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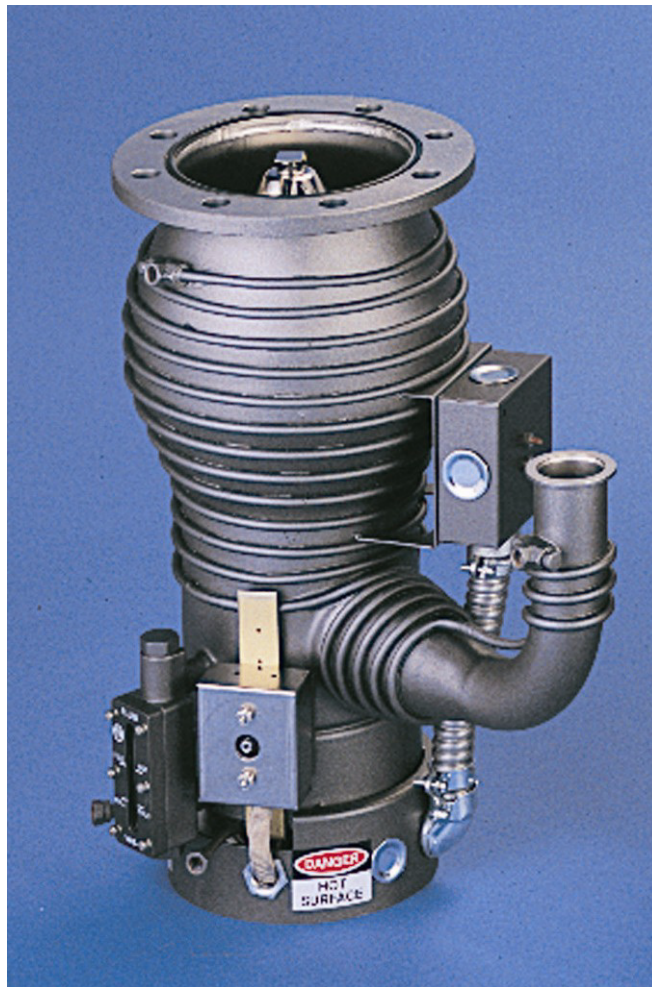


VHS-4 Diffusion Pump

INSTRUCTION MANUAL

Part No. 699901021
Rev No. D
Date October 2000

VHS-4 Diffusion Pump



Declaration of Conformity
Konformitätserklärung
Déclaration de Conformité
Declaración de Conformidad
Verklaring de Overeenstemming
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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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

Hazard	Suggested Corrective Action
Loss of utility: water and/or electricity	Provide sufficient backup water and power supply as necessary to effect a safe shutdown under worst case conditions
Overpressure in foreline	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)
Overtemperature	Fit temperature sensors and pump fluid level sensors with feedback to an interlock on the heater power supply
Insufficient water flow through the main cooling coils	Use water flow sensor and feedback to interlock the heater power supply
Water trapped between inlet and outlet of Quick Cool coil, or liquid nitrogen trapped between inlet and outlet of liquid nitrogen trap	Provide vent or pressure relief valves for both Quick Cool coil and liquid nitrogen trap
Loss of electrical ground integrity	Incorporate ground fault interrupt circuit into heater power supply
Positive pressure in pumping system	Integrate pressure relief valve in vacuum system
High voltage	Prevent personnel contact with high voltages; design and attach warnings
Toxicity and Corrosivity	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
Explosion	Integrate pressure relief valves in all systems using pumps 10 inches or larger in diameter.
	Do not use hydrocarbon-based pumping oils

VHS-4 Diffusion Pump

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

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

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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

Prohibited Action	Result
Do not block inlet or vent of liquid nitrogen trap and lines	LN ₂ trap and/or lines burst
Do not close isolation valves at inlet and discharge of main water cooling coils when pump is reheated	Water turns to steam and bursts coils
Do not pressurize the pump body	Body of pump bursts
Do not make a hole through the vacuum wall	Loss of structural integrity of wall

- ❑ *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 1×10^{-3} Torr (1.3×10^{-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.

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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

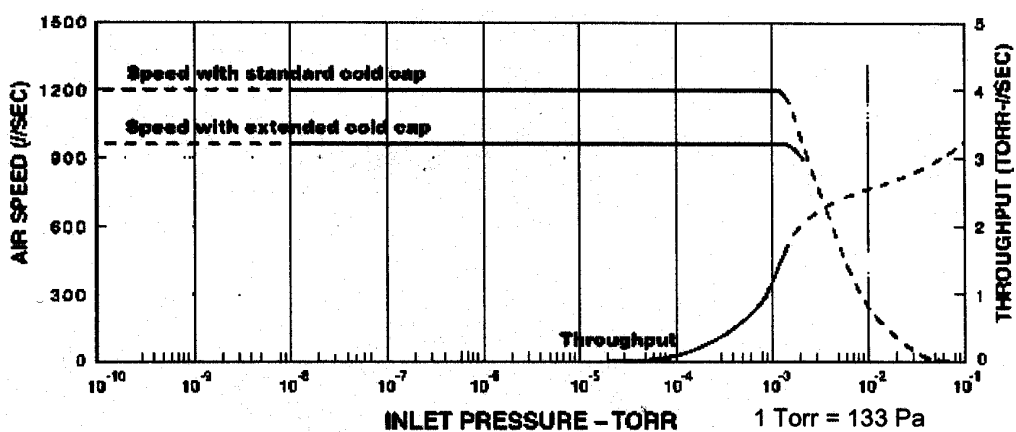
Table 1 lists the specifications for all standard type 0183 models of the pump.

<i>Table 1. Pump Specifications</i>	
Power Rating	1450 watts
Optimum Operating Range (Torr)	1×10^{-3} to $<5 \times 10^{-9}$ (.133 Pa) < (.000000665 Pa)
Maximum Pumping Speed l/s – Air Helium	1200 with std cold cap; 950 with extended cold cap 1500 with std cold cap; 1200 with extended cold cap
Maximum Throughput (liters/second at 0.01 Torr (13.3 Pa))	2.5
Maximum Forepressure	No Load – 0.65 Torr (86.45 Pa) Full Load – 0.55 Torr (73.15 Pa)
Backstreaming Rate at Pump Inlet	2×10^{-3} mg/cm ² /minute (with std cold cap)
Electrical Requirements (approximately)	120, 240, 208, 50/60 Hz, single phase
Warm-up Time	8 minutes
Cooldown Time (using quick cool coil)	10 minutes
Fluid Charge	300 cc
Cooling Water Requirements	max. inlet temperature – 60/80 degrees F max. outlet temperature at foreline – 120 degrees F general flow rate – 0.15 gpm
Pressure drop across coils	4 psi
Backing Pump Size Recommended	10 cfm for maximum throughput
Jet Assembly	4-stage, self-aligning, stainless steel
Foreline Baffle	Stacked half moon
Cold Cap	Nickel-plated Copper
Water Connections	1 $\frac{1}{8}$ FPT
Thermal Switches	Manual reset at 300°F
Heater circuit resistance (ohms)	1450 watts 120V 10 208V 31 240V 41
Clearance (for heater removal)	6 inches minimum

VHS-4 Diffusion Pump

Table 1. Pump Specifications (Cont'd)

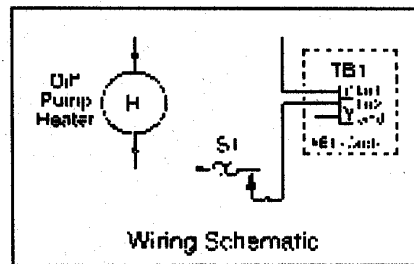
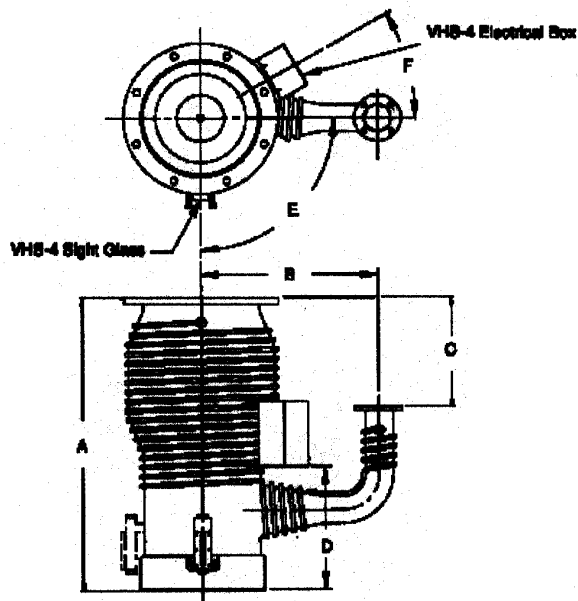
Materials	
Body, flanges, foreline baffle	Stainless steel
Jet Assembly	Stainless steel
Body Cooling Coils	Copper
Quick Cooling Coil	Stainless steel
Cold cap	Nickel-plated copper
Shipping Weight	50 pounds



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

VHS-4 Speed and Throughput Curves

VHS-4 Diffusion Pump



	VHS-4					
	ASA		ISO		ConFlat	
	In	mm	In	mm	In	mm
A Height	18.05	458	18.05	458	18.05	458
B Centerline to Centerline	10.62	270	10.62	270	10.62	270
C Flange Face to Flange Face	5.03	128	5.03	128	5.03	128
D Electrical Box Height	8.63	219	8.63	219	8.63	219
E Sight Glass Degrees from Foreline	90° clockwise		90° clockwise		90° clockwise	
F Electrical Box, Degrees from Foreline	30° counter clockwise		30° counter clockwise		30° counter clockwise	
Inlet Flange, Nominal Size	4" ASA		ISO-160-K		8" CFF	
Inlet Flange, OD	9.00	229	7.09	180	7.96	202
Inlet Flange, ID	5.91	150	5.78	147	5.91	150
Inlet Flange, Thickness	0.50	13	0.47	12	0.93	24
Inlet Flange, Bolt Circle	7.50	191	N/A	N/A	7.12	181
Inlet Flange, Number of Holes	8		N/A		20	
Inlet Flange, Hole Size	0.69	18	N/A	N/A	0.33	8
O-ring Groove ID	6.06	154	N/A	N/A	N/A	N/A
O-ring Groove Width	0.18	4	N/A	N/A	N/A	N/A
Foreline Flange, Nominal Size	KF-40		KF-40		2 3/4" CFF	
OD	2.16	55	2.16	55	2.73	69
ID	1.38	35	1.38	35	1.38	35
Thickness	0.20	5	0.20	5	0.50	13
Bolt Circle	N/A	N/A	N/A	N/A	2.31	59
Number of Holes	N/A		N/A		6	
Hole Size	N/A	N/A	N/A	N/A	0.27	7
O-ring Groove ID	N/A	N/A	N/A	N/A	N/A	N/A
O-ring Groove Width	N/A	N/A	N/A	N/A	N/A	N/A

VHS-4 Diffusion Pump

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 (.000133 Pa). For pressure below 10^{-6} Torr (.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 \pm 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.

VHS-4 Diffusion Pump

- 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

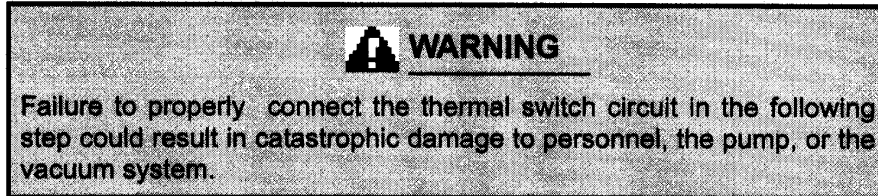
Diffusion pump heaters operate at voltages high enough to kill through electrical shock. During installation, check the drawings and be sure to attach all hazard warnings and cautions. Always break the primary circuit of the power supply when direct access to the heater or wiring is required. **Read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

VHS-4 Diffusion Pump

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.



- 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 back-streaming.

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.

VHS-4 Diffusion Pump

- f 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.
- g 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.
- h Reinstall the diffusion pump in the system using all new O-rings.
- i Charge the pump with the proper amount of fluid.
- j Reconnect the water cooling lines and the power supply.
- k Evacuate the diffusion pump with the appropriate mechanical pump.
- l Turn on the cooling water.
- m 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 $\frac{3}{16}$ 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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

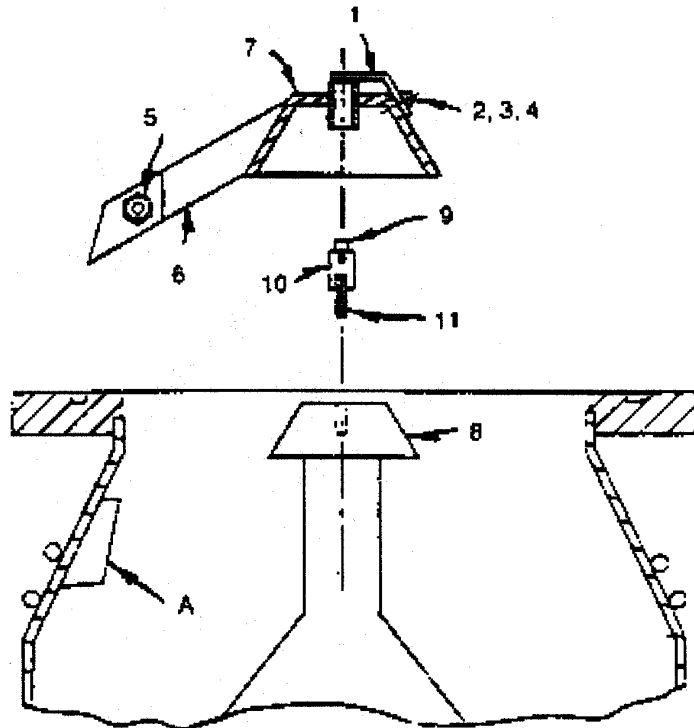
NOTE

In the following step, be sure that no strain is applied to the ceramic standoff when tightening the nut (5) at the copper bar (A).

the copper bar (A), and level the cold cap as accurately as possible.

- d Tighten the nut (5) at the copper bar (A).

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Cold Cap Removal/Installation

- 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.

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3-6 HEATER REPLACEMENT

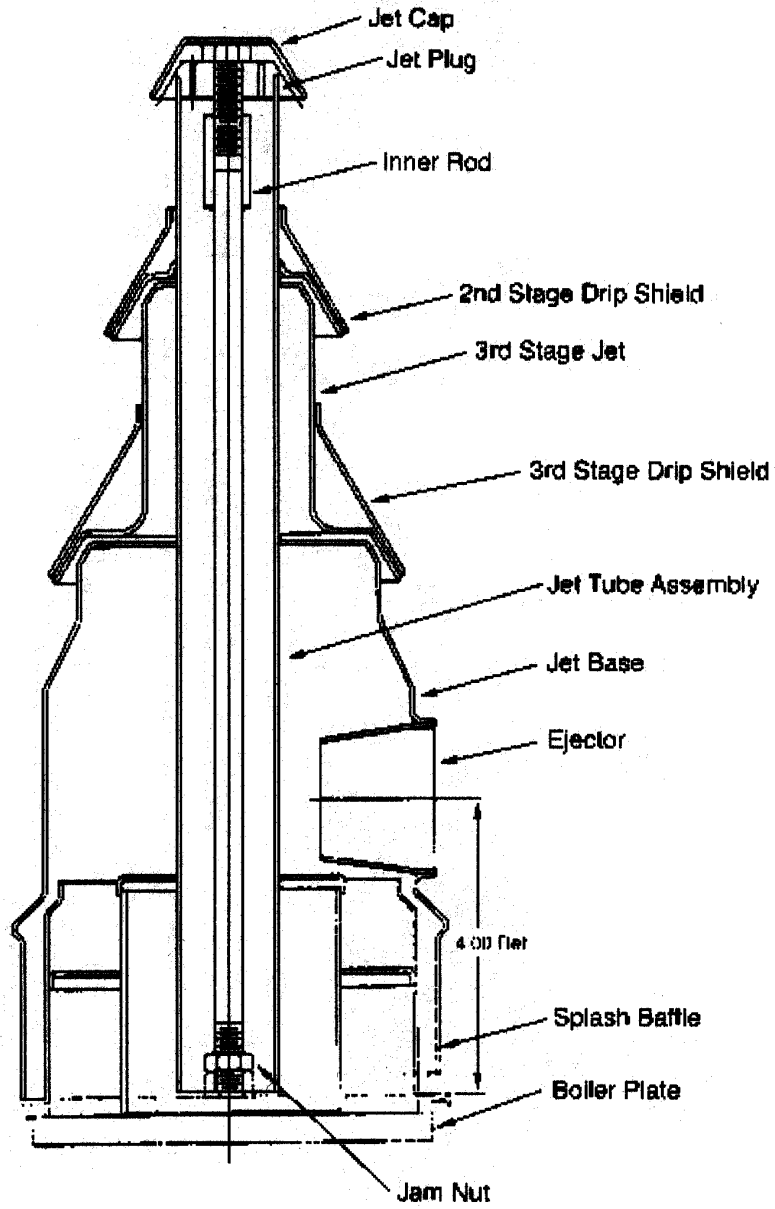
- a Turn off the power to the diffusion pump and disconnect the power supply.
- b Remove the heater cover and the insulation from the bottom of the diffusion pump.
- c Label the heater wires for proper location during installation. Refer to the schematic diagram.
- d Disconnect the terminal leads. **Use 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
Jet Assembly**

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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:

$$Q = \frac{V \times \Delta P}{\Delta t}$$

where: V is the isolated volume, ΔP is the pressure rise, and Δt 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.

Fault	Probable Cause	Repair Action
Poor system pressure	a. Leak in system, virtual or real	Locate and repair.
	High process gas load	Measure gas load, eliminate outgassing.
	System dirty	Clean system to reduce outgassing.
Poor ultimate pressure	a. Contaminated pump fluid	Examine, clean pump, and replace fluid.
	b. Low heat input.	Check voltage. Check for continuity, burned out element, poor thermal contact.
	c. Inadequate cooling water flow.	Check water pressure. Check tubing for obstructions or backpressure.

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Table 2. Troubleshooting (Cont'd)

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

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SECTION V

REPLACEMENT PARTS

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

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

VHS-4 Diffusion Pump

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Order On-line:

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