AX-65 Diffusion Pump for Beckman Coulter Equipment
AX-65 Diffusion Pump
for Beckman Coulter Equipment
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, Inc. 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, Inc. assumes no liability for personal injury or damage resulting from operation or service of the equipment.

Varian, Inc. 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, Inc. 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 Customer’s expense; in addition, a charge for testing and examination may be made on Products so returned.

3/1/00
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Declaration of Conformity

We declare under our sole responsibility that the product, to which this declaration relates, is in conformity with the following standard(s) or other normative documents.

AX-65 Diffusion Pump for Beckman Coulter Equipment

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</tr>
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<td></td>
</tr>
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<td></td>
</tr>
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Low Voltage Directive

73/023/EEC
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, Inc.
Lexington, Massachusetts, USA

October 2002
Preface

Documentation Conventions

This manual uses the following documentation conventions:

**WARNING**  
*Warnings indicate a particular procedure or practice, which if not followed correctly, could lead to serious injury.*

**CAUTION**  
*Cautions indicate a particular procedure or practice, which if not followed, could cause damage to the equipment.*

**NOTE**  
*Notes contain important information.*

Before operating or servicing equipment, read and thoroughly understand all operation/maintenance manuals provided by Varian. Be aware of the hazards associated with this equipment, know how to recognize potentially hazardous conditions, and how to avoid them. Read carefully and strictly observe all cautions and warnings. The consequences of unskilled, improper, or careless operation of the equipment can be serious.

In addition, consult local, state, and national agencies regarding specific requirements and regulations. Address any safety, operation, and/or maintenance questions to your nearest Varian office.

**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 xv for a list of prohibited actions that can result in explosions, and Table 3 on page xvi 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 hazards in Table 1, 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 (0.67 mbar)</td>
</tr>
<tr>
<td>Overtemperature</td>
<td>Fit temperature sensors and pump fluid level sensors with a feedback to an interlock on the heater power supply</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>Vent toxic and/or corrosive gases to a safe location; ensure adequate dilution or scrubbing to safe levels; take all actions required to meet air quality standards</td>
</tr>
<tr>
<td>Explosion</td>
<td>Integrate pressure relief valves</td>
</tr>
<tr>
<td></td>
<td>Do not use hydrocarbon-based pumping fluids</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 are fuels. Hydrocarbon fluids are more prone to oxidize and explode than synthetic silicone-based fluid. The oxidizer can be air, which can be introduced by a leak, deliberately brought in via a process, or inadvertently admitted by operator error. 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.

- 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.
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 (0.66 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 fluid or solvent residue in pump</td>
<td>Source of ignition</td>
</tr>
<tr>
<td>Do not use unsuitable pumping fluid</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 for pressurization, 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>
<thead>
<tr>
<th>Table 3  Pressurization Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prohibited Action</strong></td>
</tr>
<tr>
<td>Do not pressurize the pump body (above 1 atm.)</td>
</tr>
<tr>
<td>Do not make a hole through the vacuum wall</td>
</tr>
</tbody>
</table>

- **Pressure Relief Devices**: Systems 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 corrosiveness, 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 over-pressurizing it above the normal operating range, approximately $1 \times 10^{-3}$ Torr ($1.3 \times 10^{-3}$ mbar) decomposes the fluid and possibly makes it toxic. This is especially true of backstreamed mechanical pump fluids which are more volatile (unstable). Overheating of accidentally introduced or backstreamed mechanical pump fluids cannot be protected against by thermal switches which are set for diffusion pump fluid.

❑ **Process Gasses:** Process 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. 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.
High Voltages

Diffusion pump heaters operate at voltages (up to 480 V) 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.

Asphyxiation

All diffusion pumps are typically cleaned with acetone or alcohol. Acetone, alcohol, and most other solvents are very volatile (unstable). During cleaning, the volatility of these cleaners may permit their gases to displace air and its life-supporting oxygen which could cause death or serious injury by asphyxiation. Always ensure that cleaning operations are performed in large, well-ventilated areas.
Installation

Before unpacking and installing the AX-65 Diffusion Pump, thoroughly familiarize yourself with this instruction manual and the diffusion pump specifications. Further, 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.

This chapter consists of:

- “Operating Characteristics”
- “Installation” on page 1-3

Operating Characteristics

The operating characteristics and physical specifications of the AX-65 diffusion pump are given in Table 1-1. The graph in Figure 1-1 on page 1-3 shows air speed and throughput as a function of inlet pressure.

NOTE

All tests were done using polyphenyl ether fluid (Santovac 5).
### Table 1-1 Operating Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Units</th>
<th>AX-65 with cold cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Range</td>
<td>Torr, mbar</td>
<td>3x10^{-3} to &lt;5x10^{-8} 3.9x10^{-3} to &lt;6.5x10^{-8}</td>
</tr>
<tr>
<td>Pumping Speed, Maximum</td>
<td>l/s, Air, l/s, Helium</td>
<td>65, 90</td>
</tr>
<tr>
<td>Throughput (Air), Max.</td>
<td>Torr-l/s, mbar-l/s</td>
<td>0.19, 0.25</td>
</tr>
<tr>
<td>Optimum Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overload Range (@ 1x10^{-2} Torr)</td>
<td>Torr-l/s, mbar-l/s</td>
<td>0.30, 0.40</td>
</tr>
<tr>
<td>Forepressure, Max.</td>
<td>Torr, mbar</td>
<td>0.75, 1.00</td>
</tr>
<tr>
<td>No Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Load</td>
<td>Torr, mbar</td>
<td>0.60, 0.78</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>Air He</td>
<td>4x10^6, 2x10^6</td>
</tr>
<tr>
<td>Backstreaming Rate at Pump Inlet</td>
<td>mg/cm^2/min</td>
<td>&lt;2x10^{-4}</td>
</tr>
<tr>
<td>Warmup Time</td>
<td>minutes</td>
<td>7</td>
</tr>
<tr>
<td>Cooldown Time</td>
<td>minutes</td>
<td>10</td>
</tr>
<tr>
<td>Electrical Configurations</td>
<td></td>
<td>115 V, 200 W</td>
</tr>
<tr>
<td>Fluid Charge</td>
<td>cc</td>
<td>30</td>
</tr>
<tr>
<td>Recommended backing pump capacity</td>
<td>cfm (m^3/hr)</td>
<td>≥ 1.5 (2.5)</td>
</tr>
<tr>
<td>Cooling Fan</td>
<td>cfm</td>
<td>35</td>
</tr>
<tr>
<td>Body</td>
<td>N/A</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Jet Assembly</td>
<td>N/A</td>
<td>Three-stage, self-aligning, aluminum, w/aluminum cold cap</td>
</tr>
<tr>
<td>Net Weight</td>
<td>lbs (kg)</td>
<td>8 (3.63)</td>
</tr>
</tbody>
</table>
Installation

Installation consists of:

- “Unpacking”
- “Pump Fluid Choice and Installation” on page 1-4
- “Vacuum System Connections” on page 1-4
- “Electrical Connections” on page 1-6
- “Thermal Switch” on page 1-6

Unpacking

To unpack:

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

NOTE

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

The pump requires no initial cleaning prior to charging it with the appropriate diffusion pump fluid.
Pump Fluid Choice and Installation

When a diffusion pump is integrated into a system that has internal electronics, use a polyphenyl ether diffusion pump fluid such as Santovac 5. These fluids have higher boiling temperatures and should, therefore, be used in pumps with 250 Watt heaters. Fluids with lower boiling points, such as DC-704, should be used in pumps with 200 Watt heaters.

The recommended fluid charge for the AX-65 diffusion pump is 30 cc. The fluid can be poured into the inlet or foreline connections.

Vacuum System Connections

Refer to Figure 1-2 during this procedure.

**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.

To establish vacuum system connections:

1. Install the diffusion pump with the body vertical and plumb. The boiler plate must be within ±1° of horizontal to prevent uneven fluid level. Failure to meet this requirement could result in overheating of the diffusion pump boiler plate.

2. Install 1" ID tubing onto the inlet adapter and 5/8" ID tubing onto the foreline adapter and secure with the hose clamps.

3. Connect the foreline tubing to the backing pump (customer-supplied).

4. Ensure the integrity of the vacuum connections by using a helium mass spectrometer leak detector to check for leaks.
Figure 1-2  AX-65 Diffusion Pump Installation Diagram
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.*

**NOTE**

*Make all electrical connections in accordance with all applicable laws and industrial codes.*

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. The wiring harness terminates with a 3-pin connector (P/N AMP 1-480700-0). Pins 1 and 3 provide system power, while pin 2 provides system ground.

**Thermal Switch**

A normally-closed, overtemperature thermal switch has been attached to pump body on the side of the pump. Loss of cooling, high pressure, or low fluid level causes the contacts of the thermal switch to open, shutting power off to the pump heater. When the temperature decreases to approximately 300 °F (149 °C) the thermal switch automatically resets and power is again supplied to the heater.

A *Pump Ready* thermal switch is available as an option. It is normally open and closes when the pump reaches operating temperature (see Appendix B “Replacement Parts”).

**NOTE**

*When an abnormal condition causes overheating (e.g. loss of cooling water or low fluid level), the pump power continues to cycle on and off until the condition is resolved.*
Operation

Operation consists of:

- “Startup Procedure”
- “Shutdown Procedure” on page 2-2

**WARNING**

*The following conditions increase the risk of explosion:*

- Air leaks into the system
- Roughing through a hot diffusion pump, which can cause hot hydrocarbon fluids to ignite or explode when exposed to air
- Air release or the admission of air to a pump with a hot boiler (permitting a strong oxidizer to contact the hot pump fluid)
- Pressure above 1 milliTorr ($1.3 \times 10^{-3}$ mbar). High-pressure operation may cause excessive backstreaming.
- Insufficient (or low level of) pump fluid
- Foreign matter in the pumping fluid, which changes its viscosity and obstructs flow passages

**CAUTION**

- Do not turn on the heater without fluid in the pump. This may ruin the heaters and damage the pump.
- Do not air-release the pump while the boiler is hot. Most diffusion pump fluids break down under these conditions.
- Do not operate the pump heater unless the system cooling fan is running as it causes the pump and fluid to overheat.
- Do not operate without the internal splash baffle or a foreline baffle. This can cause a greater than normal fluid loss.

### Startup Procedure

*To start the pump:*

**NOTE**

During initial operation of the diffusion pump, new diffusion pump fluid may go through a degassing process. This may result in inlet and foreline pressure fluctuations. These pressure fluctuations are normal.
1. Evacuate (rough pump) the diffusion pump with the appropriate mechanical pump (customer supplied). The backing pump should remain connected to the foreline of the diffusion pump. The gas load must be reduced to the maximum throughput specification (0.30 Torr-liters/sec) or less.

2. Turn on the system fan to cool the pump body.

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

4. Monitor inlet and foreline pressures.

**CAUTION**

*Do not operate the pump with forepressure (outlet pressure) above approximately 0.5 Torr (see Table 1-1 on page 1-2 for tolerable forepressure). The pump will not function properly and excessive backstreaming results.*

*During operation of the diffusion pump, the gas load at the inlet should not exceed the maximum throughput capability of the pump. The discharge pressure should not exceed the specified tolerable forepressure.*

### Shutdown Procedure

**WARNING**

*Hot Surfaces*

*Boiler temperatures reach 275 °C (530 °F), which can cause serious burns when touched. Always ensure that surfaces have cooled near room temperature before touching them.*

*Explosion Possibility*

*Air-releasing (or admitting air) to a pump when the boiler is hot permits a strong oxidizer to contact the hot pump oil.*

*Read the safety section in the front of this manual.*

To shutdown the pump:

1. Turn off the power to the diffusion pump.

2. Make sure the cooling fan remains blowing across the pump. It takes approximately ten minutes for the pump to cool down enough so that the pump can be vented to atmosphere.

The temperature of the pump body just above the boilerplate should be a maximum of 130 °F before the pump is vented. This can be confirmed by measuring the pump body temperature approximately 1" above the pump base with a temperature measurement device supplied by the customer.
Troubleshooting

Troubleshooting consists of:

- “Leakage”
- “Outgassing”
- “Poor Pump or System Performance” on page 3-2

Leakage

If leakage is the suspected cause of poor system performance, first check the following items:

- Inlet and foreline connections
- Drain and fill plugs
- Other compression fittings, such as high-vacuum gauges in the system
- Threaded connections, such as a foreline gauge

Before proceeding with a program of step-by-step troubleshooting, check the performance and accuracy of the vacuum gauges used on the system.

Outgassing

High-vacuum systems, even without external leakage, can have 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 \( p = \frac{Q}{S} \). 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 due to the mechanical backing pump.

To estimate the gas load, isolate the system from all pumps after evacuation and measure the rate of pressure increase.

The gas load can be estimated from the following relationship:

\[
Q = \frac{V \times \Delta P}{\Delta t}
\]

where \( V \) is the isolated volume, \( \Delta P \) is the pressure rise, and \( \Delta t \) is the time period of measurement.
## Poor Pump or System Performance

Table 3-1 lists the faults, the probable causes and corrective actions to take if you have a problem with a large diffusion pump.

**Table 3-1  Troubleshooting Guide**

<table>
<thead>
<tr>
<th>Fault</th>
<th>Probable Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor system pressure</td>
<td>Leaks in system, virtual or real</td>
<td>Locate and repair</td>
</tr>
<tr>
<td>Poor ultimate pressure</td>
<td>Contaminated pump fluid</td>
<td>Examine and clean pump; replace fluid</td>
</tr>
<tr>
<td>Low heat input</td>
<td>Low heat input</td>
<td>Check voltage. Check for continuity, burned-out element, poor thermal contact</td>
</tr>
<tr>
<td>Excessive cooling</td>
<td>Excessive cooling</td>
<td>Check temperature and correct.</td>
</tr>
<tr>
<td>High forepressure</td>
<td>High forepressure</td>
<td>Check for leak in foreline, poor mechanical pump performance, breakdown of mechanical pump fluid</td>
</tr>
<tr>
<td>Low speed (Prolonged cycle after checking gas load conditions)</td>
<td>Low heat input</td>
<td>Check heaters</td>
</tr>
<tr>
<td></td>
<td>Low fluid level</td>
<td>Add fluid</td>
</tr>
<tr>
<td></td>
<td>Improperly located jets</td>
<td>Check and repair or replace</td>
</tr>
<tr>
<td>Inlet pressure surges</td>
<td>Incorrect heater voltage</td>
<td>Check and correct voltage</td>
</tr>
<tr>
<td></td>
<td>Fluid outgassing</td>
<td>Condition fluid by operating the pump for a 24 hours</td>
</tr>
<tr>
<td></td>
<td>Leak in system ahead of pump inlet</td>
<td>Check and correct</td>
</tr>
<tr>
<td>High chamber contamination of the pump fluid</td>
<td>Forepressure too high</td>
<td>Check for leak in foreline, poor mechanical pump performance, breakdown of pump fluid, and incorrect valve operation</td>
</tr>
<tr>
<td></td>
<td>Prolonged operation in overload range: $10^{-3}$ Torr</td>
<td>Adhere to operating procedures</td>
</tr>
<tr>
<td></td>
<td>Improper system operation and air release procedures</td>
<td>Adhere to operating procedures</td>
</tr>
<tr>
<td>Excessive fluid loss</td>
<td>Incorrect air release procedure</td>
<td>Review operating procedure</td>
</tr>
<tr>
<td></td>
<td>Prolonged operation in overload range: $10^{-3}$ Torr</td>
<td>Review operating procedures and valve sequencing. Reduce gas load</td>
</tr>
<tr>
<td></td>
<td>Foreline baffle missing</td>
<td>Reinstall</td>
</tr>
</tbody>
</table>
Table 3-1  Troubleshooting Guide (Continued)

<table>
<thead>
<tr>
<th>Fault</th>
<th>Probable Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump will not start</td>
<td>Safety circuits open</td>
<td>Inspect for electrical short or overtemperature condition</td>
</tr>
<tr>
<td></td>
<td>Main power off</td>
<td>Check main power source</td>
</tr>
</tbody>
</table>
This page intentionally left blank.
Appendix A. Maintenance and Service

Pump maintenance consists of:

- “Cleaning” on page A-1
- “Changing the Heater Element” on page A-3

Perform these periodic checks to ensure trouble-free operation. This maintenance prevents costly down-time and cleaning procedures. Maintain a day-to-day log of pump and system performance to identify marked variations that require corrective action.

Cleaning

**WARNING**  
Cleaning a diffusion pump involves the use of acetone and alcohol, both of which are toxic and explosive. Take careful note of the following warnings before starting a cleaning process.

- When heated, sprayed or exposed to high temperature equipment, these solvents become flammable and explosive, causing serious injury or death.
- When heated or sprayed, acetone or alcohol also becomes 4 to 5 times heavier than air and flows down, settling in tanks, pits, and low areas, thus displacing air which can kill by asphyxiation.
- Acetone, alcohol, and other solvents are irritants, narcotics, depressants, and carcinogenic. Their inhalation and ingestion may produce serious effects. Prolonged or continued contact with the skin will result in absorption through the skin and moderate toxicity.
- Do not use near a high temperature source. Ventilate the working area with a blower and use in a large, well-ventilated room. The use of a self-contained breathing apparatus may also be necessary.
- Always ensure that cleaning operations are carried out in large, well-ventilated rooms. Wear eyeshields, gloves, and protective clothing.

**CAUTION**  
Solvents degrade O-ring materials reducing their ability to hold vacuum. Do not use solvents on O-rings. If necessary to clean O-rings, wipe them with a clean, lint-free cloth or use a small amount of diffusion pump oil.
To clean the pump:

1. Turn off the power and disconnect the power supply connector.
2. Allow the pump to cool for approximately ten minutes, then turn off the cooling fan.
3. Disconnect the inlet and foreline connections.
4. Remove the NW50 and NW16 Quick clamps on the inlet and foreline and remove the hose adapters. Be careful not to scratch or damage the O-ring sealing surfaces.
5. Remove the cold cap and jet assembly (see Figure A-1).
6. Drain the diffusion pump fluid.
7. Remove all O-rings and gaskets.
8. Thoroughly clean the diffusion pump body interior and the jet assembly with acetone followed by an isopropyl alcohol rinse. The inside of the pump can be dried using dry nitrogen.
9. Install the jet assembly when the inside of the pump body and the jet assembly have dried. Make sure the ejector stage lines up with the foreline. A pin in the pump body engages in a slot in the jet assembly.
10. Place the jet cap (3) on the jet assembly (Figure A-1).
11. Put the spring (1) in the counterbore of the jet cap.
12. Place the centering plate (2) on the spring.
13. Reinstall the cold cap (4).
14. Add 30 cc of diffusion pump fluid, as described in “Pump Fluid Choice and Installation” on page 1-4.
15. Install the inlet and foreline centering rings and hose adapters using the Quick clamps.
16. Reinstall the diffusion pump in the system as described in “Installation” on page 1-3.
Changing the Heater Element

**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.*

The cartridge heater has been factory-coated with an anti-seize lubricant to facilitate removal simply by pulling on the cartridge heater electrical leads. However, in some cases, after extended operation, the heater can be more difficult to remove. In this event, proceed as follows:

1. Turn off the power to the diffusion pump and disconnect the power supply connector.
2. Let the pump cool until it is lukewarm to touch. It is easier to drain out the oil when it is still lukewarm.
3. Drain the fluid from the pump and turn the pump upside down.
4. Allow the pump to cool down completely.
5. Remove the heater cover and insulation.
6. Apply penetrating oil around the cartridge heater and let it stand for 10 minutes.
7. Drive a 1/4" wide flat blade screwdriver approximately 1/8" deep into the center of the heater between the electrical leads.

8. Gently turn the screwdriver to break the heater free.

9. Pull the heater up by the leads, twisting it if necessary.

   **NOTE** 
   *If the heater does not pull out freely, a second application of penetrating oil may be necessary.*

10. Apply an anti-seize compound to the new heater and install it.
Appendix B. Replacement Parts

Table B-1 lists the parts available from Varian. Please call the 800 number listed inside this manual. Refer to Figure B-1.

Table B-1  AX-65 Diffusion Pump Replacement Parts List

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L9674301</td>
<td>Jet Assembly</td>
</tr>
<tr>
<td>2</td>
<td>L9675301</td>
<td>Cold Cap</td>
</tr>
<tr>
<td>3</td>
<td>L9995301</td>
<td>Jet Alignment Kit</td>
</tr>
<tr>
<td>4</td>
<td>KQ16AWP</td>
<td>NW16, Aluminum, Quick Clamp, wing nut</td>
</tr>
<tr>
<td>5</td>
<td>KQ50AWP</td>
<td>NW50, Aluminum, Quick Clamp, wing nut</td>
</tr>
<tr>
<td>6</td>
<td>L9701002</td>
<td>Bottom insulation (1 required with heater harness)</td>
</tr>
<tr>
<td>7</td>
<td>R3110307</td>
<td>Heater Harness w/thermal switch, 115 V, 200 W</td>
</tr>
<tr>
<td>8</td>
<td>L9964001</td>
<td>Normally Closed Overtemp Thermal Switch (opens at 365 °F)</td>
</tr>
<tr>
<td>Not Shown</td>
<td>L9964002</td>
<td>Optional Normally Open Pump Ready Switch (closes at 170 °F)</td>
</tr>
<tr>
<td>10</td>
<td>L9676301</td>
<td>Foreline Baffle</td>
</tr>
<tr>
<td>11</td>
<td>L9680301</td>
<td>Centering Ring Assembly, NW50, with Viton O-ring</td>
</tr>
<tr>
<td>12</td>
<td>KC16AV</td>
<td>Centering Ring Assembly, NW16, with Viton O-ring</td>
</tr>
<tr>
<td>13</td>
<td>R3149301</td>
<td>Inlet Flange Assembly</td>
</tr>
<tr>
<td>14</td>
<td>R3147301</td>
<td>Mounting Plate, Beckman</td>
</tr>
<tr>
<td>15</td>
<td>R3148301</td>
<td>Foreline Hose Adapter</td>
</tr>
</tbody>
</table>
Figure B-1 Parts Diagram

Table B-2 compares diffusion pump fluid characteristics.

Table B-2 Comparison of Diffusion Pump Fluid Characteristics

<table>
<thead>
<tr>
<th>Fluid Type</th>
<th>NEOVAC SY</th>
<th>DC-702</th>
<th>DC-704</th>
<th>DC-705</th>
<th>SANTOVAC 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synthetic Hydrocarbon</td>
<td>Silicone</td>
<td>Single-Component Silicone</td>
<td>High-Purity Silicone</td>
<td>Mixed 5-Ring Polyphenyl Ether</td>
</tr>
<tr>
<td>Ultimate Pressure (Torr) Untrapped</td>
<td>Low $10^{-8}$ Range</td>
<td>$10^{-6}$</td>
<td>$10^{-7}$ to $10^{-8}$</td>
<td>$10^{-9}$ to $10^{-10}$</td>
<td>$10^{-10}$</td>
</tr>
<tr>
<td>Ultimate Pressure (Torr) Trapped</td>
<td>$1 \times 10^{-11}$ Range</td>
<td>-</td>
<td>to $10^{-11}$</td>
<td>to $10^{-11}$</td>
<td>-</td>
</tr>
<tr>
<td>Viscosity c.s.t.</td>
<td>$40 ^\circ C = 25$, $50 ^\circ C = 17$</td>
<td>$25 ^\circ C = 45$</td>
<td>$25 ^\circ C = 39$</td>
<td>$25 ^\circ C = 175$</td>
<td>$25 ^\circ C = 2400$</td>
</tr>
<tr>
<td>Ultimate Pressure</td>
<td>Very Good</td>
<td>Fair</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Table B-2  Comparison of Diffusion Pump Fluid Characteristics (Continued)

<table>
<thead>
<tr>
<th>Fluid Type</th>
<th>NEOVAC SY</th>
<th>DC-702</th>
<th>DC-704</th>
<th>DC-705</th>
<th>SANTOVAC 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synthetic Hydrocarbon</td>
<td>Silicone</td>
<td>Single-Component Silicone</td>
<td>High-Purity Silicone</td>
<td>Mixed 5-Ring Polyphenyl Ether</td>
</tr>
<tr>
<td>Thermal Stability</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Very Good</td>
</tr>
<tr>
<td>Oxidation Resistant</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Very Good</td>
</tr>
<tr>
<td>System Cleanliness</td>
<td>Very Good</td>
<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

**NOTE**

For leak detectors, Varian recommends the use of Santovac 5 only.

Table B-3 gives diffusion pump fluid part numbers.

Table B-3  Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Contents</th>
<th>Varian Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEOVAC SY</td>
<td>1 liter/1,000 cc</td>
<td>K6948301</td>
</tr>
<tr>
<td></td>
<td>1 gallon/3.8 liters</td>
<td>K6948305</td>
</tr>
<tr>
<td></td>
<td>5 gallons/18.9 liters</td>
<td>K6948315</td>
</tr>
<tr>
<td>DC-702 Silicone</td>
<td>500 cc</td>
<td>695472005</td>
</tr>
<tr>
<td></td>
<td>1 gallon/3.8 liters</td>
<td>695472008</td>
</tr>
<tr>
<td></td>
<td>5 gallons/18.9 liters</td>
<td>695472015</td>
</tr>
<tr>
<td>DC-704 Silicone</td>
<td>500 cc</td>
<td>695474005</td>
</tr>
<tr>
<td></td>
<td>1 gallon/3.8 liters</td>
<td>695474008</td>
</tr>
<tr>
<td></td>
<td>5 gallons/18.9 liters</td>
<td>695474015</td>
</tr>
<tr>
<td>DC-705 Silicone</td>
<td>500 cc</td>
<td>695475005</td>
</tr>
<tr>
<td></td>
<td>1 gallon/3.8 liters</td>
<td>695475008</td>
</tr>
<tr>
<td>Santovac 5</td>
<td>40 cc</td>
<td>695405001</td>
</tr>
<tr>
<td></td>
<td>65 cc</td>
<td>695405002</td>
</tr>
<tr>
<td></td>
<td>500 cc</td>
<td>695405005</td>
</tr>
</tbody>
</table>
This page intentionally left blank.
Request for Return
Health and Safety Certification

1. Return authorization numbers (RA#) **will not** be issued for any product until this Certificate is completed and returned to a Varian, Inc. Customer Service Representative.

2. Pack goods appropriately and drain all oil from rotary vane and diffusion pumps (for exchanges please use the packing material from the replacement unit), making sure shipment documentation and package label clearly shows assigned Return Authorization Number (RA#). VVT cannot accept any return without such reference.

3. Return products(s) to the nearest location:

<table>
<thead>
<tr>
<th>North and South America</th>
<th>Europe and Middle East</th>
<th>Asia and ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varian, Inc.</td>
<td>Varian S.p.A.</td>
<td>Varian Vacuum Technologies</td>
</tr>
<tr>
<td>121 Hartwell Ave.</td>
<td>Via F.lili Varian, 54</td>
<td>Local Office</td>
</tr>
<tr>
<td>Lexington, MA 02421</td>
<td>10040 Leini (TO) – ITALY</td>
<td></td>
</tr>
<tr>
<td>Fax: (781) 860-9252</td>
<td>Fax: (39) 011 997 9350</td>
<td></td>
</tr>
</tbody>
</table>

   For a complete list of phone/fax numbers see www.varianinc.com/vacuum

4. If a product is received at Varian, Inc. in a contaminated condition, **the customer is held responsible** for all costs incurred to ensure the safe handling of the product, and **is liable** for any harm or injury to Varian, Inc. employees occurring as a result of exposure to toxic or hazardous materials present in the product.

---

**CUSTOMER INFORMATION**

Company name: .................................................................................................................................................................

Contact person: Name: ........................................................................................................Tel: ..........................................................................................................................................................

Fax: ............................................................................................................................................................ E-mail: .................................................................................................................................

Ship method: Shipping Collect #: .................................. P.O.#: .................................................. .......

Europe only: VAT Reg Number: .................. USA only: ☐ Taxable ☐ Non-taxable

Customer ship to: ............................................. ....................... Customer bill to: ....................... ..........................................

...............................................................................................................

...............................................................................................................

**PRODUCT IDENTIFICATION**

<table>
<thead>
<tr>
<th>Product Description</th>
<th>Varian, Inc. Part Number</th>
<th>Varian, Inc. Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TYPE OF RETURN** (check appropriate box)

☐ Paid Exchange ☐ Paid Repair ☐ Warranty Exchange ☐ Warranty Repair ☐ Loaner Return

☐ Credit ☐ Shipping Error ☐ Evaluation Return ☐ Calibration ☐ Other

**HEALTH and SAFETY CERTIFICATION**

**VARIAN, INC. CANNOT ACCEPT ANY BIOLOGICAL HAZARDS, RADIOACTIVE MATERIAL, ORGANIC METALS, OR MERCURY AT ITS FACILITY. CHECK ONE OF THE FOLLOWING:**

- I confirm that the above product(s) has (have) **NOT** pumped or been exposed to any toxic or dangerous materials in a quantity harmful for human contact.

- I declare that the above product(s) has (have) pumped or been exposed to the following toxic or dangerous materials in a quantity harmful for human contact (Must be filled in):

  Print Name................................................ Signature ................................................... Date ..........................

---

**PLEASE FILL IN THE FAILURE REPORT SECTION ON THE NEXT PAGE**

Do not write below this line

Notification (RA) #: .................................. Customer ID #: .................................. Equipment #: ..................................
FAILURE REPORT
(Please describe in detail the nature of the malfunction to assist us in performing failure analysis):

**TURBO PUMPS AND TURBOCONTROLLERS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Position</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Does not start</td>
<td>❑ Noise</td>
<td>❑ Vertical</td>
</tr>
<tr>
<td>❑ Does not spin freely</td>
<td>❑ Vibrations</td>
<td>❑ Horizontal</td>
</tr>
<tr>
<td>❑ Does not reach full speed</td>
<td>❑ Leak</td>
<td>❑ Upside-down</td>
</tr>
<tr>
<td>❑ Mechanical Contact</td>
<td>❑ Overtemperature</td>
<td>❑ Other</td>
</tr>
<tr>
<td>❑ Cooling defective</td>
<td>❑ Clogging</td>
<td></td>
</tr>
</tbody>
</table>

Describe Failure:

Turbocontroller Error Message:

---

**ION PUMPS/CONTROLLERS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Bad feedthrough</td>
<td>❑ Poor vacuum</td>
</tr>
<tr>
<td>❑ Vacuum leak</td>
<td>❑ High voltage problem</td>
</tr>
<tr>
<td>❑ Error code on display</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:

---

**VALVES/COMPONENTS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Main seal leak</td>
<td>❑ Bellows leak</td>
</tr>
<tr>
<td>❑ Solenoid failure</td>
<td>❑ Damaged flange</td>
</tr>
<tr>
<td>❑ Damaged sealing area</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:

---

**LEAK DETECTORS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Cannot calibrate</td>
<td>❑ No zero/high background</td>
</tr>
<tr>
<td>❑ Vacuum system unstable</td>
<td>❑ Cannot reach test mode</td>
</tr>
<tr>
<td>❑ Failed to start</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:

---

**INSTRUMENTS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Gauge tube not working</td>
<td>❑ Display problem</td>
</tr>
<tr>
<td>❑ Communication failure</td>
<td>❑ Degas not working</td>
</tr>
<tr>
<td>❑ Error code on display</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:

---

**ALL OTHER VARIAN, INC.**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Pump doesn’t start</td>
<td>❑ Noisy pump (describe)</td>
</tr>
<tr>
<td>❑ Doesn’t reach vacuum</td>
<td>❑ Overtemperature</td>
</tr>
<tr>
<td>❑ Pump seized</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:

---

**DIFFUSION PUMPS**

<table>
<thead>
<tr>
<th>Claimed Defect</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Heater failure</td>
<td>❑ Electrical problem</td>
</tr>
<tr>
<td>❑ Doesn’t reach vacuum</td>
<td>❑ Cooling coil damage</td>
</tr>
<tr>
<td>❑ Vacuum leak</td>
<td>❑ Other</td>
</tr>
</tbody>
</table>

Describe failure:

Customer application:
Canada
Central coordination through:
Varian, Inc.
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 1000031
P.R. China
Tel: (86) 10 6608 1031
Fax: (86) 10 6608 1541

France and Benelux
Varian s.a.
7 avenue des Tropiques
Z.A. de Courtabeouf – 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
Alsfelder 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
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