top nuts to hold the tool in place.
16. Hand tighten the Ramp Port compression nuts.




**RAMP LEAD HOLD-DOWN TOOL**
ILLUSTRATION 1-11

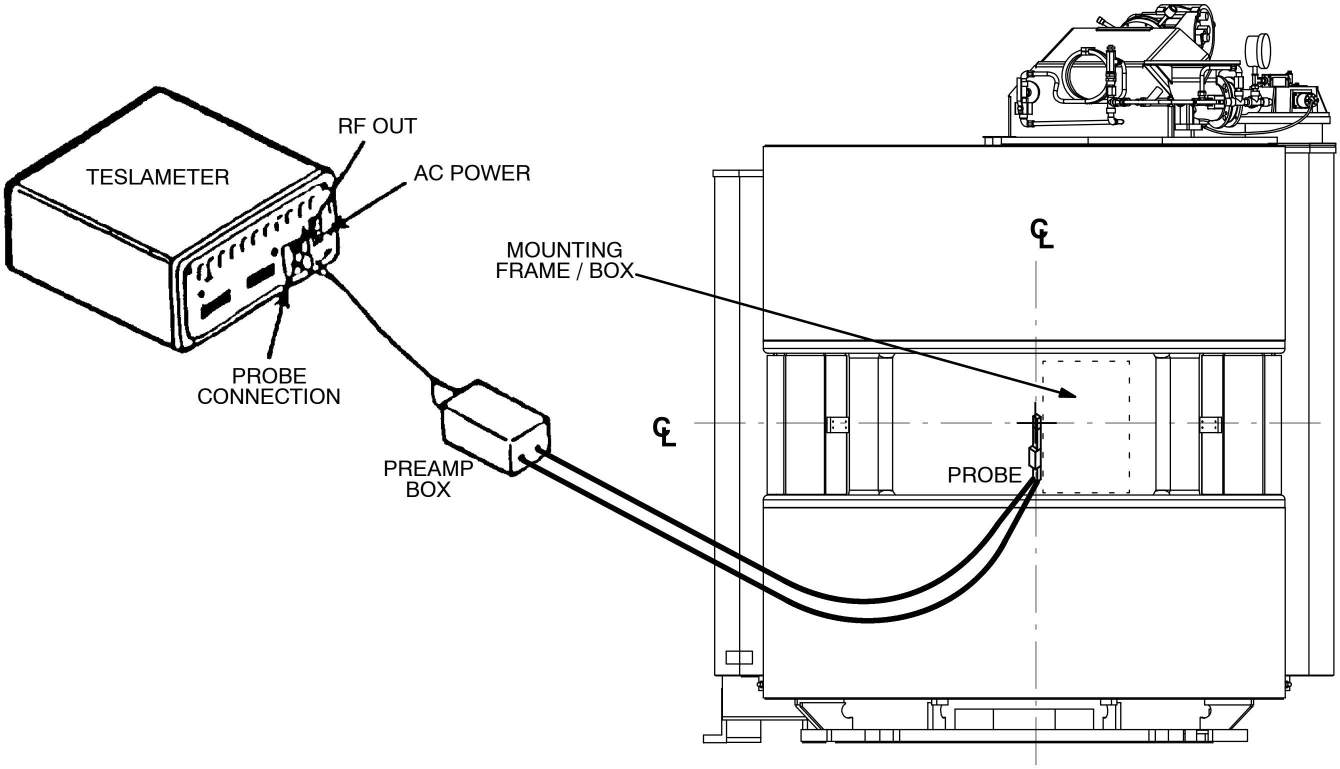
**CAUTION**

**Make sure the Gas Flow Holes in the Main Lead Extensions are not blocked ( i.e., the 10-32 screws have been removed ) and that gaseous helium is exiting through the holes before ramping down. Blocked holes prevent heat dissipation and result in high contact resistance.**

## 1-6 TESLAMETER / PROBE SET-UP AND ADJUSTMENT - PERSON 1

### 1-6-1 Set-Up

1. Mount and center the #4 Probe ( 0.35T - 1.05T ) in the magnet using a cardboard / wood box or frame made from nonferromagnetic material. See Illustration 1-12.
2. Connect the Preamp Box to the two Teslameter Probe inputs: the white Preamp Box wire to the Teslameter Probe left jack and the black Preamp Box wire to the right, lacing connector end of the Probe. See Illustration 1-12.
3. Turn on AC Power to the meter. The meter's rear view is shown in Illustrations 1-12 and 1-13.




**PROBE SET-UP AND TESLAMETER INTERCONNECTIONS**
ILLUSTRATION 1-12

4. Pull the Lock / Manual Switch and set in the "MANUAL" position.

**CAUTION**

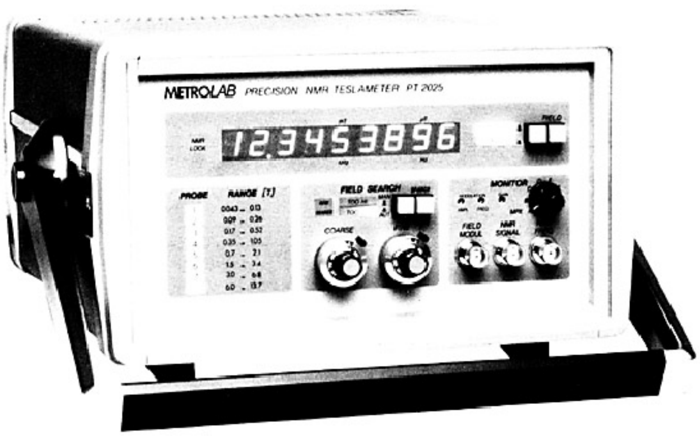
**If the Lock / Manual Switch is not in "MANUAL" position at start of field search during Ramping, the Teslameter's sweep will be in the ±5,000 gauss range and the system could lock onto the mechanical oscillation harmonic produced by the Cryocooler Coldhead, resulting in an erroneous reading.**

### 1-6-1 Set-Up ( continued )

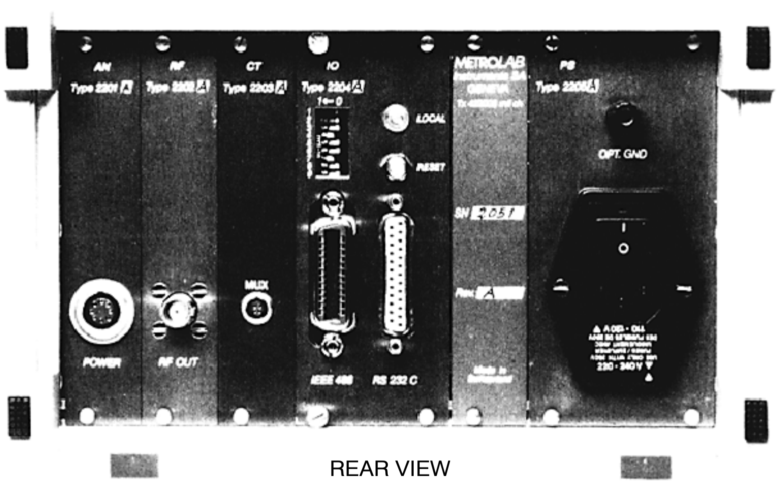
5. Turn the Coarse and Fine Control Knobs fully counterclockwise ( CCW ).

6. Pull the "Freq / Field" Switch and set to the "FIELD" position. The Teslameter is now set up and ready to start monitoring the field when ramping commences.

**Note:**
The Teslameter will not "lock in" on a probe signal until magnetic field is approximately 4000 Gauss.




FRONT VIEW




REAR VIEW

**TESLAMETER**
ILLUSTRATION 1-13

### 1-6-2 Teslameter Adjustment ( Ramp Down )

1. Increase the Coarse Control Knob until a field reading of approximately 5.000 gauss Is obtained. The field should be near but slightly below the actual field.
2. Slowly start increasing the Fine Control Knob while watching the “NO STROBE SIGNAL” LED. When the LED stops blinking and remains out, reposition the Lock / Manual Switch to the “LOCK” position.

**Note**
If the signal will not lock on, change the position of the Probe Modulation Switch.

3. Now that the Teslameter is locked on the field. note that either the “LO” or “HI” LED is lighted. Turn the Coarse Control in the direction of whichever LED is on. Slowly it will go out and stay out.
4. As the magnetic field decreases, the probe sample resonant frequency will decrease below the present setting of the Teslameter. Therefore, decrease the setting of the Coarse Control Knob to keep the Teslameter locked on the probe sample.

**Note:**
The Fine Control does not function when the Lock / Manual Switch is in the “LOCKED” position.

### 1-6-3 Teslameter Re-Sync

If the Teslameter should go out of sync while ramping the magnet up ( or down ), it can easily be resynchronized by the following procedure.

**Manual Re-Sync**

1. Reposition the Lock / Manual Switch to “MANUAL.”

**Note**:
The “NO STROBE” SIGNAL will be on; the “LO” / “HI” LEDs will be oscillating, indicating a search mode.

2. Note the present current reading on the Main Power Supply Current Meter.
3. Multiply the current times 6.85 gauss ( approximately 6.85 gauss / amp. ). The meter should be set at the resultant gauss level.
4. Slowly start increasing ( if ramping up ) the Coarse and / or Fine Control Knob while monitoring the “NO STROBE SIGNAL” LED.
5. Once the LED extinguishes, quickly place the Lock / Manual Switch to the “LOCK” position. The meter will now be in sync.

**Note:**
If the “HI” LED is lit, the Coarse Control Knob will have to be turned in the “HI” direction until the LED goes out. Repeat this adjustment as required until the parking field is reached.

### 1-6-3 Teslameter Re-Sync ( continued )

**Manual Re-Sync with Scope**

An oscilloscope can be set up near the Teslameter to display and trigger on the "FIELD MODULATION" signal from a jack on the Teslameter front panel. Adjust the time base to display one or two ramp wave forms. On the second channel, display the "SIGNAL" from the front panel of the Teslameter.

1. Leave the Teslameter in the "LOCKED" position.
2. Slowly turn the Coarse Control Knob in the direction the field is going ( e.g., if ramping up, turn the knob up to the higher numbers ).
3. As the meter is approaching the actual field, the baseline of the "FID" display will start to wander. Once the meter is in range of the field, the "FID" will appear on the scope trace as the meter locks on.
4. Once locked on, the "NO STROBE SIGNAL" LED will be out. Readjust the Coarse Control Knob slightly in the direction of the lighted "LO" / "HI" LED until that LED goes out.
5. Maintain tracking through end of ramp sequence.

## 1-7 FIELD ADJUSTMENT / RAMPDOWN PREPARATION - PERSON 1

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM.**

**SECURE THE MAGNET ROOM DOORS IN THE OPEN POSITION BEFORE CHANGING MAGNETIC FIELD.**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

1. Set up the field monitoring equipment, Probe and Teslameter in conformance with Section 1-6, Teslameter / Probe Set-Up And Adjustment. Make sure the Probe is positioned at the center of the magnet.
2. Make sure the Magnet Power Supply is installed, checked and adjusted in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5-1000-2-D-1236 Main Power Supply Calibration / Check. Verify that Heater 1 Main Power Supply is set for 810 ± 10 mA.
3. Make sure the Input Power Cable for the Power Supply is disconnected.
4. Make sure the Ramp Power Supply is connected to the magnet in conformance with SET-UP AND CALIBRATION, Sections 1-3, 1-4, and 1-5. Also make sure the Ramp Lead Hold-Down Tool is firmly in place and cooling gas is exiting from Main Lead Extensions.
5. Retrieve the Main Coil connection polarity in DATA SHEETS, Table 4.
6. Set the Heater 1 Main and Heater 2 Shim Axial switches to the “OFF” position. Set the Current Adjust and Voltage Adjust Controls to “O” ( full CCW ).
7. Connect the Input Power Cable to the Service Main Power Supply.
8. Make sure a Digital Voltmeter ( DVM ) is connected to the end of the Voltage Sense Leads and terminated at the power supply. The voltmeter will measure voltage across the Lead Extensions of the magnet.
9. Disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 1-6 and 1-7.

**Note**

Resistance measurements cannot be made and the magnet cannot be ramped with the Power Supply Jumper Cable connected.

## 1-8 RESISTANCE CHECKS - PERSON 1

**Note**

CCW = counterclockwise -------> decrease
CW = clockwise -------> increase

1. Make sure the Current Adjust and Voltage Adjust Controls on the Main Power Supply are off ( full CCW ). Turn on input power to the Power Supply.
2. Set the Heater 2 Shim Axial Switch to the "I" ( on ) position to enable power supply output.
3. Set the Voltage Adjust Control to "400" ( 4 turns counterclockwise from zero ) This will set a maximum limit of 3 V ( ~ 0.75 V / turn ) for the power supply output.
4. Observe the Main Power Supply Ammeter and slowly turn the Current Adjust Control counterclockwise to set 750A current through the Main Power Leads, Lead Extensions and persistent Main Switch.
5. Record the voltage reading on the Digital Voltmeter ( DVM ): ____________ mV.
6. A voltage reading < 150 mV indicates acceptable internal contact resistance of the Lead Extensions. If the voltage reading is > 150 mV, turn the Current Adjust Control off ( full CCW ), turn off the Power Supply Input Power and reseat the Lead Extensions on the top of the magnet.
7. Repeat Steps 1 through 5 if the Lead Extensions were reseated. Repeated readings > 150 mV indicate the need to replace the Lead Extension Contact Bands. See REPLACEMENT / MAINTENANCE, Section 12. Upon passing the internal resistance check, continue with Step 8.
8. Set the Toggle Switch on the Power Supply Voltmeter to the "Main Power Supply" position.
9. Read the voltage across the Power Supply Output Lugs. A Power Supply output voltage of 2.1 V or less at 750A indicates acceptable system resistance. If the voltage exceeds 2.1V during the test:
   a. Turn the Current Adjust Control off ( full CCW ).
   b. Turn off the input power.
   c. Check and retighten the bolts securing the Main Power Cables to the Power Supply and Lead Extensions.
   d. Turn the Power Supply back on.
   e. Repeat Step 9.
10. Upon passing Step 9, turn the Current Adjust and Voltage Adjust Controls to zero ( full CCW ) and continue with Section 1-9, Magnet Field Adjustment / Rampdown - Person 1.

## 1-9 MAGNET FIELD ADJUSTMENT / RAMPDOWN - PERSON 1

**WARNING!**

**MAKE SURE THE MAGNET IS 98% FULL OF LIQUID HELIUM AND A FULL 250-LITER OR LARGER DEWAR OF LIQUID HELIUM IS CONNECTED TO THE TRANSFER LINE BEFORE RAMPING TO PREVENT THE LIQUID HELIUM LEVEL FROM DROPPING DURING RAMPING TO A LEVEL WHERE A QUENCH MAY OCCUR.**

**A RAMPING VOLTAGE > 2.5V AT THE LEAD EXTENSIONS OF THE MAGNET MAY CAUSE THE MAGNET TO QUENCH.**

**MAKE SURE THE CONNECTION POLARITY AND THE CURRENT SETTINGS ARE THE SAME AS THE LAST ENTRY IN DATA SHEETS, SECTION 5, MAGNET RAMPING & PARKING CURRENT LOG. THE MAIN POWER SUPPLY MUST BE SET TO THE SAME CURRENT AND POLARITY IN THE MAIN COILS TO AVOID A QUENCH WHEN TURNING ON THE MAIN SWITCH.**

**IF A QUENCH OCCURS DURING FIELD ADJUSTMENT / RAMPDOWN, IMMEDIATELY TURN THE "VOLTAGE ADJUST" AND "CURRENT ADJUST" CONTROLS OF THE MAIN COIL POWER SUPPLY TO ZERO ( FULLY CCW ). A QUENCH IS A RAPID DISCHARGE OF THE MAGNETIC FIELD WHICH WILL RESULT IN THE RAPID GENERATION AND EXPULSION OF HELIUM GAS, RUPTURING THE BURST DISC IN THE VENT SYSTEM.**

### 1-9-1 Magnet Field Adjustment - Person 1

1. Make sure:
   - A new ( full ) 250 liter Dewar is installed in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.
   - The Current Adjust and Voltage Adjust Controls are set to zero ( full CCW ).
   - The Main Switch Heater is set to "OFF."
   - Magnet polarity and ramping current are retrieved from DATA SHEETS, Section 5-1, Magnet Ramping & Parking Current Log.
2. Turn the Power Supply and Auxiliary Switch Heater on.
3. Engage the Set Point Button ( depress and hold until current is set ) and set the Current Adjust Control for a maximum current of 10% above parking current.
4. Leave the Current Adjust Controls at setting in Step 3. Turn the toggle switch on the Power Supply Voltmeter to the "Main Coil" position.
5. Use the Voltage Adjust Control to set the Power Supply output current to the parking current value.

### 1-9-1 Magnet Field Adjustment - Person 1 ( continued )

6. Turn the Heater 1 Main Switch on the Power Supply to “ON” and wait 10 minutes for the switch to go normal ( resistive ).
7. Turn the Current Adjust Control to obtain the desired field as read on the Teslameter.
8. Adjust the magnetic field within the 29.803 - 29.811 MHz ( 6998.0 - 7002.0 gauss ) range.
9. Maintain the current at the final setting until the Main switch goes into “persistent” mode.
10. Set Heater 1 Main Switch to “O” ( off ). Wait a minimum of 10 minutes for the switch to fully cool and go “persistent.”

**Note**

Read the voltage on the Power Supply Voltmeter with its toggle switch in “Main Coil” position. When the switch goes “persistent” the voltage across the magnet terminals will drop to approximately 0.00V. This sudden voltage drop will indicate that the switch has gone into the persistent mode.

11. Record current value at which the switch went “persistent” in DATA SHEETS, Section 5-1, Magnet Ramping & Parking Current Log.
12. After the switch goes “persistent” slowly turn the Power Supply’s Current Adjust Controls to zero ( full CCW ) over a one minute period. Make sure the voltage reading remains at zero.
13. Gradually turn the Voltage Adjust Control to zero over a one minute period and then turn the Power Supply off.
14. Turn off the Auxiliary Switch Heater and Ramp Power Supply.
15. Disconnect Input Power Cable from the Main Power Supply.
16. Slowly open Valve V2 while observing the Pressure Gauge to depressurize the Cryostat. When the pressure reaches 0.5 psig, close Valve V2.
17. Reconnect the Power Supply Jumper Cable’s twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 1-5 and 1-7.
18. Remove the Ramp Lead Hold-Down Tool and replace the bolts on the Lead Assembly Mounting Plate.

### 1-9-1 Magnet Field Adjustment - Person 1 ( continued )

**WARNING!**

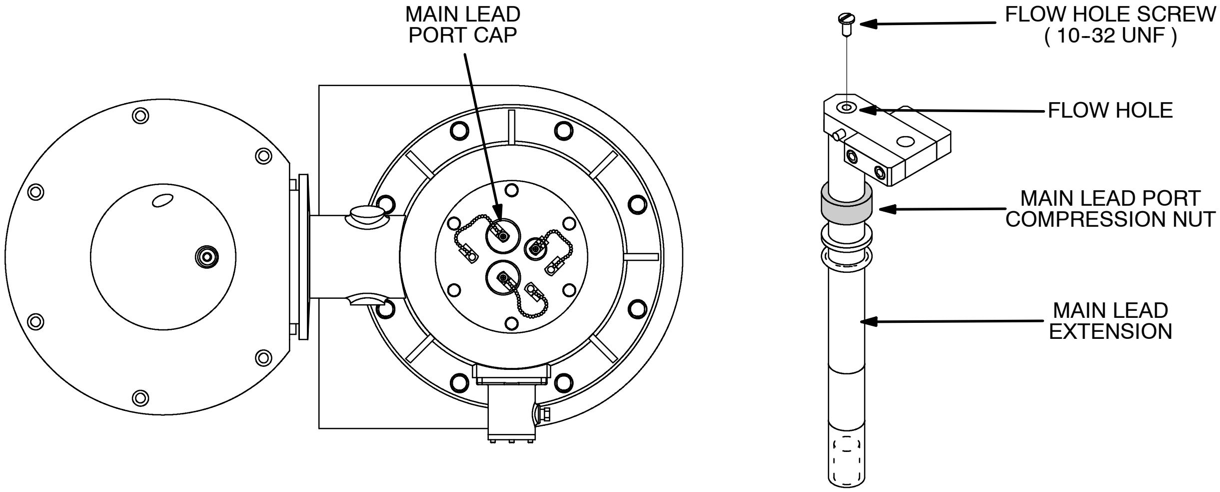
**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

19. After parking the magnet and disconnecting the Main Power Supply, plug and remove one Main Lead Extension at a time in the following sequence.
    a. Open Valve V2 to depressurize the cryostat to < 0.5 psig. Close V2.
    b. Install the screw into the flow hole of only one Main Lead Extension at a time. See Illustration 1-14.
    c. Remove all ice around the Main Lead Port compression nut on the Main Lead Extension that is being removed ( i.e. the Main Lead Extension that has the flow hole plugged in Step 19b ).
    d. Unscrew the Main Lead Port compression nut and remove the Main Lead Extension from the magnet. Immediately replace the cap onto the Main Lead Port.
    e. Repeat these steps ( a - d ) for the other Main Lead Extension.
20. Remove the Power Supply Jumper and Grounding Cables.

## 1-9-1 Magnet Field Adjustment - Person 1 ( continued )




**MAIN LEAD EXTENSION AND MAIN LEAD PORT COMPRESSION NUT**
ILLUSTRATION 1-14

## 1-9-2 Magnet Rampdown to Zero Field - Person 1

1. Make sure:
   - The Current Adjust and Voltage Adjust Controls are set to zero ( full CCW ).
   - The Main Switch Heater is set to “OFF.”
   - Magnet polarity and ramping current are retrieved from DATA SHEETS, Section 5-1, Magnet Ramping & Parking Current Log
2. Turn the Power Supply and Auxiliary Switch Heater on.
3. Engage the Set Point Button ( depress and hold until current is set ) and set the Current Adjust Control for a maximum current of 10% above parking current.
4. Leave the Current Adjust Control at its setting; turn the power supply Voltmeter’s switch to “MAIN COIL.”
5. Use the Voltage Adjust Control to set the power supply output current to the parking current value.
6. Turn the Heater 1 Main Switch on the Power Supply to “ON” and wait 5 minutes for the switch to go normal ( resistive ).

### 1-9-2 Magnet Rampdown to Zero Field - Person 1 ( continued )

7. Ramp down the magnet in conformance with Table 1-2 as follows:

   a. Slowly turn the power supply's Voltage Adjust Control to obtain the Main Coil Voltage value shown in the table, starting with -0.30 volts.

   **Note**
   Turn the power supply's Voltage Adjust Control counter clockwise to set a negative voltage value.

   b. Monitor the power supply's Current Meter. When the limit of the current range for the voltage setting is reached, slowly turn the Voltage Adjust Control to obtain the Main Coil Voltage for the next range.

TABLE 1-2
**MAIN COIL RAMP CURRENT VERSUS VOLTAGE**

| "STAGE" | MAIN COIL ( RAMP ) CURRENT RANGE ( AMPS ) | | MAIN COIL ( RAMP ) VOLTAGE ( VOLTS ) |
|---|---|---|---|
| | FROM | TO | |
| 1 | | 750 | -0.30 |
| 2 | 750 | 720 | -0.35 |
| 3 | 720 | 700 | -0.40 |
| 4 | 700 | 675 | -0.50 |
| 5 | 675 | 650 | -0.60 |
| 6 | 650 | 625 | -0.80 |
| 7 | 625 | 600 | -1.00 |
| 8 | 600 | 550 | -1.30 |
| 9 | 550 | 500 | -1.50 |
| 10 | 500 | 0 | GRADUALLY TURN THE VOLTAGE CONTROL TO ZERO ( FULL CCW ) THEN TURN THE CURRENT CONTROL TO ZERO ( FULL CCW ) |

8. When the ramping current reaches 500 amps, slowly turn the Voltage Adjust Control to 0.0 volts ( full CCW ) and then the Current Adjust Control to 0.0 amps ( full CCW ).

9. Observe the voltmeter reading with the power supply's Voltmeter Select Switch in the "MAIN COIL" position. A zero reading on the power supply's digital Voltage and Current Meters indicates that the magnet is fully discharged.

10. When the magnet is full discharged, set the Heater 1 Main and the Heater 2 Auxiliary Switches to "O" ( off ).

11. Set the Main Power and Power On Switches to "OFF."

12. Disconnect the input power cable from Magnet Power Supply.

13. Slowly open Valve V2 while observing the Pressure Gauge to depressurize the Cryostat. When the pressure reaches 0.5 psig, close Valve V2.

### 1-9-2 Magnet Rampdown to Zero Field - Person 1 ( continued )

14. Reconnect the Power Supply Jumper Cable's twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 1-5 and 1-7.

15. Remove the Ramp Lead Hold-Down Tool and replace the bolts on the Lead Assembly Mounting Plate.

16. Make sure the magnet is at 98% helium fill level.

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

17. After parking the magnet and disconnecting the Main Power Supply, plug and remove one Ramp Lead Extension at a time in the following sequence.

    a. Open Valve V2 to depressurize the cryostat to < 0.5 psig. Close V2.

    b. Install the screw into the flow hole of only one Main Lead Extension at a time. See Illustration 1-15.

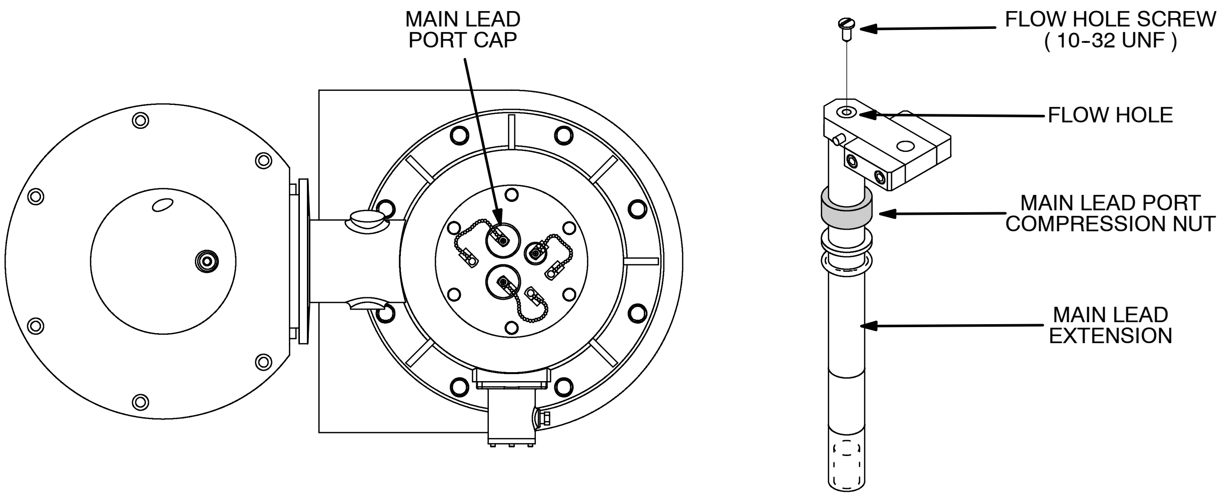
    c. Remove all ice around the Main Lead Port compression nut on the Main Lead Extension that is being removed ( i.e. the Main Lead Extension that has the flow hole plugged in Step 17b ).

    d. Unscrew the Main Lead Port compression nut and remove the Main Lead Extension from the magnet. Immediately replace the cap onto the Main Lead Port.

    e. Repeat these steps ( a - d ) for the other Main Lead Extension.

## 1-9-2 Magnet Rampdown to Zero Field - Person 1 ( continued )

18. Remove the Power Supply Jumper and Grounding Cables.




**MAIN LEAD EXTENSION AND MAIN LEAD PORT COMPRESSION NUT**
ILLUSTRATION 1-15

# SECTION 2 – ICE REMOVAL

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 2–1 INTRODUCTION

Ice can form inside the magnet's Vertical Penetration or plumbing from the "cryopumping" of air entering through a ruptured Burst Disc, open Fill / Ramp Lead Ports and / or leaks at relief valves, plumbing joints and fittings.

Maintaining a positive pressure inside the cryostat and making routine leak checks will minimize cryopumping and ice formation. See FUNCTIONAL CHECKS, Section 2–3, Leak Troubleshooting.

Ice tends to form on the cold walls and platform of the Vertical Penetration and at the entry of the shield exhaust plumbing. Icing of the Recondenser can also result from the migration of ice and moisture into the colder areas of the cryostat.

Ice in the Vertical Penetration may result in a minor thermal short, causing an increase in Cryocooler temperature and magnet pressure and / or the inability to install the Ramp Leads or Fill Stinger. Plumbing plugs will restrict or prevent venting through cryostat Vent Valve V2 or the Shield Coil Vent Valve V3. An ice plug in the Recondenser will interfere with the recondensing cycle and result in a temperature drop at the Cryocooler and Recondenser and a simultaneous pressure increase in the cryostat. If the flow from Vent Valve V2 is restricted, slightly open the Fill Port. If there is no flow from V2 or the Fill Port, immediately contact your MAC Team Representative before continuing.

Use the troubleshooting guide in FUNCTIONAL CHECKS, Section 2, Magnet Helium Loss Troubleshooting Guide, to determine the location and extent of the suspected ice before starting this procedure.

## 2-1 INTRODUCTION ( continued )

Make sure that the following DANGERS, WARNINGS and CAUTIONS are complied with before starting ice removal procedures.

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY, GAS IS AT 2400 PSI. MAKE SURE CYLINDER IS SECURE AND WILL NOT FALL DURING USE.**

**WARNING!**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD BEFORE OPENING THE VERTICAL PENETRATION OR BLOWING WARM HELIUM GAS INTO THE CRYOSTAT TO PREVENT A QUENCH AND THE RAPID EXPULSION OF LIQUID HELIUM OUT OF THE CRYOSTAT.**

**SECURE THE MAGNET ROOM DOOR IN THE OPEN POSITION AND TURN ON THE MAGNET ROOM EXHAUST FAN TO EXHAUST THE INVISIBLE, ODORLESS HELIUM GAS GENERATED DURING THE FOLLOWING PROCEDURES AND TO PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM.**

**RAPID EXHAUSTING OF COLD HELIUM GAS MAY BE ENCOUNTERED DURING THE FOLLOWING PROCEDURES. WEAR NONABSORBENT GLOVES AND GOGGLES WHEN PERFORMING THESE PROCEDURES.**

**THE CRYOSTAT MAY BE PRESSURIZED UP TO 7.5 PSIG. OBSERVE CRYOSTAT PRESSURE GAUGE READINGS AND VENT THE CRYOSTAT DOWN TO < 0.5 PSIG THROUGH VENT VALVE V2 BEFORE LOOSENING OR REMOVING ANY COMPONENT WHICH WILL ALLOW THE CRYOSTAT TO DEPRESSURIZE.**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## 2-1 INTRODUCTION ( continued )

**CAUTION**

**Turn off the Cryocooler before depressurizing and opening the cryostat to prevent the migration of ice and moisture into the Recondenser.**

**Do not allow the Vertical Penetration to remain open during deicing procedures to prevent air / moisture from entering and cryopumping the walls. Cover the open vertical stack immediately with the Cover Plate.**

The following equipment is required for ice removal:

- Lexan Cover Plate ( 2243789 ) in Spare Parts Kit 46-294232G4
- Plexiglas Cover Plate / Heater Assembly ( 2303715 )
- Flashlight
- 235 SCF Helium Gas Cylinder
- High Pressure Regulator and Hose Kit ( 46-306734G1 )
- Tygon Tubing and 0.25 x 18.00 inch ( 6.35 x 457.2 mm ) Copper or Stainless Steel Wand
- Heat Gun
- Roll of aluminum foil
- Latest revision of Direction 2231934, *GE 0.7T OpenSpeed Magent and Cryogens Subsystem Manual,* for access to referenced procedures.

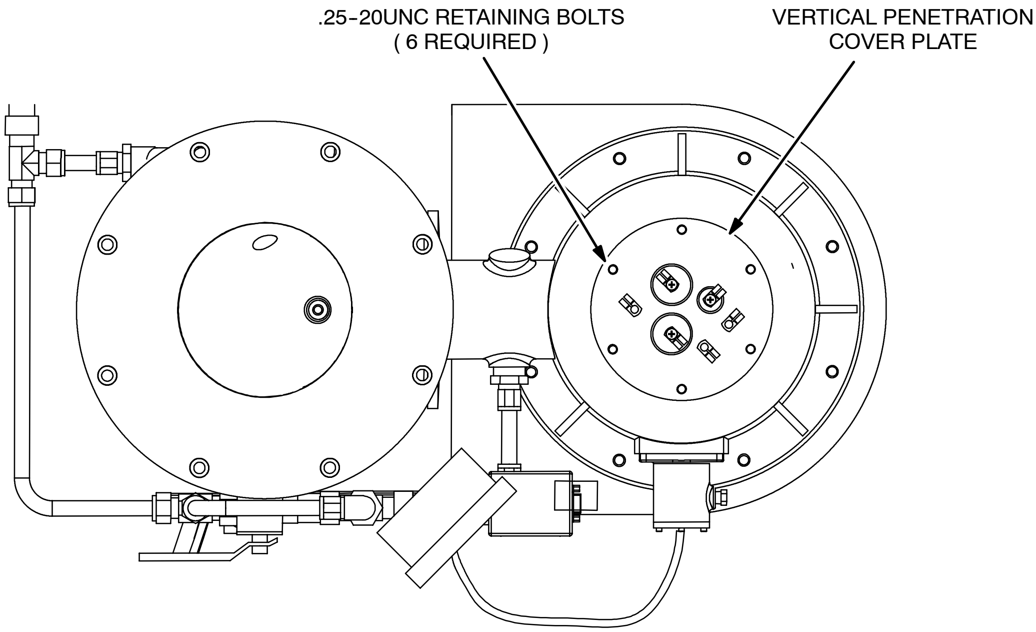
## 2-2 ICE REMOVAL FROM VERTICAL PENETRATION

**CAUTION**

**When removing ice in the Vertical Penetration, be careful not to contact the Instrumentation Lead or Lemo connector with ice-clearing tools. Contact could damage the lead or connector.**

1. Prepare the magnet as follows:
   - Ramp down to zero field in conformance with REPLACEMENT / MAINTENANCE, Section 1, Magnet Field Adjustment / Rampdown.
   - Turn off the cryocooler. Make sure all DANGERS, WARNINGS and CAUTIONS are complied with.
   - Vent cryostat down to < 0.5 psig through the Vent Valve V2.
2. Loosen and remove the six .25-20UNC retaining bolts and washers and remove the Vertical Penetration's Cover Plate. See Illustration 2-1.

## 2-2 ICE REMOVAL FROM VERTICAL PENETRATION ( continued )




**REMOVAL OF VERTICAL PENETRATION COVER PLATE**
ILLUSTRATION 2-1

**CAUTION**

**Remove, store and replace the Cover Plate carefully to prevent any damage to the Baffle Tree Assembly.**

3. Immediately position the Lexan Cover Plate with plugs in place on the Vertical Penetration and secure with the six retaining bolts ( without washers ).

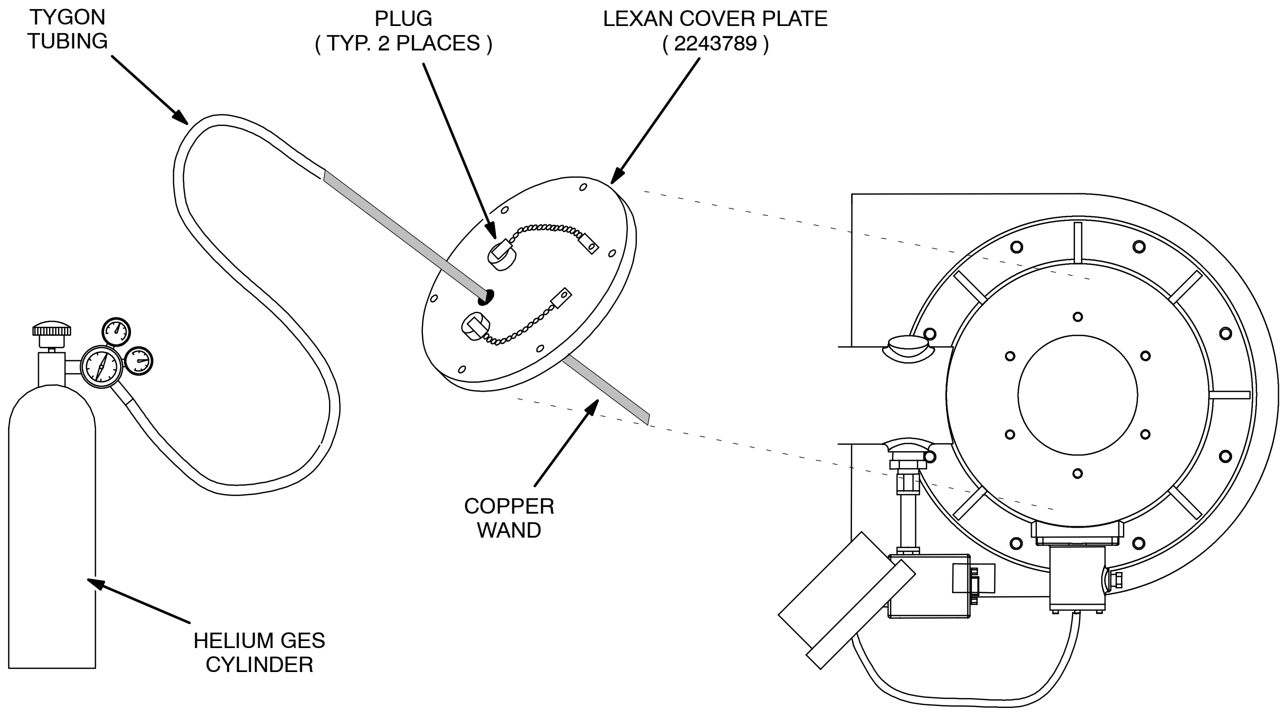
4. Shine the flashlight through the Lexan Cover Plate to inspect the Vertical Penetration for frost / ice.

**Note**:
Major ”water ice” buildup in the Vertical Penetration, resulting from a blown Burst Disc or a large leak left unattended, will require removal by chiseling and vacuuming out the contents with the Cover Plate removed. Magnet warm up is recommended for this case after all accessible ice has been removed.

5. Assemble the copper wand, tygon tubing, regulator and helium gas cylinder and purge at 4 psig helium gas flow. See Illustration 2-2.

6. Remove the plugs on the Cover Plate to allow the exhaust of gas and moisture and to insert the copper wand. Increase gas flow to 8 - 10 psig.

## 2-2 ICE REMOVAL FROM VERTICAL PENETRATION ( continued )




**ASSEMBLY OF WAND, TUBING, REGULATOR AND CYLINDER**
ILLUSTRATION 2-2

7. Direct the helium flow to remove ( scrub ) the frost / ice.

**Note:**
Some bending of the copper wand may be required to direct the gas flow onto the area of frost / ice. If the ice is difficult to remove, increase the helium flow ( 10 - 12 psig ) or use copper heat exchange coils with a heat gun to pre-heat the helium gas.

8. Inspect the Vertical Penetration for frost / ice removal. Make sure all frost and ice have been removed.

9. When all frost and ice are removed, remove the Lexan Cover Plate and immediately replace the Vertical Penetration's Cover Plate, securing it with the six retaining bolts. Use one flat washer and one lockwasher on each bolt.

10. Turn the cryocooler on and monitor the temperature drop.

11. Leak test the magnet in conformance with FUNCTIONAL CHECKS, Section 2-3, Leak Troubleshooting. Repair any leaks found.

12. Recommission the magnet ( ramp / shim ) in conformance with SET-UP AND CALIBRATION, Sections 4, 5 and 6.

## 2-2 ICE REMOVAL FROM VERTICAL PENETRATION ( continued )

**IMPORTANT !!!**

Perform all MRU checks in FUNCTIONAL CHECKS, Section 6, upon completion of Vertical Penetration ice removal to make sure no Instrumentation Lead or Lemo connector damage has occured. Correct any damage found by reconnecting the Lemo connector or replacing the Instrumentation Lead Assembly.

13. Check the Instrumentation Lead and Lemo connector for damage by performing the MRU checks in FUNCTIONAL CHECKS, Section 6.

## 2-3 REMOVAL OF ICE PLUG IN MAGNET PLUMBING

1. Make sure all DANGERS, WARNINGS and CAUTIONS are complied with.
2. Isolate the location of any ice plug in the plumbing by checking for flow through valve V2 and then V3.

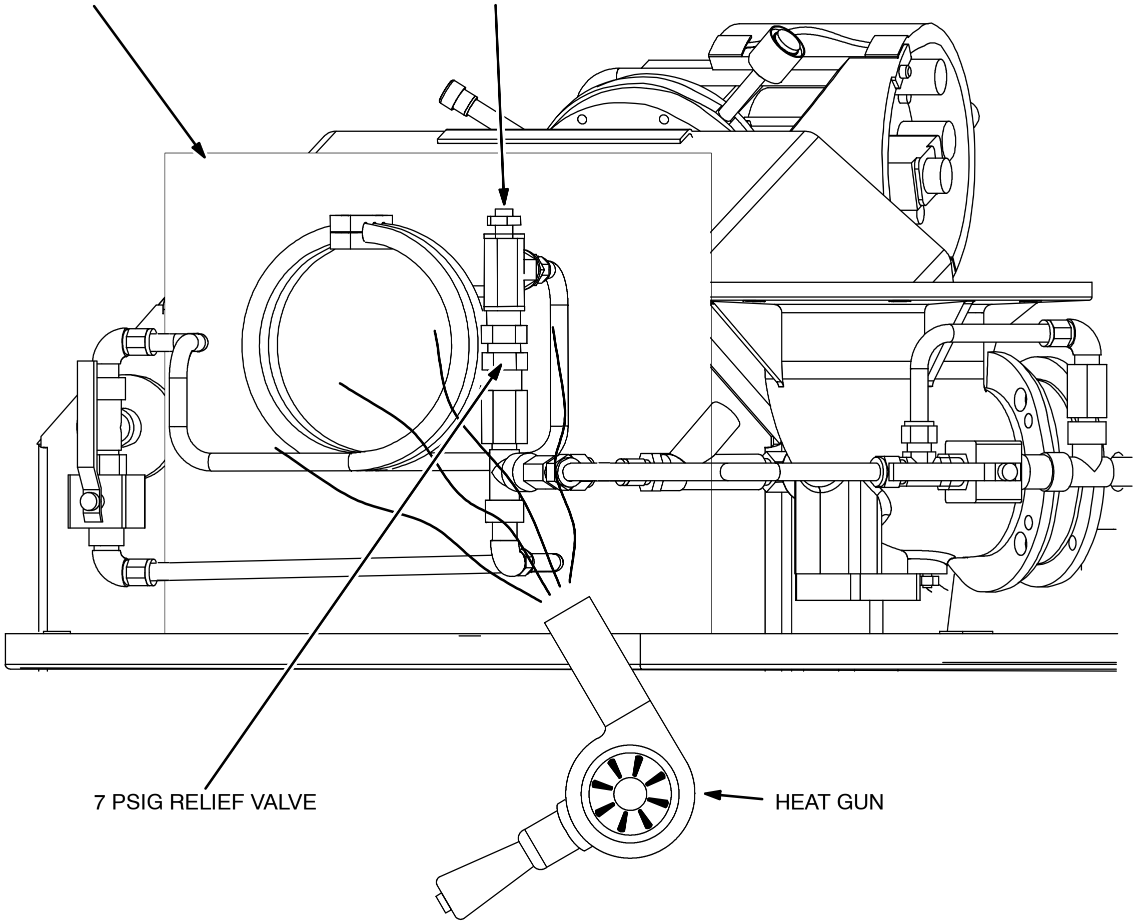
**Note**:
Any non-flow condition indicates an ice plug internal to or at the plumbing exit point on the magnet. Outside plumbing beyond that point is too warm for an ice plug.

**CAUTION**

**There may be a small magnetic attraction with the heat gun specified in Step 3. Maintain a firm hold on the heat gun at all times. Do not use a heat gun with a ferromagnetic case.**

3. Place aluminum foil as a backdrop to the plumbing exit point where ice is suspected. See Illustration 2-3.
4. Use a heat gun on the plumbing in front of the aluminum foil backdrop to melt internal ice.
5. Check for flow through valves V2 / V3 after heating the plumbing. If no flow is present, continue with Step 6.

## 2-3 REMOVAL OF ICE PLUG IN MAGNET PLUMBING ( continued )




**ASSEMBLY OF FOIL BACKDROP**
ILLUSTRATION 2-3

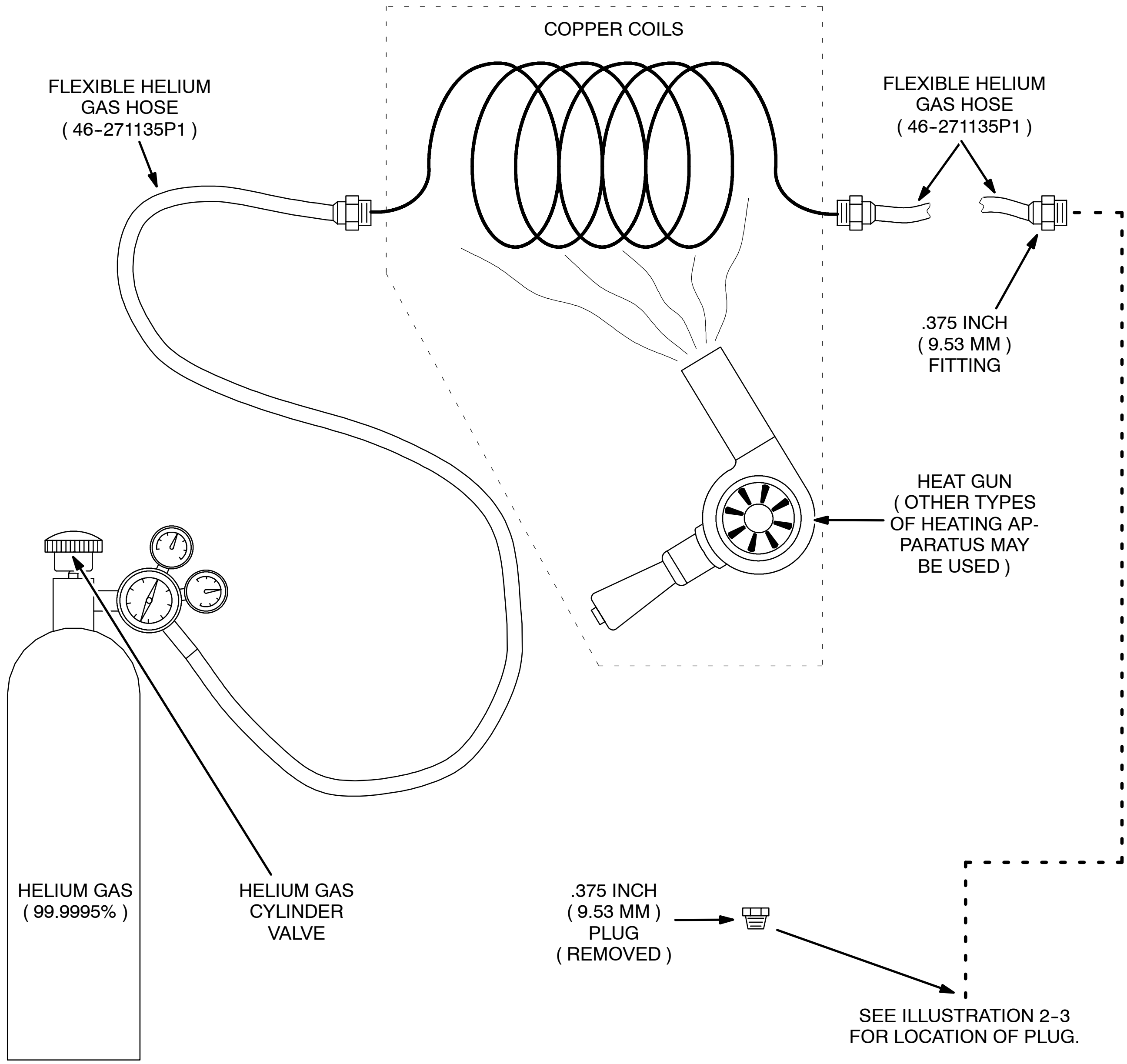
6. Vent the magnet down to < 0.5 psig and disconnect the plumbing at the exit point. See Illustration 2-4. If flow is present from the exit, there a block in the plumbing / valve assembly and it will require replacement or repair. If flow is not present, continue with Step 7.

**CAUTION**

**Do not use the copper wand or insert the tubing over two inches into the shield plumbing exit as damage to the bellows of the internal plumbing may result.**

7. Use the tygon tubing without the copper wand to blow warm helium gas into the exit port to melt the ice.
8. If flow is not restored, continue with Section 2-4, Recondenser Ice Removal. If flow still not restored, the magnet will require warming up.

## 2-3 REMOVAL OF ICE PLUG IN MAGNET PLUMBING ( continued )




**RECONDENSER PURGE SET-UP**
ILLUSTRATION 2-4

## 2-4 RECONDENSER ICE REMOVAL

### 2-4-1 Introduction

Clearing ice in the Recondenser and Shield Exhaust Plumbing is required under the following conditions:

- No helium flow exists the 5 psig relief valve when magnet pressure exceeds 5 psig.
- The Recondenser temperature is < 4.0K.
- Corresponding temperature for magnet stabilized pressure in FUNCTIONAL CHECKS, Section 2, Illustration 2-4, is more than 0.2K over the Recondenser temperature reading.

This section gives four procedures to clear ice from the the Recondenser, each involving greater cost and more down time than the one before. The first two procedures do not require a magnet ramp down, while the thrid and fourth do. The fourth procedure also requires a magnet warm-up and a dry nitrogen purge.

Always start with the first procedure and progress through no more procedures than required to clear the ice.

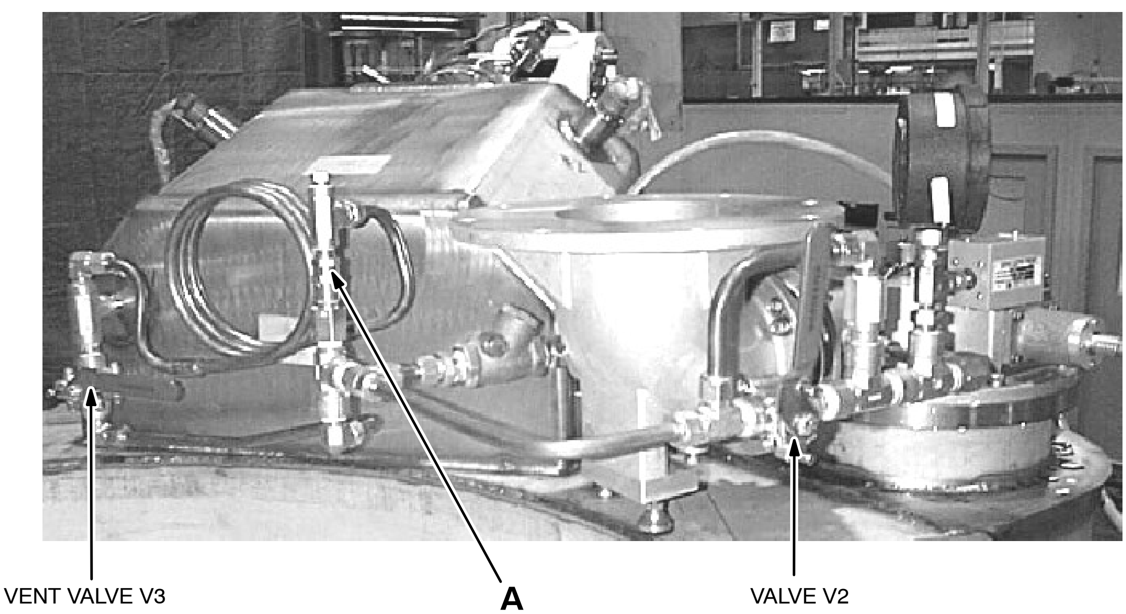
### 2-4-2 Initial Magnet Evaluation

Evaluate the magnet's condition before taking any action involving physical changes to the magnet operating condition. Presumably, the magnet is not operating in "C0BO" ( Controlled Zero Boil-Off ) condition ( where the heater maintains the Magnet Monitor pressure reading at 1 ± 0.1 psig ).

Flow through the shield cooling line should be verified either by frost on the 7.5 psig relief valve line at point "**A**" in Illustration 2-5 or by momentarily cracking the fitting at point "**B**" in Illustration 2-5.

Penetration venting should be verified by momentarily cracking open Vent Valve V2 and listening for a vigorous flow. If the penetration is plugged by ice, **DO NOT TURN OFF THE CRYOCOOLER**. Instead, immediately contact your MAC Team representative.

If the 7.5 psig relief valve line is plugged, continue with the procedures below.




**5 PSIG RELIEF VALVE PLUMBING**
ILLUSTRATION 2-5

### 2-4-3 Level One Recondenser Deicing

**CAUTION**

**Make sure the Coldhead is off during this procedure to prevent any re-icing of purged contaminants in the Recondenser.**

**Note**

This procedure simply shuts down the Coldhead, denies cooling flow to the Recondenser and expands shield-trapped gas back through the Recondenser.

No special tools are required.

1. Verify that the helium level is ≥ 90% with ≥ 1.0 psig.
2. If the pressure is ≥ 6.0 psig, partially open Vent Valve V2 and vent down to 6.0 psig so that the 7.5 psig relief valve does not open. No venting should occur through the 7.5 psig relief valve line during this procedure.
3. Turn off the Coldhead.
4. Monitor the Coldhead or Recondenser temperature. When it stabilizes at an elevated temperature ( > 80K ), slowly vent the cryostat down to 2 psig by opening V2.
5. After 4 hours, turn the Coldhead on again.
6. Monitor the Recondenser - Coldhead temperature difference as well as Coldhead performance to verify a satisfactory operating condition.
7. If the Recondenser resumes normal operation, but the Coldhead does not, allow the Coldhead several days to clean up internal contaminants before proceding with further corrective action.
8. If the Coldhead operation does not return to the operating specifications found in FUNCTIONAL CHECKS, Section1, within a few days, then replace the Coldhead.

### 2-4-4 Level Two Recondenser Deicing

**CAUTION**

**Make sure the Coldhead is off during this procedure to prevent any re-icing of purged contaminants in the Recondenser.**

**Note**

This procedure uses the same ice removal strategy as Section 2-4-3, Level One Recondenser Deicing, but also removes the Coldhead and heats the Coldhead Sleeve to improve warming. Try Level One Recondenser Deicing before progressing to Level Two.

1. Make sure the following are in the site area before proceding:
   - Universal Coldhead Replacement Tool Kit ( 2300306 )
   - Plexiglas Cover Plate / Heater Assembly ( 2303715 )
   - One **non-magnetic** 235 SCF bottle of dry nitrogen gas
   - Portable RuO Temperature Monitor ( 2171219 ) ( RuO Temperature Monitor Kit 2183710 )
2. Verify that the helium level is ≥ 90% with ≥ 1.0 psig.
3. If the pressure is ≥ 6.0 psig, partially open Vent Valve V2 and vent down to 6.0 psig so that the 7.5 psig relief valve does not open. No venting should occur through the 7.5 psig relief valve line during this procedure.
4. Prepare for Coldhead removal in conformance with REPLACEMENT / MAINTENANCE, Section 9-3-1, Removal Preparation. While doing so, listen as the Coldhead relief valve opens and makes hissing sounds as the Coldhead warms. Popping sounds indicate trapped contaminants.
5. Remove the Coldhead in conformance with REPLACEMENT / MAINTENANCE, Section 9-3-2, Coldhead Extraction.

**Note**

During Steps 6 - 8 below open Vent Valve V2 as required to maintain cryostat pressure at 6.0 psi.

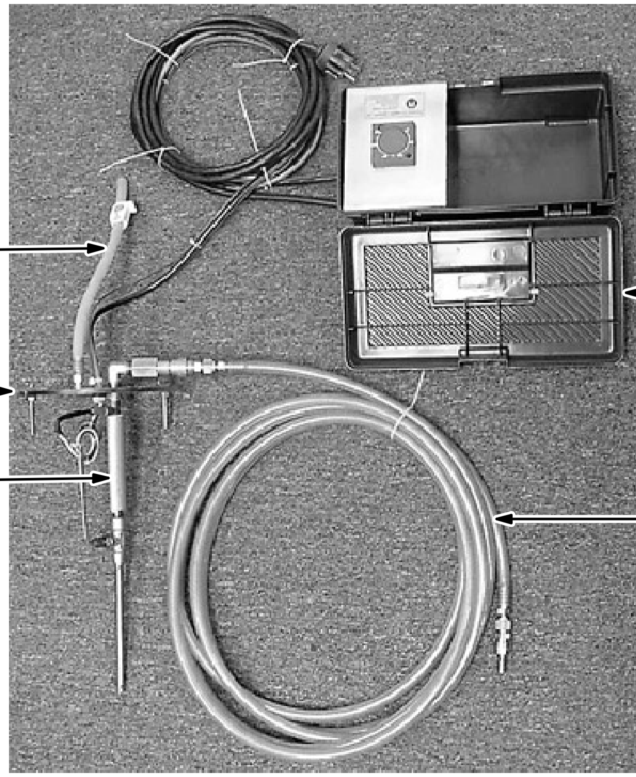
6. Install the Plexiglas Cover Plate / Heater Assembly ( 2303715 ) in conformance with REPLACEMENT / MAINTENANCE, Section 9-3-3, Sleeve Warm-Up. See Illustration 2-6.
7. Heat the Coldhead Sleeve to 275K as indicated on the RuO Temperature Monitor or the Lakeshore 208 Digital Thermometer.

**CAUTION**

**Do not heat the Sleeve in excess of 300K as the instrumentation wiring within the vessel may be damaged.**

8. Keep the Coldhead Sleeve at 275K for about 4 hours.

### 2-4-4 Level Two Recondenser Deicing ( continued )




**PLEXIGLAS COVER PLATE / HEATER ASSEMBLY ( 2303715 )**
ILLUSTRATION 2-6

9. After heating the Coldhead Sleev at 275K for 4 hours, reinstall the Coldhead in conformance with REPLACEMENT / MAINTENANCE, Section 9-5, Coldhead Replacement.

**Note**
The pressure may stay high for up to two days because the shields have warmed. The Recondenser should recover in one day.

10. Monitor the Recondenser - Coldhead temperature difference as well as Coldhead performance to verify a specification operating condition.

11. If the Recondenser resumes normal operation, but the Coldhead does not, allow the Coldhead several days to clean up internal contaminants before proceding with further corrective action.

12. If the Coldhead operation does not return to the operating specifications found in FUNCTIONAL CHECKS, Section1, within a few days, then replace the Coldhead.

### 2-4-4 Level Two Recondenser Deicing ( continued )

**WARNING!**

**MAKE SURE THE MAGNET HAS BEEN RAMPED DOWN BEFORE PERFORMING LEVEL 3 AND 4 RECONDENSER DEICING. FERROMAGNETIC OBJECTS BROUGHT INTO THE MAGNET ROOM BECOME DANGEROUS PROJECTILES IN A MAGNETIC FIELD.**

**SKIN CONTACT WITH LIQUID CRYOGENS WILL CAUSE BURNS. WEAR PROTECTIVE CLOTHING, NONABSORBENT GLOVES AND GOGGLES WHEN TRANSFERRING CRYOGENS.**

### 2-4-5 Level Three Recondenser Deicing

**CAUTION**

**Make sure the Coldhead is off during this procedure to prevent any re-icing of purged contaminants in the Recondenser.**

**Note**

This procedure uses the same ice removal strategy as Section 2-4-4, Level Two Recondenser Deicing, but also forces purge helium gas through the shield. Try Level Two Recondenser Deicing before progressing to Level Three.

1. Make sure the following are in the site area before proceding:
   - Universal Coldhead Replacement Tool Kit ( 2300306 )
   - Four **non-magnetic** 235 SCF helium gas ( 99.9995% pure ) cylinders with low pressure regulators
   - Two **non-magnetic** 235 SCF dry nitrogen gas cylinders
   - Portable RuO Temperature Monitor ( 2171219 ) ( RuO Temperature Monitor Kit 2183710 )
   - Copper tubing coil
   - Heat gun
2. Perform Steps 2 - 7 of Section 2-4-4 above.
3. Ramp the magnet down to zero field in conformance with REPLACEMENT / MAINTENANCE, Section 3, Magnet Rampdown ( Decrease To Zero )
4. Connect gas cylinder ( 235 SCF, 99.9995% pure ) and regulator to flexible gas hose. Connect gas hose to heating apparatus using gas hose with 1/2 in. NPT fitting connected on exhaust end. See Illustrations 2-7.

### 2-4-5 Level Three Recondenser Deicing ( continued )

**DANGER!!**

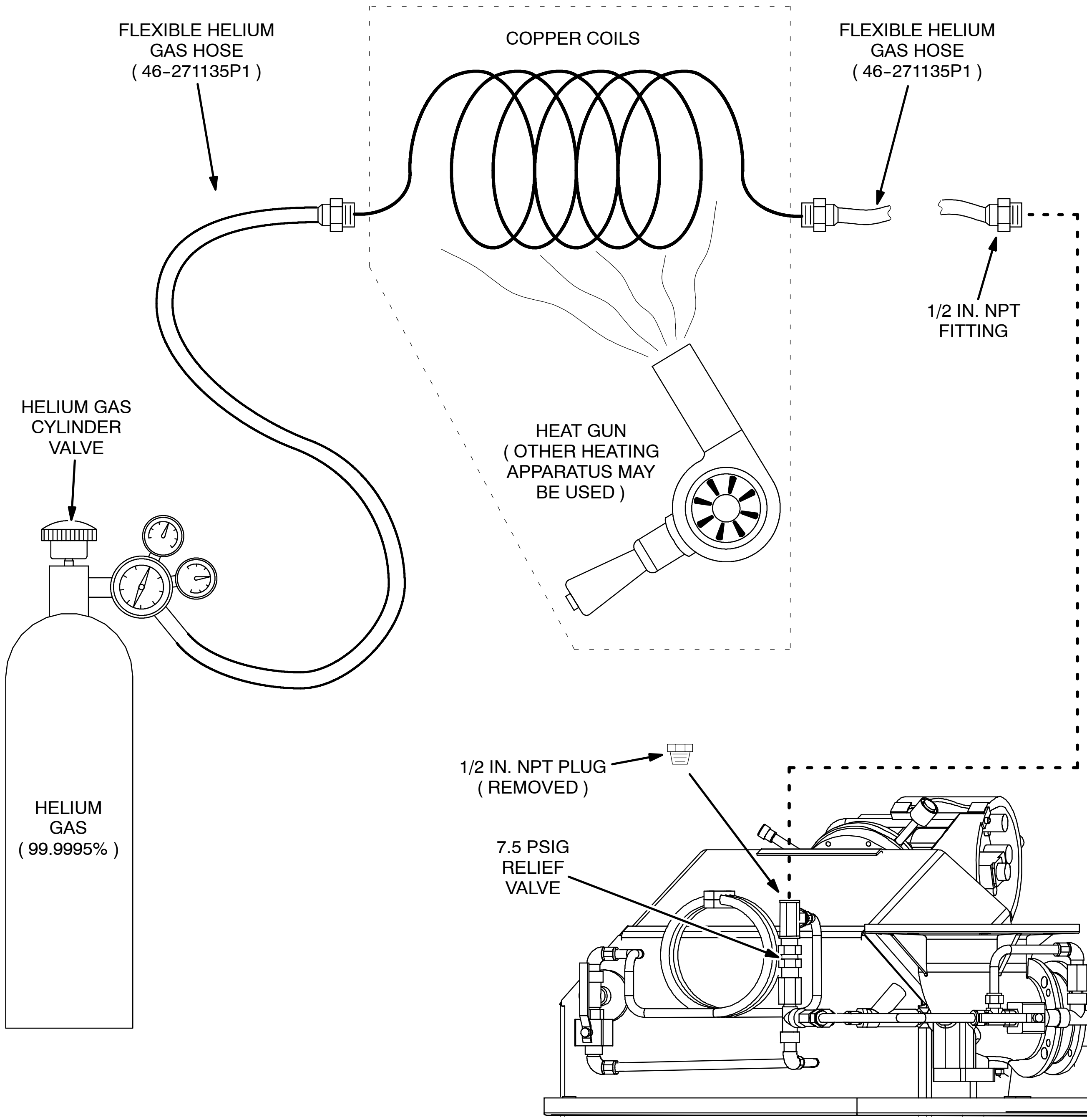
**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSIG.**

5. Make sure the regulator handle is backed out ( CCW ) to avoid regulator and line damage, then open gas cylinder slowly. The high pressure gauge should indicate 2,100 - 2,400 ( 150 - 170 kg / cm$^2$ ) psig if the cylinder is full.

**Note**
Four full gas cylinders are required for this procedure.

6. Open the cylinder valve and set low pressure gas flow at 1 psig. Purge the apparatus for one minute.
7. Remove the 1/2 in. NPT plug from relief valve tee and screw the 1/2 in. male fitting that's on the end of the gas hose onto tee. See Illustrations 2-7.
8. Open Vent Valve V2 and set purge gas pressure to 0.5 psig. Listen for gas flow in the V2 lines to make sure gas continues flowing during the purge process.
9. Monitor cryostat pressure during the purge to make sure it is ≤ 0.3 psig. Use V2 to regulate pressure.
10. Heat the helium purge gas with the heating apparatus set up in Step 4 and shown in Illustrations 2-7. The level of heat supplied should allow touching the cyostat Coldbox vent tube continuously.

### 2-4-5 Level Three Recondenser Deicing ( continued )




**RECONDENSER PURGE SET-UP**
ILLUSTRATION 2-7

### 2-4-5 Level Three Recondenser Deicing ( continued )

11. After a trickle flow of purge gas for 5 minutes, slowly increase the purge gas regulator pressure to 4 psig.

**Note**

If gas flow is not present, the Recondenser may have an ice plug. Temporarily increase gas pressure to 10 psig to blow out any ice plug, then return to the 4 psig setting. If an ice plug is still present, allow Coldhead head conduction to warm the Recondenser for one hour and then temporarily raise the gas pressure to 10 psig again.

If 10 psig is required:

- Discontinue gas flow / pressure.
- Allow the magnet to depressurize to 1 psig.
- Disconnect the 5 psig relief valve at the tee and install the 1/2 in. NPT plug removed in Step 7.
- Increase gas pressure to 10 psig.

12. Monitor the Rencondenser RuO temperature using the RuO Temperature Monitor or the Lakeshore 208 Digital Thermometer. Make sure the Recondenser temperature increases to at least 120K during the purge cycle. This increase is due to warm helium purge gas and Coldhead warming.
13. When the purge is complete, close valve V2, remove the gas line from the tee and immediately replace the plug into the tee.
14. Reinstall the Coldhead in conformance with REPALCEMENT / MAINTENANCE, Section 9-5, Coldhead Replacement.
15. Monitor the Recondenser - Coldhead temperature difference as well as Coldhead performance to verify a satisfactory operating condition.
16. If the Recondenser resumes normal operation, but the Coldhead does not, allow the Coldhead several days to clean up internal contaminants before proceding with further corrective action.
17. If the Coldhead operation does not return to the operating specifications found in FUNCTIONAL CHECKS, Section1, within a few days, then replace the Coldhead.

### 2-4-6 Level Four Recondenser Deicing

**CAUTION**

**Make sure the Coldhead is off during this procedure to prevent any re-icing of purged contaminants in the Recondenser.**

**Note**

The fourth and most extreme procedure is a complete magnet warm up and dry purge in conformance with REPALCEMENT / MAINTENANCE, Section 3, Warming Up Cryostat. Try Level Three Recondenser Deicing before progressing to Level Four.

# SECTION 3 – WARMING UP CRYOSTAT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**DANGER!!**

**FATAL EXPLOSIVE HAZARD!! TO PREVENT POSSIBLE FATAL EXPLOSIVE RELEASE OF GAS, OPEN MAIN VALVE ON GAS CYLINDER VERY SLOWLY. GAS IS AT 2400 PSI. MAKE SURE CYLINDER IS SECURE AND WILL NOT FALL DURING USE.**

## 3–1 INTRODUCTION

There will be very few situations that will require the magnet to be warmed up in the field ( e.g., the removal of an internal ice block or a field–repairable vacuum leak requiring re–evacuation ). If a magnet warm up is required, contact the Regional "MAC" Team Engineer before proceeding.

**CAUTION**

**Do not warm up the magnet if it is to be shipped from the site!**

## 3-1 INTRODUCTION ( continued )

**WARNING!**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD TO PREVENT ANY POSSIBILITY OF A QUENCH.**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON AND THAT THE MAGNET ROOM DOORS ARE SECURELY OPEN BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND TO PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**WEAR PROTECTIVE CLOTHING, NONABSORBENT GLOVES AND GOGGLES TO PROTECT AGAINST LIQUID CRYOGENS.**

**CAUTION**

**Make sure the MAC Team Leader is present and has determined that a magnet warm-up is required before proceeding.**

**Make sure that all required equipment is on site.**

## 3-2 CRYOSTAT WARM-UP

1. Turn off the Cryocooler Compressor and disconnect the power cable. Disconnect the supply and return gas lines at the Coldhead.

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG.**

**OBSERVE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN CRYOSTAT TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

**Note**

Magnet should be near / at 0% helium level prior to warming with gaseous helium.

### 3-2 CRYOSTAT WARM-UP ( continued )

2. Open Helium Vent Valve V2 and Exhaust Valve V3.

3. Remove the Burst Disc and reconnect the Vent Adapter. See REPLACEMENT / MAINTENANCE, Section 6, Burst Disc Replacement.

4. Connect the Lakeshore Cryotonic DRC-80 ( 46-265269G1 ), 208 Thermometer Kit ( 46-301477G1 ) or Low Cost Shield Temperature Diode Box ( 46-317543G1 ) to monitor silicone diode temperature in conformance with SET-UP AND CALIBRATION, Section 2-2-1.

5. Connect the helium gas ( 99.995% ) and regulator set-up to the helium Fill Port at V1.

6. Uncap the Fill Port and fully insert a Stinger ( at least 18 inches ( 457.2 mm ) long for connection in the bottom-fill tube ).

7. Blow warm helium gas regulated at 4 - 6 psig through the cryostat until the silicone diode temperature readout exceeds 90K.

**Note**
The gas may be warmed through the Heat Exchange Coil heated with a heat gun.

8. Shut off the flow of helium gas using the Positive On / Off Valve.

9. Remove the helium gas set-up and connect the nitrogen gas set-up in its place.

10. Open the Positive On / Off Valve.

11. Start and continue nitrogen gas flow, regulated at 4 to 6 psig, until silicone diode temperature readout exceeds 300 K.

12. Discontinue nitrogen gas flow, remove the Stinger and cap the helium Fill Port. Close V2.

# SECTION 4 - RE-EVACUATION OF CRYOSTAT

## Introduction

Re-evacuation of the Cryostat is required when the magnet temperature has exceeded 100K. During the warm-up gas is released into the vacuum chamber. The cryopumped gas, redeposited on the magnet's internal surfaces, can result in increased heat leakage if not removed.

Internal temperatures must be > 273K to ensure adequate pumping of water vapor.

## Procedure

1. Determine the temperature of the Magnet Cartridge using a Lakeshore 208 Thermometer ( 46-301478P1; Kit: 46-301477G2 ) or equivalent.

2. If re-evacuation of the Cryostat is required, contact the GE Regional Service Engineer ( MAC Team ).

**Note**

A Vacuum Pump Cart has been developed to re-evacuate the Cryostat. Connection, monitoring and pumping procedures are included with the cart. A 3 inch Valve Port Operator ( 46-252210P1 ) is required to connect the vacuum pumping equipment to the magnet's Pumpout Port.

# SECTION 5 - RE-EVACUATION OF VACUUM JACKETED TRANSFER LINE

Re-evacuate the vacuum-jacketed helium transfer line whenever the efficiency of liquid helium transfer to the magnet decreases below 50% under normal transfer conditions or whenever frost is seen on the line.

1. Set up the vacuum pumping equipment similar to setup in REPLACEMENT / MAINTENANCE, Section 4. Install an LF100 blanking plate on the Turbomolecular Pump if the pumping equipment is not connected to the magnet's vacuum port.

**Note**

See Illustration 5-1 for Steps 2 through 17.

2. Remove the plastic cover protecting the vacuum-jacketed helium transfer line's evacuating port.
3. Connect the pump-out fitting to the evacuating port.
4. Remove the KF10 blanking disc from the KF25-KF16 reducer on the vacuum pumping equipment.
5. Connect the Valve Port Operator to the vacuum pumping equipment port from which the KF10 blanking disc was removed.
6. Close the KF25 valve to the pump-out fitting.
7. Turn on the Rotary Pump.
8. When the vacuum is between $10^{-1}$ and $10^{-2}$ Torr, turn on the Turbomolecular Pump.
9. After the vacuum reaches between $10^{-5}$ and $10^{-6}$ Torr, turn the Valve Port Operator knob counterclockwise. This opens the valve on the vacuum-jacketed helium transfer line.
10. Slowly open the KF25 valve to begin evacuation.
11. Continue evacuation until the vacuum reaches between $10^{-5}$ and $10^{-6}$ Torr.
12. Turn the Valve Port Operator knob clockwise.
13. Close the KF25 valve and remove the pump-out fitting.

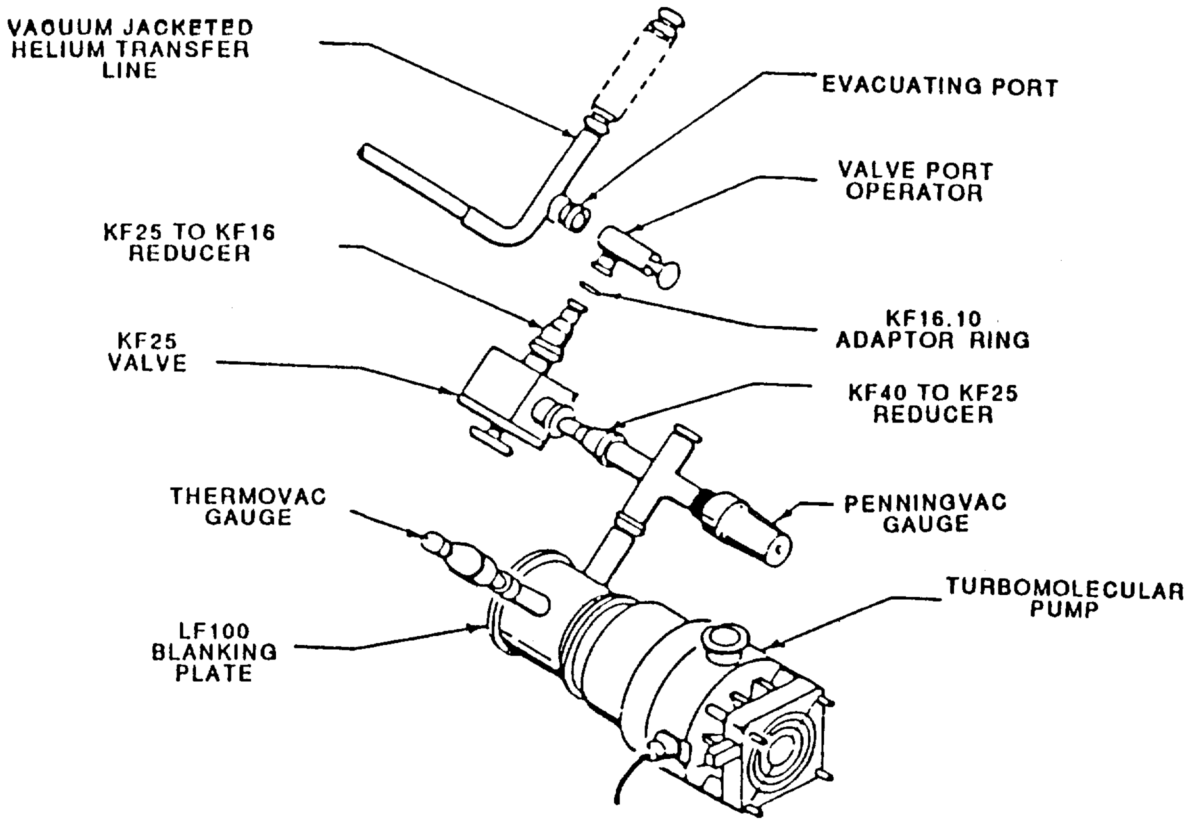
**SECTION 5 – RE-EVACUATION OF VACUUM JACKETED TRANSFER LINE ( continued )**

14. Turn off the Turbomolecular Pump.

15. Turn off the Rotary Pump.

16. After waiting a few minutes, slowly open the KF25 valve to stop the Turbomolecular Pump.

17. Replace the KF10 blanking disc on the vacuum equipment.




**VACUUM JACKETED HELIUM TRANSFER LINE EVACUATION SET-UP**
ILLUSTRATION 5-1

# SECTION 6 – BURST DISC REPLACEMENT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND TO PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**WEAR PROTECTIVE CLOTHING, NONABSORBENT GLOVES AND GOGGLES WHEN REPLACING THE BURST DISC ON A COLD VENT SYSTEM.**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD TO PREVENT ANY POSSIBILITY OF A QUENCH.**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE, ALLOWING THE INTERNAL CRYOSTAT PRESSURE TO BUILD UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN THE CRYOSTAT TO < 0.5 PSIG THROUGH CRYOSTAT VENT VALVE V2 BEFORE EITHER REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

## SECTION 6 – BURST DISC REPLACEMENT ( continued )

### IMPORTANT !!!

When a Burst Disc is ruptured on a ramped magnet there will be no cold helium gas pressure in the helium vessel to cool the Ramp Lead Extensions, and they will burn out during a ramp down. If this condition exists, the Burst Disc will need to be replaced with the magnet at field. The following warnings **MUST** be adhered to in order to prevent exposure to the rapid expulsion of cold ( cryogenic ) helium gas should the magnet quench during Burst Disc replacement:

**WARNING!**

**THE FOLLOWING SAFETY MEASURES MUST BE TAKEN DURING THIS PROCEDURE TO MAKE SURE THE INDIVIDUAL IS NOT EXPOSED TO THE RAPID EXPULSION OF CROGENIC HELIUM GAS IN THE UNLIKELY CASE OF A MAGNET QUENCH DURING OPERATION:**

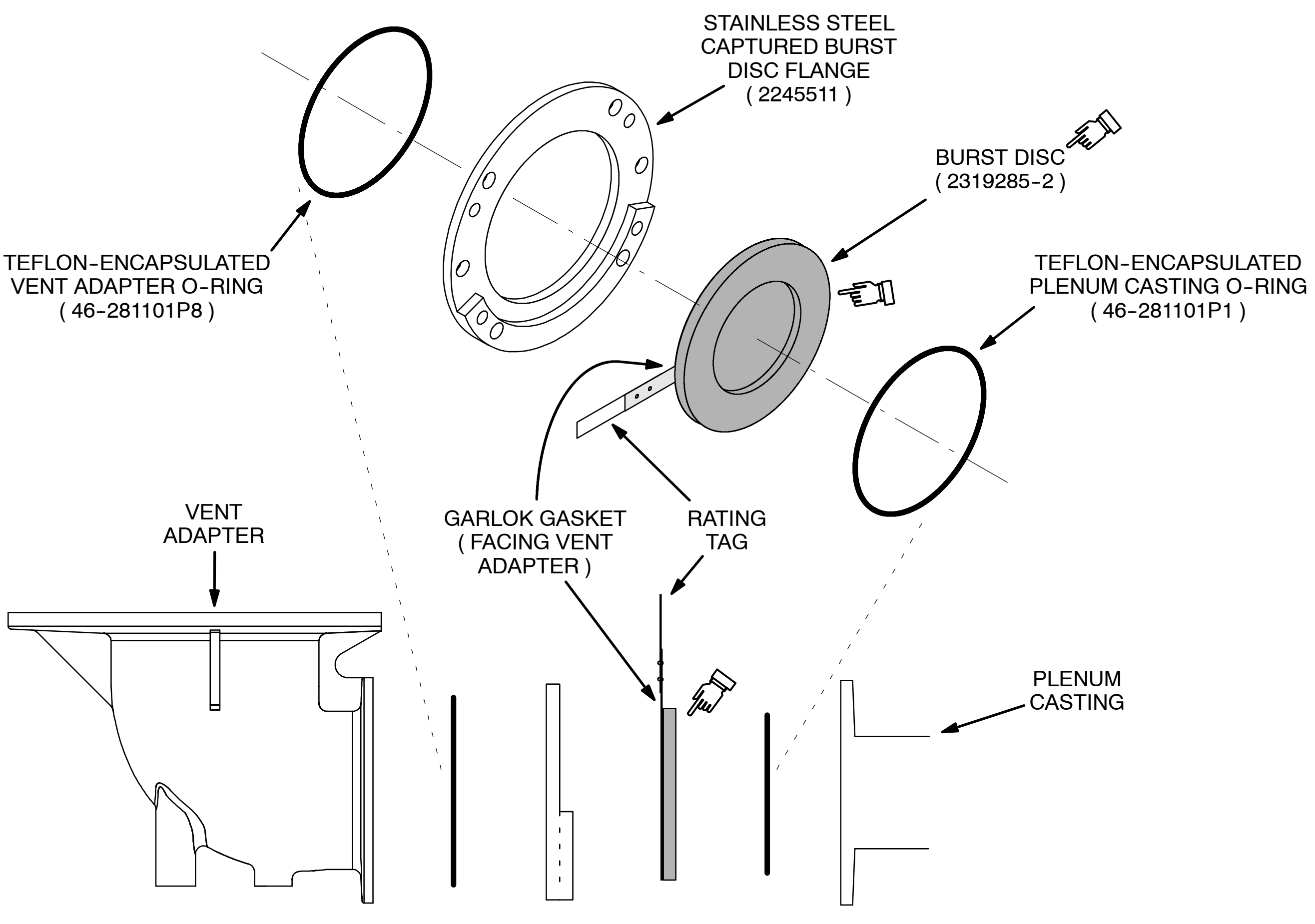
- **WEAR ALL PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR CRYOGEN SAFETY ( NONABSORBANT GLOVES, GOGGLES / FACESHIELD, JACKET AND PANTS ).**
- **MAKE SURE THE MAGNET ROOM DOOR IS SECURED IN THE OPEN POSITION AND THAT THE EXHAUST VENT SYSTEM AND FANS ARE OPERATING PROPERLY.**
- **DO NOT PUT YOUR FACE ABOVE OR NEAR THE MAGNET PLENUM FLANGE.**
- **MAKE SURE BURST DISC REPLACEMENT IS PERFORMED QUICKLY BY A PROPERLY TRAINED PERSON.**
- **MAKE SURE THE REQUIRED REPLACEMENT BURST DISC IS PRESENT.**
- **NEVER ALLOW THE OPEN PLENUM TO REMAIN UNCLOSED ANY LONGER THAN NECESSARY.**
- **MAKE SURE THE SERVICE LADDER PLATFORM AT THE MAGNET IS SECURE AND ALLOWS RAPID ESCAPE.**
- **MAKE SURE AN EXIT PATH AT LEAST 28 INCHES ( 711 MM ) WIDE IS MAINTAINED AT ALL TIMES.**
- **MAKE SURE A SECOND PERSON TRAINED IN MAGNET / CRYOGEN SAFETY PRACTICES AND FAMILIAR WITH THE SITE ( EXITS, OUTSIDE PHONE LOCATION, ETC. ) IS PRESENT DURING REPLACEMENT.**
- **UNDERSTAND AND COMPLY WITH ALL MAGNET SAFETY REQUIREMENTS AND SERVICE SAFETY REQUIREMENTS ITEMS PUBLISHED FOR GE SUPERCONDUCTING MAGNETS.**
- **IF A QUENCH STARTS TO OCCUR, ABANDON ALL WORK UNDERWAY AND EXIT THE ROOM IMMEDIATELY.**

## 6-1 INTRODUCTION

The Burst Disc and retaining assembly has been designed to minimize gasket leaks and Burst Disc cracks which develop over time from exposure to cold helium during fill. Burst Disc 2319285-2, which directly replaces the Burst Disc And Gasket Assembly ( 2253802-2 ) in this design, also eliminates the thermal expansion prestress problems of metal ring Burst Disks.

The design, shown in Illustration 6-1, contains a Teflon encased o-ring mounted in the Plenum Flange to contact the cold / pressure side of the Burst Disc and a vertical "slide in" Burst Disc replacement significantly reducing gasket cracks and replacement difficulties.

If the Burst Disc from the spare parts kit is used, order a new Burst Disc ( 2319285-2 ) for the kit.




**BURST DISC AND RETAINING ASSEMBLY**
ILLUSTRATION 6-1

## 6-1 INTRODUCTION ( continued )

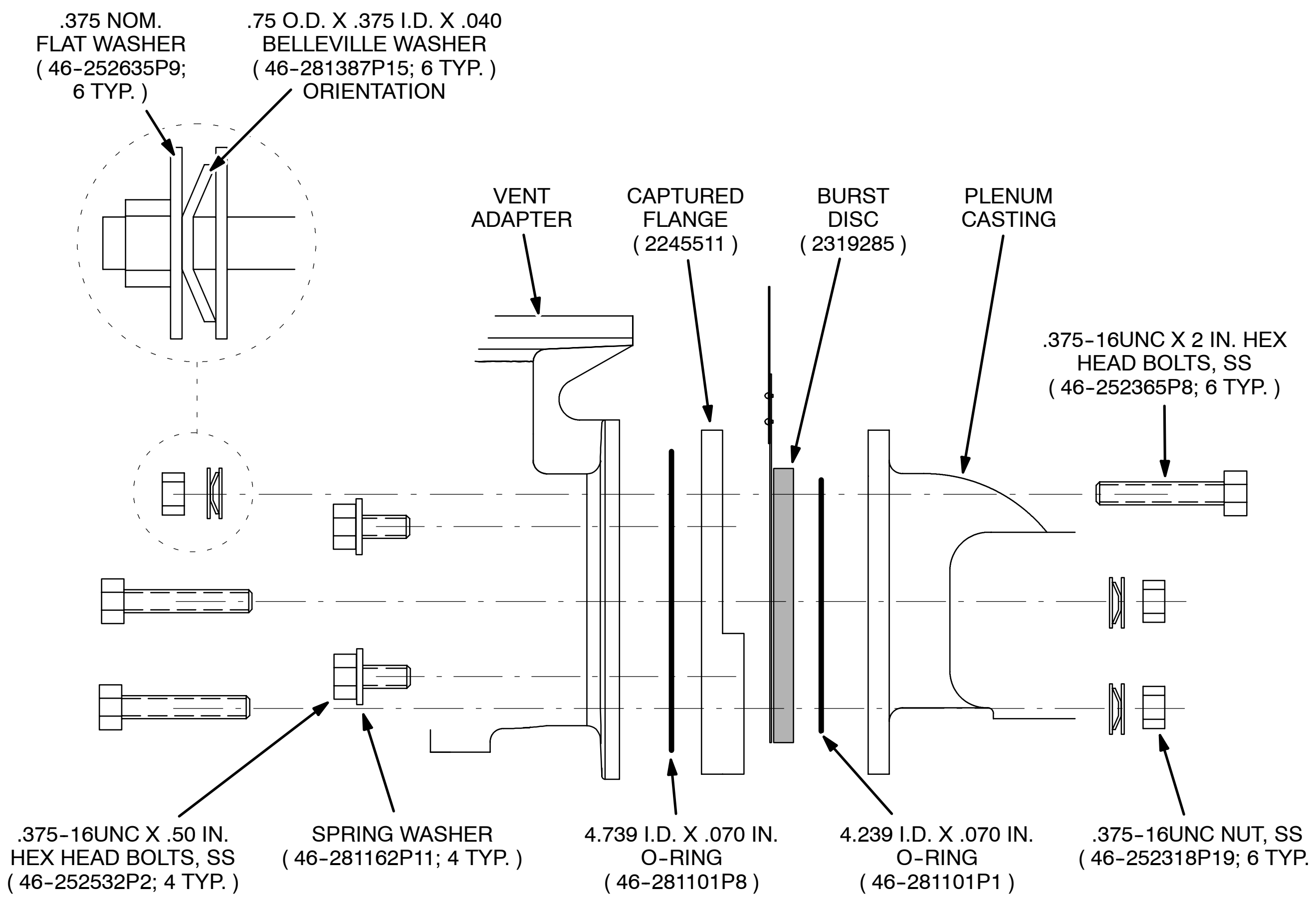
**CAUTION**

**Replace the Burst Disc immediately after rupturing to avoid cryopumping. Ice blocks can form inside the exhaust lines and vertical stack if the Burst Disc is not replaced promptly.**

**Make sure Coldhead / Cryocooler power is turned off before starting this procedure to prevent ice formation in the Recondenser.**

## 6-2 PROCEDURE

1. Loosen all six retaining bolts on the Burst Disc retaining assembly sufficiently to prevent any binding when the Burst Disc is removed and replaced. See Illustration 6-2.




**BURST DISC BOLT / WASHER ASSEMBLY**
ILLUSTRATION 6-2

### 6-2 PROCEDURE ( continued )

2. Remove the top two retaining bolts. Make sure the Belleville and flat washers are placed back on the bolts after removal in the same orientation as removed and that the nuts are screwed onto the bolt to retain the hardware. See Illustration 6-3.

**CAUTION**

**Be careful when removing the old Burst Disc and inserting the new Burst Disc so as not to dislodge the o-ring in the Plenum Flange or scratch the sealing surface of the flange.**

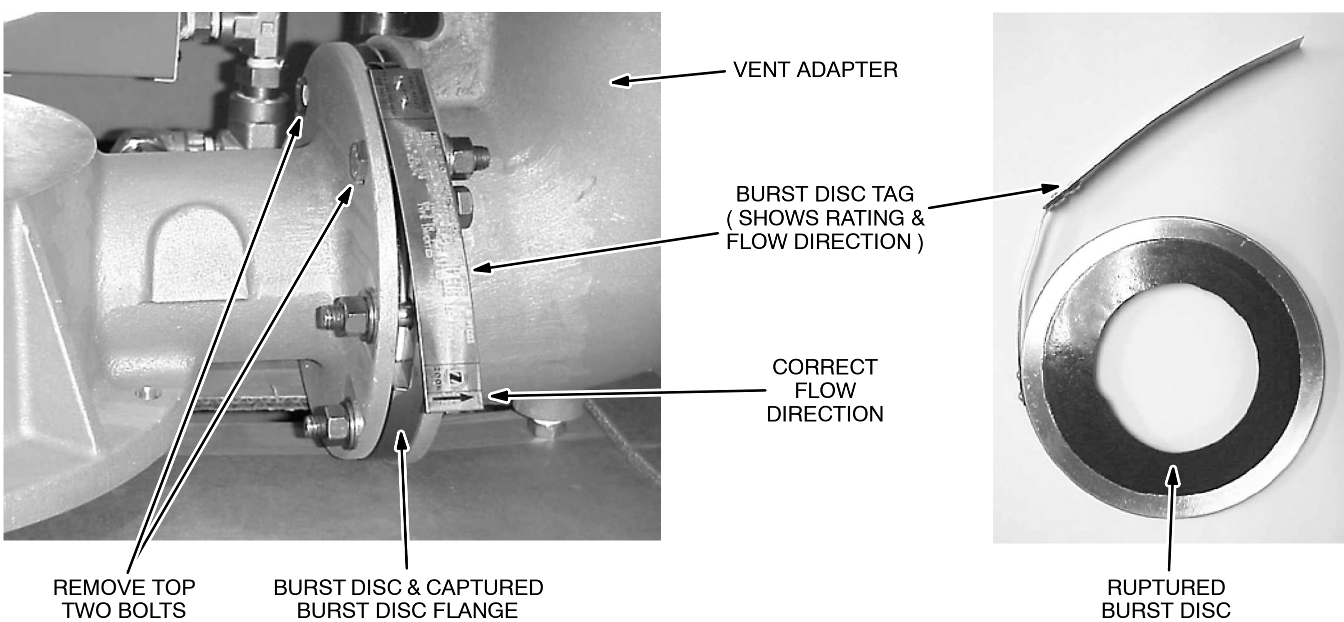
**CAUTION**

**Make sure the replacement Burst Disc ( 2253802-2 ) has the proper pressure rating ( 11 - 13 psig ) and is installed with the Burst Disc tag's flow arrow pointing towards the Vent Adapter. See Illustration 6-1.**

3. Grab the metal Burst Disc tab and pull straight up to remove the old Burst Disc. See Illustration 6-3. Note orientation of the disc. The tab's flow arrow should be pointing towards the Vent Adapter, as in Illustration 6-1.

**Note**

If the old Burst Disc binds during removal, gently spread the gap between the plenum and Captured Flange with a blunt object such as a box end wrench.




**BOLTS AND BURST DISC REMOVAL**
ILLUSTRATION 6-3

## 6-2 PROCEDURE ( continued )

4. Clean any Burst Disc fragments out of the bottom of the Vent Adapter.

5. Insert a new Burst Disc by pushing it down straight in the gap left by the old disc. Make sure the flow arrow on the Burst Disc tag points towards the Vent Adapter. See Illustration 6-4.

**Note**

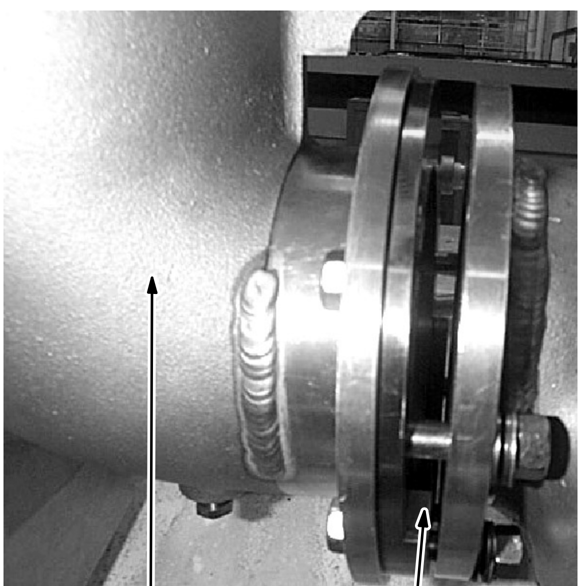
If the new Burst Disc binds during insertion, gently spread the gap between the plenum and Captured Flange with a blunt object such as a box end wrench.

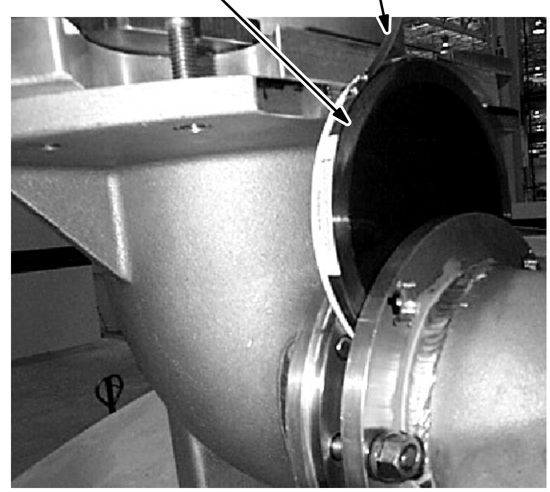
6. When the Burst Disc is fully in place replace the top two retaining bolts and washers in the same orientation and position as removed.

7. Tighten the retaining bolts in a "star" pattern 1/2 turn at a time to obtain an even pressure of the o-ring seal on the disc. Tighten bolts until Belleville washer is flattened, further tightening is not required. See Illustration 6-2.

8. Leak test the plenum o-ring gasket side of the Burst Disc for leaks. Repair any leaks found.

9. If a magnet fill is not immediately scheduled at disc replacement, verify that magnet pressure increase to between 0.9 and 1.0 psig. The magnet monitor should increase vessel pressure.




**BURST DISC INSTALLATION**
ILLUSTRATION 6-4

# SECTION 7 - BAFFLE TREE REPLACEMENT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL “WORK ASSISTANTS” OR “WORK OBSERVERS” COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

**WARNING!**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD BEFORE STARTING THIS PROCEDURE. A MAGNET QUENCH DURING THE PROCEDURE COULD RESULT IN THE RAPID EXPULSION OF COLD HELIUM GAS / LIQUID OUT THE VERTICAL PENETRATION. ALSO A VACUUM CLEANER WILL BE REQUIRED TO REMOVE BAFFLE DEBRIS FROM THE VERTICAL PENETRATION AND CANNOT BE BROUGHT INTO A MAGNETIC FIELD.**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND TO PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**RAPID EXHAUSTING OF COLD HELIUM GAS MAY BE ENCOUNTERED DURING THE FOLLOWING PROCEDURE. WEAR NON-ABSORBENT GLOVES AND GOGGLES WHEN PERFORMING THIS PROCEDURE.**

**Description**

The Cover Plate Assembly is designed with a replaceable Baffle Tree Assembly ( 2226764 ). The Baffle Tree Assembly should be replaced after a quench or if it is determined that a fault exists ( such as a high boil-off ).

## 7-1 COVER PLATE REMOVAL

1. Ramp the magnet down to zero field in conformance with REPLACEMENT / MAINTENANCE, Section 1.

**CAUTION**

**Make sure power to the Coldhead and Cryocooler is turned off before starting this procedure to prevent ice formation in Recondenser.**

2. Turn off Coldhead / Cryocooler power.

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM HAS A 7.5 PSIG RELIEF VALVE WHICH ALLOWS INTERNAL CRYOSTAT PRESSURE TO BUILD TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN CRYOSTAT TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE PERFORMING THIS PROCEDURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

2. Slowly open Vent Valve V2 and vent the magnet until internal pressure drops below 0.5 psi on the Cryostat Pressure Gauge. Close V2.

**CAUTION**

**Perform Steps 3 and 5 rapidly to prevent cryopumping of air into the Vertical Penetration. Make sure the Lexan Cover Plate ( 2117683 ) is located before removing the Cover Plate Assembly.**

3. Loosen and remove the Cover Plate Assembly's six 1/4-20 retaining bolts. Remove the Cover Plate Assembly with the Baffle Tree.

4. Immediately cover the Vertical Penetration with the Lexan Cover Plate. Align the Lexan Plate scribe mark to the Vent Adaptor.

5. Secure the Lexan Cover Plate to the Vertical Penetration with the six 1/4-20 retaining bolts removed in Step 3.

### 7-1 COVER PLATE REMOVAL ( continued )

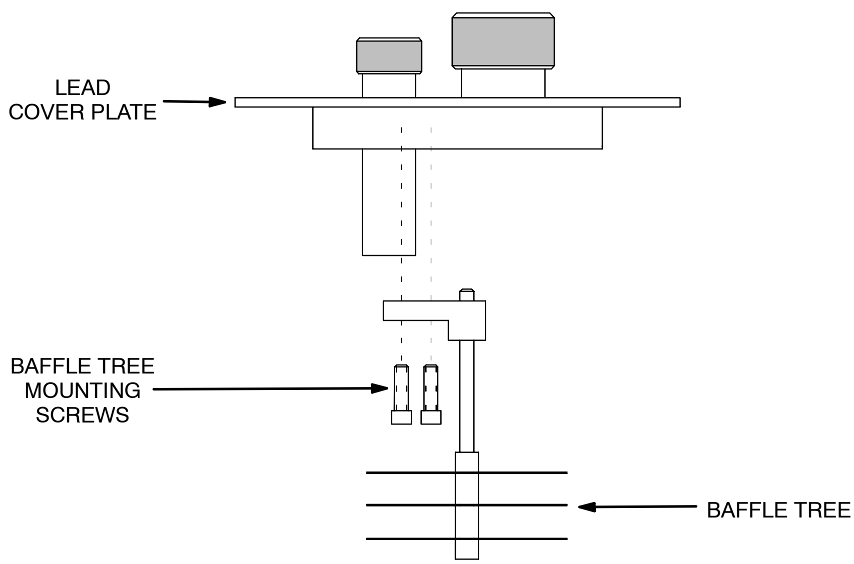
6. Inspect the Baffle Tree for defects.

   a. If the Baffle Tree needs replacement, proceed to Section 7-2 below.

   b. If the Baffle Tree does not need replacement, replace the Cover Plate.

### 7-2 BAFFLE TREE REPLACEMENT / COVER PLATE INSTALLATION

1. Remove the 2 hex head screws that secure the Baffle Tree to the Cover Plate Assembly.
2. Remove the defective Baffle Tree Assembly and discard.
3. Position the new Baffle Tree Assembly ( 2226764 ) onto the Cover Plate oriented as shown in Illustration 7-1.




**BAFFLE TREE MOUNTING**
ILLUSTRATION 7-1

4. Mount the Baffle Tree Assembly to the Cover Plate Assembly with the 2 hex head screws removed in Step 1.
5. Remove the Lexan Plate from the Vertical Penetration.
6. Carefully vacuum any baffle debris inside the Vertical Penetration using a vacuum cleaner's extension wand.
7. Quickly place the Cover Plate Assembly onto the Vertical Penetration.
8. Replace the six 1/4 - 20 Cover Plate Assembly Retaining Bolts, removed in Section 7-1.

## 7-2 BAFFLE TREE REPLACEMENT / COVER PLATE INSTALLATION ( continued )

9. Perform a “Leak” Test, using a Snoop Liquid Leak Detector ( 46-252065P71 ), on the Instrumentation Lead and Shim Lead Assembly mountings and all plumbing connections. Correct any leaks found.

10. Turn on Coldhead / Cryocooler power.

11. Ramp and shim the magnet in conformance with this manual.

**CAUTION**

**Cryostat pressure must be checked after magnet installation and ramping to make sure the proper conditions are maintained and no leaks are present in the helium vent system.**

# SECTION 8 – INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL “WORK ASSISTANTS” OR “WORK OBSERVERS” COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 8–1 INTRODUCTION

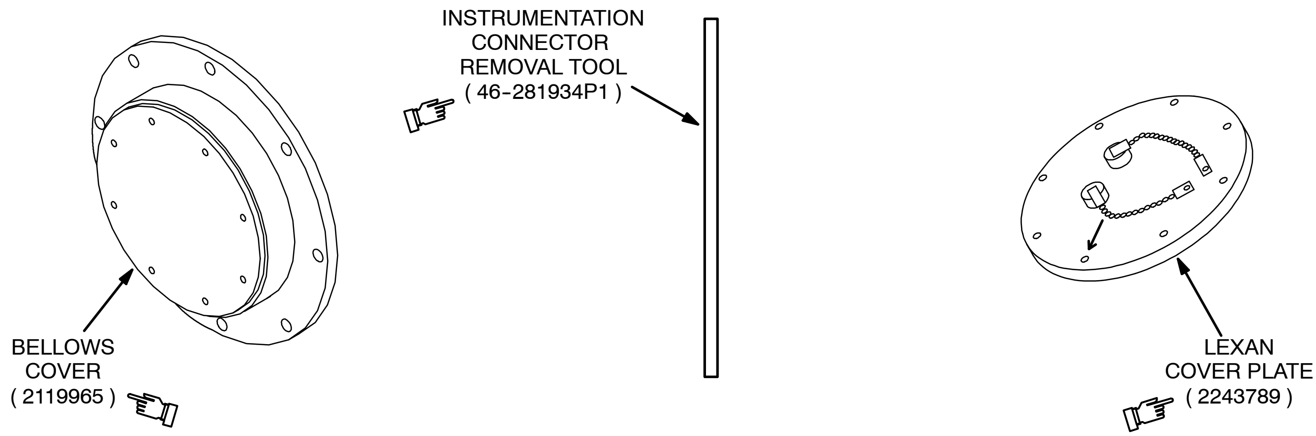
The Instrumentation Lead Assembly ( 2226951 ) must be replaced when opens or shorts in the lead assembly have resulted in the inability to read magnet temperatures or helium levels, activate main switch heaters or perform an emergency rundown using the MRU.

Before initiating this replacement procedure, contact your MAC Team Representative and make sure that the following parts and tools are on site:

- Instrumentation / Electrical Lead Assembly ( 2226951 )
- Included in Sav–Con / Instrumentation Lead Installation / Removal Kit ( 46–294872G3 ):
  - Intrumentation Connector Removal Tool ( 46–281934P1 )
  - Bellows Cover ( 2119965 )

**8-1 INTRODUCTION ( continued )**

- Included in Field Spare Parts Kit ( 46-294232G4 ):
  - Lexan Cover Plate ( 2243789 )
  - Instrumentation Lead O-Ring ( 46-281101 P4 )
  - Cover Plate Assembly O-Ring ( 46-281101P1 )
  - Turret O-Ring ( 46-281101P6 )
- Vacuum grease
- Snoop Liquid Leak Detector ( 46-252065P71 ) ( or equivalent )
- Teflon Tape ( 46-252065P1 )
- Masking Tape
- Heat Gun




**INSTRUMENTATION REMOVAL / REPLACEMENT TOOLS**
ILLUSTRATION 8-1

It is recommended that the Instrumentation Lead Assembly replacement be performed by the GE MAC Team Representative. The procedure must be performed quickly to avoid excessive boil-off and frost / ice formation in the Vertical Penetration.

Ramp the magnet down to zero field in conformance with REPLACEMENT / MAINTENANCE, Section 1, before starting this procedure.

## 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT

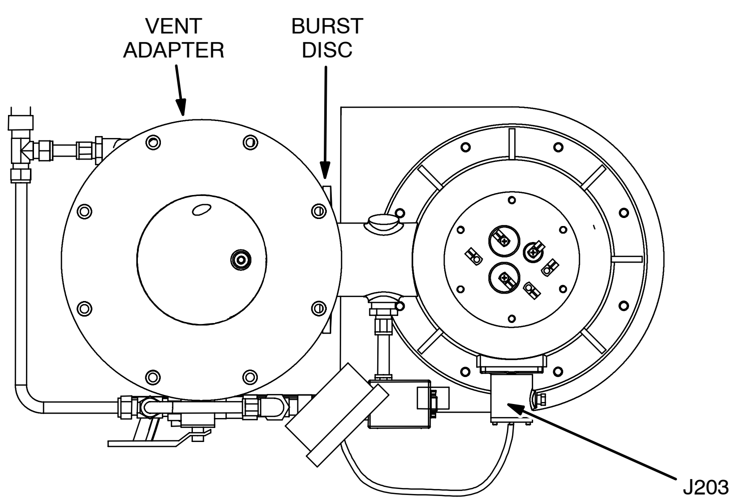
**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**RAPID EXHAUSTING OF COLD HELIUM GAS MAY BE ENCOUNTERED DURING THE FOLLOWING PROCEDURE. WEAR NON-ABSORBENT GLOVES AND GOGGLES WHEN PERFORMING THIS PROCEDURE.**

**MAKE SURE THE MAGNET IS RAMPED DOWN TO ZERO FIELD BEFORE STARTING THIS PROCEDURE. A MAGNET QUENCH DURING THE PROCEDURE COULD RESULT IN THE RAPID EXPULSION OF COLD HELIUM GAS / LIQUID OUT OF THE VERTICAL PENETRATION.**

1. Turn off all level sensor, diode and main heater sources and disconnect J203. See Illustration 8-2.
2. Make sure the Lexan Cover Plate ( 2243789 ) is immediately accessible for mounting on the Vertical Penetration when the Cover Plate Assembly is removed and the Pipe Plugs are in place.




**INSTRUMENTATION LEAD CONNECTOR LOCATION**
ILLUSTRATION 8-2

## 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

**CAUTION**

**Make sure Coldhead / Cryocooler power is turned off before starting this procedure to prevent ice formation in Recondenser.**

3. Turn off Coldhead / Cryocooler power.

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE WHICH CAN RESULT IN INTERNAL CRYOSTAT PRESSURE BUILD-UP TO 7.5 PSIG.**

**OBSERVE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT DOWN CRYOSTAT TO < 0.5 PSIG THROUGH THE CRYOSTAT VENT VALVE ( V2 ) BEFORE PERFORMING THIS PROCEDURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

4. Open Vent Valve V2 to depressurize the Cryostat to < 0.5 psig. Close V2.
5. Unbolt and remove the four retaining bolts holding the Vent Adaptor to the Turret Assembly. See Illustration 8-2.
6. Remove the Cover Plate Assembly in conformance with REPLACEMENT / MAINTENANCE, Section 7-1.
7. Align the scribe mark on the Lexan Cover Plate towards the Vent Adapter and immediately place the Cover Plate over opening. Secure the Cover Plate with the eight bolts removed in Step 6. Tighten finger tight.
8. Warm the Instrumentation Connector Removal Tool ( 46-281934P1 ) with a heat gun to remove any moisture.

**CAUTION**

**Make sure there is no moisture or other contamination on the Instrumentation Connector Removal Tool. Any moisture remaining on tool may result in the tool freezing to the connector.**

9. Shine a flashlight through the Lexan Cover Plate and inspect the Instrumentation Lead Assembly Connector for frost. Remove visible frost by temporarily removing a Pipe Plug from the Turret Cover, inserting a helium gas hose and blowing warm helium gas at approximately 8 - 10 psig on the frosted location.

### 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

10. After frost removal, remove the helium gas hose from the Cover Plate and insert the Instrumentation Connector Removal Tool.

11. Shine a flashlight through the cover again and align the end of the Instrumentation Connector Removal Tool with the threaded top on the connector P101 at the bottom of the Vertical Penetration. See Illustration 8-3.

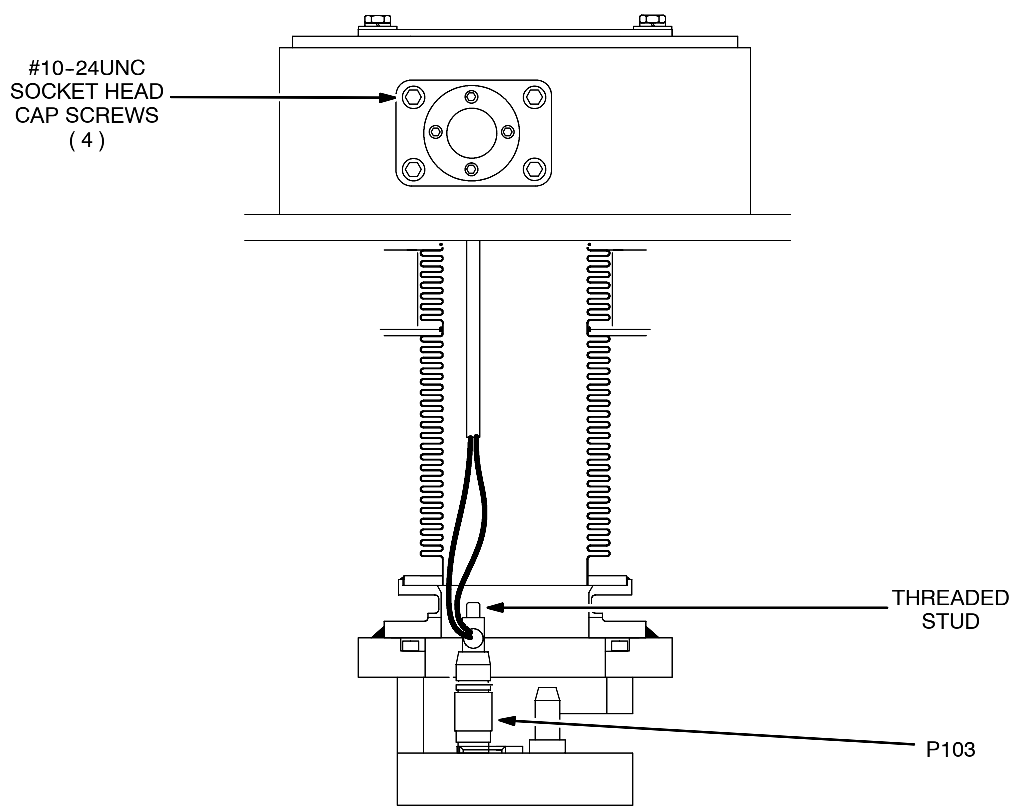
**Note**

Repeated application of helium gas on the Instrumentation Lead Connector may be needed if excessive icing prevents the ability to disconnect the Instrumentation Lead Connector.

12. Thread the tool onto the connector ( clockwise ) until snug, back off 1/4 turn ( counter clockwise ) and then pull upwards on tool until the connector disengages.

**Note**

The Instrumentation Connector Removal Tool cannot be easily removed now. The tool and the Instrumentation Lead Assembly will be removed upon removal of the Service Turret.



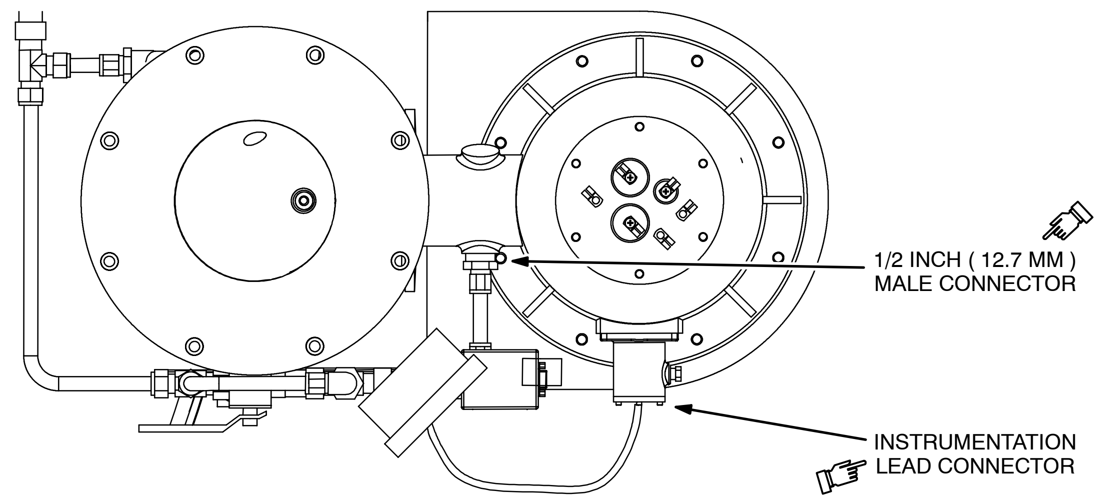

**ATTACHING THE CONNECTOR REMOVAL TOOL**
ILLUSTRATION 8-3

## 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

**CAUTION**

**These procedures must be performed rapidly to prevent cryopumping and frost build-up.**

13. Loosen the eight bolts securing the Service Turret Assembly to the Vertical Penetration Flange. See Illustration 8-6.
14. Disconnect the male connector on the 1/2 inch plumbing from the Turret Assembly. See Illustration 8-4.




**PLUMBING AND INSTRUMENTATION LEAD CONNECTOR LOCATION**
ILLUSTRATION 8-4

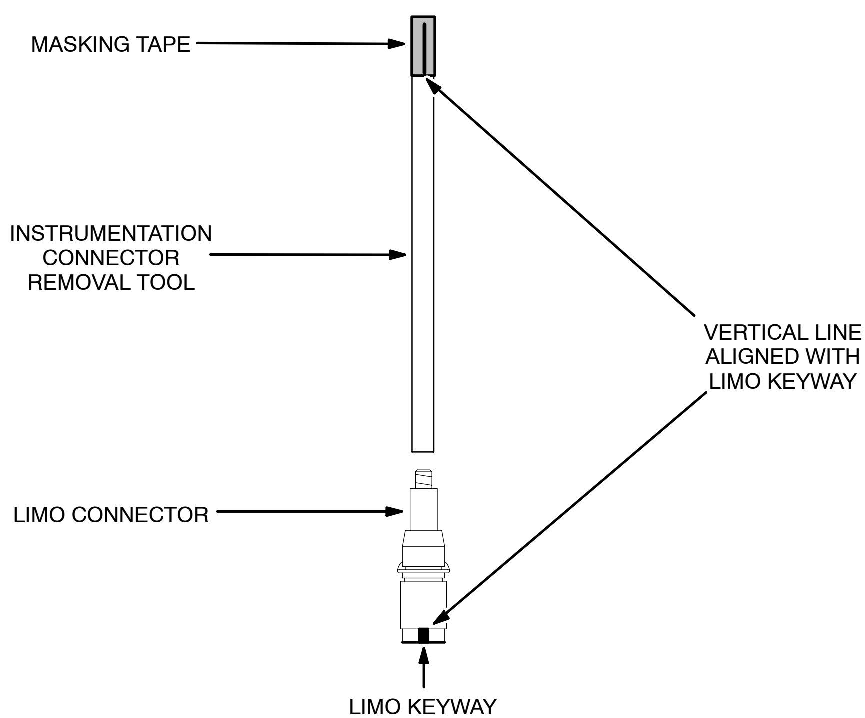
15. Remove the eight bolts securing the Service Turret Assembly then remove the Service Turret Assembly.
16. Immediately place Bellows Cover ( 2119965 ) over Service Turret and secure with bolts removed above.
17. Unplug the Instrumentation Lead Assembly Connector. See Illustration 8-4.

**Note**
Make sure the Turret Cover is immediately accessible for mounting on the Vertical Penetration when the Turret Assembly is removed.

18. Remove the six hex bolts holding the Instrumentation Lead Assembly to the Turret Assembly. Remove the defective Instrumentation Lead from the Turret Assembly.
19. Install a new o-ring ( 46-281101P4 ) on the new Instrumentation Lead Assembly. Use vacuum grease when installing the new o-ring.
20. Insert the new Instrumentation Lead Assembly into the Service Turret.

### 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

21. Secure the new Instrumentation Lead Assembly to the Service Turret with the six hex bolts removed in Step 18.
22. Plug the Instrumentation Lead Assembly Connector into J203.
23. Warm the insertion end of the Instrumentation Lead Assembly and the Instrumentation Connector Removal Tool to remove any moisture.
24. Wrap a piece of masking tape around the end of the Instrumentation Connector Removal Tool opposite the threaded end. The tape will be used to mark the location of the Limo Connector keyway in Step 25.
25. Screw the Instrumentation Connector Removal Tool onto the new Limo Connector through the Lexan Cover Plate that was installed on the Turret Assembly in Step 7. Place a mark on the masking tape to indicate the location of the Limo Connector keyway. See Illustration 8-5.
26. Apply vacuum grease to the Turret O-Ring.
27. Remove the Bellows Cover, then **quickly** replace the Turret O-Ring and mount the Turret Assembly with new Instrumentation Lead Assembly onto the Vertical Penetration Flange using the bolts removed in Step 13.




**LIMO CONNECTOR KEYWAY IDENTIFICATION**
ILLUSTRATION 8-5

## 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

28. Reconnect the male connector.

**Note**
Before connecting P101, make sure there is no ice buildup on J101.

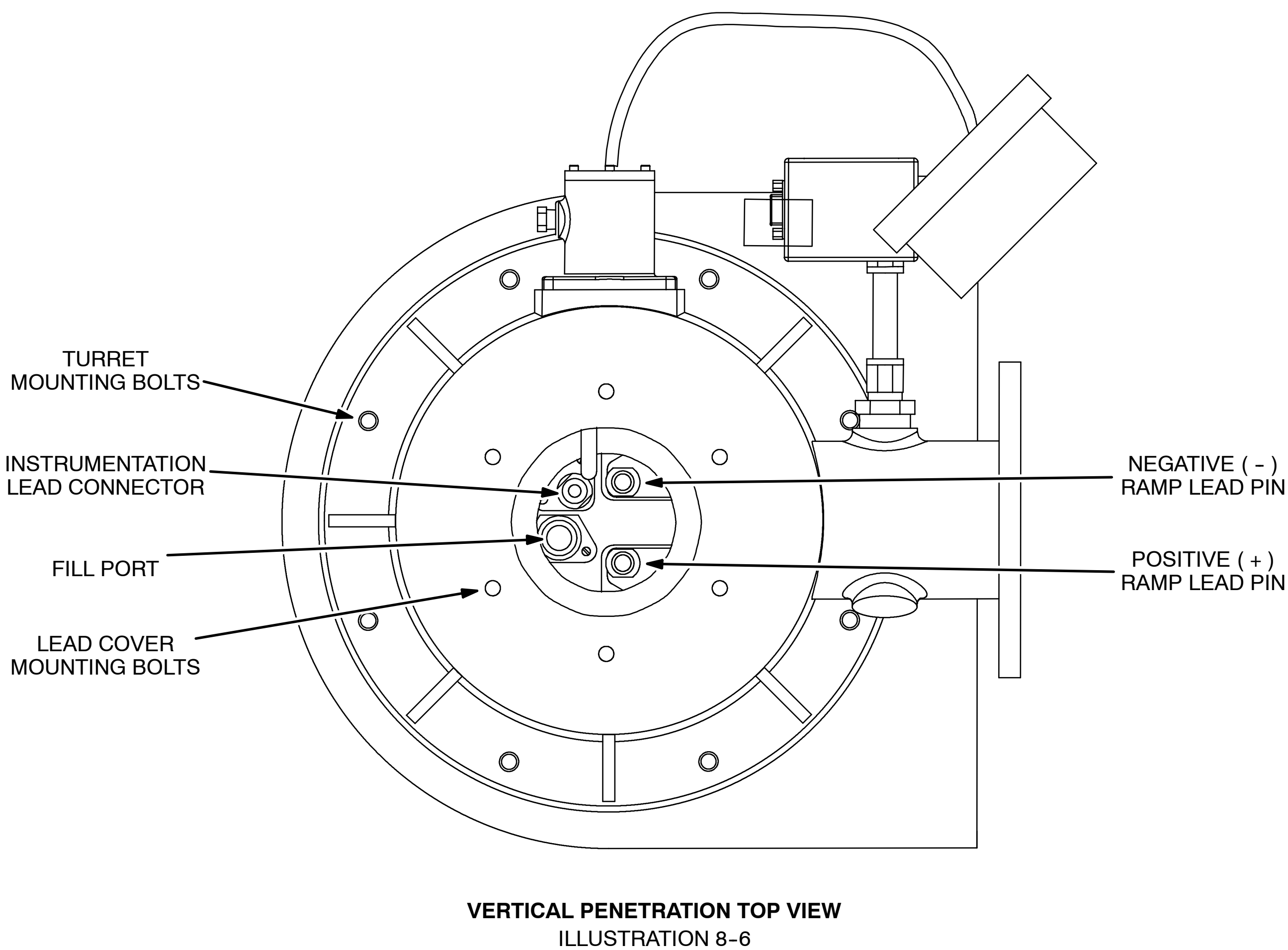
**Note**
Study the location of the keyways on the Instrumentation Lead Limo Connector and J101 for easy installation.

29. Shine a flashlight into the Vertical Penetration. Using the Instrumentation Connector Removal Tool with the Instrumentation Connector previously attached, position the connector at the bottom of the Vertical Penetration and insert into J101 until properly seated. See Illustration 8-6 for location of the Instrumentation Lead Connector.

30. Unscrew the Instrumentation Connector Removal Tool from the connector. Remove the tool.

31. Replace the 1/4 inch ( 6.3 mm ) Pipe Plug in the Lexan Top Cover. Clean and wrap the remaining threads on the male run Tee with teflon tape.

32. Attach the 1/4 inch ( 6.3 mm ) copper Vent Line removed earlier.




**VERTICAL PENETRATION TOP VIEW**
ILLUSTRATION 8-6

### 8-2 INSTRUMENTATION LEAD ASSEMBLY REMOVAL / REPLACEMENT ( continued )

33. Prepare the Cover Plate Assembly by removing the old o-ring and installing a new o-ring ( 46- 281101P1 ). Use vacuum grease when installing the o-ring.

**CAUTION**

**Lower the Cover Plate Assembly into the Vertical Penetration carefully to prevent damage to the baffles.**

**Note**

The Cover Plate Assembly must be in the "Retracted" position ( i.e., the guide post must be completely screwed into the double-threaded brass screw ) before installing.

34. Remove the Lexan Top Cover and immediately install the Cover Plate Assembly into the Vertical Penetration. Secure with the six 1/4-20 screws and washers removed previously.
35. Reconnect the Vent Adaptor to the Turret Assembly with the bolts removed in Step 5.
36. Perform a Leak Test, using Snoop Liquid Leak Detector ( 46-252065P71 ), on the Instrumentation Lead / Shim Lead Assembly mountings and all plumbing connections. Correct any leaks found.
37. Reconnect J203 and perform electrical checks in conformance with FUNCTIONAL CHECKS, Section 5.
38. Turn on Coldhead / Cryocooler power.
39. Ramp / Fill the magnet in conformance with SET-UP AND CALIBRATION, Section 4.
40. Re-Shim the Magnet in conformance with SET-UP AND CALIBRATION, Section 6.

## IMPORTANT !!!

Perform all MRU checks in FUNCTIONAL CHECKS, Section 6, upon completion of Instrumentation Lead Assembly replacement to make sure no Instrumentation Lead or Lemo connector damage has occured. Correct any damage found by reconnecting the Lemo connector or replacing the Instrumentation Lead Assembly.

41. Check the Instrumentation Lead and Lemo connector for damage by performing the MRU checks in FUNCTIONAL CHECKS, Section 6.

# SECTION 9 - TWO-STAGE CRYOCOOLER COLDHEAD REPLACEMENT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2-5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 9-1 INTRODUCTION

Maintenance of cryocooler temperatures within specification is essential for proper operation of a zero boil-off magnet. Coldhead replacement is required when elevated thermal station ( first / second stage ) temperature problems have been isolated to the Coldhead or the complete cryocooler system or from catastrophic failure of the Coldhead. See FUNCTIONAL CHECKS, Section 2, for fault isolation of Coldhead problems.

It is important to change out Coldheads as soon as defects are uncovered. Complete Coldhead replacement will take approximately three hours. Make sure a new Coldhead and all required tools and equipment are on-site before starting the procedure. Perform the change-out rapidly to minimize temperature rise in the magnet.

### 9-1 INTRODUCTION ( continued )

**WARNING!**

**THE FOLLOWING PRECAUTIONS MUST BE TAKEN WHEN CHANGING OUT A COLDHEAD AT MAGNET FIELD TO PREVENT ACCIDENTS, INJURIES, COLD BURNS AND DANGEROUS PROJECTILES IN A MAGNETIC FIELD:**

- **PROCEDURE MUST BE PERFORMED BY TRAINED AND QUALIFIED PERSONNEL ONLY.**
- **WEAR PROTECTIVE CLOTHING ( LONG-SLEEVE SHIRT, ETC. ) AND GOGGLES WHILE PERFORMING THIS PROCEDURE, TO PREVENT CRYOGEN BURNS OR EYE INJURY.**
- **REPLACE COLDHEAD USING THE COLDHEAD EXTRACTION / INSERTION TOOL. IT IS IMPORTANT TO HAVE THE TOOL INSTALLED BEFORE REMOVING THE COLDHEAD.**
- **DO NOT BRING ANY FERROMAGNETIC OBJECTS ( TOOLS, EQUIPMENT, GAS CYLINDERS, PERSONAL ITEMS, ETC. ) INTO THE MAGNET ROOM. THEY WILL BECOME DANGEROUS PROJECTILES IN THE MAGNETIC FIELD.**
- **MAKE SURE THE MAGNET RUNDOWN UNIT ( MRU ) IS FUNCTIONING PROPERLY TO ENABLE THE MAGNETIC FIELD TO BE QUICKLY DISCHARGED IN CASE OF AN EMERGENCY.**
- **REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## IMPORTANT !!!

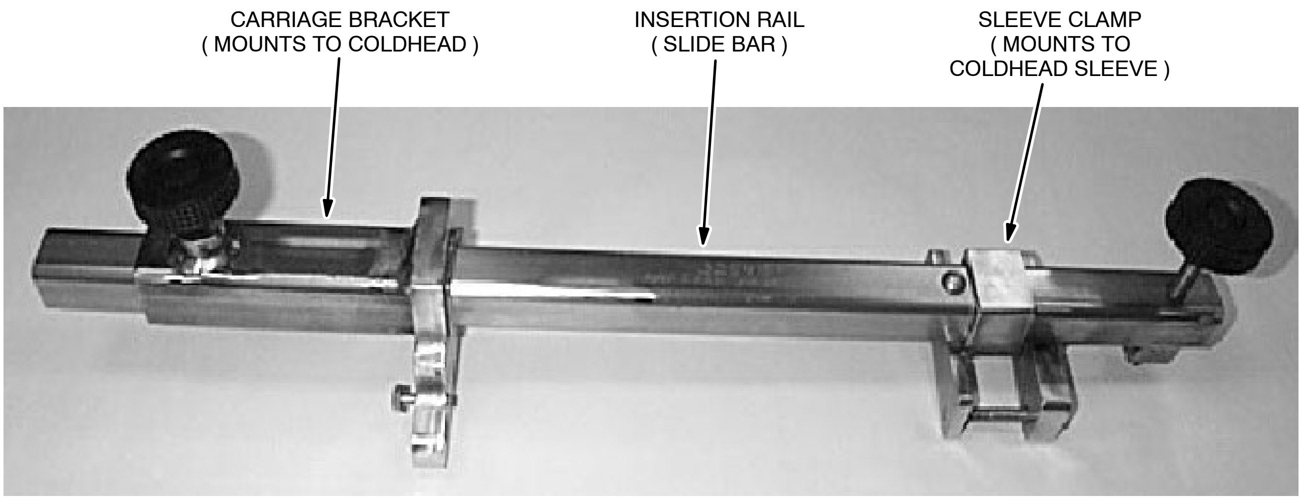
Monitor cryostat pressure throughout Coldhead replacement procedure. If magnet pressure is above 5 psig, vent the magnet down to 5 psig through Vent Valve V2. Pressure may require venting multiple times to prevent cold helium gas from cooling the shield and first stage heat station in the Coldhead Sleeve during Coldhead replacement. Cold helium exhaust flows through the shield exhaust plumbing, cooling the shield and first stage heat station.

## 9-2 TOOLS / EQUIPMENT

Make sure the following parts, tools and equipment are on-site before starting this procedure:

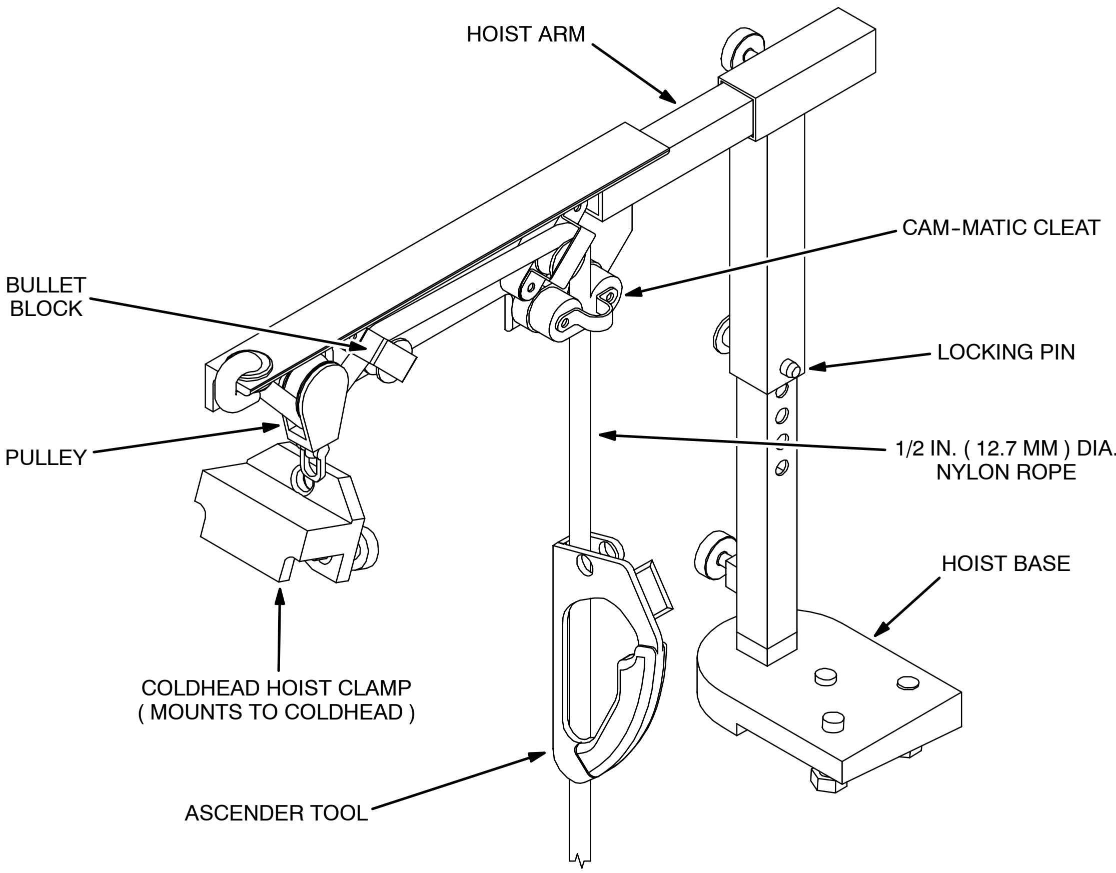
| | |
|---|---|
| • New / Reconditioned Coldhead* | 2218465 |
| • Coldhead Replacement Gasket Kit | 2171620 |
| • Universal Coldhead Replacement Tool Kit | 2300306 |
| • Non-Magnetic Coldhead Wrench Kit | 46-294804G1 |
| • Coldhead Insertion / Removal Tool Kit | 2262686 |
|   • Coldhead Insertion / Removal Tool ( 2254151 ): Illustration 9-1 | |
|   • Coldhead Hoist ( 2254615 ): Illustration 9-2 | |
|   • Purge Cover Plate ( 2275776 ): Illustration 9-3 | |
| • Coldhead Stand ( Holding Tool ) | 2214919 |
| • Portable Temperature Monitor<br>RuO Temperature Monitor Kit | 2171219 or<br>2183710 |
| • Pump-Out Port Dual O-Ring Plug | 2236606 |
| • Portable $O_2$ Monitor | 2106236 or 2106237 |
| • Full, nonmagnetic nitrogen gas cylinder | |
| • Gas Regulator Kit | 46-306734G1 |
| • Aluminum Tape | 46-260802P1 / P6 |
| • Flashlight | |
| • Black Light ( preferred ) or clean, lint-free white gloves | |
| • Scotch-Brite™ pads | |
| • Leather gloves ( for opening / closing motor shield and handling removed coldhead ) | |
| • Vacuum with non-magnetic extension hose | |

* New / reconditioned Coldhead must have been inspected and be free of defects before bringing to the site.

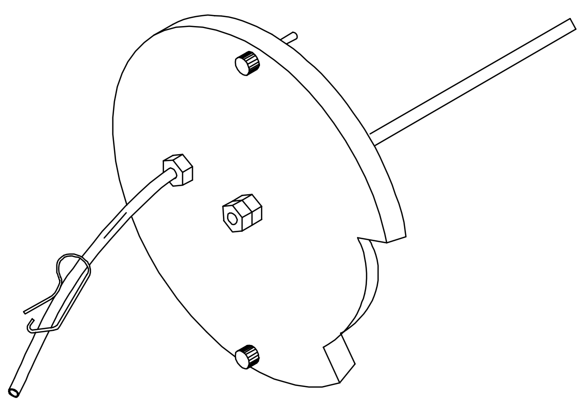



**MAJOR COMPONENTS, COLDHEAD INSERTION / REMOVAL TOOL ( 2254151 )**
ILLUSTRATION 9-1

## 9-2 TOOLS / EQUIPMENT ( continued )




**COLDHEAD HOIST ( 2254615 )**
ILLUSTRATION 9-2



**PURGE COVER PLATE ( 2275776 )**
ILLUSTRATION 9-3

## 9-3 COLDHEAD REMOVAL

### 9-3-1 Removal Preparation

**CAUTION**

**Make sure lines are removed immediately after power is disconnected to prevent contamination of lines and compressor.**

1. If magnet pressure is > 3 psig, vent the magnet down through vent valve V2 to 1 psig. Monitor pressure throughout procedure and vent through V2 as required to keep cryostat pressure < 4 psig.
2. Immediately upon site arrival, turn off the Compressor and disconnect the power cable from the Coldhead.

**CAUTION**

**Do not put any bending force on Aeroquip fittings while connecting / disconnecting helium flexlines. A bending force will create difficulty in the rapid thread engagement / disengagement required to prevent helium loss and contamination. It can also result in bending or leaking of the Aeroquip stems. Support gas lines to prevent a bending force when connecting / disconnecting to coldhead at top of magnet.**

3. Once Coldhead power is disconnected, immediately disconnect the helium gas lines at the Coldhead in conformance with REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections / Replacement.
4. Shine a black light at the surfaces inside the supply Flexline fitting. Any violet-colored glow indicates oil contamination in the Coldhead-Compressor system. The Coldhead, Compressor and Flexlines must be replaced to remove all oil contaminating the system.

   **Note**

   Clean, lint-free white gloves may be used in place of the preferred black light. Wipe the gloves inside the fitting. Any stains on the gloves indicate oil contamination.
5. Remove enclosures required for Coldhead access.

### 9-3-1 Removal Preparation ( continued )

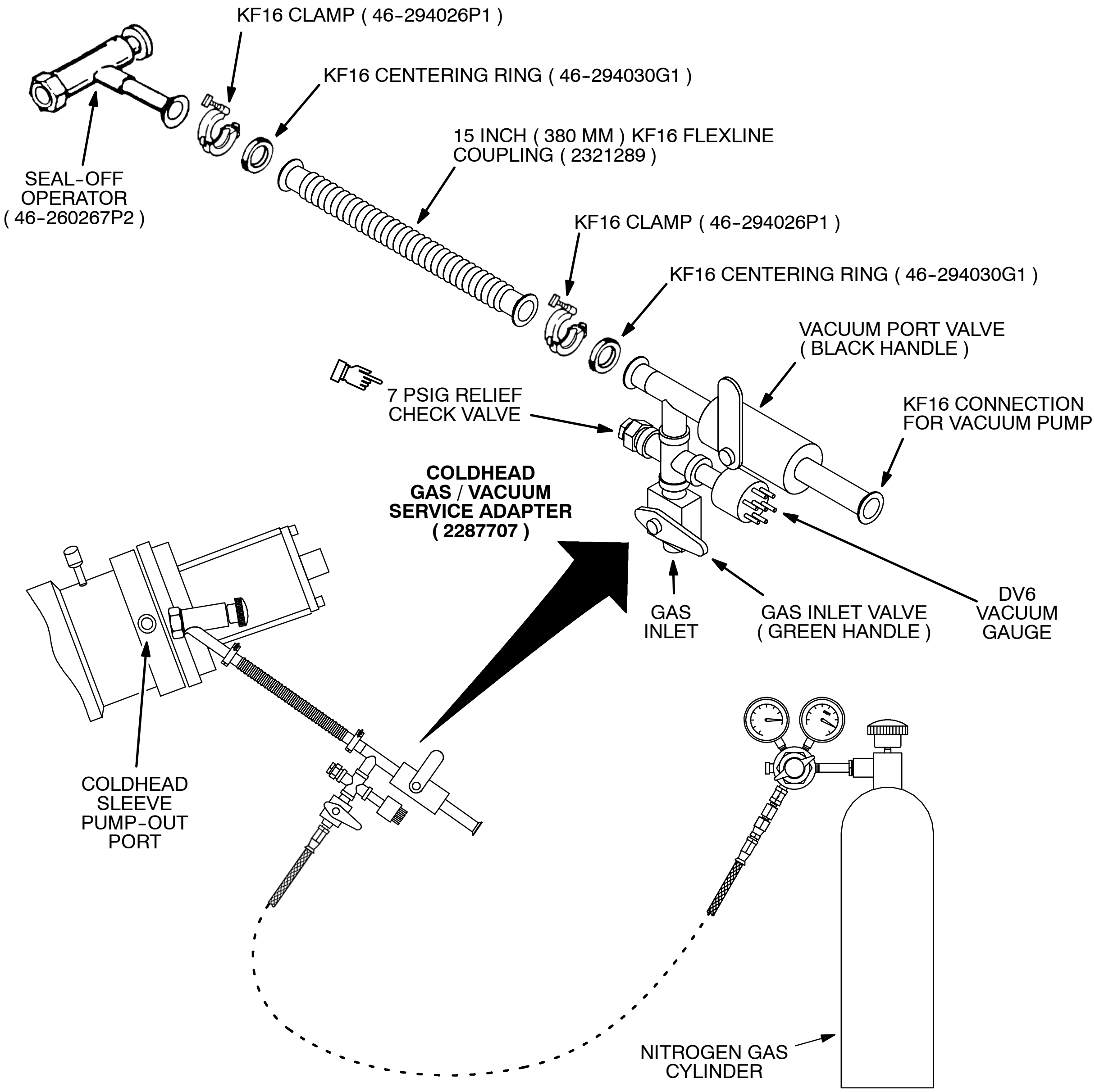
**WARNING!**

**THE COLDHEAD MOTOR SHIELD IS MADE OF FERROMAGNETIC MATERIAL AND HAS A LARGE ATTRACTIVE FORCE TO THE MAGNET. DO NOT LOOSEN OR REMOVE THE MOTOR SHIELD MOUNTING SCREWS UNDER ANY CIRCUMSTANCE.**

**WEAR LEATHER GLOVES AND USE EXTREME CAUTION WHEN PIVOTING TOP HALF OF MOTOR SHIELD TOWARD THE MAGNET TO EXPOSE THE COLDHEAD OR PERSONAL INJURY MAY RESULT. DO NOT PUT FINGERS OR HAND BETWEEN THE MOTOR SHIELD AND MOUNTING BRACKET WHEN PIVOTING THE MOTOR SHIELD TOWARD THE MAGNET.**

6. Open the Coldhead motor shield by removing the .25-20UNC stainless steel socket head cap screw in the end of the motor shield. Put the screw in a secure place for replacement later.
7. Clean all vacuum fittings on apparatus shown in Illustrations 9-4 and 9-5. Then lightly coat o-rings with vacuum grease to make sure vacuum seals are tight.
8. Attach the seal-off operator to the pump-out port on the Coldhead sleeve. See Illustration 9-4. Tighten the seal-off operator to the pump-out port by holding the body of the operator and tightening the nut with a wrench.
9. Connect the service adapter to the seal-off operator.

### 9-3-1 Removal Preparation ( continued )



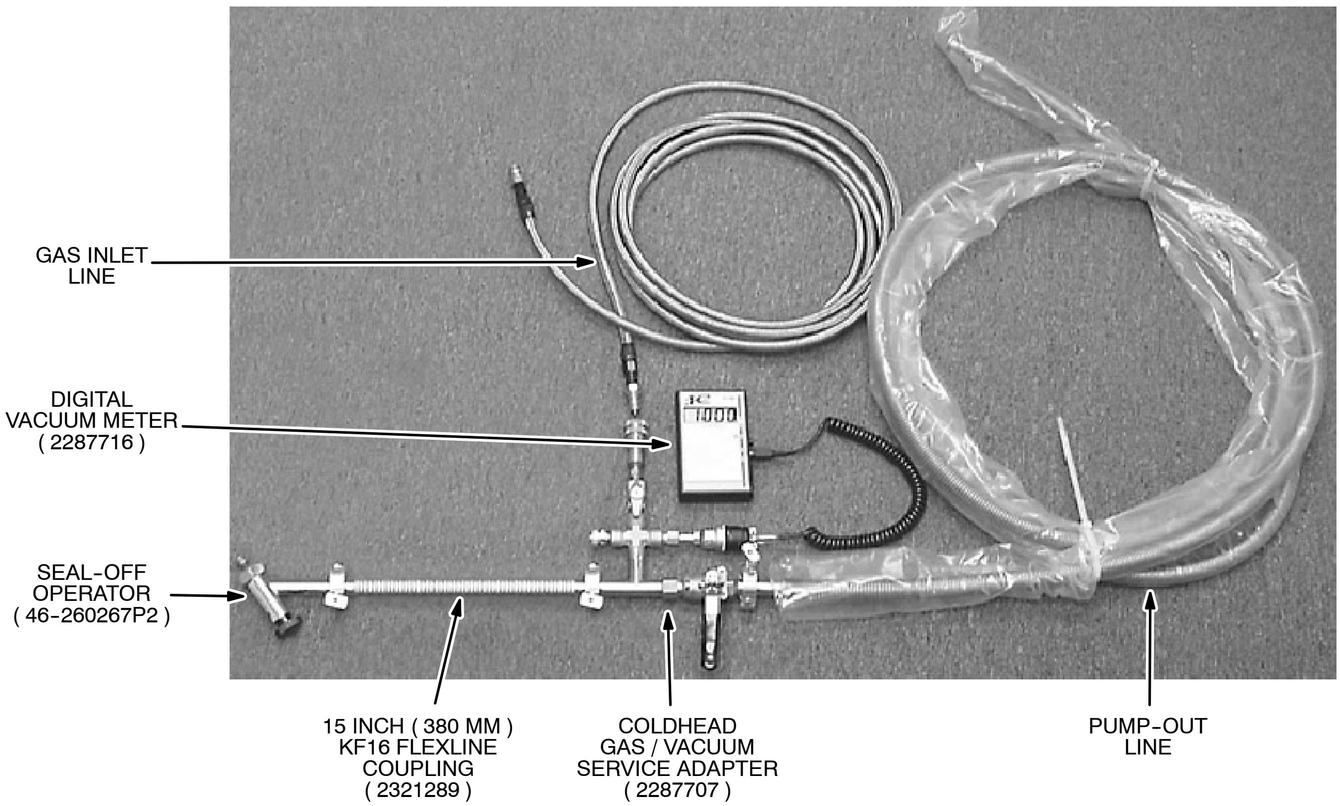

**COLDHEAD GAS / VACUUM SERVICE APPARATUS**
ILLUSTRATION 9-4

10. Connect the gas regulator to the nitrogen gas cylinder. Connect a flexible hose from the gas regulator to the service adapter inlet valve on the ( green handle ). See Illustrations 9-5 and 9-6.

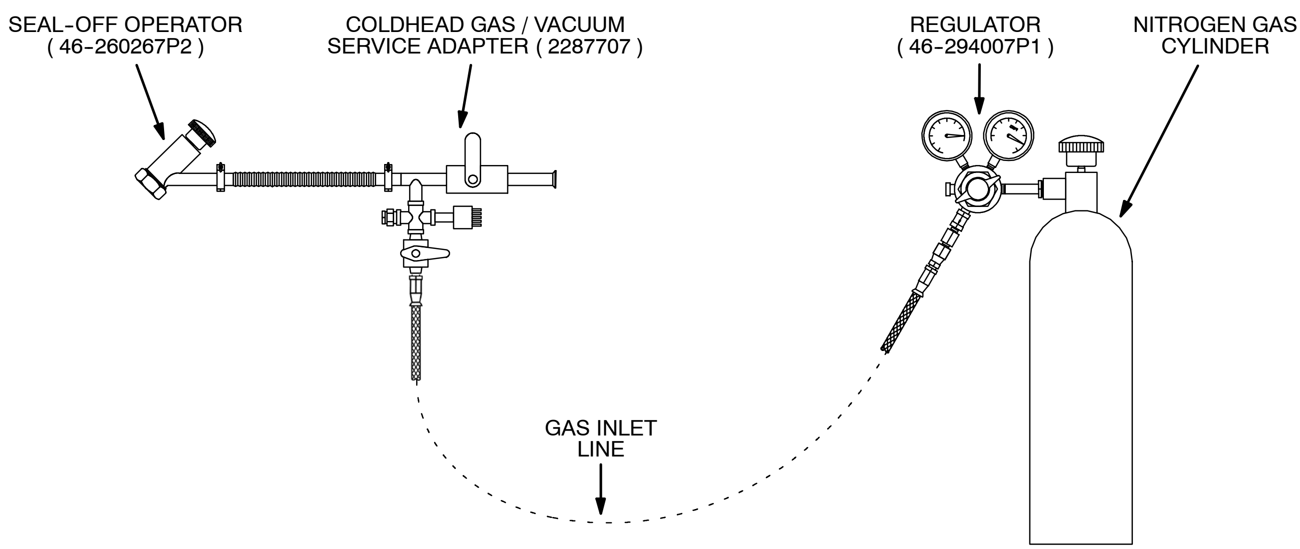
11. Make sure the regulator handle is backed out counterclockwise ( CCW ) to avoid regulator damage, then open the gas cylinder slowly. The high pressure gauge should indicate 2100 - 2400 psig if the cylinder is full.

12. Open the gas inlet valve and set a low pressure gas flow ( 1 psig ) as indicated on the regulator gauge.

### 9-3-1 Removal Preparation ( continued )



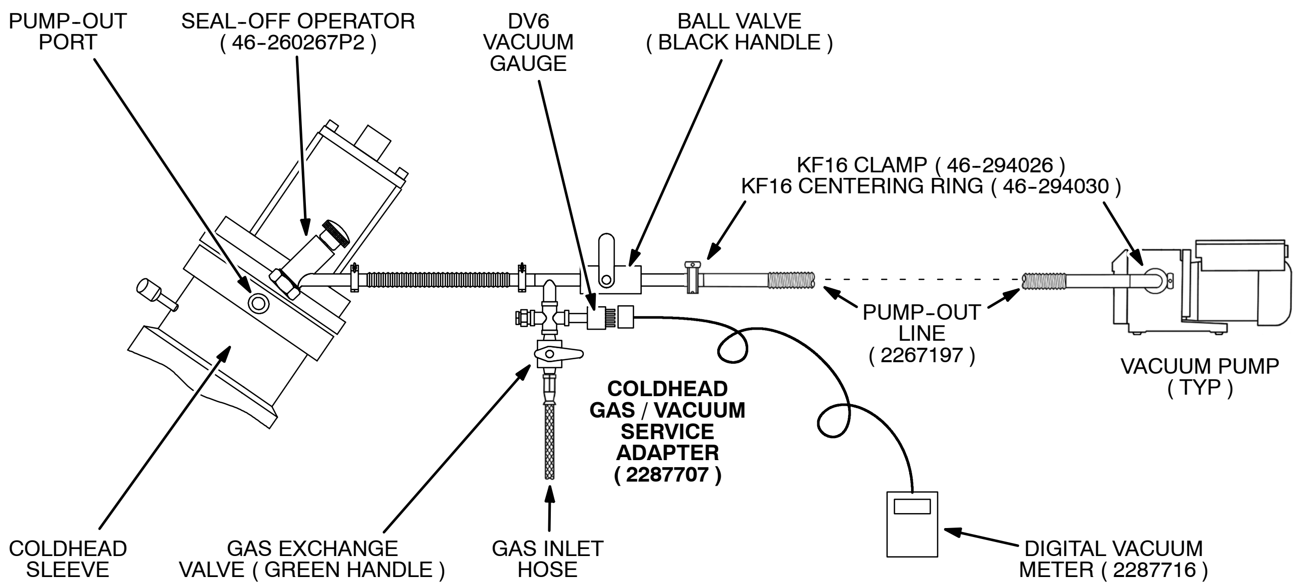

**COLDHEAD GAS / VACUUM SERVICE ADAPTER AND CONNECTIONS**
ILLUSTRATION 9-5




**NITROGEN GAS CONNECTION**
ILLUSTRATION 9-6

### 9-3-1 Removal Preparation ( continued )

13. Open the vacuum port valve ( black handle ) on the adapter and allow gas to flow out for 30 seconds to purge the assembly of air.
14. Close the vacuum port and gas inlet valves.
15. Make sure the black and green handles on the service adapter are closed. Connect the vacuum pump apparatus as shown in Illustration 9-7. Apply a light coat of vacuum grease to the centering o-rings.




**VACUUM PUMP APPARATUS SET-UP**
ILLUSTRATION 9-7

16. Turn on the vacuum pump, open the vacuum valve ( black handle ) on the service adapter and allow the pump to evacuate the vacuum line and service adapter to 50 millitorr ( 50 microns ). Read on the digital vacuum gauge. Then close the vacuum valve ( black handle ).
17. Repeat opening and closing the vacuum valve ( black handle ) two more times while pumping.
18. When 50 millitorr ( 50 microns ) is reached, close the vacuum valve ( black handle ). Observe the vacuum gauge to make sure the service adapter and seal-off operator are leak tight. If the gauge rises > 200 millitorr ( 200 microns ) over 30 seconds, suspect a leak and:
    a. Turn off the vacuum pump and temporarily open the green handle to bring the apparatus to atmospheric pressure.
    b. Remove the vacuum line and reassemble the seal-off operator and service adapter.
    c. Repeat Steps 15 - 18 until the system is leak tight.
19. When the apparatus is leak tight, open the vacuum valve ( black handle ) and make sure the vacuum is ≤ 50 millitorr ( 50 microns ) before continuing with Step 20.

### 9-3-1 Removal Preparation ( continued )

20. Push in and rotate the black handle of the seal-off operator clockwise ( CW ) to engage the plug in the pump-out port. When the handle is engaged, pull the handle out to open the pump-out port.

21. Immediately check the vacuum on the digital vacuum meter for a reading of ≤ 50 millitorr ( 50 microns ). A reading of >> 100 millitorr ( 100 microns ) indicates a poor vacuum in the sleeve that may cause cooling problems. If this condition occurs:

    a. Pump out the sleeve again to achieve a vacuum < 100 millitorr ( 100 microns ).

    b. Operate the Coldhead to establish final temperature.

**Note**

The service adapter has a 5 psig relief valve to prevent the build-up of excess pressure in the Coldhead sleeve when any nitrogen, frozen to the Coldhead, regassifies during Coldhead warm-up. Some audible gas escaping may be encountered.

**Note**

Save the bolts and washers removed in the next step, leaving the same number of washers on each bolt. These will be used to mount the new Coldhead and will make sure the proper interface spacing is maintained. Bolts are installed through the sleeve flange.

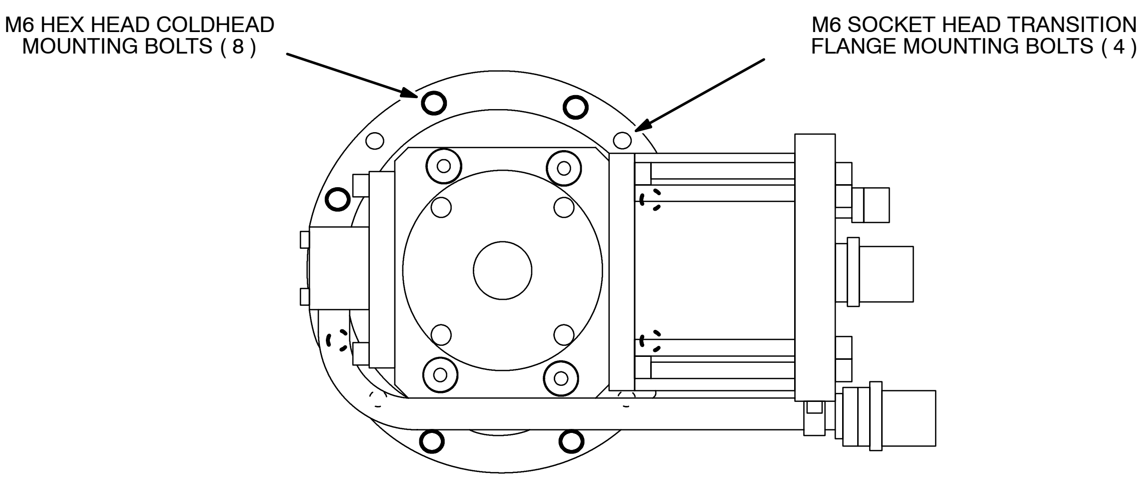
22. Loosen and remove the eight Coldhead mounting bolts and Belleville washers. See Illustration 9-8.

23. Rethread two bolts without Belleville washers 3 - 4 threads deep into holes 180° apart.

**Note**

These two bolts ensure that the Coldhead can be contained when gas pressure is applied. Save bolts and washers to mount the new Coldhead.

24. Close the vacuum valve ( black handle ). Then open the gas inlet valve ( green handle ) and fill the vacuum space in the sleeve with nitrogen gas at a small positive pressure ( 1 - 3 psig on the low-pressure regulator ) to break the Coldhead away from the first and second stage contacts.



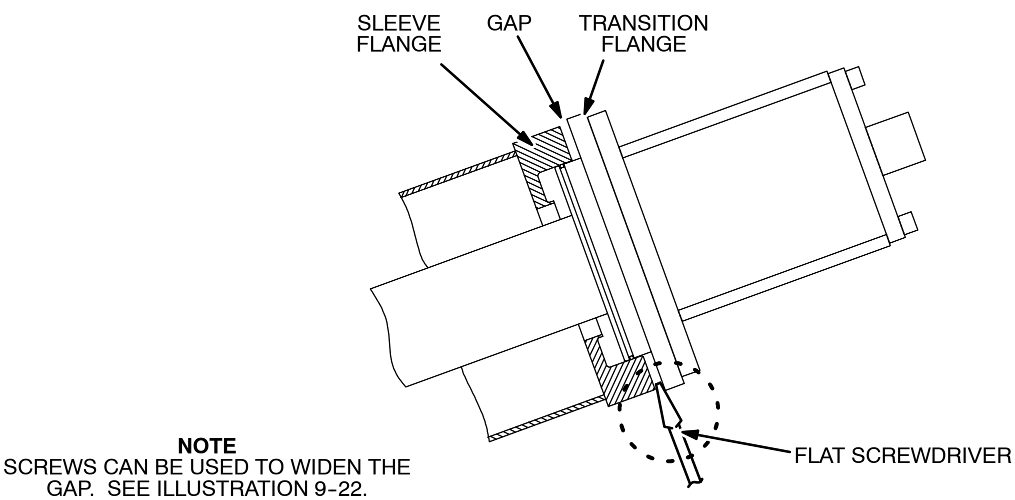

**COLDHEAD MOUNTING**
ILLUSTRATION 9-8

### 9-3-1 Removal Preparation ( continued )

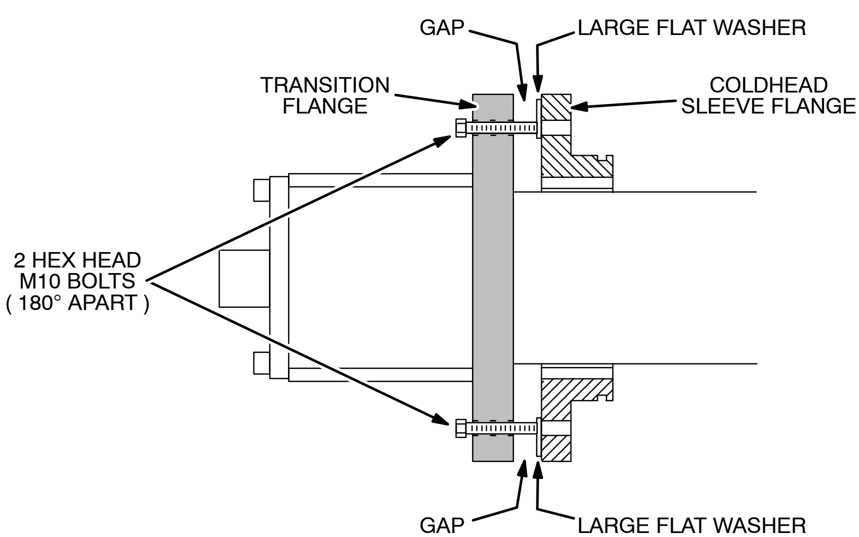
25. If required to dislodge the Coldhead, carefully insert a large screwdriver or other similar wedge-shaped tool in the gap between the sleeve flange and transition flange. Gradually pry the transition flange away from the sleeve flange by tapping the end of a screwdriver or wedge while moving it around the circumference of the gap. See Illustration 9-9. Or use two M10 bolts as a jackscrew to apply a separating force between the coldhead sleeve flange and the transition flange. See Illustration 9-10.

**Note**

Two M10 hex head bolts inserted 180° apart can be used as "jackscrews" to break the indium seal between the second-stage heat station of the sleeve and Coldhead. Torque bolts to apply force between Coldhead sleeve flange and transition flange. See Illustration 9-10.




**SEPARATION OF TRANSITION FLANGE FROM SLEEVE FLANGE USING A FLAT SCREWDRIVER**
ILLUSTRATION 9-9




**SEPARATION OF TRANSITION FLANGE FROM SLEEVE FLANGE USING TWO JACK SCREWS ( M10 BOLTS )**
ILLUSTRATION 9-10

### 9-3-1 Removal Preparation ( continued )

**WARNING!**

**WEAR INSULATED LEATHER GLOVES WHEN REMOVING COLDHEAD. DO NOT TOUCH THE FIRST OR SECOND COLD STATIONS OF A REMOVED COLDHEAD TO PREVENT "COLD BURNS".**

**WHEN REMOVING COLDHEAD, KEEP AWAY FROM THE TOP OF THE COLDHEAD TO PREVENT INJURY IF THE COLDHEAD POPS OUT UNDER GAS PRESSURE.**

**CAUTION**

**Make sure nitrogen gas is flowing through the pump-out port connection, the Plexiglas Cover Plate / Heater Assembly, the separate cover plate, the Coldhead Insertion / Removal Tool and the Coldhead Hoist are within reach before proceding.**

26. When the Coldhead breaks away from the first and second stage contacts, remove the remaining two bolts and partially extract the Coldhead until the Transition Flange o-ring is exposed.

**Note**

Partial extraction of Coldhead is required for Coldhead Extraction / Insertion Tool installation.

### 9-3-2 Coldhead Extraction

**WARNING!**

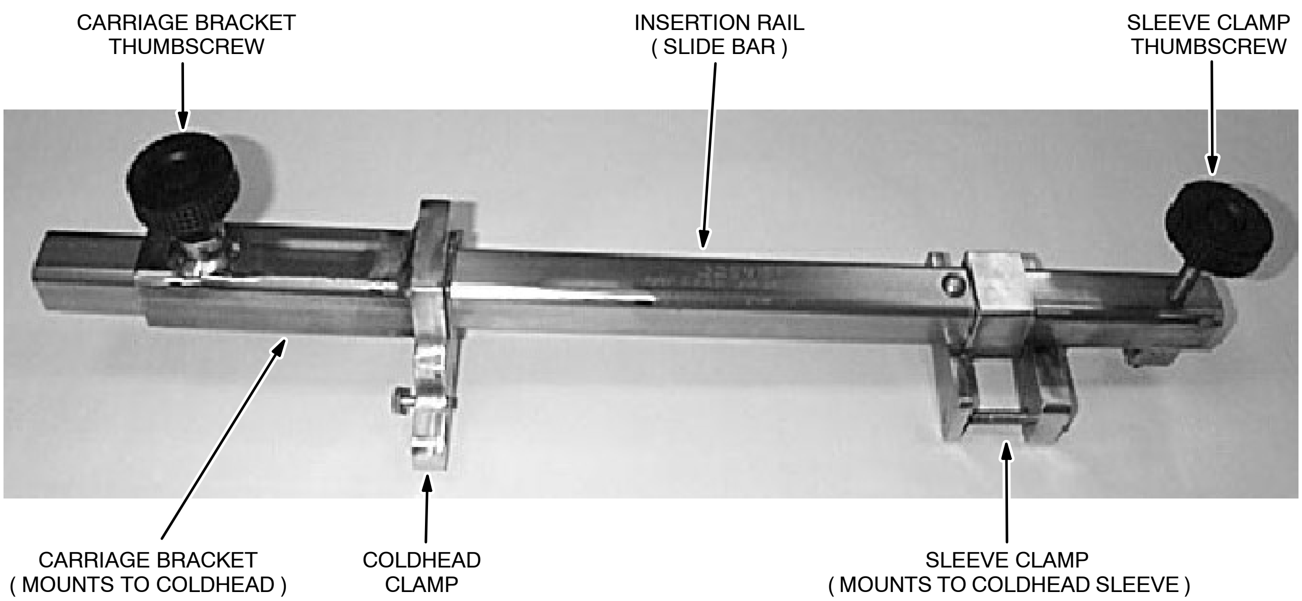
**WEAR LEATHER GLOVES WHEN REMOVING COLDHEAD TO PREVENT COLD BURNS AND / OR INJURY TO HANDS.**

**CAUTION**

**Do not slide the Coldhead out too far in Step 1. Maintain contact between the Coldhead transition flange and the Sleeve cavity to prevent the Coldhead first stage from dropping onto the Sleeve.**

1. Slide the Coldhead out 5/16- 3/8 inches ( 8 - 10 mm ) from the Sleeve to allow assembly of the Coldhead Insertion / Removal Tool's sleeve clamp onto the sleeve flange. Position the clamp straddling the sleeve flange and aligned with the holes in the flange's bottom. Insert the clamping bolts and tighten. See Illustrations 9-11 and 9-12.

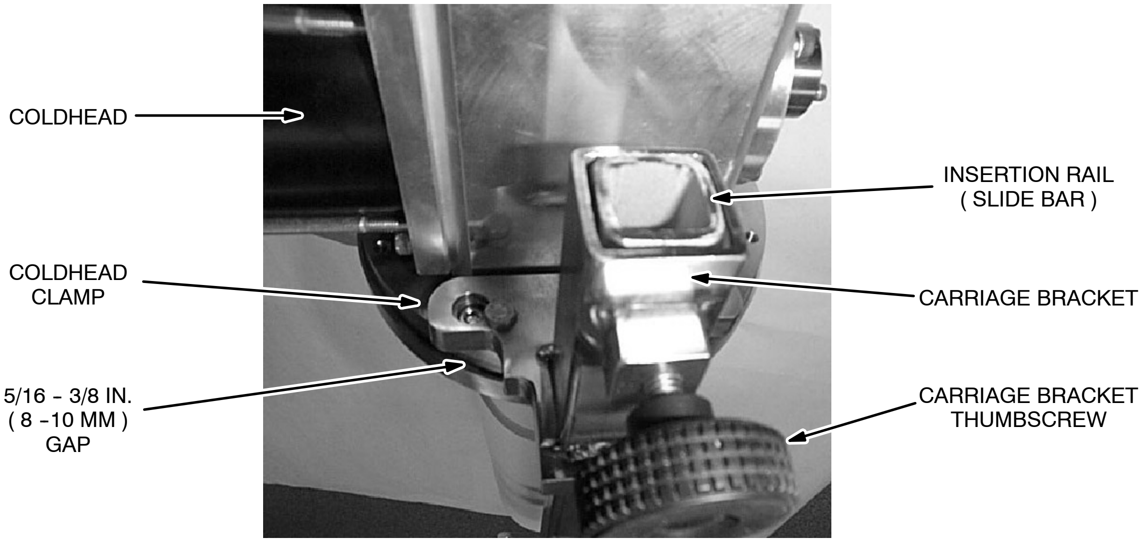
2. Tighten the sleeve clamp thumbscrew hand tight against the Coldhead sleeve to prevent the bar from pivoting at the clamp.



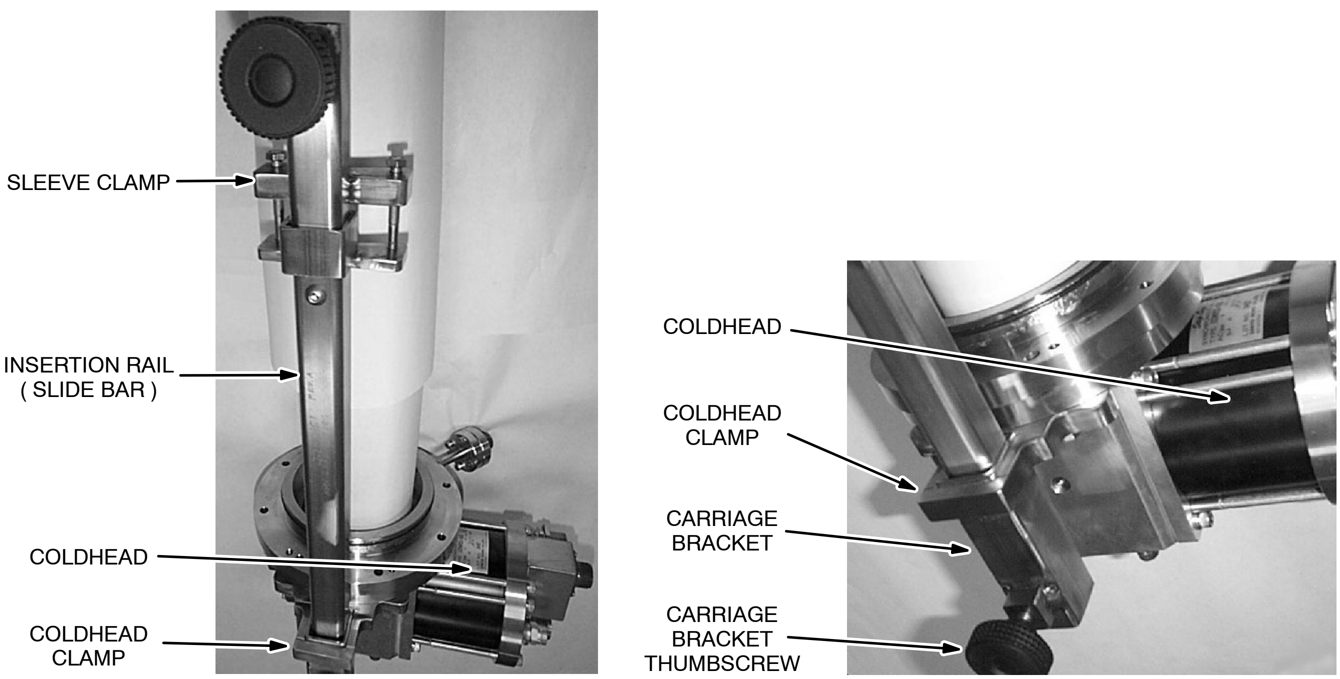

**COLDHEAD INSERTION / REMOVAL TOOL ( 2254151 )**
ILLUSTRATION 9-11

### 9-3-2 Coldhead Extraction ( continued )

3. Slide the carriage bracket of the Insertion / Removal Tool onto and along the insertion rail until it contacts the Coldhead flange. Tightly fasten the carrying bracket to the Coldhead flange's two bottom threaded holes using the bracket's bolts. See Illustrations 9-12 and 9-13.



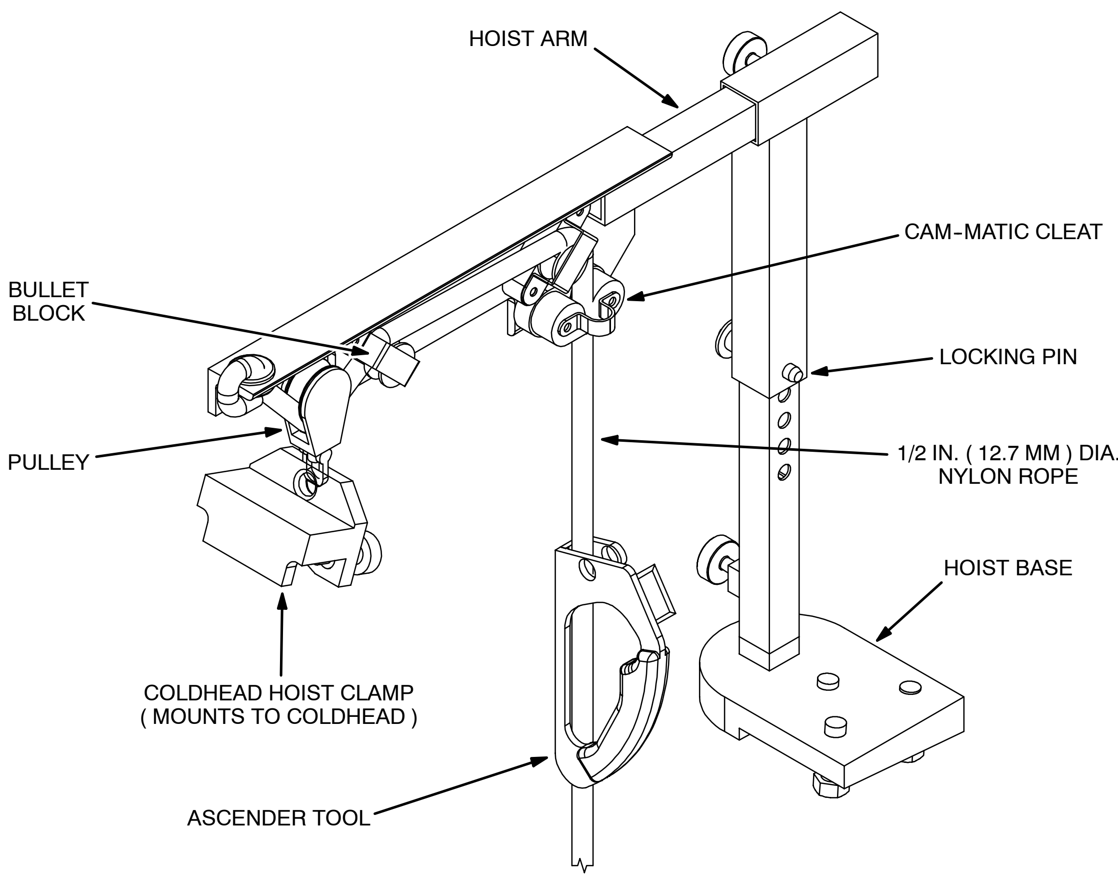

**COLDHEAD CLAMP INSTALLATION**
ILLUSTRATION 9-12




**INSERTION RAIL INSTALLATION**
ILLUSTRATION 9-13

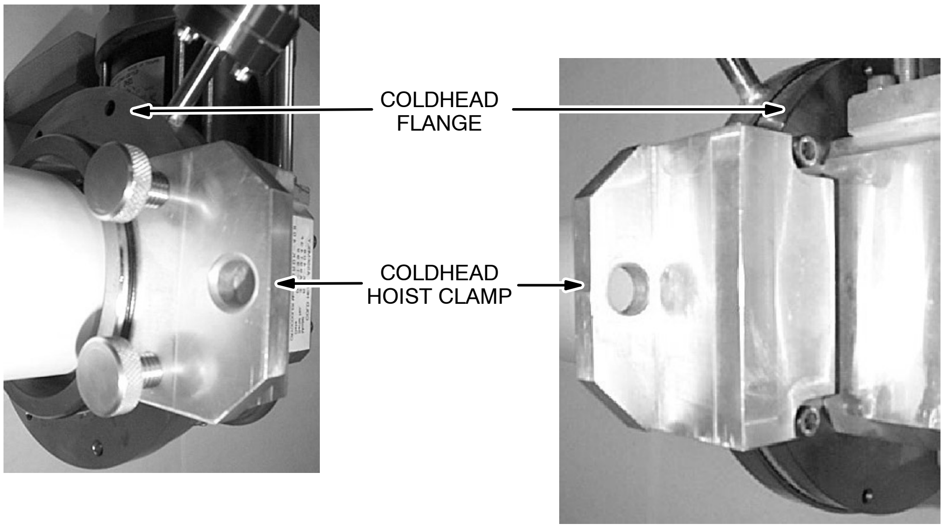
### 9-3-2 Coldhead Extraction ( continued )

4. Pull the Coldhead out along the insertion rail 3 – 4 inches ( 75 – 100 mm ).
5. Fasten the coldhead hoist clamp onto the Coldhead flange by inserting and tightening the two hoist clamp thumb screws through the threaded holes at the top of the Coldhead flange. See Illustrations 9-14 and 9-15.
6. Assemble the Coldhead Hoist base onto Motor Shield bracket with the three Allen head screws provided.
7. Assembly the hoist onto the hoist base. Adjust the Coldhead Hoist vertically and horizontally to allow safe Coldhead lowering and raising from the end of the insertion rail. See Illustration 9-14.
8. Make sure the Coldhead Hoist's rope and ascender tool are assembled as shown in the Illustration 9-14. Make sure the rope is securely fastened to the outer end of the hoist arm.




**COLDHEAD HOIST ( 2254615 )**
ILLUSTRATION 9-14

### 9-3-2 Coldhead Extraction ( continued )




**COLDHEAD HOIST CLAMP**
ILLUSTRATION 9-15

9. Slide the Coldhead out to the end of the insertion rail, taking up all slack in the hoist rope by pulling it through the Cam-Matic cleat.

10. Gradually pull the Coldhead and carriage bracket off the insertion rail, allowing hoist to support the Coldhead's weight via the grip of the cleat on the rope. See Illustration 9-14.

**CAUTION**

**The Coldhead and bracket weigh approximately 50 pounds:**

- **Use the Coldhead Insertion / Removal Tool to lift the Coldhead, making sure weight of the Coldhead is properly supported on the fixture.**
- **Hold the Coldhead firm on Service Platform while removing the carriage bracket and hoist clamp, to prevent Coldhead attraction to the magnet.**

11. Firmly grip the ascender tool and rope with both hands and pull the rope out of the cleat's grip, taking control of the Coldhead's weight. Gradually lower the Coldhead to the service platform and hold firmly in place.

12. Remove the carriage bracket and hoist clamp from the old Coldhead. Leave the rest of the Coldhead Insertion / Removal Tool attached to the sleeve.

### 9-3-2 Coldhead Extraction ( continued )

**WARNING!**

**THE COLDHEAD CONTAINS FERROMAGNETIC MATERIAL. TO PREVENT THE REMOVED COLDHEAD FROM BEING ATTRACTED INTO THE MAGNET SECURELY CARRY IT DIRECTLY AWAY FROM THE MAGNET AND ALONG THE PERIMETER WALL, AS FAR FROM THE MAGNET AS POSSIBLE, TO THE ROOM EXIT. KEEP THE COLDHEAD AWAY FROM THE MAGNET BORE AT ALL TIMES.**

13. Carefully carry the removed Coldhead off the service platform, directly to the side wall and along the wall to the room's exit.

**Note**
Package the old Coldhead in the new Coldhead's shipping carton for return.

### 9-3-3 Sleeve Warm-Up

1. After the Coldhead is removed, immediately install the Plexiglas Cover Plate / Heater Assembly onto the Coldhead sleeve flange. See illustration 9-16.

**Note**
The relief valve on the removed Coldhead may exhaust helium gas with a popping or hissing sound as it warms up.

2. Close gas inlet valve ( green handle ) on the service adapter and connect the nitrogen gas supply to the gas line connection on the Plexiglas Cover Plate / Heater Assembly. See Illustration 9-16.

3. Set the nitrogen gas flow to 3 - 4 psig on the regulator low pressure gauge.

**WARNING!**

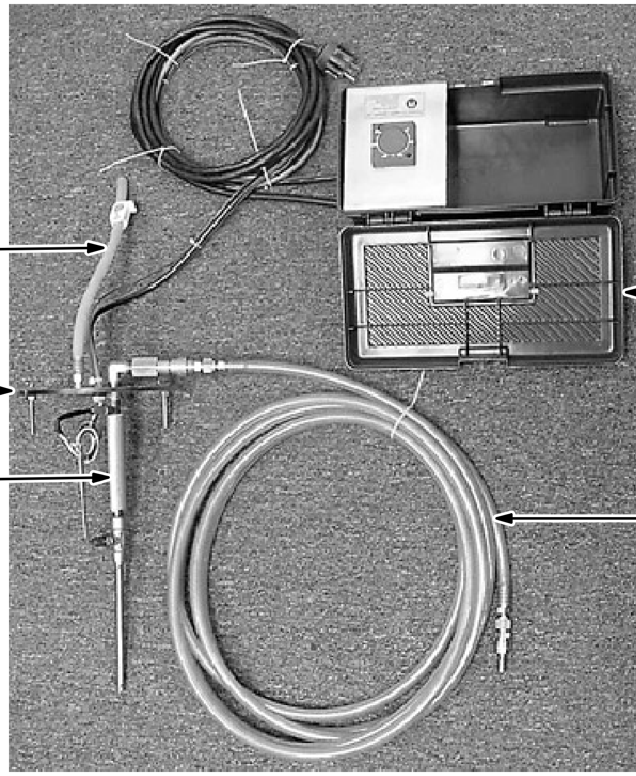
**MAKE SURE NITROGEN GAS IS FLOWING BEFORE PLUGGING IN THE HEATER.**

**DO NOT TOUCH THE HEATER OR EXISTING GAS TO PREVENT BURNS TO THE HANDS.**

**DO NOT EXCEED 285K MONITORED RECONDENSER TEMPERATURE TO PREVENT THE POSSIBILITY OF A MAGNET QUENCH OR INTERNAL DAMAGE.**

4. Plug in the gas heater and set gas temperature on the Plexiglas Cover Plate / Heater Assembly's control box to 110° - 120°F. Make sure warm gas is exiting the slit in the exhaust tubing on the the Plexiglas Cover Plate / Heater Assembly. See Illustration 9-16.

### 9-3-3 Sleeve Warm-Up ( continued )




**PLEXIGLAS COVER PLATE / HEATER ASSEMBLY ( 2303715 )**
ILLUSTRATION 9-16

5. Shine flashlight light through the plexiglas cover to observe the first and second stage heat stations inside the Coldhead sleeve.

**CAUTION**

**Do not keep the plexiglas cover off the sleeve flange for an extended period of time ( > 1 minute at a time ) to minimize cryopumping and icing of the first stage heat station.**

6. If indium is present on the first or second stage heat stations, temporarily remove the Plexiglas Cover Plate / Heater Assembly and remove the indium with a long-handled flat-head screwdriver or similar device, being careful not to scratch the copper heat station.

**Note**
Indium material on the heat station may be warmed using the warm gas from the nitrogen gas supply line to make it easier to remove. A separate cover plate is included in the Universal Coldhead Replacement Tool Kit that can be used while cleaning out the sleeve.

7. When all indium is removed, take a Scotch Brite™ pad and long tweezers to polish the heat stations.

### 9-3-3 Sleeve Warm-Up ( continued )

**WARNING!**

**DO NOT BRING SHOP VACUUM CLOSE TO RAMPED MAGNET. FERROMAGNETIC OBJECTS WILL BECOME DANGEROUS PROJECTILES IN A STRONG MAGNETIC FIELD. VACUUM USING A NON-MAGNETIC EXTENSION HOSE AT LEAST 18 FEET ( 5.5 METERS ) LONG.**

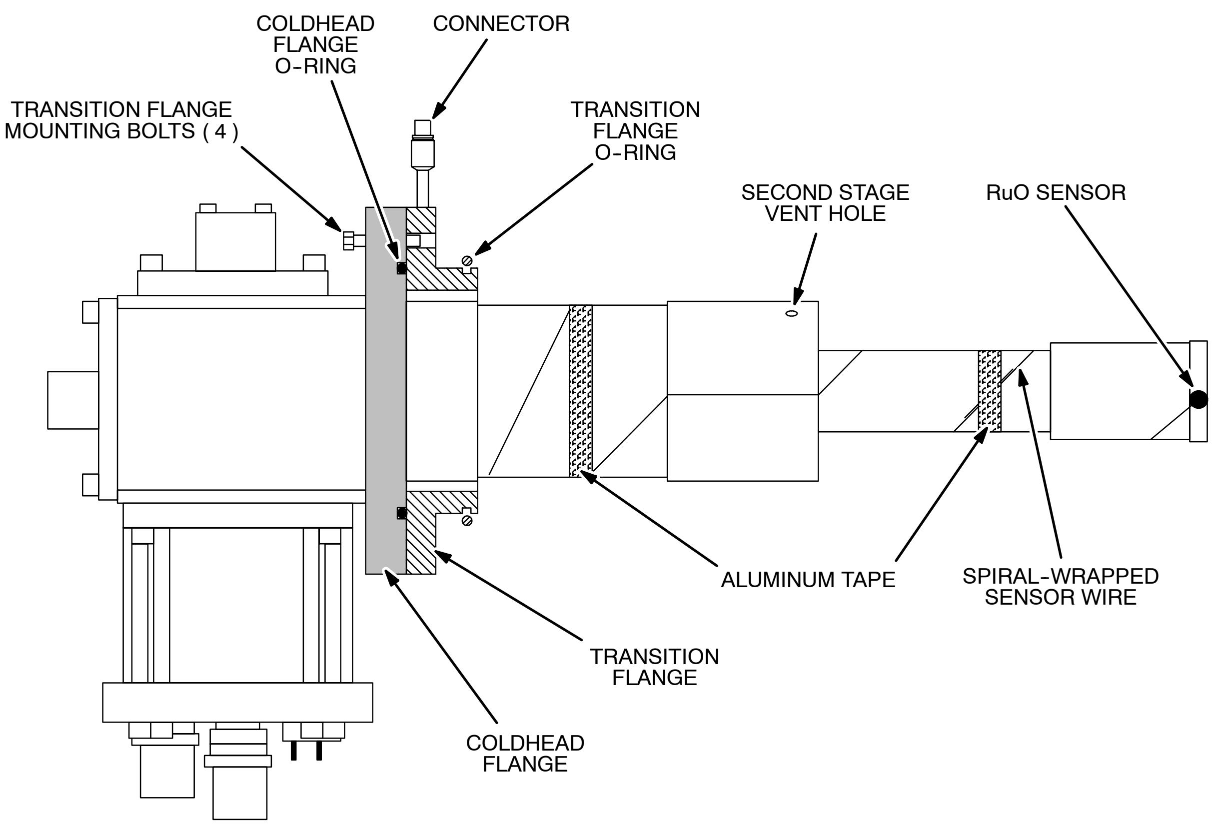
8. Evacuate all residue in the sleeve with a shop vacuum. Securely position the cannister of the vacuum away from the magnet's field and vacuum using a non-magnetic extension hose at least 18 feet ( 5.5 M ) long.
9. When the heat stations are clean, secure the Plexiglas Cover Plate / Heater Assembly's cover plate. Continue the gas flow to warm the sleeve and heat stations to the required temperature while preparing the new Coldhead.
10. Use the packaging materials from the new Coldhead to return the old Coldhead.

## 9-4 NEW COLDHEAD PREPARATION

**CAUTION**

**If the old Coldhead is being re-inserted, make sure it is at room temperature and free of moisture before starting this procedure to prevent a poor interface and a contaminated sleeve. Warm Coldhead with a heat gun if necessary.**

1. Remove the new Coldhead and gasket kit from its packaging. Place these on the Coldhead Stand ( Holding Tool ). Save the shipping container and packing material for return if damage is found. If reinstalling the old Coldhead, make sure it is dry and at room temperature.
2. Inspect the Coldhead using Illustration 9-17 as a reference. The RuO wire wrapping may be slightly different than configuration shown. The items identified in the illustration must be present and installed approximately where shown. The RuO sensor must be securely mounted in area shown. Make sure the RuO sensor wires are not broken or disconnected, the insulation is intact and the tape / clamps are secure.
3. Inspect the electrical cable and connector. Make sure it is not cracked or broken and that no wires are loose or exposed ( insulation split or missing ).




**COLDHEAD O-RING PLACEMENT**
ILLUSTRATION 9-17

### 9-4 NEW COLDHEAD PREPARATION ( continued )

4. Remove the transition flange o-ring from its packaging and inspect for any visible damage ( i.e. broken, nicked, cut, etc. ).
5. Clean the o-ring and the o-ring groove in the transition flange with a lint-free cloth or towel. Apply a thin film of vacuum grease to the entire surface of the o-ring.
6. Slide the lubricated o-ring over the two stations of the Coldhead and place in the groove of the transition flange. See Illustration 9-17.

**Note**

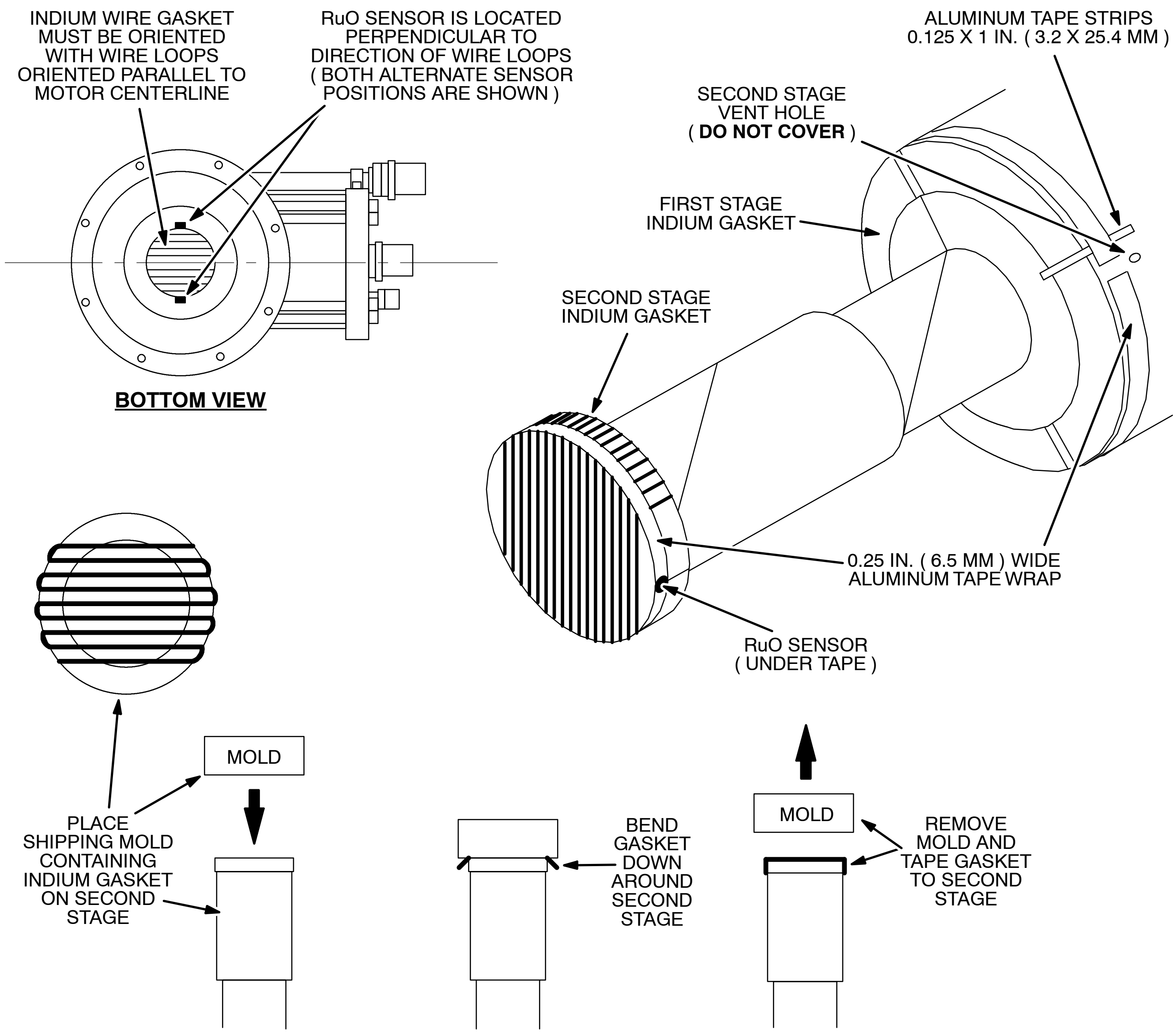
Assemble the new indium gaskets on the first and second stage heat stations of the coldhead. Wear the cloth gloves provided in the Gasket Kit.

**CAUTION**

**Make sure the 0.125 inch ( 3 mm ) wide aluminum tape strips are indented <u>into</u> the notches in the first stage surface and that the 0.25 inch ( 6.5 mm ) wide circumferential tape wrap does not cover the second stage vent hole. Both are required to allow adequate second stage venting during vacuum pumping.**

7. Clean the first stage heat station with a Scotch Brite™ pad to remove all residue before installing its gasket.
8. Place the large indium gasket on the large copper first stage heat station of the Coldhead. Secure the gaskets to the surface of the station by putting pressure on the gasket, forcing Indium **<u>into</u>** the small notches in the surface of the station. To prevent the large gasket falling from off the Coldhead during installation, use 0.125 x 1 inch ( 3 x 25 mm ) strips of aluminum tape, followed by a 0.25 inch ( 6.5 mm ) wide circumferential tape wrap with a gap left at the second stage vent hole. Make sure the second stage vent hole is not covered. See Illustration 9-18.
9. Clean the second stage heat station with a Scotch Brite™ pad to remove all residue before installing its gasket.
10. Place the indium wire gasket over the Coldhead second stage, orienting the gasket's length with the motor and perpendicular to the RuO sensor. Fold the gasket's wire loops over the station's side. Tape circumferentially with 0.25 inch ( 6.5 mm ) wide aluminum tape. Be very careful not to damage the small RuO sensor wires. See Illustration 9-18.

## 9-4 NEW COLDHEAD PREPARATION ( continued )

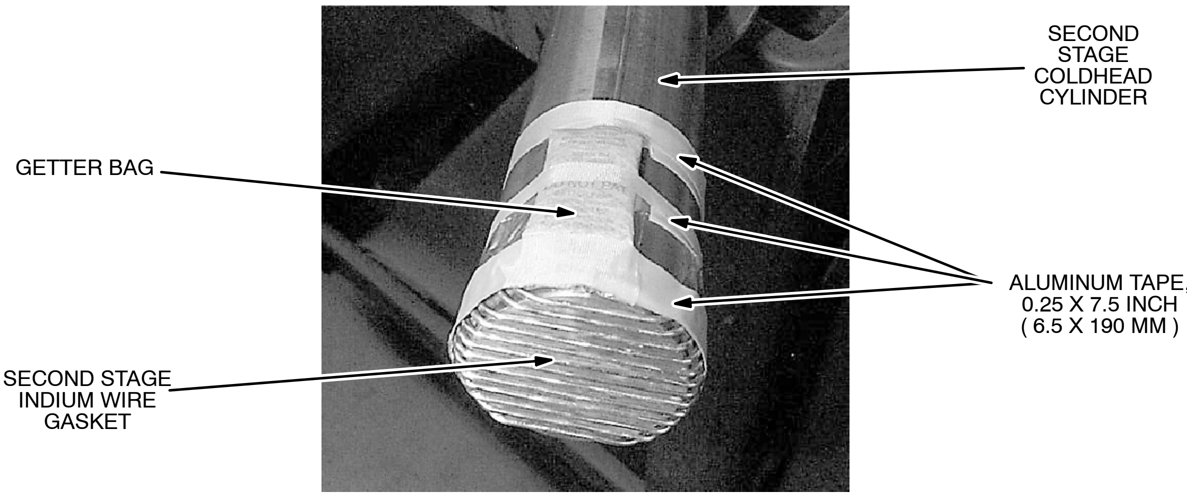



**INSTALLATION OF INDIUM GASKETS**
ILLUSTRATION 9-18

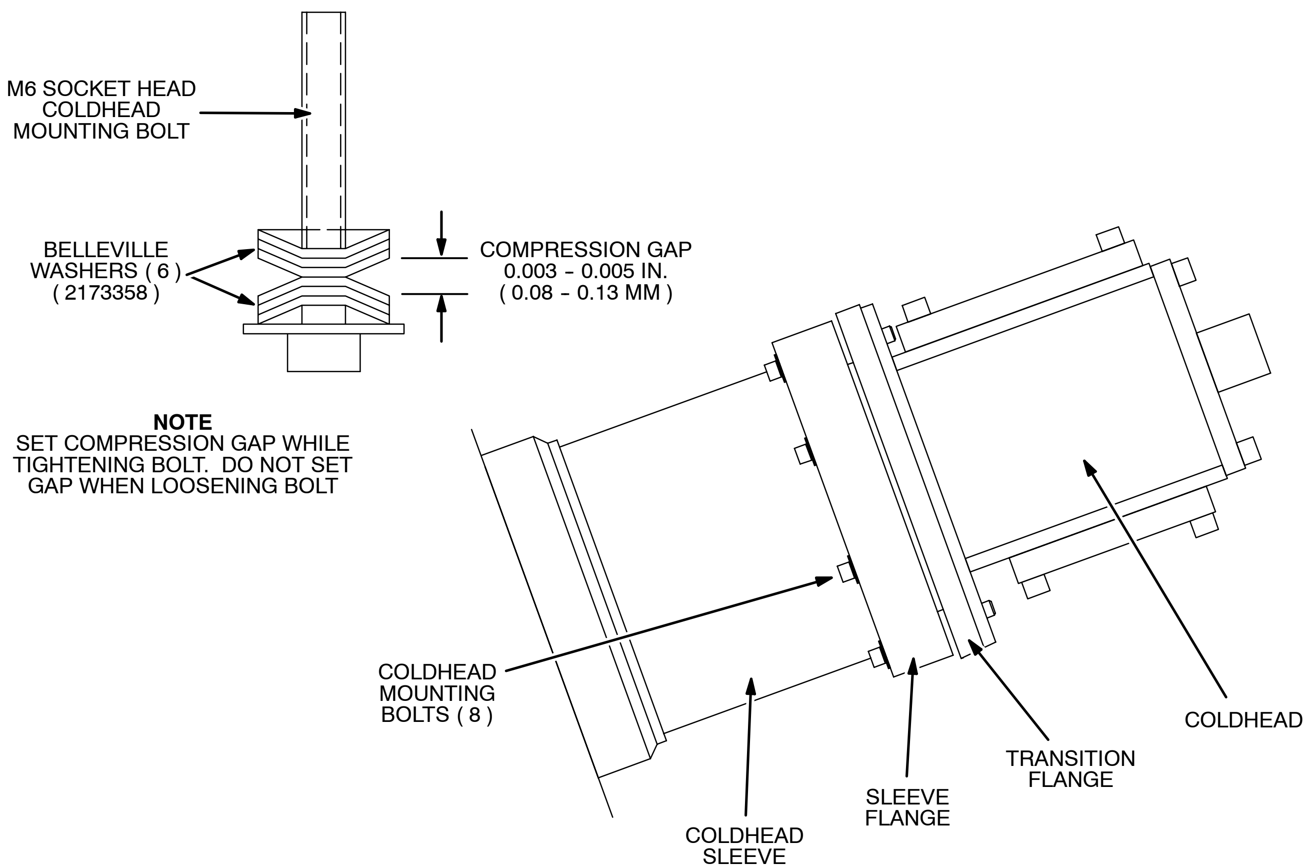
11. Install a getter bag to the side of the second stage with three circumferential wraps of 0.25 inch ( 6.5 mm ) wide aluminum tape. Make sure the bag is tightly secured in place. See Illustration 9-19.

12. Apply a thin film of anti-seize compound to the eight hex head bolts that were removed. Make sure all bolts have the same number and orientation of washers shown in Illustration 9-20.

## 9-4 NEW COLDHEAD PREPARATION ( continued )




**INSTALLED GETTER BAG**
ILLUSTRATION 9-19




**COLDHEAD MOUNTING BOLT GAP SETTING**
ILLUSTRATION 9-20

## 9-5 COLDHEAD REPLACEMENT

### 9-5-1 Before Coldhead Insertion

**CAUTION**

**Make sure the following critical conditions are confirmed prior to inserting new Coldhead into sleeve.**

- **Make sure Recondenser temperature reading is approximately 275K on the RuO Temperature Monitor ( 2171219 ) or a Lakeshore 208 Digital Thermometer.**
- **Shine a flashlight through the plexiglas cover and make sure that no visible ice is present on the first and stage stage heat stations of the Coldhead sleeve before turning off gas flow and removing cover. If ice is present, remove it with warm nitrogen gas.**
- **Make sure a new Coldhead is completely prepared and ready for insertion before removing the plexiglas cover. Insert the new Coldhead immediately after cover removal to prevent cryopumping in the sleeve.**

**WARNING!**

**DO NOT EXCEED 285K MONITORED RECONDENSER TEMPERATURE TO PREVENT THE POSSIBILITY OF A MAGNET QUENCH OR INTERNAL DAMAGE.**

1. Read the recondenser temperature. When the temperature is 275K ( ± 10K ), turn off the nitrogen gas flow, disconnect the nitrogen gas hose.
2. Remove the Plexiglas Cover Plate / Heater Assembly.
3. Connect the gas hose to the gas inlet valve ( green handle ) on the service adapter. Open the gas valve ( green handle ) and set gas flow to 1 psig on the low pressure regulator.

### 9-5-2 Coldhead Insertion

**WARNING!**

**THE COLDHEAD CONTAINS FERROMAGNETIC MATERIAL. TO PREVENT THE PREPARED COLDHEAD FROM BEING ATTRACTED INTO THE MAGNET CARRY IT FROM THE MAGNET ROOM DOOR ALONG THE PERIMETER WALL, AS FAR FROM THE MAGNET AS POSSIBLE, UNTIL ADJACENT TO THE SERVICE PLATFORM, AND THEN SECURELY CARRY IT DIRECTLY TO THE SERVICE PLATFORM. KEEP THE COLDHEAD AWAY FROM THE MAGNET BORE AT ALL TIMES.**

1. Carry the prepared Coldhead into the magnet room and around the perimeter wall until adjacent to the Service Platform.
2. Move the new Coldhead directly to the service platform, keeping the Coldhead away from the magnet bore and outer surface of the magnet.
3. Attach the carriage bracket and hoist clamp to the new Coldhead in the same way they were attached to the old Coldhead. See Illustrations 9-12 - 9-15. Make sure the screws are tight.

**Note**
The hoist clamp should still have the rope attached.

**CAUTION**

**The Coldhead and bracket weight is approximately 50 pounds. Use the Coldhead Insertion / Removal Tool to lift the Coldhead, making sure weight of the Coldhead is properly supported on the fixture.**

4. Grip the ascender tool and rope with both hands and insert the rope into the Cam-Matic cleat. Make sure the rope is securely attached to the end of the hoist arm as shown in Illustration 9-14.
5. Gradually lift the new Coldhead up to where the carriage bracket is in line with the insertion rail allowing the Cam-Matic cleat's grip on the rope to help support the Coldhead's weight.
6. Slip the carriage bracket onto the insertion rail. Slide the bracket and Coldhead along the rail far to where the Coldhead is 3 - 5 inches ( 75 - 100 mm ) from the sleeve.
7. Once the Coldhead's weight is fully supported by the Coldhead Insertion / Removal Tool, remove the hoist clamp from the Coldhead.
8. Gradually slide the Coldhead down the insertion rail until the Coldhead just enters the sleeve and there's a 5/16 – 3/8 inch ( 8 - 10mm ) gap between the sleeve and transition flange as in Illustration 9-21.

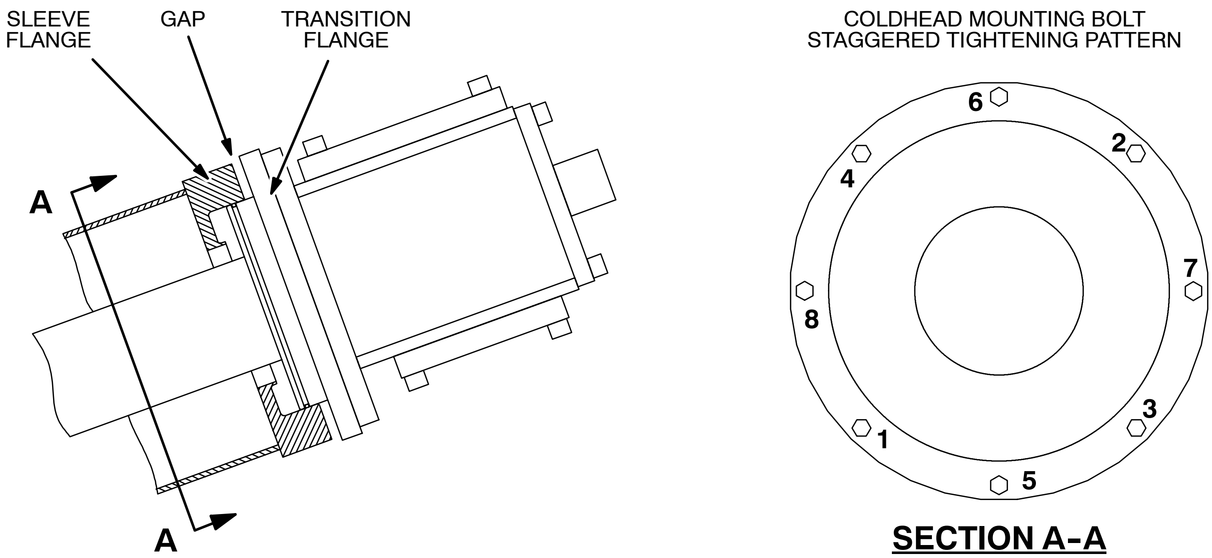
### 9-5-3 After Coldhead Insertion

1. Temporarily remove the Belleville washers from three bolts.

2. Insert the three bolts prepared without Belleville washers in the mounting holes spaced 90°, 135° and 135° around the Coldhead flange.

**Note**

Make sure to maintain an even gap between the transition and sleeve flanges around the full circumference during insertion and tightening. See Illustration 9-21.




**SLEEVE AND TRANSITION FLANGE GAP; BOLT TIGHTENING PATTERN**
ILLUSTRATION 9-21

3. Thread and evenly tighten the three bolts, giving each a quarter-turn at a time, until the o-ring is fully captured into the sleeve. Immediately close the gas flow valve ( green handle ) on the service adapter.

4. Remove the three bolts and re-assemble with Belleville washers on each. Make sure the Belleville washers are in the proper orientation ( as shown in Illustration 9-20 ) on all eight bolts.

5. Thread and evenly tighten six Coldhead mounting bolts with Belleville washers into the Coldhead transition flange until a 0.015 ( 0.38 mm ) gap exists between the Coldhead transition flange and the Coldhead Insertion / Removal Tool mounting bracket.

**Note**

Two mounting holes are blocked by the Coldhead Insertion / Removal Tool bracket.

6. Remove the carriage bracket from the Coldhead and slide it off insertion rail.

7. Remove the rest of the Insertion / Removal Tool from the Coldhead sleeve.

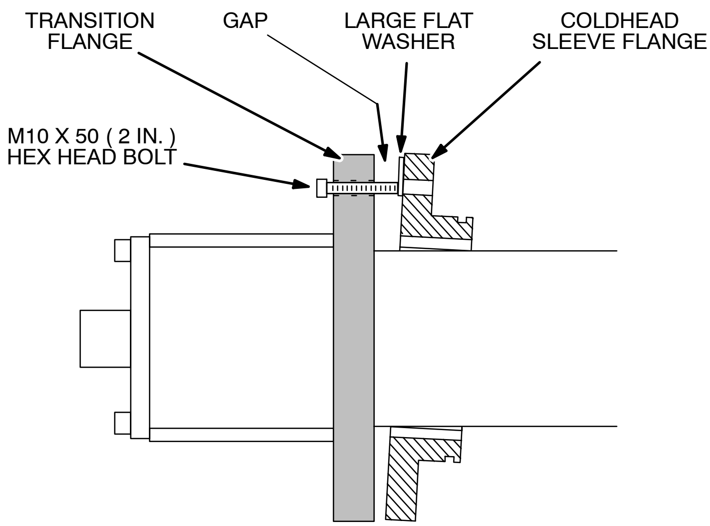
8. Assemble the remaining two mounting bolts with Belleville washers in the proper orientation into the Coldhead transition flange. See Illustration 9-20.

### 9-5-3 After Coldhead Insertion ( continued )

9. Continue tightening the Coldhead mounting bolts in a staggered pattern until the gap between the Belleville washer stacks on all bolts is 0.015 inch ( 0.38 mm ).

**Note**

Gap adjustments can be made before fully tightening the mounting bolts by using two flathead screwdrivers wedged between the transition and sleeve flanges. Gap adjustments can also be made by temporarily removing the desired mounting bolt, inserting and fully threading a M10 x 50 ( 2 inch ) long hex head bolt through the transition flange and using that bolt like a jack screw against a flat washer on the sleeve flange to wedge open the gap slightly. See Illustration 9-22.




**ADJUSTING SLEEVE AND TRANSITION FLANGE GAP USING JACK SCREW ( M10 BOLT )**
ILLUSTRATION 9-22

**CAUTION**

**Make gap adjustments before the Belleville washers have been compressed. Make only small adjustments at a time to prevent cocking Coldhead and placing a bending moment on the mounting bolts.**

10. With the vacuum pump operating, open the vacuum valve ( black handle ) on the service operator to evacuate the sleeve space. See illustration 9-7.

11. When the vacuum reaches 50 millitorr ( 50 microns ), close the vacuum check valve ( black handle ) and open the gas flow valve ( green handle ) on the service adapter.

12. When the pressure within the sleeve reaches 1 atmosphere, close the gas flow valve ( green handle ) and open the vacuum valve ( black handle ) to re-evacuate the sleeve.

13. Repeat Steps 11 and 12 a second time ( i.e., two evacuation / backfill cycles ), then continue evacuating the sleeve while performing Section 9-6, Coldhead Interface Adjustment.

## 9-6 COLDHEAD INTERFACE ADJUSTMENT

## IMPORTANT !!!

- **It is very important to establish complete contact between the second stage heat station of the Coldhead and sleeve to have a minimal temperature gradient and good heat transfer from the recondenser.**
- **A poor temperature gradient will result in increased cryostat pressure and less time between a cryocooler shutdown from a power outage or improper cooling and the loss of helium through the relief valve.**
- **Observe second stage Coldhead and Recondenser temperatures to determine that complete contact is made. The temperature difference must be within specification.**

**CAUTION**

**It is important to perform all Coldhead adjustments prior to turning the Coldhead on. This will allow the second stage gasket to compress and fill the gaps at the second stage interface before the gasket cools and hardens in the sleeve.**

1. Tighten the Coldhead bolts a half-turn each in the staggered pattern shown in Illustration 9-21 to set the gap between Belleville washers on all bolts evenly with a 0.015 inch ( 0.38 mm ) feeler gauge. Wait one minute, and repeat the bolt tightening, setting the gap between Belleville washers evenly with a 0.010 inch ( .25 mm ) feeler gauge. After another minute tighten all bolts again and use a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) feeler gauge to set a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) gap between Belleville washers on all bolts. See Illustration 9-20.

   **Note**

   Make sure an even gap is maintained between the transition and sleeve flanges around the full circumference.

2. Allow the Coldhead to sit "warm" and the sleeve to evacuate for 15 minutes, checking and maintaining a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) Belleville washer gap on all Coldhead bolts.

**WARNING!**

**DO NOT PUT ANY BENDING FORCE ON THE AEROQUIP FITTINGS DURING HELIUM FLEXLINE CONNECTING / DISCONNECTING. A BENDING FORCE WILL CREATE DIFFICULTY IN THE RAPID THREAD ENGAGEMENT / DISENGAGEMENT REQUIRED TO PREVENT HELIUM LOSS AND CONTAMINATION. IT CAN ALSO RESULT IN BENDING OR LEAKING OF THE AEROQUIP STEMS. SUPPORT THE GAS LINES TO PREVENT A BENDING FORCE WHEN CONNECTING / DISCONNECTING TO THE COLDHEAD AT THE TOP OF THE MAGNET AND THE COMPRESSOR.**

## 9-6 COLDHEAD INTERFACE ADJUSTMENT ( continued )

**CAUTION**

**Make sure the helium flexlines are connected in the sequence stated below. Gas back pressure may prevent the Coldhead from starting if gas lines are connected in the reverse sequence. Order and technique are important when connecting helium flexlines to prevent inoperative Coldheads and system contamination.**

**Note**

Make sure the o-ring on the female Aeroquip fitting at the Coldhead is present and in good condition.

3. During the 15 minute period the Coldhead sits "warm", connect the Coldhead gas lines in the following sequence:

   **FIRST:** connect the **return** flexline ( green mark )

   **SECOND:** connect the **supply** flexline ( yellow mark )

4. Make sure the digital vacuum gauge reads < 100 millitorr ( 100 microns ) and that the sleeve has been evacuated for at least 15 minutes, then close the pump-out port operator by pushing the knob in and gently rotating it clockwise ( CW ). Next rotate the knob counterclockwise ( CCW ) until the knob extension is fully disengaged from the pump-out port. Do **not** pull the knob out at this time.
5. When the pump-out port operator is closed, close the vacuum valve ( black handle ) on the service operator. Observe the vacuum gauge while pulling out the pump-out port knob about 2 inches ( 50 mm ). A decreasing reading means the vacuum has increased due to the pump-out port plug moving during operation. If no change is observed, continue with this procedure.
6. Connect the Coldhead power cable in conformance with SET-UP AND CALIBRATION, Section 1-4, Cryocooler Installation and Checkout.
7. Turn off the vacuum pump and open the gas inlet valve ( green handle ) to vent system. Disconnect and remove all apparatus.
8. Close the Coldhead motor shield and reinstall in the end of the motor shield the .25-20UNC stainless steel socket head cap screws removed earlier.
9. Turn the Cryocooler on. Connect the Portable Temperature Monitor ( 2171219 ) and monitor second stage temperatures for Coldhead and Recondenser cooldown.
10. When temperature equilibrium is reached, make sure:
    - The Belleville washer gaps are within the 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) range.
    - The Recondenser temperature is < 4.4K.
    - The Coldhead - Recondenser second stage temperature difference is < 0.2 K.

**Note**

The RuO sensor reading of second stage Coldhead temperature may show a small oscillation of 0.1 - 0.3 K due to Displacer motion and sampling rate. If this occurs, average the maximum and minimum temperature readings.

11. If the readings found in Step 10 are out of acceptable range, make minor adjustments ( if possible ) and / or repeat the Coldhead replacement procedure with the same Coldhead.

# SECTION 10 – ONE–STAGE SHIELDCOOLER COLDHEAD REPLACEMENT

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 10–1 INTRODUCTION

Maintenance of cryocooler temperatures within specification is essential for proper operation of a zero boil–off magnet. Coldhead replacement is required when elevated thermal station temperature problems have been isolated to the Coldhead or the complete cryocooler system or from catastrophic failure of the Coldhead. See FUNCTIONAL CHECKS, Section 2, for fault isolation of Coldhead problems.

It is important to change out Coldheads as soon as defects are uncovered. Complete Coldhead replacement will take approximately three hours. Make sure a new Coldhead and all required tools and equipment are on–site before starting the procedure. Perform the change–out rapidly to minimize temperature rise in the magnet.

**10-1 INTRODUCTION ( continued )**

**WARNING!**

**THE FOLLOWING PRECAUTIONS MUST BE TAKEN WHEN CHANGING OUT A COLDHEAD AT MAGNET FIELD TO PREVENT ACCIDENTS, INJURIES, COLD BURNS AND DANGEROUS PROJECTILES IN A MAGNETIC FIELD:**

- **PROCEDURE MUST BE PERFORMED BY TRAINED AND QUALIFIED PERSONNEL ONLY.**
- **WEAR PROTECTIVE CLOTHING ( LONG-SLEEVE SHIRT, ETC. ) AND GOGGLES WHILE PERFORMING THIS PROCEDURE, TO PREVENT CRYOGEN BURNS OR EYE INJURY.**
- **REPLACE COLDHEAD USING THE COLDHEAD EXTRACTION / INSERTION TOOL. IT IS IMPORTANT TO HAVE THE TOOL INSTALLED BEFORE REMOVING THE COLDHEAD.**
- **DO NOT BRING ANY FERROMAGNETIC OBJECTS ( TOOLS, EQUIPMENT, GAS CYLINDERS, PERSONAL ITEMS, ETC. ) INTO THE MAGNET ROOM. THEY WILL BECOME DANGEROUS PROJECTILES IN THE MAGNETIC FIELD.**
- **MAKE SURE THE MAGNET RUNDOWN UNIT ( MRU ) IS FUNCTIONING PROPERLY TO ENABLE THE MAGNETIC FIELD TO BE QUICKLY DISCHARGED IN CASE OF AN EMERGENCY.**
- **REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## IMPORTANT !!!

Monitor cryostat pressure throughout Coldhead replacement procedure. If magnet pressure is above 5 psig, vent the magnet down to 5 psig through Vent Valve V2. Pressure may require venting multiple times to prevent cold helium gas from cooling the shield and first stage heat station in the Coldhead Sleeve during Coldhead replacement. Cold helium exhaust flows through the shield exhaust plumbing, cooling the shield and first stage heat station.

## 10-2 TOOLS / EQUIPMENT

Make sure the following parts, tools and equipment are on-site before starting this procedure:

- New / Reconditioned Coldhead* — 2218465
- Coldhead Replacement Gasket Kit — 2171620
- Universal Coldhead Replacement Tool Kit — 2300306
- Lexan Purge Cover Plate — 2232560
- Coldhead Stand ( Holding Tool ) — 2214919
- Pump-Out Port Dual O-Ring Plug — 2236606
- Portable $O_2$ Monitor — 2106236 or 2106237
- Vacuum with non-magnetic extension hose
- Full, nonmagnetic nitrogen gas cylinder
- Gas Regulator Kit — 46-306734G1
- Non-Magnetic Coldhead Wrench Kit — 46-294804G1
- Aluminum Tape — 46-260802P1 / P6
- Flashlight
- Black Light ( preferred ) or clean, lint-free white gloves
- Scotch-Brite™ pads
- Leather gloves ( for opening / closing motor shield and handling removed coldhead )

* New / reconditioned Coldhead must have been inspected and be free of defects before bringing to the site.

## 10-3 COLDHEAD REMOVAL

**CAUTION**

**Make sure lines are removed immediately after power is disconnected to prevent contamination of lines and compressor.**

1. Immediately upon site arrival, turn off the Compressor and disconnect the power cable from the Coldhead.

**10-3 COLDHEAD REMOVAL ( continued )**

**CAUTION**

**Do not put any bending force on Aeroquip fittings while connecting / disconnecting helium flexlines. A bending force will create difficulty in the rapid thread engagement / disengagement required to prevent helium loss and contamination. It can also result in bending or leaking of the Aeroquip stems. Support gas lines to prevent a bending force when connecting / disconnecting to coldhead at top of magnet.**

2. Once Coldhead power is disconnected, immediately disconnect the helium gas lines at the Coldhead in conformance with REPLACEMENT / MAINTENANCE, Section 11, Helium Flexline Connections / Replacement.

3. Shine a black light at the surfaces inside the supply Flexline fitting. Any violet-colored glow indicates oil contamination in the Coldhead-Compressor system. The Coldhead, Compressor and Flexlines must be replaced to remove all oil contaminating the system.

   **Note**

   Clean, lint-free white gloves may be used in place of the preferred black light. Wipe the gloves inside the fitting. Any stains on the gloves indicate oil contamination.

4. Remove enclosures required for Coldhead access.

**WARNING!**

**THE COLDHEAD MOTOR SHIELD IS MADE OF FERROMAGNETIC MATERIAL AND HAS A LARGE ATTRACTIVE FORCE TO THE MAGNET. DO NOT LOOSEN OR REMOVE THE MOTOR SHIELD MOUNTING SCREWS UNDER ANY CIRCUMSTANCE.**

**WEAR LEATHER GLOVES AND USE EXTREME CAUTION WHEN PIVOTING TOP HALF OF MOTOR SHIELD TOWARD THE MAGNET TO EXPOSE THE COLDHEAD OR PERSONAL INJURY MAY RESULT. DO NOT PUT FINGERS OR HAND BETWEEN THE MOTOR SHIELD AND MOUNTING BRACKET WHEN PIVOTING THE MOTOR SHIELD TOWARD THE MAGNET.**

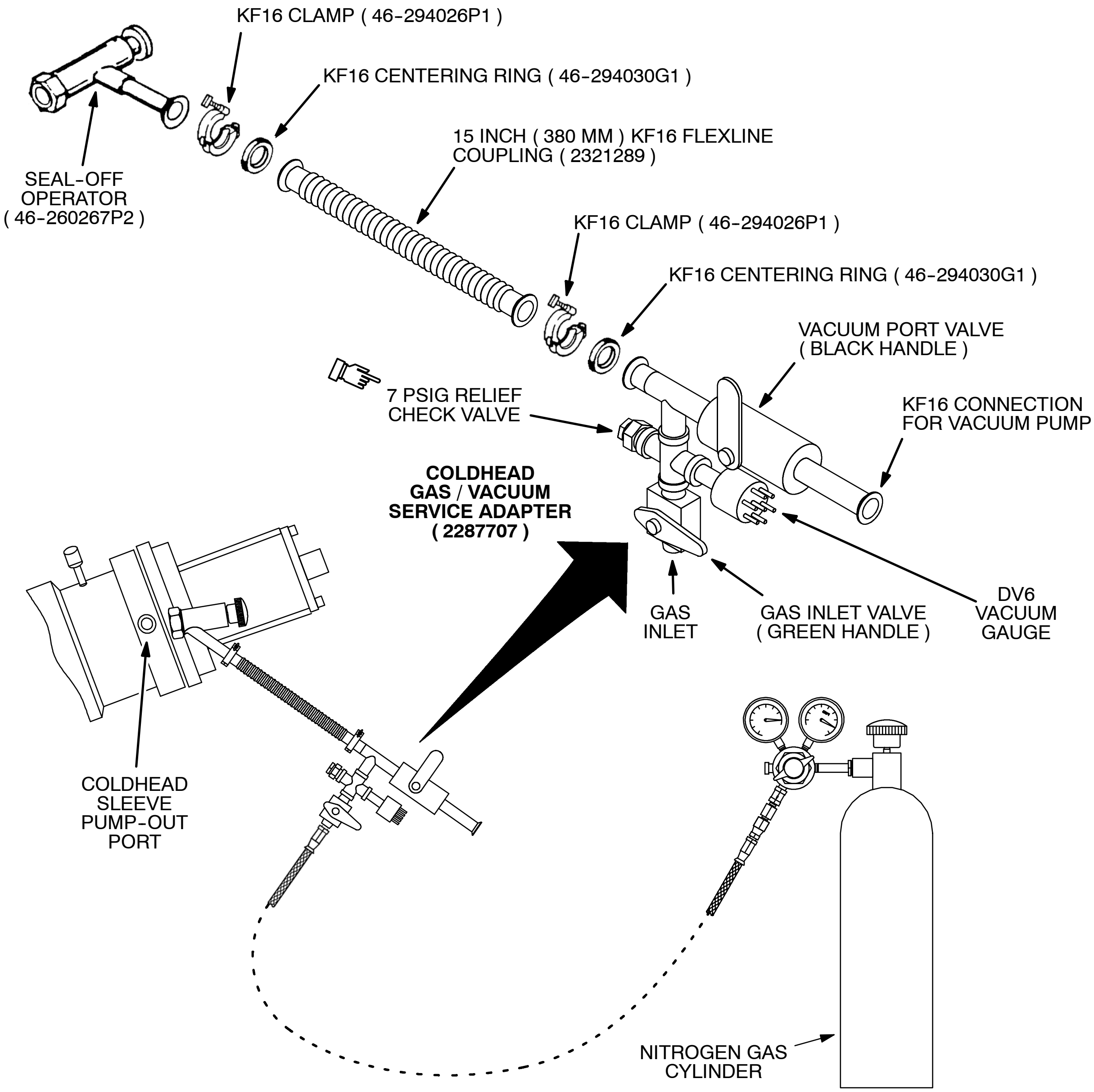
5. Open the Coldhead motor shield by removing the .25-20UNC stainless steel socket head cap screw in the end of the motor shield. Put the screw in a secure place for replacement later.

6. Clean all vacuum fittings on apparatus shown in Illustrations 10-1 and 10-2. Then lightly coat o-rings with vacuum grease to make sure vacuum seals are tight.

7. Attach the seal-off operator to the pump-out port on the Coldhead sleeve. See Illustration 10-1. Tighten the seal-off operator to the pump-out port by holding the body of the operator and tightening the nut with a wrench.

8. Connect the service adapter to the seal-off operator.

## 10-3 COLDHEAD REMOVAL ( continued )



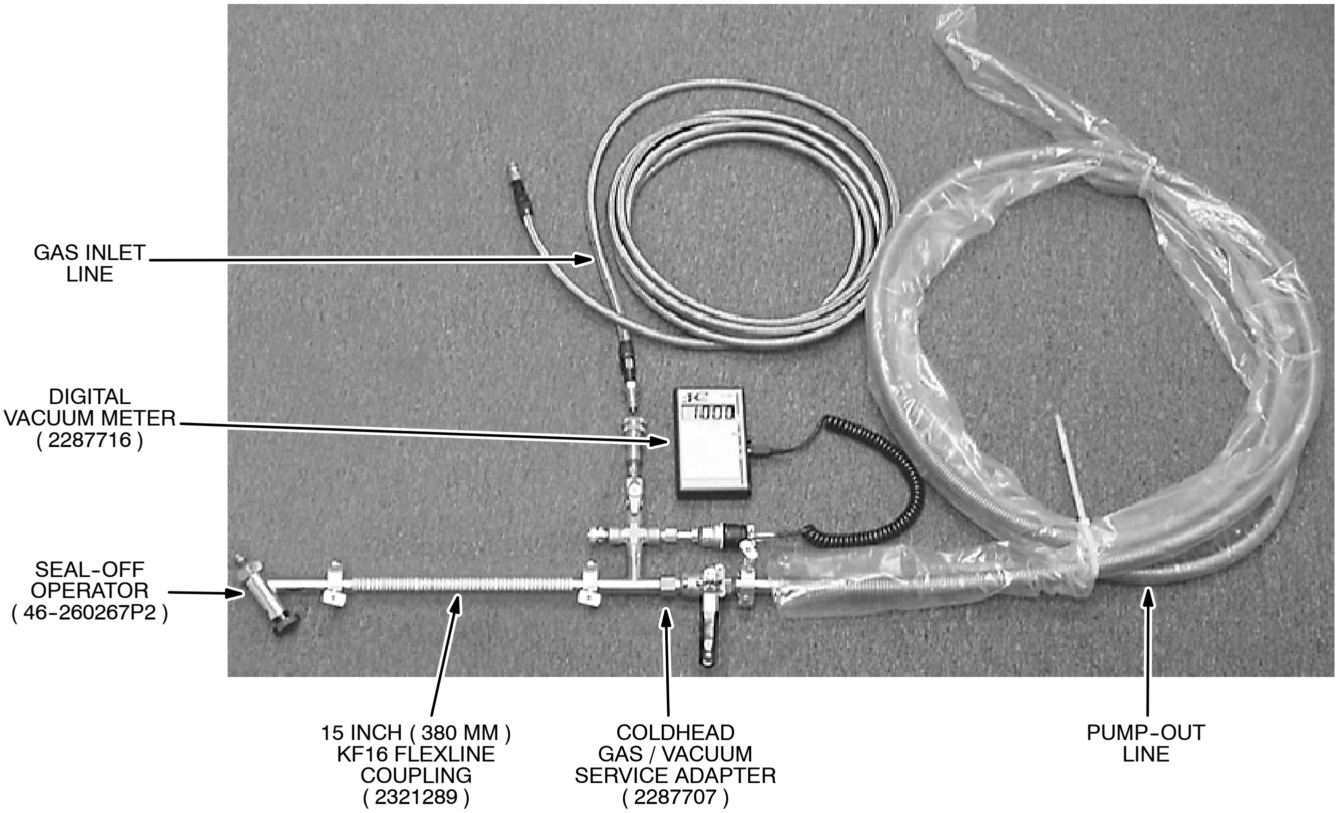

**COLDHEAD GAS / VACUUM SERVICE APPARATUS**
ILLUSTRATION 10-1

9. Connect the gas regulator to the nitrogen gas cylinder. Connect a flexible hose from the gas regulator to the service adapter inlet valve on the ( green handle ). See Illustrations 10-2 and 10-3.

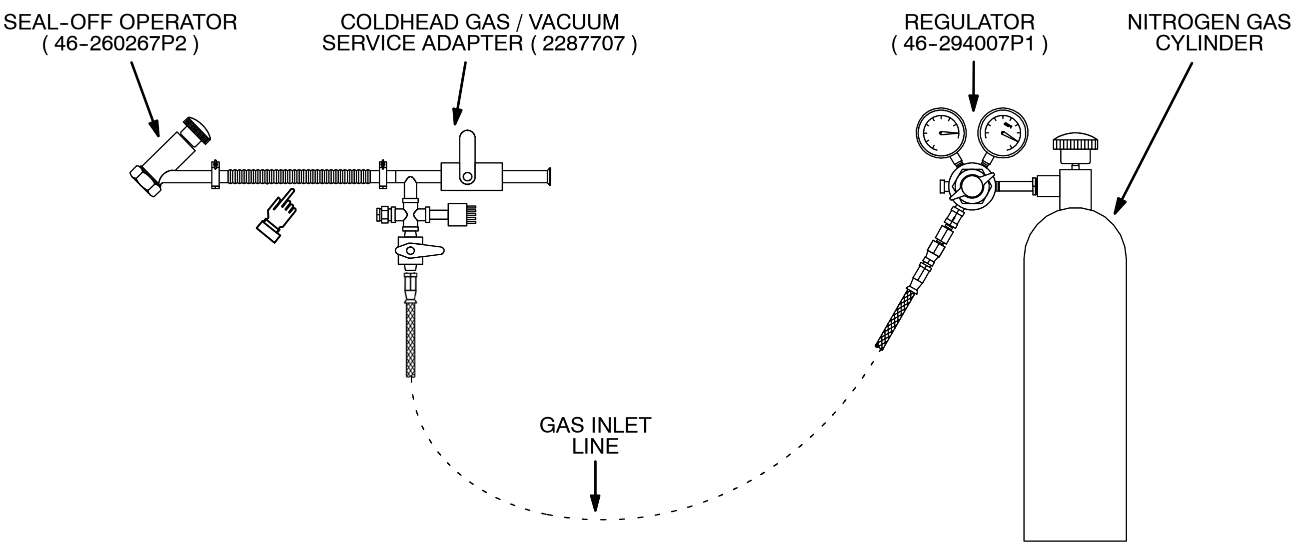
10. Make sure the regulator handle is backed out counterclockwise ( CCW ) to avoid regulator damage, then open the gas cylinder slowly. The high pressure gauge should indicate 2100 - 2400 psig if the cylinder is full.

11. Open the gas inlet valve and set a low pressure gas flow ( 1 psig ) as indicated on the regulator gauge.

## 10-3 COLDHEAD REMOVAL ( continued )



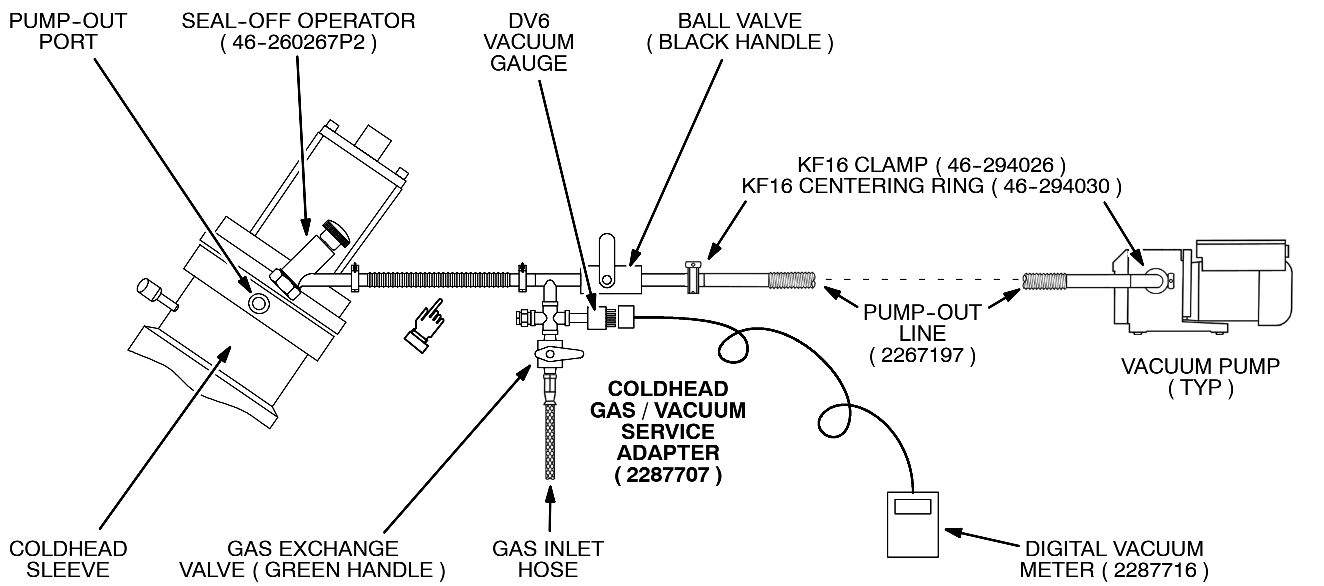

**COLDHEAD GAS / VACUUM SERVICE ADAPTER AND CONNECTIONS**
ILLUSTRATION 10-2




**NITROGEN GAS CONNECTION**
ILLUSTRATION 10-3

**10-3 COLDHEAD REMOVAL ( continued )**

12. Open the vacuum port valve ( black handle ) on the adapter and allow gas to flow out for 30 seconds to purge the assembly of air.
13. Close the vacuum port and gas inlet valves.
14. Make sure the black and green handles on the service adapter are closed. Connect the vacuum pump apparatus as shown in Illustration 10-4. Apply a light coat of vacuum grease to the centering o-rings.




**VACUUM PUMP APPARATUS SET-UP**
ILLUSTRATION 10-4

15. Turn on the vacuum pump, open the vacuum valve ( black handle ) on the service adapter and allow the pump to evacuate the vacuum line and service adapter to 50 millitorr ( 50 microns ). Read on the digital vacuum gauge. Then close the vacuum valve ( black handle ).
16. Repeat opening and closing the vacuum valve ( black handle ) two more times while pumping.
17. When 50 millitorr ( 50 microns ) is reached, close the vacuum valve ( black handle ). Observe the vacuum gauge to make sure the service adapter and seal-off operator are leak tight. If the gauge rises > 200 millitorr ( 200 microns ) over 30 seconds, suspect a leak and:
    a. Turn off the vacuum pump and temporarily open the green handle to bring the apparatus to atmospheric pressure.
    b. Remove the vacuum line and reassemble the seal-off operator and service adapter.
    c. Repeat Steps 14 - 17 until the system is leak tight.
18. When the apparatus is leak tight, open the vacuum valve ( black handle ) and make sure the vacuum is ≤ 50 millitorr ( 50 microns ) before continuing with Step 19.

### 10-3 COLDHEAD REMOVAL ( continued )

19. Push in and rotate the black handle of the seal-off operator clockwise ( CW ) to engage the plug in the pump-out port. When the handle is engaged, pull the handle out to open the pump-out port.

20. Immediately check the vacuum on the digital vacuum meter for a reading of ≤ 50 millitorr ( 50 microns ). A reading of >> 100 millitorr ( 100 microns ) indicates a poor vacuum in the sleeve that may cause cooling problems. If this condition occurs:

    a. Pump out the sleeve again to achieve a vacuum < 100 millitorr ( 100 microns ).

    b. Operate the Coldhead to establish final temperature.

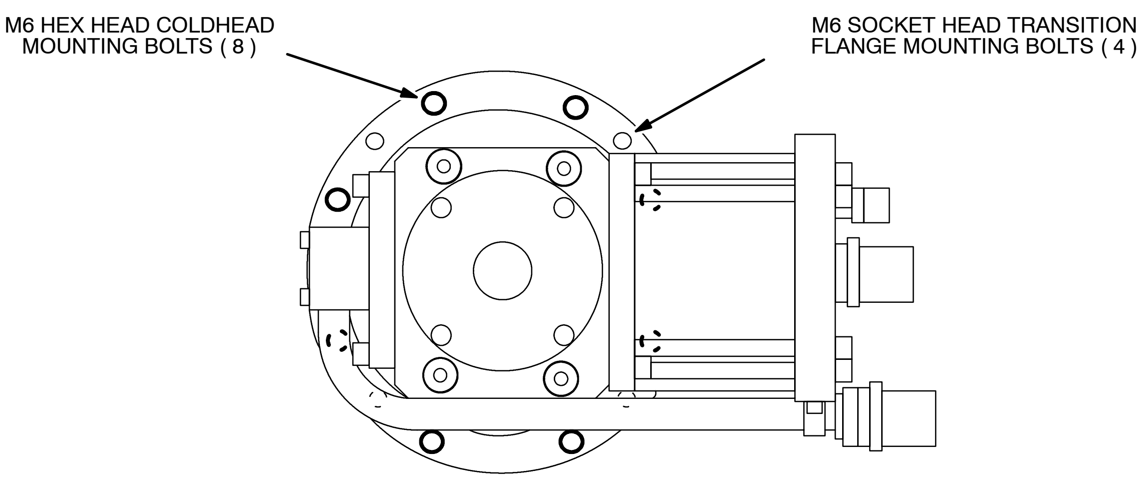
**Note**
The service adapter has a 5 psig relief valve to prevent the build-up of excess pressure in the Coldhead sleeve when any nitrogen, frozen to the Coldhead, regassifies during Coldhead warm-up. Some audible gas escaping may be encountered.

**Note**
Save the bolts and washers removed in the next step, leaving the same number of washers on each bolt. These will be used to mount the new Coldhead and will make sure the proper interface spacing is maintained. Bolts are installed through the sleeve flange.

21. Loosen and remove the eight Coldhead mounting bolts and Belleville washers. See Illustration 10-5.

22. Rethread two bolts without Belleville washers 3 - 4 threads deep into holes 180° apart.

**Note**
These two bolts ensure that the Coldhead can be contained when gas pressure is applied. Save bolts and washers to mount the new Coldhead.




**COLDHEAD MOUNTING**
ILLUSTRATION 10-5

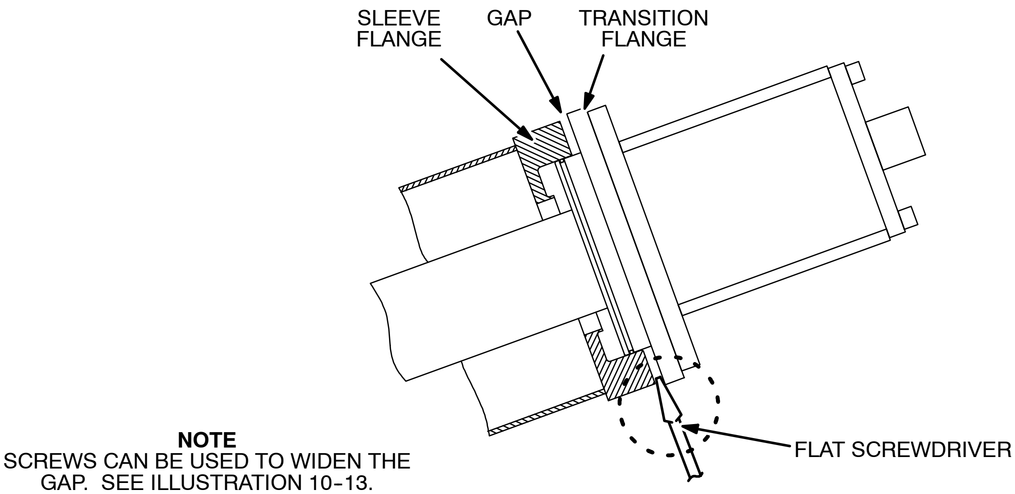
23. Close the vacuum valve ( black handle ). Then open the gas inlet valve ( green handle ) and fill the vacuum space in the sleeve with nitrogen gas at a small positive pressure ( 1 - 3 psig on the low-pressure regulator ) to break the Coldhead away from the thermal stage contacts.

## 10-3 COLDHEAD REMOVAL ( continued )

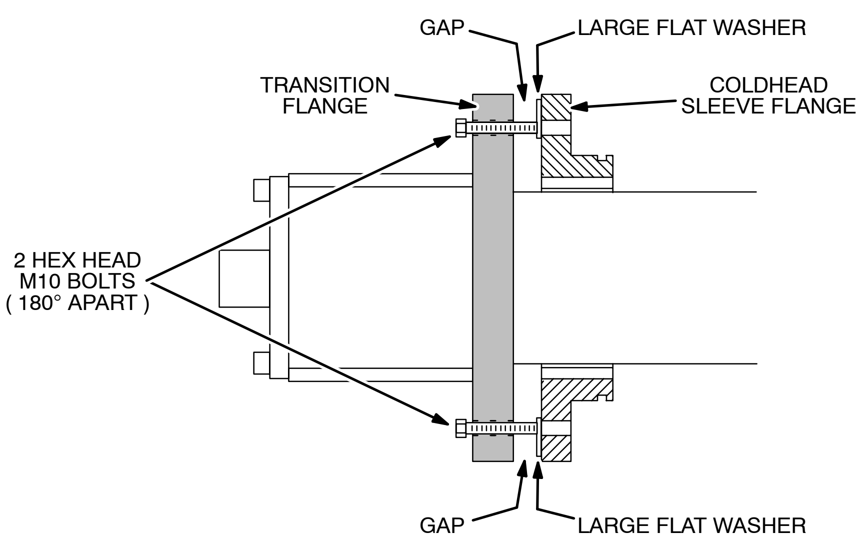
24. If required to dislodge the Coldhead, carefully insert a large screwdriver or other similar wedge-shaped tool in the gap between the sleeve flange and transition flange. Gradually pry the transition flange away from the sleeve flange by tapping the end of a screwdriver or wedge while moving it around the circumference of the gap. See Illustration 10-6. Or use two M10 bolts as a jackscrew to apply a separating force between the Coldhead sleeve flange and the transition flange. See Illustration 10-7.

**Note**

Two M10 hex head bolts inserted 180° apart can be used as "jackscrews" to break the indium seal between the thermal station contacts in the sleeve and Coldhead. Torque bolts to apply force between Coldhead sleeve flange and transition flange. See Illustration 10-7.




**SEPARATION OF TRANSITION FLANGE FROM SLEEVE FLANGE USING A FLAT SCREWDRIVER**
ILLUSTRATION 10-6




**SEPARATION OF TRANSITION FLANGE FROM SLEEVE FLANGE USING TWO JACK SCREWS ( M10 BOLTS )**
ILLUSTRATION 10-7

### 10-3 COLDHEAD REMOVAL ( continued )

**WARNING!**

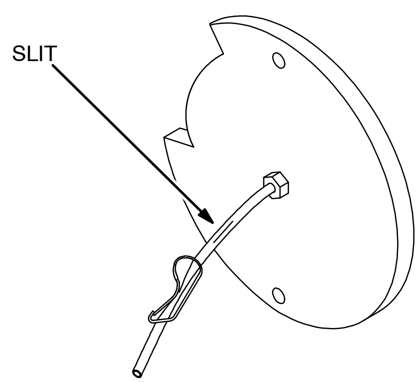
**WEAR INSULATED LEATHER GLOVES WHEN REMOVING COLDHEAD. DO NOT TOUCH THE THERMAL STATIONS OF A REMOVED COLDHEAD TO PREVENT "COLD BURNS".**

**WHEN REMOVING COLDHEAD, KEEP AWAY FROM THE TOP OF THE COLDHEAD TO PREVENT INJURY IF THE COLDHEAD POPS OUT UNDER GAS PRESSURE.**

**CAUTION**

**Make sure nitrogen gas is flowing through the pump-out port connection and that the Lexan Purge Cover Plate is within reach before proceding. Immediately cover the hole with the cover plate to prevent cryopumping of air into the sleeve.**

25. When the Coldhead breaks away from the thermal station contacts, remove the remaining two bolts and partially extract the Coldhead until the Transition Flange o-ring is exposed.
26. Lift the Coldhead straight out of the Coldhead sleeve using the Coldhead motor and Transition Flange as lifting points.
27. Immediately carry the old Coldhead away from the magnet.
28. After the Coldhead is removed, immediately install the Lexan Purge Cover Plate ( 2232560 ) onto the sleeve flange. See illustration 10-8.
29. Adjust the low pressure regulator to send a nitrogen gas flow of 3 - 4 psig to warm up the sleeve.
30. Make sure nitrogen purge gas is venting through the slit in the cover plate tube. See illustration 10-8.




**LEXAN PURGE COVER PLATE ( 2232560 )**
ILLUSTRATION 10-8

## 10-3 COLDHEAD REMOVAL ( continued )

**Note**

The relief valve on the removed Coldhead may exhaust helium gas with a popping or hissing sound as it warms up.

31. Inspect the inside of the sleeve cylinder through the Lexan Purge Cover Plate using a flashlight. Make sure no indium gasket material is present on the copper seating surfaces of the thermal station contact.

**CAUTION**

**Do not have the Lexan Purge Cover Plate off the sleeve flange for more than one minute at a time to minimize cryopumping and icing of the thermal station.**

32. If indium gasket material is spotted inside the sleeve cylinder, temporarily move the cover plate while continuing the helium gas purge. Quickly remove the contaminating material with the end of the gas wand, long-handled tweezers or a long-handle screwdriver, being careful not to damage the thermal station surfaces. Replace the cover plate back over the sleeve flange opening as quickly as possible.

**Note**

Indium is more easily removed as the sleeve warms up.

**Note**

A shop vacuum with a long hose can be used to remove indium gasket material inside the sleeve. However, **DO NOT** bring the shop vacuum itself too close to the magnet.

33. Continue the nitrogen purge gas flow warming the sleeve while preparing the new Coldhead.

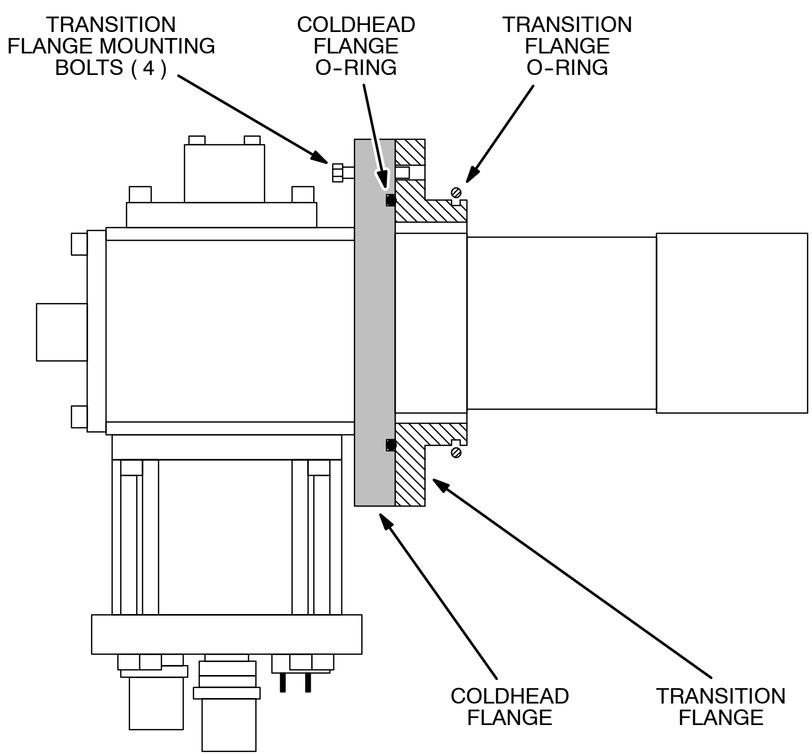
34. Use the packaging materials from the new Coldhead to return the old Coldhead.

## 10-4 NEW COLDHEAD PREPARATION

**CAUTION**

**If the old Coldhead is being re-inserted, make sure it is at room temperature and free of moisture before starting this procedure to prevent a poor interface and a contaminated sleeve. Warm Coldhead with a heat gun if necessary.**

1. Remove the new Coldhead and gasket kit from its packaging. Place these on the Coldhead Stand ( Holding Tool ). Save the shipping container and packing material for return if damage is found. If reinstalling the old Coldhead, make sure it is dry and at room temperature.
2. Inspect the Coldhead using Illustration 10-9 as a reference.
3. Remove the transition flange o-ring from its packaging and inspect for any visible damage ( i.e. broken, nicked, cut, etc. ).
4. Clean the o-ring and the o-ring groove in the transition flange with a lint-free cloth or towel. Apply a thin film of vacuum grease to the entire surface of the o-ring.
5. Slide the lubricated o-ring over the Coldhead thermal station and place in the groove of the transition flange. See Illustration 10-9.




**COLDHEAD O-RING PLACEMENT**
ILLUSTRATION 10-9

## 10-4 NEW COLDHEAD PREPARATION ( continued )

**Note**

Wear the cloth gloves provided in the Gasket Kit while assembling the new Indium gasket onto the Coldhead thermal station.

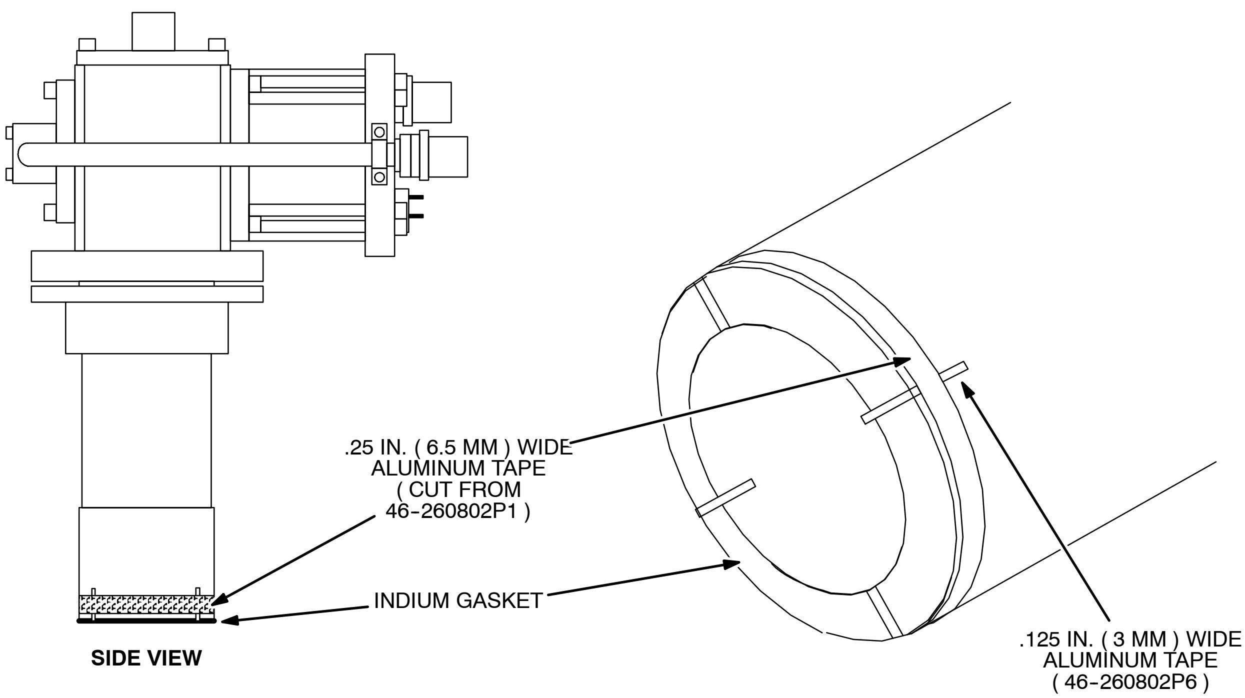
6. Clean the thermal station with a Scotch Brite™ pad to remove all residue before installing its gasket.

**CAUTION**

**Make sure the 0.125 inch ( 3 mm ) wide aluminum tape strips are indented <u>into</u> the notches in the thermal station surface. Tape not in contact with the thermal station surface can increase thermal resistance between the gasket and the sleeve contact surface, thus causing thermal station performance problems.**

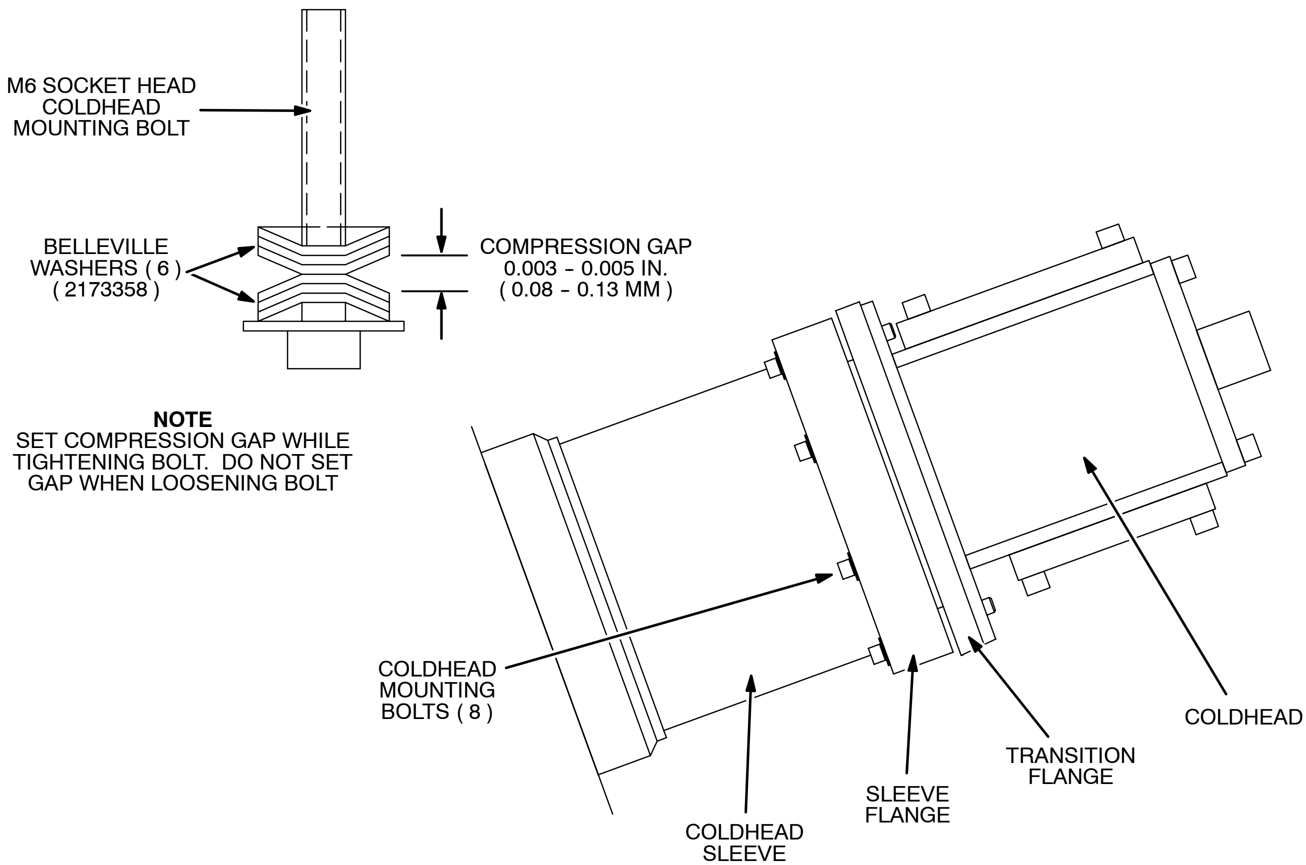
7. Place the large indium gasket on the large copper thermal station of the Coldhead. Secure the gasket to the surface of the station by putting pressure on the gasket, forcing Indium **<u>into</u>** the small notches in the surface of the station. To prevent the large gasket falling from off the Coldhead during installation, use 0.125 x 1 inch ( 3 x 25 mm ) strips of aluminum tape as shown in Illustration 10-10.

8. Apply a thin film of anti-seize compound to the eight hex head bolts that were removed. Make sure all bolts have the same number and orientation of the washers shown in Illustration 10-11.




**INSTALLATION OF INDIUM GASKET**
ILLUSTRATION 10-10

## 10-4 NEW COLDHEAD PREPARATION ( continued )




**COLDHEAD MOUNTING BOLT GAP SETTING**
ILLUSTRATION 10-11

## 10-5 COLDHEAD REPLACEMENT

**CAUTION**

**Make sure the following critical conditions are confirmed prior to inserting new Coldhead into sleeve.**

- **Shine a flashlight through the Lexan Purge Cover Plate and make sure that no visible ice is present on the thermal station of the Coldhead sleeve before turning off gas flow and removing cover. If ice is present, remove it with warm nitrogen gas.**
- **Make sure a new Coldhead is completely prepared and ready for insertion before removing the cover plate. Insert the new Coldhead immediately after cover plate removal to prevent cryopumping in the sleeve.**

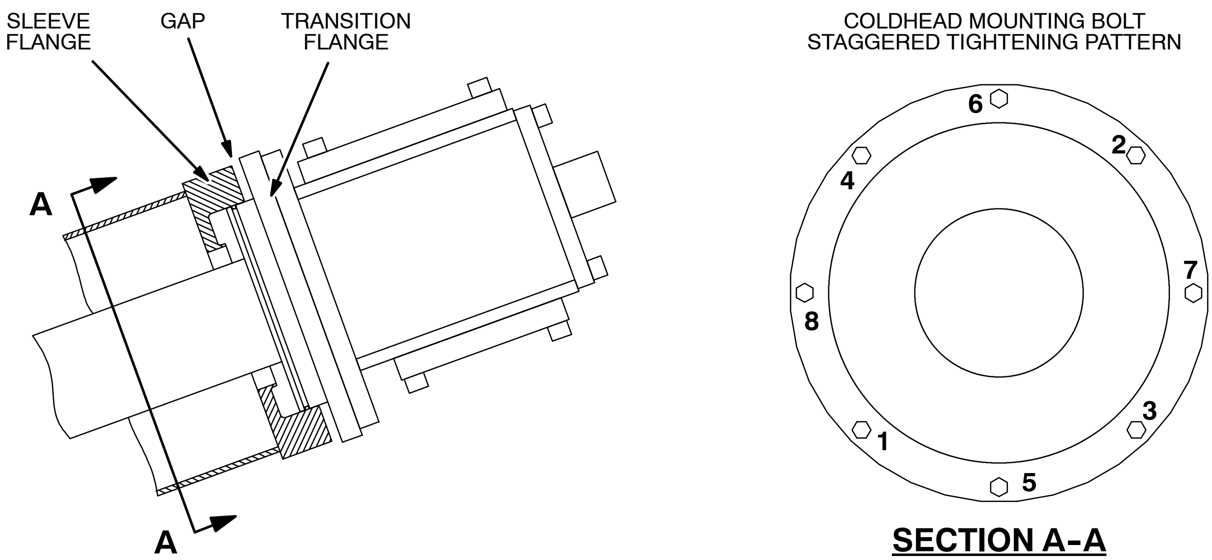
### 10-5 COLDHEAD REPLACEMENT ( continued )

1. Close the gas inlet valve ( green handle ) to stop nitrogen gas flow into the sleeve.
2. Remove the Lexan Purge Cover Plate.

**CAUTION**

**A Coldhead weighs is approximately 35 pounds. Make sure the weight of the Coldhead is properly supported by lifting at the motor and Coldhead flange in positions 180 degrees apart.**

3. Carry the new / prepared Coldhead to the rear of the magnet.
4. Carefully lift the Coldhead and align it with the sleeve. Gradually insert the Coldhead into the sleeve until there's a 5/16 - 3/8 inch ( 8 - 10mm ) gap between the sleeve and transition flange, as in Illustration 10-12.




**SLEEVE AND TRANSITION FLANGE GAP; BOLT TIGHTENING PATTERN**
ILLUSTRATION 10-12

5. Temporarily remove the Belleville washers from three bolts.
6. Insert the three bolts prepared without Belleville washers in the mounting holes spaced 90°, 135° and 135° around the Coldhead flange.

**Note**
Make sure to maintain an even gap between the transition and sleeve flanges around the full circumference during insertion and tightening. See Illustration 10-12.

7. Thread and evenly tighten the three bolts, giving each a quarter-turn at a time, until the o-ring is fully captured into the sleeve. Immediately close the gas flow valve ( green handle ) on the service adapter.

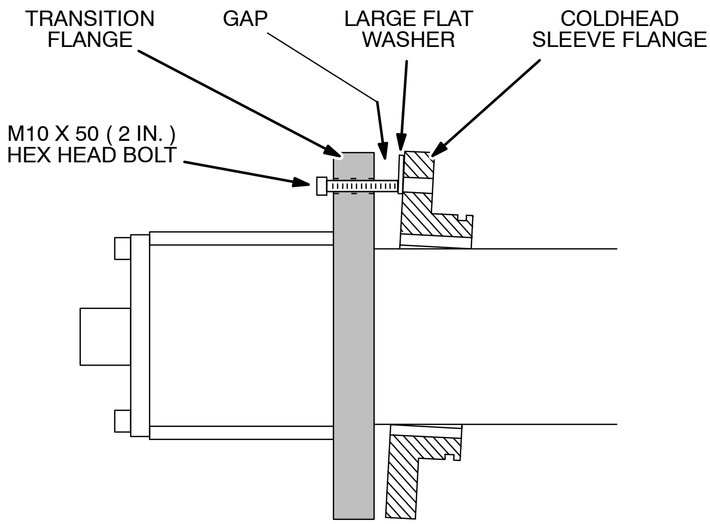
## 10-5 COLDHEAD REPLACEMENT ( continued )

8. Remove the three bolts and re-assemble with Belleville washers on each. Make sure the Belleville washers are in the proper orientation ( as shown in Illustration 10-11 ) on all eight bolts.

9. Thread and evenly tighten all eight Coldhead mounting bolts into the Coldhead transition flange until a 0.015 ( 0.38 mm ) gap exists between the Coldhead transition flange and the sleeve around the full circumference.

**Note**

Gap adjustments can be made before fully tightening the mounting bolts by using two flathead screw-drivers wedged between the transition and sleeve flanges. Gap adjustments can also be made by temporarily removing the desired mounting bolt, inserting and fully threading a M10 x 50 ( 2 inch ) long hex head bolt through the transition flange and using that bolt like a jack screw against a flat washer on the sleeve flange to wedge open the gap slightly. See Illustration 10-13.




**ADJUSTING SLEEVE AND TRANSITION FLANGE GAP USING JACK SCREW ( M10 BOLT )**
ILLUSTRATION 10-13

**CAUTION**

**Make gap adjustments before the Belleville washers have been compressed. Make only small adjustments at a time to prevent cocking the Coldhead and placing a bending moment on the mounting bolts.**

10. With the vacuum pump operating, open the vacuum valve ( black handle ) on the service operator to evacuate the sleeve space. See illustration 10-4.

11. When the vacuum reaches 50 millitorr ( 50 microns ), close the vacuum check valve ( black handle ) and open the gas flow valve ( green handle ) on the service adapter.

## 10-5 COLDHEAD REPLACEMENT ( continued )

12. When the pressure within the sleeve reaches 1 atmosphere, close the gas flow valve ( green handle ) and open the vacuum valve ( black handle ) to re-evacuate the sleeve.
13. Repeat Steps 11 and 12 a second time ( i.e., two evacuation / backfill cycles ), then continue evacuating the sleeve while performing Section 10-6, Coldhead Interface Adjustment.

## 10-6 COLDHEAD INTERFACE ADJUSTMENT

**CAUTION**

**It is important to perform all Coldhead adjustments prior to turning the Coldhead on. This will allow the indium gasket to compress and fill the gaps at the thermal station interface before the gasket cools and hardens in the sleeve.**

1. Tighten the Coldhead bolts a half-turn each in the staggered pattern shown in Illustration 10-12 to set the gap between Belleville washers on all bolts evenly with a 0.015 inch ( 0.38 mm ) feeler gauge. Wait one minute, and repeat the bolt tightening, setting the gap between Belleville washers evenly with a 0.010 inch ( .25 mm ) feeler gauge. After another minute tighten all bolts again and use a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) feeler gauge to set a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) gap between Belleville washers on all bolts. See Illustration 10-11.

   **Note**

   Make sure an even gap is maintained between the transition and sleeve flanges around the full circumference.

2. Allow the Coldhead to sit “warm” and the sleeve to evacuate for 15 minutes, checking and maintaining a 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) Belleville washer gap on all Coldhead bolts.

**WARNING!**

**DO NOT PUT ANY BENDING FORCE ON THE AEROQUIP FITTINGS DURING HELIUM FLEX-LINE CONNECTING / DISCONNECTING. A BENDING FORCE WILL CREATE DIFFICULTY IN THE RAPID THREAD ENGAGEMENT / DISENGAGEMENT REQUIRED TO PREVENT HELIUM LOSS AND CONTAMINATION. IT CAN ALSO RESULT IN BENDING OR LEAKING OF THE AEROQUIP STEMS. SUPPORT THE GAS LINES TO PREVENT A BENDING FORCE WHEN CONNECTING / DISCONNECTING TO THE COLDHEAD AT THE TOP OF THE MAGNET AND THE COMPRESSOR.**

### 10-6 COLDHEAD INTERFACE ADJUSTMENT ( continued )

**CAUTION**

**Make sure the helium flexlines are connected in the sequence stated below. Gas back pressure may prevent the Coldhead from starting if gas lines are connected in the reverse sequence. Order and technique are important when connecting helium flexlines to prevent inoperative Coldheads and system contamination.**

**Note**
Make sure the o-ring on the female Aeroquip fitting at the Coldhead is present and in good condition.

3. During the 15 minute period the Coldhead sits "warm", connect the Coldhead gas lines in the following sequence:

   **FIRST:** connect the **return** flexline ( green mark )

   **SECOND:** connect the **supply** flexline ( yellow mark )

4. Make sure the digital vacuum gauge reads < 100 millitorr ( 100 microns ) and that the sleeve has been evacuated for at least 15 minutes, then close the pump-out port operator by pushing the knob in and gently rotating it clockwise ( CW ). Next rotate the knob counterclockwise ( CCW ) until the knob extension is fully disengaged from the pump-out port. Do **not** pull the knob out at this time.

5. When the pump-out port operator is closed, close the vacuum valve ( black handle ) on the service operator. Observe the vacuum gauge while pulling out the pump-out port knob about 2 inches ( 50 mm ). A decreasing reading means the vacuum has increased due to the pump-out port plug moving during operation. If no change is observed, continue with this procedure.

6. Connect the Coldhead power cable in conformance with SET-UP AND CALIBRATION, Section 1-4, Cryocooler Installation and Checkout.

7. Turn off the vacuum pump and open the gas inlet valve ( green handle ) to vent system. Disconnect and remove all apparatus.

8. Close the Coldhead motor shield and reinstall in the end of the motor shield the .25-20UNC stainless steel socket head cap screws removed earlier.

9. Turn the Cryocooler on.

10. When temperature equilibrium is reached, make sure the Belleville washer gaps are within the 0.003 - 0.005 inch ( 0.08 - 0.13 mm ) range.

11. If the readings found in Step 10 are out of acceptable range, make minor adjustments ( if possible ) and / or repeat the Coldhead replacement procedure with the same Coldhead.

# SECTION 11
# HELIUM FLEXLINE CONNECTIONS / REPLACEMENT

## 11-1 INTRODUCTION

Follow the procedures in this section to prevent helium loss and damage to the Coldhead and Aeroquip fittings during gas line replacement. Make sure the gas line insulation is reinstalled on the new gas lines to prevent "spike" noise and image problems.

**CAUTION**

**Order and technique are important when connecting helium flexlines to prevent inoperative coldheads and system contamination.**

**WARNING!**

**DO NOT PUT ANY BENDING FORCE ON AEROQUIP FITTINGS WHILE CONNECTING / DISCONNECTING HELIUM FLEXLINES. A BENDING FORCE WILL CREATE DIFFICULTY IN THE RAPID THREAD ENGAGEMENT / DISENGAGEMENT REQUIRED TO PREVENT HELIUM LOSS AND CONTAMINATION. IT CAN ALSO RESULT IN BENDING OR LEAKING OF THE AEROQUIP STEMS. SUPPORT THE GAS LINES TO PREVENT A BENDING FORCE WHEN CONNECTING / DISCONNECTING TO THE COLDHEAD AT THE TOP OF THE MAGNET OR TO THE COMPRESSOR.**

## 11-2 FLEXLINE CONNECTION SEQUENCE FOR SUMITOMO CRYOCOOLERS

1. Connect the return line ( green mark ) and the supply line ( yellow mark ) to the Compressor.
2. Then connect the return line ( green mark ) to the Coldhead.
3. Finally connect the supply line ( yellow mark ) to the Coldhead.

## 11-3 CONNECTING AEROQUIP COUPLINGS

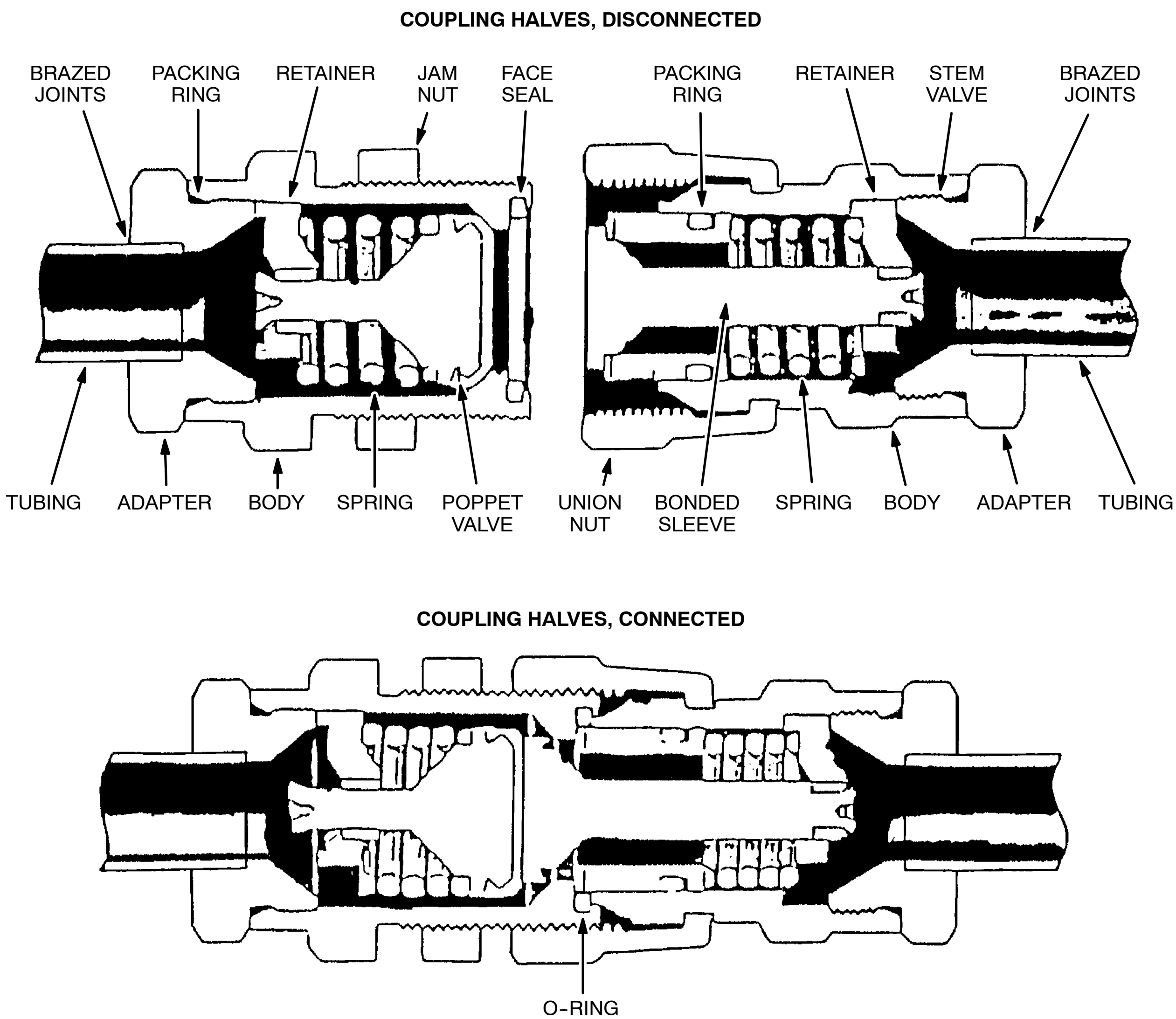
**Note**

Refer to Illustrations 11-1 and 11-3 for this procedure. Make sure the Aeroquip o-ring is present and in good condition on the female fittings on the Coldhead side.

1. The system gas connections are shipped with caps and plugs to keep the fittings clean and free from damage. Remove the caps and plugs and thread them together for storage.

2. Wipe the coupling faces with a lint-free cloth to insure they are clean and free of chips and dust.

3. Make sure the face seal is in place on the inside periphery of the male coupling and is not damaged.



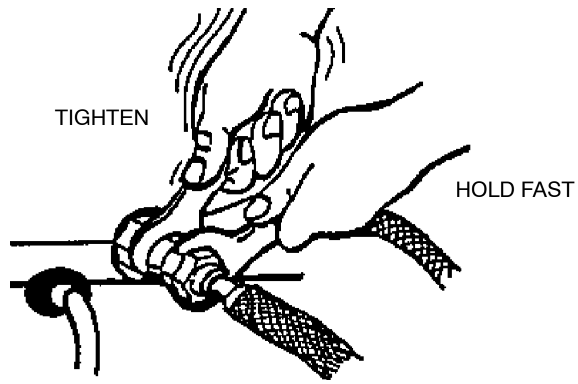

**VIEW OF DISCONNECTED AND CONNECTED SELF-SEALING ( AEROQUIP ) COUPLINGS**
ILLUSTRATION 11-1

### 11-3 CONNECTING AEROQUIP COUPLINGS ( continued )

4. To make the connection, start the hose-side union nut onto the male connector by hand. Then, using the supplied wrenches, hold the stationary part of the female coupling with one wrench while turning the union nut with the other wrench.

5. As the poppet inside the fitting begins to open, there will be a slight venting of gas. Continue tightening the connection until the female coupling is firmly seated against the male coupling's face seal. The required torques are:

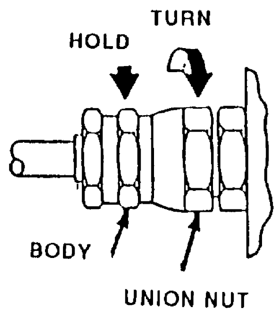
   - 35 ft-lbs ( 47.5 N-m ) for the 1/2 inch connection
   - 45 ft-lbs ( 61.0 N-m ) for the 3/4 inch connection



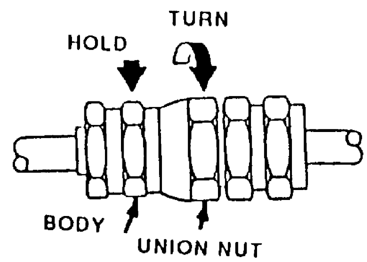

**PROPER 2-WRENCH CONNECTION TECHNIQUE FOR AEROQUIP COUPLINGS**
ILLUSTRATION 11-2

## 11-3 CONNECTING AEROQUIP COUPLINGS ( continued )

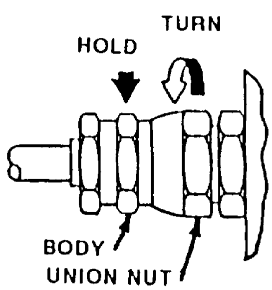
**CONNECTING TO COMPRESSOR**




**CONNECTING TO COLDHEAD**

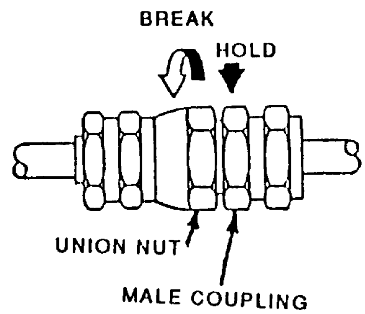



**DISCONNECTING FROM COMPRESSOR**

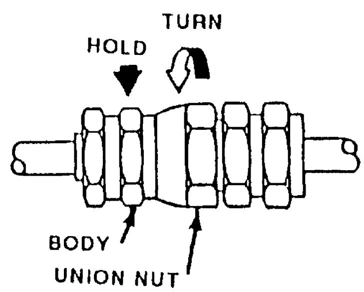



**DISCONNECTING FROM COLDHEAD**

1.
HOLD MALE
COUPLING TO
BREAK




2.
HOLD FEMALE
COUPLING TO
DISCONNECT




**CONNECTING AND DISCONNECTING GAS LINES**
ILLUSTRATION 11-3

## 11-4 DISCONNECTING AEROQUIP COUPLINGS

**IMPORTANT !!!**

Make sure the male couplings at the Compressor and Coldhead DO NOT ROTATE when disconnecting lines. Avoid torsional forces on the flex sections.

**Note**

Excessive gas will escape if the fittings are not aligned properly during connection or disconnection.

1. To disconnect the gas line at the Coldhead:

   a First use one wrench to turn the female coupling's union nut about 1/8 turn, while holding the male coupling stationary with the other wrench. This will overcome the initial torque required to break the connection without loosening the male connector from its adapter.

   b Make sure the hose does not rotate to avoid a torsional force on the hose.

   c Place the second wrench on the stationary part of the female coupling and continue to unthread the union nut. Be sure the male connector does not rotate when disconnecting.

   d Make sure the bulkhead jam nut is secure and the male coupling does not rotate when removing the gas line.

2. To disconnect the gas line at the Compressor:

   a Turn the union nut on the female coupling while holding the stationary part of female coupling with a second wrench. Since the male coupling is bulkheaded to Compressor front panel with a lock washer, the male coupling should not rotate from its adapter while removing.

   b When the hoses are disconnected, check each coupling to make sure its face seal is in place and not damaged.

   **Note**

   While the hose is venting during disconnection, the face seal is often blown out of its gland and into the female coupling. Failure to remove the seal from the female coupling will cause the connection to leak when reconnected, with or without another face seal installed.

   c If all seals are in their proper place, replace the dust caps and plugs to the coupling halves.

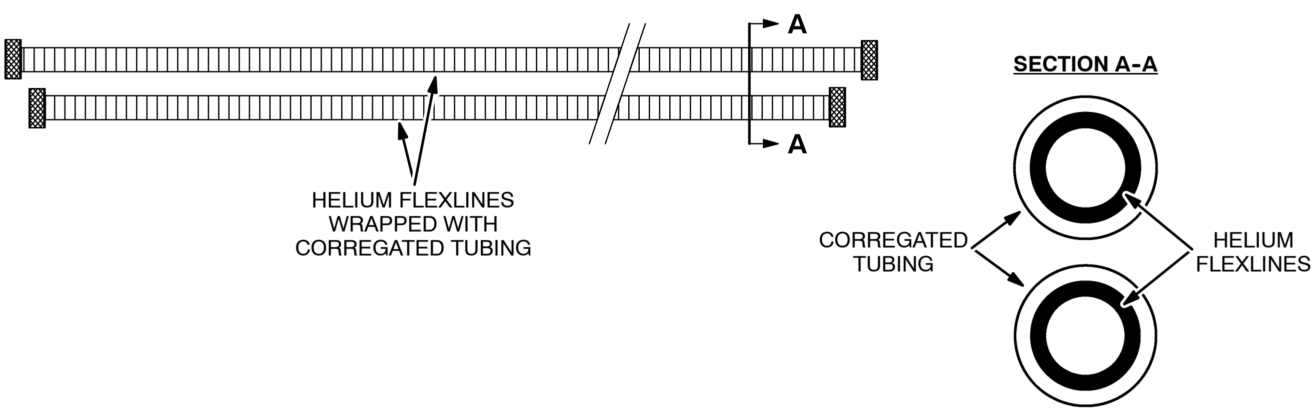
## 11-5 REPLACING GAS LINE INSULATION CASING

1. Slide the old insulated casing / tubing off the gas line. See Illustration NO TAG.

2. Cover the gas line completely with Corregated Plastic Tubing ( 2251611 ) from the helium line fittings on the Coldhead to the Penetration Panel where the lines exit the magnet room.

**Note**

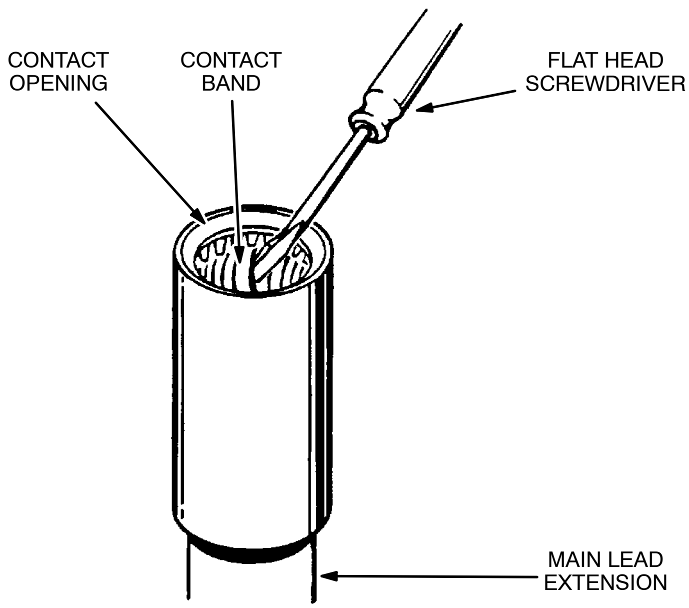
Corregated plastic tubing is used to isolate helium gas lines from each other and from ground to prevent spike noise.




**HELIUM LINE INSULATION**
ILLUSTRATION 11-4

# SECTION 12
# MAIN LEAD EXTENSION CONTACT BAND REPLACEMENT

1. Insert a flat head screwdriver into the 1/2 inch ( 12.7 mm ) diameter contact opening in the end of the Main Lead Extension. See Illustration 12-1.




**CONTACT BAND REMOVAL**
ILLUSTRATION 12-1

2. Engage the Contact Band's louvers with the screwdriver tip and gradually pry the old Contact Band out of the contact opening without scouring the contact opening's walls.

**CAUTION**

**The contact area on which the Contact Band seats is silver plated and must be cleaned with a non-abrasive cloth and cleaning solution.**

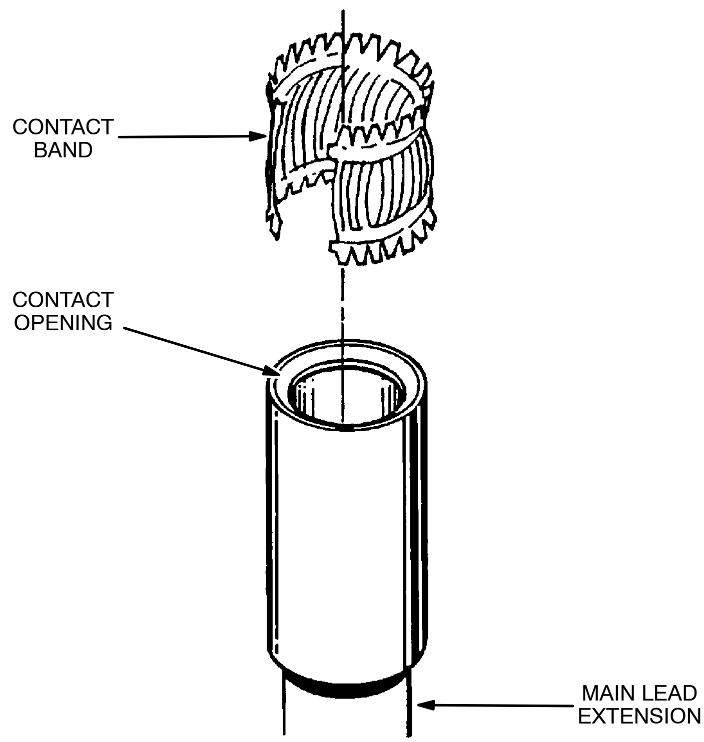
3. Clean the cavity in which the Contact Band seats using a nonabrasive cloth and a degreasing solution such as trichlorethylene.

4. Obtain and inspect a new Contact Band ( 46-281256P1 ).

**SECTION 12 – MAIN LEAD EXTENSION CONTACT BAND REPLACEMENT ( continued )**

5. Roll the new Contact Band into a uniform cylinder of less than 1/2 inch ( 12 mm ) diameter, then fully insert it into the contact opening. See illustration 12–2.

6. Make sure the Contact Band has expanded against walls of the contact opening and is fully seated below rim on contact opening.




**CONTACT BAND INSERTION**
ILLUSTRATION 12–2

# SECTION 13 - RTD TEMPERATURE SENSORS AND IRON POLE / RING / POST HEATER CHECK AND REPLACEMENT

## 13-1 INTRODUCTION

Heaters are attached to the iron poles, rings and posts of the magnet to maintain a uniform temperature of 28 degrees centigrade. This temperature is controlled by temperature sensors and a temperature control unit which controls the power input to the heaters.

Failure of a heater element or temperature sensor is very unlikely. If a failure is indicated, use the following procedure to confirm the failure and replace the component.

If a failure occurs on a primary temperature sensor ( RTD ) or heater element, switch to the alternate sensor / element on the connector board. If both the primary and alternate units fail, the component will have to be replaced.

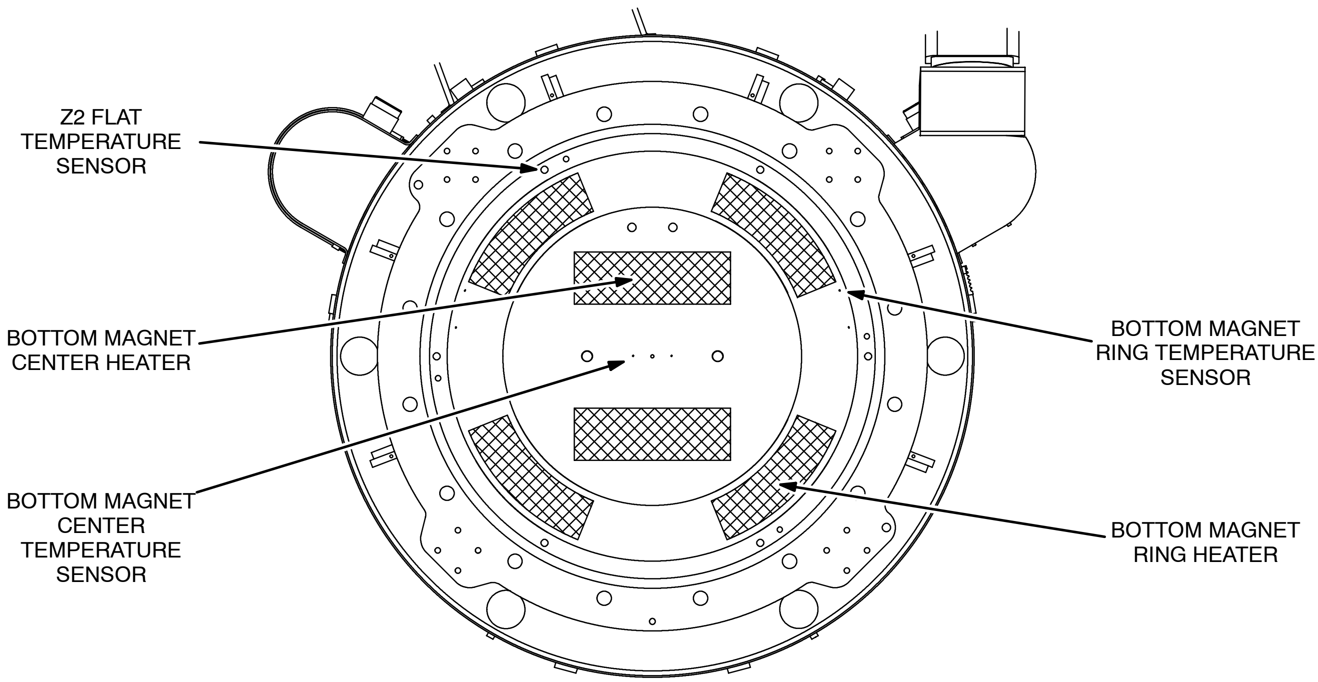
Illustration 13-1 shows the Flexible Heater mounting to the iron rings, poles and posts and shows the location of the RTD Temperature Sensors. Illustration 13-2 shows the connector box.

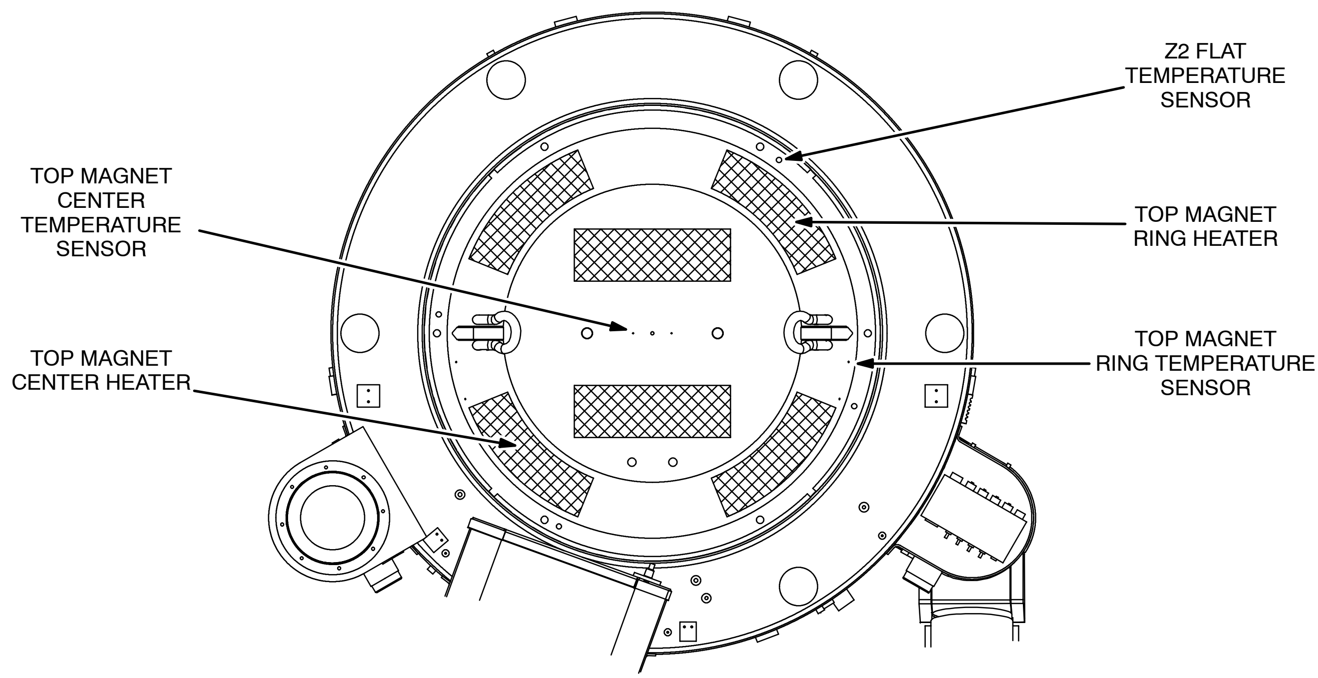
Heater and RTD Temperature Sensor schematics and connector pinouts are shown in SCHEMATICS / INTERCONNECTS, Section 5.

**WARNING!**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

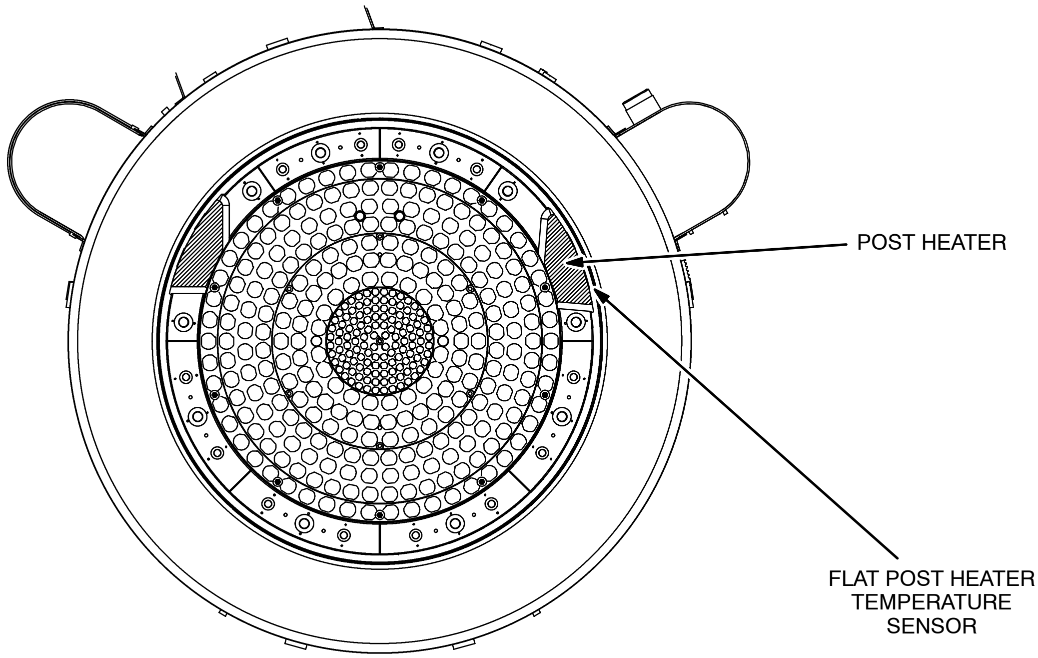
## 13-1 INTRODUCTION ( continued )



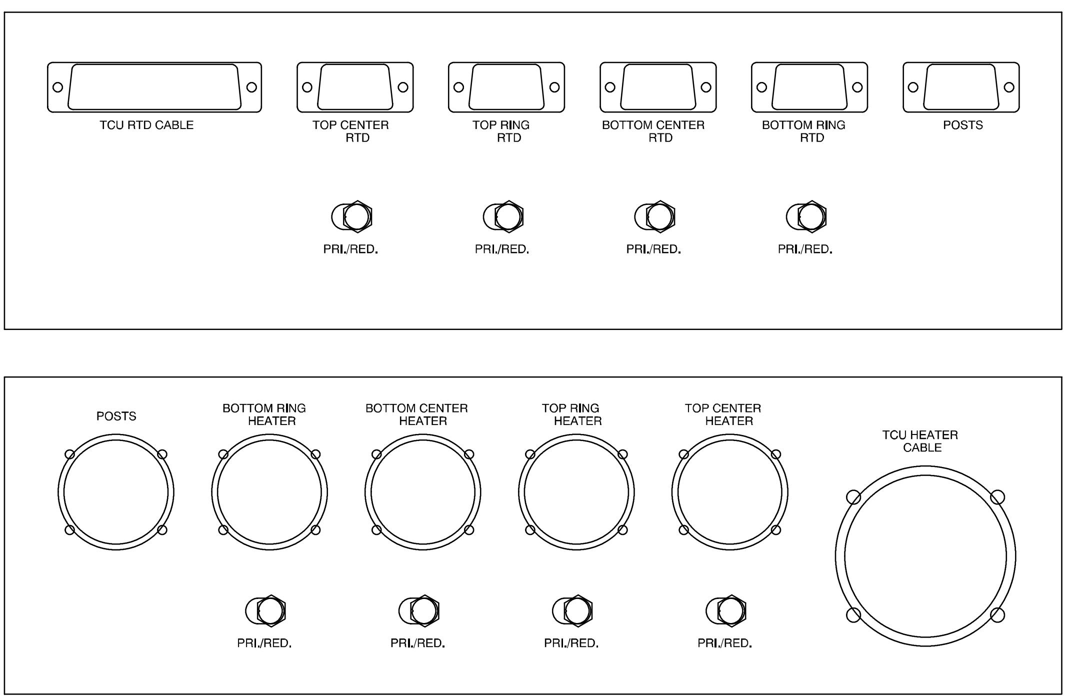




**FLEXIBLE HEATERS AND "RTD" TEMPERATURE SENSOR LOCATIONS**
ILLUSTRATION 13-1

## 13-1 INTRODUCTION ( continued )




**FLEXIBLE HEATERS AND "RTD" TEMPERATURE SENSOR LOCATIONS ( CONTINUED )**
ILLUSTRATION 13-1




**HEATER CONNECTOR BOX - 2269994**
ILLUSTRATION 13-2

## 13-2 RTD TEMPERATURE SENSOR ELEMENT CHECK

1. Determine the pinouts of a suspect RTD(s) Temperature Sensor from SCHEMATICS / INTERCONNECTS, Section 5.
2. Remove the connector from the terminal board. Use a Digital Voltmeter ( DVM ) to check resistance at its pinouts.
3. Note the temperature indications of adjacent sensors on the Temperature Control Unit ( TCU ).
4. Compare the resistance reading with the applicable temperature value shown in Table 13-1. A difference larger than 2% between the reading and the table indicates a failed RTD.
5. If the primary sensor has failed, switch to the alternate. If both sensors have failed, the unit will have to be replaced.

TABLE 13-1
**100 OHM PLATINUM RTD OHMS VS. TEMPERATURE**

| ( C ) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| ( 10 ) | 103.90 | 104.29 | 104.68 | 105.07 | 105.46 | 105.85 | 106.24 | 106.63 | 107.02 | 107.40 |
| ( 20 ) | 107.79 | 108.18 | 108.57 | 108.96 | 109.35 | 109.73 | 110.12 | 110.51 | 110.90 | 111.28 |
| ( 30 ) | 111.67 | 112.06 | 112.45 | 112.83 | 113.22 | 113.61 | 113.99 | 114.38 | 114.77 | 115.15 |

## 13-3 HEATER CHECK

1. Determine the pinouts of the suspect heater from SCHEMATICS / INTERCONNECTS, Section 5.
2. Remove the connector from the terminal board. Use a Digital Voltmeter ( DVM ) to check resistance at its pinouts.
3. Compare the resistance reading with the applicable range shown in Table 13-2. A reading outside the range boundaries indicates a failed heater.
4. If the primary heater has failed, switch to the alternate. If both heaters have failed, the unit will have to be replaced.

TABLE 13-2
**FLEXIBLE HEATER RESISTANCE TABLE**

| HEATER | CONNECTOR | PINS | RESISTANCE VALUE ( OHMS ) |
|---|---|---|---|
| POSTS CONNECTOR | J11 | 1 - 2 | 91.2 - 100.8 |
| | | 3 - 4 | |
| BOTTOM RING HEATER CONNECTOR | J1 | 1 - 2 | 45.6 - 50.4 |
| | | 3 - 4 | |
| BOTTOM CENTER HEATER CONNECTOR | J1 | 1 - 2 | 91.2 - 100.8 |
| | | 3 - 4 | |
| TOP RING HEATER CONNECTOR | J1 | 1 - 2 | 45.6 - 50.4 |
| | | 3 - 4 | |
| TOP CENTER HEATER CONNECTOR | J1 | 1 - 2 | 91.2 - 100.8 |
| | | 3 - 4 | |
| TCU HEATER CABLE CONNECTOR | J1 | A - B | 45.6 - 50.4 |
| | | C - D | 91.2 - 100.8 |
| | | E - F | |
| | | G - H | |
| | | J - K | |
| | | L - M | 45.6 - 50.4 |

## 13-4 RTD TEMPERATURE SENSOR REPLACEMENT

1. Open the required harness clamps and remove the leads, starting at the bad RTD's connector.
2. When the RTD is reached, remove any tape securing it to the surface.

**WARNING!**

**THE MAGNET MUST BE RAMPED DOWN PRIOR TO USING A HEAT GUN OR ANY FERRO-MAGNETIC TOOLS NEAR THE MAGNET TO PREVENT THE ITEM FROM BEING ATTRACTED TO THE IRON POLE AND BECOMING A DANGEROUS PROJECTILE IN THE MAGNET'S FIELD.**

3. Use a heat gun to soften the epoxy which holds the RTD to the magnet.
4. When epoxy is soft, scrape the bad RTD and epoxy off the iron surface.
5. Make sure the epoxy is fully scraped from the surface, then clean the surface with emery paper of 60 – 80 grit, followed by a degreaser that leaves no residue.
6. Use standard, fast-setting epoxy ( 5-minute ) to secure the new RTD to the same location on the cleaned surface where the removed RTD was located.
7. Tape the RTD firmly against the surface to hold in place while the epoxy is curing.
8. Route new RTD leads in same path as removed leads. Position the leads and close the harness clamps to secure them.
9. Connect the new RTD connector in the location where old one was removed.

## 13-5 HEATER REPLACEMENT

1. Open the required harness clamps and remove the leads, starting at the bad heater's connector.

**WARNING!**

**THE MAGNET MUST BE RAMPED DOWN PRIOR TO USING A HEAT GUN OR ANY FERRO-MAGNETIC TOOLS NEAR THE MAGNET TO PREVENT THE ITEM FROM BEING ATTRACTED TO THE IRON POLE AND BECOMING A DANGEROUS PROJECTILE IN THE MAGNET'S FIELD.**

2. When the bad heater is reached, use a scraper to remove the failed heating element and "RTV" sealant.
3. Make sure all material is scrapped from the metal surface, then clean the surface with emery paper of 60 – 80 grit, followed by a degreaser that leaves no residue.

## 13-5 HEATER REPLACEMENT ( continued )

4. Peel off the separator, exposing the adhesive surface of the new heating element and carefully place the adhesive side of the heater on the clean metal surface in the same position as the removed heater.

5. Apply a rolling pressure to the exposed side of the heater to achieve full contact.

6. Apply a thin layer of “RTV” material around the perimeter of the heater as a moisture barrier.

7. Route new heater leads along the same path as the removed leads. Position the leads and close the harness clamps to secure them.

8. Connect the new heater connector in location where old one was removed.

# SECTION 14 – COMPRESSOR BYPASS UNIT REPLACEMENT

**Description**

The Compressor Bypass Unit ( 2266223 ) is installed directly onto the Cryocooler Compressor and provides an alternate path for the helium gas flow when the Coldhead is cycled off while the Compressor is running.

The unit is approximately 2 pounds ( 1 KG ) in weight and is supported on the Compressor by the Aeroquip fitting connections.

**Procedure**

**WARNING!**

**BEFORE STARTING BYPASS UNIT REPLACEMENT AND BEFORE CONNECTING OR DISCONNECTING THE JUNCTION CABLE AND COLDHEAD POWER CABLE, MAKE SURE NO POWER IS APPLIED TO THE COMPRESSOR UNIT. FAILING TO OBSERVE THIS PRECAUTION MAY RESULT IN ELECTRICAL SHOCK.**

**SEALED INSIDE THE BYPASS UNIT IS HIGH PRESSURE HELIUM GAS. DAMAGE TO THE UNIT MAY CAUSE GAS TO EXCAPE, POTENTIALLY EXPLOSIVELY. HANDLE WITH EXTREME CARE.**

**CAUTION**

**Before connecting the flexlines, make sure to check the flat rubber gasket of the Bypass Unit's self-seal coupling for dirt or dust and to see whether it is attached correctly. Connecting the flexlines with that flat rubber gasket seated abnormally may cause gas to escape.**

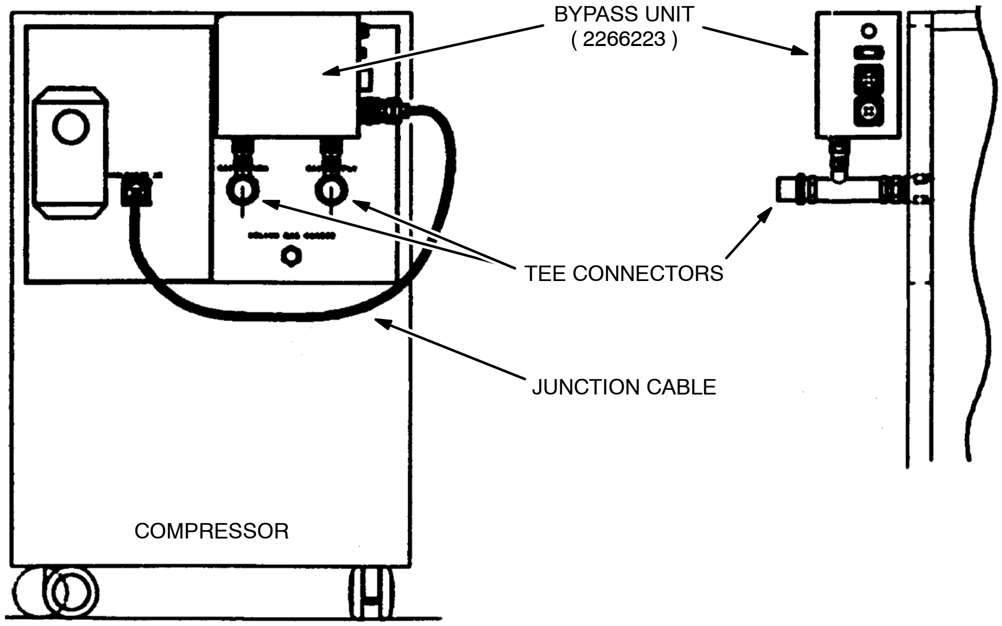
**Do not mismatch the Bypass Unit's "SUPPLY" and "RETURN" connections and the flexlines. Misconnecting the gas line may prevent the Cryocooler from operating properly.**

## IMPORTANT !!!

When connecting the Bypass Unit and flexlines, make sure the unit is oriented properly in conformance with Illustration 14-1.

Tighten the self-sealing coupling nut by hand for the first turn and finally tighten it firmly. Be careful not to tighten it excessively.

**Procedure ( continued )**




**BYPASS UNIT ATTACHED TO COMPRESSOR**
ILLUSTRATION 14-1

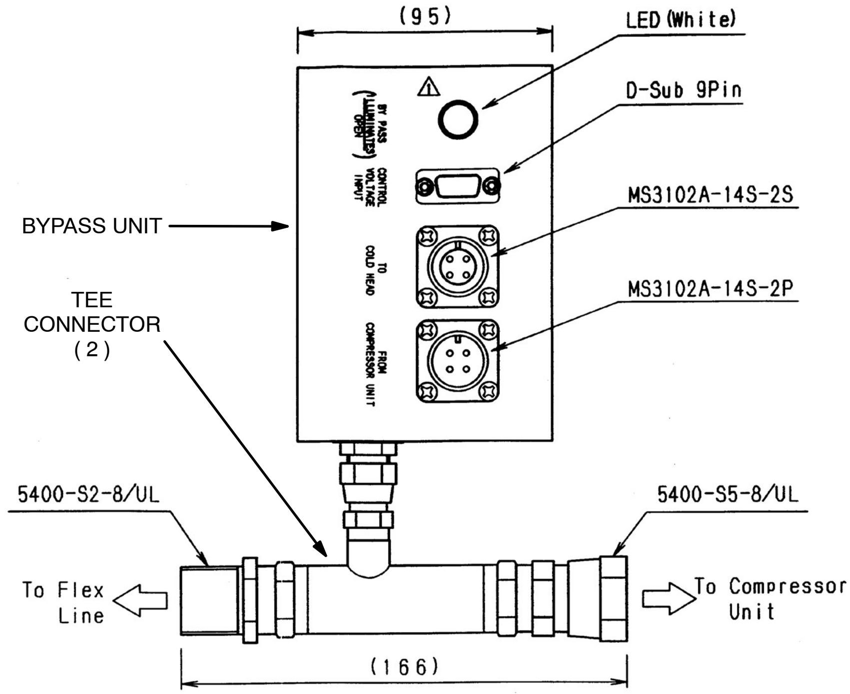
1. Disconnect the Junction Cable running between the Compressor Bypass Unit and the Compressor. See Illustration 14-1.
2. Disconnect the gas flexlines from the By-Pass Unit and then from the Compressor. See Illustration 14-1.
3. Remove all protective caps off the self-sealing connectors.

**CAUTION**

**Before connecting the flexlines, make sure to check the flat rubber gasket of the Bypass Unit's self-seal coupling for dirt or dust and to see whether it is attached correctly. Connecting the flexlines with that flat rubber gasket seated abnormally may cause gas to escape.**

4. Check the flat rubber gaskets on all self-sealing connectors to make sure they are clean and properly positioned.
5. Connect both the supply and return tee connectors to the Compressor unit. See Illustrations 14-1 and 14-2.
6. Connect the Bypass Unit. See Illustrations 14-1 and 14-2.

**Procedure ( continued )**




**BYPASS UNIT CONNECTIONS**
ILLUSTRATION 14-2

7. Reconnect the Junction Cable between Compressor unit and the Bypass Unit. See Illustration 14-1.

**CAUTION**

**Do not mismatch the Bypass Unit's "SUPPLY" and "RETURN" connections and the flexlines. Misconnecting the gas line may prevent the Cryocooler from operating properly.**

8. The following connections can now made to the Bypass Unit, in conformance with SET-UP AND CALIBRATION,Sections 1-4-5 and 1-4-7, to complete the interconnections of the Cryocooler assembly:

   - Return and supply gas lines.
   - Coldhead power cable
   - Control voltage input cable from the MR system.

# SECTION 15 – PREPARATION FOR SITE REMOVAL

1. Perform the following procedures from this manual ( Direction 2231934 ) in sequence:

   a. Ramp down the magnet in conformance with REPLACEMENT / MAINTENANCE, Section 1, Magnet Field Adjustment / Rampdown ( Field Decrease to Zero ).

   b. If the magnet is to be moved by air or sea or over land inside a closed container such as an "ISO" box, remove the liquid helium from the helium vessel using the procedure in REPLACEMENT / MAINTENANCE, Section 3, Warming Up Cryostat, to warm the magnet to > 5K.

## IMPORTANT !!!

When the bottom diode temperature starts to rise the liquid helium has been removed and the procedure may be stopped.

**CAUTION**

**Removal of helium from the helium vessel by breaking magnet vacuum will result in large quantities of helium gas being vented through the magnet vent system and damage to the internal magnet insulation.**

2. Move the magnet in conformance with Direction 2243897, *GE 0.7T OpenSpeed Magnet Delivery and Installation*.

# SECTION 4 – RAMP FILL

**DANGER!!**

**MAKE SURE THAT THE FOLLOWING ACTIONS ARE TAKEN BEFORE STARTING THIS PROCEDURE TO PREVENT POTENTIAL FATAL INJURY !!!**

- **REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THIS PROCEDURE IN SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–4, MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS.**
- **HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*, SECTION 2–5, BUDDY SYSTEM REQUIREMENTS & CERTIFICATION.**

## 4–1 INTRODUCTION

The Main and Bucking Coils of the GE 0.7T Open*Speed* Magnet are in a horizontal plane to generate a vertical magnetic field. Because of this configuration, it is essential that the magnet helium level remain between 95% and 98% during the ramp to be in contact with the Top Bucking Coil. Failure to maintain this condition will result in a cooling loss of the Top Bucking Coil and could result in a quench.

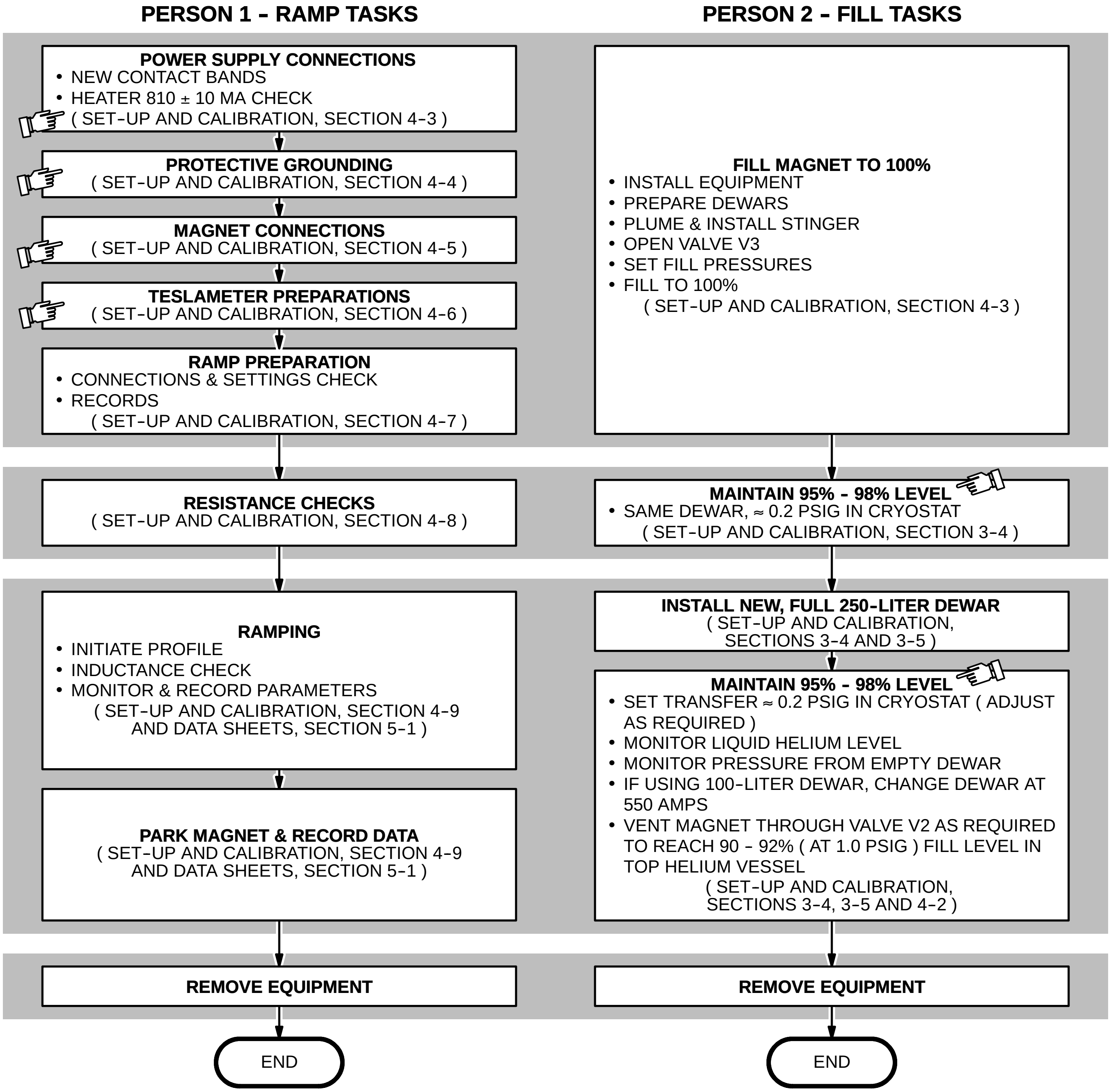
The ramp / fill procedure maintains the required helium level during the ramp through the controlled replenishment of liquid helium to compensate for loss through the Main Leads and Vent Valve V3.

Because of the complexity and simultaneous tasks of the ramp / fill procedure, two trained and certified persons are required. Person 1 performs the ramp while person 2 simultaneously performs the fill.

Before starting these procedures, review and fully understand all superconducting magnet portions of *2301164PRE, MR Magnet – Safety Requirements*, found in the SAFETY REQUIREMENTS tab of this manual. Fully comply with that document's Section 2–4, Magnet & Cryogen Service Safety Requirements. Have all "Work Assistants" or "Work Observers" comply with that document's Section 2–4, Buddy System Requirements & Certification.

Illustration 4–1 highlights the tasks and sequence for each person. Table 4–1 outlines the ramp / fill process steps. Complete DATA SHEETS, Table 5–2, Magnet Ramp / Fill Profile, for both magnet ramp up and ramp down.

## 4-1 INTRODUCTION ( continued )




**RAMP / FILL PROCESS**
ILLUSTRATION 4-1

## 4-1 INTRODUCTION ( continued )

TABLE 4-1
**RAMP / FILL PROCESS STEPS**

| **Prerequisites** |
|---|
| • Magnet Heaters must be stabilized.<br>• Perform Power Supply checks to verify functional ramp supply.<br>• Magnet Monitor must be functional and put into “FILL” mode. |
| **The process** |
| • Vent magnet down to .5 psig.<br>• If the Upper Vessel helium level is < 80%, top off the magnet to at least 95%. Valve V3 should be open when helium level is greater than 70%.<br>• If the Upper Vessel helium level is > 80%, proceed to next step.<br>• Install Protective Grounding Circuit.<br>• Insert the Main Lead Extensions.<br>• Install the Hold-down Tool, but do not fully tighten.<br>• Insert the fill line Stinger and begin filling the magnet.<br>• Tighten the Hold-Down Tool.<br>• When the Upper Vessel helium level is > 90%, do resistance checks.<br>• When the resistance checks pass, change to a new 250-liter Dewar.<br>• Park magnet at 29.791 MHz. This will account for the frequency drop when the supply is ramped down and the frequency increase when the magnet is shimmed. Specification for 0.7T Open*Speed* Magnet is 29.803 MHz ± 10 KHz.<br>• Replace Power Supply Jumper Cable before removing the Main Lead Extensions.<br>• After the supply is turned off, continue to fill while removing the Hold-Down Tool and Main Lead Extensions. This will give a higher helium level for magnet turnover to the customer. Hold-Down Tool and Main Lead Extensions should be removed quickly.<br>• Put the Magnet Monitor back into normal operating mode. |

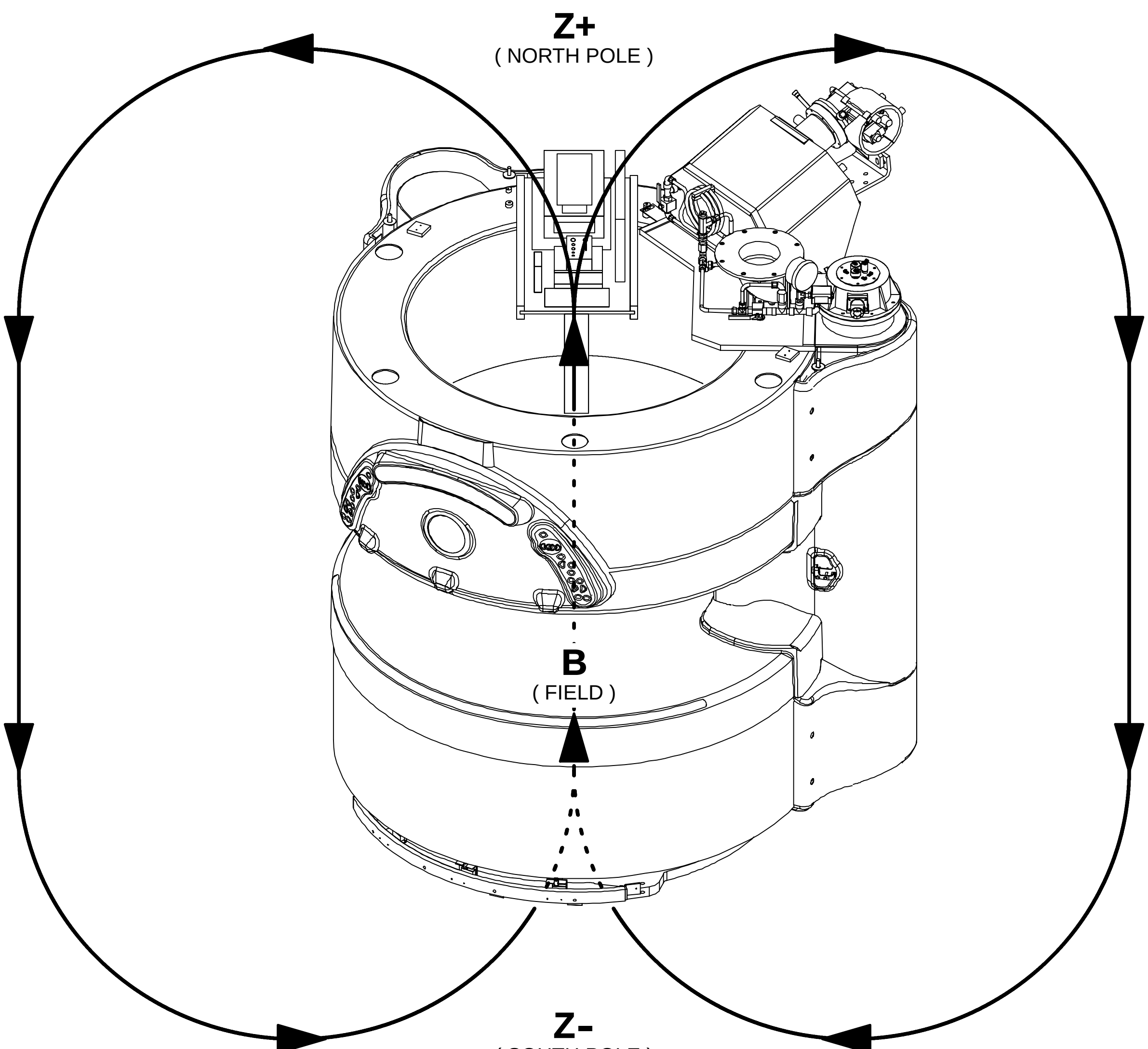
## IMPORTANT !!!

It is **essential** that the following conditions are met to prevent a 250-liter helium Dewar from running dry during the ramp. Approximately 150 liters of helium will be used under these conditions.

- Follow the ramp profile. Do not allow the ramp voltage to decay during each step of the ramp.
- Make sure contact resistance ( < 150 mV @ 750 amps ) is well within limits to minimize internal heat generation.
- Connect a new 250-liter helium dewar after resistance checks ( at start of ramp ).
- Maintain a helium level of 95% - 98% in the Top Helium Vessel during the ramp. Vessel pressure should be between 0.35 psig and 0.6 psig to maintain this helium level.
- Verify that magnet Temperature Control Units ( TCU’s ) have stabilized for at least 6 hours at a temperature of 28_C.

**Note:**
The field polarity of a normally ramped magnet is shown in Illustration 4-2.

## 4-1 INTRODUCTION ( continued )




**FIELD POLARITY OF A NORMALLY RAMPED MAGNET**
ILLUSTRATION 4-2

## 4-1 INTRODUCTION ( continued )

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM.**

**SECURE THE MAGNET ROOM DOORS IN THE OPEN POSITION BEFORE CHANGING MAGNETIC FIELD.**

**REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

## 4-2 HELIUM FILL DURING RAMP - PERSON 2

**CAUTION**

**Continuously observe the magnet vessel pressure and upper vessel helium level during the ramp / fill process. A portable helium meter should be used.**

**Note**

Portable Helium Meter 2270571 is calibrated for the GE 0.7T Open*Speed* magnet. However, any helium meter calibrated for a LCC or Florence-manufactured magnet can be used if the meter level is not allowed to drop below 97% during the ramp / fill process.

1. Open Valve V2 ( identified in Illustration 4-3 ) and vent the magnet down to < 0.5 psig. Close V2.

**CAUTION**

**Shield the pump-out port on the transfill line from cold helium gas that can harden the pump-out port o-ring and cause the line to go “soft.”**

2. Assemble the equipment, a new Dewar and cylinder of helium gas. Plume and insert the Stinger after the Main Lead Extensions and Hold-Down Tool are installed.

### 4-2 HELIUM FILL DURING RAMP - PERSON 2 ( continued )

3. Open Shield Vent Valve V3, identified in Illustration 4-3. Fill the magnet to 100% in conformance with SET-UP AND CALIBRATION, Section 3-4, Helium Precool And Fill.

**Note**

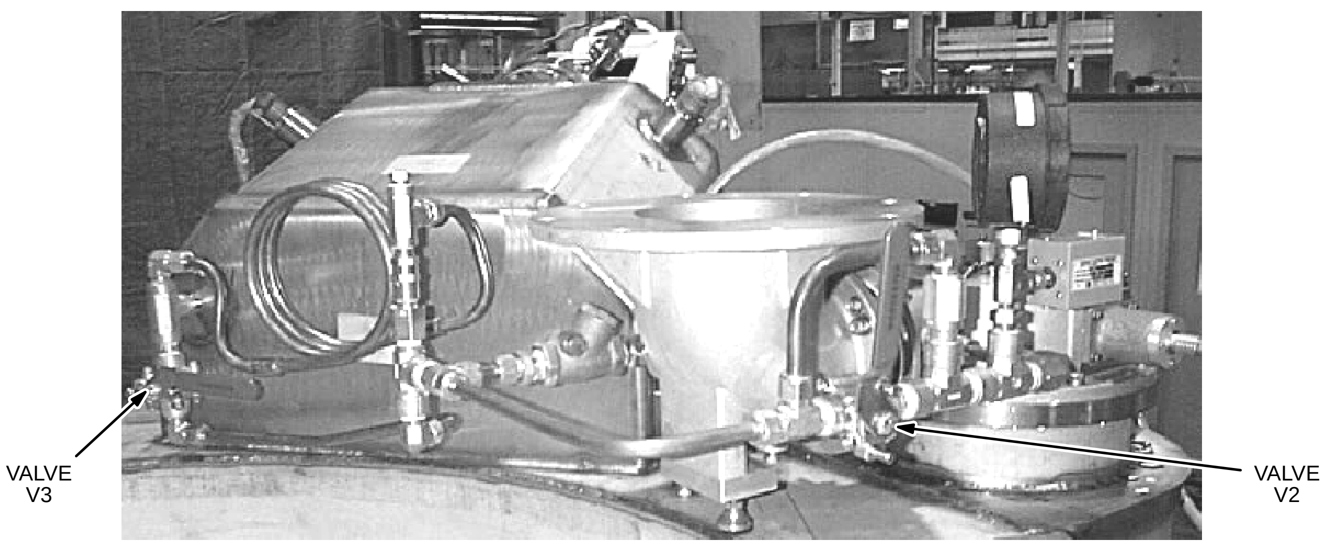
Leave Valve V3 open sufficiently to maintain 0.2 psig helium transfer pressure during the entire ramping procedure to prevent pressure build-up.

4. Maintain a 95 - 98% helium level during resistance checks. Nominal Cryostat pressure is 0.5 psig for maintaining this helium level.
5. Change to a new, full 250-liter Dewar at the start of ramp in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.

## IMPORTANT !!!

It is essential that the magnet is at 98% liquid helium level and a full 250-liter dewar is installed at the start of the ramp to prevent the Dewar from running dry during the ramp.

6. Adjust pressure from a helium gas cylinder connected to the Dewar and then to the Cryostat to produce a ~ 0.5 psig Cryostat pressure. Make minor adjustments to Dewar pressure as required to maintain between 95 - 98% liquid helium level during ramp.




**V2 AND V3 VALVE LOCATIONS**
ILLUSTRATION 4-3

## 4-2 HELIUM FILL DURING RAMP - PERSON 2 ( continued )

**CAUTION**

**Always maintain a positive pressure differential between the Dewar and the Cryostat to prevent any backflow of helium into the Dewar.**

**WARNING!**

**ALLOWING A HELIUM DEWAR TO EMPTY DURING RAMPING WILL CAUSE WARM GAS TO ENTER THE MAGNET AND CAUSE A QUENCH. CONTINUOUSLY MONITOR THE DEWAR AND MAGNET FOR A "WHISTLING" SOUND AND MAGNET PRESSURE FOR AN INCREASE; THESE INDICATE THE DEWAR IS EMPTY. WHEN AN EMPTY DEWAR IS SUSPECTED, IMMEDIATELY SHUT OFF THE DEWAR STINGER AND DISCONTINUE THE RAMP UP, MAINTAINING A CONSTANT RAMP CURRENT.**

7. Continuously monitor the magnet for a noticeable pressure increase and the Dewar Stinger for a whistling sound indicating that the Dewar is empty. If the Dewar is empty, have Person 1 park the magnet, turn the Power Supply off and change Dewars in conformance with SET-UP AND CALIBRATION, Section 3-5, Changing Helium Dewars.

8. Once the magnet is ramped and parked, close V3. Then Open Valve V2 and vent the magnet as required to reach a 90% fill level in the Top Helium Vessel.

**CAUTION**

**Fill the Top Helium Vessel only to the 90 - 92% level. Fill levels beyond 92% can result in magnet over-pressurization.**

9. Immediately discontinue helium transfer. Remove all helium fill equipment in conformance with SET-UP AND CALIBRATION, Section 3-4, Liquid Helium Fill.

## 4-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1

### Introduction

At least once a year calibrate the Ramp Power Supply in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5-1000-2-D-1236 Main Power Supply Calibration / Check.

Make sure the Ramp Power Supply is installed and checked out in conformance with the vendor manual supplied with the unit before making any Power Supply connections to the magnet. See INTRODUCTION, Section 2, Vendor Manual Matrix for vendor manual numbers.

SCHEMATICS / INTERCONNECTS, Section 1-1, Magnet Interconnect Diagram, shows the cable numbers and interconnect patterns covered in this Section.

The Main Coil Power Cables, Switch Heater Cables and Voltage Sense Leads are provided as part of the Ramp Cart / Cable Kit ( 1000 Amp ) 2180589.

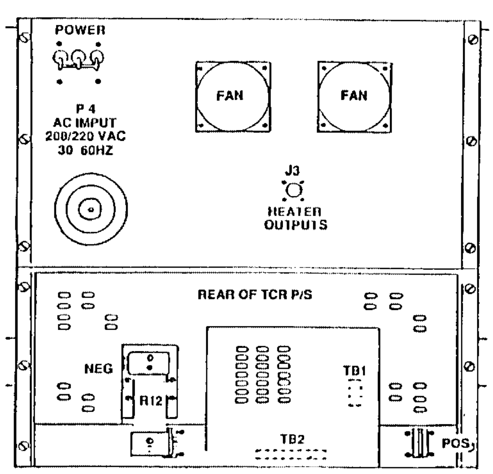
Use Main Lead Extensions 46-294204G1 from Magnet Ramping Equipment Kit 46-260703G6.

### Procedure

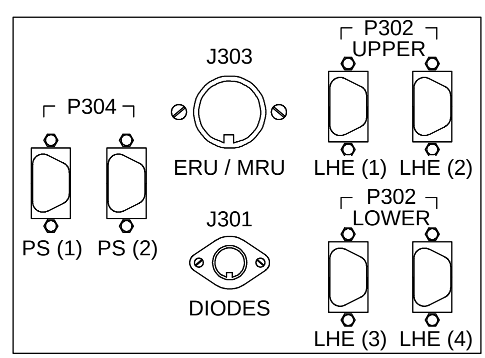
1. Verify that input power to the Main Coil Power Supply is disconnected.
2. Connect “P3” on Switch Heater Cable 46-281667G1 to Heater Outputs “J3” on the rear of the Main Coil Power Supply Cabinet ( MS6-A1 ). See Illustration 4-4.

**Note**

The magnet incorporates a “B0 Coil” to decrease moving-metal sensitivity of the magnet field. The B0 Coil Heater is energized through the Ramp Power Supply’s Axial Shim Heater Circuit. The Ramp Power Supply’s Axial Shim Heater must remain on throughout the Rampdown procedure in order to quench the B0 Coil field.




**POWER SUPPLY ( REAR )**




**CONNECTOR PANEL**

**MAGNET POWER SUPPLY OUTPUT CONNECTIONS AND MAGNET CONNECTOR PANEL**
ILLUSTRATION 4-4

## 4-3 RAMP POWER SUPPLY CIRCUIT CONNECTIONS - PERSON 1 ( continued )

3. Connect "J304" on the Switch Heater Cable to "P304" on the Magnet Connector Assembly ( MS1-A3, A1 ). See Illustration 4-4.

**Note**

Make sure the nuts installed in Steps 4 and 6 below are tightened sufficiently to prevent a high resistance contact. Connect the red cables to the Positive ( + ) Buss Bar and the black cables to the Negative ( - ) Buss Bar on the Main Power Supply. For magnets ramped with normal polarity make sure the red ( + ) cables are connected to the "+" Magnet Ramp Port and the black ( - ) cables are connected to the "-" Magnet Ramp Port.

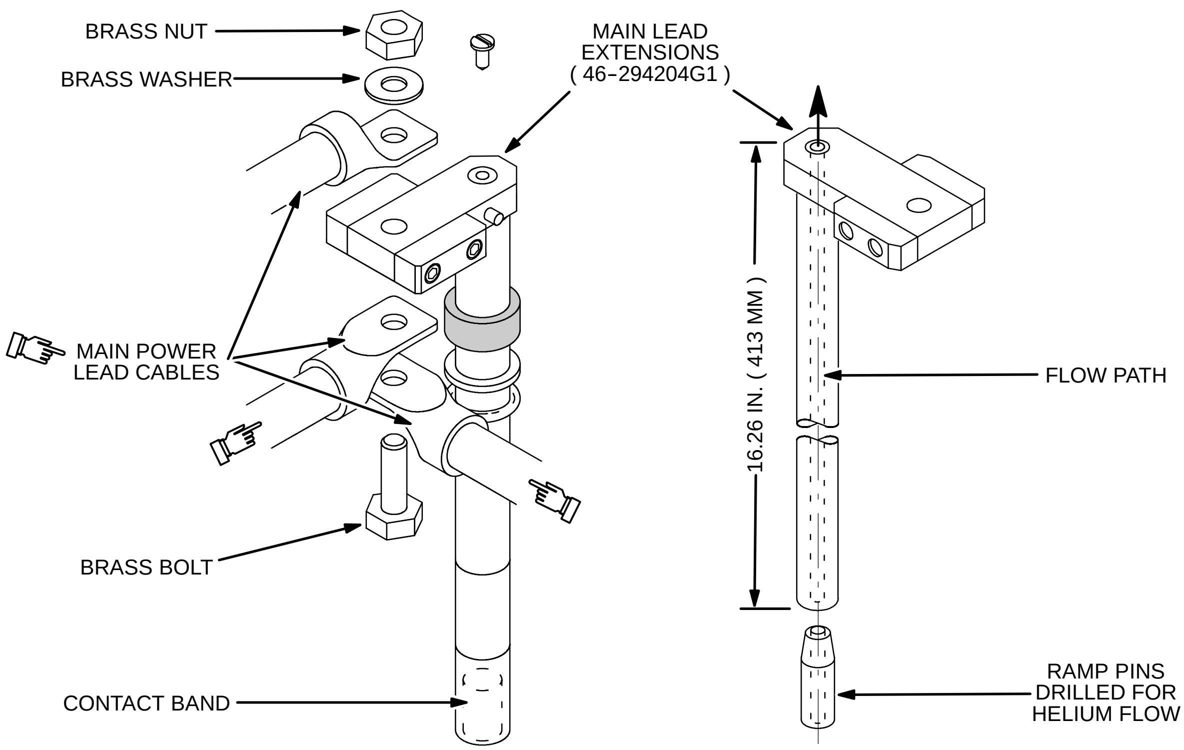
4. Connect the Main Coil Power Cables ( "+" Red: 46-260723G1; "-" Black: 46-260723G2 ) to the Main Power Supply Buss Bars with the .375 inch brass nuts, bolts and washers provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ).

**Note**

Three pairs of Main Coil Power Cables must be used when ramping the GE 0.7T Open*Speed* magnet.

5. Replace the Contact Bands on the Main Lead Extension ( 46-294204G1 ) according to REPLACEMENT / MAINTENANCE, Section 12, Main Lead Extension Contact Band Replacement. Make sure the Gas Flow Holes are not blocked.

6. Connect the other end of the Main Power Cables to the Main Lead Extensions with the brass nuts, bolts and washers provided. See Illustrations 4-5 and 4-10.




**HARDWARE MOUNTING ON MAIN LEAD EXTENSIONS**
ILLUSTRATION 4-5

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1

**WARNING!**

**MAKE SURE THE POWER SUPPLY IS ALWAYS COMPLETELY GROUNDED IN CONFORMANCE WITH THE FOLLOWING PROCEDURE BEFORE INSERTING OR EXTRACTING ANY MAIN LEAD EXTENSION TO THE MAGNET ( DURING RAMP UP, RAMP DOWN OR REPARKING MAGNET ). GROUNDING WILL PREVENT THE REMOTE POSSIBILITY OF A HIGH VOLTAGE BETWEEN THE MAIN LEAD EXTENSION AND THE CRYOSTAT GROUND IF AN UNLIKELY QUENCH AND ARC / SHORT TO THE CRYOSTAT OCCUR WHEN THE MAIN LEAD EXTENSION IS INSERTED / EXTRACTED.**

**IMPORTANT !!!**

Requirements during ramping:

- Always install the Pre-Ramp Protective Grounding Circuit and verify Main Lead Extension grounding to Cryostat ground before inserting or extracting any Main Lead Extension.
- Once the Main Lead Extensions are inserted, disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non-absorbant leather gloves with NO holes / tears. This removes the short across the power supply and enables magnet ramping up / down.
- Once the magnet is parked and the power supply turned off — but before removing the Main Lead Extensions — reconnect the Power Supply Jumper Cable's twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. This re-establishes full power supply grounding.
- After ramping up / down, when the power supply has been turned off and the Main Lead Extensions have been extracted, remove the Power Supply Jumper and Grounding Cables.

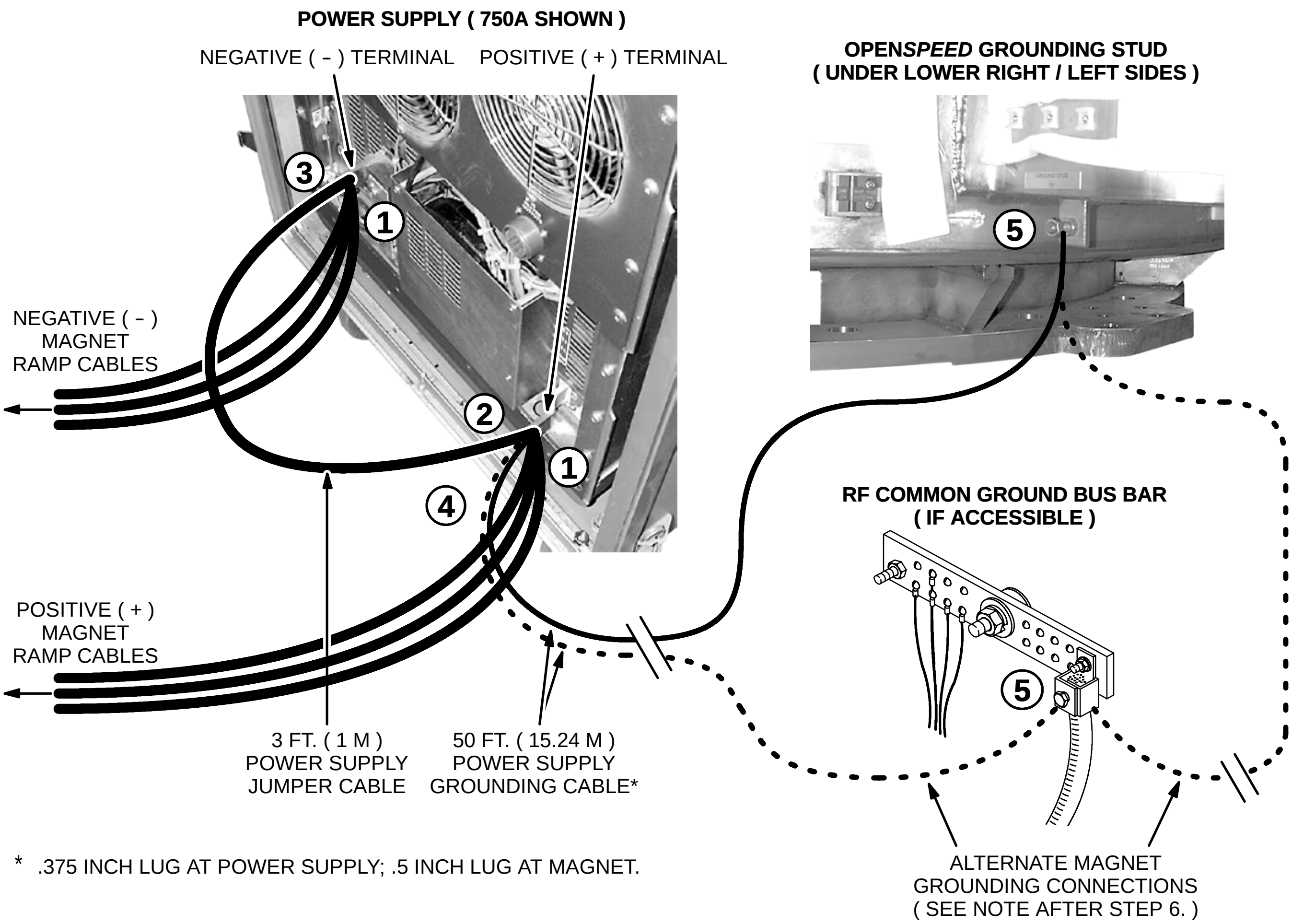
**Equipment**

- .375-16 x 1.75 inch Brass Screws, Washers and Nuts ( 2 )
- 3 ft. ( 1 M ) Power Supply Jumper Cable
- 50 ft. ( 15.24 M ) Power Supply Grounding Cable

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

### Procedure

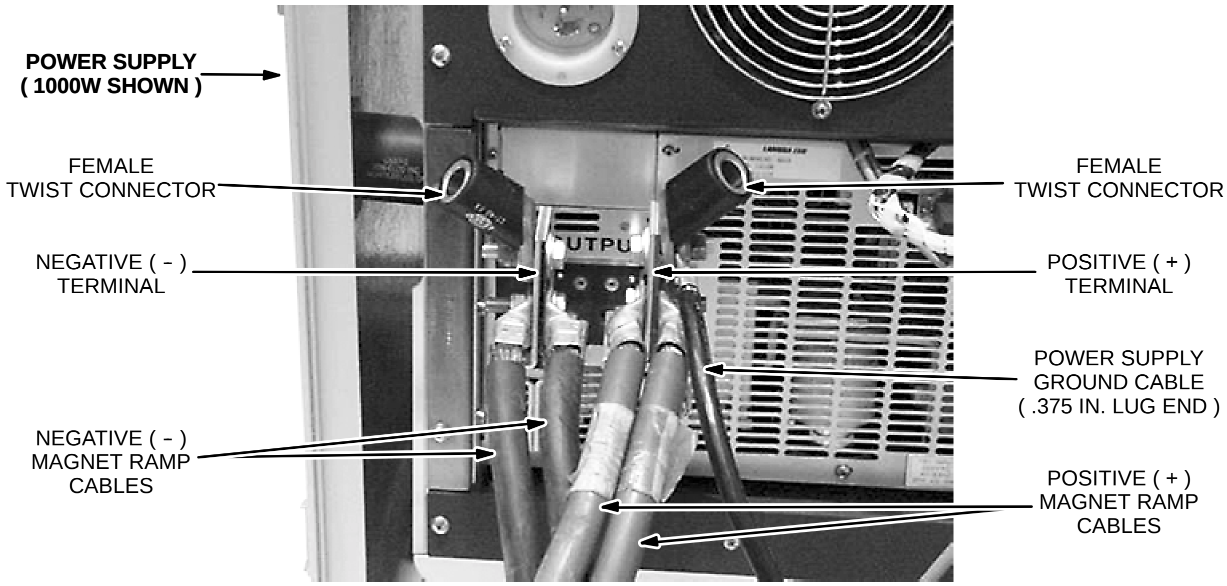
1. Connect the Magnet Ramp Leads to the Ramp Power Supply in the standard configuration and using the .375-16 x 1.75 inch brass screws, washers and nuts. See Illustration 4-6, label "1".




**PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS**
ILLUSTRATION 4-6

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

2. Disconnect the female twist connector lugs from the 3 ft. ( 1 M ) Power Supply Jumper Cable and then connect the lugs to the positive ( + ) and negative ( – ) power supply output terminals. See Illustration 4-7.

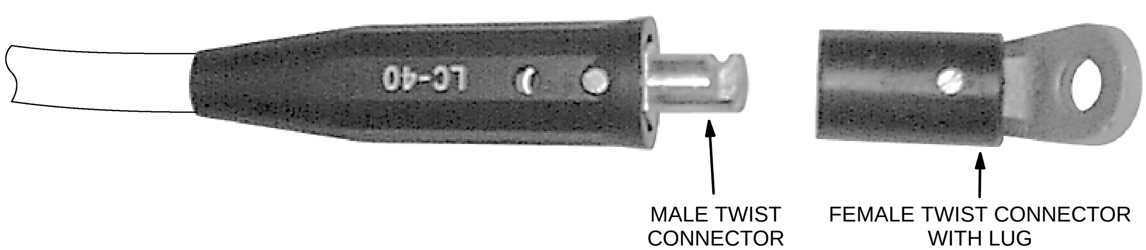



**FEMALE TWIST CONNECTORS ATTACHED TO POWER SUPPLY OUTPUT TERMINALS**
ILLUSTRATION 4-7

3. Connect one twist connector lug ( shown in Illustration 4-8 ) of the Power Supply Jumper Cable to the power supply's positive ( + ) terminal. Make sure the twist connector is fully engaged. See Illustration 4-6, label "2".

4. Connect the other twist connector lug( shown in Illustration 4-8 ) of the Jumper Cable to the power supply's negative ( – ) terminal. Make sure the twist connector is fully engaged. See Illustration 4-6, label "3".

5. Connect the .375 inch ( 9.5 mm ) lug of the 50 foot ( 15.24 M ) Power Supply Grounding Cable to the power supply's positive ( + ) terminal. See Illustration 4-6, label "4".




**TWIST CONNECTOR ON POWER SUPPLY JUMPER CABLE**
ILLUSTRATION 4-8

## 4-4 PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1 ( continued )

6. Connect the Grounding Cable's .5 inch ( 12.7 mm ) lug to the magnet's grounding lug. See Illustration 4-6, label "5".

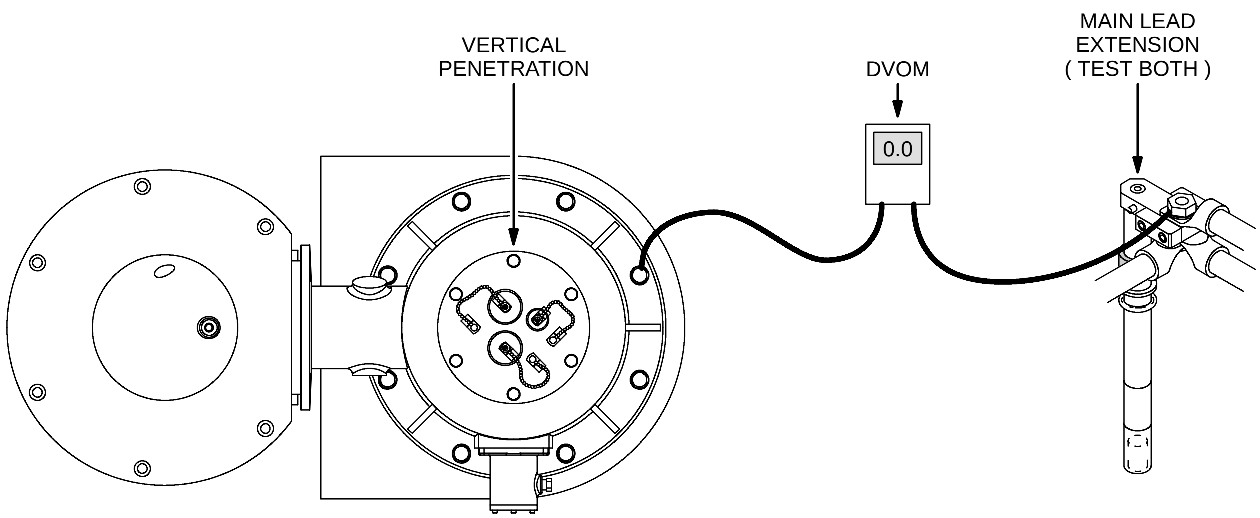
**Note**

If the magnet's grounding cable is connected to the RF Common Bus Bar at the Penetration Panel, the 50 foot ( 15.24 M ) Power Supply Grounding Cable can be connected between the power supply and the magnet or PDU ground wire clamp on the RF Common Bus Bar if more convenient. If the magnet is not grounded to the Penetration Panel, the Grounding Cable **must** be connected to the Cryostat Grounding Stud. See Illustration 4-6.

**CAUTION**

**Make sure there is a common ground ( resistance = 0 ohms ) between the Vacuum Vessel and the Main Lead Extension connections.**

7. Verify that the resistance between the Vacuum Vessel at the Vertical Penetration and each Main Lead Extension connection is zero ohms as read on a DVOM. See Illustration 4-9.



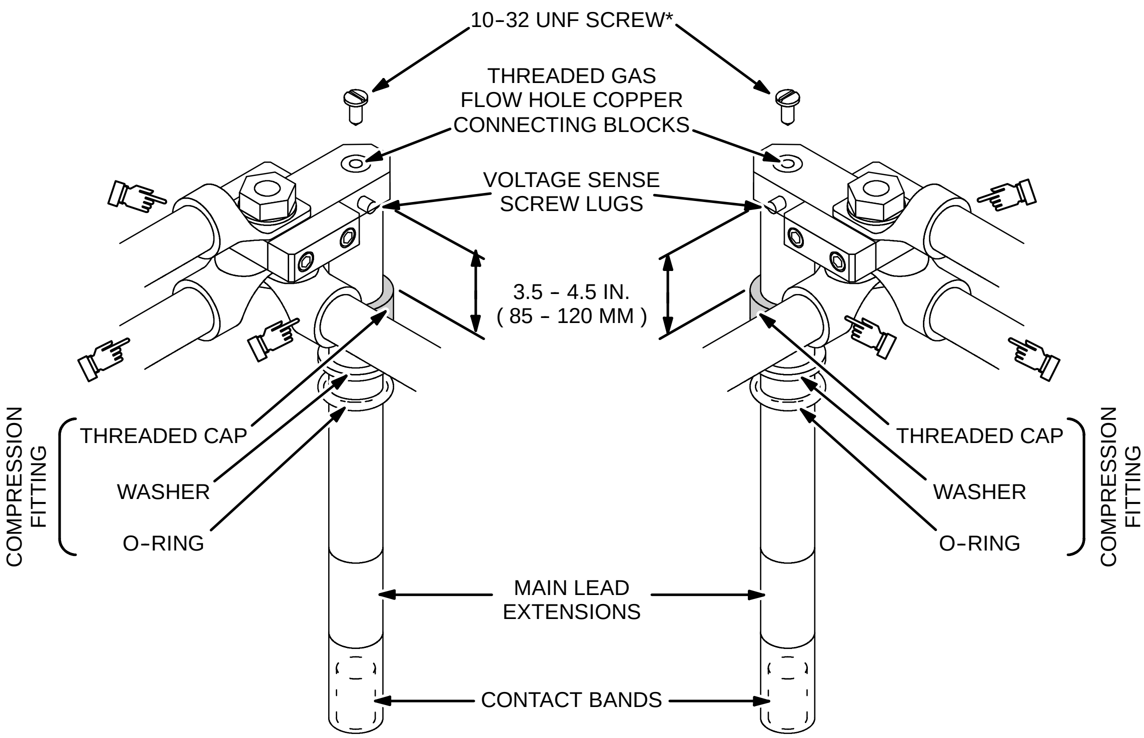

**VACUUM VESSEL TO MAIN LEAD EXTENSION RESISTANCE CHECK**
ILLUSTRATION 4-9

## 4-5 MAGNET CONNECTIONS - PERSON 1

1. Remove the threaded caps, washers and o-rings ( 46-294104P1, 46-294105P1, and 46-260389P1 ) from the plastic bag provided in the Magnet Ramping Equipment Kit ( 46-260703G4 ) and mount them on the Main Lead Extensions. See Illustration 4-10.

**WARNING!**

**DO NOT LEAVE THE VENT SCREWS IN THE GAS FLOW HOLES FOR "DVM" CONNECTION SCREWS. THIS MAY CAUSE A QUENCH.**




* USED TO TEMPORARILY STOP GAS FLOW. REMOVE PRIOR TO RAMPING.

**COMPRESSION FITTING MOUNTING ON MAIN LEAD EXTENSIONS**
ILLUSTRATION 4-10

## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

2. Place the end of the Main Power Cables on the Service Turret ( MSI-A3, A3 ). Allow about 3 feet ( 900 mm ) of slack.

3. Ty-wrap the cables at convenient locations on top of the magnet to avoid cable movement during ramping.

**WARNING!**

**MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THE ODORLESS, INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE WILL DISPLACE OXYGEN AND CAUSE ASPHYXIATION UNLESS SAFELY VENTED AWAY FROM THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**

**WARNING!**

**THE CRYOSTAT EXHAUST SYSTEM IS DESIGNED WITH A 7.5 PSIG RELIEF VALVE, ALLOWING THE INTERNAL CRYOSTAT PRESSURE TO BUILD UP TO 7.5 PSIG. OBSERVE THE INTERNAL CRYOSTAT PRESSURE GAUGE READING AND VENT THE CRYOSTAT DOWN TO < 0.5 PSIG THROUGH CRYOSTAT VENT VALVE V2 BEFORE EITHER REMOVING THE RAMP OR FILL COMPRESSION CAPS OR LOOSENING ANY COMPONENT RESULTING IN THE RELEASE OF CRYOSTAT PRESSURE. THIS WILL PREVENT EXPOSURE TO RAPID EXHAUSTING OF COLD HELIUM GAS DURING A SERVICE OPERATION.**

4. Check the Cryostat Pressure Gauge. If the pressure is above 0.5 psig, slowly open Helium Vent Valve V2 and allow pressure to drop to 0.5 psig. Then close valve V2.

## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

5. Remove the cap on one Main Lead Extension receptacle located on the magnet Vertical Penetration. Make sure the gasket inside the cap does not get lost.
6. Immediately insert one Main Lead Extension into the open receptacle with 85 - 120 mm ( 3.5 - 4.5 inches ) of Main Lead Extension exposed. Loosely tighten the compression fitting.

**CAUTION**

**Make sure the Gas Flow Holes in the Main Lead Extensions are not blocked ( i.e., the 10-32 screws have been removed ) and that gaseous helium is exiting through the holes. Blocked holes prevent heat dissipation and result in high contact resistance.**

7. Repeat Steps 5 and 6 for the second Main Lead Extension.

**Note**

The Main Lead Extensions will depress approximately 1 inch ( 25 mm ) from the point of contact to the fully engaged position. A firm contact will be felt when fully engaged. Do not rotate the Main Lead Extensions excessively when in the engaged position as internal contact wear could result.

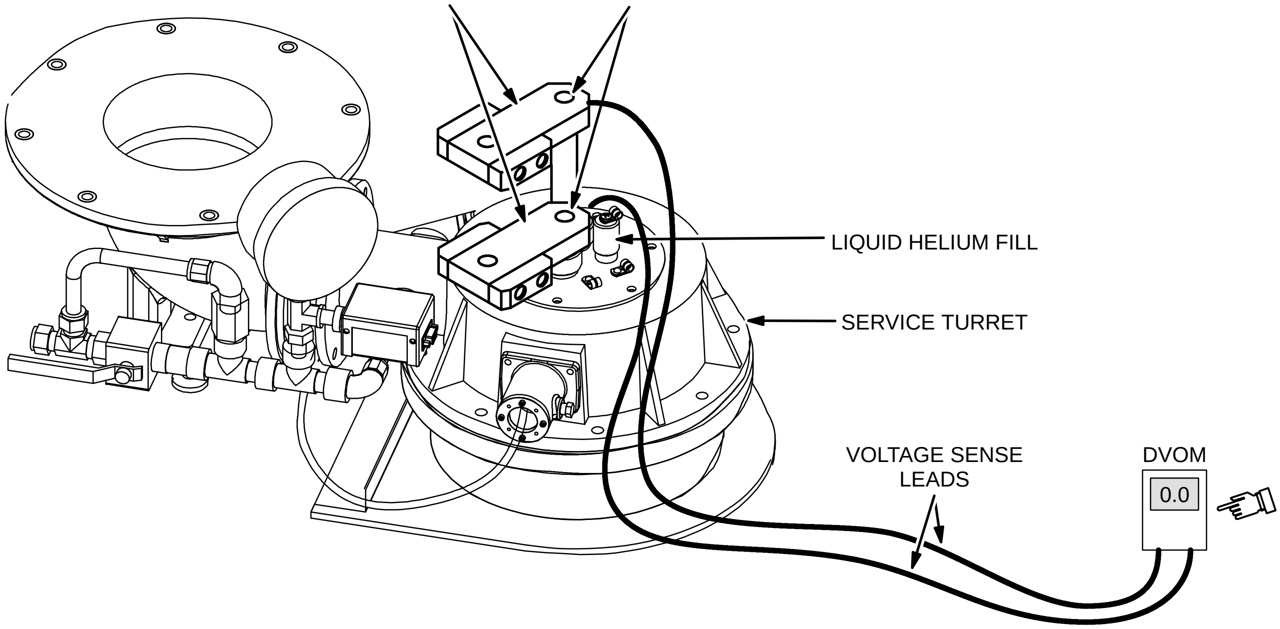
## 4–5 MAGNET CONNECTIONS – PERSON 1 ( continued )

8. When the Main Lead Extensions are sufficiently cooled, loosen the compression fittings and fully engage the Main Lead Extensions. Loosely tighten the compression fittings.

**WARNING!**

**CONNECTION POLARITIES MUST BE NOTED AND RECORDED IN DATA SHEETS, SECTION 5, MAGNET RAMPING & PARKING CURRENT LOG, TO PREVENT THE POSSIBILITY OF MIS-WIRING AND A RESULTANT QUENCH DURING FUTURE MAGNET RAMPING.**

9. Connect the Voltage Sense Leads to the Main Lead Extensions by clamping the spade lugs on the Voltage Sense Leads to the Main Lead Extensions with the screw lugs provided on the Lead Buss Bar. Terminate the other end of the Voltage Sense Leads to a DVM or DVOM placed near the Main Coil Power Supply. See Illustration 4–11.




**MAIN COIL AND VOLT SENSE LEAD CONNECTIONS**
ILLUSTRATION 4–11

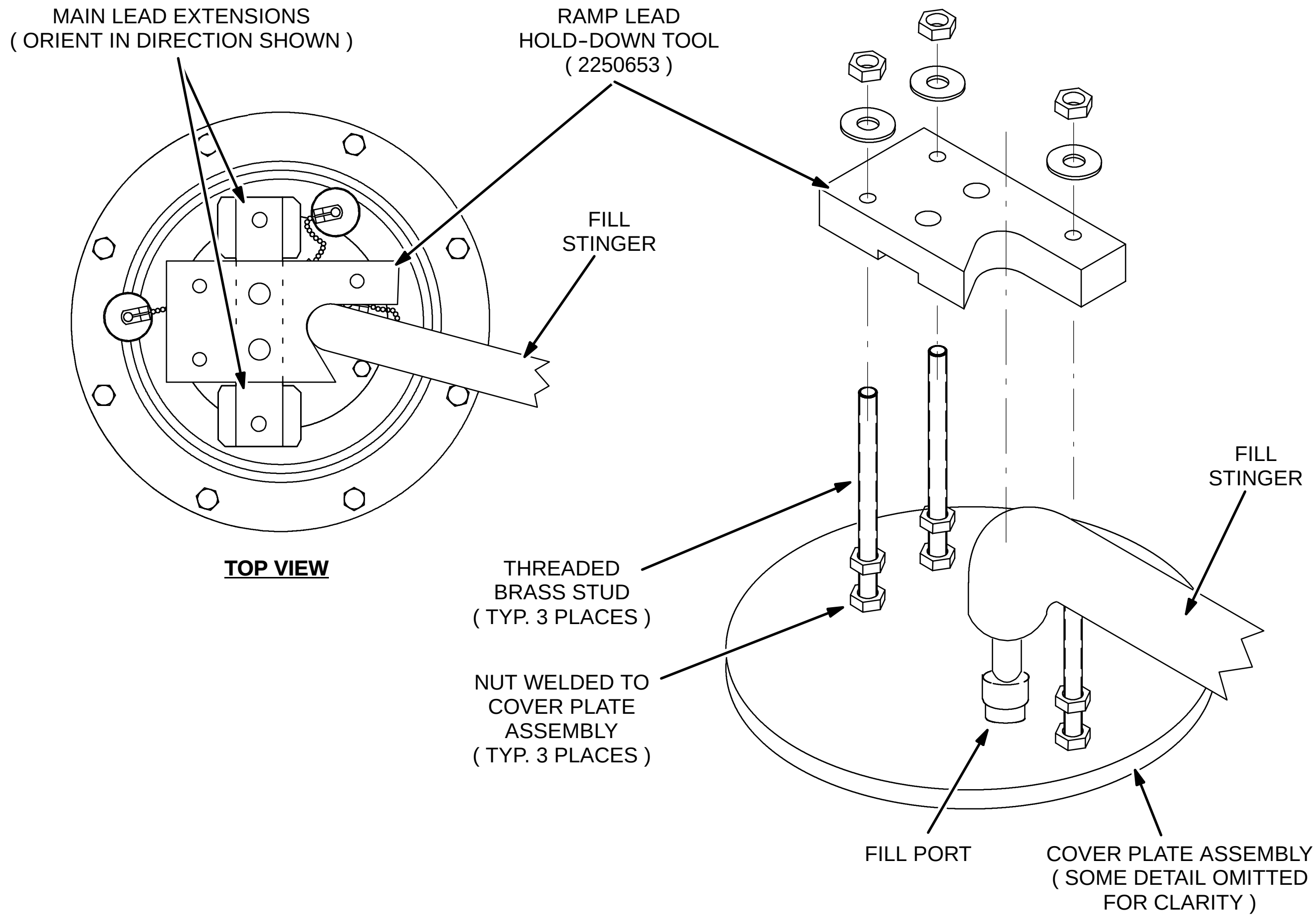
10. Insert three threaded brass studs into the nuts on the Vertical Penetration Cover Plate. See Illustration 4–12.

11. Install the Ramp Lead Hold–Down Tool ( 2250653 ). Make sure it is oriented properly, as shown in Illustration 4–12.

**Note**

The Ramp Lead Hold–Down Tool, contained in the magnet collector, will minimize Lead Extension motion and help obtain good contact resistance.

## 4-5 MAGNET CONNECTIONS - PERSON 1 ( continued )




**RAMP LEAD HOLD-DOWN TOOL**
ILLUSTRATION 4-12

12. Thread and tighten the top nuts to hold the tool in place.

13. Hand tighten the Ramp Port compression nuts.

**CAUTION**

**Make sure the Gas Flow Holes of the Main Lead Extensions are not blocked ( i.e., the 10-32 screws have been removed ) and that gaseous helium is exiting through the holes before ramping. Blocked holes prevent heat dissipation and result in high contact resistance.**

## 4-6 TESLAMETER / PROBE SET-UP AND ADJUSTMENT - PERSON 1

### 4-6-1 Set-Up

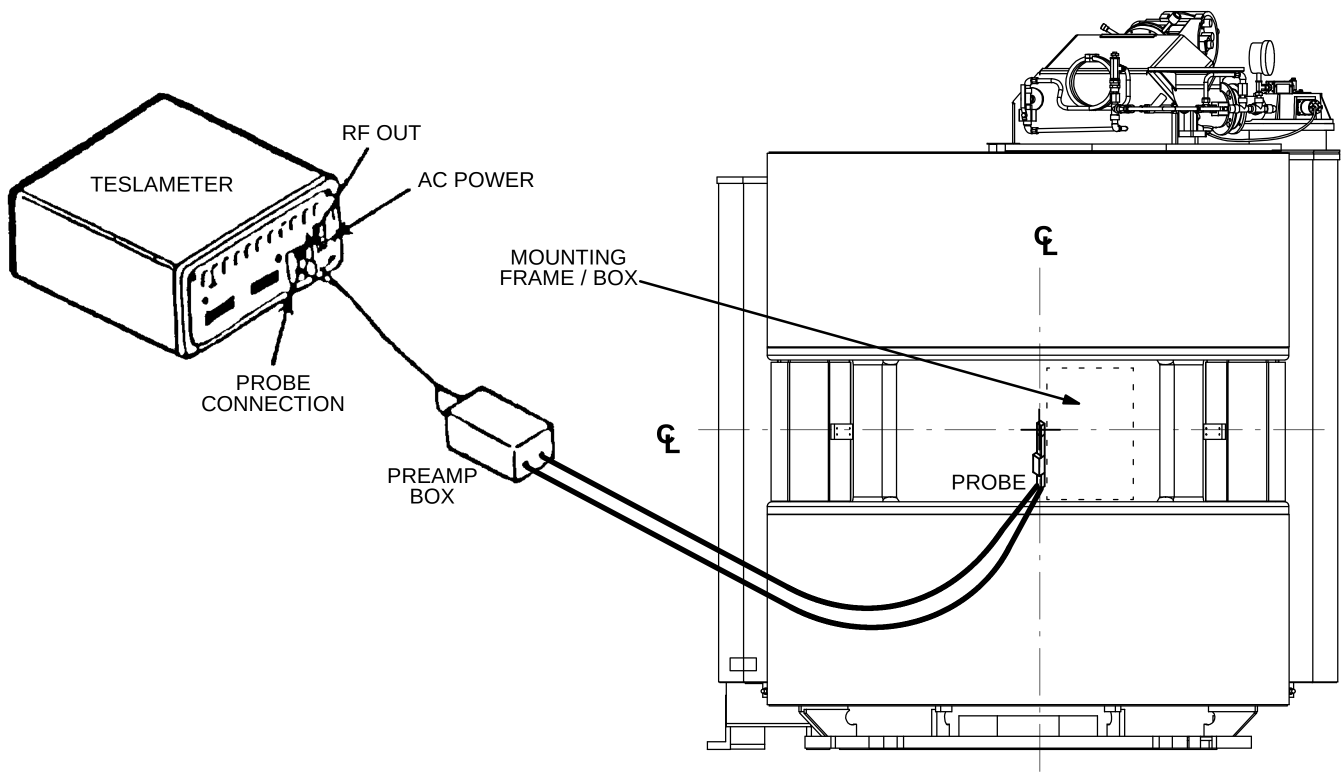
1. Mount and center the #4 Probe ( 0.35T - 1.05T ) in the magnet using a cardboard / wood box or a frame made from non-ferromagnetic material. See Illustration 4-13.

**Note**

Centering the Probe between enclosure surfaces will give sufficiently accurate magnet field strength readings for ramping purposes.

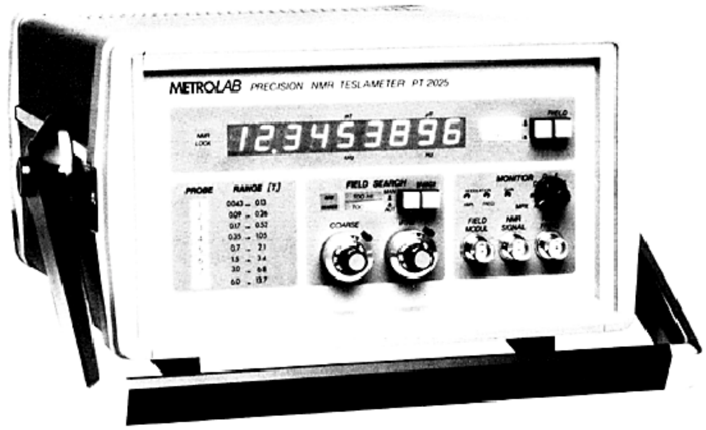
2. Connect the Preamp Box to the two Teslameter Probe inputs: the white Preamp Box wire to the Teslameter Probe left jack and the black Preamp Box wire to the right, lacing connector end of the Probe. See Illustration 4-13.

3. Turn on AC Power to the meter. The meter's rear view is shown in Illustrations 4-13 and 4-14.

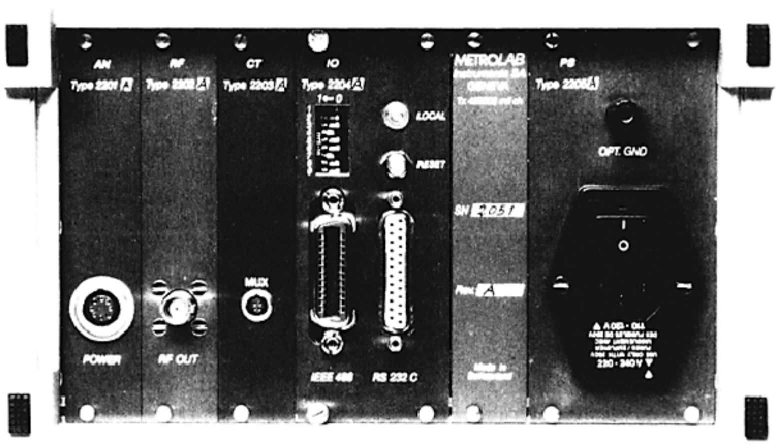



**PROBE SET-UP AND TESLAMETER INTERCONNECTIONS**
ILLUSTRATION 4-13

## 4-6-1 Set-Up ( continued )




FRONT VIEW




REAR VIEW

**TESLAMETER**
ILLUSTRATION 4-14

4. Pull the Lock / Manual Switch and set in the “MANUAL” position.

**CAUTION**

**If the “Lock / Manual” Switch is not in the “MANUAL” position at the start of field search during Ramping, the Teslameter’s sweep will be in the ±5,000 gauss range and the system could lock onto the mechanical oscillation harmonic produced by the Cryocooler Coldhead, resulting in an erroneous reading.**

5. Set the Coarse and Fine Control Knobs fully counterclockwise ( CCW ).

## 4-6-1 Set-Up ( continued )

6. Pull the “Freq / Field” Switch and set to the “FIELD” position. The Teslameter is now set up and ready to start monitoring the field when ramping commences.

**Note**
The Teslameter will not “lock in” on a probe signal until magnetic field is approximately 4000 Gauss.

## 4-6-2 Teslameter Adjustment ( Ramp Up )

1. Once ramping has started, monitor the power supply’s Current Meter until an indication of approximately 450 amps is approached. At this time, start monitoring the Teslameter.
2. As the developing field approaches the adjustable limit of the Teslameter probe ( approximately 4000 gauss ), the “NO STROBE SIGNAL” LED will start blinking. Watch for when this LED goes out.
3. When the “NO STROBE SIGNAL” LED is out, change the Lock / Manual Switch to the “LOCK” position. See Illustration 4-14.

**Note**
If the signal does not lock in, change the position of the Probe Modulation switch.

4. As the field continues to increase, note when the “HI” LED to the right of the Coarse Control Knob begins to light. Turn the Coarse Control Knob clockwise ( towards the lighted LED ) until the LED is extinguished.

**Note**
As the magnetic field increases, the probe sample resonant frequency will increase above the range setting of the Teslameter. Therefore, increase the setting of the Coarse Control Knob periodically to keep the Teslameter locked on the probe sample.

**Note**
The Fine Control Knob does not function when the Lock / Manual Switch is in the “LOCKED” position.

## 4-6-3 Teslameter Re-Sync

If the Teslameter should go out of sync while ramping the magnet up ( or down ), it can be resynchronized by the following procedure.

### Manual Re-Sync

1. Reposition the Lock / Manual Switch to “MANUAL.”

**Note**
The “NO STROBE” Signal will be on, and the “LO” / “HI” LEDs will be oscillating, indicating search mode.

2. Note the present Current reading on the Main Power Supply’s Current Meter.

## 4-6-3 Teslameter Re-Sync ( continued )

### Manual Re-Sync ( continued )

3. Multiply the Current read from the Main Power Supply's Current Meter by 6.85 ( approximately 6.85 gauss / amp ) and reset the meter at the resultant gauss level.

4. Slowly start increasing ( if ramping up ) the Coarse and / or Fine Control Knob while monitoring the "NO STROBE SIGNAL" LED.

5. Once the LED extinguishes, quickly place the Lock / Manual Switch to the "LOCK" position. The meter will now be in sync.

**Note**

If the "HI" LED is lit, the Coarse Control Knob will have to be turned in the "HI" direction until the LED goes out. Repeat this adjustment as required until the parking field is reached.

### Manual Re-Sync Using an Oscilloscope

An Oscilloscope can be set up near the Teslameter to display and trigger on the "FIELD MODULATION" Signal from a jack on the Teslameter front panel. Adjust the time base to display one or two ramp wave forms. On the second channel, display the NMR Signal from the front panel of the Teslameter.

1. Leave the Teslameter in the "LOCKED" position.

2. Slowly turn the Coarse Control Knob in the direction the field is going ( i.e., if ramping up, turn the control knob up to the higher numbers ).

3. As the meter is approaching the actual field, the baseline of the "FID" Display will start to wander. Once the meter is in range of the field, the "FID" will appear on the Oscilloscope Trace as the meter "locks on."

4. When "locked on" the "NO STROBE SIGNAL" LED will be unlit. Readjust the Coarse Control Knob slightly in the direction of the lighted "LO" / "HI" LED until that LED goes out.

5. Maintain tracking through end of ramp sequence.

## 4-7 RAMPING PREPARATION – PERSON 1

**WARNING!**

**THE FOLLOWING REQUIRED SAFETY ACTIONS MUST BE TAKEN PRIOR TO RAMPING THE MAGNET:**

- **MAKE SURE THE MAGNET ROOM VENT EXHAUST FAN IS TURNED ON BEFORE STARTING THIS PROCEDURE. THIS IS REQUIRED TO EXHAUST THE ODORLESS AND INVISIBLE HELIUM GAS GENERATED DURING THIS PROCEDURE AND PREVENT OXYGEN DISPLACEMENT IN THE MAGNET ROOM. REVIEW AND FOLLOW SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **NOTIFY SITE ADMINISTRATION BEFORE RAMPING THE MAGNET THAT ALL MAGNETIC SAFETY PRECAUTIONS MUST BE TAKEN.**
- **POST WARNING SIGNS OUTSIDE THE 5-GAUSS ZONE TO ALERT PERSONNEL WITH CARDIAC PACEMAKERS, NEUROSTIMULATORS AND OTHER BIOSTIMULATION DEVICES NOT TO PROCEED INTO THE DESIGNATED AREA. POST THESE SIGNS ON THE MAGNET ROOM LEVEL AS WELL AS AREAS BELOW THE MAGNET TO WHICH THE 5 GAUSS ZONE EXTENDS. SEE SAFETY REQUIREMENTS, *2301164PRE, MR MAGNET - SAFETY REQUIREMENTS*.**
- **POST "RAMPED MAGNET" AND "AUTHORIZED PERSONNEL ONLY" WARNING SIGNS AT MAGNET ROOM ENTRANCE AND AT MR SUITE ENTRANCE, RESPECTIVELY, PRIOR TO RAMPING THE MAGNET. WARNINGS ARE TO ALERT PERSONNEL THAT NO FERROMAGNETIC MATERIAL OR INDIVIDUALS WITH CARDIAC PACEMAKERS, NEUROSTIMULATORS OR STEEL PLATES ARE ALLOWED IN THE MAGNET ROOM WHEN THE MAGNET IS RAMPED.**
- **REMOVE ALL LOOSE FERROMAGNETIC MATERIAL FROM THE MAGNET ROOM. PULL THE POWER SUPPLIES AS FAR AWAY FROM THE MAGNET AS THE CABLES AND SITE GEOMETRY ALLOW. METAL OBJECTS CAN BECOME DANGEROUS PROJECTILES IN A MAGNETIC FIELD. MAKE SURE THE MAGNET LIFTING SHACKLE, JACKING RAIL AND MOUNTING BRACKETS HAVE BEEN REMOVED FROM AND STORED OUTSIDE THE MAGNET ROOM.**
- **MAKE SURE THE MAGNET RUNDOWN UNIT IS INSTALLED AND OPERATIONAL TO ENABLE THE MAGNETIC FIELD TO BE QUICKLY DISCHARGED IN CASE OF AN EMERGENCY. SEE SET-UP AND CALIBRATION, SECTION 1-6.**
- **DO NOT WEAR STEEL-TOED SAFETY SHOES NEAR A RAMPED MAGNET. USE A FIBER / COMPOSITION TYPE SAFETY SHOE.**

## 4-7 RAMPING PREPARATION – PERSON 1 ( continued )

1. Set up the field monitoring equipment, Probe and Teslameter in conformance with SET–UP CALIBRATION, Section 4–6, Teslameter / Probe Set–Up And Adjustment. Make sure the Probe is positioned at the center of the magnet.
2. Make sure the Magnet Power Supply is installed, checked and adjusted in conformance with FUNCTIONAL CHECKS, Section 8, ESS7.5–1000–2–D–1236 Main Power Supply Calibration / Check. Verify that the Heater 1 Main Power Supply is set for 810 ± 10 mA.
3. Make sure the Input Power Cable for the Power Supply is disconnected.
4. Make sure the Ramp Power Supply is connected to the magnet in conformance with SET–UP AND CALIBRATION, Sections 4–3, 4–4 and 4–5. Also make sure the Ramp Lead Hold–Down Tool is firmly in place and cooling gas is exiting from Main Lead Extensions.
5. Record the Main Coil connection polarity in DATA SHEETS, Table 4.
6. Set Heater 1 Main and Heater 2 Shim Axial Switches to the “OFF” position. Set the Current Adjust and Voltage Adjust Controls to zero ( full CCW ).
7. Connect the Input Power Cable to the Service Main Power Supply.
8. Make sure a Digital Voltmeter ( DVM ) is connected to the end of the Voltage Sense Leads and terminated at the power supply. The Voltmeter will measure voltage across the Lead Extensions of the magnet.
9. Make sure DATA SHEETS, Table 5–2, Magnet Ramp / Fill Profile, is filled out. Readings should be recorded at 3 minute intervals.
10. Disconnect and remove the Power Supply Jumper Cable from the power supply while wearing non–absorbant leather gloves with NO holes / tears. See Illustrations 4–7 and 4–8.

**Note**

Resistance measurements cannot be made and the magnet cannot be ramped with the Power Supply Jumper Cable connected.

## 4-8 RESISTANCE CHECKS - PERSON 1

**Note**
CCW = counterclockwise -----> decrease
CW = clockwise -----> increase

1. Make sure the Current Adjust and Voltage Adjust Controls on the Main Power Supply are off ( full CCW ). Turn on input power to the Power Supply.
2. Set Heater 2 Shim Axial Switch to the "I" ( on ) position to enable power supply output.
3. Set the Voltage Adjust Control to "400" ( 4 turns counterclockwise from zero ). This will set a maximum limit of 3 V ( ~ 0.75 V / turn ) for the power supply output.
4. Observe the Main Power Supply Ammeter and slowly turn the Current Adjust Control counterclockwise to set 750A current through the Main Power Leads, Lead Extensions and persistent Main Switch.
5. Record the voltage reading on the Digital Voltmeter ( DVM ): ________________ mV.
    - A voltage reading < 50 mV indicates the Power Supply Jumper Cable is still in place.
    - A 50 - 150 mV reading indicates acceptable internal contact resistance of the Lead Extensions.
    - If the voltage reading is > 150 mV, turn the Current Adjust Contol off ( full CCW ), turn off the Power Supply Input Power and reseat the Lead Extensions on the top of the magnet.
6. Repeat Steps 1 through 5 if the Lead Extensions were reseated. Repeated readings > 150 mV indicate the need to replace the Lead Extension Contact Bands. See REPLACEMENT / MAINTENANCE, Section 12. Upon passing the internal resistance check, continue with Step 7.
7. Set the Toggle Switch on the Power Supply Voltmeter to the "Main Power Supply" position.
8. Read the voltage across the Power Supply Output Lugs. A Power Supply output voltage of 2.1 V or less at 750A indicates acceptable system resistance. If the voltage exceeds 2.1V during the test:
    a. Turn the Current Adjust Control off ( full CCW ).
    b. Turn off the input power.
    c. Check and retighten the bolts securing the Main Power Cables to the Power Supply and Lead Extensions.
    d. Turn the Power Supply back on.
    e. Repeat Step 8.
9. Upon passing Step 8, turn the Current Adjust and Voltage Adjust Controls to zero ( full CCW ) and continue with Section 1-9, Ramping - Person 1.

## 4-9 RAMPING - PERSON 1

**WARNING!**

**MAKE SURE THE MAGNET IS 98% FULL OF LIQUID HELIUM AND A FULL 250-LITER OR LARGER DEWAR OF LIQUID HELIUM IS CONNECTED TO THE TRANSFER LINE BEFORE RAMPING TO PREVENT THE LIQUID HELIUM LEVEL FROM DROPPING DURING RAMPING TO A LEVEL WHERE A QUENCH MAY OCCUR.**

**A RAMPING VOLTAGE IN EXCESS OF 2.5V ACROSS THE MAIN COIL OF THE MAGNET COULD CAUSE THE MAGNET TO QUENCH.**

**IF A QUENCH OCCURS DURING RAMPING, IMMEDIATELY TURN "VOLTAGE ADJUST" AND "CURRENT ADJUST" CONTROLS ON THE MAIN COIL POWER SUPPLY TO ZERO ( FULLY CCW ). A QUENCH IS A RAPID DISCHARGE OF THE MAGNETIC FIELD WHICH WILL RESULT IN THE RAPID GENERATION AND EXPULSION OF HELIUM GAS, RUPTURING THE BURST DISC IN THE VENT SYSTEM.**

**IMPORTANT !!!**

To prevent a quench if a Dewar should run empty, Person 2 shuts off helium flow and performs the following:

a. Park the magnet at the present setting ( Steps 8 - 16 of this section ).
b. Record the parking current and frequency in DATA SHEETS, Table 5-1.
c. Wait for Dewar change, Stinger plume and Stinger insertion into Fill Port V1.
d. Turn power supply on ( heaters off ) and set parking current in power supply.
e. Turn on the Main Axial Shim Heaters.
f. Continue the ramp.

1. Make sure:
   - A new 250-liter Dewar is installed;
   - A 98% liquid helium level is being maintained;
   - The power supply's Current and Voltage Adjust Controls are set to zero ( full CCW ); and
   - The Axial Switch set to "I" ( on ).
2. Engage the Set Point Button ( depress and hold until the current is set ) and set the Current Adjust Controls for a reading of 800A.
3. Leave the Current Adjust Controls at setting in Step 2. Turn the power supply's Voltmeter Select Switch to the "Main Coil" position.

## 4-9 RAMPING - PERSON 1 ( continued )

4. Set the Heater 1 Main Switch to "I" ( on ) and wait 3 minutes. Make sure gas flow is visible from Lead Extensions.
5. Ramp the magnet in conformance with Table 4-2 as follows:
   a. Slowly turn the power supply's Voltage Adjust Control to obtain the Main Coil ( Ramp ) Voltage value shown in the table, starting with 2.50 volts.
   b. Allow the voltage to decay over the current interval shown in the table.
   c. Monitor the power supply's Current Meter. When the limit of the current range for the voltage setting is reached, slowly turn the Voltage Adjust Control to obtain the Main Coil Voltage for the next range.
6. When the Main Coil ( Ramp ) Current reaches 200 amps, estimate the system inductance by measuring current change over a 10-second ramping interval:

$$L_{(\text{ inductance })} = 10 \text{ x Voltage / Current Change}$$

**Note:**
this method will give inaccurate values of inductance when the current is less than 200 amps.

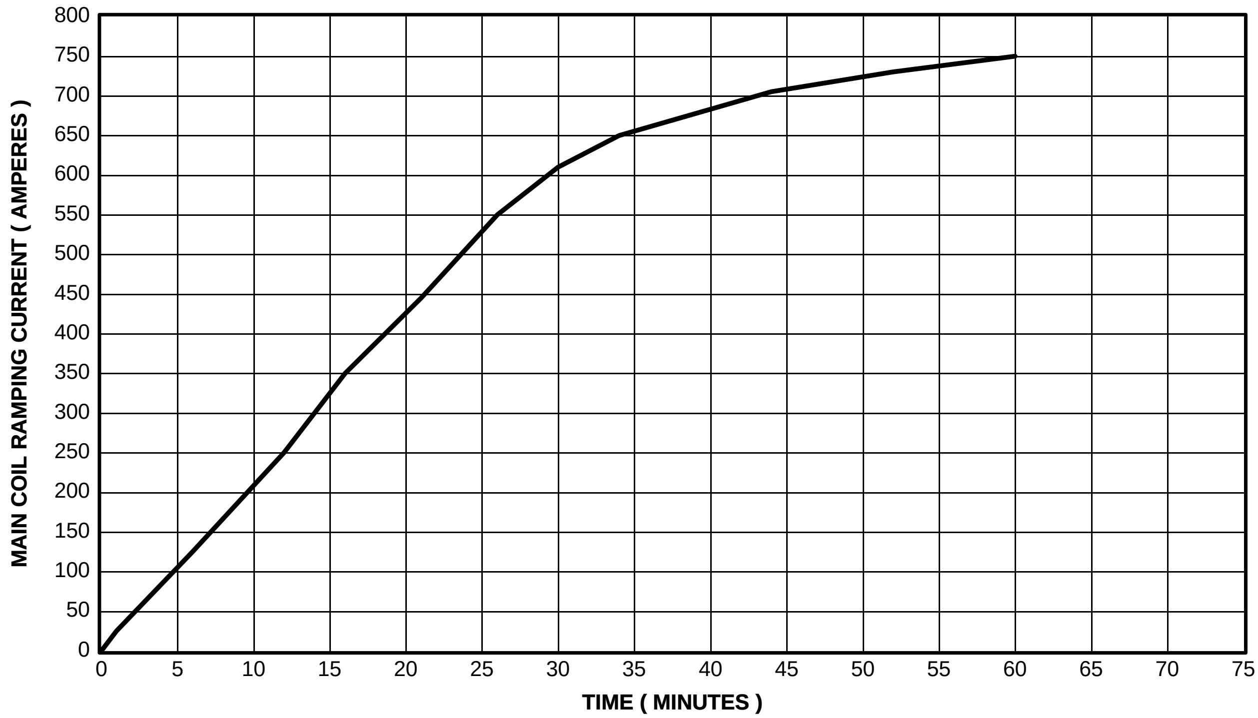
7. If the inductance ( L ) is outside the range of 5.3 - 5.5 henries, discontinue ramping, measure the main coil resistance in conformance with FUNCTIONAL CHECKS, Section 5, and contact your regional Magnet Team Engineer.

TABLE 4-2
**MAIN COIL RAMP CURRENT VERSUS VOLTAGE**

| "STAGE" | MAIN COIL ( RAMP ) VOLTAGE ( VOLTS ) | MAIN COIL ( RAMP ) CURRENT RANGE ( AMPS ) |
|---|---|---|
| 1 | 2.50 | 0 - 100 |
| 2 | 2.30 | 100 - 200 |
| 3 | 2.10 | 200 - 300 |
| 4 | 1.90 | 300 - 400 |
| 5 | 1.70 | 400 - 500 |
| 6 | 1.50 | 500 - 550 |
| 7 | 1.30 | 550 - 600 |
| 8 | 1.00 | 600 - 625 |
| 9 | 0.80 | 625 - 650 |
| 10 | 0.60 | 650 - 675 |
| 11 | 0.50 | 675 - 700 |
| 12 | 0.40 | 700 - 720 |
| 13 | 0.35 | 720 - 750 |
| 14 | 0.30 | 750 - PARKING AMPS |
| 15 | 0.00 | PARKING AMPS |

**Note**
Illustration 4-15, Magnet Ramping Profile, plots typical Main Coil ramping currents over time.

## 4–9 RAMPING – PERSON 1 ( continued )




**MAGNET RAMPING PROFILE**
ILLUSTRATION 4–15

8. As the magnet field approaches the desired parking frequency ( 29.800 – 29.802 MHz ), adjust the Main Coil driving voltage to 0.00 V.

**Note**

The ramping field in step 9 was chosen at the low end of the allowable range because passive shimming will increase the field frequency. The system specification for frequency is 29.793 MHz to 29.813 MHz

9. Check the Teslameter and adjust the Voltage Control as required to bring magnetic field to 29.802 – 29.803 MHz. This will account for the decrease in field after dialing the ramp supply down and the increase in field caused by passive shimming.

## 4-9 RAMPING - PERSON 1 ( continued )

**CAUTION**

**Observe the voltage displayed on the power supply Voltmeter ( toggle switch in "Main Coil" position ). When the switch goes "persistent" ( zero resistance ), the voltage across the magnet terminals will drop to approximately 0.00 V. This sudden voltage drop indicates that the switch has gone into the persistent mode. Make sure the switch is in the persistent mode before adjusting the voltage / current controls to prevent magnet rampdown to zero.**

10. Maintain the final current setting until the Main Switch goes into the "persistent" mode.
11. Set Heater 1 Main Switch to "O" ( off ). Wait a minimum of 7 minutes for the switch to fully cool and go "persistent".

**WARNING!**

**MAKE SURE THE CONNECTION POLARITY AND FINAL RAMPING CURRENT ARE RECORDED IN DATA SHEETS, TABLE 5-1. THIS INFORMATION IS ESSENTIAL FOR LATER CHANGING OF THE MAGNETIC FIELD. THE MAIN POWER SUPPLY MUST BE SET TO THE SAME CURRENT AND POLARITY IN THE MAIN COILS TO AVOID A QUENCH WHEN TURNING ON THE MAIN SWITCH HEATER.**

12. Record the final ramping ( parking ) current and lead extension voltage / polarity values at which the switch went "persistent" in DATA SHEETS, Table 5-1, Magnet Ramping / Parking Current Log.
13. After the switch goes "persistent", slowly turn the power supply Voltage Adjust Control to zero over a one minute period ( full CCW ). Make sure voltage reading remains at zero.
14. Gradually turn the Current Adjust Control to zero ( over a one minute period ).
15. Set Heater 2 Shim Axial Switch to its "O" ( off ) position.
16. Turn off the Ramp Power Supply.
17. Disconnect the Input Power Cable from the Main Power Supply.
18. Reconnect the Power Supply Jumper Cable's twist connectors to the power supply while wearing non-absorbant leather gloves with NO holes / tears. See Illustrations 4-6 and 4-8.

## 4-9 RAMPING - PERSON 1 ( continued )

19. Remove the Ramp Lead Hold-Down Tool and replace the bolts on Lead Assembly Mounting Plate.

20. Make sure the magnet is at 100% helium fill level.

**WARNING!**

**A SUPERCONDUCTING MAGNET AT FIELD IS A HIGH ENERGY STORAGE DEVICE CAPABLE OF DISCHARGING RAPIDLY.**

**MAKE SURE ALL ITEMS COVERED BELOW ARE FULLY IMPLEMENTED WHEN INSERTING / EXTRACTING MAIN LEAD EXTENSIONS:**

- **MAKE ALL PRE-RAMP POWER SUPPLY PROTECTIVE CIRCUIT CONNECTIONS IN CONFORMANCE WITH SECTION 4-4, PRE-RAMP PROTECTIVE GROUNDING CIRCUIT CONNECTIONS - PERSON 1.**
- **INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW TO COOL BEFORE CONTACTING THE MAIN LEAD PINS.**
- **DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOW THEM TO COME IN CONTACT WITH EACH OTHER.**
- **WEAR NON-ABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**
- **DO NOT COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING DURING INSERTION / EXTRACTION OF THE MAIN LEAD EXTENSIONS.**

21. After parking the magnet and disconnecting the Main Power Supply, plug and remove one Main Extension Lead at a time in the following sequence.

    a. Open Valve V2 to de-pressurize the cryostat to 0.50 psig. Close V2.

    b. Install the screw into the flow hole of only one Main Lead Extension at a time. See Illustration 4-16.

    c. Remove all ice around the Main Lead Port compression nut on the Main Lead Extension that is being removed ( i.e. the Main Lead Extension that has the flow hole plugged in Step 21b ).

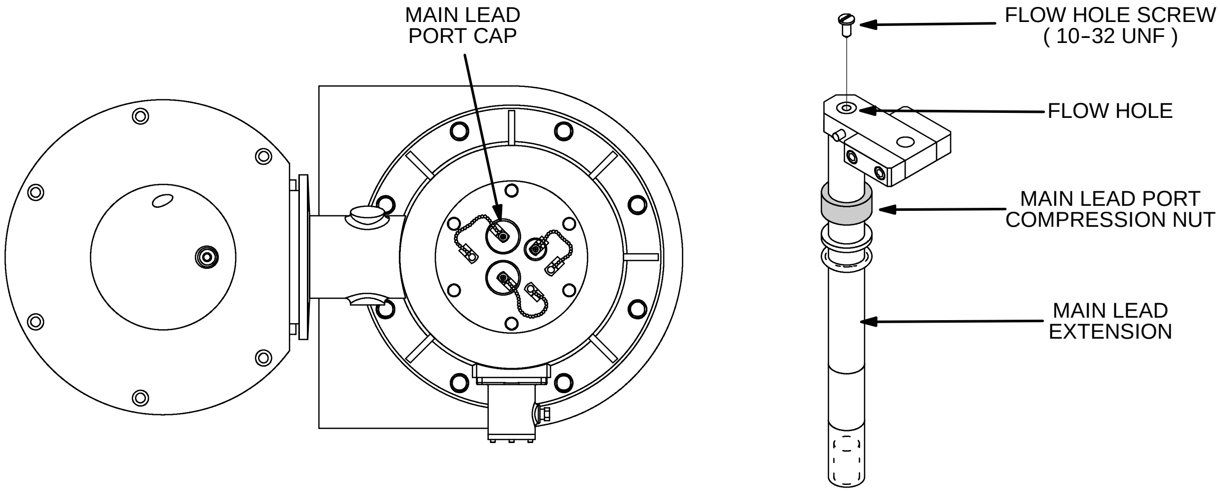
    d. Unscrew the Main Lead Port compression nut and remove the Main Lead Extension from the magnet. Immediately replace the cap onto the Main Lead Port.

    e. Repeat these steps ( a - d ) for the other Main Lead Extension.

## 4–9 RAMPING – PERSON 1 ( continued )

22. Remove the Power Supply Jumper and Grounding Cables.

23. Keep the Field Probe centered in magnet and proceed to SET–UP AND CALIBRATION, Section 5, Shimming Preparation / Field Stabilization.

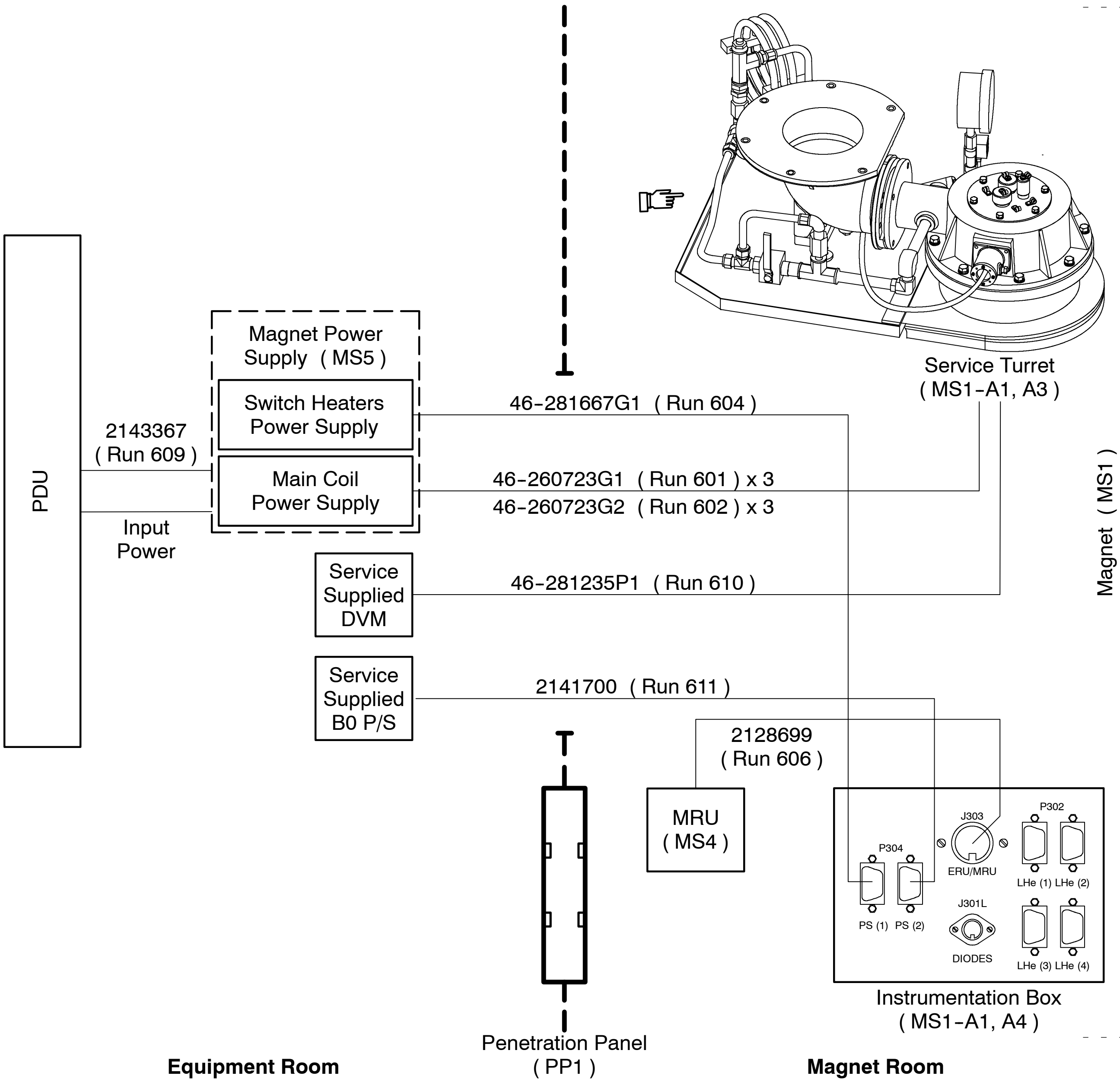



**MAIN LEAD EXTENSION AND MAIN LEAD PORT COMPRESSION NUT**
ILLUSTRATION 4–16

# SCHEMATICS / INTERCONNECTS

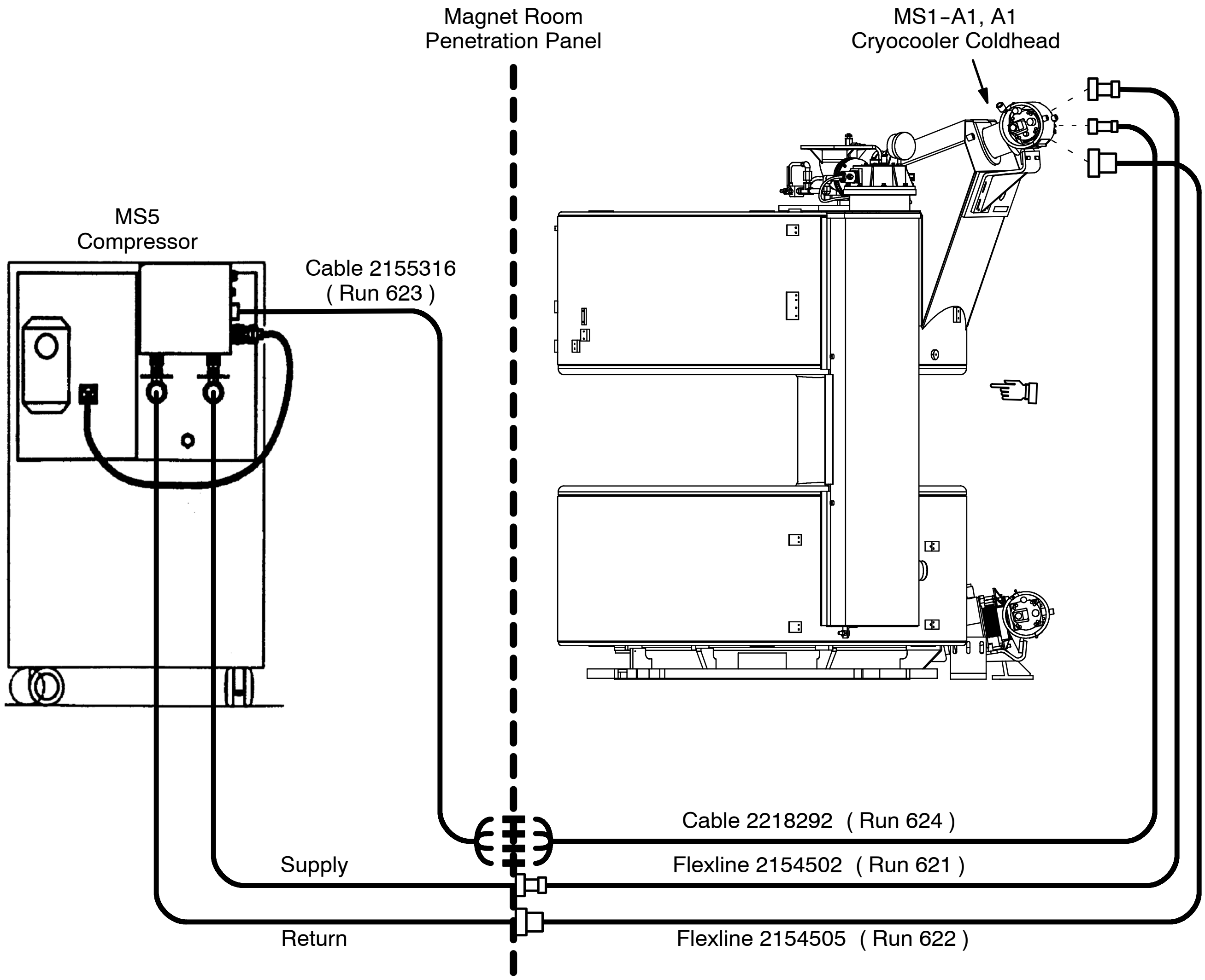
## TABLE OF CONTENTS

# SECTION 1 – INTERCONNECT DIAGRAMS



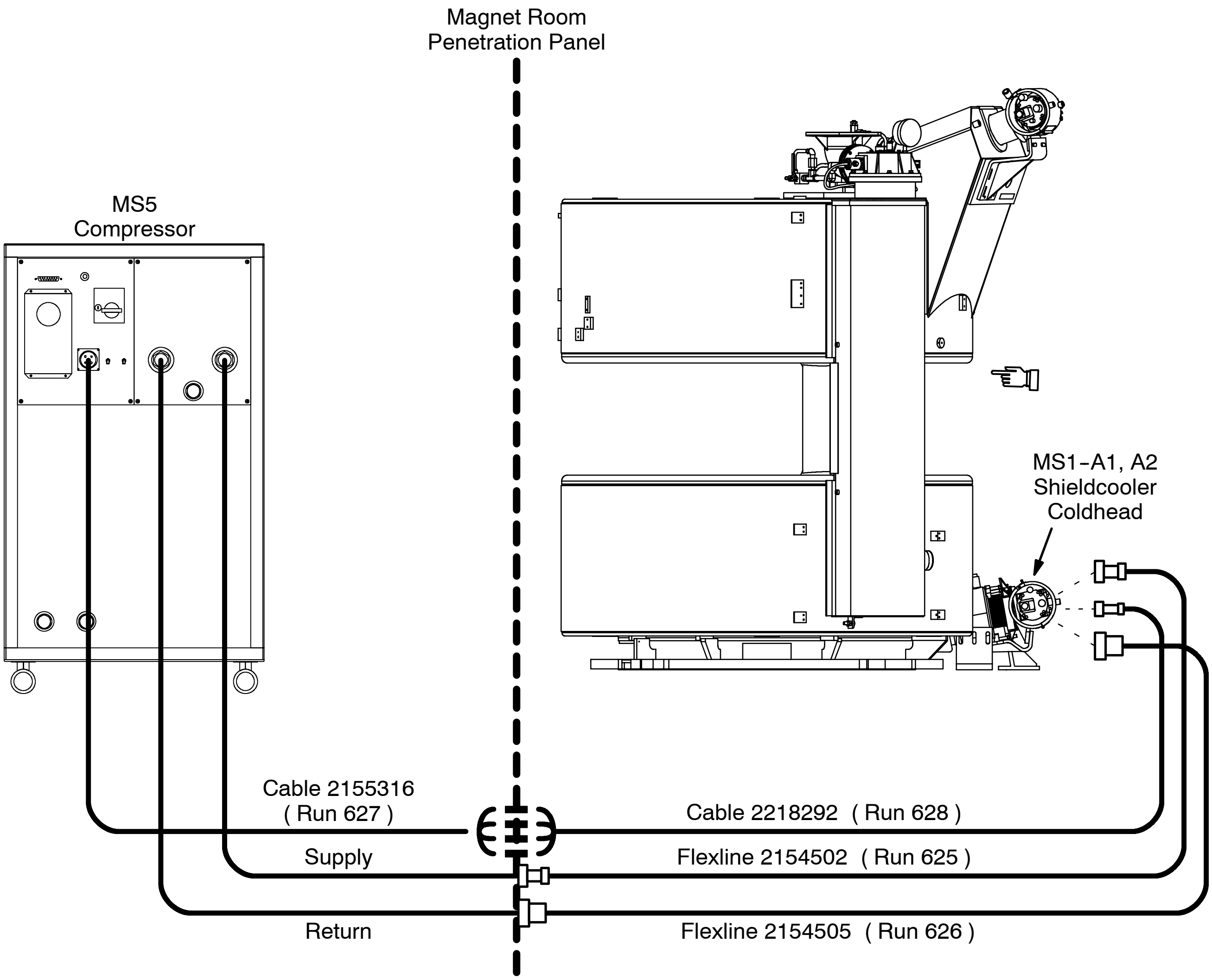

**MAGNET SYSTEM INTERCONNECT DIAGRAM**
ILLUSTRATION 1–1

## SECTION 1 – INTERCONNECT DIAGRAMS ( continued )




**MAGNET CRYOCOOLER INTERCONNECT DIAGRAM**
ILLUSTRATION 1–2

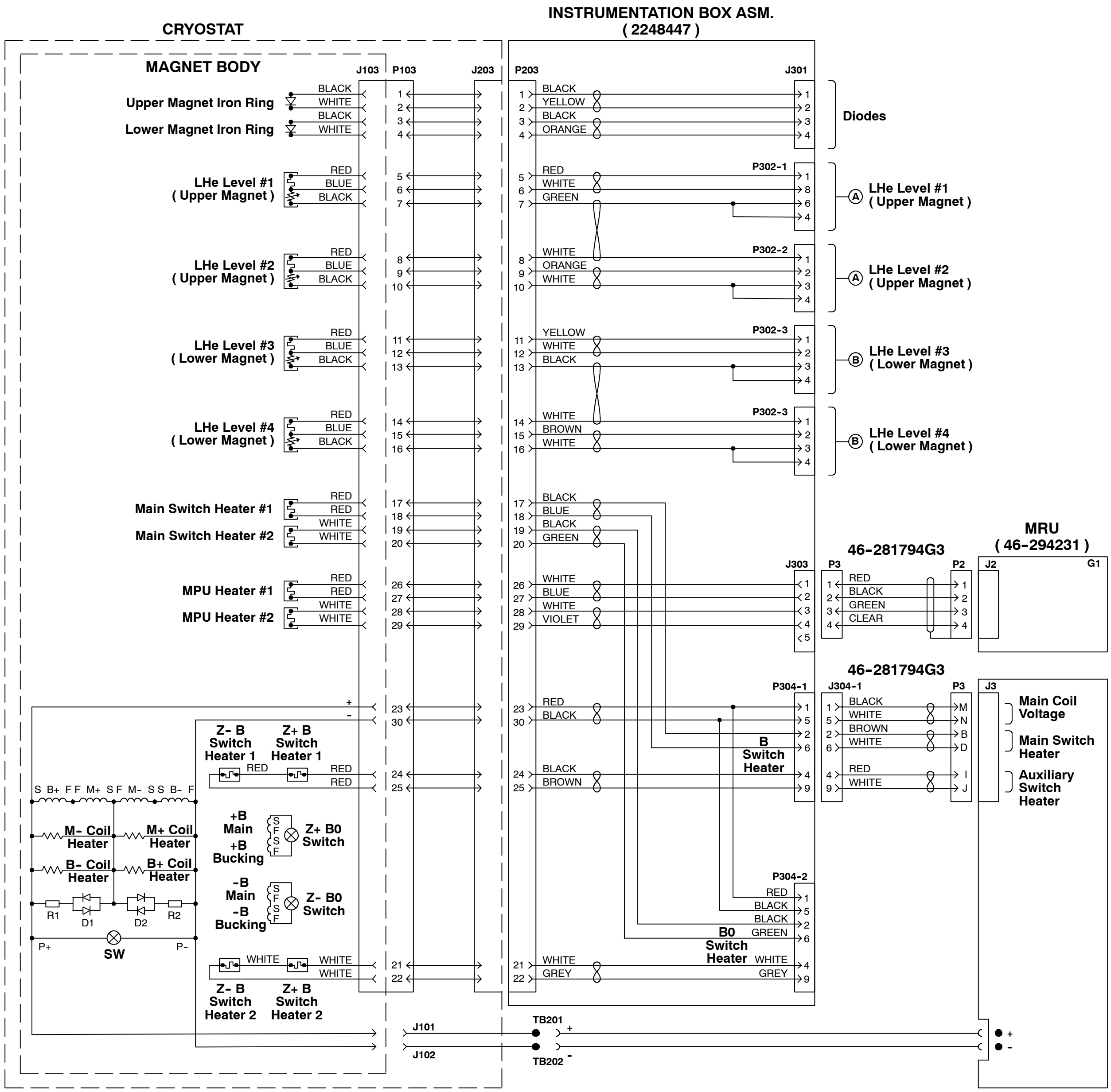
## SECTION 1 – INTERCONNECT DIAGRAMS ( continued )




**MAGNET SHIELDCOOLER INTERCONNECT DIAGRAM**
ILLUSTRATION 1–3

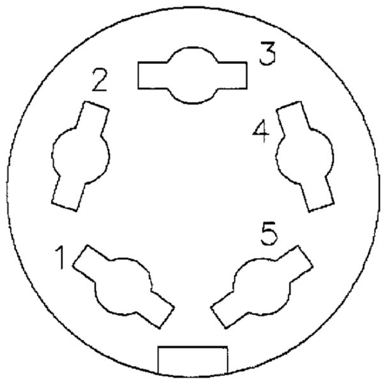
# SECTION 2 – WIRING DIAGRAMS

## 2-1 MAGNET SYSTEM WIRING DIAGRAM

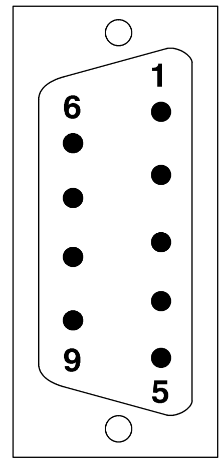



**MAGNET SYSTEM WIRING DIAGRAM**
ILLUSTRATION 2-1

## 2–2 CONNECTOR PIN LOCATIONS



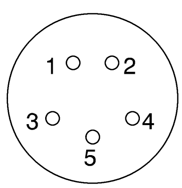

**J303**




**P304**

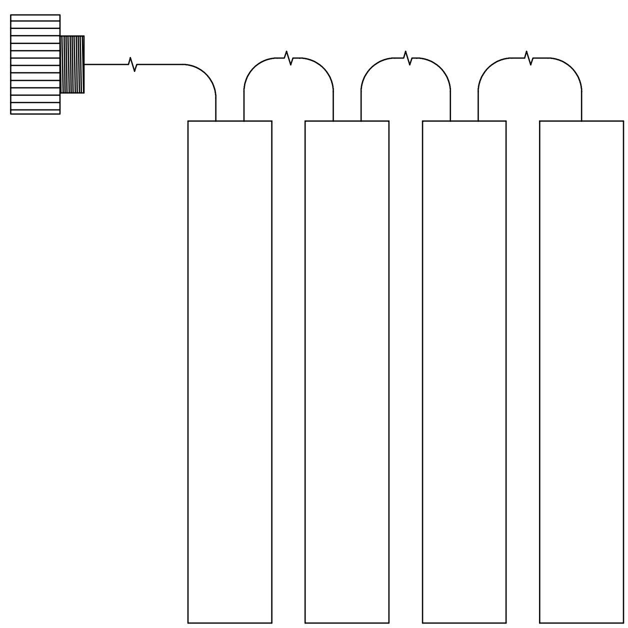
**CONNECTOR PIN LOCATIONS**
ILLUSTRATION 2–2

## 2–3 MAGNET HEATERS



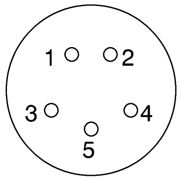

**Plug Assembly Pin Layout**

1. Primary Line
2. Primary Neutral
3. Redundant Line
4. Redundant Neutral
5. Shield



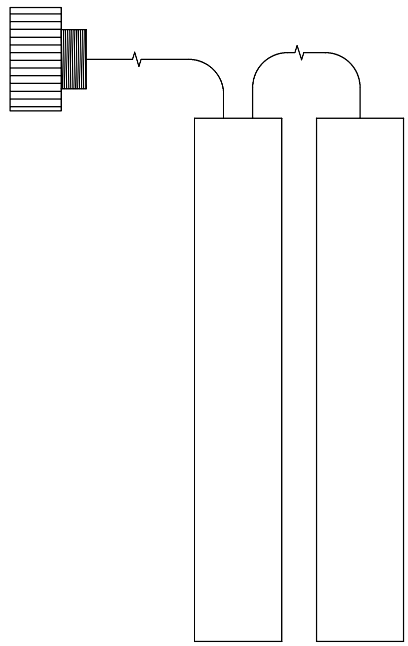
**BOTTOM MAGNET RING HEATER ( 2267036 )**
ILLUSTRATION 2–3

## 2-3 MAGNET HEATERS ( continued )

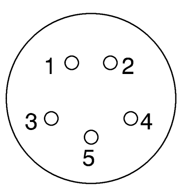



**Plug Assembly Pin Layout**

1. Primary Line
2. Primary Neutral
3. Redundant Line
4. Redundant Neutral
5. Shield

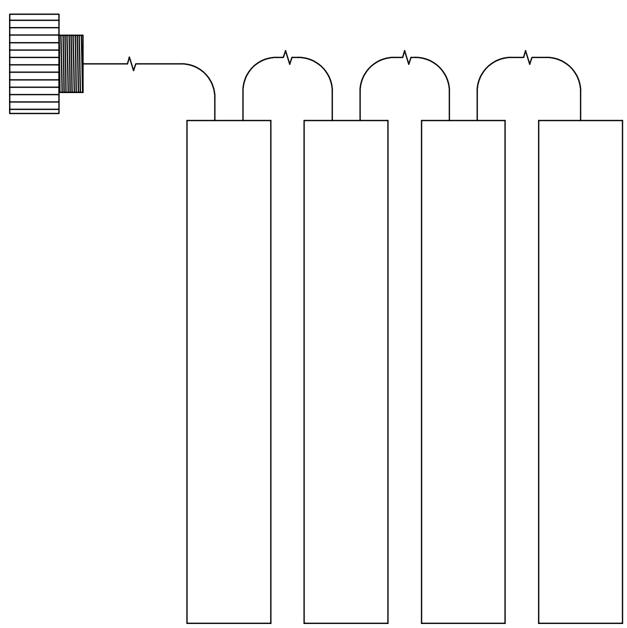


**BOTTOM MAGNET CENTER HEATER ( 2267036-2 )**
ILLUSTRATION 2-4



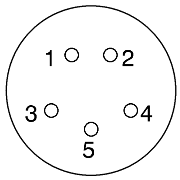

**Plug Assembly Pin Layout**

1. Primary Line
2. Primary Neutral
3. Redundant Line
4. Redundant Neutral
5. Shield



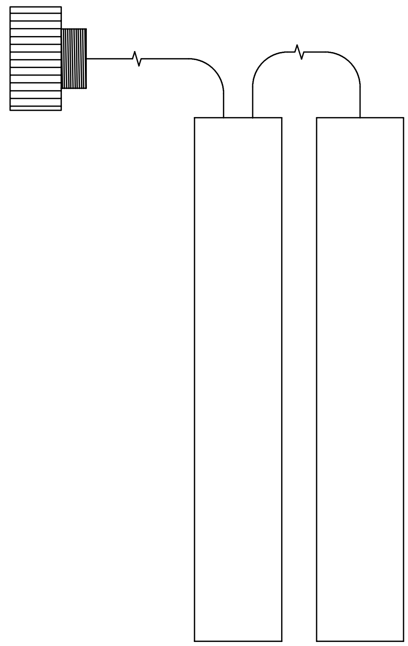
**TOP MAGNET RING HEATER ( 2267036-3 )**
ILLUSTRATION 2-5

## 2-3 MAGNET HEATERS ( continued )

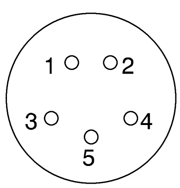



**Plug Assembly Pin Layout**

1. Primary Line
2. Primary Neutral
3. Redundant Line
4. Redundant Neutral
5. Shield

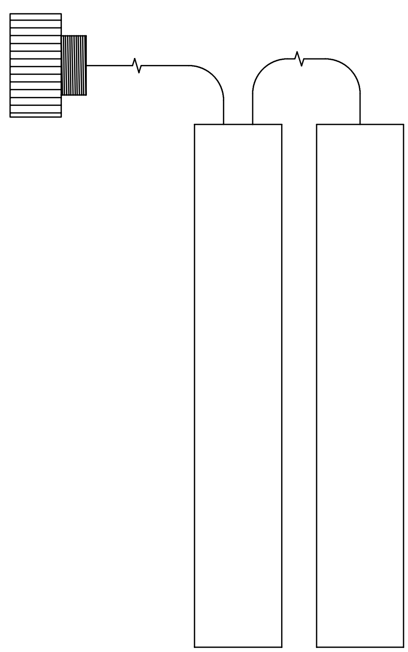


**TOP MAGNET CENTER HEATER ( 2267036-4 )**
ILLUSTRATION 2-6



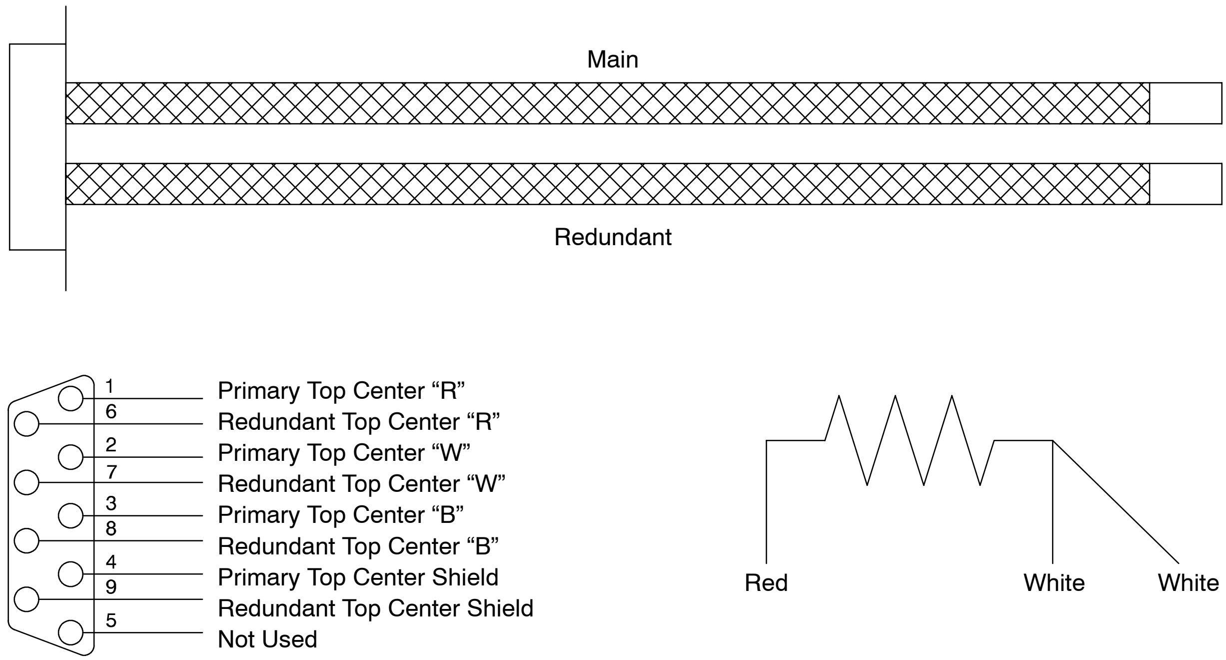

**Plug Assembly Pin Layout**

1. Primary Line
2. Primary Neutral
3. Redundant Line
4. Redundant Neutral
5. Shield

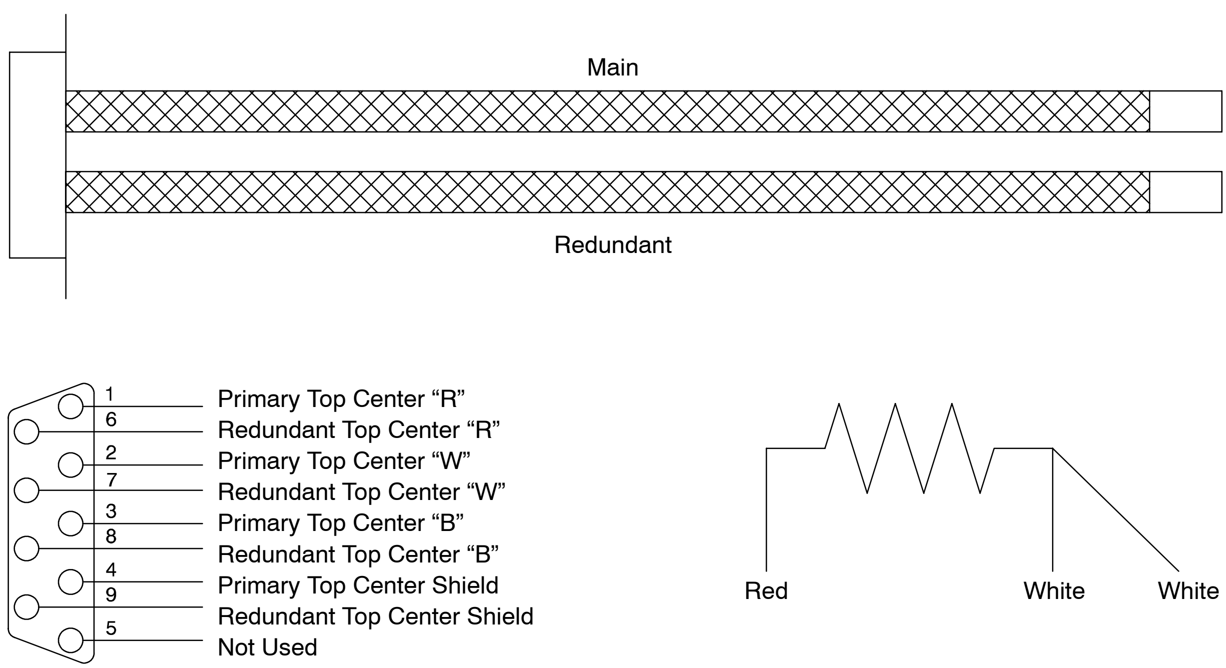


**POST HEATERS ( 2267036-5 )**
ILLUSTRATION 2-7

## 2-4 MAGNET TEMPERATURE SENSORS

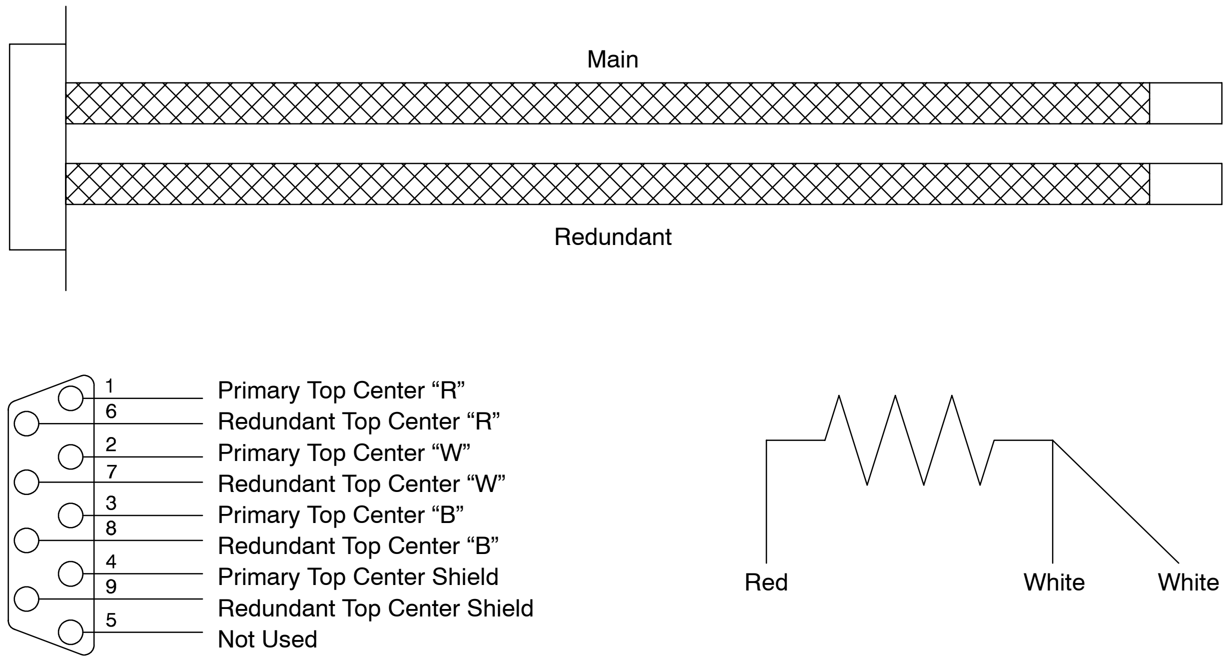



**TOP MAGNET CENTER TEMPERATURE SENSORS ( 2268386 )**
ILLUSTRATION 2-8

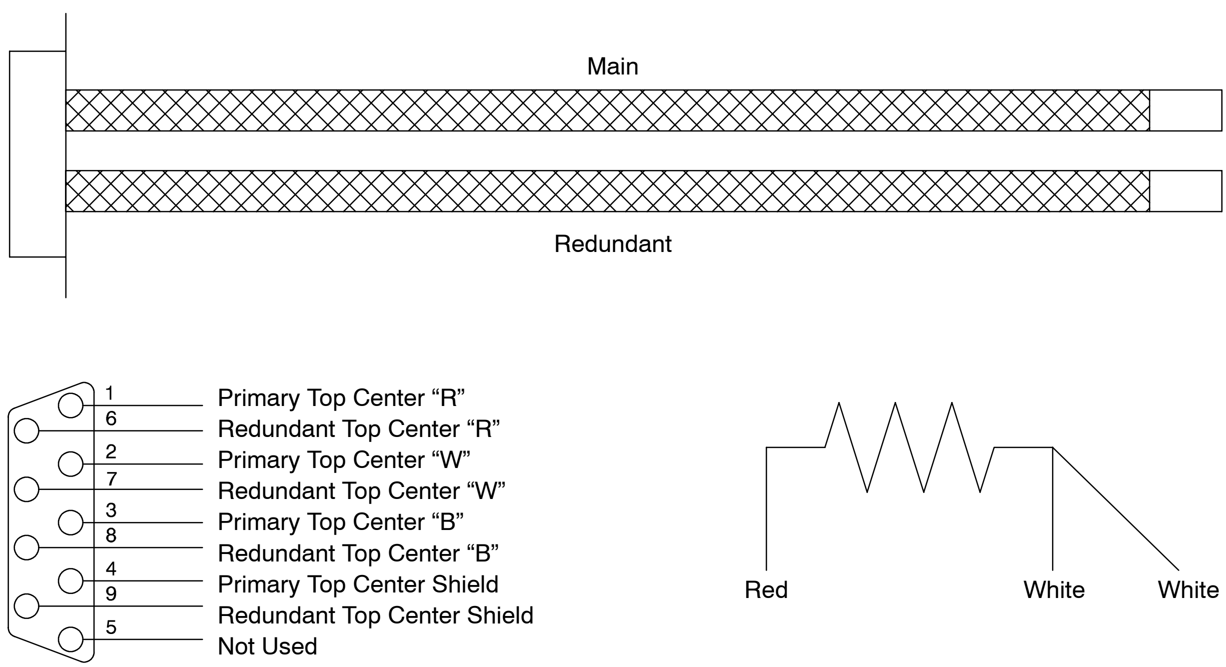



**TOP MAGNET RING TEMPERATURE SENSORS ( 2268386-2 )**
ILLUSTRATION 2-9

## 2-4 MAGNET TEMPERATURE SENSORS ( continued )

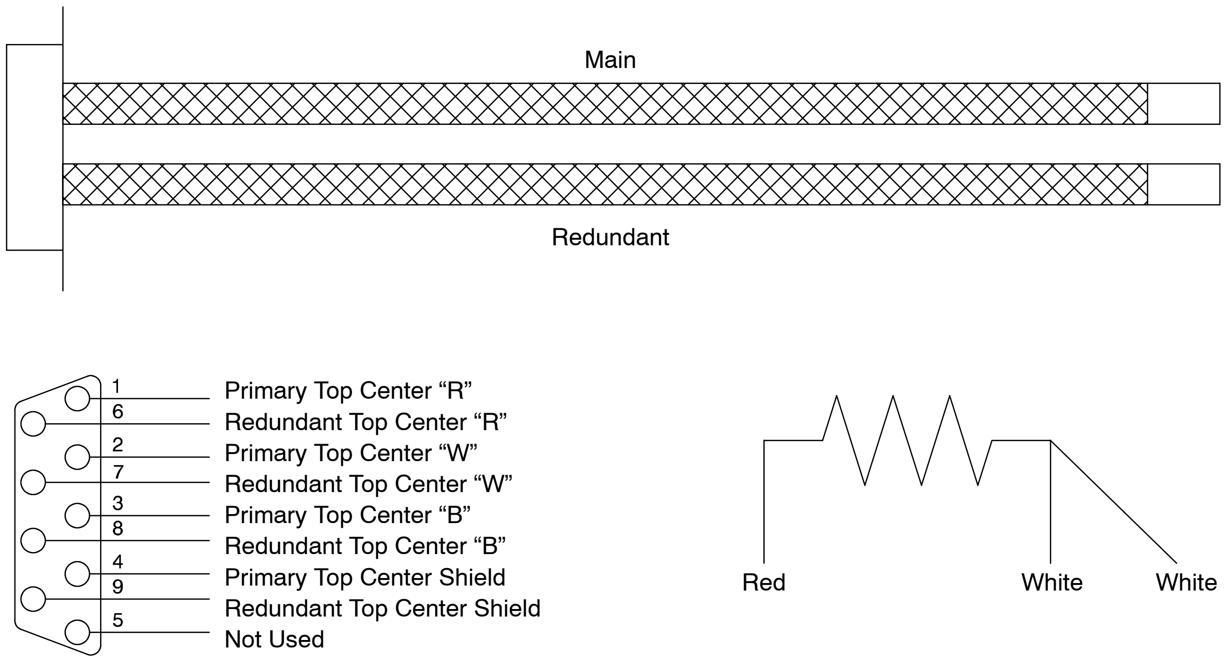



**BOTTOM MAGNET CENTER TEMPERATURE SENSORS ( 2268386-3 )**
ILLUSTRATION 2-10



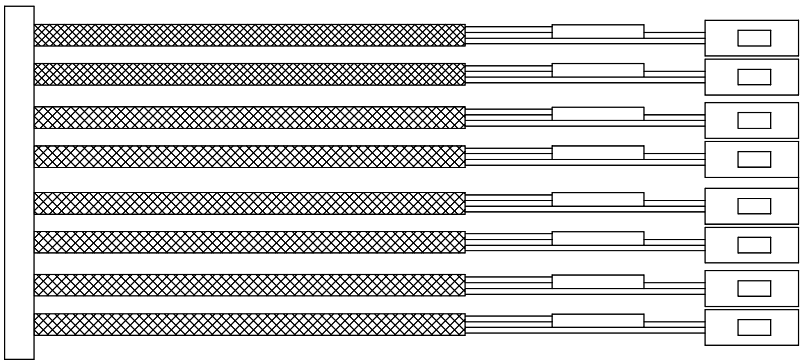

**BOTTOM MAGNET RING TEMPERATURE SENSORS ( 2268386-4 )**
ILLUSTRATION 2-11

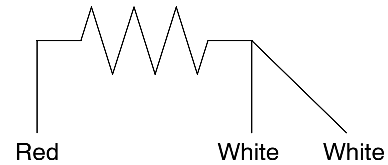
## 2-4 MAGNET TEMPERATURE SENSORS ( continued )

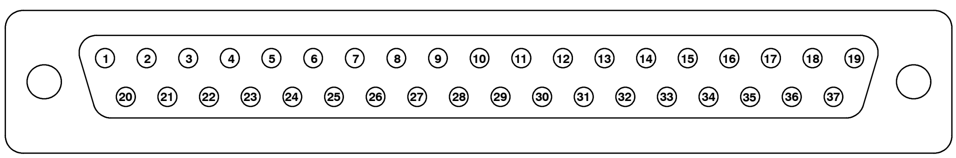



**POST TEMPERATURE SENSOR ( 2268387 )**
ILLUSTRATION 2-12

## 2-4 MAGNET TEMPERATURE SENSORS ( continued )



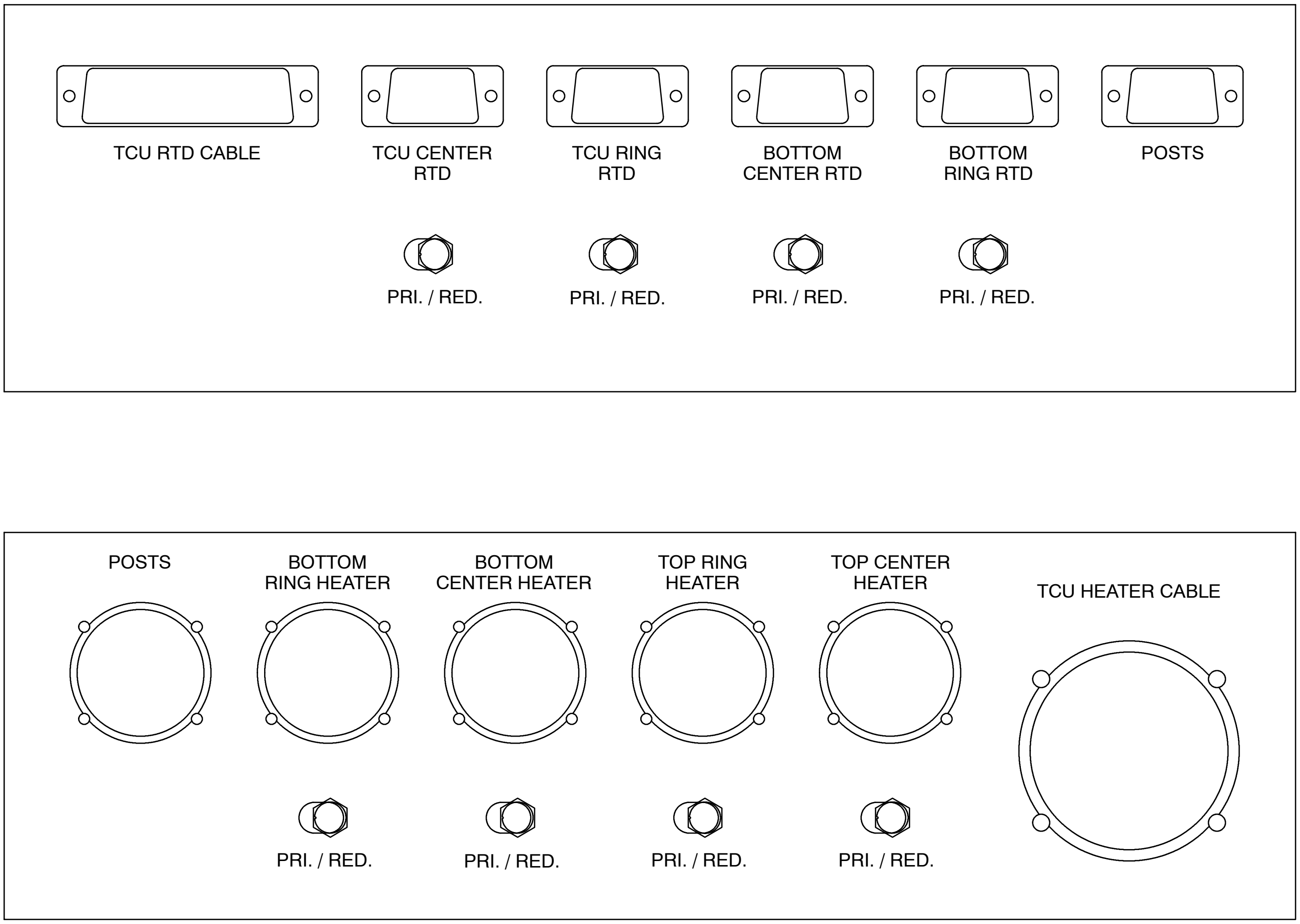



| Pin Number | Location | Wire Color | Pin Number | Location | Wire Color |
|---|---|---|---|---|---|
| 1 | U1 | Red | 20 | B1 | Red |
| 2 | U1 | White | 21 | B1 | White |
| 3 | U1 | White | 22 | B1 | White |
| 4 | U1 | Shield | 23 | B1 | Shield |
| 5 | U2 | Red | 24 | B2 | Red |
| 6 | U2 | White | 25 | B2 | White |
| 7 | U2 | White | 26 | B2 | White |
| 8 | U2 | Shield | 27 | B2 | Shield |
| 9 | U3 | Red | 28 | B3 | Red |
| 10 | U3 | White | 29 | B3 | White |
| 11 | U3 | White | 30 | B3 | White |
| 12 | U3 | Shield | 31 | B3 | Shield |
| 13 | U4 | Red | 32 | B4 | Red |
| 14 | U4 | White | 33 | B4 | White |
| 15 | U4 | White | 34 | B4 | White |
| 16 | U4 | Shield | 35 | B4 | Shield |
| 17 | Not Used | | 36 | Not Used | |
| 18 | Not Used | | 37 | Not Used | |
| 19 | Not Used | | | | |

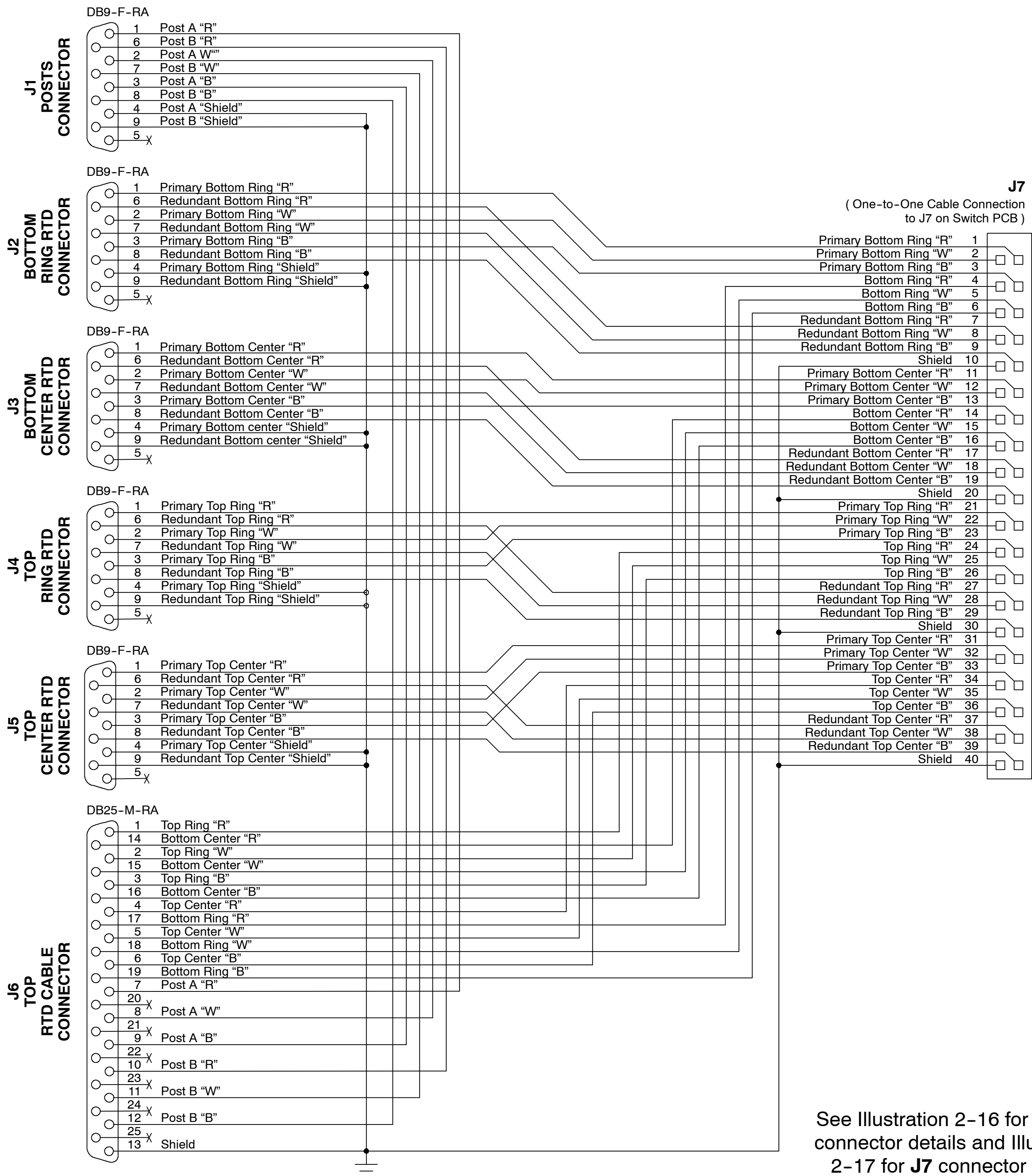
**MAGNET TEMPERATURE SENSOR**
ILLUSTRATION 2-13

## 2-5 HEATER CONNECTOR BOX




**HEATER CONNECTOR BOX ( 2269994 )**
ILLUSTRATION 2-14

## 2-5 HEATER CONNECTOR BOX ( continued )




See Illustration 2-16 for **J1** - **J6** connector details and Illustration 2-17 for **J7** connector detail.

**HEATER CONNECTOR BOX - SCHEMATIC**
ILLUSTRATION 2-15

## 2-5 HEATER CONNECTOR BOX ( continued )

**Posts Connector** — J1 (DB9-F-RA)

| | |
|---|---|
| 1 | Post A “R” |
| 6 | Post B “R” |
| 2 | Post A W“” |
| 7 | Post B “W” |
| 3 | Post A “B” |
| 8 | Post B “B” |
| 4 | Post A “SHIELD” |
| 9 | Post B “SHIELD” |
| 5 | X |

**Top Ring RTD Connector** — J4 (DB9-F-RA)

| | |
|---|---|
| 1 | Primary Top Ring “R” |
| 6 | Redundant Top Ring “R” |
| 2 | Primary Top Ring “W” |
| 7 | Redundant Top Ring “W” |
| 3 | Primary Top Ring “B” |
| 8 | Redundant Top Ring “B” |
| 4 | Primary Top Ring “SHIELD” |
| 9 | Redundant Top Ring “SHIELD” |
| 5 | X |

**Bottom Ring RTD Connector** — J2 (DB9-F-RA)

| | |
|---|---|
| 1 | Primary Bottom Ring “R” |
| 6 | Redundant Bottom Ring “R” |
| 2 | Primary Bottom Ring “W” |
| 7 | Redundant Bottom Ring “W” |
| 3 | Primary Bottom Ring “B” |
| 8 | Redundant Bottom Ring “B” |
| 4 | Primary Bottom Ring “SHIELD” |
| 9 | Redundant Bottom Ring “SHIELD” |
| 5 | X |

**Top Center RTD Connector** — J5 (DB9-F-RA)

| | |
|---|---|
| 1 | Primary Top Center “R” |
| 6 | Redundant Top Center “R” |
| 2 | Primary Top Center “W” |
| 7 | Redundant Top Center “W” |
| 3 | Primary Top Center “B” |
| 8 | Redundant Top Center “B” |
| 4 | Primary Top Center “SHIELD” |
| 9 | Redundant Top Center “SHIELD” |
| 5 | X |

**Bottom Center RTD Connector** — J3 (DB9-F-RA)

| | |
|---|---|
| 1 | Primary Bottom Center “R” |
| 6 | Redundant Bottom Center “R” |
| 2 | Primary Bottom Center “w” |
| 7 | Redundant Bottom Center “w” |
| 3 | Primary Bottom Center “B” |
| 8 | Redundant Bottom Center “B” |
| 4 | Primary Bottom Center “SHIELD” |
| 9 | Redundant Bottom Center “SHIELD” |
| 5 | X |

**Top RTD Cable Connector** — J6 (DB25-M-RA)

| | |
|---|---|
| 1 | Top Ring “R” |
| 14 | Bottom Center “R” |
| 2 | Top Ring “W” |
| 15 | Bottom Center “W” |
| 3 | Top Ring “B” |
| 16 | Bottom Center “B” |
| 4 | Top Center “R” |
| 17 | Bottom Ring “R” |
| 5 | Top Center “W” |
| 18 | Bottom Ring “W” |
| 6 | Top Center “B” |
| 19 | Bottom Ring “B” |
| 7 | Post A “R” |
| 20 | X |
| 8 | Post A “W” |
| 21 | X |
| 9 | Post A “B” |
| 22 | X |
| 10 | Post B “R” |
| 23 | X |
| 11 | Post B “W” |
| 24 | X |
| 12 | Post B “B” |
| 25 | X |
| 13 | Shield |

See Illustration 2-15 for schematic.

**HEATER CONNECTOR BOX - CONNECTOR DETAILS**
ILLUSTRATION 2-16

## 2-5 HEATER CONNECTOR BOX ( continued )

J7

| | |
|---|---|
| Primary Bottom Ring “R” | 1 |
| Primary Bottom Ring “W” | 2 |
| Primary Bottom Ring “B” | 3 |
| Bottom Ring “R” | 4 |
| Bottom Ring “W” | 5 |
| Bottom Ring “B” | 6 |
| Redundant Bottom Ring “R” | 7 |
| Redundant Bottom Ring “W” | 8 |
| Redundant Bottom Ring “B” | 9 |
| Shield | 10 |
| Primary Bottom Center “R” | 11 |
| Primary Bottom Center “W” | 12 |
| Primary Bottom Center “B” | 13 |
| Bottom Center “R” | 14 |
| Bottom Center “W” | 15 |
| Bottom Center “B” | 16 |
| Redundant Bottom Center “R” | 17 |
| Redundant Bottom Center “W” | 18 |
| Redundant Bottom Center “B” | 19 |
| Shield | 20 |
| Primary Top Ring “R” | 21 |
| Primary Top Ring “W” | 22 |
| Primary Top Ring “B” | 23 |
| Top Ring “R” | 24 |
| Top Ring “W” | 25 |
| Top Ring “B” | 26 |
| Redundant Top Ring “R” | 27 |
| Redundant Top Ring “W” | 28 |
| Redundant Top Ring “B” | 29 |
| Shield | 30 |
| Primary Top Center “R” | 31 |
| Primary Top Center “W” | 32 |
| Primary Top Center “B” | 33 |
| Top Center “R” | 34 |
| Top Center “W” | 35 |
| Top Center “B” | 36 |
| Redundant Top Center “R” | 37 |
| Redundant Top Center “W” | 38 |
| Redundant Top Center “B” | 39 |
| Shield | 40 |

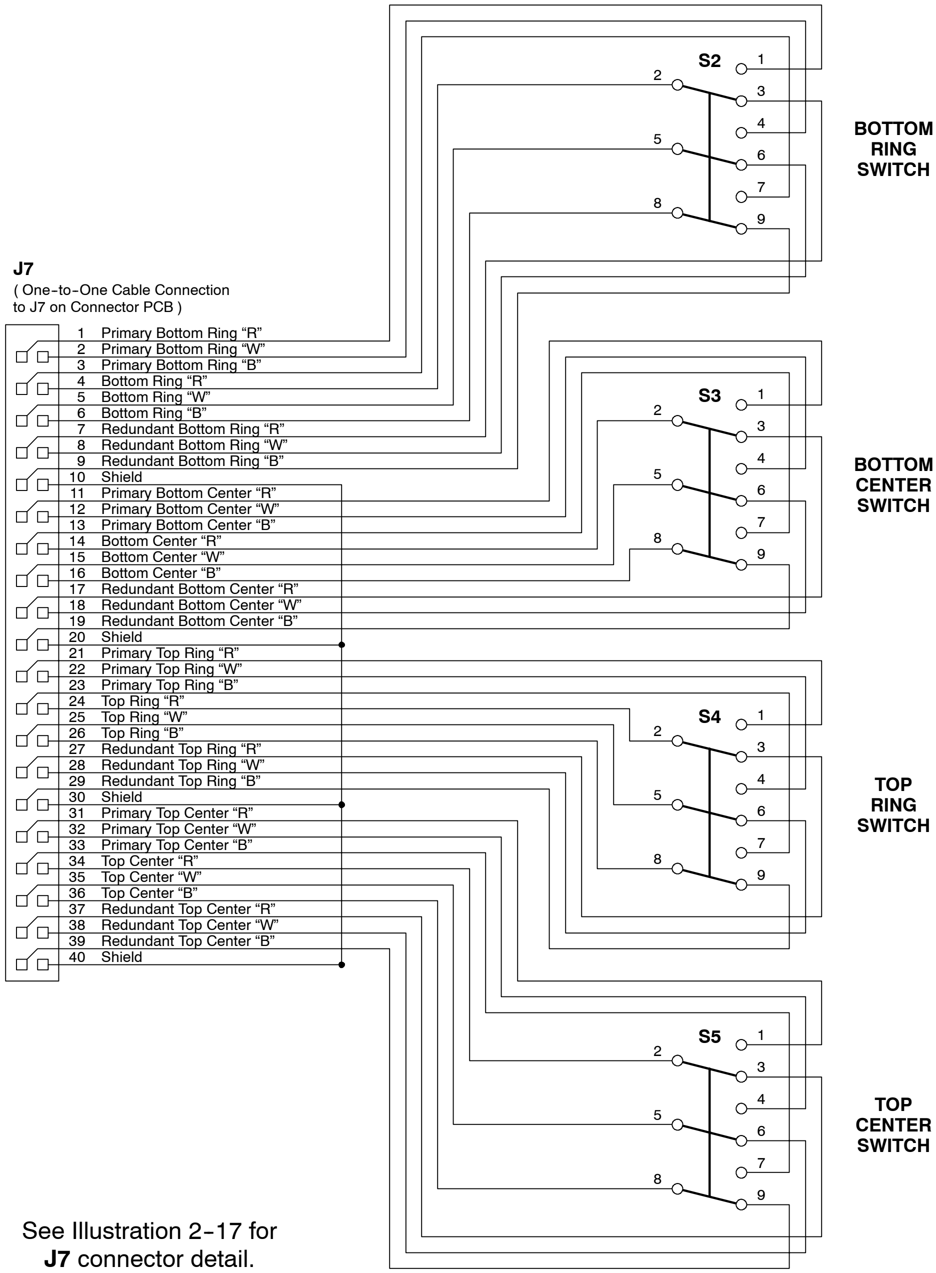
One-to-one cable between these two connectors

TO SW PCB

See Illustration 2-15 for schematic.

**HEATER CONNECTOR BOX - CONNECTOR DETAIL**
ILLUSTRATION 2-17

## 2-5 HEATER CONNECTOR BOX ( continued )




**HEATER CONNECTOR BOX - SCHEMATIC**
ILLUSTRATION 2-18

## 2-5 HEATER CONNECTOR BOX ( continued )

**J7**

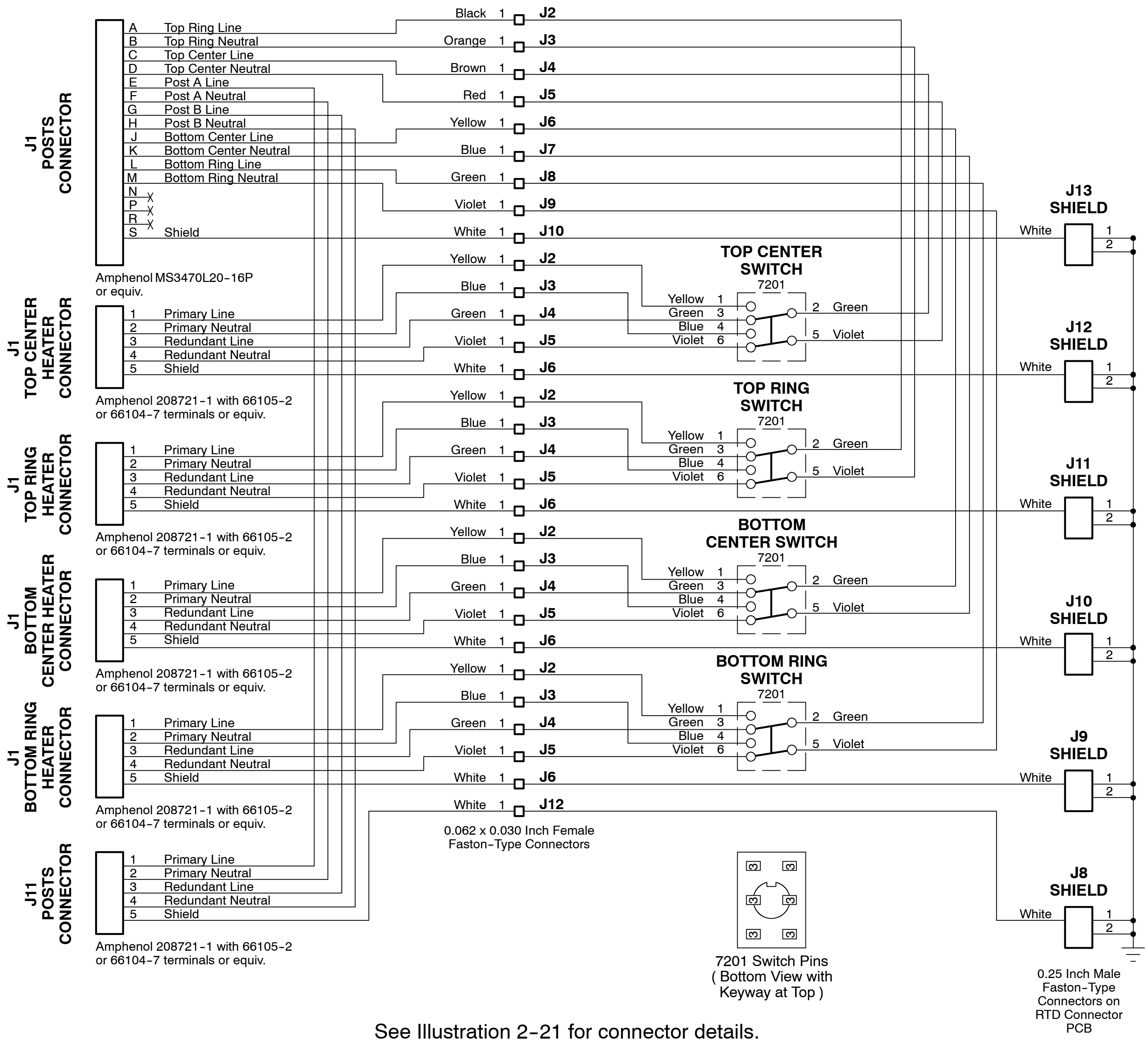
| | |
|---|---|
| 1 | Primary Bottom Ring “R” |
| 2 | Primary Bottom Ring “W” |
| 3 | Primary Bottom Ring “B” |
| 4 | Bottom Ring “R” |
| 5 | Bottom Ring “W” |
| 6 | Bottom Ring “B” |
| 7 | Redundant Bottom Ring “R” |
| 8 | Redundant Bottom Ring “W” |
| 9 | Redundant Bottom Ring “B” |
| 10 | Shield |
| 11 | Primary Bottom Center “R” |
| 12 | Primary Bottom Center “W” |
| 13 | Primary Bottom Center “B” |
| 14 | Bottom Center “R” |
| 15 | Bottom Center “W” |
| 16 | Bottom Center “B” |
| 17 | Redundant Bottom Center “R” |
| 18 | Redundant Bottom Center “W” |
| 19 | Redundant Bottom Center “B” |
| 20 | Shield |
| 21 | Primary Top Ring “R” |
| 22 | Primary Top Ring “W” |
| 23 | Primary Top Ring “B” |
| 24 | Top Ring “R” |
| 25 | Top Ring “W” |
| 26 | Top Ring “B” |
| 27 | Redundant Top Ring “R” |
| 28 | Redundant Top Ring “W” |
| 29 | Redundant Top Ring “B” |
| 30 | Shield |
| 31 | Primary Top Center “R” |
| 32 | Primary Top Center “W” |
| 33 | Primary Top Center “B” |
| 34 | Top Center “R” |
| 35 | Top Center “W” |
| 36 | Top Center “B” |
| 37 | Redundant Top Center “R” |
| 38 | Redundant Top Center “W” |
| 39 | Redundant Top Center “B” |
| 40 | Shield |

TO CON PCB

See Illustration 2-18 for schematic.

**HEATER CONNECTOR BOX - CONNECTOR DETAIL**
ILLUSTRATION 2-19

## 2-5 HEATER CONNECTOR BOX ( continued )




See Illustration 2-21 for connector details.

**HEATER CONNECTOR BOX - SCHEMATIC**
ILLUSTRATION 2-20

## 2-5 HEATER CONNECTOR BOX ( continued )

**Top Center Heater Connector**

J1

| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

Amp 208721-1 with 66105-2 or 66104-7 terminals or equivalent

**Top Ring Heater Connector**

J1

| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

Amp 208721-1 with 66105-2 or 66104-7 terminals or equivalent

**Bottom Center Heater Connector**

J1

| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

Amp 208721-1 with 66105-2 or 66104-7 terminals or equivalent

**Bottom Ring Heater Connector**

J1

| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

Amp 208721-1 with 66105-2 or 66104-7 terminals or equivalent

**Posts Connector**

J11

| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

Amp 208721-1 with 66105-2 or 66104-7 terminals or equivalent

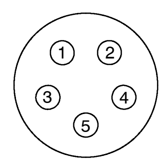
**TCU Heater Cable Connector**

J1

| | |
|---|---|
| A | Top Ring Line |
| B | Top Ring Neutral |
| C | Top Center Line |
| D | Top Center Neutral |
| E | Post A Line |
| F | Post A Neutral |
| G | Post B Line |
| H | Post B Neutral |
| J | Bottom Center Line |
| K | Bottom Center Neutral |
| L | Bottom Ring Line |
| M | Bottom Ring Neutral |
| N | X |
| P | X |
| R | X |
| S | Shield |

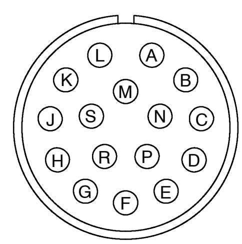
Amphenol MS3470L20-18P or equivalent

**Plug Assembly**




| | |
|---|---|
| 1 | Primary Line |
| 2 | Primary Neutral |
| 3 | Redundant Line |
| 4 | Redundant Neutral |
| 5 | Shield |

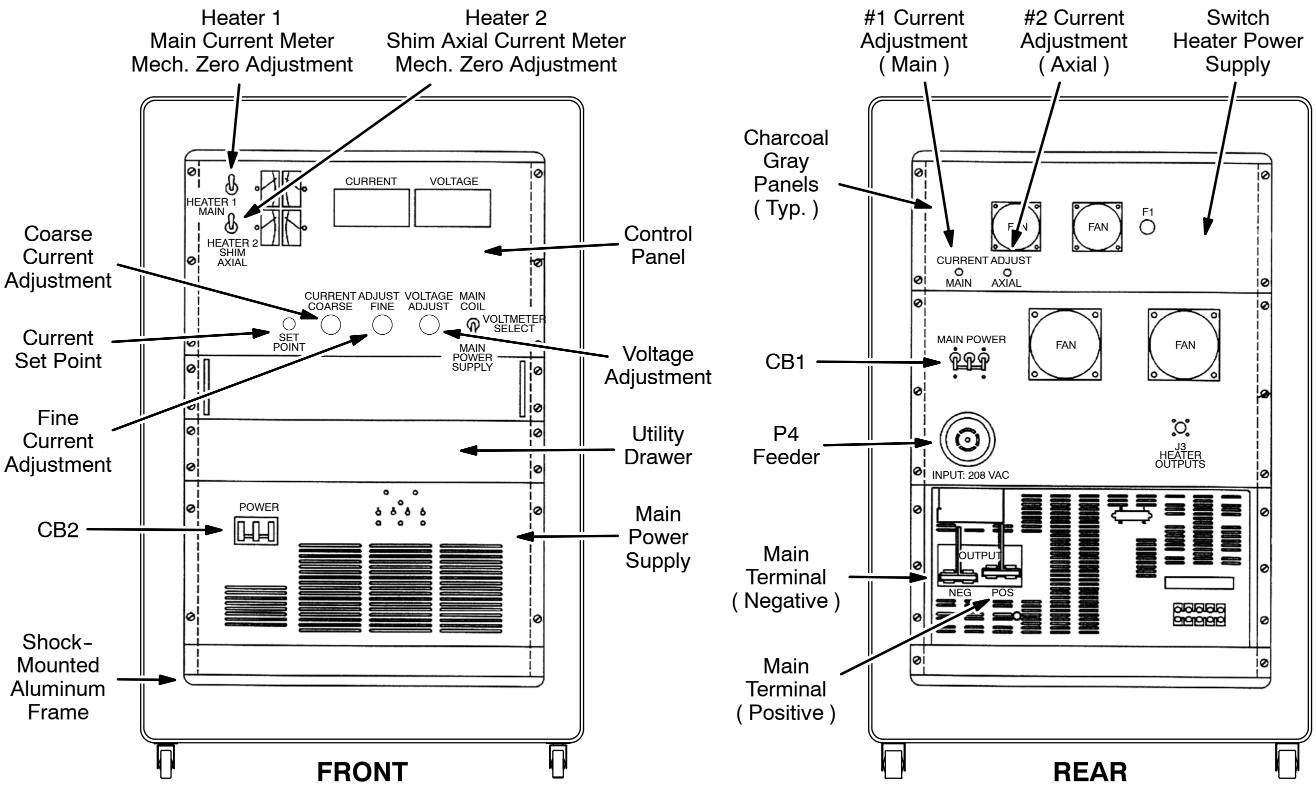
**16-Pin Plug**



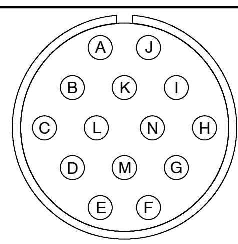

See Illustration 2-18 for schematic.

**HEATER CONNECTOR BOX - CONNECTOR DETAILS**
ILLUSTRATION 2-21

# SECTION 3 - POWER SUPPLIES




**J3**
**Magnet Power Supply**
MSA3102A20-27S

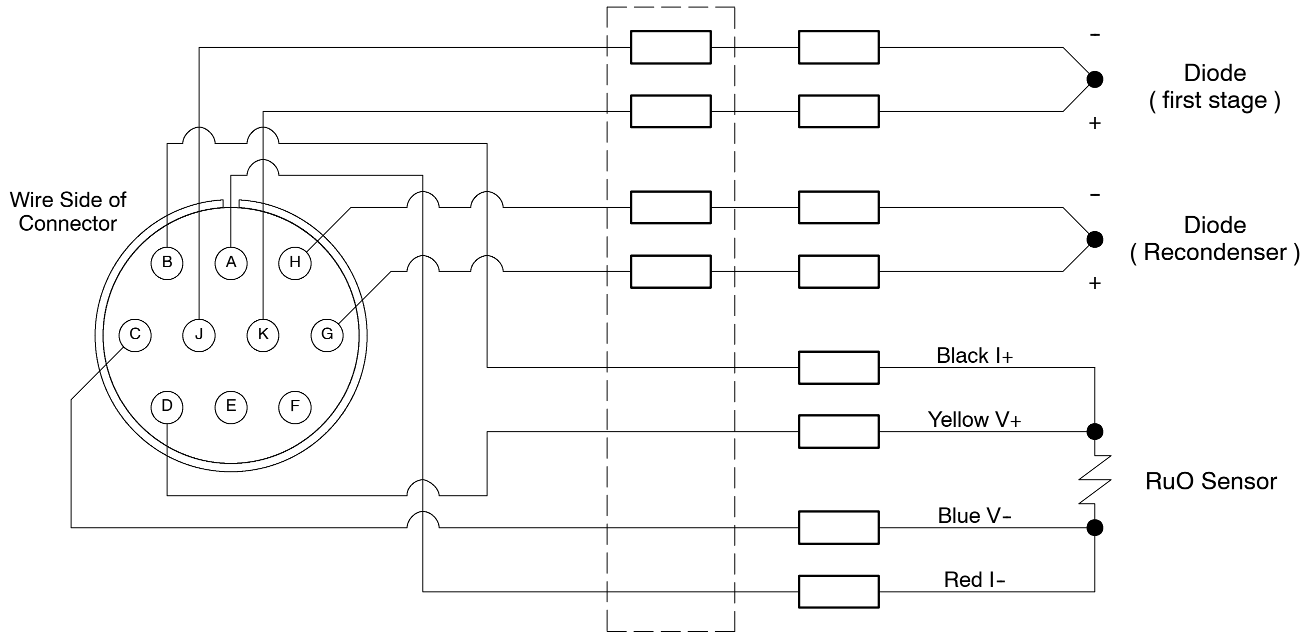



| | | | |
|---|---|---|---|
| A | | H | |
| B | Main Switch Htr + | I | Axial Switch Htr + |
| C | | J | Axial Switch Htr - |
| D | Main Switch Htr - | K | |
| E | | L | |
| F | | M | Main Coil V+ |
| G | | N | Main Coil V- |

| | Designator | Rating and Type | Connection |
|---|---|---|---|
| **Input Power** | P4 | 208 / 220 VAC, 50 - 60 Hz | |
| | TB1 | 30 Amp, 602Y | AC Input, Main Power Supply |
| **Output Connection** | Main Terminal Positive | 1,000 Amp Bus Bar | Red ( + ) Main Power Leads ( MS3-A2 ) |
| | Main Terminal Negative | 1,000 Amp Bus Bar | Black ( - ) Main Power Leads ( MS3-A2 ) |
| | J3 | 1 Amp, MS3106A20-27P | Heater Wire Harness ( MS3-A5 ) P3 |
| **Fuses and Circuit Breakers** | CB1 Cabinet | 3 Pole, 30 Amp, 250 VAC | |
| | CB1 Supply | 3 Pole, 30 Amp, 250 VAC | |
| | F1 | 1 Amp, 250 VAC, MDA | |

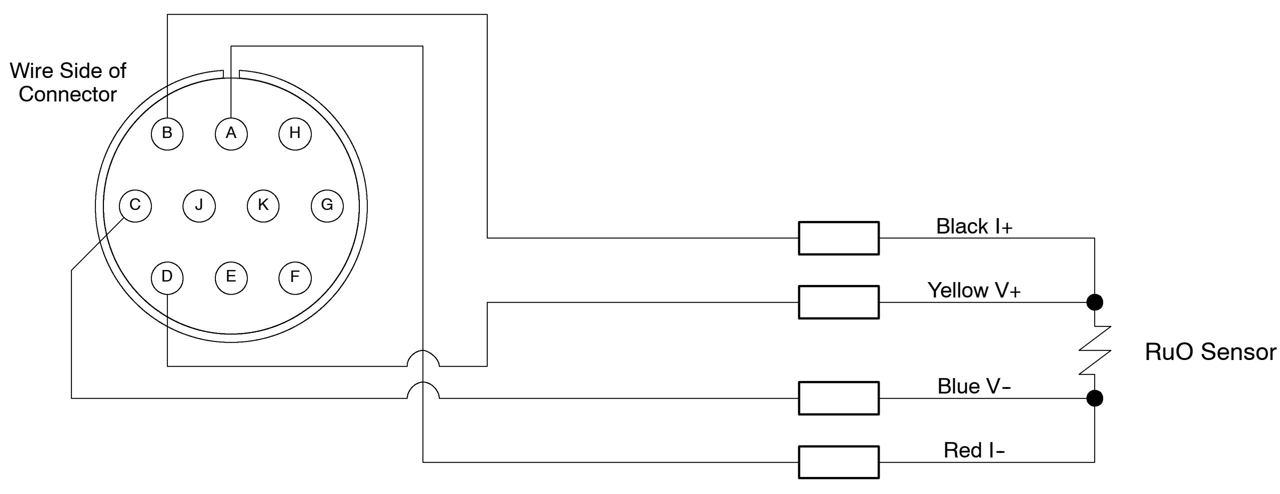
**1,000 AMP SUPERCONDUCTING MAIN COIL SERVICE POWER SUPPLY CABINET**
**MODEL ESS 7.5-1000-2-D-1236**
ILLUSTRATION 3-1

# SECTION 4 – TEMPERATURE SENSOR CONNECTORS



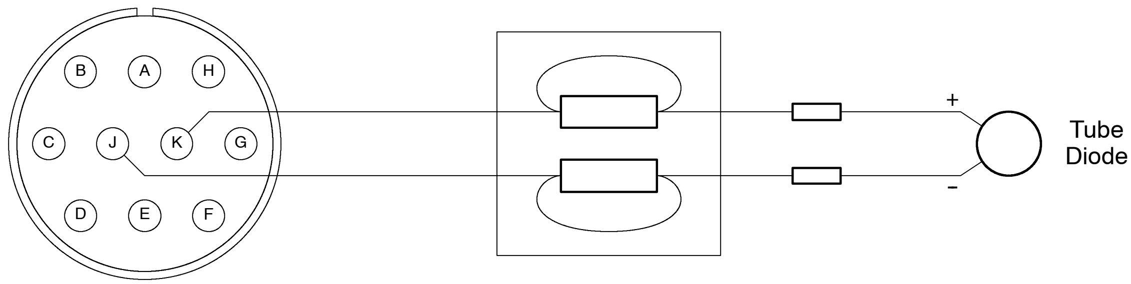

**Recondenser Vacuum Sleeve Wiring Diagram**

**Coldhead Transition Flange Wiring Diagram**

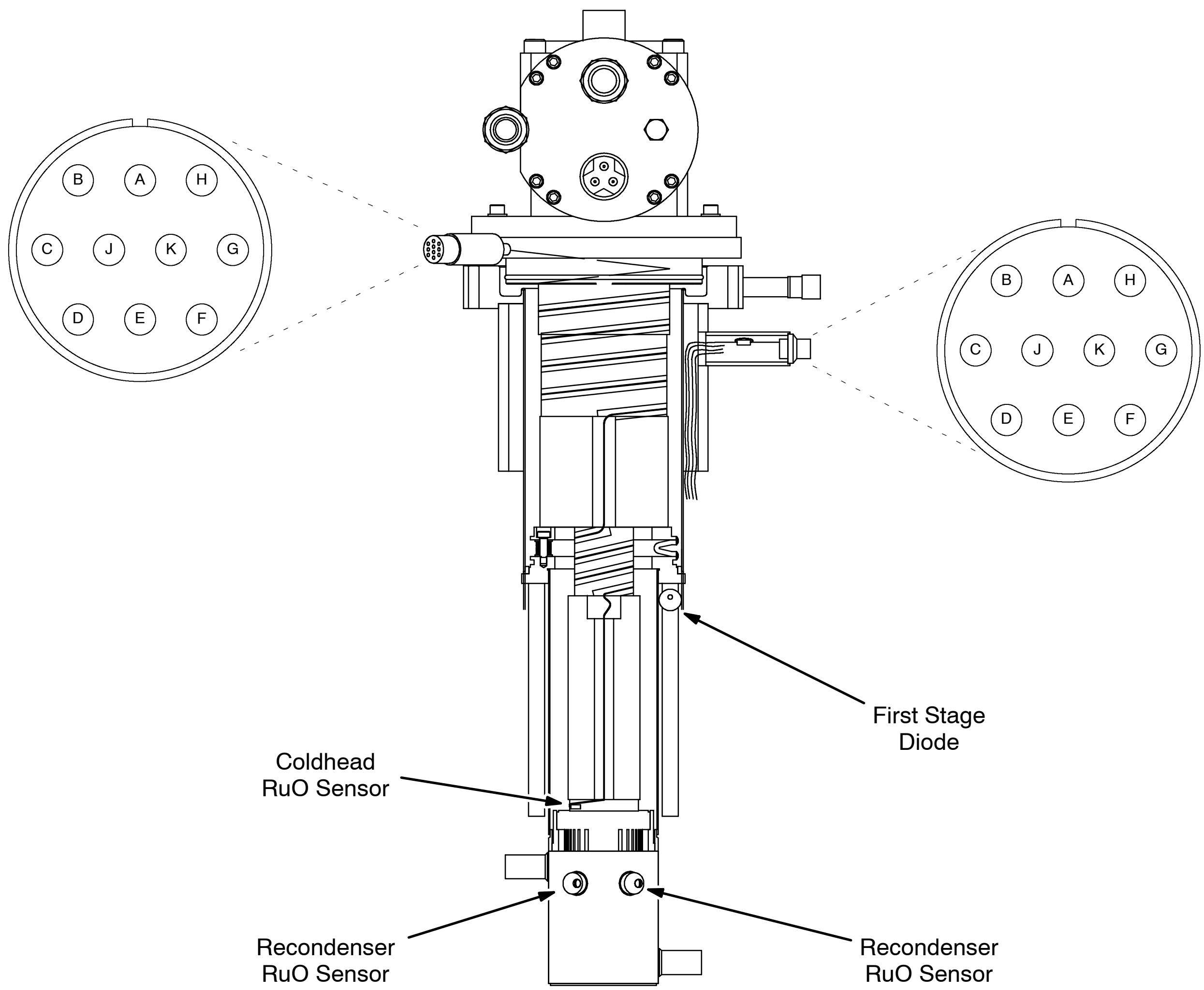



**TWO STAGE CRYOCOOLER COLDHEAD**
**TEMPERATURE SENSOR CONNECTOR PINOUTS**
ILLUSTRATION 4–1

## SECTION 4 – TEMPERATURE SENSOR CONNECTORS ( continued )

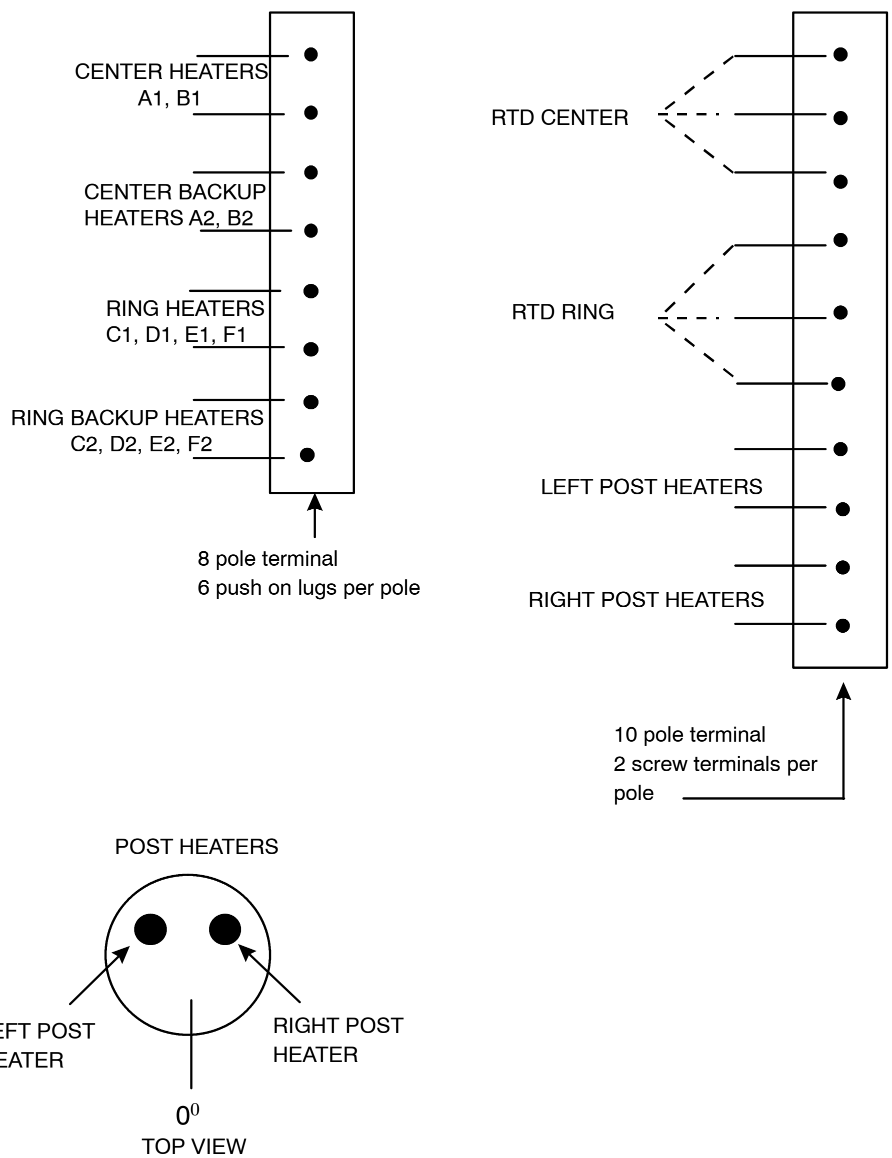



**SINGLE STAGE SHIELDCOOLER TEMPERATURE SENSOR CONNECTOR PINOUTS**
ILLUSTRATION 4–2



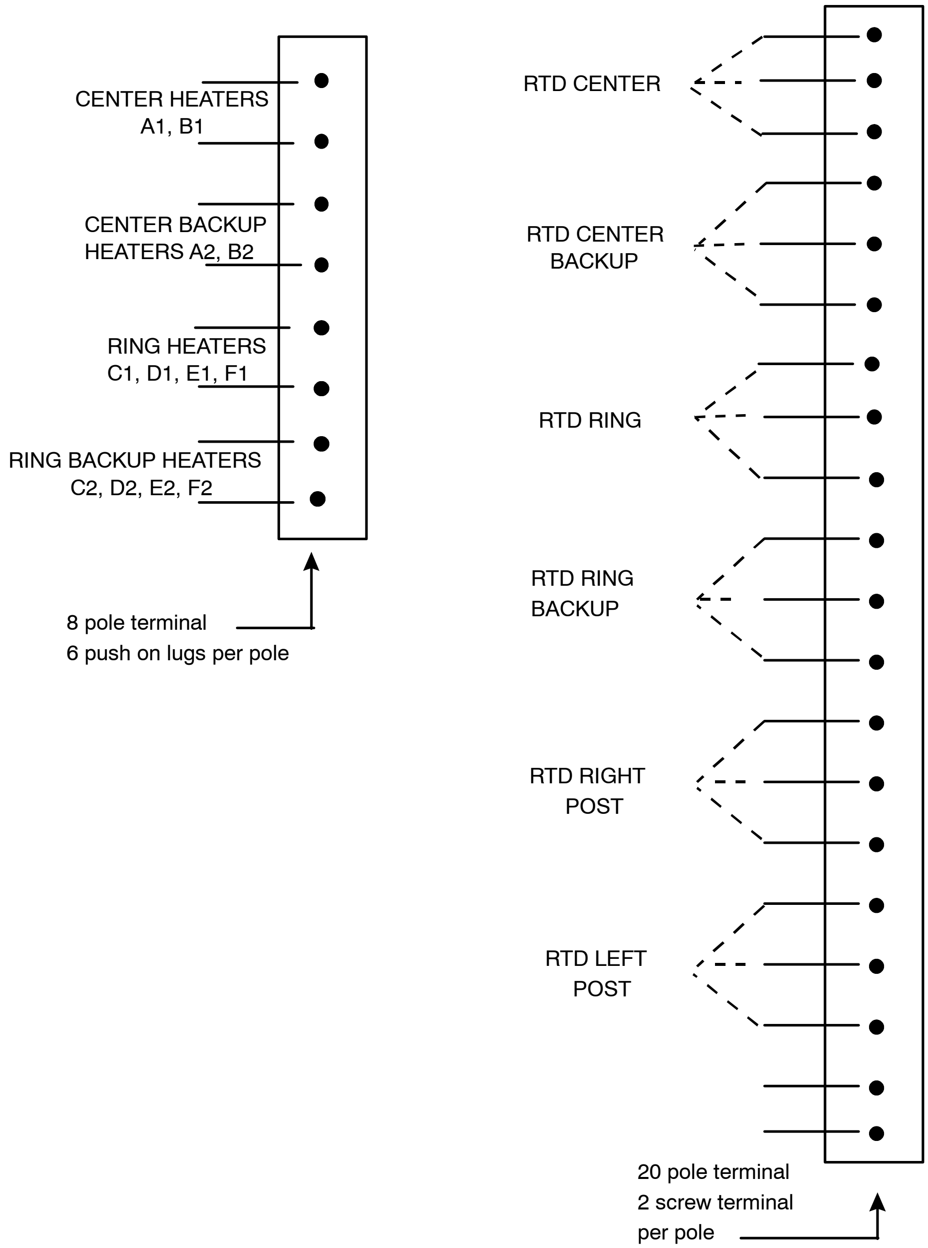

**TWO STAGE CRYOCOOLER COLDHEAD**
**TEMPERATURE SENSOR CONNECTOR LOCATIONS**
ILLUSTRATION 4–3

# SECTION 5
# MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAMS



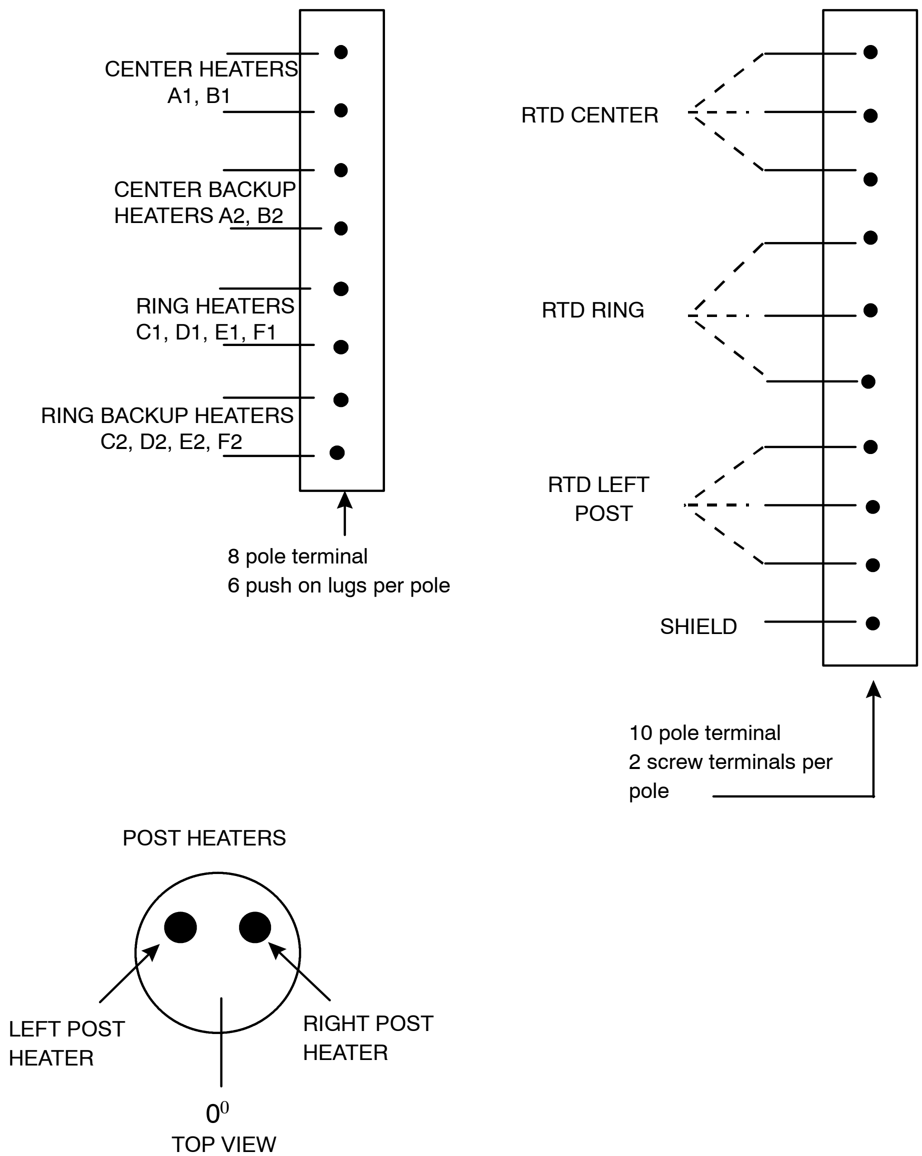

**NMR MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAM,**
**UPPER MAGNET TERMINAL BLOCKS – ARGUS 3**
ILLUSTRATION 5–1

## SECTION 5 – MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAMS ( continued )



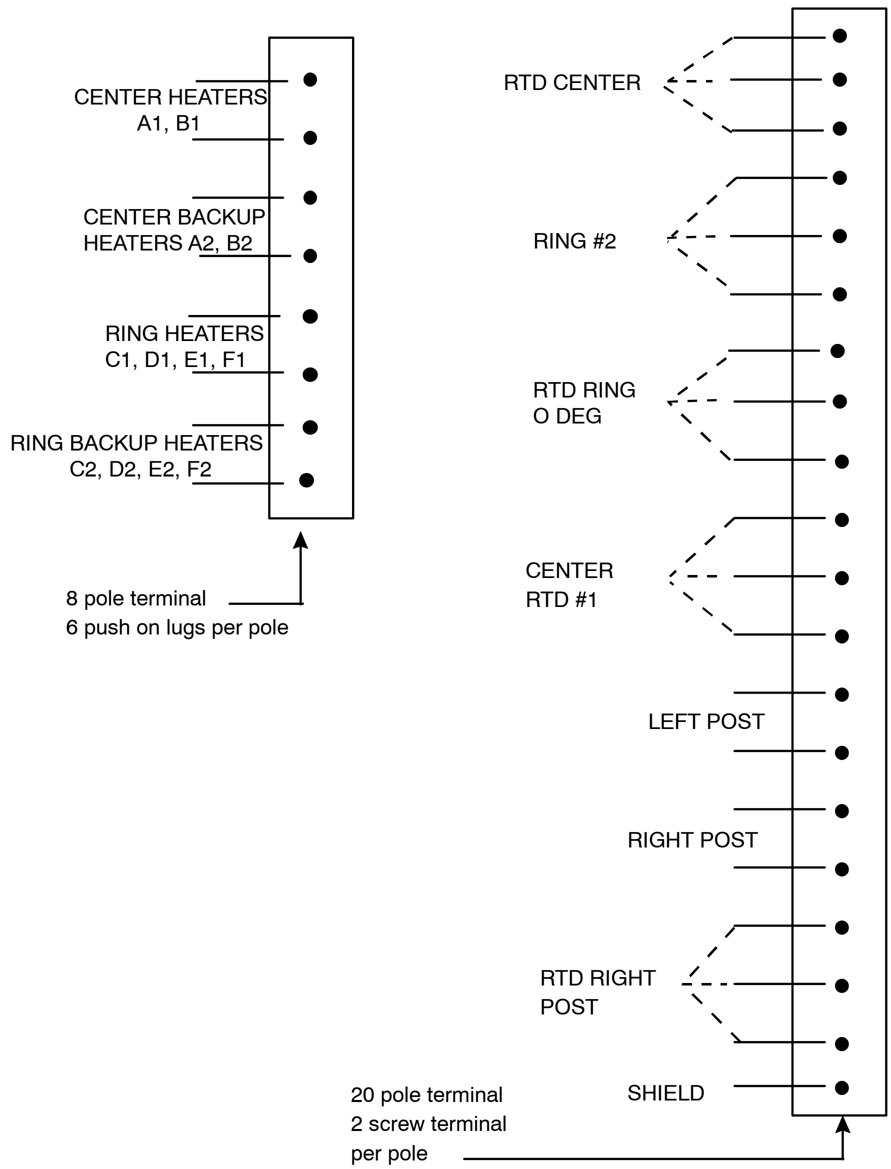

**NMR MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAM,**
**LOWER MAGNET TERMINAL BLOCKS – ARGUS 3**
ILLUSTRATION 5–2

## SECTION 5 – MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAMS ( continued )



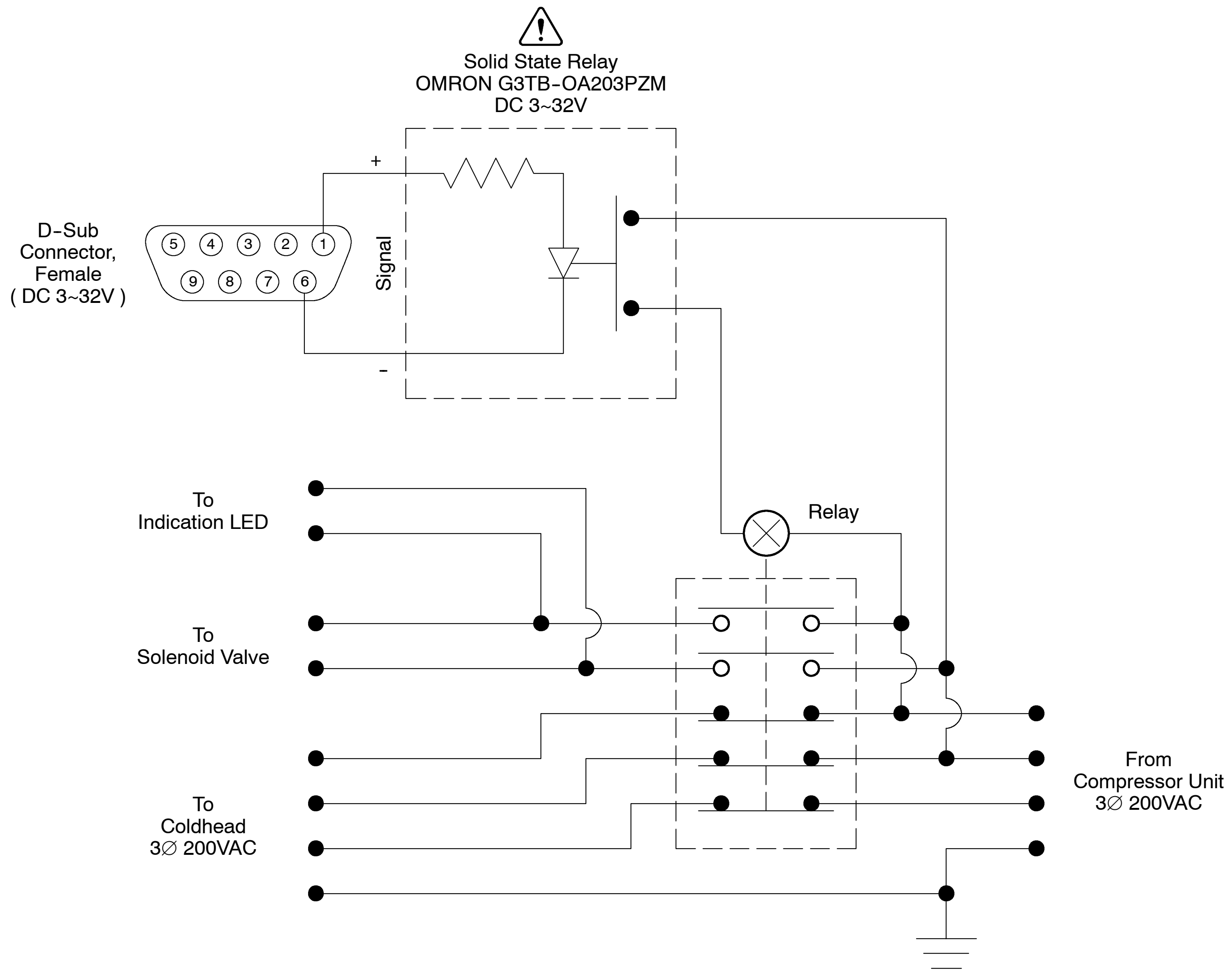

**NMR MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAM,**
**UPPER MAGNET TERMINAL BLOCKS – ARGUS 4, 5 AND 6**
ILLUSTRATION 5-3

## SECTION 5 – MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAMS ( continued )



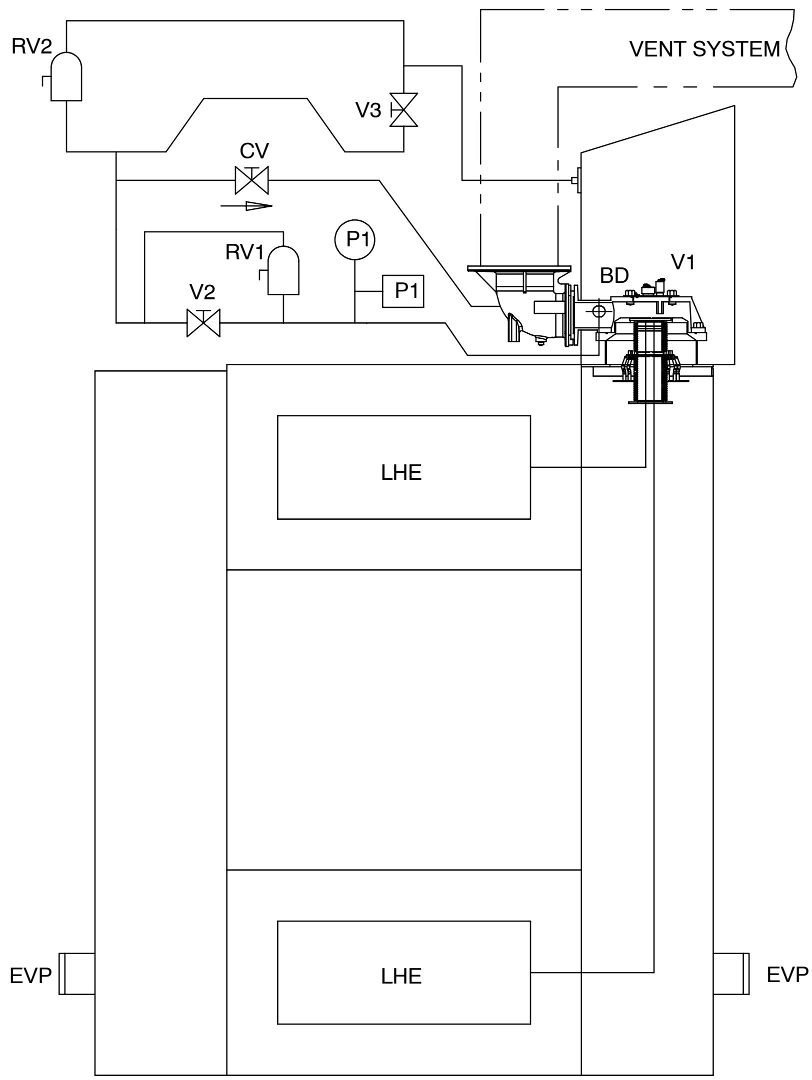

**NMR MAGNET IRON POLE / POSTS HEATER CONNECTOR DIAGRAM,**
**LOWER MAGNET TERMINAL BLOCKS – ARGUS 4, 5 AND 6**
ILLUSTRATION 5–4

# SECTION 6 – CRYOCOOLER BYPASS UNIT SCHEMATIC




**CRYOCOOLER BYPASS UNIT SCHEMATIC**
ILLUSTRATION 6-1

# SECTION 7 - MAGNET PLUMBING SCHEMATIC




| | |
|---|---|
| V1 | Helium Fill |
| V2 | Vent Valve |
| V3 | Shield Vent Valve |
| BD | 12 psig Burst Disk |
| RV1 | 10 psig Relief Valve |
| RV2 | 7.5 psig Relief Valve |
| CV | Check Valve |
| P1 | Helium Vessel Pressure |
| EVP | Evacuation Port |

**MAGNET PLUMBING SCHEMATIC**
ILLUSTRATION 7-1

# RENEWAL PARTS

## TABLE OF CONTENTS

# TABLE OF CONTENTS

# SECTION 1 – MAGNET SYSTEM

TABLE 1–1
**MAGNET MODEL / ASSEMBLY NUMBERS**

| MAGNET MODEL NUMBER | MAGNET ASSEMBLY NUMBER |
|---|---|
| 2228677 | 2244211 |

## 1–1 GE 0.7T OPEN*SPEED* MAGNET SYSTEM

**MAGNET SHIPPING COLLECTOR 2228677 REV. 4**
**MAGNET SHIPPING COLLECTOR, WITH MOUNTING PLATE 2228677–2 REV. 1**
**MAGNET SHIPPING COLLECTOR,**
**TRANSPORTABLE / RELOCATABLE WITH MOUNTING PLATE 2228677–3 REV. 1**
**MAGNET SHIPPING COLLECTOR, SEISMIC WITH MOUNTING PLATE 2228677–4 REV. 1**

| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 1 | 46–252065P133 | N | Liquid Helium | 380 | Preloaded liquid helium, liters |
| 2 | 2259409 | N | Manuals | 1 | GE & vendor service manuals |
| 3 | 2259620 | N | Pen. Panel | 1 | Penetration Panel Assembly |
| 4 | 2270347[c] | N | Mounting Kit | 1 | Magnet Mounting Kit, without Mounting Plate |
| 4A | 2270347–2[d] | N | Mounting Kit | 1 | Magnet Mounting Kit, with Mounting Plate |
| 4B | 2270347–3[e] | N | Mounting Kit | 1 | Magnet Mounting Kit, Seismic with Mounting Plate |
| 5 | 2271500 | N | Table Kit | 1 | Open*Speed* Table Installation Kit |
| 6 | 46–260852G3 | 2 | Vacuum Tool | 1 | Emergency Evacuation Release Tool |
| 7 | 46–318057G5 | 1 | Vent Kit | 1 | Magnet Vent Kit |
| 8 | 46–252283P68 | N | Cable Tie | 100 | Cable Tie, .190 In. x 14 In. |
| 9 | 46–294232G4 | N | Spare Parts | 1 | Field Spare Parts Kit |
| 10 | 46–258770G4 | 2 | Sign Kit | 1 | Warning Sign and Label Kit |
| 11 | 2128700 | 2 | MRU Kit | 1 | Magnet Rundown Unit ( MRU ) Kit |
| 12 | 2256565 | 2 | Ladder | 1 | Service Platform / Ladder |
| 13 | 2207855 | N | Shielding Kit | 1 | RF Shielding Kit |
| 14 | 2254862–3 | 1 | Shim Kit | 1 | Field Shim Kit |
| 15 | 2219400 | 1 | Monitor | 1 | Magnet Monitor |
| 16A | 2265809 | 2 | Monitor Cable | 1 | Magnet Monitor Cable Kit |
| 16B | 2265809–2[f] | 2 | Monitor Cable | 1 | Magnet Monitor Cable Kit, Transportable / Relocatable |
| 17 | 2219341 | 1 | Sensor Amp. | 1 | Ruthenium Oxide Sensor Amplifier |
| 18 | 2271499 | 2 | Coldhead Cable | 1 | Coldhead Adapter Cable, Shielded |
| 19 | 2276094 | 2 | Power Supply | 1 | Uninterruptible Power Supply |
| 20 | 2245794 | 1 | Modem | 1 | Global Modem Kit |
| 21 | 2266628 | N | Alarm | 1 | Magnet Monitor Remote Alarm Box |
| 22 | 2232300 | 2 | Shroud | 1 | Protective Poly Bubble Shroud |
| 23 | 2255503 | N | Crate | 1 | Domestic Shipping Crate |

## 1-1 GE 0.7T OPEN*SPEED* MAGNET SYSTEM ( continued )

| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 24 | 2188940-2 | 1 | Compressor | 2 | High Voltage CSW-71D Shield Cooler Compressor |
| 25[a] | 2188184-2 | 1 | Compressor | 2 | Low Voltage CSW-71C Shield Cooler Compressor |
| 26[b] | 2266223 | 1 | Bypass Unit | 1 | Sumitomo Compressor Bypass Unit |

[a] Alternate to item 24.
[b] Included in M2060JW and M2060JY Compressor kits for 2188940-2 and 2188184-2 Compressors, respectively, but shown here for convenience.
[c] Included in 2228677 only.
[d] Included in 2228677-2 and 2228677-3.
[e] Included in 2228677-4 only.
[f] Included in 2228677-3 only.

## 1-2 WATER-COOLED COMPRESSOR KITS

### 1-2-1 High Voltage Water-Cooled Compressor Kit — M2060JW REV. 2
### Low Voltage Water-Cooled Compressor Kit — M2060JY REV. 2

| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 1A[a] | 2188440-2 | 1 | Compressor | 2 | High Voltage CSW-71D Shield Cooler Compressor |
| 1B[b] | 2188184-2 | 1 | Compressor | 2 | Low Voltage CSW-71C Shield Cooler Compressor |
| 2A[a] | 2274978 | 2 | Compressor Kit | 2 | HV Compressor Kit with 5 M ( 16.4 Ft. ) Power Cable |
| 2B[b] | 2274978-2 | 2 | Compressor Kit | 2 | LV Compressor Kit with 5 M ( 16.4 Ft. ) Power Cable |
| 3 | 2266223 | 1 | Bypass Unit | 1 | Compressor Bypass Unit |
| 4 | 2266223-2 | N | Cable | 1 | Bypass Unit Junction Cable |
| 5 | 2251611 | 2 | Raceway | 4 | Flexible Raceway, 50 Ft. ( 15.24 M ) |
| 6 | 2273967 | 2 | Adapter | 2 | Flexline Adapter Elbow, Supply |
| 7 | 2237967-2 | 2 | Adapter | 2 | Flexline Adapter Elbow, Return |

[a] Included in M2060JW only.
[b] Included in M2060JY only.

### 1-2-2 HV Compressor Kit with 5 M ( 16.4 Ft. ) Power Cable — 2274978 REV. 0
### LV Compressor Kit with 5 M ( 16.4 Ft. ) Power Cable — 2274978-2 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 1 | 2154502-2 | 1 | Flexline | 1 | Flexible Gas Supply Line, 20 M ( 65.6 Ft. ) |
| 2 | 2154505-2 | 1 | Flexline | 1 | Flexible Gas Return Line, 20 M ( 65.6 Ft. ) |
| 3 | 2259837 | N | Cable | 1 | Coldhead Control Cable Assembly |
| 4A[a] | 2274831 | 1 | Cable | 1 | HV Compressor Power Input Cable, 5 M ( 16.4 Ft. ) |
| 4B[b] | 2274830 | 1 | Cable | 1 | LV Compressor Power Input Cable, 5 M ( 16.4 Ft. ) |

[a] Included in kit 2274978 only.
[b] Included in kit 2274978-2 only.

## 1-3 MANUALS

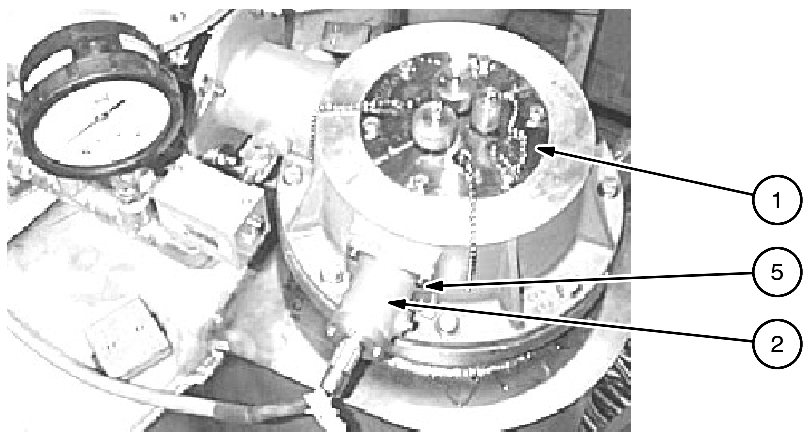
### GE & VENDOR SERVICE MANUALS 2259409 REV. 0

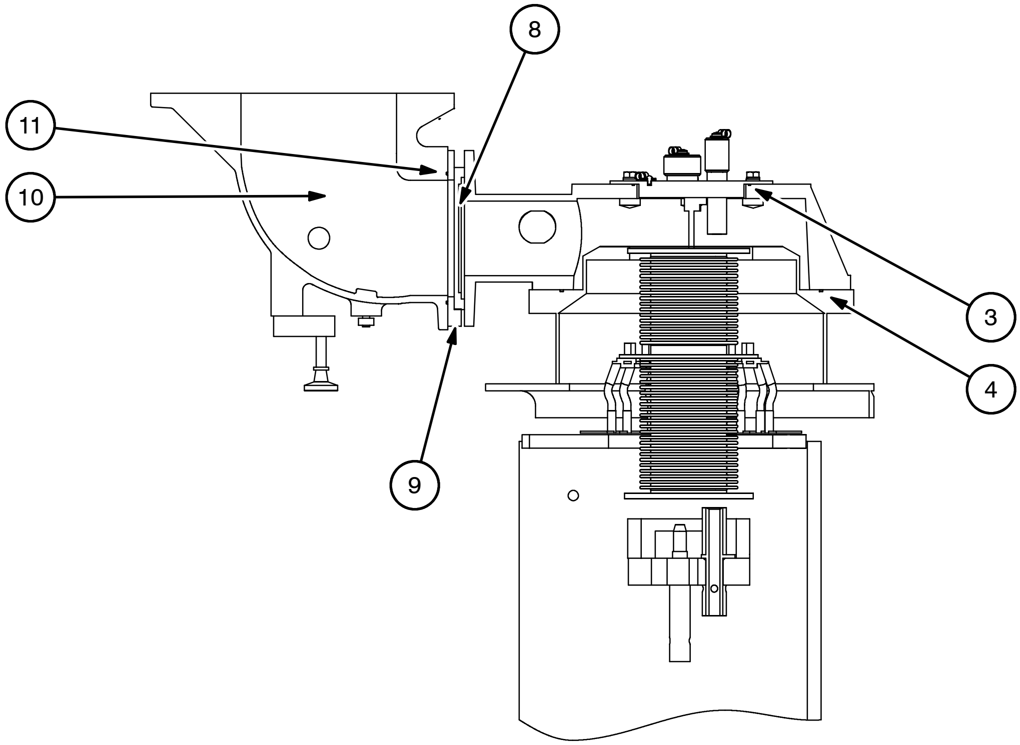
| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 1 | 2231934 | N | Manual | 1 | GE 0.7T Open*Speed* Magnet & Cryogens Subsystem |
| 2 | 2243897 | N | Manual | 1 | GE 0.7T Open*Speed* Magnet Delivery & Installation |
| 3 | 2114641 | N | Manual | 1 | Magnet Monitoring Hardware Installation |
| 4 | 46-318393 | N | Manual | 1 | Magnet Rundown Unit ( MRU ) Service Manual |
| 5 | 46-318394 | N | Manual | 1 | Magnet Rundown Unit ( MRU ) Operation Manual |
| 6 | 2262271 | N | Manual | 1 | Sumitomo Cryocooler Manual Set |

# SECTION 2 – MAGNET COMPONENTS

## 2–1 MAGNET COMPONENTS

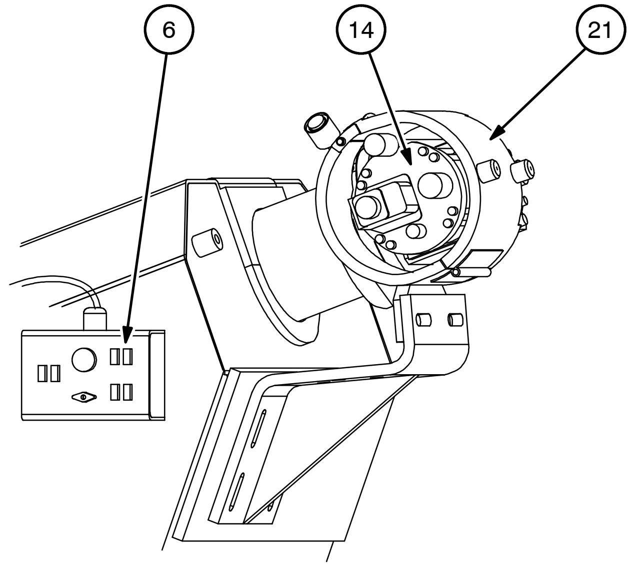
### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY 2244211 REV. 3 & 7

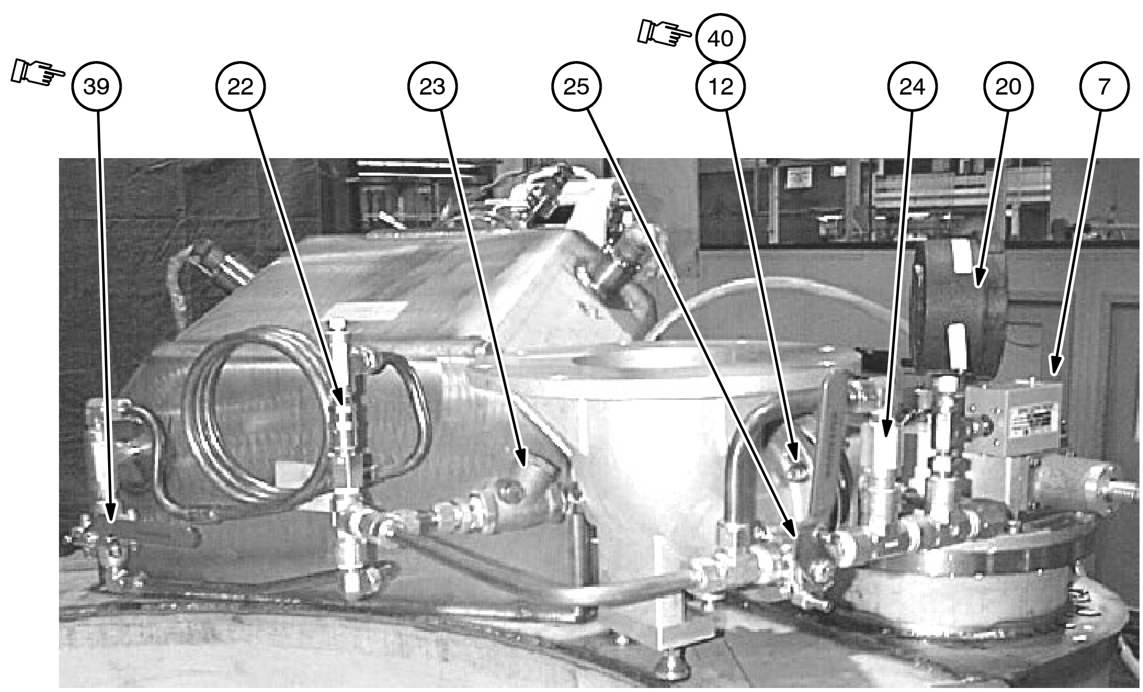


## 2-1 MAGNET COMPONENTS ( continued )

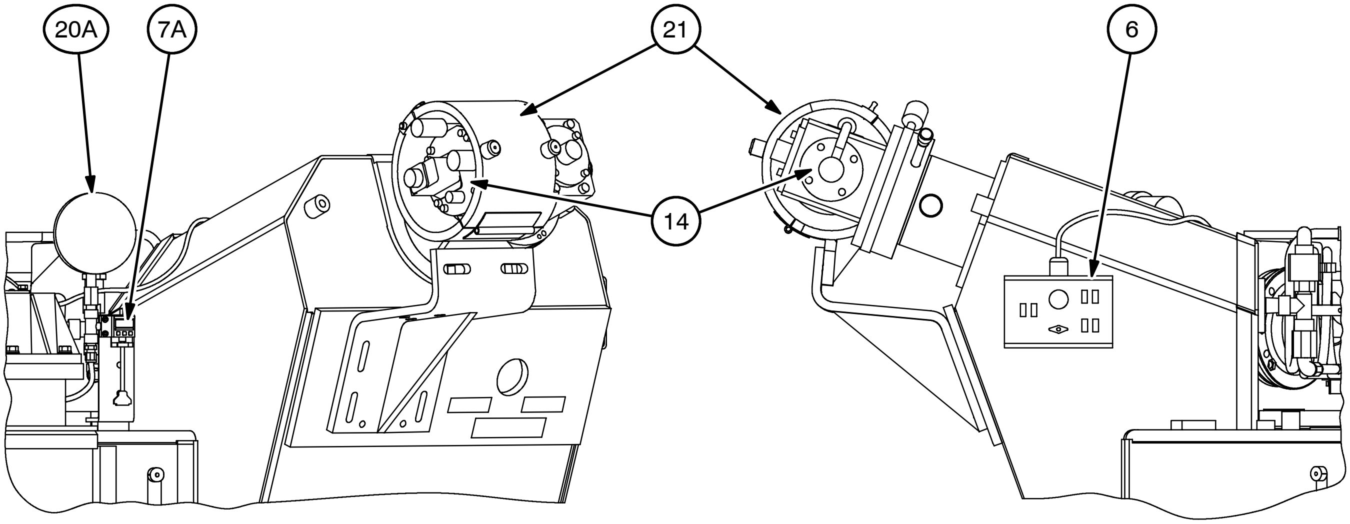
### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY 2244211 REV. 3

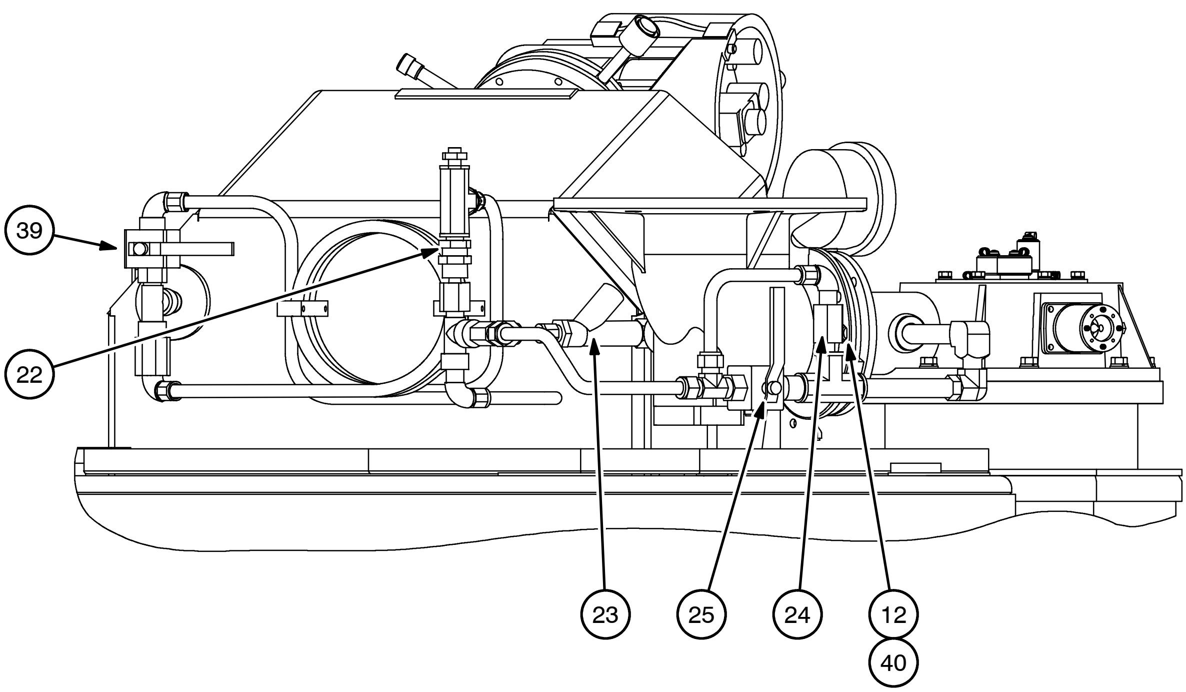


## 2-1 MAGNET COMPONENTS ( continued )

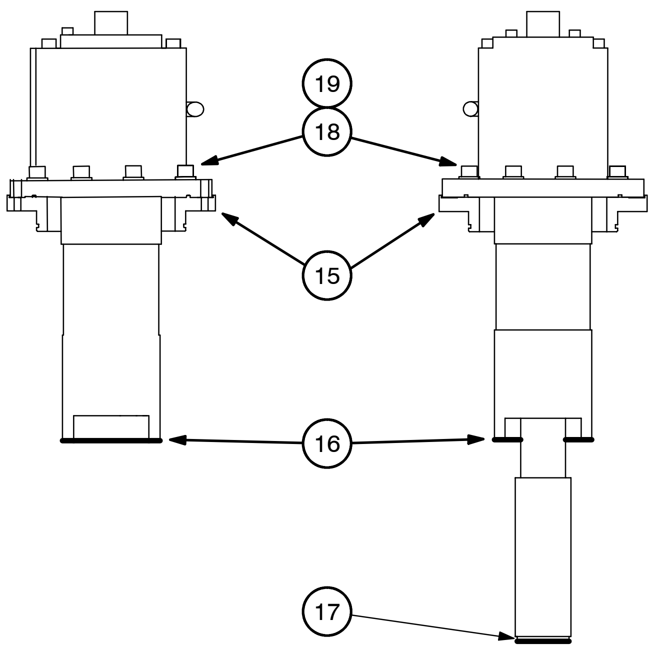
### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY 2244211 REV. 7

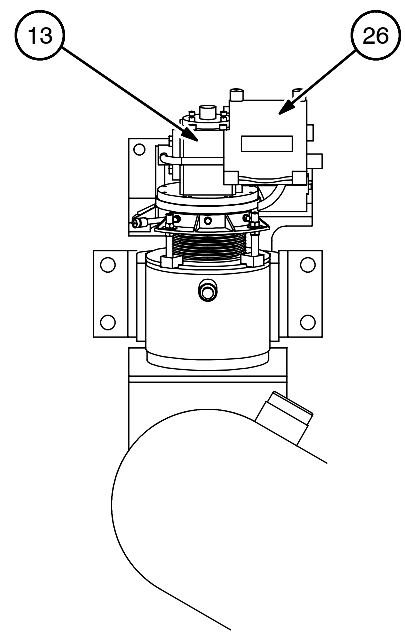


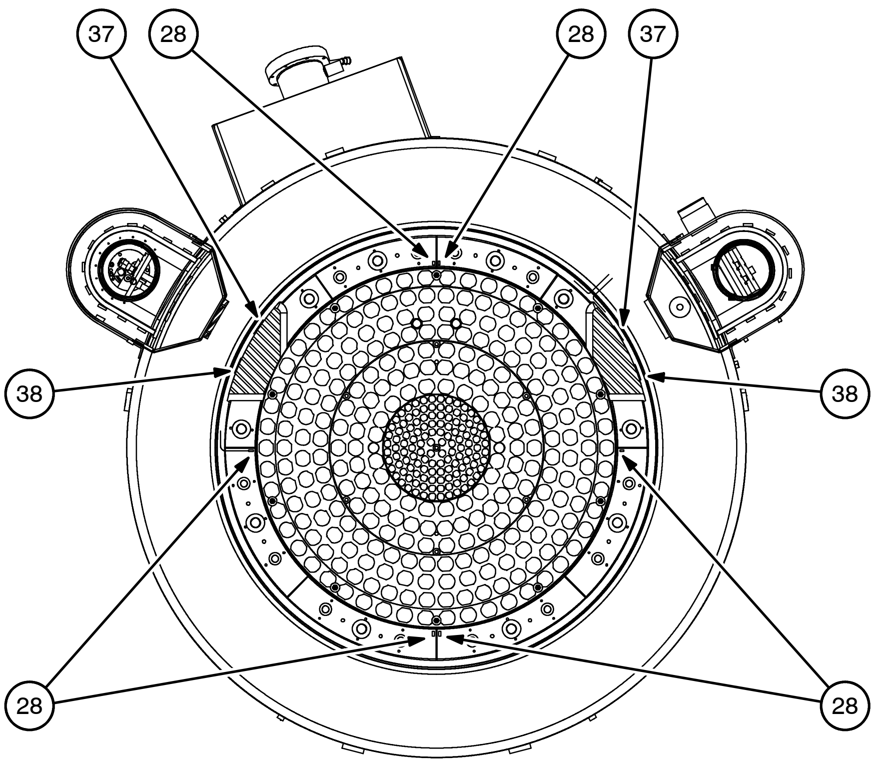



## 2-1 MAGNET COMPONENTS ( continued )

### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY **2244211 REV. 3 & 7**



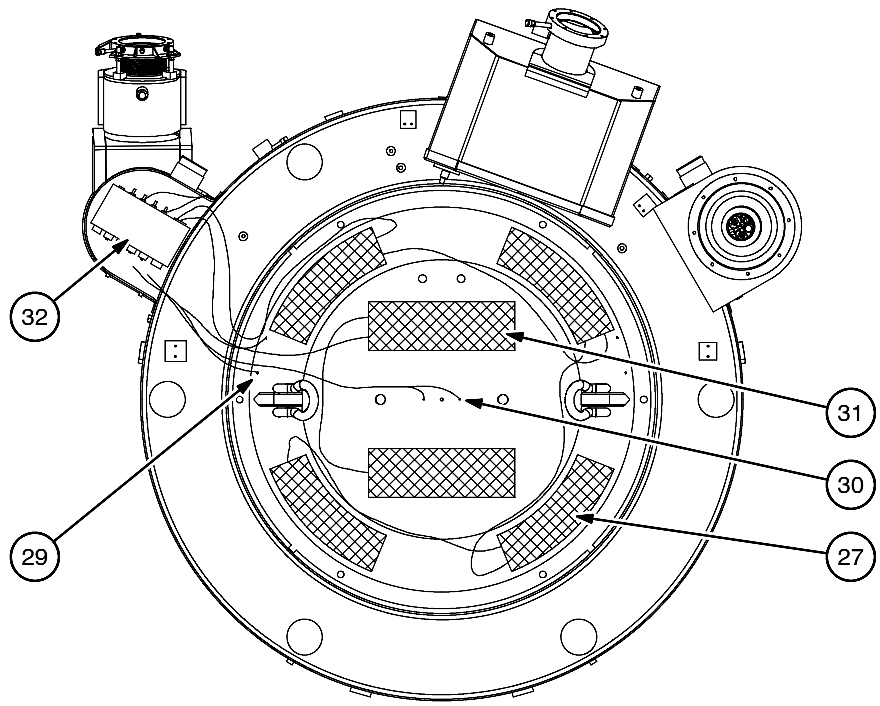



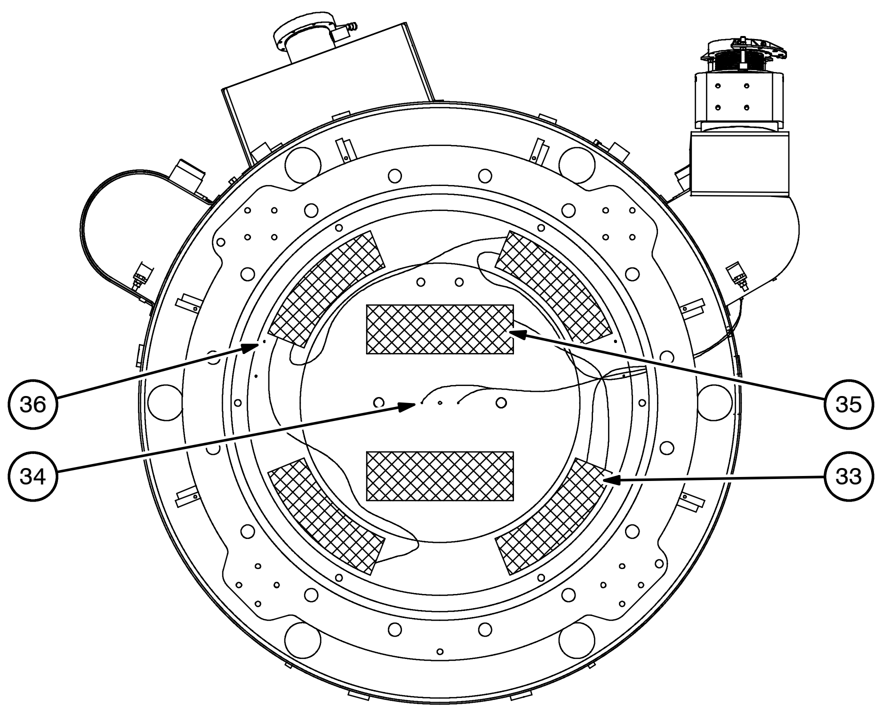
## 2–1 MAGNET COMPONENTS ( continued )

## GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY 2244211 REV. 3 &. 7

**Top ( Looking Down )**




**Bottom ( Looking Up )**



## 2-1 MAGNET COMPONENTS ( continued )

### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY 2244211 REV. 3 & 7

| Item | Part Number | FRU | Name | Qty. | Description | Magnet Assembly* 2244211 Rev. 3 | Magnet Assembly** 2244211 Rev. 7 | Plumbing Assembly 2260854 Rev. 0 | Plumbing & Turret Asm. 2287975 Rev. 1 | Cryostat & Iron Asm. 2244209 Rev. 5 | Cryostat & Iron Asm. 2244209 Rev. 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| * | **2260854 Rev. 0** | | | | **Plumbing Assembly** | **X** | – | | | | |
| ** | **2287975 Rev. 1** | | | | **Plumbing & Turret Assembly** | – | **X** | | | | |
| * | **2244209 Rev. 5** | | | | **Cryostat & Iron Assembly** | **X** | – | | | | |
| ** | **2244209 Rev. 7** | | | | **Cryostat & Iron Assembly** | – | **X** | | | | |
| 1 | 2223686 | N | Pen. Cover | 1 | Penetration Cover Plate Assembly | X | X | – | – | – | – |
| 2 | 2226951 | 1 | Instr. Lead | 1 | Instrumentation Lead Assembly | X | X | – | – | – | – |
| 3 | 46-281101P1 | 1 | O-Ring | 1 | O-Ring, 4.239 in. ID x .070 in. thick | X | X | – | – | – | – |
| 4 | 46-281101P6 | 1 | O-Ring | 1 | O-Ring, 9.487 in. ID x .103 in. thick | X | X | – | – | – | – |
| 5 | 46-281101P9 | 1 | O-Ring | 1 | O-Ring, 1.487 in. ID x .103 in. thick | X | X | – | – | – | – |
| 6 | 2248447 | 2 | Wiring Box | 1 | Instrument Wiring Box Assembly | X | X | – | – | – | – |
| 7 | 2266040 | 2 | Transducer Box | 1 | Transducer Box & Gauge Asm. | – | – | X | – | – | – |
| 7A | 2299843 | 1 | Transducer | 1 | Pressure Transducer | – | X | – | – | – | – |
| 8 | 2319285-2 | 1 | Burst Disk | 1 | Burst Disk, 12 psi | – | – | X | X | – | – |
| 9 | 2245511 | 2 | Flange | 1 | Burst Disk Flange | – | – | X | X | – | – |
| 10 | 2253376 | N | Vent Adapter | 1 | Cast Vent Adapter | – | – | X | X | – | – |
| 11 | 46-281101P8 | 1 | O-Ring | 1 | O-Ring, 4.739 in. ID x .070 in. thick | – | – | X | X | – | – |
| 12 | 46-281387P13 | 1 | Washer | 6 | Belleville Washer, .375 in. nominal | – | – | X | X | – | – |
| 13 | 2244334 | 1 | Coldhead | 1 | Single Stage Coldhead | X | X | – | – | – | – |
| 14 | 2218465 | 1 | Coldhead | 1 | Dual Stage Coldhead | X | X | – | – | – | – |
| 15 | 46-281247P1 | 1 | O-Ring | 2 | O-Ring, 4.987 in. ID x .103 in. thick | X | X | – | – | – | – |
| 16 | 46-281241P1 | 1 | Indium Gasket | 2 | Large Indium Gasket, 3.37 in. OD | X | X | – | – | – | – |
| 17 | 46-294878P13 | 1 | Indium Wire | 3.5 ft. | Indium Wire, .06 in. OD x 500 ft. | X | X | – | – | – | – |
| 18 | 46-318764P46 | 2 | Screw | 16 | Socket head cap screw, M6 X 60 | X | X | – | – | – | – |
| 19 | 2173358 | 1 | Washer | 96 | Belleville Washer, 6.2 mm ID, SS | X | X | – | – | – | – |
| 20 | 2271544 | 2 | Gauge | 1 | 0-15 psig Pressure Gauge | – | – | X | – | – | – |
| 20A | 2249367 | 2 | Gauge | 1 | 0-15 psig Pressure Gauge | – | X | – | – | – | – |
| 21 | 2187575 | N | Motor Shield | 1 | Coldhead Motor Shield, Dual Stage | X | X | – | – | – | – |
| 22 | 2242756 | 1 | Valve | 1 | 7.5 psig Relief Valve | – | – | X | X | – | – |
| 23 | 46-260926P1 | 2 | Valve | 1 | Check Valve | – | – | X | X | – | – |
| 24 | 2268107 | 1 | Valve | 1 | 10 psig Relief Valve | – | – | X | X | – | – |
| 25 | 46-252223P1 | 2 | Valve | 1 | Cryogenic Ball Valve | – | – | X | X | – | – |
| 26 | 2187575 | N | Motor Shield | 1 | Coldhead Motor Shield, Single Stage | X | X | – | – | – | – |
| 27 | 2267036-3 | N | Heater | 1 | Top Magnet Ring Heater | – | – | – | – | X | X |
| 28 | 2271365-2 | 1 | Sensor | 1 | Z2 Flat Temperature Sensor | – | X | – | – | X | – |

* Magnet Assembly 224411 Rev. 3 includes Plumbing Assembly 2260854 and Cryostat and Iron Assembly 2244209 Rev.5.
** Magnet Assembly 224411 Rev. 6 includes Plumbing and Turret Assembly 2287975 and Cryostat and Iron Assembly 2244209 Rev. 7.

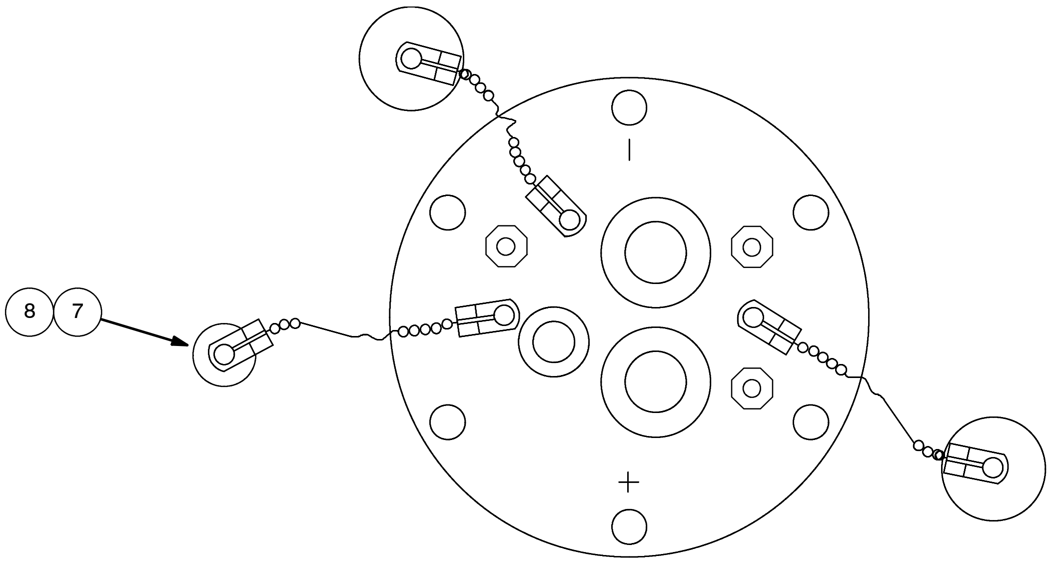
## 2-1 MAGNET COMPONENTS ( continued )

### GE 0.7T OPEN*SPEED* MAGNET ASSEMBLY ( continued ) 2244211 REV. 3 & 7

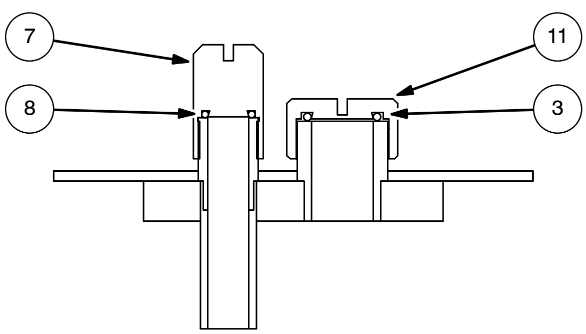
| Item | Part Number | FRU | Name | Qty. | Description | Magnet Assembly* 2244211 Rev. 3 | Magnet Assembly** 2244211 Rev. 7 | Plumbing Assembly 2260854 Rev. 0 | Plumbing & Turret Asm. 2287975 Rev. 1 | Cryostat & Iron Asm. 2244209 Rev. 5 | Cryostat & Iron Asm. 2244209 Rev. 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 2268386-2 | N | Sensor | 1 | Top Magnet Ring Temp. Sensor | - | - | - | - | X | X |
| 30 | 2268386 | N | Sensor | 1 | Top Magnet Center Temp. Sensor | - | - | - | - | X | X |
| 31 | 2267036-4 | N | Heater | 1 | Top Center Magnet Heater | - | - | - | - | X | X |
| 32 | 2269994 | 1 | Connector Box | 1 | Heater Connector Box | - | X | - | - | X | - |
| 33 | 2267036 | N | Heater | 1 | Bottom Magnet Ring Heater | - | - | - | - | X | X |
| 34 | 2268386-3 | N | Sensor | 1 | Bottom Magnet Center Temp. Sensor | - | - | - | - | X | X |
| 35 | 2267036-2 | N | Heater | 1 | Bottom Magnet Center Heater | - | - | - | - | X | X |
| 36 | 2268386-4 | N | Sensor | 1 | Bottom Magnet Ring Temp. Sensor | - | - | - | - | X | X |
| 37 | 2267036-5 | N | Heater | 1 | Post Heater | - | X | - | - | X | - |
| 38 | 2268387 | N | Sensor | 1 | Flat Post Heater Temp. Sensor | - | X | - | - | X | - |
| 39 | 2268206 | 2 | V3 Valve | 1 | V3 Valve Assembly | X | - | - | - | - | - |
| 39A | 2287970 | N | V3 Valve | 1 | V3 Valve Assembly | - | X | - | - | - | - |
| 40 | 46-252365P9 | 2 | Screw | 6 | Cap Screw, .375-16UNC x 1.75 in. | - | - | X | X | - | - |

* Magnet Assembly 224411 Rev. 3 includes Plumbing Assembly 2260854 and Cryostat and Iron Assembly 2244209 Rev.5.
** Magnet Assembly 224411 Rev. 6 includes Plumbing and Turret Assembly 2287975 and Cryostat and Iron Assembly 2244209 Rev. 7.

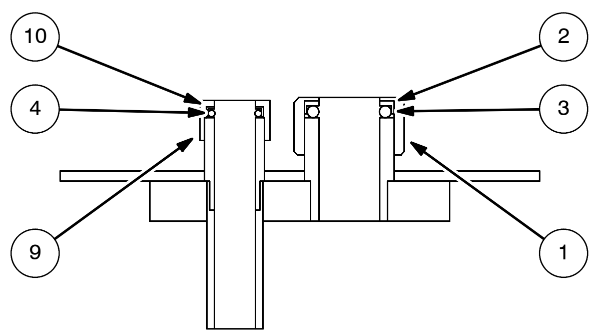
## 2-2 COVER PLATE COMPONENTS




**Top View**




**Shipping / Operating Configuration**




**Ramping Configuration**

### PENETRATION COVER PLATE ASSEMBLY 2223686 REV. 2

| Item | Part Number | FRU | Name | Quantity | Description ( Remarks ) |
|---|---|---|---|---|---|
| 1 | 46-294104P1 | 1 | Nut | 2 | Vacuum Nut, quick-coupling |
| 2 | 46-294105P1 | 1 | Retaining Ring | 2 | Retaining Ring, quick coupling |
| 3 | 46-260389P3 | 1 | O-Ring | 4 | Nitrile ( buna-n ) O-Ring, Parker #2-116 |
| 4 | 46-260342P10 | 1 | O-Ring | 1 | Silicone O-Ring, Parker #2-112 |
| 5 | | | | | Not Used |
| 6 | | | | | Not Used |
| 7 | 2326325 | 2 | Cap | 1 | Extended Cap Assembly |
| 8 | 46-260389P4 | 1 | O-Ring | 1 | Silicone O-Ring, Parker #2-205 |
| 9 | 46-318619P1 | 2 | Nut | 1 | Extended Coupling Nut |
| 10 | 46-260272P1 | 2 | Retaining Ring | 1 | Retaining Ring, quick coupling |
| 11 | 2184199 | 2 | Cap | 2 | Vacuum Coupling Cap |

# SECTION 3 – MAGNET ACCESSORIES

## 3–1 SUMITOMO SHIELD COOLER COMPRESSOR 2188440–2
## ( Part Number Cross Reference, Supplier P/N* to GE P/N )

| Item | Supplier Part Number* | FRU | Description | GE Part Number |
|---|---|---|---|---|
| 1 | RE71TN0408 | 1 | Adsorber | 2172241 |
| 2 | RE38VT0689 | N | Hose Nipple, 12 x .375 in. | 2205309 |
| 3 | RE71WT0600 | 1 | Fuse, 2A | 2191112 |
| 4 | RE71WT0602 | 1 | Class G Fuse, 2A | 2191112–2 |
| 5 | RE71WT0601 | 1 | Class G Fuse, 3A | 2191112–3 |
| 6 | RE71WT0603 | 1 | Class G Fuse, 5A | 2191112–4 |
| 7 | RE71WN0538 | 1 | Phase Failure Relay | 2191112–5 |
| 8 | RD42ZT0697 | 1 | O–Ring | 2191112–6 |
| 9 | RE71WT701 | 1 | Class G Fuse, 4A | 2191112–7 |
| 10 | H7ET–FBV | 1 | Hour Meter | 2191112–8 |
| 11 | RE71WT0768 | 1 | Class G Fuse, 1A | 2191112–9 |
| 12 | RE71WT0767 | 1 | Glass Body Fuse, 1A | 2191112–10 |

* Supplier parts shown in supplier service manual.

## 3–2 MRU KIT ASSEMBLY 2128700 REV. 0

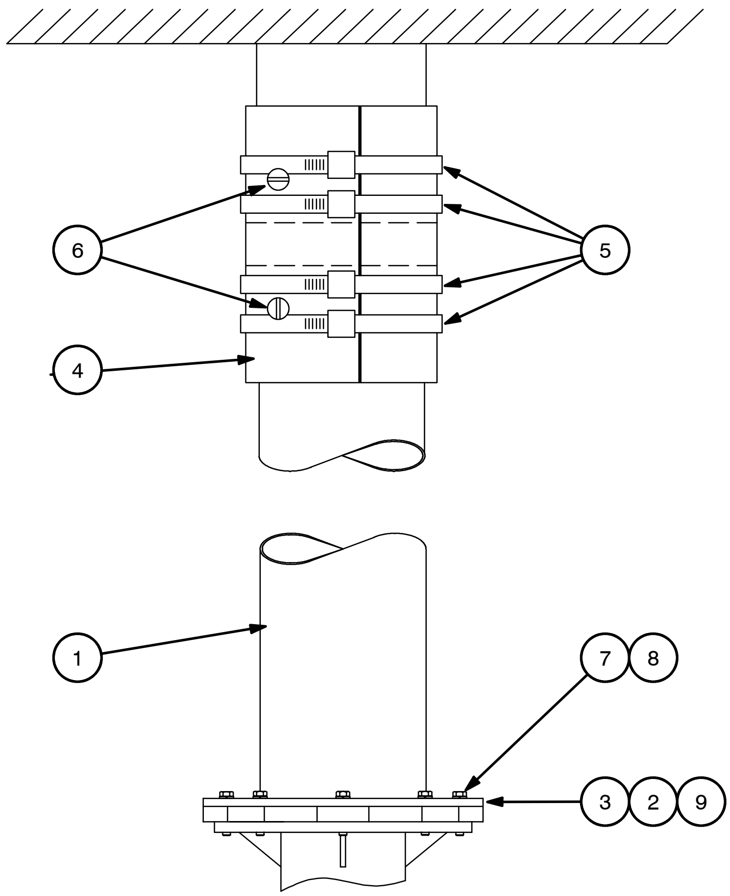
| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 46–294231G1 | 1 | MRU | 1 | Magnet Rundown Unit |
| 2 | 2128699 | 1 | Cable | 1 | Shielded Cable |

## 3–3 MAGNET RUNDOWN UNIT 46–294231G1 REV. 6

| Item | Vendor Part Number* | FRU | Description | GE Part Number |
|---|---|---|---|---|
| 1 | EF1001 | 1 | Fuse, F1, 110VAC .400 GDC Time Lag | 46–294231P1 |
| 2 | EF1002 | 1 | Fuse, F1, 220VAC .125 GDC Time Lag | 46–294231P2 |
| 3 | EF1008 | 1 | Fuse, F2, 2.5A GDC Time Lag | 46–294231P3 |
| 4 | EF1004 | 1 | Fuse, F3/F4, 1.25A GDB | 46–294231P4 |
| 5 | GS4063 | 1 | Battery, Gel Cel 6V 1.2AH Yuasa NP1.2–6 | 46–294231P5 |
| 6 | EC1140 | 1 | Capacitor, C1, 470uF, 50V | 46–294231P6 |

* Supplier parts shown in supplier service manual.

## 3-4 VENT KIT ASSEMBLY




### VENT KIT ASSEMBLY 46-318057G5 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2258644-2 | 2 | Pipe | 1 | Vent Pipe, 8 in. OD X 12 in. |
| 2 | 46-281101P2 | 1 | O-Ring | 1 | Teflon O-Ring, #2-172, 8.237 in. ID x .103 in. thick |
| 3 | 46-318043P1 | 2 | Clamp Ring | 1 | Clamp Ring, #304 stainless steel |
| 4 | 46-281971P2 | 1 | Connector | 1 | Fiberglass Connector Sleeve, 8 in. X 80 in. |
| 5 | 46-281972P2 | 2 | Hose Clamp | 4 | Hose Clamp, stainless steel |
| 6 | 46-318057P1 | N | Screw | 2 | Pan Head Screw, #10 x 1 in., self-tapping, stainless steel |
| 7 | 46-252635P9 | 1 | Washer | 8 | Washer, .375 in. nom., stainless steel |
| 8 | 46-281046P38 | N | Screw | 8 | Hex Head Cap Screw, .375-16 x 1.75 in., brass |
| 9 | 2262680 | 2 | Clamp Ring | 1 | Clamp Ring |

## 3-5 FIELD SPARE PARTS KIT 46-294232G4 REV 2

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | | | | | Not Used |
| 2 | 2319285-2 | 1 | Burst Disc | 1 | Burst Disc, 12 psig |
| 3 | 46-260389P1 | 1 | O-Ring | 4 | Silicone O-Ring, #2-116 |
| 4 | 46-260389P2 | 1 | O-Ring | 2 | Silicone O-Ring, #2-014 |
| 5 | 46-281101P1 | 1 | O-Ring | 2 | Teflon O-Ring, #2-046, 4.239 in. ID x .070 in. thick |
| 6 | 46-281101P6 | 1 | O-Ring | 2 | Teflon O-Ring, #2-177, 9.487 in. ID x .103 in. thick |
| 7 | 46-281101P8 | 1 | O-Ring | 2 | Teflon O-Ring, #2-048, 4.739 in. ID x .070 in. thick |
| 8 | 46-281101P9 | 1 | O-Ring | 2 | Teflon O-Ring, #2-128, 1.487 in. ID x .103 in. thick |
| 9 | 2250653 | 2 | Hold-Down Tool | 1 | Ramp Lead Hold-Down Tool Assembly |
| 10 | 2243789 | 2 | Pen. Cover | 1 | Penetration Cover Assembly |
| 11 | 46-260902P5 | 2 | Plug | 1 | Tube Plug, .25 in. OD, brass |
| 12 | | | | | Not Used |

## 3-6 CRYOCOOLER REPLACEMENT GASKETS KIT 2171620 REV. 3

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2191112-6 | 1 | O-Ring | 1 | O-Ring, Sumitomo p/n RD42ZT0697 |
| 2 | 46-281247P1 | 1 | O-Ring | 1 | O-Ring, #2-159, 4.987 in. ID x .103 in. thick |
| 3 | 46-281241P1 | 1 | Indium Gasket | 1 | Large Indium Gasket, 3.37 in. OD |
| 4* | 2171621 | 1 | Indium Gasket | 1 | Small Indium Gasket Wire & Mold Kit |
| 4A* | 2151863 | 2 | Gasket Mold | 1 | Indium Gasket Mold |
| 4B* | 46-294878P13 | 1 | Indium Wire | 1 | Indium Wire, .06 in. OD x 3.458 ft. |
| 5 | 46-252065P64 | N | Gloves | 1 | Cotton Gloves |
| 6 | 2188185 | 1 | Gauge | 1 | Feeler Gauge, 0.003 in., green |
| 7 | 2188185-2 | 1 | Gauge | 1 | Feeler Gauge, 0.005 in., blue |
| 8 | 2290272 | 1 | Getter Bag Kit | 1 | Charcoal Getter Bag Kit |

* Item 4 consists of items 4a and 4b, which can be ordered separately.

## 3-7 RF SHIELDING KIT 2207855 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 46-260860G1 | 2 | Adapter | 2 | RF Penetration Assembly Adapter |
| 2 | 46-318068P1 | 2 | Wool | 6 | Bronze Wool |
| 3 | 46-252283P22 | N | Tie | 3 | Cable Tie |

## 3-8 SUMITOMO WATER-COOLED, HIGH VOLTAGE COMPRESSOR KIT 2211446 REV. 1

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2154502-2 | 1 | He Gas Line | 1 | Helium Supply Line, 65.6 ft. ( 20 M ) |
| 2 | 2154505-2 | 1 | He Gas Line | 1 | Helium Return Line, 65.6 ft. ( 20 M ) |
| 3* | 2259837 | 1 | Cable Assembly | 1 | Coldhead Control Cable Assembly |
| 3A* | 2155316-2 | 1 | Cable | 1 | Cable, Compressor to Penetration Panel |
| 3B* | 2218292 | 1 | Cable | 1 | Coldhead Control Cable ( Pen. Panel to Coldhead ) |
| 4 | 2200835 | 1 | Cable | 1 | CSW-71D HV Compressor Power Cable, 10 M |

* Item 3 consists of items 3a and 3b, which can be ordered separately.

## 3-9 SUMITOMO WATER-COOLED, HIGH VOLTAGE COMPRESSOR KIT 2274978 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2154502-2 | 1 | He Gas Line | 1 | Helium Supply Line, 65.6 ft. ( 20 M ) |
| 2 | 2154505-2 | 1 | He Gas Line | 1 | Helium Return Line, 65.6 ft. ( 20 M ) |
| 3* | 2259837 | 1 | Cable Assembly | 1 | Coldhead Control Cable Assembly |
| 3A* | 2155316-2 | 1 | Cable | 1 | Cable, Compressor to Penetration Panel |
| 3B* | 2218292 | 1 | Cable | 1 | Coldhead Control Cable ( Pen. Panel to Coldhead ) |
| 4 | 2274831 | 1 | Cable | 1 | CSW-71D HV Compressor Power Cable, 5 M |

* Item 3 consists of items 3a and 3b, which can be ordered separately.

## 3-10 SUMITOMO WATER-COOLED, LOW VOLTAGE COMPRESSOR KIT 2274978-2 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2154502-2 | 1 | He Gas Line | 1 | Helium Supply Line, 65.6 ft. ( 20 M ) |
| 2 | 2154505-2 | 1 | He Gas Line | 1 | Helium Return Line, 65.6 ft. ( 20 M ) |
| 3* | 2259837 | 1 | Cable Assembly | 1 | Coldhead Control Cable Assembly |
| 3A* | 2155316-2 | 1 | Cable | 1 | Cable, Compressor to Penetration Panel |
| 3B* | 2218292 | 1 | Cable | 1 | Coldhead Control Cable ( Pen. Panel to Coldhead ) |
| 4 | 2274830 | 1 | Cable | 1 | CSW-71C LV Compressor Power Cable, 5 M |

* Item 3 consists of items 3a and 3b, which can be ordered separately.

## 3-11 MAGNET MONITOR CABLE KIT 2265809 REV. 3

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 46-328000G975 | N | Cable | 1 | Cable ( 824 ), PP1-J10 to FJ1 |
| 2 | 46-328000G976 | N | Cable | 1 | Cable ( 829 ), MS1-FJ2 to PP1-J48 |
| 3 | 2263200-40 | N | Cable | 1 | Cable ( 825 ), PP1-J48 TO MSM1-J8 |
| 4 | | | | | Not Used |
| 5 | 46-328000G978 | N | Cable | 1 | Cable ( 826 ), FJ3 to MSM1-A1-J9 |
| 6 | 46-328578P1 | 2 | Cable | 1 | Cable ( 827 ), FJ3 to FJ4 & MS5A5 |
| 7 | 2263200-41 | N | Cable | 1 | Cable ( 823 ), MSM1-J10 to MR2-A11-J24 |
| 8 | 2204485 | 2 | Cable | 1 | SYSCAB Interface Cable |
| 9 | 46-328000G981 | N | Cable | 1 | Cable ( 833 ), FJ4 to MS5-A1-A6-JR |
| 10 | 2333825 | 1 | Sensor Asm | 1 | Water Flow ( Turbine ) / Temperature Sensor Assembly |
| 11 | 46-265067P1 | 2 | Connector | 10 | I / F Panel Cable Screwlock Connector |
| 12 | 2264859 | N | Cable | 1 | Cable ( 919 ), MS1-A1-A4-P302-1 to PP1-J10 |
| 13 | 2279237 | N | Cable | 1 | Magnet Room Interface Cable ( 830 ) |
| 14 | 46-296816P1 | 2 | Adapter | 1 | BNC Tee Adapter, 50 ohm, Amphenol 31-200 |
| 15 | 2263158 | N | Cable | 1 | Cable ( 913 ), MS1-A1-A4-P302-3 to PP1-J62 |
| 16 | 2262699 | 2 | Cable | 1 | Cable ( 914 ), PP1-J62 to FJ5 |
| 17 | 2263160 | 2 | Cable | 1 | Cable ( 915 ), MSM1-A2-J1 to FJ5 |
| 18 | 2263159 | N | Cable | 1 | Cable ( 916 ), MSM1-J7 to FJ1, FJ5 & FJ6 |
| 19 | 2276569 | N | Cable | 1 | Cable ( 939 ), MDP-UPS OUT to MSM4 |
| 20 | 2276568 | N | Cable | 1 | Cable ( 940 ), MSM3-RS-232 to MSM1-J1 |
| 21 | 2271497 | N | Cable | 1 | Ethernet Cable ( 942 ) |
| 22 | 2263200-39 | N | Cable | 1 | Cable ( 941 ), MSM1-J11 to SCC-J1 |
| 23 | 2279530 | N | Strain Relief | 1 | UPS Input Cable Strain Relief |
| 24 | 2279530-2 | N | Strain Relief | 1 | UPS Output Cable Strain Relief |
| 25 | 2279530-3 | N | Strain Relief | 1 | MUX Input Cable Strain Relief |
| 26 | 2279530-4 | N | Strain Relief | 1 | Modem / Magnet Monitor Input Cable Strain Relief |

## 3-12 FIELD SHIM KIT 2254862-3 REV. 0

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | 2248902 | 2 | Pellet | 5,000 | Pellet, 80 mil dia. iron |
| 2 | 2248903-2 | 2 | Pellet | 3,000 | Pellet, .08 in. dia. 85% noryl, red |
| 3 | 2269589 | 2 | Shim Disk | 7 | Shim Disk, small, gray |
| 4 | 2269589-2 | 2 | Shim Disk | 20 | Shim Disk, small, red |
| 5 | 2269589-3 | 2 | Shim Disk | 32 | Shim Disk, small, green |
| 6 | 2269589-4 | 2 | Shim Disk | 44 | Shim Disk, small, yellow |
| 7 | 2269589-5 | 2 | Shim Disk | 56 | Shim Disk, small, purple |
| 8 | 2269589-6 | 2 | Shim Disk | 53 | Shim Disk, small, blue |
| 9 | 2267155 | 2 | Shim Disk | 29 | Shim Disk, large, gray |
| 10 | 2267155-2 | 2 | Shim Disk | 10 | Shim Disk, large, red |
| 11 | 2267155-3 | 2 | Shim Disk | 46 | Shim Disk, large, green |
| 12 | 2267155-4 | 2 | Shim Disk | 39 | Shim Disk, large, yellow |
| 13 | 2257155-5 | 2 | Shim Disk | 46 | Shim Disk, large, purple |
| 14 | 2267155-6 | 2 | Shim Disk | 23 | Shim Disk, large, blue |
| 15 | 2274081-7 | N | Shim Disk | 4 | Loaded Shim Disk, large, gray, 12 pellets |
| 16 | 2274081-8 | N | Shim Disk | 4 | Loaded Shim Disk, large, red, 12 pellets |
| 17 | 2274081-9 | N | Shim Disk | 4 | Loaded Shim Disk, large, green, 12 pellets |
| 18 | 2274081-10 | N | Shim Disk | 4 | Loaded Shim Disk, large, yellow, 12 pellets |
| 19 | 2274081-11 | N | Shim Disk | 4 | Loaded Shim Disk, large, purple, 12 pellets |
| 20 | 2274081-12 | N | Shim Disk | 22 | Loaded Shim Disk, large, blue, 12 pellets |
| 21 | 2270652-11 | 2 | Shim Disk | 9 | Loaded Shim Disk, large, gray, 12 pellets |
| 22 | 2270652-12 | 2 | Shim Disk | 2 | Loaded Shim Disk, large, gray, 24 pellets |
| 23 | 2270652-21 | 2 | Shim Disk | 17 | Loaded Shim Disk, large, red, 12 pellets |
| 24 | 2270652-22 | 2 | Shim Disk | 21 | Loaded Shim Disk, large, red, 24 pellets |
| 25 | 2270652-23 | 2 | Shim Disk | 8 | Loaded Shim Disk, large, red, 49 pellets |
| 26 | 2270652-24 | 2 | Shim Disk | 4 | Loaded Shim Disk, large, red, 74 pellets |
| 27 | 2270652-31 | 2 | Shim Disk | 8 | Loaded Shim Disk, large, green, 12 pellets |
| 28 | 2270652-32 | 2 | Shim Disk | 4 | Loaded Shim Disk, large, green, 24 pellets |
| 29 | 2270652-33 | 2 | Shim Disk | 2 | Loaded Shim Disk, large, green, 49 pellets |
| 30 | 2270652-41 | 2 | Shim Disk | 14 | Loaded Shim Disk, large, yellow, 12 pellets |
| 31 | 2270652-42 | 2 | Shim Disk | 13 | Loaded Shim Disk, large, yellow, 24 pellets |
| 32 | 2270652-43 | 2 | Shim Disk | 9 | Loaded Shim Disk, large, yellow, 49 pellets |
| 33 | 2270652-44 | 2 | Shim Disk | 4 | Loaded Shim Disk, large, yellow, 74 pellets |
| 34 | 2270652-45 | 2 | Shim Disk | 1 | Loaded Shim Disk, large, yellow, 114 pellets |
| 35 | 2270652-51 | 2 | Shim Disk | 7 | Loaded Shim Disk, large, purple, 12 pellets |
| 36 | 2270652-52 | 2 | Shim Disk | 10 | Loaded Shim Disk, large, purple, 24 pellets |
| 37 | 2270652-53 | 2 | Shim Disk | 8 | Loaded Shim Disk, large, purple, 49 pellets |
| 38 | 2270652-54 | 2 | Shim Disk | 7 | Loaded Shim Disk, large, purple, 74 pellets |
| 39 | 2270652-55 | 2 | Shim Disk | 2 | Loaded Shim Disk, large, purple, 114 pellets |
| 40 | 2270652-61 | 2 | Shim Disk | 8 | Loaded Shim Disk, large, blue, 12 pellets |
| 41 | 2270652-62 | 2 | Shim Disk | 15 | Loaded Shim Disk, large, blue, 24 pellets |
| 42 | 2270652-63 | 2 | Shim Disk | 14 | Loaded Shim Disk, large, blue, 49 pellets |
| 43 | 2270652-64 | 2 | Shim Disk | 16 | Loaded Shim Disk, large, blue, 74 pellets |
| 44 | 2270652-65 | 2 | Shim Disk | 24 | Loaded Shim Disk, large, blue, 114 pellets |
| 45 | 46-281314P4 | 2 | Safety Label | 1 | Caution Label “Contents Magnetic” |

## 3-12 FIELD SHIM KIT ( continued )

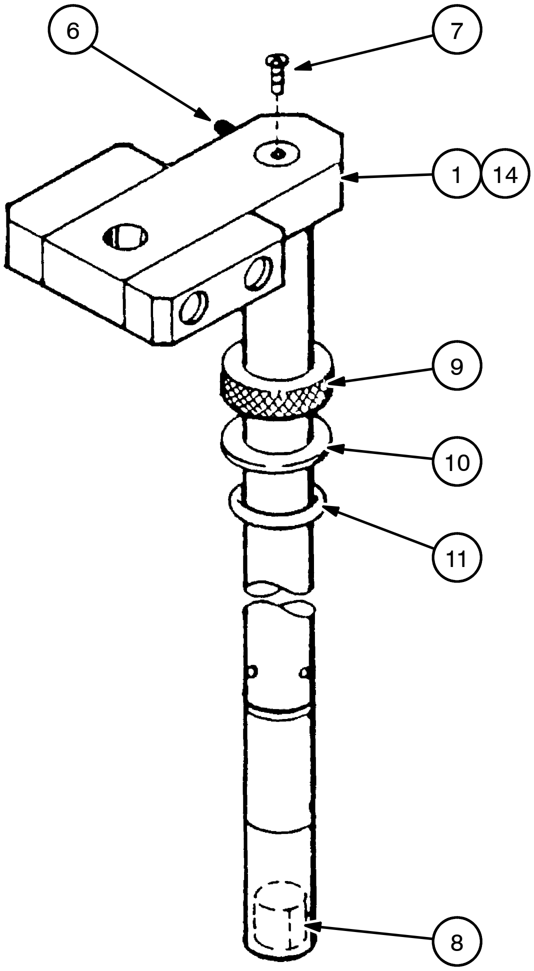
| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 46 | 46-252065P134 | 2 | Label | 2 | Label, polyester |
| 47 | 2304529 | N | Label | 1 | Tray 1 Contents Map |
| 48 | 2304529-2 | N | Label | 1 | Tray 2 Contents Map |
| 49 | 46-294167P29 | 2 | Case | 1 | Field Shim Kit Case |

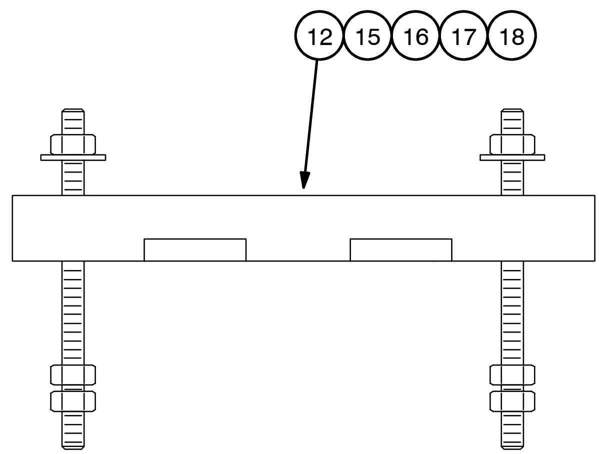
## 3-13 MAGNET MOUNTING KIT 2270347 REV. 1

| Item | Part Number | FRU | Name | Quantity | Description |
|---|---|---|---|---|---|
| 1 | | | | | Not Used |
| 2 | 2180498-4 | N | Locating Stud | 1 | Support Ring Locating Stud, M20 x 88 mm, stn. steel |
| 3 | 46-318508P62 | N | Screw | 12 | Hex Head Screw, M20 x 100 mm, stainless steel |
| 4 | 46-294167P38 | 2 | Washer | 12 | Fiber Washer, 37 mm OD x 21 mm ID x 2.4 mm |
| 5 | 2274122 | 2 | Washer Pad | 12 | Foam Washer Pad, 3.25 in. OD x .80 in. ID |
| 6 | 2274072 | 2 | Mounting Pad | 1 | Foam Mounting Pad, front |
| 7 | 2274072-2 | 2 | Mounting Pad | 1 | Foam Mounting Pad, back |
| 8 | 2274072-3 | 2 | Mounting Pad | 2 | Foam Mounting Pad, left and right |
| 9 | 2267987-2 | N | Anchor | 3 | Expansion Anchor, stainless steel |
| 10 | 2286065 | N | Bracket | 1 | Single-Stage Coldhead Bellows Anchor Bracket |
| 11 | 46-318508P23 | 2 | Screw | 3 | Hex Head Cap Screw, M10 x 40 |
| 12 | 46-318936P3 | 2 | Nut | 3 | Nut, M10 stainless steel |
| 13 | 46-252635P23 | N | Washer | 6 | Plain Washer, 375 in. ID x 1.25 in. OD x .100 in. stn. steel |
| 14 | 46-281162P11 | 2 | Lockwasher | 3 | Spring Lockwasher, .375 in. |
| 15 | 2286066 | N | Pad | 1 | Conductive Pad |
| 16 | 46-294151P7 | 2 | Compound | 1 | Lubricating Anti-Seeze Compound |

# SECTION 4 – SERVICE KITS, OPTIONS & TOOLS

## 4–1 MAGNET RAMPING EQUIPMENT KIT 46–260703G6 REV. 1



## 4-1 MAGNET RAMPING EQUIPMENT KIT ( continued ) 46-260703G6 REV. 1

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-260817G3 | Main Leads | 2 | Main Lead Extensions |
| 2 | 46-252366P4 | Screw | 3 | Cap Screw, .375-16 x 1.00 in. |
| 3 | 46-252320P19 | Nut | 6 | Brass Nut, .375-16 |
| 4 | 46-252322P8 | Washer | 12 | Brass Washer, .375 in. |
| 5 | 46-281046P35 | Screw | 3 | Brass Cap Screw, .375-16 x 1.25 in. |
| 6 | 46-252351P2 | Screw | 4 | Brass Round Head Screw, #10-24 x .50 in. |
| 7 | 46-252351P51 | Screw | 4 | Brass Round Head Screw, #10-32 x .438 in. |
| 8 | 46-281256P1 | Contact Bands | 20 | Main Lead Extensions Contact Bands |
| 9 | 46-294104P1 | Retaining Nut | 4 | Knurled Brass Quick-Coupling Retaining Nut |
| 10 | 46-294105P1 | Retaining Ring | 4 | Quick-Coupling Retaining Ring |
| 11 | 46-260389P1 | O-Ring | 8 | Silicon O-Ring, #2-116 |
| 12† | 2142687 | Hold-Down Tool | 1 | Ramp Lead Hold-Down Tool, Signa V |
| 12A† | 46-252365P35 | Screw | 1 | Hex Head Screw, Stainless Steel, .375-16 x 5 in. |
| 12B† | 46-281003P19 | Stud | 2 | Threaded Rod, Brass, .25-20 x 4.5 in. |
| 12C† | 46-252320P15 | Nut | 6 | Hex Nut, Brass, .25-20 |
| 12D† | 46-252322P7 | Washer | 2 | Washer, Brass, .31 |
| 13 | 46-294236G1 | Case | 1 | Storage Case |
| 14 | 46-294204G1 | Lead Extensions | 2 | Main Lead Extensions, SIV |
| 15*† | 2152359 | Hold-Down Tool | 1 | Ramp Lead Fixture |
| 15A† | 46-281003P5 | Stud | 2 | Threaded Rod, Brass, .25-20 x 7.12 in. |
| 15B† | 46-252320P15 | Nut | 6 | Hex Nut, Brass, .25-20 |
| 15C† | 46-252322P7 | Washer | 2 | Washer, Brass, .31 |
| 16*† | 2185743 | Hold-Down Tool | 1 | Ramp Lead Fixture, Conquest |
| 17*† | 2193922 | Hold-Down Tool | 1 | Ramp Lead Fixture, LCC |
| 18*† | 2250653 | Hold-Down Tool | 1 | Ramp Lead Hold-Down Tool, Open*Speed* |

* Hold-Down Tool Hardware Kit 2236233 ( containing 2 Threaded Rods 46-281003P5, 6 Nuts 46-252320P15 and 2 Washers 46-252322P7 ) is available for these kits.

† Item 12 includes hardware items 12A, 12B, 12C and 12D. Item 15 includes Ramp Lead Block 2152320 and hardware items 15A, 15B and 15C. Item 18 includes Ramp Lead Hold-Down Tool Block 2234431 and hardware items 15A, 15B and 15C. Items 16 and 17 do not include hardware.

## 4-2 POWER SUPPLIES

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-260776G4 | Main P/S | 1 | 1000 Amp Main Coil Power Supply |
| 2 | 2141701 | B0 P/S Kit | 1 | B0 Power Supply Kit |
| 2A | 2141700 | B0 P/S | 1 | B0 Power Supply |
| 2B | 2141700-2 | Container | 1 | Storage Container |
| 2C | 2140361 | Label | 1 | Container Label |
| 2D | 46-294151P39 | Epoxy | 1 | Epoxy, Armstrong A-12 |

* Item 2 includes items 2a, 2b, 2c and 2d.

## 4-3 SERVICE POWER SUPPLY RENEWAL PARTS 46-260776G3, G4, 46-260777G3
## ( Part Number Cross Reference, Vendor P/N* to GE P/N )

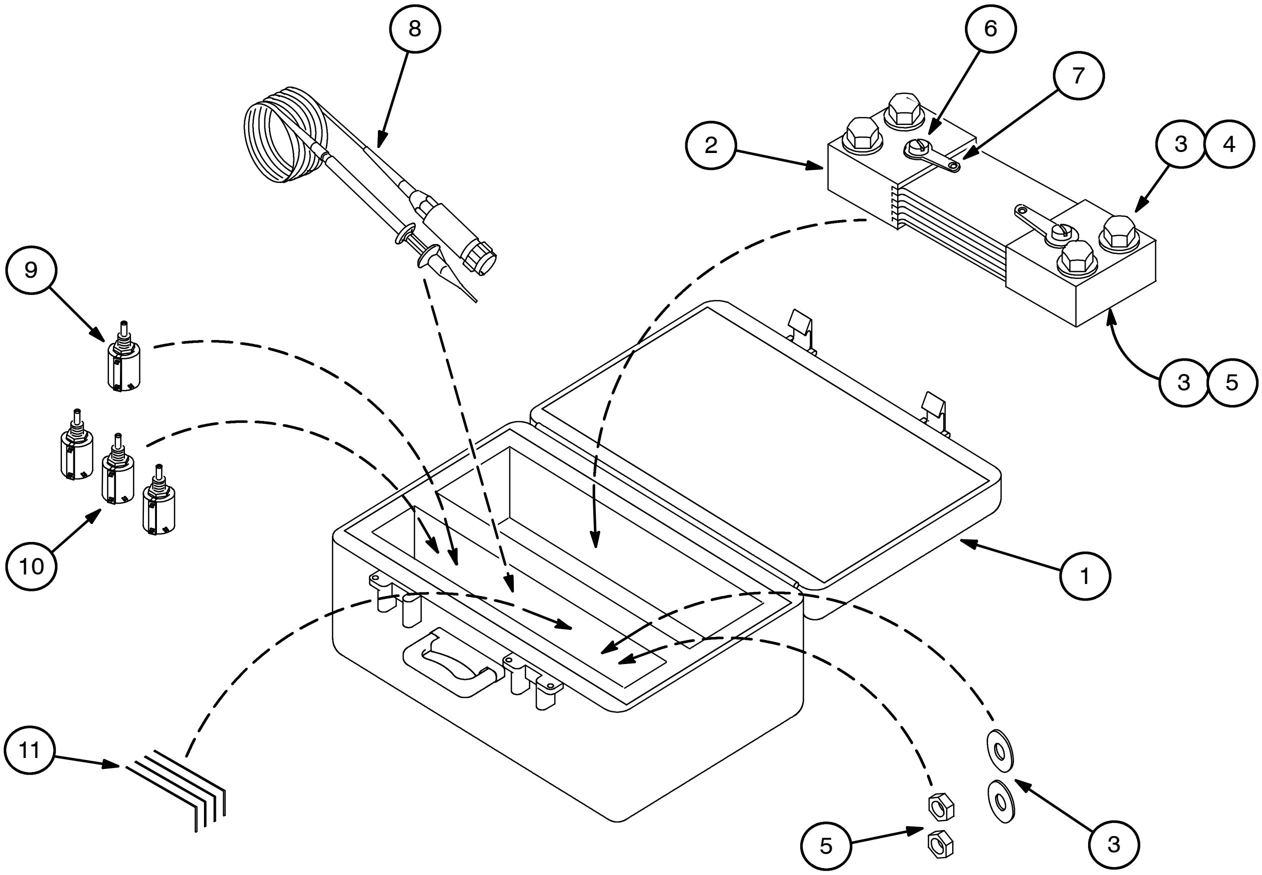
| Item | Vendor Part Number* | Description | GE Part Number |
|---|---|---|---|
| 1 | 12-452-028 | Control Panel Assembly | 46-281468P1 |
| 2 | 12-452-026 | Heater, P/S Heater & 24 VDC Power Supply | 46-281468P2 |
| 3 | 25-611-000 | Input / Output Connect Panel | 46-281468P3 |
| 4 | 00-467-498 | TCR 7.5T750 Main Coil Power Supply | 46-281468P4 |
| 5 | 51-001-001 | Fan, 3.12 in., 115V | 46-260219P12 |
| 6 | 58-005-010 | Fuse, MDA, 4A, 250V | 46-281468P5 |
| 7 | 20-292-002 | PWB, Printed Circuit Assembly | 46-281468P6 |
| 8 | 20-230-000 | PWB, +24 & ±15 Power Supply Assembly | 46-281468P7 |
| 9 | 71-024-000 | Dial, turns counting | 46-260219P27 |
| 10 | 66-065-006 | Voltmeter, Analog, 0-36 VDC | 46-281468P8 |
| 11 | 62-062-009 | Ammeter, Analog, 0-1 ADC | 46-281468P9 |
| 12 | 66-082-007 | Volmeter, Digital, 3.5 digit | 46-281468P10 |
| 13 | 66-082-008 | Ammeter, Digital 5.5 digit | 46-281468P11 |
| 14 | 67-055-007 | Potentiometer, 10-turn, 5K, WW | 46-281468P12 |
| 15 | 68-012-005 | Switch, push-button, MOM, white | 46-260219P33 |
| 16 | 68-004-001 | Switch, DPDT toggle | 46-281468P13 |
| 17 | 68-008-003 | Switch, DPDT, locking toggle | 46-281468P14 |
| 18 | 20-354-000 | PWP, PCB P-Set Amplifier | 46-281468P15 |
| 19 | 58-006-010 | Fuse, MDV, 0.125A, 250V | 46-281468P16 |
| 20 | 58-001-008 | Fuse, AGC, 2A, 250V | 46-281468P17 |
| 21 | 20-137-087 | PCB, A100, Control | 46-281468P18 |
| 22 | 54-072-002 | Capacitor, 350 KMF/10V | 46-281468P19 |
| 23 | 61-011-001 | SCR, dual pack | 46-281468P20 |
| 24 | 56-069-004 | Breaker, 3-pole, 30A | 46-281468P21 |
| 25 | 51-002-002 | Fan, 468 in. sq., 220V | 46-260219P2 |
| 26 | 67-023-005 | Resistor, 3 ohm, 25W | 46-281468P22 |
| 27 | 63-004-001 | LED Indicator, red | 46-281468P23 |
| 28 | 51-009-001 | Fan, biscuit | 46-281468P24 |
| 29 | 51-002-001 | Fan, 4.68 SW. 115V | 46-260219P20 |
| 30 | 56-001-002 | Breaker, 3-pole, 30A | 46-281468P25 |

## 4–3 SERVICE POWER SUPPLY RENEWAL PARTS ( continued ) ( Part Number Cross Reference, Vendor P/N* to GE P/N )

| Item | Vendor Part Number* | Description | GE Part Number |
|---|---|---|---|
| 31 | 12–452–027 | Control Panel Assembly | 46–281469P1 |
| 32 | 58–005–013 | Fuse, MDA, 6.25A, 250A | 46–281469P2 |
| 33 | 12–452–025 | Supply Switch Heater & Internal Power | 46–281469P |
| 34 | 25–612–000 | Input / Output PaneL | 46–281469P4 |
| 35 | 00–452–084 | Module, Shim P/S #1 thru #6 | 46–281469P5 |
| 36 | 58–005–006 | Fuse, MDA, 1A, 250V | 46–281469P11 |
| 37 | 60–010–001 | Diode, dual pak, 600V, 15A | 46–281469P12 |
| 38 | 20–292–001 | PWB, A700, PCB Assembly | 46–281469P13 |
| 39 | 65–047–001 | Relay, DPDT, 24VDC | 46–281469P14 |
| 40 | 66–082–012 | Voltmeter, Digital, 4.5 digit | 46–281469P15 |
| 41 | 66–082–011 | Ammeter, Digital, 4.75 digit | 46–281469P16 |
| 42 | 68–037–007 | Switch, 8pl, 6stn, select | 46–281469P17 |
| 43 | 67–055–011 | Potentiometer, 2000 ohm, 10–turn | 46–281469P18 |
| 44 | 65–024–007 | Relay, 4PDT, 25A | 46–281469P19 |
| 45 | 68–008–001 | Thermostat, N/O 195 degrees F | 46–281469P20 |
| 46 | 62–005–020 | Transistor, 2N5685 | 46–281469P21 |
| 47 | 62–005–014 | Transistor, MJ2955 | 46–281469P22 |
| 48 | 68–002–002 | Thermostat N/C, 210 degrees F | 46–281469P23 |
| 49 | 20–350–001 | PWB, A100 Assembly | 46–281469P24 |
| 50 | 67–055–005 | Potentiometer, 20K, 10–turn, 2W | 46–281469P25 |
| 51 | 00–481–1305 | Main Coil Power Supply ( ESS7.5–1000–2–D–1236 ) | 46–260219P113 |
| 52 | 67–136–001 | Potentiometer, 10–turn, 100 ohm WW Oil–Filled | 46–260219P114 |
| 53 | 66–062–009 | Analog Ammeter, 0–1 ADC | 46–260219P115 |
| 54 | 66–082–014 | Digital Voltmeter / Ammeter, 5.5 digit | 46–260219P116 |
| 55 | 80–001–013 | PS1 Meter, P.S. +/– 12, +5 | 46–260219P117 |
| 56 | 67–136–002 | Potentiometer, 10–turn, 5K, WW Oil–Filled | 46–260219P118 |

* Vendor parts shown in vendor service manual.

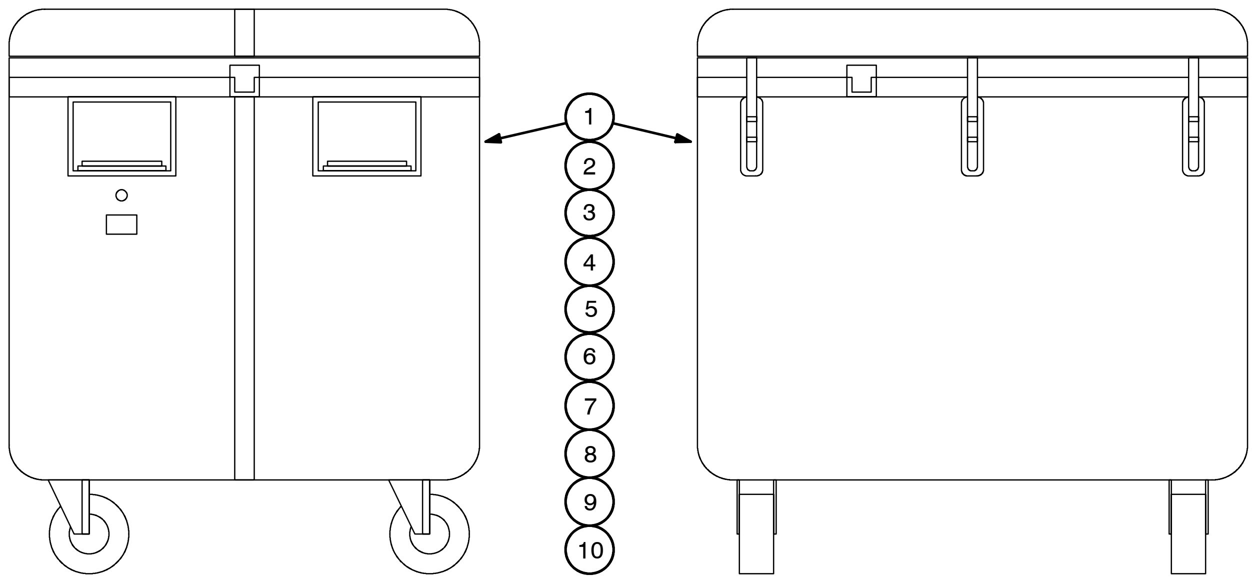
## 4-4 POWER SUPPLY CALIBRATION KIT 2101360 REV. 3




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2103227 | Case | 1 | Case Assembly |
| 2 | 2101358 | Ammeter Shunt | 1 | Type B DC Ammeter Shunt |
| 3 | 46-252322P8 | Washer | 6 | Plain Washer, brass |
| 4 | 46-281046P38 | Screw | 4 | Hex Head Cap Screw, .375-16 x 1.75 in., brass |
| 5 | 46-260942P3 | Nut | 6 | Hex Nut, .375-16UNC, brass |
| 6 | 46-294167P14 | Lockwasher | 4 | Lockwasher, #10 internal tooth |
| 7 | 2101361 | Solder Lug | 4 | Solder Lug |
| 8 | 46-294167P15 | Probe | 1 | X1 Monolithic Probe |
| 9 | 46-281468P26 | Potentiometer | 1 | Potentiometer, 10-turn, 100 ohm, WW |
| 10 | 46-281468P12 | Potentiometer | 1 | Potentiometer, 10-turn, 5K, WW |
| 11 | 46-294167P17 | Allen Wrench | 4 | Allen Wrenches, hex key, .050 in. across flats |

## 4-5 RAMP CART / CABLE KITS

### 4-5-1 1000 Amp Ramp Cart / Cable Kit w/ Ground 2353394 REV. B




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2135434 | Cart | 1 | Ramp Cable Cart |
| 2 | 46-260723G1 | Cable | 3 | Power Cable Assembly, Positive 4/0 |
| 3 | 46-260723G2 | Cable | 3 | Power Cable Assembly, Negative 4/0 |
| 4 | 46-260724G1 | Cable | 1 | Switch Heater Cable Assembly |
| 5 | 46-281667G1 | Cable | 1 | RJC & RJD Switch Heater Cable |
| 6 | 46-281235P1 | Cable | 1 | Voltage Sense Lead, 40’ |
| 7 | 46-294167P20 | Tape | 1 | Black / Yellow Checkered Tape, roll |
| 8 | 2353392 | Label | 1 | Upgraded Ramp Kit Label |
| 9 | 2351842* | Cable | 1 | Power Supply Grounding Cable |
| 10 | 2351843* | Cable | 1 | Power Supply Jumper Cable |

* Also included in the HFO Pre-Ramp Grounding Cable Kit ( 2351844 ).

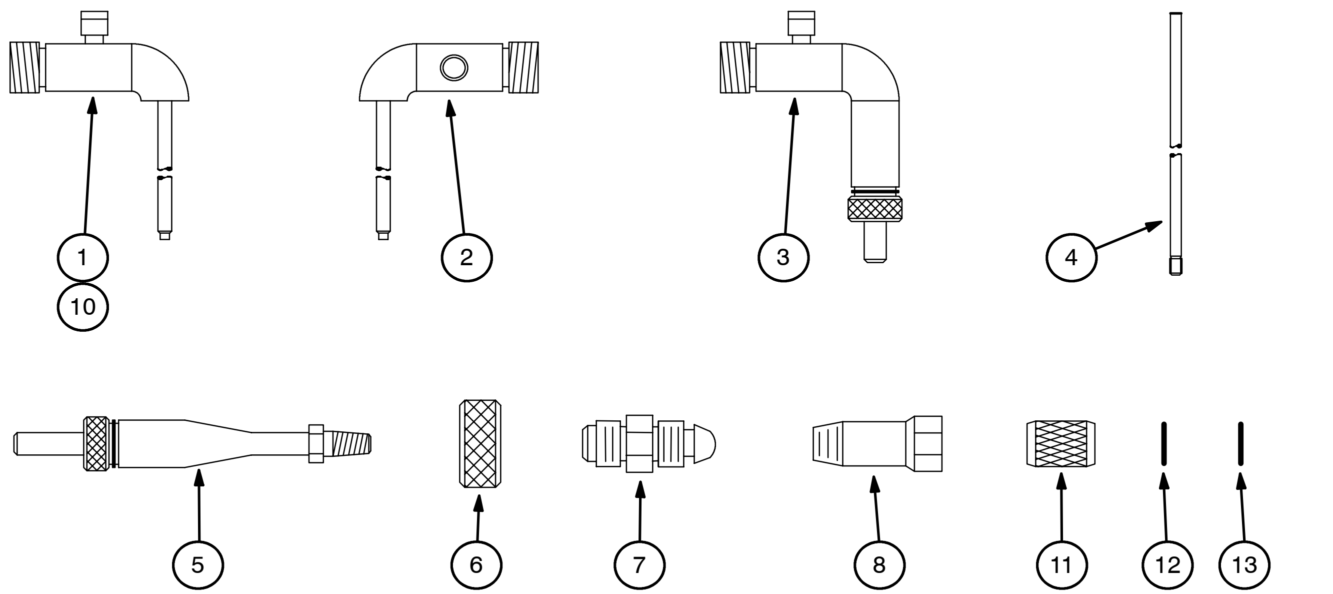
### 4-5-2 Ramp Cart / Cable Kit Upgrade, 750 Amp ( 2135435 ) To 1000 Amp ( 2353394 ) 2353397 REV. B

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-260723G1 | Cable | 1 | Power Cable Assembly, Positive 4/0 |
| 2 | 46-260723G2 | Cable | 1 | Power Cable Assembly, Negative 4/0 |
| 3 | 46-294167P20 | Tape | 1 | Black / Yellow Checkered Tape, roll |
| 4 | 2353392 | Label | 1 | Upgraded Ramp Kit Label |
| 5 | 2351842 | Cable | 1 | Power Supply Grounding Cable |
| 6 | 2351843 | Cable | 1 | Power Supply Jumper Cable |

## 4-6 SAFETY SIGNAGE KIT — 46-258770G4 REV. 1

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-255326P1 | Warning Sign | 10 | Sign, Warning: 5-Gauss Exclusion Zone |
| 2 | 46-255325P1 | Warning Sign | 2 | Sign, Warning: Magnetic Field Security Zone |
| 3 | 46-255813P1 | Warning Label | 50 | 5 x 3 inch ( 127 x 76 mm ) Label, Warning: No Magnetic Objects |
| 4 | 2289812 | Warning Sign | 2 | Floor Sign, Warning: Authorized Personnel Only |
| 5 | 46-255814P1 | Warning Label | 50 | 2.5 x 1.5 inch ( 63.5 x 38 mm ) Label, Warning: No Magnetic Objects |
| 6 | 46-282214P1 | Caution label | 2 | Coolant Caution Label |
| 7 | 46-301671P1 | Warning Placard | 1 | Placard, Warning: Low Oxygen Level Alarm |

## 4-7 UNIVERSAL FILL LINE KIT — 46-294705G1 REV. 4



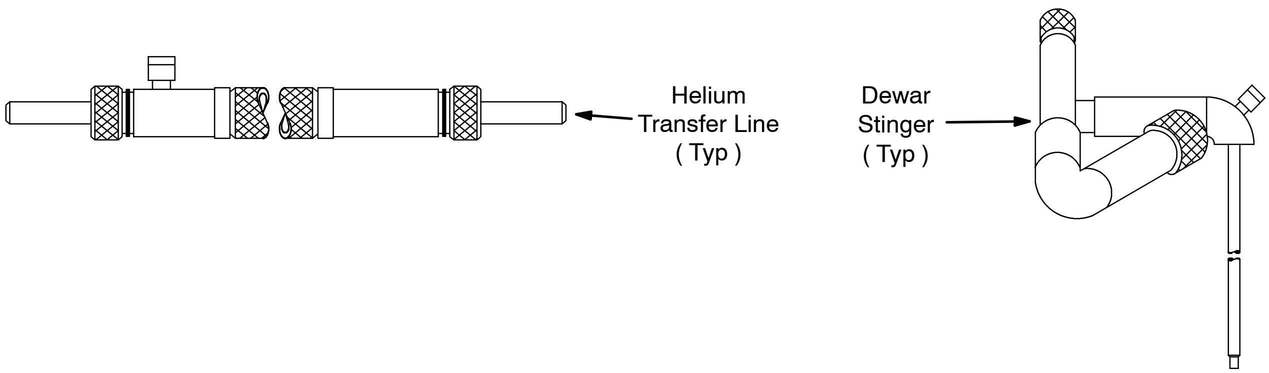

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294512P3 | 7 In. Stinger | 1 | Cryostat Stinger, 7 in., Air Products #CSA-7 |
| 2 | 46-294512P4 | 14.75 In. Stinger | 1 | Cryostat Stinger, 14.75 in., Air Products #CSA-14 |
| 3 | 46-294512P5 | 3 In. Reducer | 1 | Reducer, .50 in. x 3.00 in. male bayonet, Air Products #MBR-6-3 |
| 4 | 46-294512P12 | 16 In. Stinger Ext. Tip | 1 | Cryostat Stinger Extension, 16 in. with Teflon Tip, Air Products #CSE-16 |
| 5 | 46-294512P13 | Adapter | 1 | Purge / Precool Adapter, Air Products #PPA-1 |
| 6 | 46-294512P15 | Blanking Cap | 1 | Blanking Cap, 1.5 in. OD knurled brass, Air Products #BBC-1.5 |
| 7 | 46-294512P16 | Nitrogen Adapter | 1 | Nitrogen Fill Line Adapter, Air Products #FLA-1 |
| 8 | 46-294512P17 | Helium Adapter | 1 | Helium Fill Line Adapter, Air Products #GLA-1 |
| 9 | 46-294512P14 | Case | 1 | Black Carrying Case, Air Products #PCC-27 |
| 10 | 46-294512P25 | 17 In. Stinger | 1 | Cryostat Stinger Assembly, 17 in., Air Products #CSE-17 |
| 11 | 46-318619P1 | Nut | 1 | Extended coupling nut, .75-20UNEF knurled brass |
| 12 | 46-260272P1 | Retaining Ring | 1 | Retaining ring, .687 in. OD stainless steel |
| 13 | 46-260342P9 | O-Ring | 1 | O-Ring, buna-n, .489 in. ID x .625 in. OD |

## 4-8 CRYOGEN SAFETY WEAR KIT 46-271137G1 REV. AB

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-271135P10 | Head Gear | 1 | Head Gear without visor |
| 2 | 46-271135P11 | Vision Shield | 1 | Vision Shield for 46-271135P10 |
| 3 | 46-271135P12 | Safety Glasses | 1 | Safety Glasses |
| 4 | 46-258217P2 | Cryogen Gloves | 1 | Cryogen Handling Gloves |

## 4-9 LIQUID HELIUM TRANSFER LINE KIT 46-294513G1 REV. 3

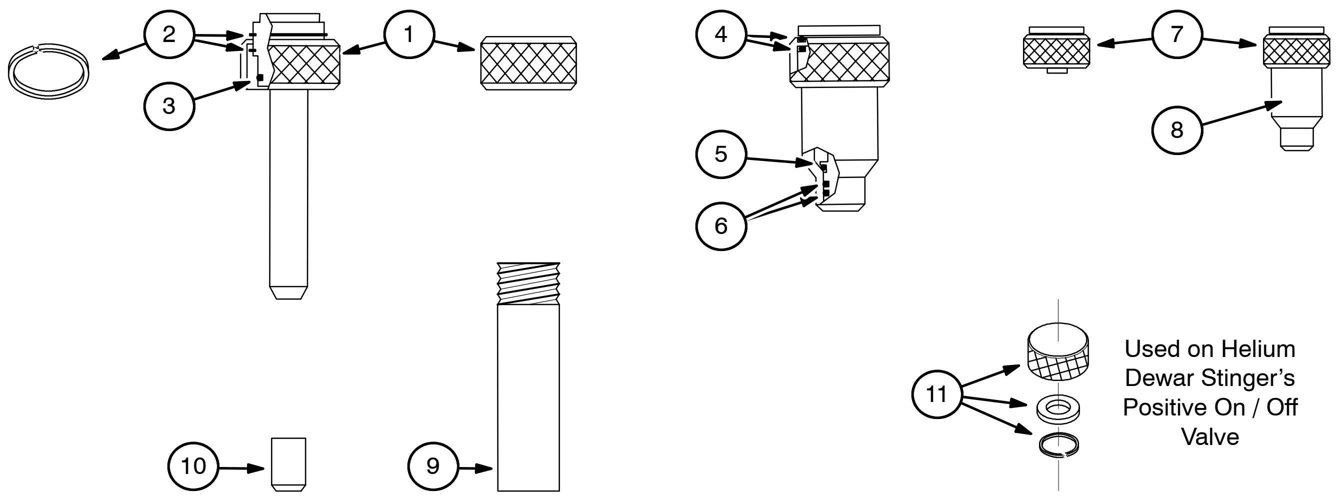
### 4-9-1 Dewar Stingers, Helium and Nitrogen Transfer Lines




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294511P1 | Dewar Stinger | 1 | 250 Liter Helium Dewar Stinger, Air Products #DSA-59 |
| 2 | 46-294511P2 | Dewar Stinger | 1 | 500 Liter Helium Dewar Stinger, Air Products #DSA-64 |
| 3 | 46-294512P1 | He Transfer Line | 1 | 12 Ft. Flexible Helium Transfer Line, Air Products #FS-12-2B6 |
| 4 | 46-294512P2 | He Transfer Line | 1 | 8 Ft. Flexible Helium Transfer Line, Air Products #FS-8-2B6 |
| 5 | 46-252805P2 | $N_2$ Transfer Line | 1 | 10 Ft. Nitrogen Transfer Line |
| 6 | 46-252805P3 | $N_2$ Transfer Line | 1 | 15 Ft. Nitrogen Transfer Line |
| 7* | 46-271135P1 | Flex Hose | 1 | Flex Hose with NPT fittings for helium bottle |

* Not included in Liquid Helium Transfer Line Kit 46-294513G1.

### 4-9-2 Helium Transfer Line Kit Renewal Parts

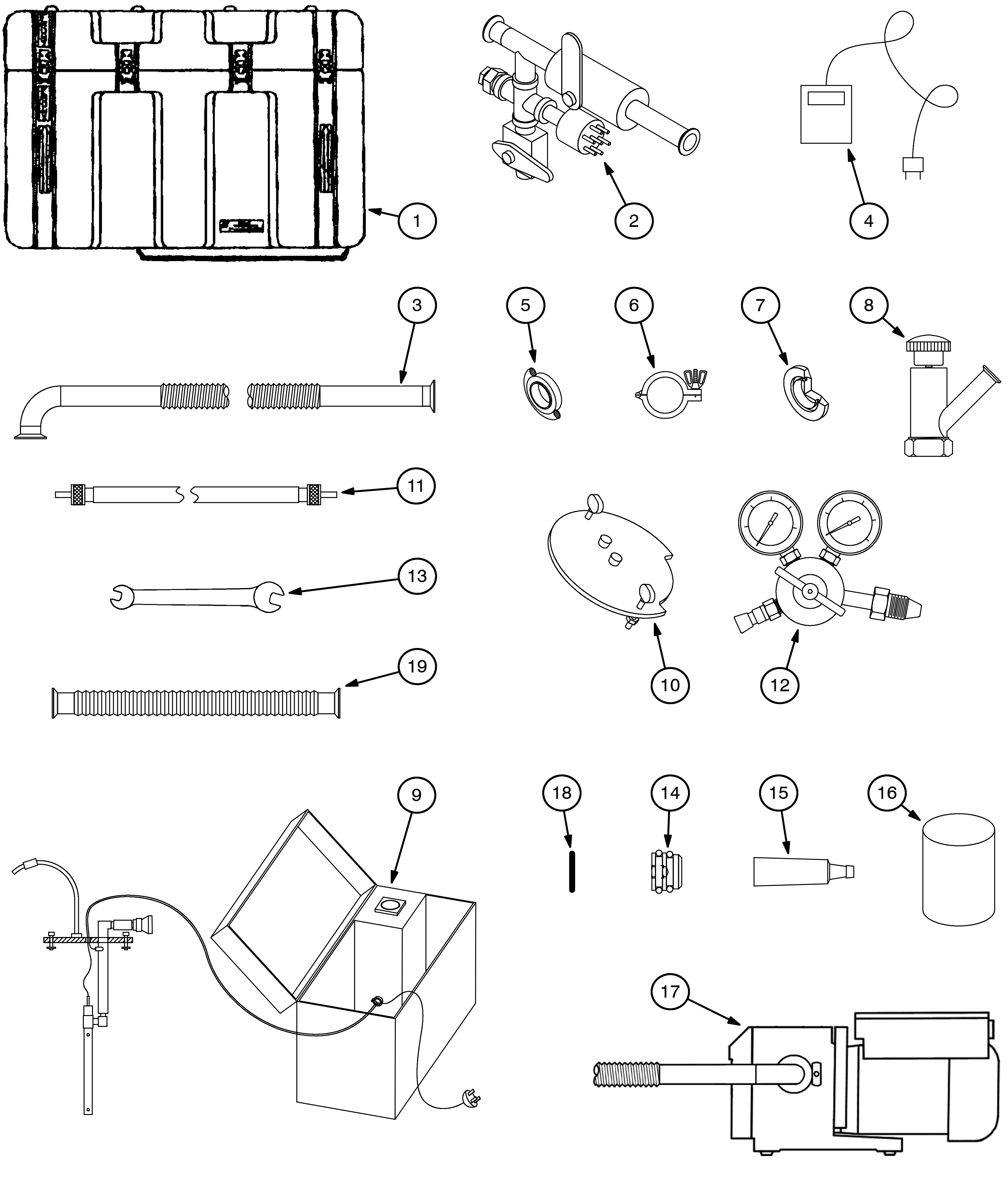



| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294512P6 | Coupling Nut | 1 | Male Bayonet Coupling Nut, Air Products #BCN-1 |
| 2 | 46-294512P7 | Retainer Ring | 1 | Male Bayonet Nut Retainer Ring, Air Products #BRR-1 |
| 3 | 46-294512P8 | O-Ring | 1 | Male Bayonet O-ring, Air Products #BOR-1 |
| 4 | 46-294512P9 | O-Ring | 2 | VAC Port & Relief Valve O-Ring, large, AP #VPOR-1 |
| 5 | 46-294512P10 | O-Ring | 1 | VAC Port & Relief Valve O-Ring, med., AP #VPOR-2 |
| 6 | 46-294512P11 | O-Ring | 2 | VAC Port & Relief Valve O-Ring, small, AP #VPOR-3 |
| 7 | 46-294512P18 | Cap | 1 | VAC Port Cap, Air Products #VPC-1 |
| 8 | 46-294512P19 | Valve | 1 | VAC Port Valve, Air Products #VPV-1 |
| 9 | 46-294512P20 | Protector | 1 | Bayonet Protector, set of 2, Air Products #BP-PVC |
| 10 | 46-294512P21 | Teflon Tip | 1 | Teflon Tip, set of 2, Air Products #STT-1 |
| 11 | 46-294512P22 | Valve Stem Kit | 1 | Valve Stem Cap Kit, Air Products #VSC-K |

## 4-10 OTHER HELIUM TRANSFER SERVICE ITEMS

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-271137G1 | Safety Kit | 1 | Safety Wear Kit, Air Products #295-A-MRK500 |
| 2 | 46-265286G1 | He Resistance Box | 1 | GE Magnet Helium Resistance Box |
| 3 | 46-306734G1 | Reg. & Hose Kit | 1 | Helium Regulator And Hose Kit |
| 4 | 46-258150P1 | Helium Cart | 1 | Non-Magnetic Cylinder Cart |

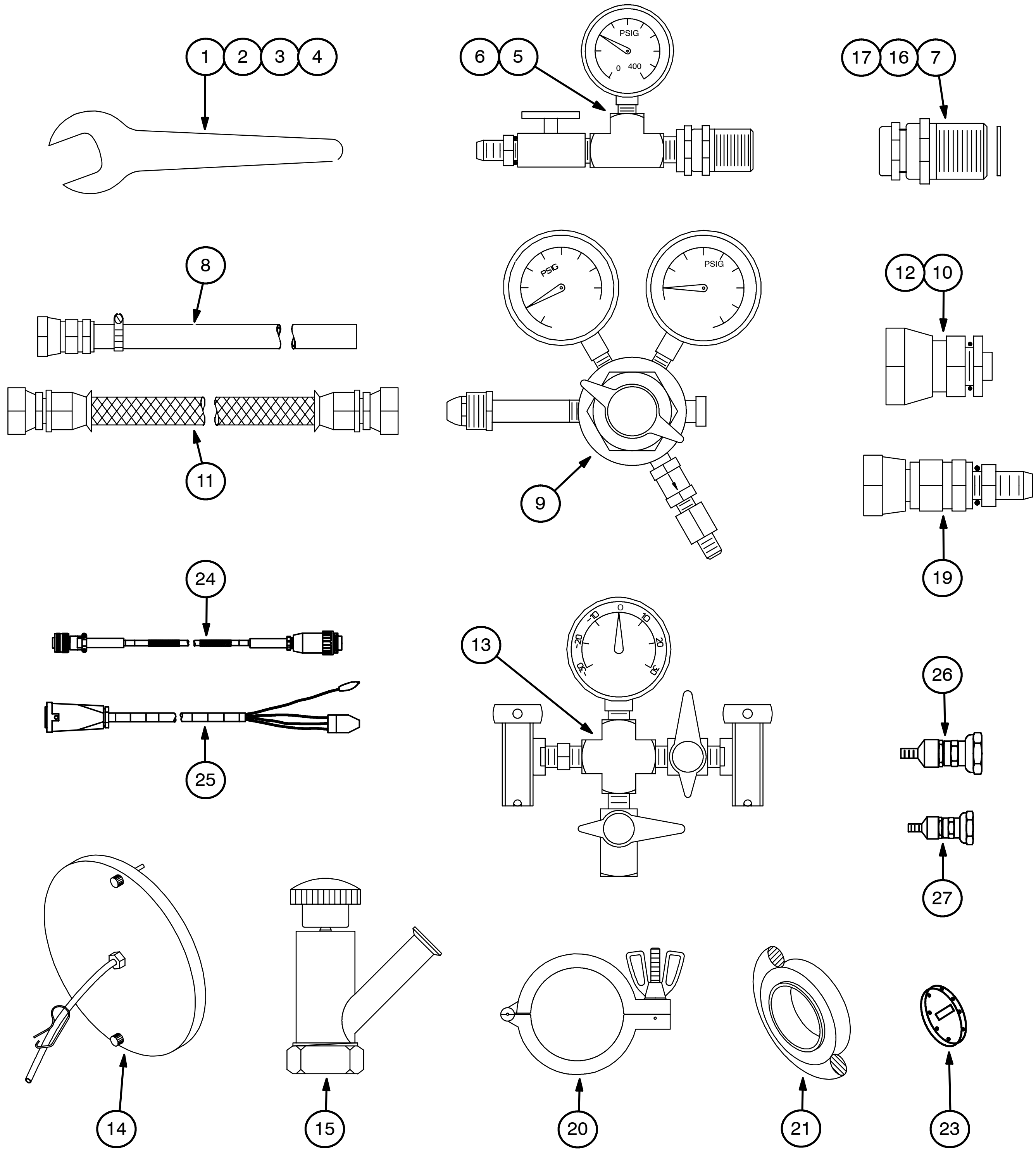
## 4-11 UNIVERSAL COLDHEAD REPLACEMENT TOOL KIT 2300306 REV. 0



## 4-11 UNIVERSAL COLDHEAD REPLACEMENT TOOL KIT ( continued )

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2306020 | Case | 1 | Case with Label |
| 2 | 2287707 | Service Adapter | 1 | Coldhead Service Adapter |
| 3 | 2267197 | Pump-Out Line | 1 | Coldhead Sleeve Pump-Out Line |
| 4 | 2287716 | Instrument | 1 | Digital Vacuum Instrument |
| 5 | 46-294030G1 | Centering Ring | 7 | KF16 Centering Ring |
| 6 | 46-294026P1 | Clamp | 7 | KF16 Clamp |
| 7 | 46-294028P1 | Blanking Flange | 2 | Blanking flange |
| 8 | 46-260267P2 | Seal-Off Operator | 1 | Sleeve Seal-Off Operator |
| 9 | 2303715 | Heater Assembly | 1 | Plexiglas Cover Plate / Heater Assembly |
| 10 | 2303728 | Cover Plate | 1 | Lexan Cover Plate |
| 11 | 2303724 | Gas Line | 1 | Nitrogen Gas Line |
| 12 | 2303731 | Regulator | 1 | Regulator / Flowmeter with quick connect |
| 13 | 46-320472P5 | Wrench | 1 | Open End Wrench, 8 mm x 10 mm |
| 14 | 2236606 | Plug | 1 | Double O-Ring Plug |
| 15 | 46-252065P24 | Grease | 1 | Vacuum Grease |
| 16 | 46-294041P5 | Oil | 1 | DuoSeal SWSII Oil, quart |
| 17 | 2305056PSP | Specification | 1 | Vacuum Pump Specification |
| 18 | 46-260342P2 | O-Ring | 2 | O-Ring, .612 in. I.D. x .818 in. O.D. |
| 19 | 2321289 | Flexline | 1 | KF16 Flexline Coupling, 15 in. |

## 4–12 COLDHEAD / COMPRESSOR INSTALLATION & MAINTENANCE KIT 46–281088G3 REV. 0



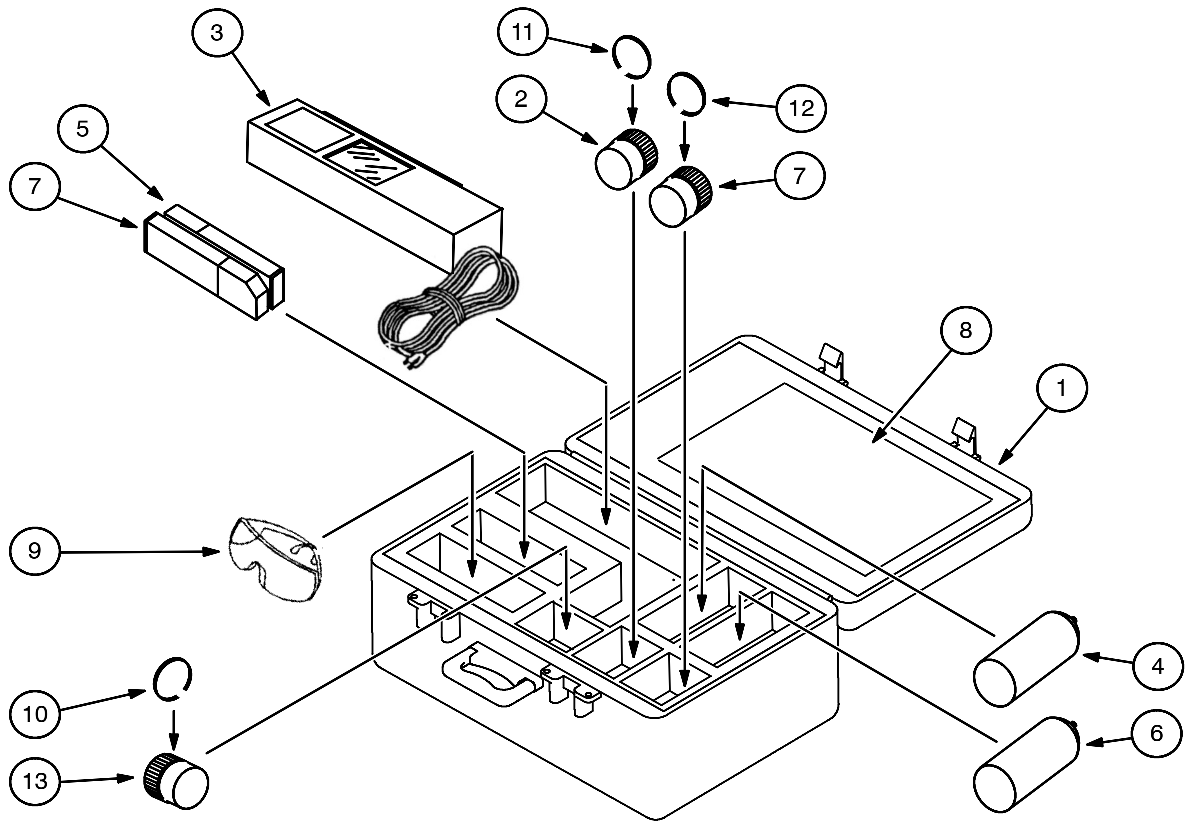
## 4-12 COLDHEAD / COMPRESSOR INSTALLATION & MAINTENANCE KIT ( continued )

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294150P13 | Wrench | 1 | 1 in. Open End Wrench, Leybold #722-81-018 |
| 2 | 46-294150P14 | Wrench | 2 | 1 3/16 in. Open End Wrench, Leybold #722-81-019 |
| 3 | 46-294150P15 | Wrench | 1 | 1 3/8 in. Open End Wrench, Leybold #722-81-020 |
| 4 | 46-294150P16 | Wrench | 2 | 1 5/8 in. Open End Wrench, Leybold #722-81-021 |
| 5 | 46-317904P1 | Purge Tool | 2 | #8 ( 1/2 in. ) Male Aeroquip Purge Tool with 0 - 400 psi gauge |
| 6 | 46-317904P2 | Purge Tool | 2 | #12 ( 3/4 in. ) Male Aeroquip Purge Tool with 0 - 400 psi gauge |
| 7 | 46-294937P1 | Coupling | 1 | #4 Male Aeroquip Coupling with tube adapter |
| 8 | 46-294003P1 | Charging Hose | 1 | #4 Fitting Charging Hose |
| 9 | 46-294009P1 | Regulator | 1 | Helium High Pressure Regulator |
| 10 | 46-294936P1 | Coupling | 1 | #8 Female Aeroquip Coupling with tube adapter |
| 11 | 46-294002P1 | Adapter Hose | 1 | Line Adapter Hose |
| 12 | 46-294006G1 | Discharge Tool | 1 | #12 Aeroquip Discharge Tool Assembly |
| 13 | 46-294007G1 | Adapter | 1 | Coldhead Change ( backfill pumpdown ) Adapter |
| 14 | 46-294010G1 | Purge Cover | 1 | Plexiglass Cover Plate |
| 15 | 46-260267P2 | Seal-Off Operator | 1 | Sleeve Seal-Off Operator |
| 16 | 46-294000G1 | Fitting | 1 | #12 Aeroquip Male Fitting |
| 17 | 46-281999G1 | Fitting | 1 | #8 Aeroquip Male Fitting |
| 18 | 46-252065P63 | Wire Brush | 1 | Welder's Brush |
| 19 | 46-294005G1 | Fitting | 1 | #4 Aeroquip Fitting |
| 20 | 46-294026P1 | Clamp | 1 | KF16 Clamp |
| 21 | 46-294030G1 | Centering Ring | 1 | KF16 Centering Ring |
| 22 | 46-294939G50 | Case | 1 | Carrying Case for tools |
| 23 | 46-281989G1 | Port Cover | 1 | Coldhead Port Cover |
| 24 | 46-318911P1 | Power Cable | 1 | Balzer Compressor to Coldhead Power Cable |
| 25 | 46-318910P1 | Power Cable | 1 | Leybold Compressor to Coldhead Power Cable |
| 26 | 2100316 | Fitting | 1 | Aeroquip to Helium Line Adapter Fitting, large |
| 27 | 2100317 | Fitting | 1 | Aeroquip to Helium Line Adapter Fitting, small |
| 28 | 2102476DDW | Instructions | 1 | Upgrade Kit Instructions |
| 29 | 2102181 | Label | 1 | Shield Cooler Tool Kit Upgrade Label |

## 4-13 EXTRA EQUIPMENT NEEDED TO SERVICE COLDHEAD AND COMPRESSOR

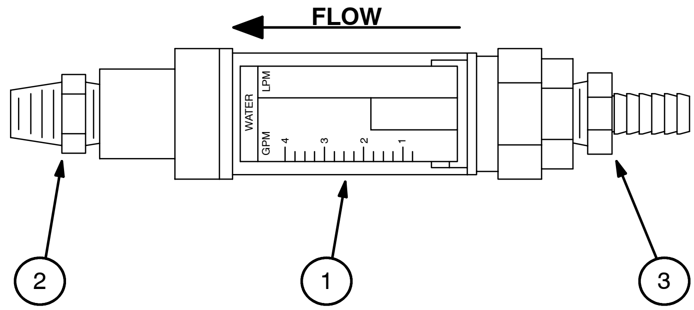
| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-306734G1 | Reg. & Hose Kit | 1 | Helium Tank Regulator and Hose Kit |
| 2 | 46-294047G1 | Vacuum Pump Kit | 1 | Shield Cooler Vacuum Pump Kit |

## 4-14 SHIELD COOLER TEST KIT 46-318784G2 REV. 1



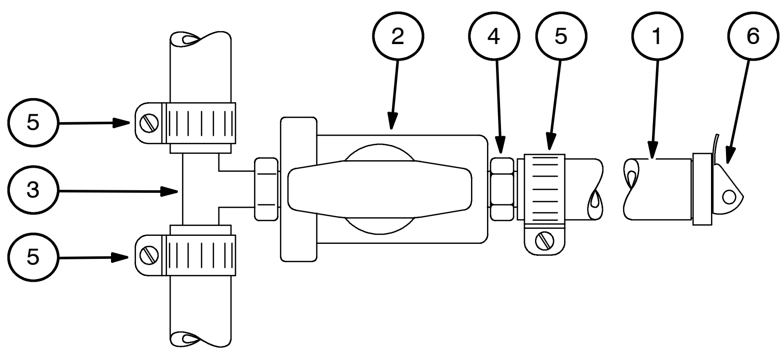

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2100644 | Case | 1 | Kit Case Assembly |
| 2 | 2100660 | Container | 3 | Specimen Container |
| 3 | 2100976 | UV Light | 1 | UV Light & Label |
| 4 | 2100661 | Solution | 1 | Solution for solids |
| 5 | 46-318649P1 | Tester | 1 | Dissolved Solids Tester |
| 6 | 2100662 | Solution | 1 | Solution for ph |
| 7 | 46-318648P1 | Meter | 1 | Ph Meter |
| 8 | 2101994APR | Instructions | 1 | Kit Operating Instructions |
| 9 | 46-318829P1 | Goggles | 1 | UV Light Safety Goggles |
| 10 | 2101986 | Label | 1 | Adhesive-Backed Label: Sample |
| 11. | 2101987 | Label | 1 | Adhesive-Backed Label: Solids |
| 12. | 2101988 | Label | 1 | Adhesive-Backed Label: Ph |
| 13. | 2100660 | Container | 1 | Specimen Container ( empty - for samples ) |

## 4-15 WATER FLOW METER KIT 46-294052G1 REV. 0



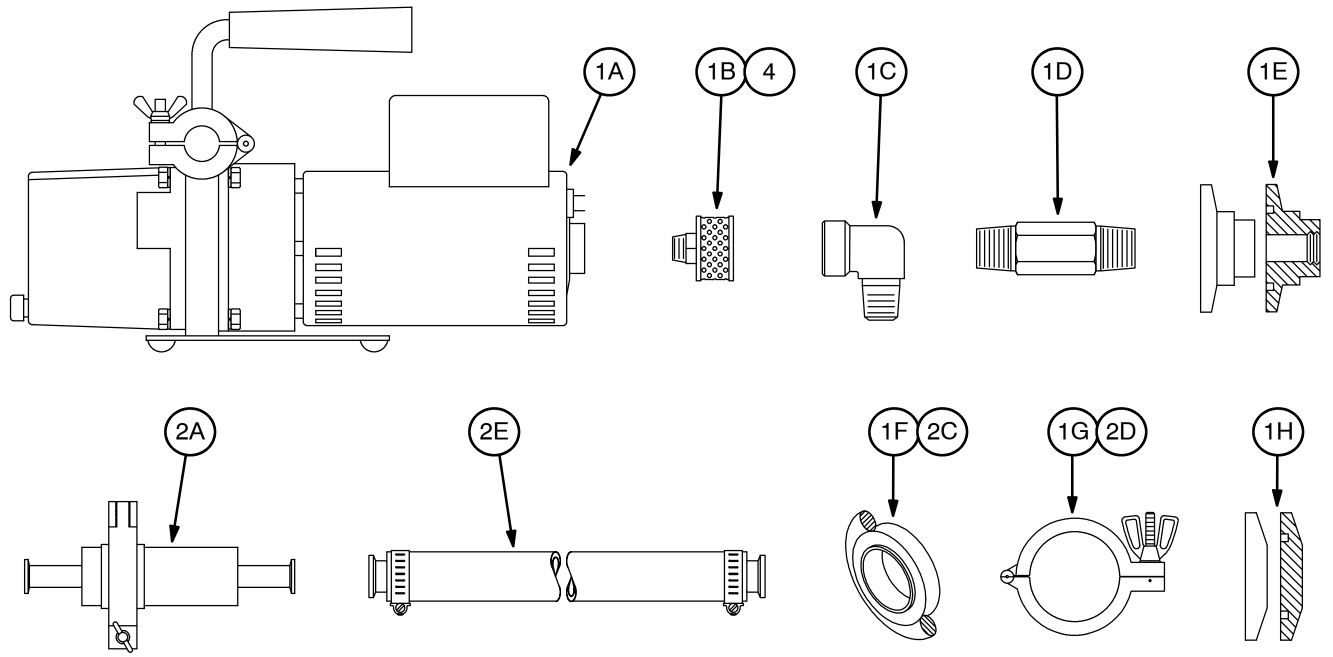

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294052P1 | Flow Meter | 1 | Inline Flowmeter, 0.5 - 4.0 gpm |
| 2 | 46-294052P2 | Nipple | 1 | Hex Nipple, brass, .50 in. NPT x .50 in. NPT |
| 3 | 46-294052P3 | Connector | 1 | Hose Connector, brass, .50 in. NPT x .50 in. ID |
| 4 | 46-252065P19 | Teflon Tape | AR | Teflon Tape, .50 in. wide |

## 4-16 WATER TEE ASSEMBLY 46-318696G1 REV. 0




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294167P9 | Tubing | 1 | Clear PVC Tubing, .50 in. ID x 12 in. long |
| 2 | 46-294167P10 | Ball Valve | 1 | PVC Ball Valve, .50 in. ID pipe |
| 3 | 46-294167P11 | Tee | 1 | Male Tee Fitting, .50 in. ID x .50 in. ID x .50 in. NPT nylon hose fitting |
| 4 | 46-294167P12 | Nipple | 1 | Male Nipple Fitting, .50 in. ID x .50 in. NPT nylon hose fitting |
| 5 | 46-294167P13 | Clamp | 3 | Hose Clamp |
| 6 | 46-294167P16 | Plug | 1 | Quicksnap expandable plug for .50 in. ID hose |
| 7 | 2102426APR | Instructions | 1 | Water Tee Assembly Instructions |

## 4-17 SHIELD COOLER VACUUM PUMP KIT 46-294047G1 REV. AE



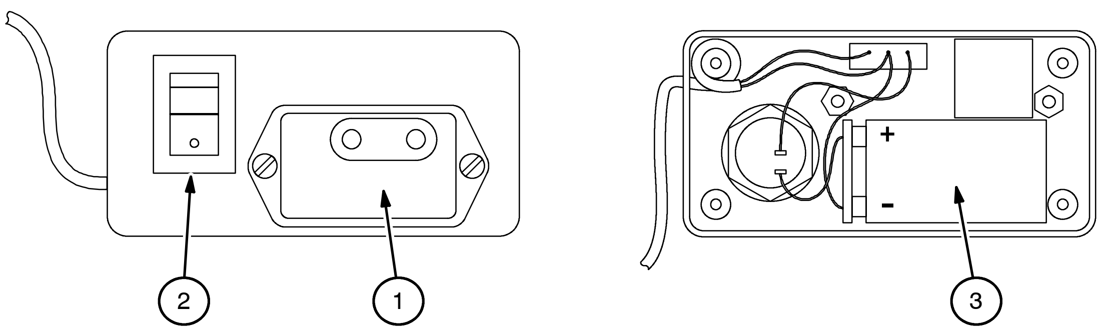

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-294833G1 | Shield Pump Kit | 1 | Shield Pump Kit |
| 1A* | 46-294041P1 | Vacuum Pump | 1 | Sargent-Welch Vacuum Pump |
| 1B* | 46-294041P2 | Filter | 2 | Exhaust Filter |
| 1C* | 46-252557P2 | Elbow | 1 | 90° Plumbing Elbow |
| 1D* | 46-294029P1 | Nipple | 1 | 2 in. Nipple |
| 1E* | 46-294027P1 | Adapter | 1 | Adapter, KF16 to .25 in. NPT |
| 1F* | 46-294030G1 | Centering Ring | 1 | KF16 Centering Ring with O-Ring |
| 1G* | 46-294026P1 | Clamp | 1 | KF16 Hose Clamp |
| 1H* | 46-294028P1 | Blanking Flange | 1 | KF16 Blanking Flange |
| 2 | 46-294834G1 | Hose & Filter Asm. | 1 | Hose & Filter Assemble |
| 2A† | 46-294041P3 | Oil Trap | 1 | Inlet Foreline Oil Trap |
| 2B† | 46-294041P4 | Oil Filter | 1 | Replacement Filter Cartridge for Oil Trap |
| 2C† | 46-294030G1 | Centering Ring | 1 | KF16 Centering Ring with O-Ring |
| 2D† | 46-294026P1 | Clamp | 2 | KF16 Hose Clamp |
| 2E† | 46-294040G1 | Hose Asm. | 1 | Vacuum Pump-Out Port Hose Assembly |
| 3 | 46-294041P5 | Oil | 1 | Vacuum Pump Oil, one quart |
| 4 | 46-294041P2 | Filter | 2 | Exhaust Filter |
| 5 | 46-294837G50 | Case | 1 | Vacuum Pump Case Assembly |

* Included in 46-294047G1 via 46-294833G1.
† Included in 46-294047G1 via 46-294834G1

## 4-18 VACUUM MAINTENANCE EQUIPMENT

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-252210P1 | Operator | 1 | 3 in. Valve Port Operator |
| 2 | 46-265273G1 | He Meter | 1 | Helium Level Meter |
| 3 | 46-265387G1 | He Gage Asm. | 1 | Helium Guage Assembly |
| 4 | 46-251867G1 | Pumpdown Kit | 1 | Magnet Vacuum Pumpdown Kit |
| 5 | 46-260201P1 | Syphon | 1 | $N_2$ Precool Syphon |
| 6 | 46-260267P2 | Operator | 1 | 1 in. Instrument Port Seal-Off Operator |

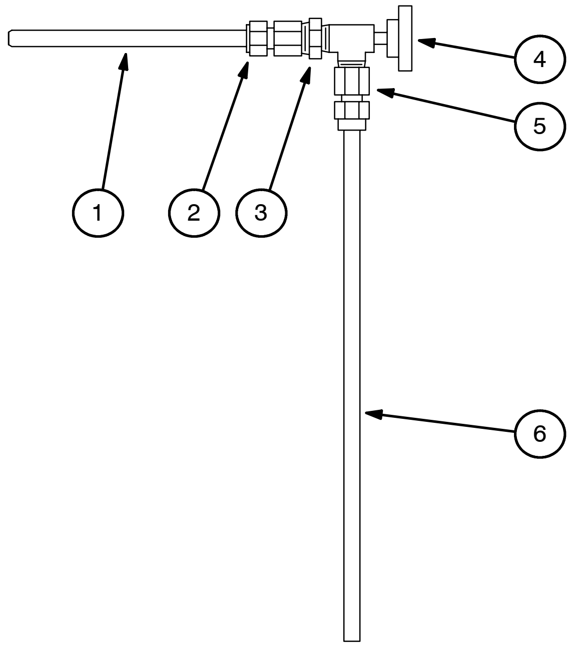
## 4-19 TAO MONITOR 46-281406G1 REV. AA




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1* | 46-281406P2 | Transducer | 1 | Transducer, low pres. diff., 0-27.68 in. H20 Omega PX162-027D5V |
| 2* | 46-281406P5 | Switch | 1 | Switch, SPST rocker, 6A AT 125VAC, Radio Shack no. 275-690 |
| 3* | 46-281406P7 | Battery | 1 | Battery, 9V rect., Radio Shack no. 23-464 or equiv. |

* Parts are not available as individual items, only as assembled part.

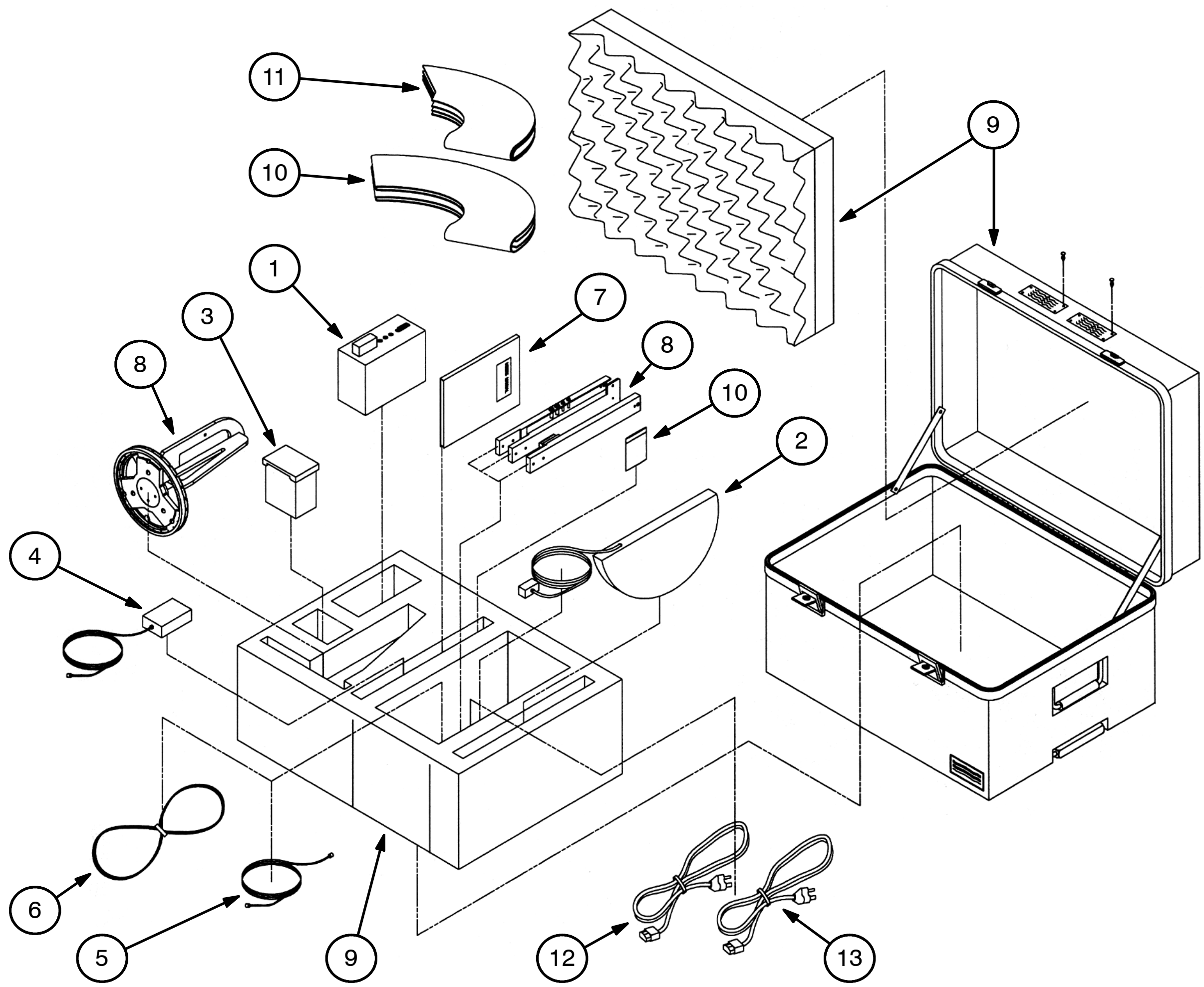
## 4-20 FILL LINE ADAPTER FOR TAO MONITORING 46-281232G1 REV. 0




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1* | 46-281232P1 | Tubing | 1 | Stainless Steel Tubing, .50 in. OD x .049 in. wall |
| 2* | 46-260912P1 | Connector | 1 | Female Connector, .50 in. ODT x 1.5 in. NPT brass |
| 3* | 46-252204P3 | Bushing | 1 | Reduction Bushing, 2 in. - 1 in. NPT brass |
| 4* | 46-281109P1 | Valve | 1 | Angle-Fill Line Dampener Valve |
| 5* | 46-281169P1 | Connector | 1 | Female Connector, .25 in. ODT x .25 in. NPT brass |
| 6* | 46-252065P45 | Tubing | 1 | Polyethylene Tubing, .25 in. OD x .040 in. wall, Imperial cat. # 44-P NATURAL |

* Parts not available separately.

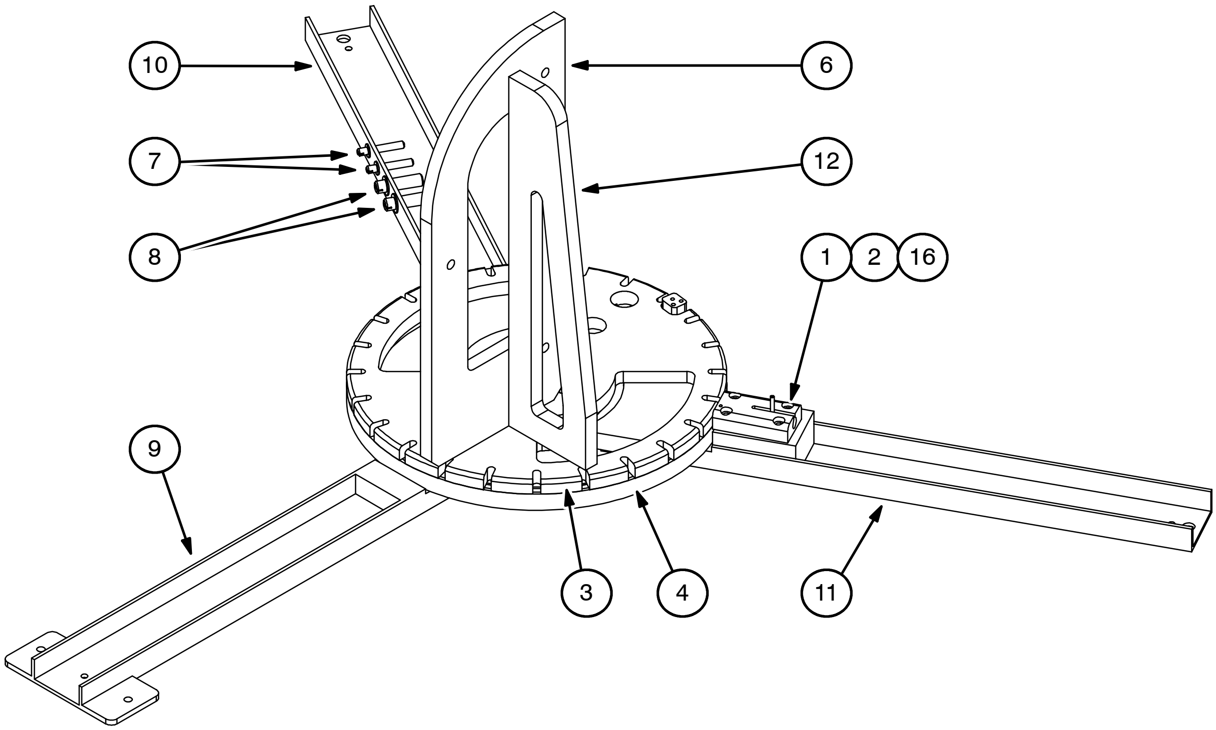
## 4-21 SHIM CAMERA KIT 2281754 REV. 0

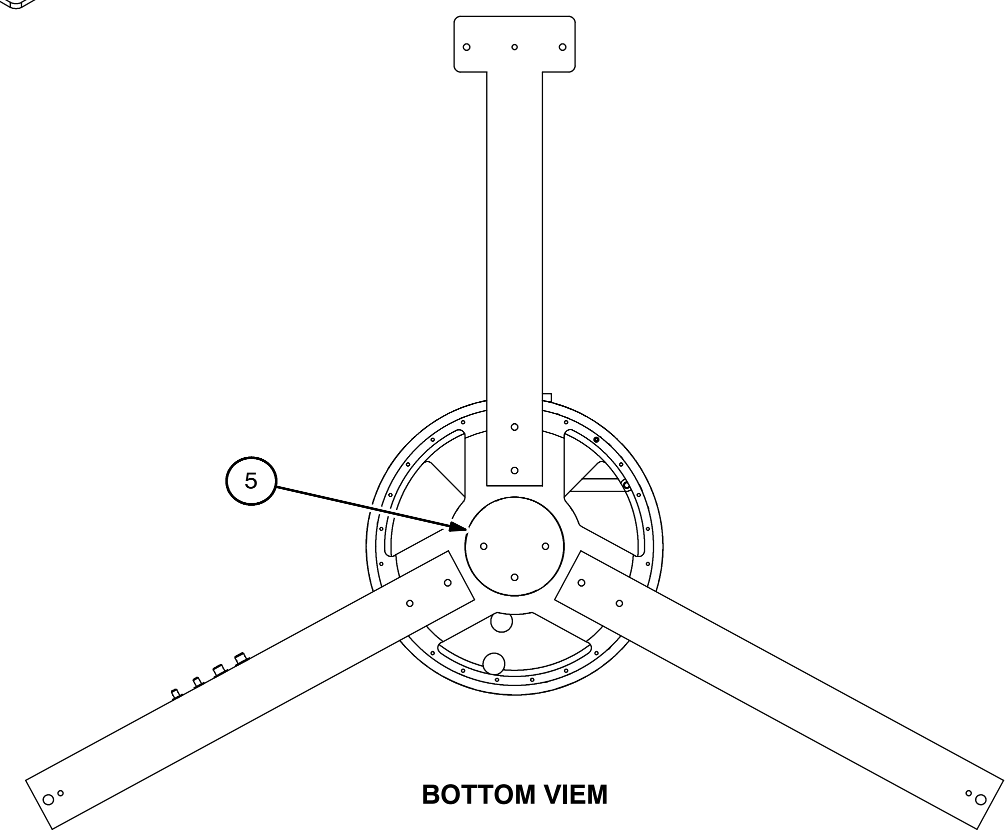



| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2276277 | Camera | 1 | Magnetic Field ( Shim ) Camera |
| 2 | 2276277-2 | Probe Array | 1 | Probe Array |
| 3 | 2276277-3 | Power Supply | 1 | Power Supply |
| 4 | 2276277-4 | Remote Box | 1 | Remote Control Box |
| 5 | 2276277-5 | Cable | 1 | RS-232 Cable |
| 6 | 2276277-6 | Cable | 1 | Cable, shim camera to power supply |
| 7 | 2276277-7 | Manual / Software | 1 | Metrolab Operating Manual & Software |
| 8* | 2276686 | Mapping Fixture | 1 | Mapping Fixture Assembly |
| 9 | 2281993 | Case | 1 | Shim Camera Carrying Case |
| 10 | 2283131 | Thermal Blanket | 2 | Front Thermal Blanket |
| 11 | 2283131-2 | Thermal Blanket | 2 | Rear Thermal Blanket |
| 12 | 2276277-8 | Cable | 1 | Power Cable, U.S. |
| 13 | 2276277-9 | Cable | 1 | Power Cable, Europe |

* See Section 4-22, Mapping Fixture Assembly.

## 4–22 MAPPING FIXTURE ASSEMBLY 2276686 REV. 1



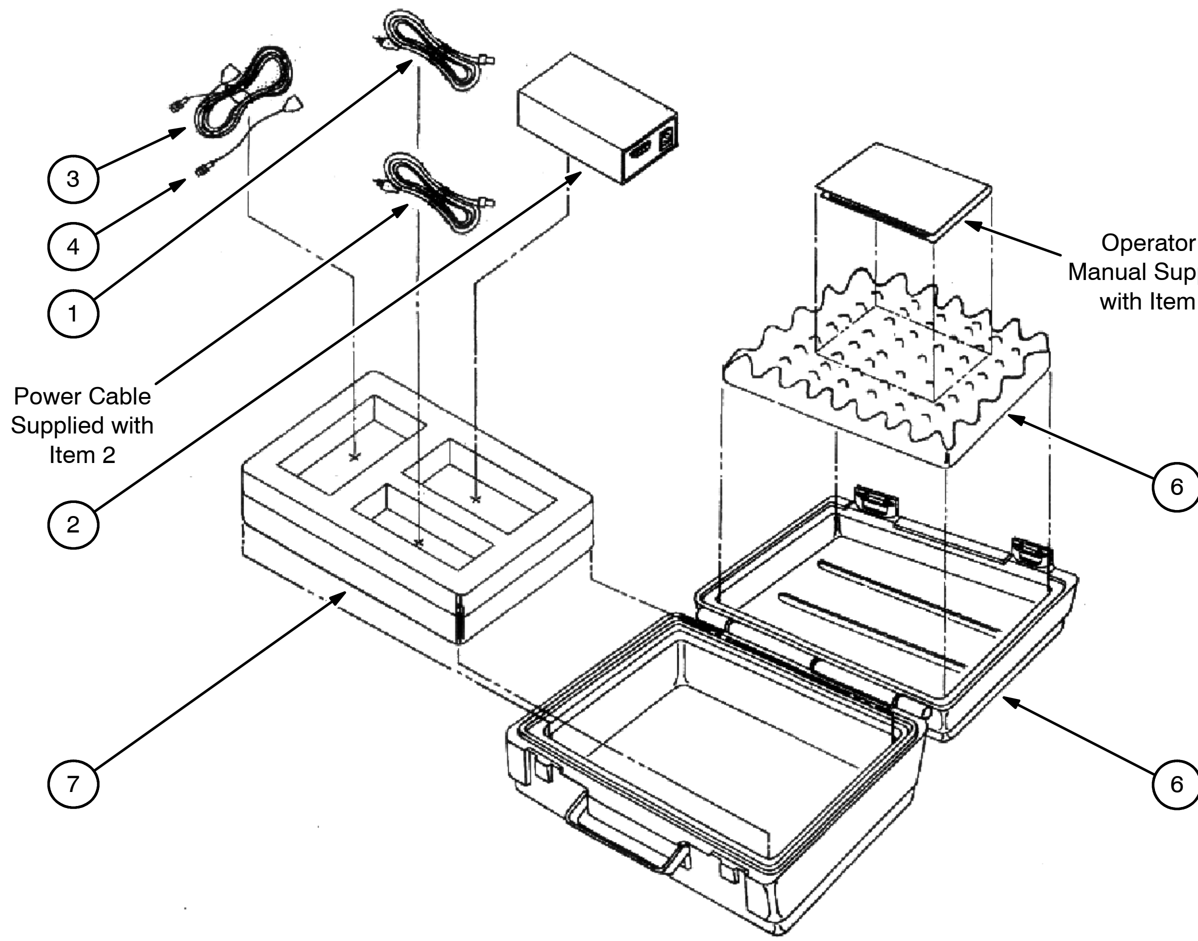




**BOTTOM VIEM**

## 4-22 MAPPING FIXTURE ASSEMBLY ( continued ) 2276686 REV. 1

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2276668 | Clamp | 1 | Body Clamp |
| 2 | 2276669 | Pin | 1 | Retaining Clamp Pin |
| 3 | 2276670 | Disk | 1 | Camera Mounting Disk, 24 position |
| 4 | 2276671 | Disk | 1 | Main Structure Disk |
| 5 | 2280794 | Pivot | 1 | Main Pivot |
| 6 | 2276673 | Plate | 1 | Vertical Camera Mounting Plate |
| 7 | 2276674 | Pin | 2 | M6 Pin, .236 in. diameter |
| 8 | 2276675 | Pin | 2 | M10 Pin, .396 in. diameter |
| 9 | 2276677 | Support | 1 | Rear Support Leg |
| 10 | 2276679 | Support | 1 | Left Support Leg |
| 11 | 2276680 | Support | 1 | Right Support Leg |
| 12 | 2276681 | Bracket | 1 | Camera Mounting Angle Bracket |
| 13 | 46-260793P97 | Screw | 6 | Round Head Screw, .312-18 x .75 in. |
| 14 | 46-260177P5 | Screw | 5 | Flat Head Screw, .25-20UNC x 1.00 in. |
| 15 | 46-260793P58 | Screw | 4 | Round Head Screw, #10-32 X .75 in. brass |
| 16 | 46-294167P31 | Pipe Plug | 1 | Hex Pipe Plug, .125 in. NPT brass |
| 17 | 46-260756P115 | Screw | 3 | Flat Head Screw, .312-18UNC x 1.00 in. brass |
| 18 | 46-294151P2 | Loctite | 1 | Loctite |

## 4-23 LAKESHORE 208 THERMOMETER KIT 46-301477G2 REV. A




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-301453P6 | Case | 1 | Blow-Molded Case |
| 2 | 46-301478P1 | Thermometer | 1 | Thermometer, Digital, 3W, 4-digit |
| 3 | 46-301619P1 | Cable | 1 | Interconnecting Cable to balzer diodes |
| 4 | 46-301620P1 | Cable | 1 | Interface Cable to GE Magnet |
| 5 | 2129919 | Cable | 1 | Interface Cable to GE Magnet w / DIN connector |
| 6 | 46-301618P1 | Foam | 1 | Convoluted Top Foam |
| 7 | 46-301618P2 | Foam | 1 | Two-Layered Bottom Foam |
| 8* | 2300866 | Cable | 1 | Interface Cable, Coldhead silicon diode to 46-301477G2 |

* Not included in 46-301477G2.

## 4-24 LOW COST SHIELD TEMPERATURE DIODE BOX

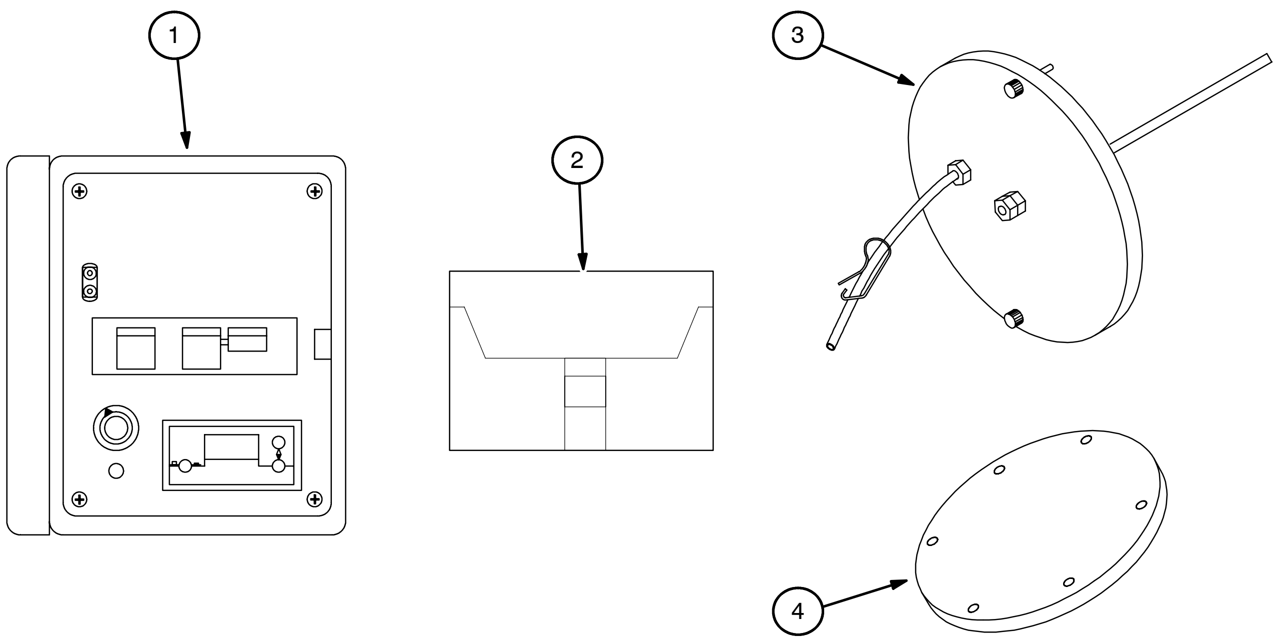
**46-317543G1 REV. 1, 46-317543G2 REV. A**

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46-317537P1 | Meter | 1 | Current Source Meter |
| 2 | 46-317537P2 | Cable | 1 | Meter cable |
| 3 | 46-317537P3 | Case | 1 | Carrying case |
| 4* | 2136506 | Cable | 1 | Cable |
| 5* | 2131412 | Label | 1 | SI-410 diode voltage / temperature characteristics tag |

* Items included with 46-317543G2 only

## 4-25 MAGNET TOOL KIT

**2183710 REV. 0**




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2171219 | Monitor | 1 | RuO Temperature Monitor |
| 2 | 2167169 | Battery Charger | 1 | Battery Charger Kit |
| 3 | 2174214 | Cover | 1 | Purge Cover Plate for heat exchanger |
| 4* | 2183760 | Cover & O-Ring | 1 | Coldhead Sleeve Cover Plate & O-Ring |
| 4A* | 2181961 | Cover | 1 | Coldhead Sleeve Cover Plate |
| 4B* | 46-252841P12 | O-Ring | 1 | Cover Plate O-Ring |
| 5 | 2183709 | Case | 1 | Carrying Case |

* Item 4 consists of items 4a and 4b, which can be ordered separately.

## 4-26 OXYGEN MONITORS

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1* | 2107184 | Monitor Kit | 1 | Enmet Oxygen Monitor Kit |
| 1A* | 46-317271G1 | Monitor | 1 | Oxygen Monitor |
| 1B* | 46-294439P5 | Manual | 1 | Supplier Manual |
| 1C* | 46-015336 | Manual | 1 | Service Manual |
| 2 | 2106236 | Monitor | 1 | Connecticut Analytical Portable Oxygen Monitor ( preferred model ) |
| 3 | 2106237 | Monitor | 1 | McNeill International Portable Oxygen Monitor ( alternate model ) |

* Item 1 contains items 1a - 1c.

## 4-27 HELIUM LEVEL METER

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2270571 | Meter | 1 | Portable Liquid Helium Level Meter with battery charger, cable and case American Magnetics, Inc. Model: 150A-120-N-18.5-IN-PCT-C with case |

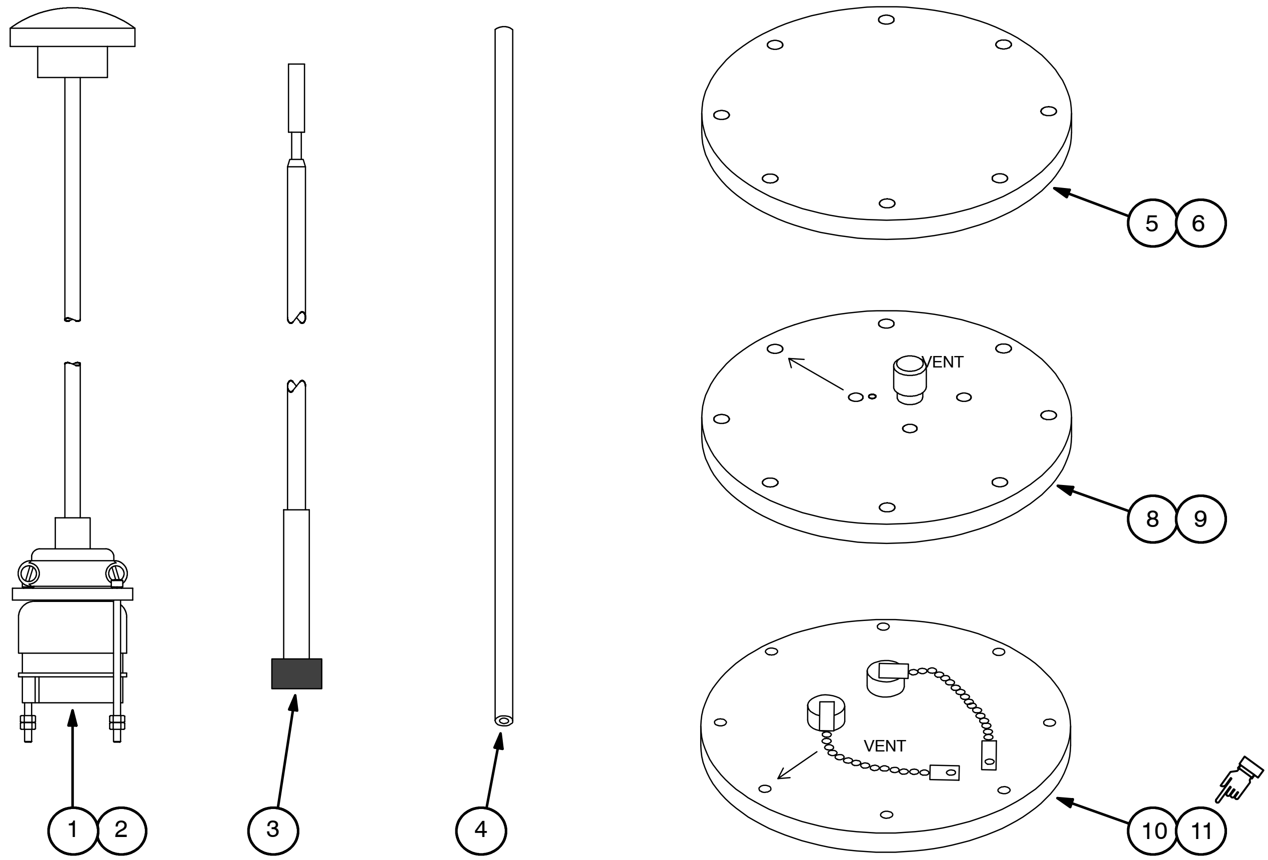
## 4-28 INSTRUMENTATION LEAD INSTALLATION / REMOVAL COMPONENTS

| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2226951 | Lead Assembly | 1 | Instrumentation Wiring Lead Assembly, HFO |
| 2* | 46-281101P4 | O-Ring | 1 | Instrumentation Lead O-Ring |
| 3* | 46-281101P1 | O-Ring | 1 | Cover Plate Assembly O-Ring |
| 4* | 46-281101P6 | O-Ring | 1 | Turret O-Ring |
| 5 | 46-252065P1 | Tape | 1 | Teflon Tape |
| 6 | 46-306830G3 | Heat Gun | 1 | Heat Gun |
| 7* | 2243789 | Cover | 1 | Lexan Cover Plate with pipe plug |
| 8** | 2119965 | Cover | 1 | Bellows Cover |
| 9** | 46-281934P1 | Tool | 1 | Connector Removal Tool |

* Supplied in Field Spare Parts Kit 46-294232G4.
** Included in Sav-Con / Instrumentation Lead Installation / Removal Kit 46-294872G3.

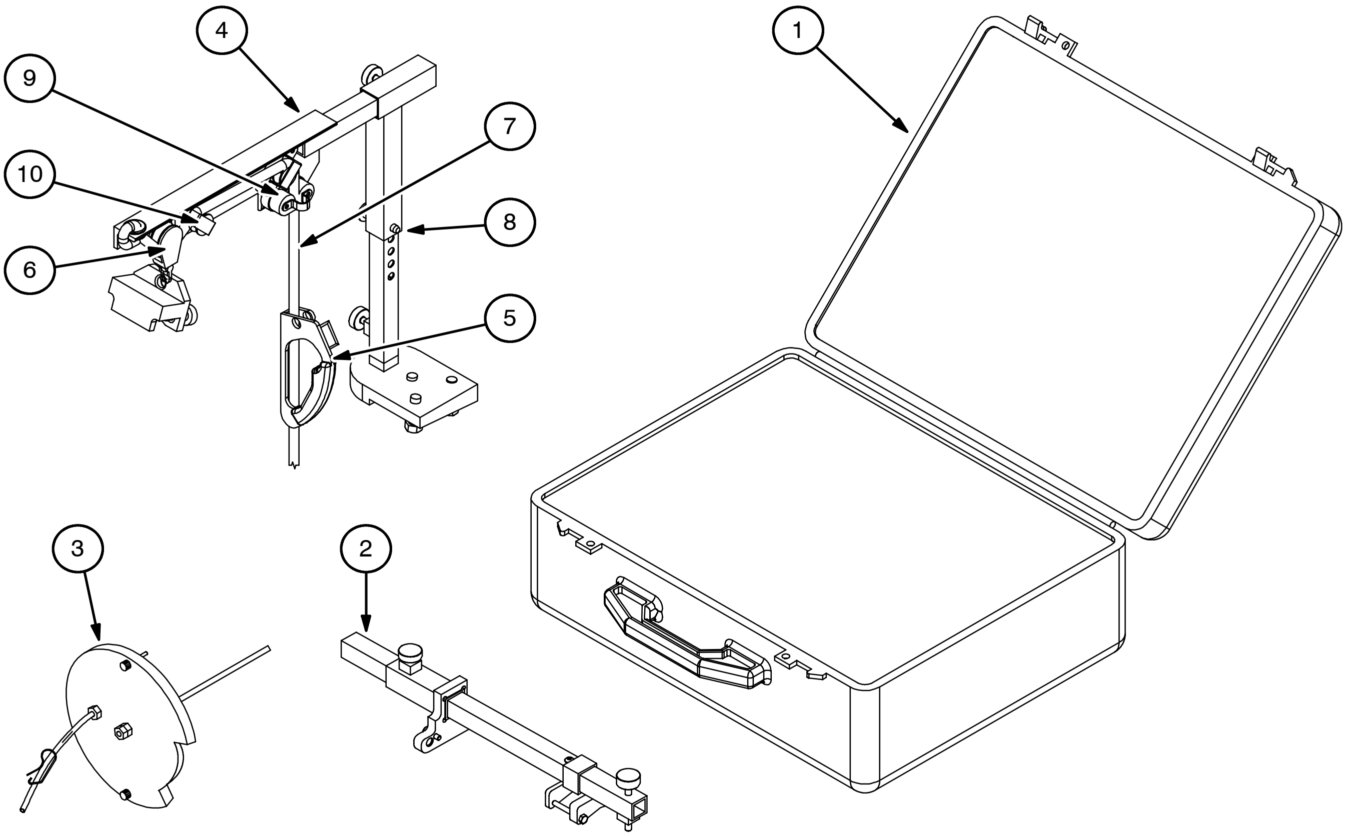
## 4–29 SAV–CON AND INSTRUMENTATION LEAD INSTALLATION / REMOVAL KIT

**46–294872G3 REV. L**




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 46–294310G1 | Tool | 1 | Sav–Con Installation / Removal Tool, SIV |
| 2 | 46–294310G2 | Tool | 1 | Sav–Con Installation / Removal Tool, SII, MAX |
| 3 | 46–294292G1 | Tool | 1 | Extended Sav–Con Allen Head Screw Removal Tool |
| 4 | 46–281934P1 | Tapped G–10 Rod | 1 | Instrumentation Lead Removal Tool |
| 5 | 46–318561P1 | Lexan Cover Plate | 1 | Lexan Vertical Penetration Blanking Plate, SIV |
| 6 | 46–260963P2 | Lexan Cover Plate | 1 | Lexan Blanking Plate, SII, MAX |
| 7 | 2119965 | Bellows Cover | 1 | Bellows Cover Assembly |
| 8 | 46–294306G1 | Lexan Cover Plate | 1 | Lexan Cover Plate / Tool Guide, SIV |
| 9 | 46–318241G1 | Lexan Cover Plate | 1 | Lexan Cover Plate / Tool Guide, SII, MAX |
| 10 | 46–294765G1 | Lexan Cover Plate | 1 | Lexan Vertical Penetration Cover, SIV |
| 11 | 2117683 | Penetration Cover | 1 | Penetration Cover Assembly |
| 12 | 46–318612G51 | Case | 1 | Case and Foam Assembly |

## 4-30 COLD HEAD EXTRACTION / INSERTION TOOL KIT 2262686 REV. 0




| Item | Part Number | Name | Quantity | Description |
|---|---|---|---|---|
| 1 | 2262749 | Case | 1 | Tool Kit Case |
| 2 | 2254151 | Tool | 1 | Coldhead Tool |
| 3 | 2275776 | Cover | 1 | Purge Cover Plate Assembly |
| 4* | 2254615 | Hoist | 1 | Coldhead Hoist |
| 5* | 2279643 | Ascender | * | Ascender Tool |
| 6* | 2279647 | Pulley | * | Pulley |
| 7* | 2270738 | Rope | * | Nylon Rope, .50 in. dia. x 25 ft. |
| 8* | 2279644 | Pin | * | Locking Pin |
| 9* | 2275600 | Cam-Matic | * | Cam-Matic |
| 10* | 2279642 | Block | * | Bullet Block |

* Item 4 consists of items 5 - 10, which can be ordered separately.

# DATA SHEETS

## TABLE OF CONTENTS

# SECTION 1 – MAGNET TEMPERATURE / PRESSURE DATA

TABLE 1–1
**MAGNET TEMPERATURE / PRESSURE DATA**

| Date | Cryostat Pressure | Cryocooler Temperatures ( RuO ) | | | Shieldcooler Temperatures ( SI410 ) | Cryocooler Temperatures ( SI410 ) | Fill Level | |
|---|---|---|---|---|---|---|---|---|
| | | First Stage ( Sleeve ) | Second Stage ( Recondenser ) | $\Delta$ T | Sleeve | Sleeve | Top | Bottom |
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## SECTION 1 – MAGNET TEMPERATURE / PRESSURE DATA ( continued )

TABLE 1–1 ( CONTINUED )
**MAGNET TEMPERATURE / PRESSURE DATA**

| Date | Cryostat Pressure | Cryocooler Temperatures ( RuO ) | | | Shieldcooler Temperatures ( SI410 ) | Cryocooler Temperatures ( SI410 ) | Fill Level | |
|---|---|---|---|---|---|---|---|---|
| | | First Stage ( Sleeve ) | Second Stage ( Recondenser ) | Δ T | Sleeve | Sleeve | Top | Bottom |
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# SECTION 2 – LIQUID HELIUM REFILL LOG

TABLE 2–1
**LIQUID HELIUM REFILL CHART**

FILLED BY:______________________________ DATE:______________________________

| Time | | Dewar Weight ( Pounds ) | | LHe Used ( $L_U$ ) ($\Delta$ lbs x 3.63) | Helium Level ( $L_I$ ) Top | | | | Helium Level ( $L_I$ ) Top | | | | Transfer Efficiency ( $\Delta L_I / L_U$ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Start | | Finish | | Start | | Finish | | |
| Start | Finish | Start | Finish | | Meter % | Amt ( L ) | Meter % | Amt ( L ) | Meter % | Amt ( L ) | Meter % | Amt ( L ) | |
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## SECTION 2 – LIQUID HELIUM REFILL CHART ( continued )

TABLE 2-1 ( CONTINUED )
**LIQUID HELIUM REFILL CHART**

FILLED BY:______________________________ DATE:______________________________

| Time | | Dewar Weight ( Pounds ) | | LHe Used ( $L_U$ ) (Δ lbs x 3.63) | Helium Level ( $L_I$ ) Top | | | | Helium Level ( $L_I$ ) Top | | | | Transfer Efficiency ( Δ $L_I$ / $L_U$ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Start | | Finish | | Start | | Finish | | |
| Start | Finish | Start | Finish | | Meter % | Amt ( L ) | Meter % | Amt ( L ) | Meter % | Amt ( L ) | Meter % | Amt ( L ) | |
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# SECTION 3 – HELIUM FILL DATA

TABLE 3–1
**HELIUM FILL DATA SHEET**

| | | |
|---|---|---|
| 1 | Date | |
| 2 | Filled By | |
| 3 | Fill Line Number | |
| 4 | Dewar Serial Number | |
| 5 | Dewar Tare Weight | |
| 6 | Dewar Weight Full | |
| 7 | Dewar Weight Empty | |
| 8 | Helium Volume Lbs. ( Line 6 – Line 7 ) | |
| 9 | Helium Volume Liters ( Line 8 X 3.63 ) | |
| 10 | End % Volume ( From Table Below ) | |
| 11 | Start % Volume ( From Table Below ) | |
| 12 | Actual Helium Transfer Volume ( Line 10 – Line 11 ) | |
| 13 | Transfer Efficiency ( Line 12 / Line 9 ) | |
| 14 | Fill Time from Fill History ( T! – T1 ) | |
| **NOTE:** Volumetric conversion of liquid helium level is provided in Table 4–1 and Graph 4–1. | | |

**FILL HISTORY**

| | START TIME | START MEASUREMENT | GAS PSI | MAGNET PSI |
|---|---|---|---|---|
| T1 | | | | |
| T2 | | | | |
| T3 | | | | |
| T4 | | | | |
| T5 | | | | |
| T6 | | | | |
| T7 | | | | |
| T8 | | | | |
| T9 | | | | |
| END T! | | | | |

FOR YOUR INFORMATION: Predicted Monitor Reading*: ____________________
Volume of Helium Gas Used**: ____________________

* Use starting meter reading. Look up helium liter level on table. Subtract Line 5 from Line 6. Multiply level. Record meter percent that reflects this level as your predicted meter reading.

** Record and note the amount of helium gas used by the pressure level gauge on the helium gas tanks.

## SECTION 3 – HELIUM FILL DATA ( continued )

TABLE 3–1 ( CONTINUED )
**HELIUM FILL DATA SHEET**

| | | |
|---|---|---|
| 1 | Date | |
| 2 | Filled By | |
| 3 | Fill Line Number | |
| 4 | Dewar Serial Number | |
| 5 | Dewar Tare Weight | |
| 6 | Dewar Weight Full | |
| 7 | Dewar Weight Empty | |
| 8 | Helium Volume Lbs. ( Line 6 – Line 7 ) | |
| 9 | Helium Volume Liters ( Line 8 X 3.63 ) | |
| 10 | End % Volume ( From Table Below ) | |
| 11 | Start % Volume ( From Table Below ) | |
| 12 | Actual Helium Transfer Volume ( Line 10 – Line 11 ) | |
| 13 | Transfer Efficiency ( Line 12 / Line 9 ) | |
| 14 | Fill Time from Fill History ( T! – T1 ) | |
| **NOTE:** Volumetric conversion of liquid helium level is provided in Table 4–1 and Graph 4–1. | | |

**FILL HISTORY**

| | START TIME | START MEASUREMENT | GAS PSI | MAGNET PSI |
|---|---|---|---|---|
| T1 | | | | |
| T2 | | | | |
| T3 | | | | |
| T4 | | | | |
| T5 | | | | |
| T6 | | | | |
| T7 | | | | |
| T8 | | | | |
| T9 | | | | |
| END T! | | | | |

FOR YOUR INFORMATION: Predicted Monitor Reading*: ______________________
Volume of Helium Gas Used**: ______________________

* Use starting meter reading. Look up helium liter level on table. Subtract Line 5 from Line 6. Multiply level. Record meter percent that reflects this level as your predicted meter reading.

** Record and note the amount of helium gas used by the pressure level gauge on the helium gas tanks.

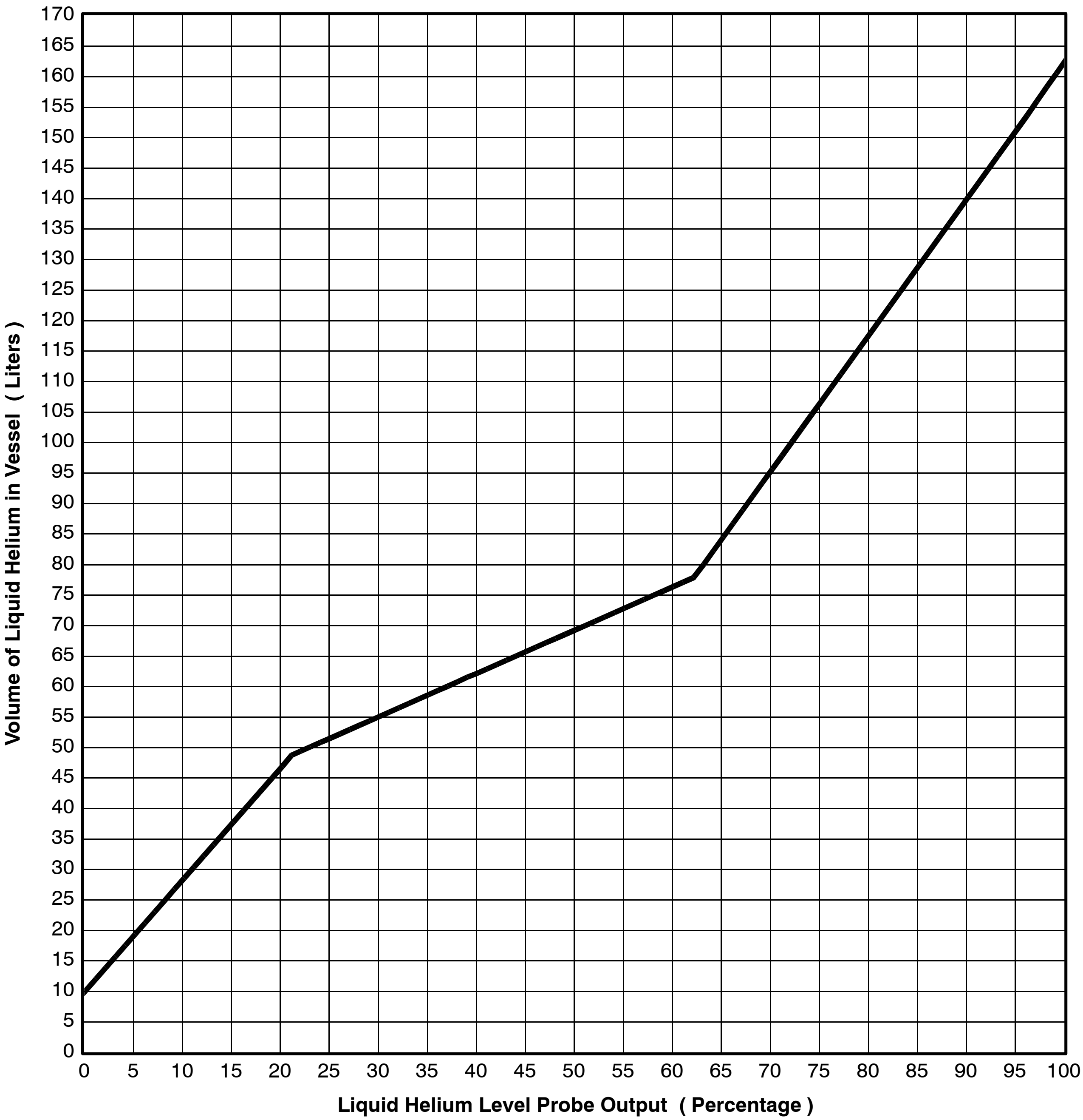
# SECTION 4
# VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL

TABLE 4-1
**VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL FOR TOP VESSEL**
**( LEVEL PERCENTAGE TO LIQUID LITERS CORRELATION )**

| Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10.48 | 6.1 | 25 | 51.86 | 30.5 | 50 | 69.61 | 40.9 | 75 | 106.98 | 62.9 |
| 1 | 12.31 | 7.0 | 26 | 52.57 | 30.9 | 51 | 70.32 | 41.4 | 76 | 109.21 | 64.0 |
| 2 | 14.14 | 8.0 | 27 | 53.28 | 31.3 | 52 | 71.03 | 41.8 | 77 | 111.44 | 65.6 |
| 3 | 15.97 | 9.0 | 28 | 53.99 | 31.8 | 53 | 71.74 | 42.2 | 78 | 113.67 | 66.9 |
| 4 | 17.80 | 10.4 | 29 | 54.70 | 32.2 | 54 | 72.45 | 42.0 | 79 | 115.90 | 68.2 |
| 5 | 19.63 | 11.0 | 30 | 55.41 | 32.6 | 55 | 73.16 | 43.0 | 80 | 118.13 | 69.5 |
| 6 | 21.46 | 12.6 | 31 | 56.12 | 33.0 | 56 | 73.87 | 43.5 | 81 | 120.36 | 70.8 |
| 7 | 23.29 | 13.7 | 32 | 56.83 | 33.4 | 57 | 74.58 | 43.9 | 82 | 122.59 | 72.1 |
| 8 | 25.12 | 14.8 | 33 | 57.54 | 33.8 | 58 | 75.29 | 44.3 | 83 | 124.82 | 73.4 |
| 9 | 26.97 | 15.9 | 34 | 58.25 | 34.3 | 59 | 76.00 | 44.7 | 84 | 127.05 | 74.7 |
| 10 | 28.78 | 16.9 | 35 | 58.96 | 34.7 | 60 | 76.71 | 45.1 | 85 | 129.28 | 76.0 |
| 11 | 30.61 | 18.0 | 36 | 59.67 | 35.1 | 61 | 77.42 | 45.5 | 86 | 131.51 | 77.4 |
| 12 | 32.44 | 19.1 | 37 | 60.38 | 35.0 | 62 | 78.13 | 46.0 | 87 | 133.74 | 78.7 |
| 13 | 34.27 | 20.0 | 38 | 61.09 | 35.9 | 63 | 80.22 | 47.2 | 88 | 135.97 | 80.0 |
| 14 | 36.10 | 21.0 | 39 | 61.88 | 36.4 | 64 | 82.45 | 48.5 | 89 | 138.20 | 81.3 |
| 15 | 37.93 | 22.3 | 40 | 62.51 | 36.8 | 65 | 84.68 | 49.8 | 90 | 140.43 | 82.6 |
| 16 | 39.76 | 23.0 | 41 | 63.22 | 37.2 | 66 | 86.91 | 51.1 | 91 | 142.66 | 83.9 |
| 17 | 41.59 | 24.5 | 42 | 63.93 | 37.6 | 67 | 89.14 | 52.0 | 92 | 144.89 | 85.2 |
| 18 | 43.42 | 25.5 | 43 | 64.64 | 38.0 | 68 | 91.37 | 53.0 | 93 | 147.12 | 86.0 |
| 19 | 45.25 | 26.6 | 44 | 65.35 | 38.4 | 69 | 93.60 | 55.0 | 94 | 149.35 | 87.9 |
| 20 | 47.08 | 27.7 | 45 | 66.06 | 38.9 | 70 | 95.83 | 56.4 | 95 | 151.58 | 89.2 |
| 21 | 49.02 | 28.0 | 46 | 66.77 | 39.3 | 71 | 98.06 | 57.0 | 96 | 153.81 | 90.5 |
| 22 | 49.73 | 29.3 | 47 | 67.48 | 39.7 | 72 | 100.29 | 59.0 | 97 | 156.14 | 91.8 |
| 23 | 50.44 | 29.7 | 48 | 68.19 | 40.1 | 73 | 102.52 | 60.3 | 98 | 158.47 | 93.2 |
| 24 | 51.15 | 30.1 | 49 | 68.90 | 40.5 | 74 | 104.75 | 61.6 | 99 | 160.70 | 94.5 |
| | | | | | | | | | 100 | 163.07 | 95.9 |
| | | | | | | | | | | 170.00 | 100.0 |

## SECTION 4 - VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL ( continued )

GRAPH 4-1
**VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL FOR TOP VESSEL**




**NOTE:** Volume in interface between top and bottom vessels = 36 liters.

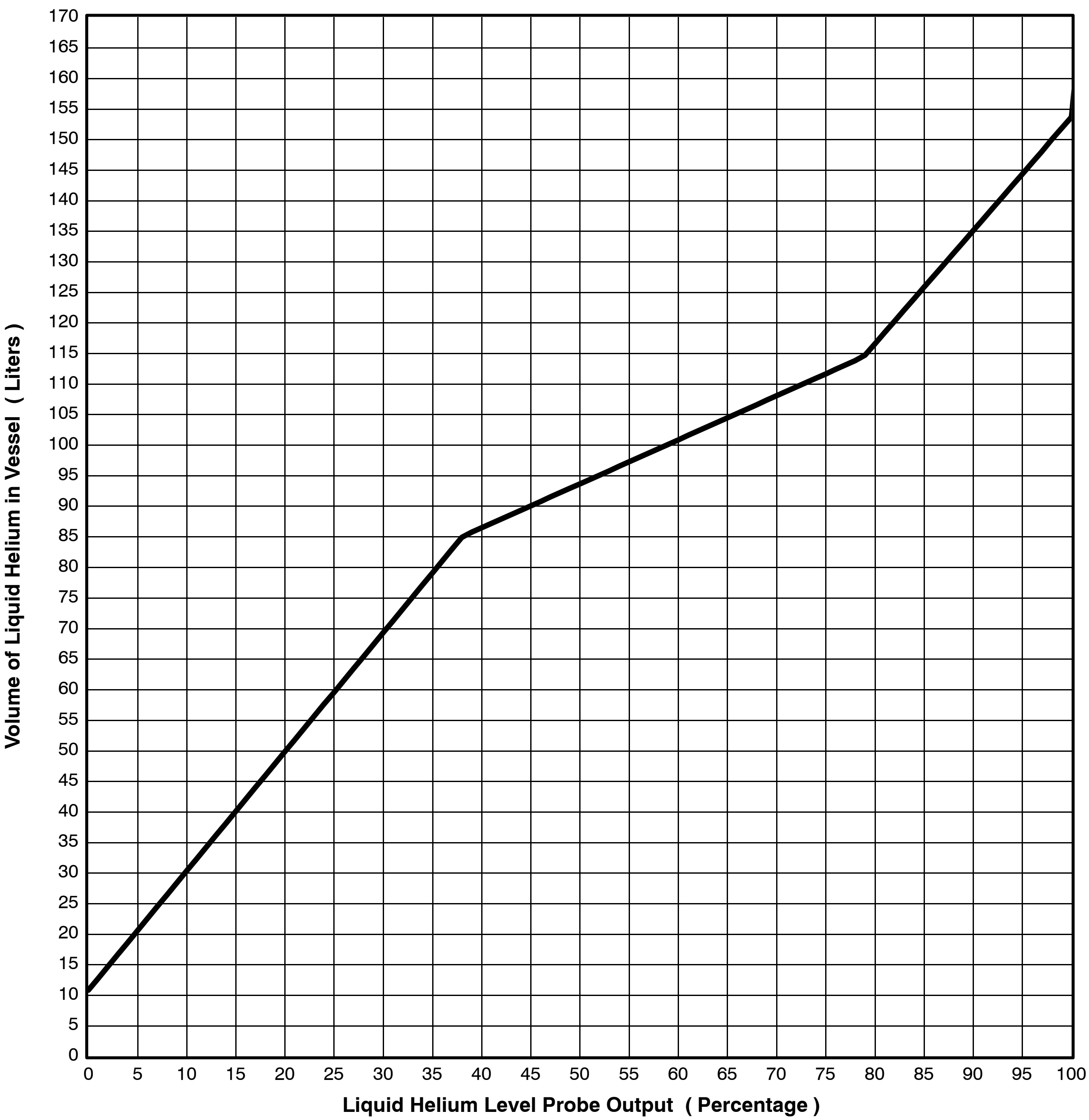
## SECTION 4 – VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL ( continued )

CHART 4–2
**VOLUMETRIC CONVERSION OF LIQUID HELIJM LEVEL FOR BOTTOM VESSEL**
**( LEVEL PERCENTAGE TO LIQUID LITERS CORRELATION )**

| Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % | Meter % | Liquid Helium ( liters ) | Actual % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10.76 | 6.3 | 25 | 59.51 | 35.0 | 50 | 93.59 | 55.1 | 75 | 111.59 | 65.6 |
| 1 | 12.71 | 7.5 | 26 | 61.46 | 36.2 | 51 | 94.31 | 55.5 | 76 | 112.31 | 66.1 |
| 2 | 14.66 | 8.6 | 27 | 63.41 | 37.3 | 52 | 95.03 | 55.9 | 77 | 113.03 | 66.5 |
| 3 | 16.61 | 9.7 | 28 | 65.36 | 38.4 | 53 | 95.75 | 56.3 | 78 | 113.75 | 66.9 |
| 4 | 18.56 | 10.9 | 29 | 67.31 | 39.6 | 54 | 96.47 | 56.7 | 79 | 114.64 | 67.4 |
| 5 | 20.51 | 12.1 | 30 | 69.26 | 40.7 | 55 | 97.19 | 57.1 | 80 | 116.49 | 68.5 |
| 6 | 22.46 | 13.2 | 31 | 71.21 | 41.2 | 56 | 97.91 | 57.6 | 81 | 118.34 | 69.6 |
| 7 | 24.41 | 14.4 | 32 | 73.16 | 43.0 | 57 | 98.63 | 58.0 | 82 | 120.19 | 70.7 |
| 8 | 26.36 | 15.5 | 33 | 75.11 | 44.2 | 58 | 99.35 | 58.4 | 83 | 122.04 | 71.8 |
| 9 | 28.31 | 16.7 | 34 | 77.06 | 45.3 | 59 | 100.07 | 58.8 | 84 | 123.89 | 72.9 |
| 10 | 30.26 | 17.8 | 35 | 79.01 | 46.5 | 60 | 100.79 | 59.3 | 85 | 125.74 | 74.0 |
| 11 | 32.21 | 18.9 | 36 | 80.96 | 47.6 | 61 | 101.51 | 59.7 | 86 | 127.59 | 75.1 |
| 12 | 34.16 | 20.1 | 37 | 82.91 | 48.8 | 62 | 102.23 | 60.1 | 87 | 129.44 | 76.1 |
| 13 | 36.11 | 21.2 | 38 | 84.86 | 49.9 | 63 | 102.95 | 60.6 | 88 | 131.29 | 77.2 |
| 14 | 38.06 | 22.6 | 39 | 85.67 | 50.4 | 64 | 103.67 | 61.0 | 89 | 133.14 | 78.3 |
| 15 | 40.01 | 23.5 | 40 | 86.39 | 50.8 | 65 | 104.39 | 61.4 | 90 | 134.99 | 79.4 |
| 16 | 41.96 | 24.7 | 41 | 87.11 | 51.2 | 66 | 105.11 | 61.8 | 91 | 136.84 | 80.5 |
| 17 | 43.91 | 25.8 | 42 | 87.83 | 51.7 | 67 | 105.83 | 62.3 | 92 | 138.69 | 81.6 |
| 18 | 45.86 | 27.0 | 43 | 88.55 | 52.1 | 68 | 106.55 | 62.7 | 93 | 140.54 | 82.7 |
| 19 | 47.81 | 28.1 | 44 | 89.27 | 52.5 | 69 | 107.27 | 63.1 | 94 | 142.39 | 83.8 |
| 20 | 49.76 | 29.3 | 45 | 89.99 | 52.9 | 70 | 107.99 | 63.5 | 95 | 144.24 | 84.9 |
| 21 | 51.71 | 30.4 | 46 | 90.71 | 53.4 | 71 | 108.71 | 63.9 | 96 | 146.09 | 85.9 |
| 22 | 53.66 | 31.6 | 47 | 91.43 | 53.8 | 72 | 109.43 | 64.4 | 97 | 147.94 | 87.0 |
| 23 | 55.61 | 32.7 | 48 | 92.15 | 54.2 | 73 | 110.15 | 64.8 | 98 | 149.88 | 88.0 |
| 24 | 57.56 | 33.9 | 49 | 92.87 | 54.6 | 74 | 110.87 | 65.2 | 99 | 151.73 | 89.3 |
| | | | | | | | | | 100 | 153.62 | 90.4 |
| | | | | | | | | | | 170.00 | 100.0 |

## SECTION 4 – VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL ( continued )

GRAPH 4–3
**VOLUMETRIC CONVERSION OF LIQUID HELIUM LEVEL FOR BOTTOM VESSEL**




**NOTE:** Volume in interface between top and bottom vessels = 36 liters.

# SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS

TABLE 5–1
**MAGNET RAMPING / PARKING CURRENT LOG**

Magnet Model No.________________________ Service Engineer:
Magnet Serial No.________________________ ________________________

| Date | Time | Connection Polarity Normal (+/-) Reverse (-/+) | Lead Extension Voltage Drop ( mV ) | Parking Current ( A ) | Magnet Field... | |
|---|---|---|---|---|---|---|
| | | | | | Before Shimming Hz ( Gauss ) | After Mechanical Shimming Hz ( Gauss ) |
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## SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS ( continued )

TABLE 5-1 ( CONTINUED )
**MAGNET RAMPING / PARKING CURRENT LOG**

Magnet Model No.____________________ Service Engineer:
Magnet Serial No.____________________ ____________________

| Date | Time | Connection Polarity Normal (+/-) Reverse (-/+) | Lead Extension Voltage Drop ( mV ) | Parking Current ( A ) | Magnet Field... Before Shimming Hz ( Gauss ) | Magnet Field... After Mechanical Shimming Hz ( Gauss ) |
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## SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS ( continued )

TABLE 5–2
**MAGNET RAMP / FILL PROFILE**

Magnet Serial No. ______________________________ Service Engineer ______________________________________

| Time | Voltage | Current | Frequency | LHe Level | Vessel Pressure | Dewar Pressure | Notes |
|---|---|---|---|---|---|---|---|
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## SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS ( continued )

TABLE 5-2 ( CONTINUED )
**MAGNET RAMP / FILL PROFILE**

Magnet Serial No. ______________________________ Service Engineer ______________________________

| Time | Voltage | Current | Frequency | LHe Level | Vessel Pressure | Dewar Pressure | Notes |
|---|---|---|---|---|---|---|---|
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## SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS ( continued )

TABLE 5-3
**MAGNET UNCOMPENSATED DRIFT LOG**

Magnet Model No. ______________________ Service Engineer:
Magnet Serial No. ______________________ ______________________

| DATE | TIME | FREQUENCY 1 | FREQUENCY 2 |
|---|---|---|---|
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## SECTION 5 – MAGNET RAMPING & PARKING CURRENT LOGS ( continued )

TABLE 5-3 ( CONTINUED )
**MAGNET UNCOMPENSATED DRIFT LOG**

Magnet Model No. ______________________ Service Engineer:
Magnet Serial No. ______________________ ______________________

| DATE | TIME | FREQUENCY 1 | FREQUENCY 2 |
|---|---|---|---|
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# SECTION 6 – SIGNA OPEN*SPEED* PASSIVE SHIM DATA SHEET

TABLE 6–1
**SIGNA OPEN*SPEED* PASSIVE SHIM DATA SHEET**

Magnet Model No. **T**____________________ Service Engineer: ____________________
Site Name ____________________ Date ____________________

| Iteration # | Map File Name ( _____.map ) | Shim File Name ( _____.shm ) | Center Frequency ( mhz ) | Total Shims | Changed Shims | Total Mass | Net Mass Changed | Target | Unrounded PPM | Quantized PPM |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 (Virgin) | | | | | | | | | | |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |

| Iteration # | DSV ( cm ) | Uncompensated | Compensated | Specification ( Compensated ) |
|---|---|---|---|---|
| | 40 | | | ≤ 14.0 |
| | 35 | | | ≤ 4.0 |
| | 30 | | | ≤ 2.0 |
| | 20 | | | ≤ 0.5 |