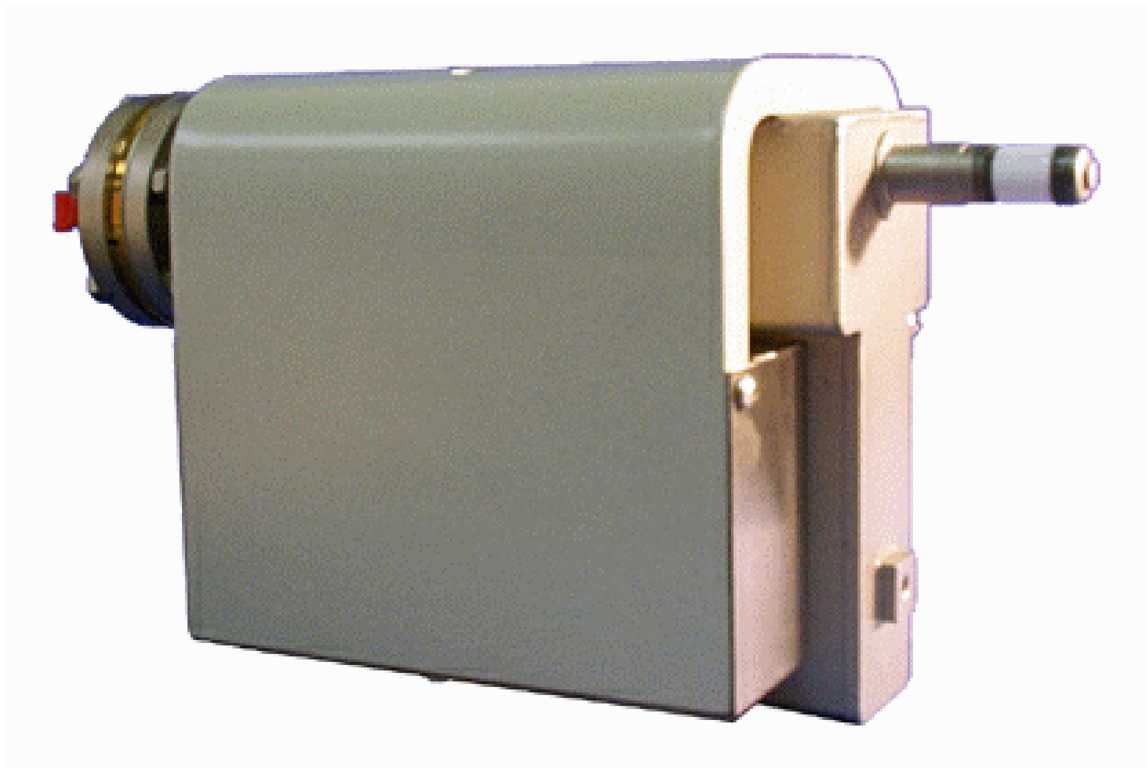
# Instruction Manual

## Sputter - Ion Pump Model GIP/25







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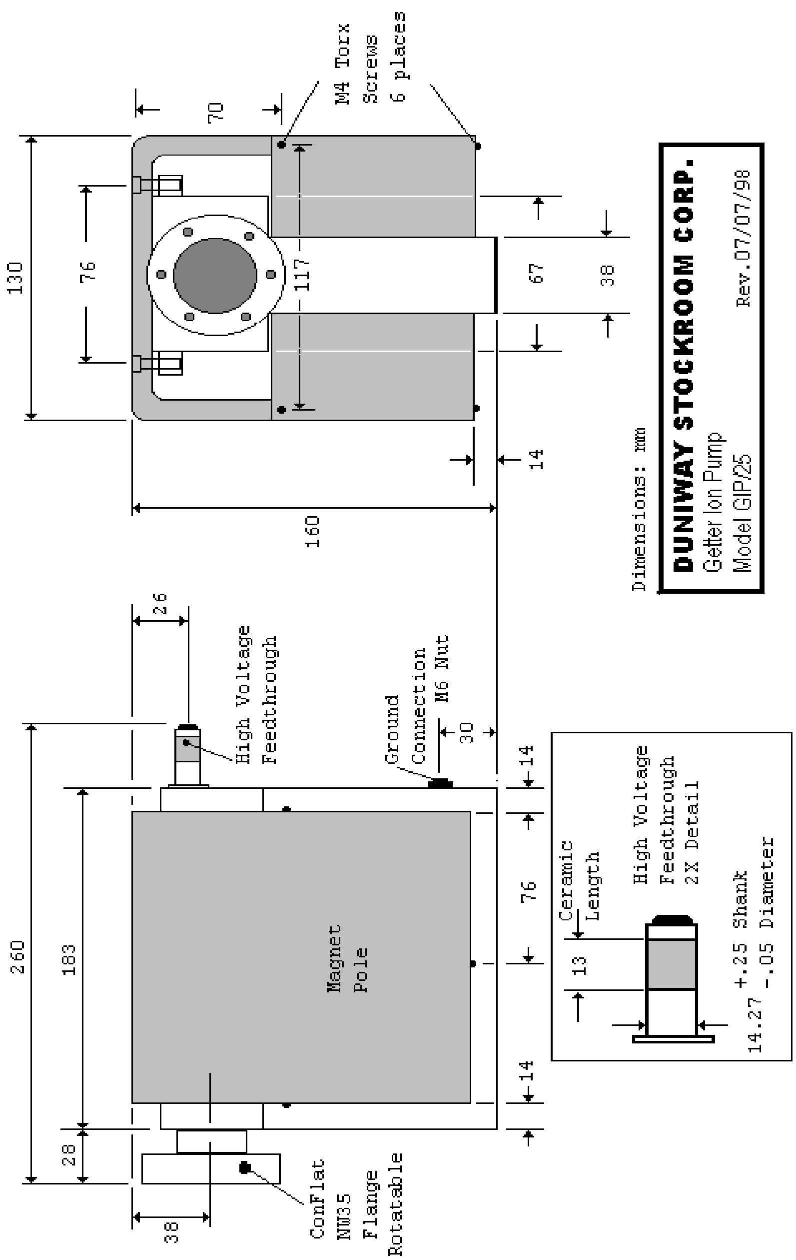
# I Technical Specification

## A. Drawing with Dimensions (mm)





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## B. Weight

| | |
|---|---|
| Pump With Magnet | 32 lb (14.5 kg) |
| Shipping Weight | Add 4 lb (2 kg) |

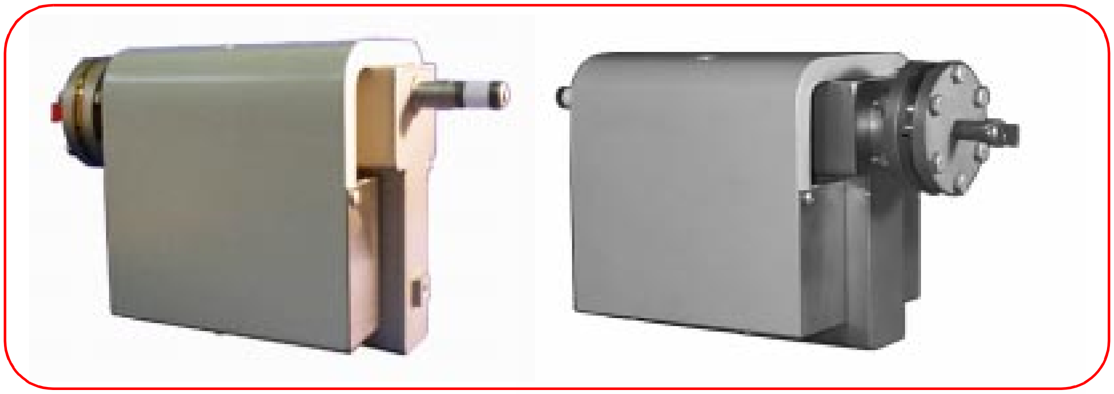

**Figure 2: Photographs of GIP/25 Sputter-Ion Pump**

## C. High Voltage Supply Input Rating

It is important to operate the pump with the proper control unit.The ion pump is rated to operate with a control unit that supplies +5,500 volts DC with a short circuit current of between 100 ma and 200ma.

## D. Vacuum Flange Connection

The vacuum flange connection from the pump to the vacuum system is a rotatable ConFlat type flange, Type CF35. Outer diameter is 2.75 inches (70mm) and inner diameter 1.4 inches (38mm). The pump comes sealed, under vacuum with a cover flange, a copper gasket with pinch off and 6 stainless steel screw/nut sets (#6x35mm. Hex head). Connection to the vacuum system requires a new copper gasket. (Duniway Stockroom Corp. Part Number G-275).

## E. Grounding Requirements

Due to the hazardous nature of the high voltage used to operate this pump, it is important that proper grounding be present at all times during pump operation. Dual grounding means are provided: The first grounding means is through the high voltage connector outer cable shield and shell which are positively connected to the pump body when installed.The second grounding means is through a separate grounding cable which is connected to the case of the control unit and the grounding boss/lug on the pump case.


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## F. External Environmental Range

| | |
|---|---|
| Operating temperature range: | $0^oC$ ($32^oF$) to $38^o$ C ($100^oF$) |
| Maximum baking temperature: | operating, with magnet: $200^oC$ ( 400 $^oF$) |
| | non operating: without magnet: $775^oF$ ($450^oC$) |
| Relative Humidity: | 0% - 90% non-condensing |
| Elevation: | -300 meters (-1000 ft) to +3000 meters (+10,000 ft) MSL |

## G. Vacuum Operation Range

| | |
|---|---|
| Maximum Starting Pressure: | 0.266 pascal (2 x $10^{-3}$ torr, 2 microns) |
| Continuous Operating Range: | from 1.3 x $10^{-2}$ pascal ($10^{-4}$ torr) |
| | to below 1.3 x $10^{-9}$ pascal ($10^{-11}$ torr) |



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# II Installation

## A. Preliminary Tests

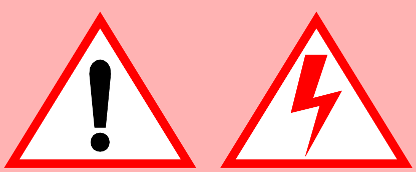
The sputter-ion pump arrives well protected in a package and under vacuum. After carefully unpacking the pump, inspect it for signs of shipping damage. If any shipping damage is suspected, immediately contact Duniway Stockroom Corp. Before opening the flange with the copper pinch-off, it is advisable to check to be sure that it is still under vacuum, as it was shipped. This is accomplished by properly grounding the pump case (see above), connecting the high voltage connector and applying the operating voltage to the pump. The magnet must be in place. Normally, there will be a brief surge of current, of less than 100 micro-amperes, due to pressure rise during shipment, which will dissipate rapidly. Within a brief time, the current should fall to the microamp level, corresponding to pressure of less than $2.6\times10^{-6}$ pascal ($1\times10^{-8}$ torr). If a high current is observed, or if the current does not fall rapidly to less than a few microamps, or if no current at all is observed, the pump is probably not under vacuum. Contact Duniway Stockroom immediately.

## B. Mounting Requirements

The system should have a mounting flange which is the same as the pump flange: ConFlat 2.75 inches OD. A new copper gasket and the set of bolts and nuts from the original closure flange are required. See the drawing for dimensional clearance requirements.Grounding Requirements

Due to the hazardous nature of the high voltage used to operate this pump, it is important that proper grounding be present at all times during pump operation. Dual grounding means are provided: The first grounding means is through the high voltage cable shield and connector shell which are positively connected to the control unit chassis and pump body when installed. The second grounding means is through a separate grounding cable which is connected to the case of the control unit and the grounding boss/lug on the pump case.

## C. Connecting the High Voltage Supply



**Caution: The voltages utilized by sputter-ion pumps are hazardous and can cause severe injury or death if proper procedures are not followed.**

Be sure that the High Voltage cable is in good condition, as supplied with the control unit. Check to be sure that all grounding and protection circuits are installed and in good working condition.



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Do not remove or install the high voltage cable from the ion pump while the control unit is turned on. Always turn off the ion pump control unit before working with the cable or connectors.

## D. Starting the Pump

1. Introduction

Sputter-ion pumps have many advantages in simplicity, cleanliness and reliability for high and ultra-high vacuum systems. The transition from the roughing pressure to independent operation at high vacuum is referred to as "starting". With some attention to preparation and operation during starting, this transition can be made smoothly and with a minimum of problems.

2. Preparation

Before beginning the operation of a sputter ion pump, it is advisable to consider some system and safety issues. If these issues are taken into account, both personal and equipment convenience will be assured. First of all, in order to take maximum advantage of the pumping speed available from the sputter-ion pump, the conductance, or access for gas flow should be maximized. This means decreasing the length and increasing the diameter of the tubing connecting the sputter-ion pump to the system.

Second, cleanliness should be observed in handling and preparing both the system and the sputter-ion pump. Exposure to oils, water vapor or dust can significantly add to the gas load, both during starting and continued operation. Even fingerprints can be harmful in contributing to gas loads. Sputter-ion pumps do not deteriorate just by being stored at atmospheric pressure, if they are kept clean. Aluminum foil or a plastic cover on the inlet flange during storage will keep out dust, dirt and debris.

Finally, for personal safety, always establish a definite electrical grounding connection from the sputter-pump case to control unit ground. Sputter-ion pumps operate with high voltages and current levels which can be fatal if accidental contact is made. By assuring proper grounding of the pump, personal safety is greatly improved, and proper operation of control unit overload circuits is provided.

3. Using Pump Current as an Indication of Pressure

Sputter-ion pump current is proportional to pressure, especially in the pressure ranges below 1.3 x $10^{-3}$ pascal (1 x $10^{-5}$ torr). This relationship is expressed by the equation: I/P = constant. Thus, at lower pressures, pump current can be used as an indicator of the pressure. An example of the relationship between sputter-ion pump current and pressure is shown attached as Figure 2; in this case for the GIP/25. The slope of the I/P curve shown is 1.7 amps per pascal (225 amps per torr). (Calculated by choosing a typical point on the curve, say 1 milliamp at $6x10^{-4}$ pascal, and dividing the current at that point by the pressure at that point).



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4. Roughing/Trapping

Sputter-ion pumps operate by using a low pressure gas discharge called the Penning discharge. Through a combination of magnetic field and electric field, gas ions are formed and captured on active metal plates, such as titanium. The Penning discharge only operates at pressures below approximately 0.13 pascal ($10^{-3}$ torr), so the pressure in the pump and vacuum system must be reduced by other means to reach that pressure range.

A variety of rough vacuum pumps is available, including rotary mechanical pumps, turbomolecular pumps and sorption pumps. Since the sputter-ion pump is inherently clean and typically used in clean, ultra-high vacuum applications, it is important to use a clean technique for rough pumping. Also, the roughing pump should have a valve to isolate it from the sputter-ion pump after the starting phase, since the sputter-ion pump can operate independently on a closed system. In addition to the gases contained in the volume of the system, the main gas load at the lower pressures is represented by the water vapor that is adsorbed on all the surfaces of the system.

It is a good idea to check the base pressure obtained by the roughing pump to assure that the pump is reaching a pressure adequately low for sputter-ion pump starting. A properly calibrated thermocouple gauge will do the job, and a pressure below 1.3 pascal (10 millitorr) indicates adequate roughing pump performance. Lower pressure before starting will generally lead to quicker results.

The cleanest roughing pump technology is the **sorption pump**, which uses ultra-high surface area materials such as molecular sieve, which are chilled to liquid nitrogen temperatures. Water vapor, oxygen, nitrogen, argon and most organic vapors are pumped by sorption pumps, thus reducing the pressure to a few pascal (millitorr). For small systems a single stage sorption pump is sufficient to reach the starting pressure for sputter-ion pumps; for larger systems a sequenced, two stage sorption pump is recommended. Prior to using a sorption pump, it is important to remove the previously absorbed gases, particularly water vapor, by baking the pump.

**Rotary mechanical pumps**, which use oil-sealed vanes, can also be used for rough pumping; however, an efficient trap must be provided between the mechanical pump and the sputter-ion pump. Either a liquid nitrogen trap or a molecular sieve trap can be used to keep the mechanical pump oil from migrating into the sputter-ion pumped system. In addition, the trap will help remove water vapor, the major gas load during the later stages of rough pumping. Mechanical pumps are not efficient at removing water vapor, since it just gets recycled through the oil on each rotation of the pump rotor.

Another good alternative for rough pumping is the **turbomolecular pump**. This pumping technology is clean and provides a better pumping speed and lower roughing pressure than other alternatives.

5. Starting

When the roughing pressure falls below 1.3 pascal (10 millitorr), the sputter-ion starting process can begin. To review the precautions, be sure that the pump is properly grounded, that the control unit voltage polarity and power rating are matched to the pump being started.

Verify that the control unit "Start-Protect" switch is set to the "Start" position, and that the "Meter Range" switch is set to "Voltage". Now turn on the "Power" switch. Immediately after turning on the power switch, observe the voltage reading on the meter. In the starting mode, the voltage should be in the 300-1000 volt range, and then gradually rise as the pump starts. (If the voltage reading is either at zero or at the open circuit rating of the control unit when the pump is turned on during starting, immediately turn the control unit off, because there is either an electrical short in the pump or an open circuit which must be found and corrected before proceeding.)

Next, turn the meter switch to the highest current scale and verify that the current is near the appropriate (near short circuit current) for the control unit. Return the meter range switch to the "Voltage" position to monitor the operation of the pump. When it appears that the roughing system has reached its base pressure, close the valve between the roughing system and the sputter-ion pump and observe the results on the "Voltage" scale of the control unit. If the voltage falls, indicating a rising current (rising pressure), reopen the roughing valve. If the voltage increases or remains the same, leave the roughing valve closed.

NOTE: with a sputter-ion pump, a modest rise in pressure is normal during the initial starting phase. This is caused by heating of the pump components by the dissipated power and normally precedes operation in the normal mode. Some heating during starting is beneficial because it causes out-gassing of components which will not have to take place during later stages of the system pump down. Excessive heating due to prolonged high pressure operation or a mismatched control unit can damage a pump. Operation in the start mode should always be monitored. The electrical discharge in a sputter-ion pump gives off a blue/purple glow due to the electron-gas ionization process taking place. At starting pressures, above 1.3 x $10^{-2}$ pascal ($10^{-4}$ torr), the discharge occurs throughout the pump; in some cases it can extend into the system itself. If the presence of this discharge in the system is a problem, a stainless steel, electrically grounded screen can be placed across the mouth of the pump. As the sputter-ion pump starts, the discharge confines itself to the area within the pump elements, and gradually becomes fainter as the pressure, and thus the rate of ionization, falls.


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# III Operation/Protection

## A. Introduction

After the sputter-ion pump starts, as indicated by the voltage rising toward the open-circuit rating and current falling to below about 25% of the rated value on the control unit meter, normal operation can commence.

In normal operation, the roughing pump valve is closed and the “Start/Protect” switch on the control unit is placed in the “Protect” position. The pump is now protected against a pressure rise above approximately 1 pascal (0.5 millitorr) while unattended. Should such a pressure rise occur due to a leak or other failure, the control unit will automatically turn off after a brief delay. This protects both the pump and control unit against excessive current and heat conditions.

During normal operation, pump current is proportional to pressure over a wide operating range. This is illustrated in the typical current vs. pressure curves shown below in Figure 2. By knowing the current and using the correct curve for that pump and control unit, the pressure can be calculated. In addition, most control units have a “Pressure” scale, which is a logarithmic scale from below 1.3 x $10^{-7}$ pascal ($10^{-9}$ torr) to above 1.3 x $10^{-2}$ pascal ($10^{-4}$ torr). Also, a recorder and control signal, with a range from 0 to 100 mV, is normally available for monitoring the pump pressure.

## B. Pressure Indication

As discussed above, sputter-ion pump current is proportional to pressure over the operating range. The graph below shows typical plots of Ion Pump Current vs. Pressure for the GIP/25. For example, with a current indication of 1 ma, the pressure would be about $4 \times 10^{-4}$ pascal. Caution should be used in using ion pump current to indicate pressure, especially at low pressures, due to potential leakage current, as discussed below in “Maintenance”.


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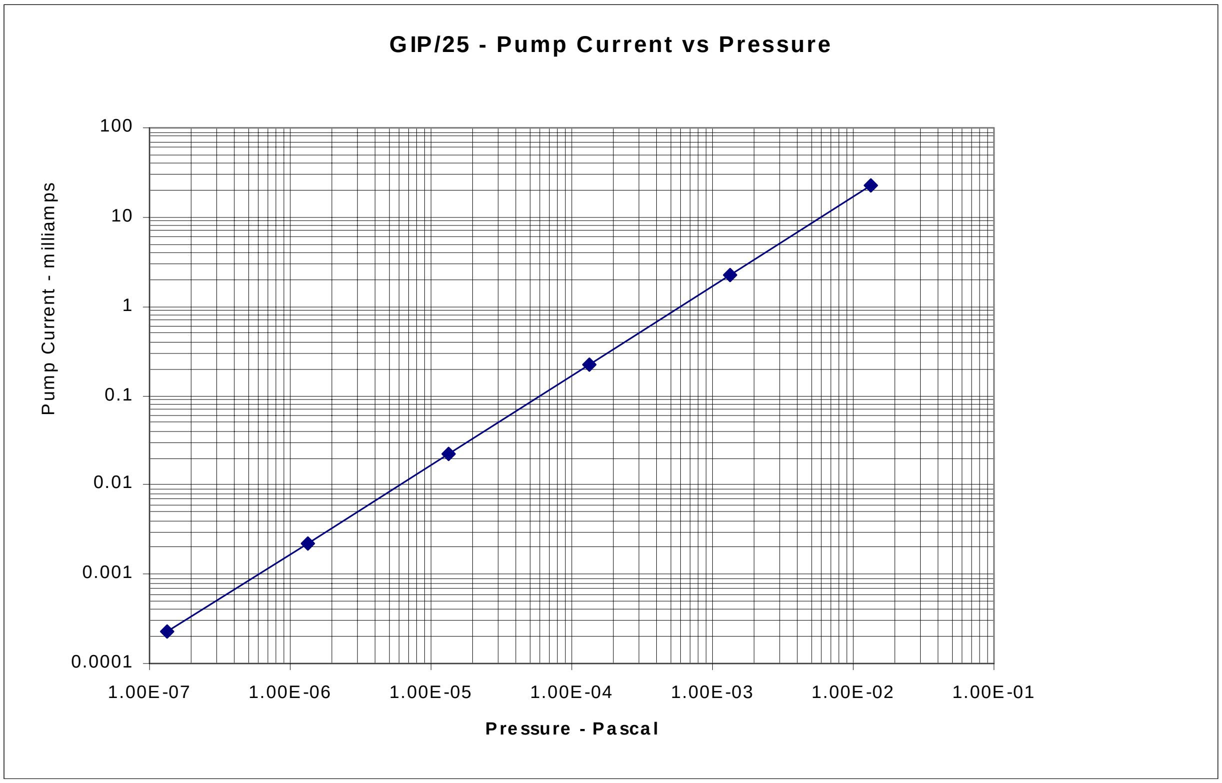


**Figure 3: Sputter-Ion Pump Current vs. Pressure**


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# IV Maintenance

## A. Leakage Current & Hi-Potting

After prolonged operation, which generates quantities of sputtered material inside the pump, it is possible that current leakage, not related to pump pressure, may develop in the pump. There are two types of leakage: "Resistive Leakage" and "Field Emission Leakage". (In both cases, such leakage can be confirmed by removing the pump magnets, which should not substantially change the leakage current.)

Resistive Leakage is due to resistive coatings or short circuits of insulating elements in the pump. The presence of this leakage can be detected by using a simple ohm-meter or multi meter on the ohm or resistance scale. When resistive leakage occurs, pumping action is usually reduced or stopped, and the pump or pump elements must be rebuilt. See Section IV-E below for factory maintenance.

Field Emission Leakage is due to electron release from small points or flakes in the pump, at the high voltages inside the pump. This problem does not effect the pumping action of the pump, however it may be annoying if the pump current is used as an indication of the pressure in the system. In order to reduce or eliminate field emission leakage, it is possible to apply an over voltage, a process known as "hi-potting". Since field emission current grows exponentially with voltage, the application of higher than normal voltage can cause enough current to flow to melt the sharp points and reduce the leakage to an acceptable level. A Hi-Pot unit with voltages of 12-15 KV AC at a few milliamps is usually adequate to reduce the field emission leakage to an acceptable level. For more information on this procedure, call Duniway Stockroom Corporation.

**NOTE: Extreme caution must be excersized when performing such an operation due to the hazardous nature of the voltages involved. Proper insulation and grounding must be supplied in order to avoid injury to personnel and damage to equipment.**

## B. Leak Checking

If prolonged operation, especially after baking of the system, does not result in appropriately low pressures, it is possible that there is a leak in the system. Some level of leak checking can be performed by observing the ion pump current while probing the exterior of the system with a probe gas such as helium. When the probe gas enters the system through a leak, it will cause a pump current fluctuation, related to the difference in leak rate for different diameter atoms and the difference



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in ionization potential of the probe gas in the ion pump discharge. More sensitivity may be obtained by using a strip chart recorder or computer display to record the pump current.

## C. Magnet Checking

If the sputter ion pump does not seem to be operating with its normal pumping speed, it is possible that there may be a problem with magnet field strength or magnet installation. The following illustration shows proper magnet installation for a variety of pump configurations. Following the illustration is a discussion of procedures for checking magnet installation.

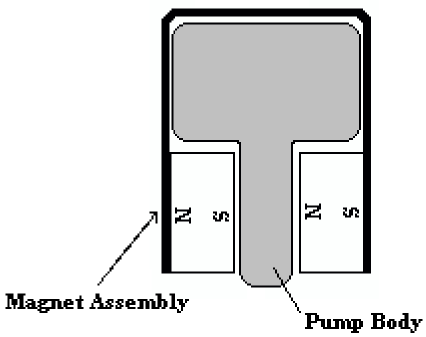


**Figure 4: Magnet Orientation for the GIP/25**

1. All magnets, including the Earth, have a <u>N</u>orth pole and a <u>S</u>outh pole. A simple compass can be used to determine the polarity of a magnet segment, however, readings should be made away from iron pole pieces.

2. Like poles (N-N or S-S) repel each other and unlike poles (N-S or S-N) attract each other.

3. In an Ion Pump magnet array, the magnet sections must be arranged in a magnetic circuit; that is N-S-N-S-N-S…etc, <u>all the way</u> around the pump.

4. The magnetic field should be above 1600 gauss for the GIP/25. Higher magnetic fields give somewhat higher pumping speed, especially at low pressure.

5. When assembling an Ion Pump magnet array, the magnets will tend to ‘pull’ into a correct circuit configuration and ‘push’ out of an incorrect circuit configuration.

6. In Figure 3, (a cross section of a pump such as the GIP/25 model), as long as the individual blocks on the magnet assembly are installed correctly, the orientation of the magnet assembly does not matter.



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## D. Demounting the Pump

If for any reason, it becomes necessary to remove the pump from the system, be sure to take the proper precautions for personnel and equipment safety. First of all, turn the control unit to the off condition. Then, remove the high voltage connector from the pump. At this point it is a good idea to remove the magnet from the pump to reduce the weight of the pump assemble. Then make sure that the pump is properly supported before starting to remove the bolts from the connection flange. Also, it is not a good idea to let the system up to atmospheric pressure by removing the sputter-ion pump, because any loose material around the gasket may be swept into the system. Loosen slightly all the bolt/nut combinations before completely removing any of the bolts.

## E. Factory Maintenance

If it should become necessary to perform maintenance on the pump, such as replacing the pumping elements or high voltage feedthrough, it is best to return the pump, without its magnets, to the factory for maintenance. Please call Duniway Stockroom Corporation for advice and details about sputter-ion pump maintenance and rebuilding.

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