VHS-4 Diffusion Pump
VHS-4 Diffusion Pump
Declaration of Conformity
Konformitätserklärung
Déclaration de Conformité
Declaración de Conformidad
Verklaring de O vereenstemming
Dichiarazione di Conformità
We/Wir/Nous/Nosotros/Wij/Noi: Varian, Inc.

Varian Vacuum Technologies
121 Hartwell Avenue
Lexington, MA, 02421-3133 USA

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a cui se riferisce questa dichiarazione è conforme alla/e sequente/l norma/o documento/l normativo/i.

VMF-11     M-2      VHS-6    HS-16
AX-65       M-4      VHS-250  HS-20
AX-150      VHS-4    VHS-10   HS-32
HS-2        M-6      VHS-400  NHS-35

73/023/EEC. Low Voltage Directive
EN 61010-1. “Safety requirements for electrical equipment for measurement, control and laboratory use”, incorporating amendments, numbers 1 and 2.

Frederick C. Campbell
Operations Manager
Varian Vacuum Technologies
Lexington, Massachusetts, USA

October 2000
### Warranty

Products manufactured by Seller are warranted against defects in materials and workmanship for twelve (12) months from date of shipment thereof to Customer, and Seller’s liability under valid warranty claims is limited, at the option of Seller, to repair, replacement, or refund an equitable portion of the purchase price of the Product. Items expendable in normal use are not covered by this warranty. All warranty replacement or repair of parts shall be limited to equipment malfunctions which, in the sole opinion of Seller, are due or traceable to defects in original materials or workmanship. All obligations of Seller under this warranty shall cease in the event of abuse, accident, alteration, misuse, or neglect of the equipment. In-warranty repaired or replaced parts are warranted only for the remaining unexpired portion of the original warranty period applicable to the repaired or replaced parts. After expiration of the applicable warranty period, Customer shall be charged at the then current prices for parts, labor, and transportation.

When products are used with toxic chemicals, or in an atmosphere that is dangerous to the health of humans, or is environmentally unsafe, it will be the responsibility of the Customer to have the product cleaned by an independent agency skilled and approved in handling and cleaning contaminated materials before the product will be accepted by Varian Associates for repair and/or replacement.

Reasonable care must be used to avoid hazards. Seller expressly disclaims responsibility for loss or damage caused by use of its Products other than in accordance with proper operating procedures.

Except as stated herein, Seller makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except as stated herein, Seller shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise. Statements made by any person, including representatives of Seller, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon Seller unless reduced to writing and approved by an officer of Seller.

### Disclaimer

Operation and maintenance of this equipment involves serious risk. It is the responsibility of the user to maintain safe operating conditions at all times. Varian assumes no liability for personal injury or damage resulting from operation or service of the equipment.

Varian has no control over the use of this equipment and is not responsible for personal injury or damage resulting from its use. The safe use and disposal of hazardous or potentially hazardous materials of any kind is the sole responsibility of the user. Observe all WARNINGS and CAUTIONS to minimize the serious hazards involved.

It is the sole responsibility of the users of Varian equipment to comply with all local, state and federal safety requirements (laws and regulations) applicable to their system. Employ the services of an industrial hygienist and/or a qualified chemical safety engineer in order to ensure safe installation and use.

Warranty Replacement and Adjustment

All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto, and must be received within the applicable warranty period by Seller or its authorized representative. Such claims should include the Product serial number, the date of shipment, and a full description of the circumstances giving rise to the claim. Before any Products are returned for repair and/or adjustment, written authorization from Seller or its authorized representative for the return and instructions as to how and where these Products should be returned must be obtained. Any Product returned to Seller for examination shall be prepaid via the means of transportation indicated as acceptable by Seller. Seller reserves the right to reject any warranty claim not promptly reported and any warranty claim on any item that has been altered or has been returned by non-acceptable means of transportation. When any Product is returned for examination and inspection, or for any other reason, Customer shall be responsible for all damage resulting from improper packing or handling, and for loss in transit, notwithstanding any defect or non-conformity in the Product. In all cases, Seller has the sole responsibility for determining the cause and nature of failure, and Seller’s determination with regard thereto shall be final.

If it is found that Seller’s Product has been returned without cause and is still serviceable, Customer will be notified and the Product returned at its expense; in addition, a charge for testing and examination may be made on Products so returned.

3/1/00
Instructions for Use

This equipment is designed for use by professionals. The user should read this instruction manual and any other additional information supplied by Varian before operating the equipment. Varian will not be held responsible for any events that occur due to non-compliance with these instructions, improper use by untrained persons, non-authorized interference with the equipment, or any action contrary to that proved for by specific national standards.

This manual uses the following standard safety protocol:

| WARNING | The warnings are for attracting the attention of the operator to a particular procedure or practice which, if not followed correctly, could lead to serious injury. |
| CAUTION | The cautions are displayed before procedures, which if not followed, could cause damage to the equipment. |
| NOTE | The notes contain important information taken from the text. |
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Diffusion Pump Hazards

Designers of systems utilizing diffusion pumps must design out hazards wherever possible. For hazards that cannot be designed out, warnings, procedures, and instructions on proper use and servicing are provided. Please use guards, safety features, and interlocks as recommended.

Refer to Table 1 for a list of general hazards and recommended actions, Table 2 on page x for a list of prohibited actions that can result in explosions, and Table 3 on page xi for a list of pressurization hazards that can result in damage to equipment.

**THE INSTALLATION, OPERATION, AND SERVICING OF DIFFUSION PUMPS INVOLVES ONE OR MORE OF THE FOLLOWING HAZARDS, ANY ONE OF WHICH IN THE ABSENCE OF SAFE OPERATING PRACTICES AND PRECAUTIONS, COULD POTENTIALLY RESULT IN DEATH OR SERIOUS HARM TO PERSONNEL.**

### Table 1  General Hazards

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Suggested Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of utility: water and/or electricity</td>
<td>Provide sufficient backup water and power supply as necessary to effect a safe shutdown under worst case conditions</td>
</tr>
<tr>
<td>Overpressure in foreline</td>
<td>Provide an interlock to ensure that the power supply to the pump heater cannot be activated if the foreline pump is not running and/or the pressure in foreline is above 0.5 Torr (0.38 mbar)</td>
</tr>
<tr>
<td>Overtemperature</td>
<td>Fit temperature sensors and pump fluid level sensors with feedback to an interlock on the heater power supply</td>
</tr>
<tr>
<td>Insufficient water flow through the main cooling coils</td>
<td>Use water flow sensor and feedback to interlock the heater power supply</td>
</tr>
<tr>
<td>Water trapped between inlet and outlet of Quick Cool coil, or liquid nitrogen trapped between inlet and outlet of liquid nitrogen trap</td>
<td>Provide vent or pressure relief valves for both Quick Cool coil and liquid nitrogen trap</td>
</tr>
<tr>
<td>Loss of electrical ground integrity</td>
<td>Incorporate ground fault interrupt circuit into heater power supply</td>
</tr>
<tr>
<td>Positive pressure in pumping system</td>
<td>Integrate pressure relief valve in vacuum system</td>
</tr>
<tr>
<td>High voltage</td>
<td>Prevent personnel contact with high voltages; design and attach warnings</td>
</tr>
<tr>
<td>Toxicity and Corrosivity</td>
<td>Toxic and/or corrosive gases must be vented to a safe location, ensuring adequate dilution or scrubbing to safe levels, taking all action required to meet air quality standards</td>
</tr>
<tr>
<td>Explosion</td>
<td>Integrate pressure relief valves in all systems using pumps 10 inches or larger in diameter.</td>
</tr>
<tr>
<td></td>
<td>Do not use hydrocarbon-based pumping oils</td>
</tr>
</tbody>
</table>
Explosion

- Operation of the diffusion pump without continuous evacuation below 0.5 Torr (0.67 mbar), or without coolant and introducing a strong oxidizer (such as air) or explosive vapors or powders or materials which may react with pumping fluids in a hot pump (above 300 °F or 150 °C) can cause an explosion. Such an explosion can violently expel valves and other hardware, slam open doors that are not designed for appropriate pressure relief, or burst other components of the vacuum system. Serious injury or death may result from expelled parts, doors, shrapnel, and shock waves.

- Three elements are required for explosion: fuel, oxidizer, and an ignition. A combination of temperature and pressure can be a source of ignition. Most diffusion pump fluids, except mercury, are fuels. Hydrocarbon oils are more prone to oxidize and explode than synthetic silicone-based oil. The oxidizer can be air, which is a strong oxidizer that is introduced by a leak, deliberately brought in via a process, or inadvertently admitted by operator or by a process controller error.

- Explosion and Fire from Acetone and Alcohol: Diffusion pumps are typically cleaned with acetone and alcohol. When combined with air, oxygen, and other oxides, alcohol and most other solvents are very flammable and explosive. Never permit any trace of these cleaners to remain in or on the pump. Always remove all traces of alcohol and acetone and other cleaners with clean, dry, oil-free compressed air. Oxygen and other strong oxidizers are even more dangerous than air. Certain conditions of temperature and pressure can cause a combustible mixture to explode. The larger the diffusion pump, the greater the risk of explosion and the greater the risk of damage and injury. Never operate large diffusion pumps utilizing hydrocarbon oils without a complete safety analysis for the entire system and for the application.

Never operate a large diffusion pump under the conditions listed in Table 2. Any of these situations increases the probability of an explosion.

**Table 2 Explosive Conditions**

<table>
<thead>
<tr>
<th>Prohibited Action</th>
<th>Explosion-Causing Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not run pump without cooling water</td>
<td>Overtemperature</td>
</tr>
<tr>
<td>Do not run pump with low level of pump fluid</td>
<td>Overtemperature</td>
</tr>
<tr>
<td>Do not run pump without proper backing or holding pump</td>
<td>Overpressure</td>
</tr>
<tr>
<td>Do not run pump when not evacuated below 0.5 Torr (0.38 mbar)</td>
<td>Overpressure</td>
</tr>
<tr>
<td>Do not admit air to, or rough through, a pump with hot boiler</td>
<td>Overpressure plus strong oxidizer</td>
</tr>
<tr>
<td>Do not open drain or fill plug while pump is under vacuum, especially when it is hot</td>
<td>Overpressure plus strong oxidizer</td>
</tr>
<tr>
<td>Do not contaminate pump with explosive vapors</td>
<td>Lower explosive threshold of gas mixtures</td>
</tr>
<tr>
<td>Do not remove, defeat, or override safety counter-measures such as pressure and thermal switches and valve sequencer interlocks</td>
<td>Overtemperature, overpressure, more combustible mixtures</td>
</tr>
<tr>
<td>Do not machine or weld any part of the pump without removing all oil or solvent residue in pump in large pumps</td>
<td>Source of ignition</td>
</tr>
<tr>
<td>Do not use unsuitable pumping fluid, especially hydrocarbon oil</td>
<td>Lower explosive threshold of gas mixture</td>
</tr>
</tbody>
</table>
Pressurization Hazards

- Large vacuum pumps and their components are designed for vacuum service; they are not designed to be pressurized which could cause them to burst possibly expelling shrapnel at lethal velocities. Serious accidents have been caused by intentional pressurization of vacuum systems and their components.
- Never pressurize any part of a vacuum system for test or any other purpose.
- Always provide pressure relief when designing diffusion pumps into systems and ensure that pressure relief motion is limited to safe envelopes.
- Never permit the hazards in Table 3 to develop.

### Table 3  Pressurization Hazards

<table>
<thead>
<tr>
<th>Prohibited Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not block inlet or vent of liquid nitrogen trap and lines</td>
<td>LN₂ trap and/or lines burst</td>
</tr>
<tr>
<td>Do not close isolation valves at inlet and discharge of main water cooling coils when pump is reheated</td>
<td>Water turns to steam and bursts coils</td>
</tr>
<tr>
<td>Do not pressurize the pump body</td>
<td>Body of pump bursts</td>
</tr>
<tr>
<td>Do not make a hole through the vacuum wall</td>
<td>Loss of structural integrity of wall</td>
</tr>
</tbody>
</table>

- Pressure Relief Devices: Systems larger than 10 inches, such as this pump, must be designed with pressure relief devices to provide safe pressure relief from internal explosions. Always recognize that safety devices can fail or malfunction; provide redundant protection by installing devices having different failure modes, failure mechanisms, and failure causes. Be certain that exhaust duct materials are capable of withstanding the corrosivity, temperature, and pressure of exhausted products.

Dangerous Substances

- Chemical Dangers of Acetone and Alcohol: Diffusion pumps are typically cleaned with acetone or alcohol. Acetone, alcohol, and most other solvents are irritants, narcotics, and depressants, and/or carcinogenic. Their inhalation and ingestion may produce serious effects. Even absorption through the skin can result in moderate toxicity. Always ensure that cleaning operations are performed in large, well-ventilated rooms. Use of self-contained breathing apparatus may be necessary depending upon the solvent type and vapor concentration in surrounding air.
- Poisonous and Corrosive Compounds: When pumping poisonous, reactive, and/or corrosive gas, vapors, or chemicals, proper operation and regeneration do not always ensure that all hazardous materials have been totally removed. If hazardous gas, vapors, chemicals, or combustible mixtures are pumped, sufficient quantities may exist during operation or remain after regeneration to cause severe injury or death.
- Pump Fluids: Overheating the pump fluid, exposing it to air or reactive materials, or overpressurizing it above the normal operating range, approximately 1x10⁻³ Torr (1.3x10⁻³ mbar) decomposes the fluid and possibly makes it toxic. This is especially true of backstreamed mechanical pump oils which are more volatile (unstable). Overheating of accidentally introduced or backstreamed mechanical pump oils cannot be protected against by thermal switches which are set for diffusion pump oil.
- Process Gasses: These gasses are frequently toxic, flammable, corrosive, explosive, or otherwise reactive. Varian has no control over the types of gasses passing through the user’s diffusion pump as these are entirely under the control of the process user and/or the hardware systems integrator. Since these gasses can cause serious injury or death, it is very important to plumb the exhaust of the pump to the facility’s hazardous gas exhaust system which incorporates appropriate filters, scrubbers and similar components to ensure that the exhaust meets all air and water pollution control regulations.
**High Temperatures**

- **Hot Surfaces:** Boiler temperatures reach 530 °F (275 °C) which can cause serious burns. Always ensure that surfaces have cooled to near room temperature before touching them.

- **Hot Cooling Water and Steam:** The water used to cool the pump can reach scalding temperatures. Touching or rupture of the cooling surface can cause serious burns. Water left inside Quick Cool coils from previous use turns to steam when the pump is reheated. This steam must be allowed to escape without contacting personnel. Whenever possible, design the water system with interlock valves so that power cannot be applied to the pump unless water is flowing in the main cooling coils (not Quick Cool coils).

**High Voltages**

- **Diffusion pump heaters operate at voltages high enough to kill.** Design systems to prevent personnel contact with high voltages. Securely attach prominent hazard warnings. Personnel should always break the primary circuit to the power supply when direct access to the heater or wiring is required.
VHS-4 Diffusion Pump

Section I

INSTALLATION

Before unpacking and installing the VHS-4 Diffusion Pump, the user should thoroughly familiarize himself with this instruction manual and the diffusion pump specifications (see Table 1). He should also examine all other technical material supplied in order to gain a better understanding of the operating principles, limitations, correct application, and the hazards involved with the use of this equipment.

1-1 SPECIFICATIONS

Table 1 lists the specifications for all standard type 0183 models of the pump.

<table>
<thead>
<tr>
<th>Table 1. Pump Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Rating</td>
</tr>
<tr>
<td>Optimum Operating Range (Torr)</td>
</tr>
<tr>
<td>Maximum Pumping Speed l/s – Air Helium</td>
</tr>
<tr>
<td>Maximum Throughput (liters/second at 0.01 Torr (13.3 Pa))</td>
</tr>
<tr>
<td>Maximum Forepressure</td>
</tr>
<tr>
<td>Backstreaming Rate at Pump Inlet</td>
</tr>
<tr>
<td>Electrical Requirements (approximately)</td>
</tr>
<tr>
<td>Warm-up Time</td>
</tr>
<tr>
<td>Cooldown Time (using quick cool coil)</td>
</tr>
<tr>
<td>Fluid Charge</td>
</tr>
<tr>
<td>Cooling Water Requirements</td>
</tr>
<tr>
<td>Pressure drop across coils</td>
</tr>
<tr>
<td>Backing Pump Size Recommended</td>
</tr>
<tr>
<td>Jet Assembly</td>
</tr>
<tr>
<td>Foreline Baffle</td>
</tr>
<tr>
<td>Cold Cap</td>
</tr>
<tr>
<td>Water Connections</td>
</tr>
<tr>
<td>Thermal Switches</td>
</tr>
<tr>
<td>Heater circuit resistance (ohms)</td>
</tr>
<tr>
<td>Clearance (for heater removal)</td>
</tr>
</tbody>
</table>
**Table 1. Pump Specifications (Cont’d)**

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Body, flanges, foreline baffle</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Jet Assembly</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Body Cooling Coils</td>
<td>Copper</td>
</tr>
<tr>
<td>Quick Cooling Coil</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Cold cap</td>
<td>Nickel-plated copper</td>
</tr>
<tr>
<td>Shipping Weight</td>
<td>50 pounds</td>
</tr>
</tbody>
</table>

*Note: Speed curves were generated according to AVS Standards 4.1*

**VHS-4 Speed and Throughput Curves**
1-2 INSTALLATION

1-2-1 Unpacking

a  Inspect the pump to ensure that no damage has occurred during shipping. Do not discard any evidence of rough handling; any damage should be reported to the carrier and to Varian without delay.

b  Diffusion pumps are factory-packed to permit prolonged storage in suitably protected areas without special precautions.

c  Remove flange covers and protective plugs from water connections. Be careful not to scratch the O-ring seal surface on the inlet and foreline flanges.

d  Inspect the internal jet assembly. It should be concentric and firmly seated on the bottom of the diffusion pump. Using a flashlight, check to ensure that the ejector nozzle is directly in line with the foreline. The location of the jet is controlled by an indexing pin located on the bottom of the pump.

e  The pump requires no initial cleaning if the required vacuum level is above \(10^{-6}\) Torr (0.000133 Pa). For pressure below \(10^{-6}\) Torr (0.000133 Pa), follow the cleaning procedure in the Maintenance section. Then charge the pump with the diffusion pump oil shipped with the pump.

1-2-2 Pump Oil Installation

a  The recommended oil charge for the VHS-4 diffusion pump is 300 cc.

b  The oil is normally poured into the pump inlet or the foreline, or by removing the fill plug and pouring it into the fill and drain assembly.

1-2-3 Vacuum System Connections

⚠️ WARNING
Utility failure can cause damage to the equipment, overheating, and explosions. Designers of the equipment using diffusion pumps must take appropriate system design action to protect personnel and property from possible hazards. Read the safety section at the beginning of this manual.

a  The diffusion pump must be installed with the body vertical and plumb. Check to ensure that the pump inlet mating flange on the system is horizontal within ± one degree. The boiler plate must be horizontal to prevent uneven fluid level. Failure to meet this requirement could result in overheating of the diffusion pump boiler plate.

b  Prepare the inlet and foreline O-rings by wiping them with a clean, lint-free cloth. A small amount of diffusion pump oil may be used to clean the O-rings.

c  Install the O-rings in the O-ring grooves. Be careful not to damage or scratch the sealing surface.

d  Check the fill and drain plugs for tightness. Apply light to medium torque, enough to compress the O-rings.

e  Using the appropriate lifting apparatus, align the bolt holes of the inlet flange with the bolt holes of the mating flange. Using the appropriate mounting hardware, tighten the bolts evenly until the O-ring is compressed and the flanges make light, metal-to-metal contact.
f To ensure the integrity of the vacuum connections, they should be checked for leaks using a helium mass spectrometer leak detector before operating the vacuum system.

1-2-4 Cooling Water Connections

a The inlet water fitting (near the inlet flange at the top of the pump) should be connected to a continuously running water supply at 0.15 gpm and at a temperature of 60 to 80°F.

NOTE

In the following step, discharge connections must be installed in accordance with all Federal, State, and local laws and regulations.

b The exit water temperature should not exceed 120°F.

c The outlet or discharge (nearest the foreline) should be connected to an open drain.

d If the diffusion pump is being cooled by a recirculating water system, the system must be capable of adequate cooling and heat exchange to ensure a continuous inlet temperature of 60 to 80°F. The recirculating system must also be capable of maintaining an adequate flow rate to ensure that exit water temperature does not exceed 120°F. The minimum rating of this system should be 85 percent of the maximum power rating of the diffusion pump.

e The quick cool coil feed line, located at the boiler plate, should be controlled by a separate three-way valve (open, closed, and vent to atmosphere).

f The quick cool drain must be connected to an open drain which is below the inlet connection of the quick cool coil. This will ensure that the quick cool coil is completely drained when the cooling water supply is turned off and the pump is vented to atmosphere.

1-2-5 Electrical Connections

WARNING

Diffusion pump heaters operate at voltages high enough to kill through electrical shock. During installation, check the drawings and be sure to attach all hazard warnings and cautions. Always break the primary circuit of the power supply when direct access to the heater or wiring is required. Read the safety section in the front of this manual.

a The diffusion pump has been designed to operate at a specific voltage. The voltage is specified on the label that is mounted on the side of the pump. Verify the heater rating by measuring the resistance of the heater circuit and comparing it to the values in Table 1-1, Specifications.

b Make the electrical connections in the junction box located near the foreline. The electrical supply should not be more than ± 5 percent of the rated voltage.

c All electrical connections should be made in accordance with all applicable State, local, and/or industrial codes.
1-2-6 Thermal Switch

a The pump has been fitted with a manually-resettable thermal switch that is preset at the factory. This switch is located in a box near the bottom of the pump and provides protection to the pump in the event of excessive fluid loss, the loss of cooling water, or high inlet pressure.

![WARNING]

Failure to properly connect the thermal switch circuit in the following step could result in catastrophic damage to personnel, the pump, or the vacuum system.

b The thermal switch is connected in series with the heater. In the event of overtemperature, the thermal switch will open and shut off the power to the pump.

c The thermal switch may be reset by pressing the button located at the center of the thermal switch. This should be done only after the root cause of a problem has been determined and the appropriate corrective action taken.
Section II

OPERATION

⚠️ CAUTION

Damage to Pump
Do not turn on the heater without fluid in the pump. This may ruin the heaters and damage the pump.

Damage to Pump Fluid
Do not air-release the pump while the boiler is hot. Most diffusion pump fluids are heat-sensitive and will break down under these conditions.

Do not operate the pump without the internal splash baffle or foreline baffle in place. If the splash baffle is omitted, the pump may be unstable and operate at low speed. If the foreline baffle is omitted, there may be more than usual fluid loss.

Do not operate the pump for extended periods at inlet pressure above 1 micron (.133 Pa). High-pressure operation may cause excessive backstreaming.

Do not operate the pump heater unless the cooling water is circulating. It will cause the pump and fluid to overheat.

2-1 STARTUP PROCEDURE

a. During initial operation of the diffusion pump, a fresh charge of diffusion pump oil may go through a degassing process. This may result in inlet and foreline pressure fluctuations. These pressure fluctuations are normal.

b. Visually inspect the sight glass assembly to ensure that the diffusion pump has been charged with the proper amount of diffusion pump fluid. When properly filled, the oil level (when the pump is cold) will be even with the FULL/COLD mark on the oil level indicator.

c. Evacuate (rough pump) the diffusion pump with a mechanical backing pump (customer-supplied). The pressure must be reduced to less than 0.5 Torr (66.5 Pa). The backing pump should remain connected to the foreline of the diffusion pump.

d. Turn on the cooling water supply to the pump body. Check that the cooling water is not being supplied to the quick cool coil at this time.

e. Turn on the power to the diffusion pump heater.

f. Monitor inlet and foreline pressures.

g. During operation of the diffusion pump, the gas load at the inlet should not exceed the maximum throughput capability of the pump. The forepressure should not exceed the specified tolerable forepressure.
2-2  SHUTDOWN PROCEDURE

a   Turn off the power to the diffusion pump. Continue to back the diffusion pump with the appropriate mechanical pump.

b   Allow cooling water to flow through the diffusion pump until the pump body temperature, located just above the boiler plate, has cooled to a temperature of approximately 130°F.

c   After isolating the backing pump, the diffusion pump may be vented to atmosphere.

d   If faster cooling is desired, the pump can be cooled using the quick cool coil at the bottom of the diffusion pump. Follow the instructions in para. 1-3-3 for proper setup of the quick cool coil line. The same procedure for shutdown can be followed.
VHS-4 Diffusion Pump

Section III

MAINTENANCE AND SERVICE

3-1 GENERAL

Diffusion pumps generally require little attention when operated correctly. It is advisable to perform some periodic inspections to ensure trouble-free operation. By performing simple preventive maintenance, costly downtime can be avoided. A day-to-day log of pump and system performance will help indicate the condition of the pump and the need for corrective action.

3-2 PERIODIC INSPECTION

The frequency of inspection will depend on the type of system, its operation, and use. The maximum interval between inspections is established on the basis of experience. It is recommended that the following items be regularly examined.

a When the pump is cold, check the condition and level of the fluid. These can be inspected by withdrawing a fluid sample through the drain and by visually checking the level of the fluid through the sight glass. A slight discoloration of the fluid does not affect performance. Always use new o-rings when replacing fill plugs or the sight glass.

b Loss of fluid can be caused by the following:
   1 Incorrect venting procedures and/or admittance of excessive air or other gas to a hot pump.
   2 Inadequate water cooling.
   3 Prolonged operation at inlet pressures above 10⁻³ Torr (.133 Pa).
   4 Failure to reinsert the foreline baffle in the pump assembly.

c Check the total heater power input.

d When the pump is cold and the power is off, check to ensure that the heater is bolted snugly to the boiler plate. Also check all heater terminal connections at the heater and inside the junction box and make certain that they are tight and in good condition.

e Check to ensure that cooling water flow is adequate and unobstructed. In areas where the mineral content of the water is high or where there is considerable sediment, it may be advisable to install water filters.

3-3 CLEANING

Complete cleaning of the pump may be periodically required because of the gradual deterioration of some pump fluids. Removal of the pump from the system is then necessary.

a Turn off the power and disconnect the power supply plug.

b After the pump has cooled, turn off the cooling water and disconnect the cooling lines.

c Unbolt the inlet flange and foreline connections. Remove the pump from the system.

d Drain the diffusion pump of all fluid.

e Remove all O-rings, the cold cap assembly, the jet assembly, and the foreline baffle from the pump.
Thoroughly clean the diffusion pump body interior and the jet assembly using acetone followed by an isopropyl alcohol rinse. Dry the pump and the jet assembly with clean, dry, oil-free compressed air.

Install the foreline baffle, the jet assembly, and the cold cap assembly in the pump body. Check that the ejector nozzle is properly aligned with the foreline. Also check that the cold cap is properly installed on the jet assembly. The space between the underside of the cold cap and the outside of the jet cap should be uniform.

Reinstall the diffusion pump in the system using all new O-rings.

Charge the pump with the proper amount of fluid.

Reconnect the water cooling lines and the power supply.

Evacuate the diffusion pump with the appropriate mechanical pump.

Turn on the cooling water.

After the pump has been evacuated to a pressure below 0.5 Torr (66.5 Pa), turn on the power to the diffusion pump.

3-4 COLD CAP REMOVAL/INSTALLATION

To remove the cold cap, proceed as follows:

a Remove the spring (1) attached by no. 8-32 x 3\(\frac{1}{4}\) round head screw (2).

b Loosen the nut (5) holding the cold cap bracket (6) to the copper bar (A) and remove the cold cap (7) from the top of the jet cap (8).

c Unscrew the no. 8-32 x 1\(\frac{1}{4}\) socket head cap screw (9) from the top of the ceramic standoff (10).

d Remove the ceramic standoff (10) and the no. 8-32 x 1\(\frac{3}{4}\) stud (11).

To install the cold cap, proceed as follows.

a Replace the stud (11) and the ceramic standoff (10) in the jet cap (8).

b Thread the no. 8-32 x 1\(\frac{3}{4}\) socket head cap screw (9) finger-tight into the top of the ceramic standoff (10). Be careful not to crack the ceramic standoff.

c Carefully place the cold cap (7) on top of the jet cap (8), align the cold cap bracket (6) with the copper bar (A), and level the cold cap as accurately as possible.

d Tighten the nut (5) at the copper bar (A).
e Install the spring (1) attached by the screw (2). Torque the screw to 10 to 12 inch lbs.

3-5 JET ASSEMBLY REMOVAL/INSTALLATION

To remove the jet assembly, proceed as follows:

a Remove the cold cap from the pump.
b Unscrew the top cap from the jet assembly.
c Lift out each section of the jet assembly. Do not dent or otherwise damage the jet assembly during disassembly or cleaning.
d Remove the splash baffle from the pump.

To install the jet assembly, proceed as follows.

a Place the splash baffle in the bottom of the pump. Check that it is located in the outer boiler groove.
b Insert the jet base, making sure the ejector is aligned with the foreline making sure the slot in the jet base locks onto the alignment pin. Assemble the remaining stages of the jet. Make sure that all stages are firmly seated and that all drip shields are in place.
c Install the cold cap assembly.
VHS-4 Diffusion Pump

3-6 HEATER REPLACEMENT

a) Turn off the power to the diffusion pump and disconnect the power supply.
b) Remove the heater cover and the insulation from the bottom of the diffusion pump.
c) Label the heater wires for proper location during installation. Refer to the schematic diagram.
d) Disconnect the terminal leads. *Use two wrenches, one on each nut, when loosening these nuts to prevent excessively torquing and possibly breaking the heater terminals.*
e) Remove the nut holding the heater clamp.
f) Lower the entire heater unit from the pump.
g) Replace the defective heater.
h) Coat the boiler stud with an antiseize compound such as FEL-PRO C5A or common milk of magnesia.
i) Support the heater unit by the heater clamp, line up the hole with the boiler stud, and push the unit up against the boiler plate. Tighten the nut finger-tight to hold it in place.
j) Tighten the heater clamp bolt to a torque of 250 inch-pounds.
k) Replace the heater insulation and the cover.

3-7 ADDING PUMP FLUID

The recommended fluid charge for the VHS-4 diffusion pump is 300 cc. The fluid charge will gradually be depleted through use, but the pump will continue to operate normally. When the charge is reduced to approximately 60 percent of the initial fill amount, the boiler plate temperature may begin to rise. Under this condition, the thermal switch, when properly connected, is designed to open the heater circuit.

a) Turn off the power to the pump.
b) Allow the pump to cool until the temperature of the pump body, measured one inch above the heater skirt, has cooled to 130 degrees F.
c) Turn off the backing pump.
d) Vent the pump to atmosphere.
e) Loosen and remove the fill plug located at the top of the sight glass assembly.
f) Add pump fluid until the fluid level is even with the FULL/COLD mark on the sight glass.
g) Replace the O-ring in the fill plug and lubricate it with pump fluid.
h) Install the fill plug and tighten it moderately.
i) Evacuate the diffusion pump and start it following the procedures outlined in previous sections.
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VHS-4 Diffusion Pump

SECTION IV

TROUBLESHOOTING

4-1 LEAKAGE

Analysis of general operational experience with diffusion pumps indicates that certain locations are more prone to vacuum leaks. The following locations should be checked first if leakage is the suspected cause of poor system performance:

1. Inlet and foreline connections
2. Drain and fill plugs
3. Other compression fittings, such as high-vacuum gauges in the system
4. Threaded connections, such as foreline gauge

4-2 OUTGASSING

High-vacuum systems, even without external leakage, can also exhibit high gas loads due to outgassing from internal surfaces or processes. The pressure in the system is a result of gas load divided by pumping speed \( P = Q/S \). If the gas load \( Q \) exceeds the maximum throughput capability of the diffusion pump, the diffusion pump will not function and the pumping action will essentially be performed by the mechanical backing pump. To estimate the gas load, isolate the system from all pumps after evacuation and measure the rate of pressure rise. The gas load created by the system can be estimated as:

\[
Q = \frac{V}{3t} \cdot P
\]

where: \( V \) is the isolated volume, \( P \) is the pressure rise, and \( t \) is the time period of measurement.

4-3 POOR PUMP OR SYSTEM PERFORMANCE

Before proceeding with a step-by-step troubleshooting program, check the performance and accuracy of the vacuum gauges used on the system. Table 2 shows the most frequent faults, their probable causes, and specific repair actions required for each.

<table>
<thead>
<tr>
<th>Fault</th>
<th>Probable Cause</th>
<th>Repair Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor system pressure</td>
<td>a. Leak in system, virtual or real</td>
<td>Locate and repair.</td>
</tr>
<tr>
<td></td>
<td>High process gas load</td>
<td>Measure gas load, eliminate outgassing.</td>
</tr>
<tr>
<td></td>
<td>System dirty</td>
<td>Clean system to reduce outgassing.</td>
</tr>
<tr>
<td>Poor ultimate pressure</td>
<td>a. Contaminated pump fluid</td>
<td>Examine, clean pump, and replace fluid.</td>
</tr>
<tr>
<td></td>
<td>b. Low heat input.</td>
<td>Check voltage. Check for continuity, burned out element, poor thermal contact.</td>
</tr>
<tr>
<td></td>
<td>c. Inadequate cooling water flow.</td>
<td>Check water pressure. Check tubing for obstructions or back pressure.</td>
</tr>
</tbody>
</table>
### Table 2. Troubleshooting (Cont'd)

<table>
<thead>
<tr>
<th>Fault</th>
<th>Probable Cause</th>
<th>Repair Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. Excessive or too cold cooling water.</td>
<td>Check temperature, adjust flow.</td>
<td></td>
</tr>
<tr>
<td>e. High forepressure.</td>
<td>Check for leak in foreline, poor mechanical pump performance, breakdown of mechanical pump fluid.</td>
<td></td>
</tr>
<tr>
<td>f. Water in quick cool coil.</td>
<td>Check and remove water.</td>
<td></td>
</tr>
<tr>
<td>Slow pumpdown (Prolonged cycle after checking gas load conditions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Low heat input.</td>
<td>Check heaters.</td>
<td></td>
</tr>
<tr>
<td>b. Low oil level.</td>
<td>Add oil.</td>
<td></td>
</tr>
<tr>
<td>c. Malfunctioning pump assembly Improperly located jets. Damaged jet system.</td>
<td>Check and repair or replace.</td>
<td></td>
</tr>
<tr>
<td>Inlet pressure surges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Incorrect heater voltage.</td>
<td>Check and correct voltage.</td>
<td></td>
</tr>
<tr>
<td>b. Fluid outgassing.</td>
<td>Condition pump fluid by operating pump for a few hours.</td>
<td></td>
</tr>
<tr>
<td>c. Leak in system ahead of pump inlet</td>
<td>Check and correct.</td>
<td></td>
</tr>
<tr>
<td>High chamber contamination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Forepressure too high</td>
<td>Check for leak in foreline, poor mechanical pump performance, breakdown of pump fluid, and incorrect valve operation.</td>
<td></td>
</tr>
<tr>
<td>b. Prolonged operation at high throughput at pressure above $10^{-3}$ Torr (.133 Pa)</td>
<td>Review operating procedures.</td>
<td></td>
</tr>
<tr>
<td>c. Improper system operation air-release procedures</td>
<td>Review operating procedures</td>
<td></td>
</tr>
<tr>
<td>Pump will not start</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Safety circuits and/or protective devices prevent contactor from staying closed</td>
<td>Check utilities, flow switches, interlocks. Check thermostat operation.</td>
<td></td>
</tr>
</tbody>
</table>
VHS-4 Diffusion Pump

SECTION V

REPLACEMENT PARTS

The following parts are available from Varian; please call the 800 number listed inside the front cover of this manual.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>86488301</td>
<td>Standard Cold Cap Assembly</td>
</tr>
<tr>
<td>F6898301</td>
<td>Extended Cold Cap Assembly</td>
</tr>
<tr>
<td>L8908301</td>
<td>Sight Glass Repair Kit</td>
</tr>
<tr>
<td>F4785301</td>
<td>Jet Assembly</td>
</tr>
<tr>
<td>F4780 301</td>
<td>Splash Baffle</td>
</tr>
<tr>
<td>86754 301</td>
<td>Foreline Baffle Assembly</td>
</tr>
<tr>
<td>642906025</td>
<td>Switch</td>
</tr>
<tr>
<td>699006025</td>
<td>Standoff, ceramic insulating, cold cap</td>
</tr>
<tr>
<td>647304205</td>
<td>120V/1450 watt Heater Element</td>
</tr>
<tr>
<td>647304210</td>
<td>208V/1450 watt Heater Element</td>
</tr>
<tr>
<td>647306250</td>
<td>240V/1450 watt Heater Element</td>
</tr>
<tr>
<td>656179100</td>
<td>Wire, No. 10 stranded, nickel</td>
</tr>
<tr>
<td>648056680</td>
<td>Lugs, Replacement, nickel</td>
</tr>
<tr>
<td>88169301</td>
<td>Heater Clamp</td>
</tr>
<tr>
<td>Commercial</td>
<td>Heater Clamp Nut, 3(\frac{3}{16})-16, Hex, stainless steel</td>
</tr>
<tr>
<td>694492156</td>
<td>Baffle Retaining Ring</td>
</tr>
<tr>
<td>K0377183</td>
<td>O-Ring Kit; includes</td>
</tr>
<tr>
<td>3</td>
<td>Butyl inlet flange O-ring, Parker No. 2-258</td>
</tr>
<tr>
<td>10</td>
<td>Viton fill and drain O-rings (old style), Parker No. 2-112</td>
</tr>
<tr>
<td>10</td>
<td>Viton fill and drain O-rings (new style, Parker No. 2-113</td>
</tr>
<tr>
<td>1</td>
<td>Sight glass O-ring, Parker No. 2-226</td>
</tr>
<tr>
<td>1</td>
<td>Sight glass O-ring, Parker No. 2-035</td>
</tr>
<tr>
<td>K6948301</td>
<td>NEOVAC SY Diffusion Pump Fluid (1000 cc)</td>
</tr>
<tr>
<td>695474005</td>
<td>DC-704 Diffusion Pump Fluid (500 cc)</td>
</tr>
<tr>
<td>695475005</td>
<td>DC-705 Diffusion Pump Fluid (500 cc)</td>
</tr>
<tr>
<td>695405005</td>
<td>Santovac 5 Diffusion Pump Fluid (500 cc)</td>
</tr>
<tr>
<td>86715001</td>
<td>Spring, Cold Cap</td>
</tr>
<tr>
<td>Commercial</td>
<td>Screw, Rd hd machine, no. 8-32 x 3(\frac{1}{16}), stainless steel</td>
</tr>
<tr>
<td>Commercial</td>
<td>Stud, no. 8-32 x 1(\frac{1}{2}), stainless steel</td>
</tr>
<tr>
<td>Commercial</td>
<td>Screw, Socket hd cap, no. 8-32 x 1(\frac{1}{4}), stainless steel</td>
</tr>
</tbody>
</table>
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Sales and Service Offices

Argentina
Varian Argentina Ltd.
Sucursal Argentina
Av. Ricardo Babbin 2316
1428 Buenos Aires
Argentina
Tel: (54) 1 783 5306
Fax: (54) 1 786 5172

Austria
Varian Australia Pty Ltd.
679-701 Springvale Road
Mulgrev, Victoria ZZ 3170
Australia
Tel: (61) 395607133
Fax: (61) 395607950

Benelux
Varian Vacuum Technologies
Rijkstraatweg 269 H,
3956 CP Leersum
The Netherlands
Tel: (31) 343 469910
Fax: (31) 343 469961

Brazil
Varian Industria e Comercio Ltda.
Avenida Dr. Cardoso de Mello 1644
Vila Olimpia
Sao Paulo 04548 005
Brazil
Tel: (55) 11 3845 0444
Fax: (55) 11 3845 9350

Canada
Central coordination through:
Varian Vacuum Technologies
121 Hartwell Avenue
Lexington, MA 02421
USA
Tel: (781) 861 7200
Fax: (781) 860 5437
Toll Free: (800) 882 7426

China
Varian Technologies - Beijing
Room 1201, Jinyu Mansion
No. 129A, Xuanwumen Xidajie
Xicheng District
Beijing 100031 P.R. China
Tel: (86) 10 6641 1530
Fax: (86) 10 6641 1534

France and Wallonie
Varian s.a.
7 avenue des Tropiques
Z.A. de Courtaboef – B.P. 12
Les Ulis cedex (Orsay) 91941
France
Tel: (33) 1 69 86 38 13
Fax: (33) 1 69 28 23 08

Germany and Austria
Varian Deutschland GmbH
Alfsfelder Strasse 6
Postfach 11 14 35
64289 Darmstadt
Germany
Tel: (49) 6151 703 353
Fax: (49) 6151 703 302

India
Varian India Pvt. Ltd.
101-108, 1st Floor
1010 Competent House
7, Nangal Raya Business Centre
New Delhi 110 046
India
Tel: (91) 11 5548444
Fax: (91) 11 5548445

Italy
Varian Vacuum Technologies
Via F.lli Varian, 54
10040 Leini, (Torino)
Italy
Tel: (39) 011 997 9350
Fax: (39) 011 997 9350

Japan
Varian Vacuum Technologies
Sumitomo Shibaura Building, 8th Floor
4-16-36 Shibaura
Minato-ku, Tokyo 108
Japan
Tel: (81) 3 5232 1253
Fax: (81) 3 5232 1263

Korea
Varian Technologies Korea, Ltd.
Shinsa 2nd Bldg. 2F
966-5 Daechi-dong
Kangnam-gu, Seoul
Korea 135-280
Tel: (82) 2 3452 2452
Fax: (82) 2 3452 2451

Mexico
Varian S.A.
Concepcion Beistegui No 109
Col Del Valle
C.P. 03100
Mexico, D.F.
Tel: (52) 5 523 9465
Fax: (52) 5 523 9472

Taiwan
Varian Technologies Asia Ltd.
18F-13 No.79, Hsin Tai Wu Road
Sec. 1, Hsi Chih
Taipei Hsien
Taiwan, R.O.C.
Tel: (886) 2 2698 9555
Fax: (886) 2 2698 9678

UK and Ireland
Varian Ltd.
28 Manor Road
Walton-On-Thames
Surrey KT 12 2QF
England
Tel: (44) 1932 89 8000
Fax: (44) 1932 22 8769

United States
Varian Vacuum Technologies
121 Hartwell Avenue
Lexington, MA 02421
USA
Tel: (781) 861 7200
Fax: (781) 860 5437
Toll Free: (800) 882 7426

Other Countries
Varian Vacuum Technologies
Via F.lli Varian, 54
10040 Leini, (Torino)
Italy
Tel: (39) 011 997 9111
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Internet Users:
Customer Service & Technical Support:
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