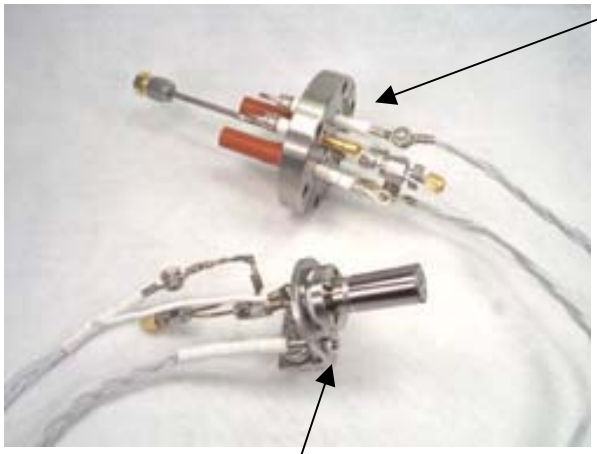
HeatWave Labs, Inc.

HOLLOW CATHODE PLASMA ELECTRON EMITTER HWPES-250



2 ¾" CF Feedthru flange assembly (101369-02) with remote cable (101369-06) connected

Remote mount assembly (101366-02) with feed line strain relief (101369-09) and remote cable (101369-06) connected

Start/standby Power Supply

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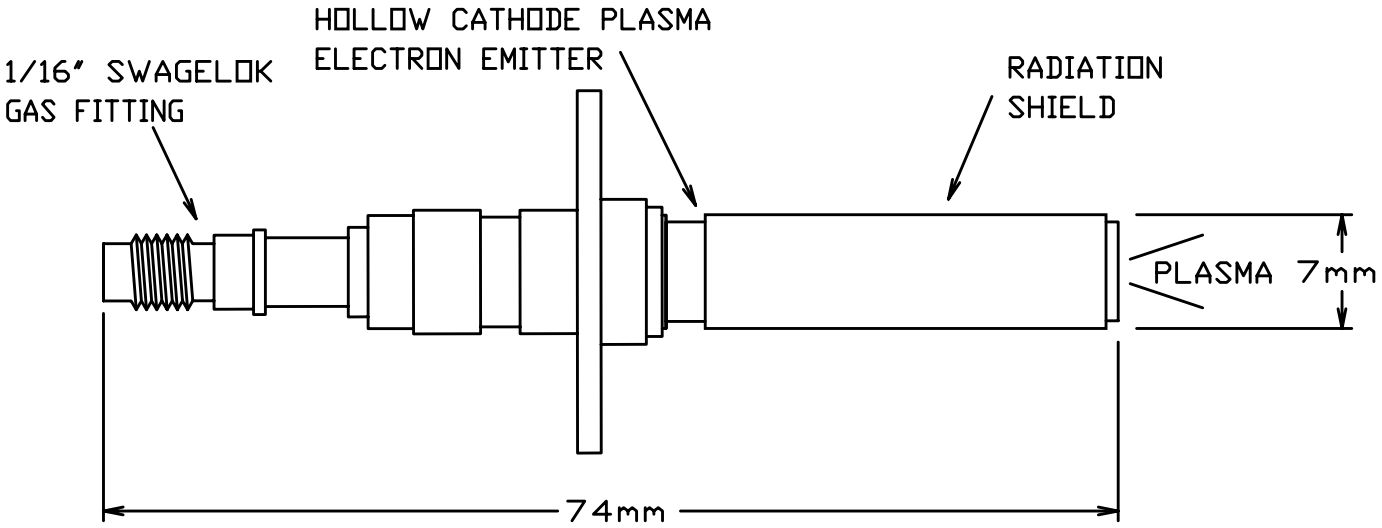


Fig. 1a

HWPES-250, 0-10 AMPS.

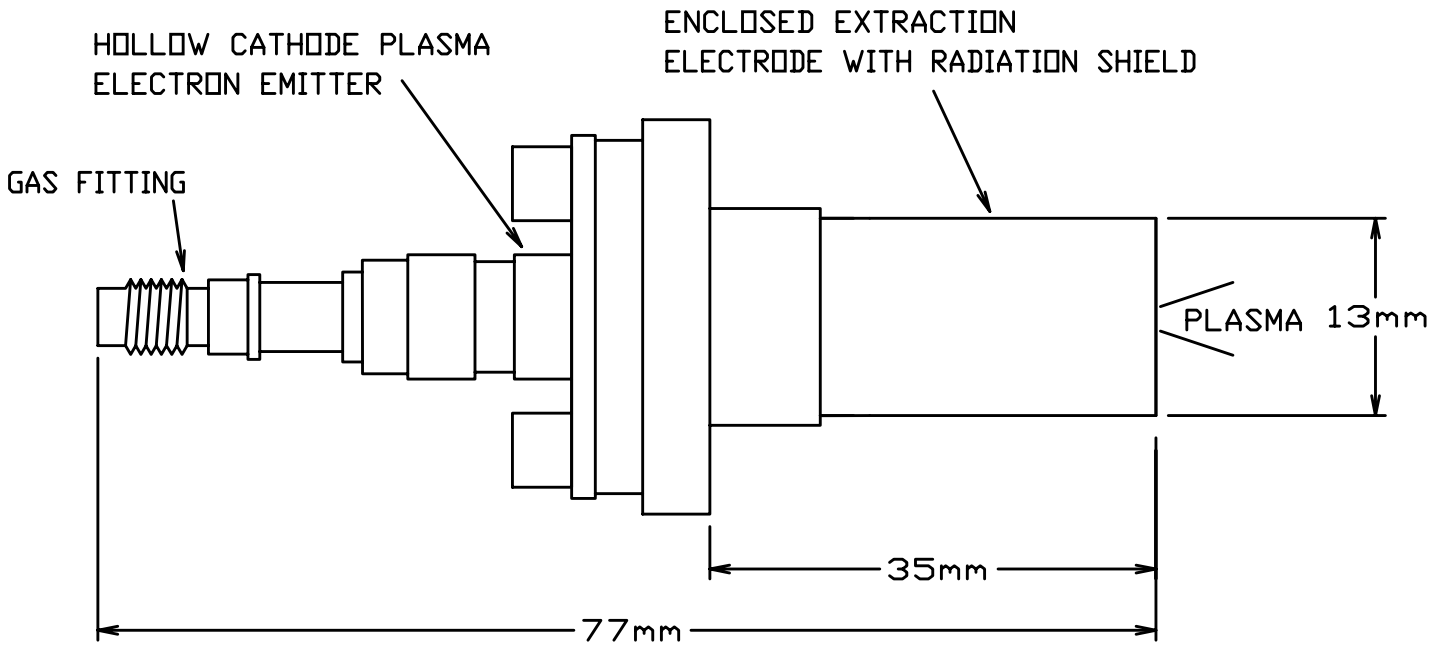


Fig. 1b

1.0 HOLLOW CATHODE PLASMA ELECTRON EMITTER HWPES-250

1.1 GENERAL DESCRIPTION

The HWPES-250 is a small, tubular device shown in Fig. 1a, inside which a dense plasma is created in a regulated gas flow using a closely coupled enclosed extraction electrode shown in Fig. 1b. Electrons are drawn from the unit by biasing an external load positive with respect to the HWPES-250. These electrons flow to the load through a plasma discharge established between the HWPES-250 and the load. The load may be a solid conductor such as a metallic electrode, a separate plasma discharge, a plasma surface or volume, a positive ion beam, or a charged surface. By biasing the external load relative to the HWPES-250 with a user supplied power supply, the electron current in the plasma discharge to the load can be adjusted to create a plasma discharge tenuous enough to simulate a space environment, or intense enough to vigorously evaporate metals. Although primarily used as a variable source of plasma electrons, the ions also present in the discharge plasma may be used for certain applications.

1.1.1 Applications

Some identified applications for the HWPES-250 include:

(i) Plasma electron flood gun for space-charge neutralizing beam lines and target/substrate charge build-up in broad ion beam systems, multi-ion beam systems, and ion implanters.

(ii) Plasma electron generators for increasing gas ionization efficiencies in magnetron and diode sputter guns to improve sputter rates and lower required operating pressures.

(iii) Plasma electron source for replacing filaments for long life and low heat load plasma production in ion and plasma source discharge chambers.

(iv) A tool for creating and manipulating new types of plasma discharges when developing substrate processing steps.

(v) A highly efficient plasma generator for space science experiments.

(vi) An easily controlled high current density plasma arc source for basic plasma physics investigations.

(vii) A high power arc source for vigorously evaporating metals.

1.1.2 Construction and Handling

The HWPES-250 has been designed and fabricated as a single welded unit. Rough treatment will break components internal to the HWPES-250 and render it unserviceable. As a general guideline, the HWPES-250 should not be subjected to mechanical shocks, or placed in an environment where it could be inadvertently knocked or dropped.

Materials used in the construction of the HWPES-250 include refractory metals and high purity Alumina ceramics. The HWPES-250 and its accessory components may all be baked to a high temperature and with the optional CF flange mount are UHV compatible.

1.1.3 Operating Pressure Environment

The plasma electron current that may be drawn from the HWPES-250 is not substantially dependent on the background pressure environment in which the unit is operated. Reliable HWPES-250 operation may be realized at background pressures as high as several mTorr. There is no lower background pressure limit to the operation of the HWPES-250.

1.2 CLEANLINESS AND CONTAMINATION

The HWPES-250 functions by creating an intense plasma discharge between an interior low work function electron emitter component and an enclosed extraction electrode. Proper operation of this electron emitter component can be impaired if the

emitter is exposed to contaminants as described in the following sections. Such contaminant exposure will increase the emitter electronic work function, which will eventually cause the HWPES-250 to operate erratically and reduce the lifetime of the unit.

1.2.1 Water Vapor

A major source of HWPES-250 contamination is water vapor. Due to ambient humidity levels, water vapor can settle on the electron emitter component as soon as the HWPES-250 is exposed to ambient air unless appropriate precautions are taken. The degree of water vapor taken up by the unit will depend upon the ambient humidity level, and the length of time the HWPES-250 is exposed to the atmosphere. The HWPES-250 incorporates an outgas feature to eliminate water vapor from the unit following atmospheric exposure. However, precautions such as minimizing atmospheric exposure, and maintaining a small gas flow through the unit during any atmospheric exposure time, will significantly reduce water vapor contamination.

1.2.2 Chemicals

HWPES-250 contamination can occur by exposure of the HWPES-250 to greases, oils and solvents which may be present in the environment. Such materials may also adversely effect the proper functioning of the electron emitter component. For this reason, the HWPES-250 should not be brought into contact with typical cleaning liquids such as acetone or alcohol. As a general guideline, the HWPES-250 should be handled with gloves or with clean, dry fingers. No cleaning of the HWPES-250 is recommended and should not be required during the lifetime of the unit.

1.2.3 Shipping Package Opening

It is important that the HWPES-250 be left in the packaging in which it is shipped until the unit is ready for use. This procedure will avoid water vapor entering the unit, and will also prevent undue contamination from other causes.

1.2.4 Working Gas Purity

Another source of contaminants which can adversely effect operation of the HWPES-250 are the various impurities in the working gas passing through the unit. This working gas should be of a research grade purity level for maximum lifetime of the unit.

1.2.5 Gas Feed Line Leaks

The HWPES-250 can be contaminated by oxygen from the ambient atmosphere entering the gas line feeding the HWPES-250. In most applications, the HWPES-250 will be supplied a precisely metered gas flow from an electronic mass flow controller assembly. Typically, the gas line between the solenoid valve of the flow controller and the gas fitting entering the vacuum chamber housing the HWPES-250 will be at a very low negative pressure of order 1 - 2 Torr. Even a slight leak in this gas line will allow significant quantities of ambient air to enter the hot interior of the HWPES-250. Oxygen in this air will react with the hot electron emitter component within the HWPES-250 and gradually diminish the efficiency, and stability, of the plasma electron emission process. Oxygen entering the HWPES-250 from gas line leaks are often overlooked, but can be a significant source of contaminant. The total oxygen impurity level in the working gas, from all sources, should not exceed about 2 - 4 ppm.

1.2.6 Gas Line Purging

Oxygen can also enter the HWPES-250 as a result of air still being present in the lines supplying the working gas to the unit. Specifically, all new gas line connections to the HWPES-250 should be thoroughly purged of trapped air by flowing the working gas through the lines while pumping on the vacuum process chamber. The small outlet in the HWPES-250 does not permit most vacuum systems to adequately pump all of the trapped air from the gas lines without performing such a purge step. Gas line purging will normally be a one-time procedure, and should take about one hour for an average gas feed line system.

1.2.7 Vacuum Pump Oils

Oil vapor from a poorly baffled diffusion pump, or an improperly trapped mechanical pump, can enter the HWPES-250. In time, this oil vapor will contaminate the electron emitter component of the HWPES-250. Where diffusion pumps are used, it is important to ensure that a properly chilled baffle is used to reduce oil backstreaming into the process chamber to negligible levels. Similarly, molecular sieves are recommended to trap mechanical pump oil vapor which might otherwise enter the process chamber during cycling of the vacuum system.

1.3 WORKING GAS CHOICES

The HWPES-250 will operate on all of the inert gases, and also on nitrogen and hydrogen.

1.3.1 Gas Flow Requirements

Use of a high atomic weight working gas will require less flow rate for a given electron emission current than use of a low atomic weight gas. Similarly, gases having a higher ionization potential will require larger gas flow rates for similar electron emission current levels. As a guideline, if a flow rate for a given electron emission level using argon is normalized to 1.0, the same emission may be achieved with xenon at a normalized flow rate of about 0.4. Conversely, helium may require a normalized flow of about 3.0, while hydrogen may require a normalized flow of about 10.0. Actual flow rate requirements will depend on the specific end use application.

1.4 PREPARATION FOR OPERATION

When it is time to remove the HWPES-250 from its packaging for first use, it is advisable to install the unit it is end use equipment application with minimal exposure time to the ambient air to avoid the accumulation of water vapor in the unit.

1.4.1 Initial Gas Purging and Outgassing

The HWPES-250 can only be operated from the Start and Standby Power System, HWPES-250 PS. The HWPES-250 PS is provided with an outgas function which must be used prior to first time use. For first time use, the HWPES-250 must be purged with the desired working gas for a period of about one hour, or until it is felt that any trapped air in the gas feed lines has been removed. The HWPES-250 must then be outgassed for a minimum period of one hour, while the working gas is passed through the unit at a minimum flow rate of about 2 sccm. Outgassing is initiated by turning the HWPES-250 PS rocker switch to the "OUTGAS" position (note that the middle position for this switch is off).

The primary function of the outgassing procedure is to remove all water vapor which may have collected on the low work function electron emitter component internal to the HWPES-250. During outgassing, the HWPES-250 is automatically maintained at a temperature adequate to drive off any accumulated water vapor. The temperature of the HWPES-250 during this period will rise from ambient to a dull red. This temperature will then be maintained during the remainder of the outgassing time period.

1.4.2 Gas Purging and Outgassing after Short Term Atmosphere Exposure

Once first time gas purging and outgassing has been completed, this procedure does not usually need to be repeated. This is true if the unit is exposed to atmospheric conditions for short periods of minutes or hours where the working gas flow rate has been maintained. Under such conditions, gas purging is not required, and the outgassing period may be reduced to thirty minutes.

1.4.3 Gas Purging and Outgassing After Extended Atmosphere Exposure

If the HWPES-250 is left under atmospheric conditions for extended time periods of days or more where continuous gas purging is not practical, it should be assumed that significant atmospheric water vapor has entered the unit and the initial gas purging and outgassing procedure will need to be repeated.

1.4.4 Exposure to Volatile Compounds

After completion of the initial use gas purging and outgassing procedure, and under continuous vacuum conditions, the HWPES-250 can be repeatedly started, operated, and shut down without further gas purging or outgassing of the unit. If the HWPES-250 has been kept under vacuum in an off condition, and without a gas flow, while other processes were occurring in the vacuum chamber which may have released volatile
compounds, it should be assumed that such compounds entered the HWPES-250. To avoid possible contamination of the electron emitter component, the HWPES-250 should be outgassed for about 15-30 min. prior to restarting. Contamination from such volatile compounds can be reduced by passing a small flow of the working gas through the unit.

1.5 STARTING CHARACTERISTICS

Following completion of the initial use gas purging and outgassing procedure, the HWPES-250 may be started by turning the HWPES-250 PS rocker switch to the on position (note that the middle position for this switch is off). If the HWPES-250 is at ambient temperature, a time period of approximately three minutes will pass during which time the HWPES-250 PS will rapidly bring the HWPES-250 to operating temperature. Startup of the HWPES-250 is identified by the presence of a plasma jet streaming from the orifice of the enclosed extraction electrode.

1.5.1 Starting Voltages

The highest voltage in the HWPES-250 PS during startup is only 50 volts.

1.5.2 Running Voltages

During operation, the HWPES-250 enclosed extraction electrode may be as high as 30 V positive of the cathode common structure, for very lean gas flow operation, and about 10 V positive of the cathode common structure during higher gas flow, and low coupling impedance operation. These voltage levels will change with different working gases.

1.5.3 Cyclic Operation

If the HWPES-250 is operated in a cyclic mode under continuous vacuum, conditions in a duty cycle where the off time is not long enough for the HWPES-250 to cool, start times will be considerably shorter than three minutes. Typically, restart within about five seconds after shutdown will be immediate; restart about one minute after shutdown will take thirty seconds.

1.5.4 Standby Operation With No Plasma Discharge

The HWPES-250 may be left in the outgassing mode for indefinite time periods. If left in this mode, turning the PS 250 to the on state will usually effect a rapid turn on of the HWPES-250 plasma discharge. This feature is useful if a rapid-on condition is desired.

1.6 OPERATING CHARACTERISTICS

The HWPES-250 is capable of emitting continuous electron emission currents from virtually zero to approximately ten ampere. Lifetime of the HWPES-250 will be reduced if the unit is operated for long periods at the upper end of its emission current range.

1.6.1 Self-Heating Mode

For electron emission currents above about 2-3 A, the HWPES-250 will operate in a self-heating mode and the HWPES-250 PS may be turned off. Heat will continue to be supplied to the HWPES-250 while in this mode by indirect heating from the plasma discharge, which will be entirely sustained by the user power supply coupling the HWPES-250 to the load. The exact switch-over to the self-heating mode will depend on the specific load conditions. Some experimentation may be required to determine the actual emission current point where this operating mode is possible.

1.6.2 Transition Mode

If the HWPES-250 discharge extinguishes when the HWPES-250 PS is turned off at an electron emission current of about 2-3 A, it is because the specific load conditions did not provide enough self-heating power to the HWPES-250. In this case, the HWPES-250 may be operated in a transition mode with the HWPES-250 PS turned to the outgas condition.

1.6.3 Emission Current

Plasma electron emission from the HWPES-250 will increase with gas flow, and the density of the plasma environment downstream of the unit. For argon, in a worst case metallic load electrode configuration, with no magnetic fields to enhance ionization, electron emission currents are generally of order 1.5 - 2.0 A/sccm of gas flow. For xenon, in the same worst case load scenario, electron emission currents are of order 3 - 5 A/sccm of gas flow.

1.6.3 Operational Lifetime

The HWPES-250 will operate longest and most stable in a contamination free environment and while under continuous vacuum. Ultimate lifetime for the HWPES-250 can be of order several tens of thousands of ampere-hours while operating in such conditions using argon gas. Here, lifetime in ampere-hours is the product of the unit operating time in hours, and the average electron emission current drawn from the unit during that period. Operation with xenon may be expected to yield slightly longer lifetimes, while operation with lower atomic weight gases will result in shorter lifetimes.

Cyclic operation of the HWPES-250 will result in shorter lifetimes, as will operation near, or at, the 10 A maximum rated electron current draw of the unit. Atmospheric cycling will also reduce operational lifetime since it is never possible to completely remove all contaminants from the unit prior to restarting. Lifetime of the HWPES-250 will depend upon the specific application.

The end of the useful life of the HWPES-250 will be signaled by an inability of the HWPES-250 PS to start the unit.

1.6.5 Excessive Heating

Allowing the HWPES-250 to get too hot will reduce the lifetime of the unit. For electron emission currents above about 4-5 A, the HWPES-250 PS must be shut off and the HWPES-250 must be operated in a self-heating mode. While the HWPES-250 is rated for sustained electron emission currents of up to 10 A, the unit can be overheated by severe operating conditions. Severe conditions can be quickly reached if the HWPES-250 is operated at too low a gas flow, and the voltage between the HWPES-250 and the plasma load is allowed to rise to several tens of volts.

1.6.6 Pulsed Operation

The HWPES-250 may be operated at electron emission currents as high as high as 20 A for time periods not exceeding thirty seconds, and for duty cycles not exceeding 10%. Similarly, the HWPES-250 can be pulsed repetitively from a user configured pulsing power supply interposed between the cathode common of the HWPES-250 PS and the load. This pulsing power system can be either a regulated current source or a capacitor bank. In the case of the latter arrangement, electron emission currents much greater than 20 A can be achieved for very short pulse lengths. If used in a pulsing power system configuration, care must be taken to ensure that adequate gas flow exists during the current pulse to ensure that the HWPES-250 is not run too lean. Excessively lean operation will result in too high a unit temperature, and too high a pulsing voltage requirement, both of which will reduce the lifetime of the unit. Pulsed operation may reduce HWPES-250 lifetime.

1.6.7 Operation in a Reactive Background Gas

Some applications of the HWPES-250 may require that the unit be operated in a background pressure environment containing reactive gases such as oxygen, fluorine, chlorine, etc. Under such background pressure conditions, it is essential that an inert working gas such as argon or xenon be passing through the HWPES-250 at all times. It should be assumed that the lifetime of the HWPES-250 in a reactive background gas environment may be significantly reduced.

1.7 COOL DOWN AFTER OPERATION

During normal operation, the HWPES-250 electron emitter component will be at a temperature of about 1,100 - 1,200^{o} C, while the exterior surfaces of the enclosed

extraction electrode and the mounting components will be at lesser temperatures. Exposing the HWPES-250 to atmosphere while at these temperatures will severely oxidize the unit and effectively render it inoperable.

1.7.1 Minimum Vent Temperature Requirements

Before the HWPES-250 can be exposed to atmospheric conditions following operation, it must be cooled to an interior temperature of about 150^{o} C or lower. A cool down time period of one hour will usually ensure that this required cool down temperature is reached prior to exposing the unit to atmosphere. A working gas flow of a few sccm or greater should be maintained during cool down and after exposure to the atmosphere to avoid water vapor contamination.

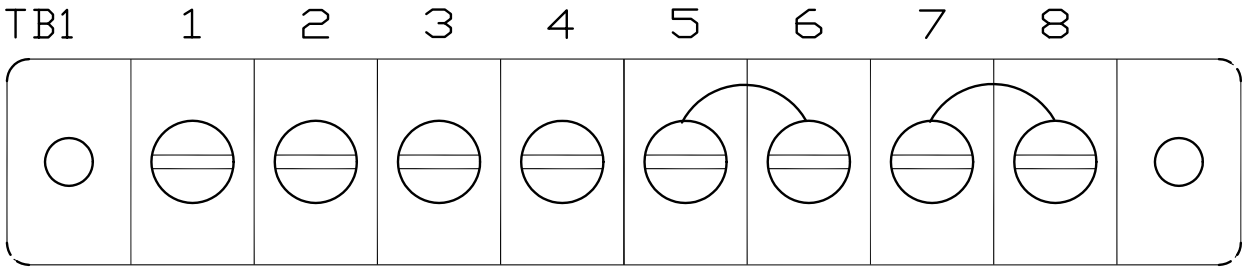
1.8 LONG TERM STORAGE

The HWPES-250 may be stored for indefinite periods between use with no degradation of the unit. Such storage can be accomplished by maintaining the unit under continuous vacuum, or by placing the unit in a sealed plastic bag where no water vapor is present. Under either of these conditions, the HWPES-250 may be stored successfully for years. Initial use gas purging and outgassing procedures should be followed after removing the HWPES-250 from extended storage.

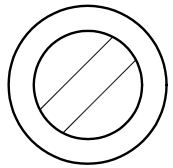
CAUTION
RISK OF ELECTRIC SHOCK
DO NOT OPEN

CAUTION: TO REDUCE THE RISK OF ELECTRIC SHOCK, DO NOT REMOVE COVERS.

NO USER-SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICING PERSONNEL.



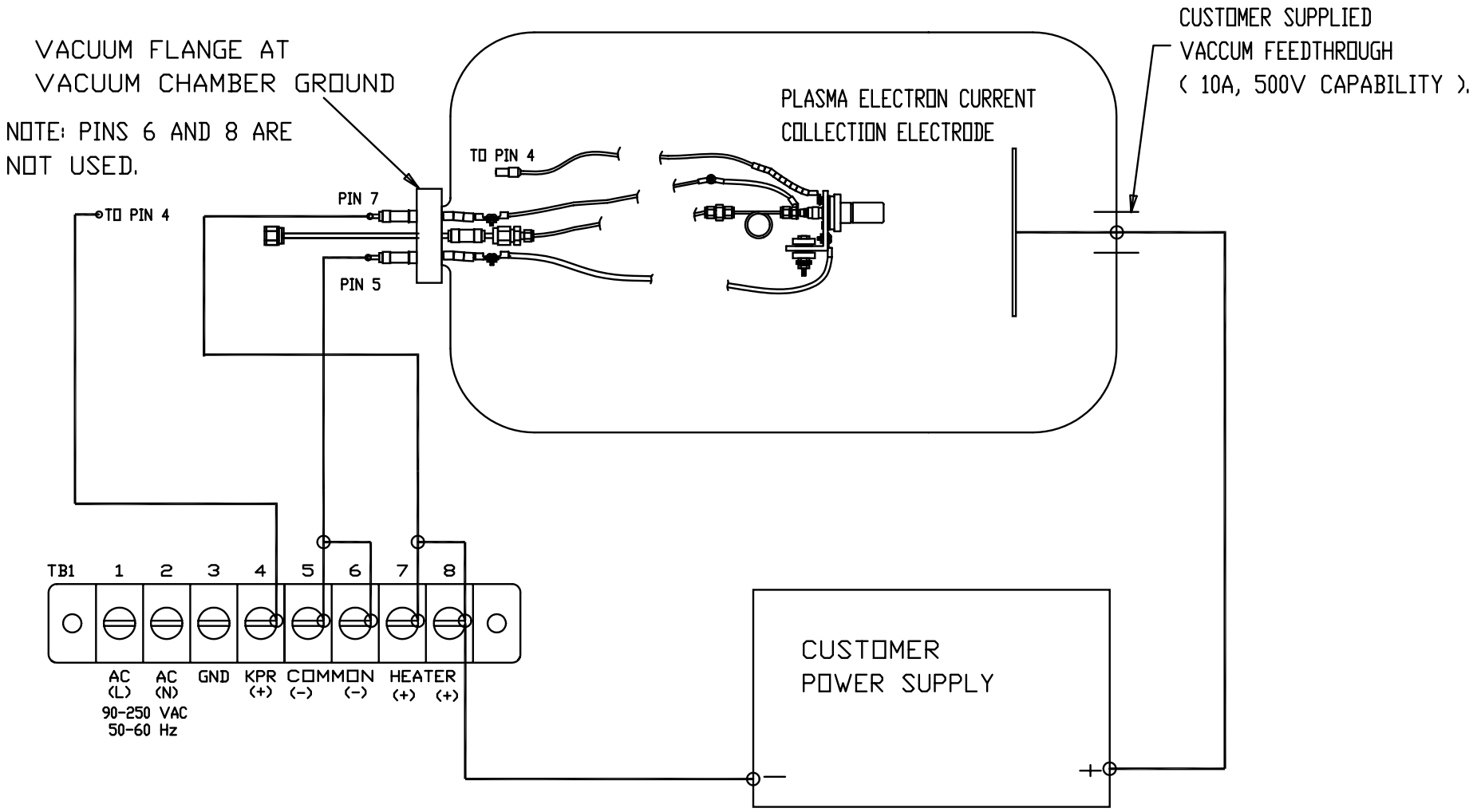
90-250 VAC
50-60 Hz



250V 10A
SLO BLO

SER. No.

Fig. 2



NOTES:

CUSTOMER SUPPLY SHOULD BE CURRENT REGULATED.
(NOTE THAT THIS POWER SUPPLY SHOULD BE SIZED FOR THE PLASMA ELECTRON CURRENT DESIRED, WHICH MAY BE UP TO 10 A CONTINUOUS FOR THE HWPES-250).

Fig. 3 Typical Biasing Configuration.

1.9 CAUTIONS

The following major precautions must always be observed when operating the HWPES-250:

(i) Never start the unit unless gas is flowing and this gas is of research grade purity.

(ii) Do not attempt startup unless the gas feed system has been

properly purged and the unit has been properly outgassed.

(iii) Do not break vacuum to atmosphere unless the unit temperature Is less than 150^{o} C.

(iv) Always operate the unit in a self-heating mode for sustained Electron emission currents above 4-5A.

(v) Prior to operation, check all electrical connections.

1.0 START AND STANDBY POWER SYSTEM HWPES-250 PS

2.1 HANDLING

The HWPES-250 PS has been designed and fabricated with care to provide reliable operation. Handling of the HWPES-250 PS should be in accordance with the same procedures given to any piece of electronic test equipment.

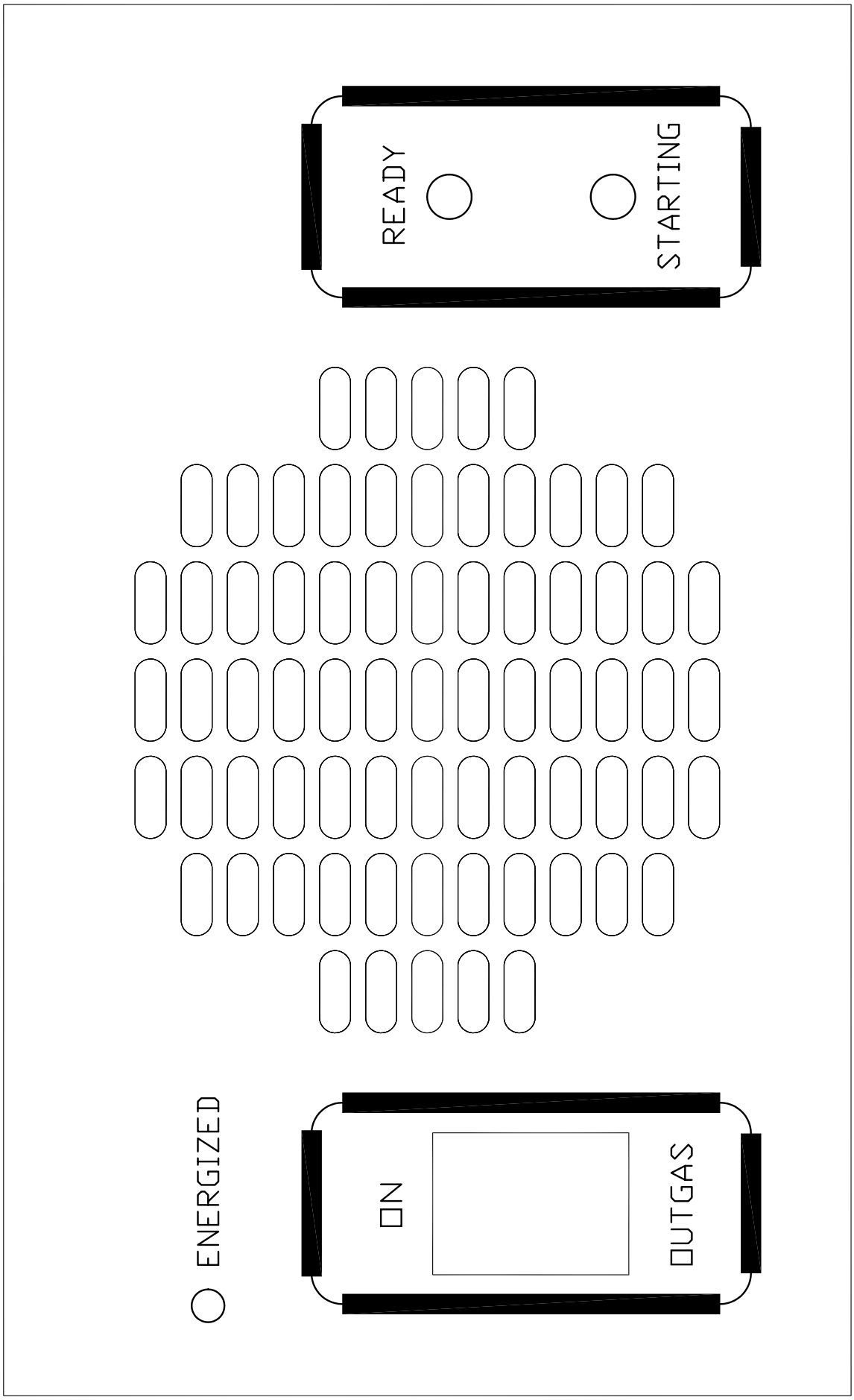


Fig. 4

2.2 CAUTIONS

The HWPES-250 PS has been designed for safe operation, however, the following precautions must always be observed:

(i) Operation should be carried out only by technically competent personnel generally familiar with the principles of electrical safety. All standard safety procedures for the work place in which this equipment is installed, should be followed.

(ii) The input/output terminal block connections on the unit are all potentially hazardous. This terminal block must never be worked on without first unplugging the unit from the AC line circuit. Remember that even after removing the AC line power, energy can still be stored in the unit capacitors for several seconds.

(iii) The unit is capable of delivering high DC currents. While output voltages are limited to about 50 V DC, the presence of high output currents can readily vaporize metal objects such as rings and screw drivers. This can result in molten metal being sprayed on people.

(iv) Mounting of the HWPES-250 PS must be in a location and orientation which allows the free unobstructed passage of cooling air through the vented top panel of the unit.

(v) Always ground the unit.

2.3 CONNECTIONS

The HWPES-250 PS input and output connections are all placed on terminal block TB1 as shown in Fig. 2.

2.3.1 AC Input Power

The AC power cord should be a three conductor cord of 14 AWG. The AC power cord ground must be connected to TB1-3, and the AC line (L) and AC neutral (N) connected to TB1-1 and TB1-2 respectively. The HWPES-250 PS will automatically

adjust to any AC voltage applied to TB1 that is in the range of 90-250 VAC and 50-60 Hz.

2.3.2 Wiring Connection

The HWPES-250 PS comes with a wire harness kit, HWPES-250 WH. The HWPES-250 WH uses push connectors to attach to the pins on the atmosphere side of the flange of the HWPES-250 MU. These pins are held tightly and care must be taken in attaching and separating these pin connectors to avoid pin bending and breakage of the flange feedthroughs. Attention must be given to assure that the connectors on the wiring harness attach to the appropriate pins on the flange (see Fig. 4).

2.3.3 Voltage Bias Limits

The HWPES-250 PS may be biased up to 500 V positive or negative with respect to ground on either the KPR, COMMON, or HEATER output connections.

2.3.4 Biasing Configurations

The HWPES-250 is a source of dense plasma from which either electrons or ions can be drawn. In most applications, electrons will be drawn from the HWPES-250 to a load via the establishment of a plasma coupling circuit. For many ion beam and surface space-charge neutralization loads, adequate electron currents can be drawn by connecting the COMMON connection on the HWPES-250 PS to test facility common or ground. In applications where larger electron currents are required, a coupling power supply may be used. This user provided power supply is usually operated in a current regulated mode. The negative of this supply is attached to the COMMON connection of the HWPES-250 PS, and the positive of the supply is attached to the load.

Similarly, the HWPES-250 may be used to create a plasma discharge in an anode structure. In this application, the negative of the user provided power supply is attached to the COMMON connection of the HWPES-250 PS, and the positive of the supply is attached to the anode structure. Biasing the HWPES-250 to augment another plasma discharge will be dependent on the specific process application.

HWPES-250 Hookup Detail

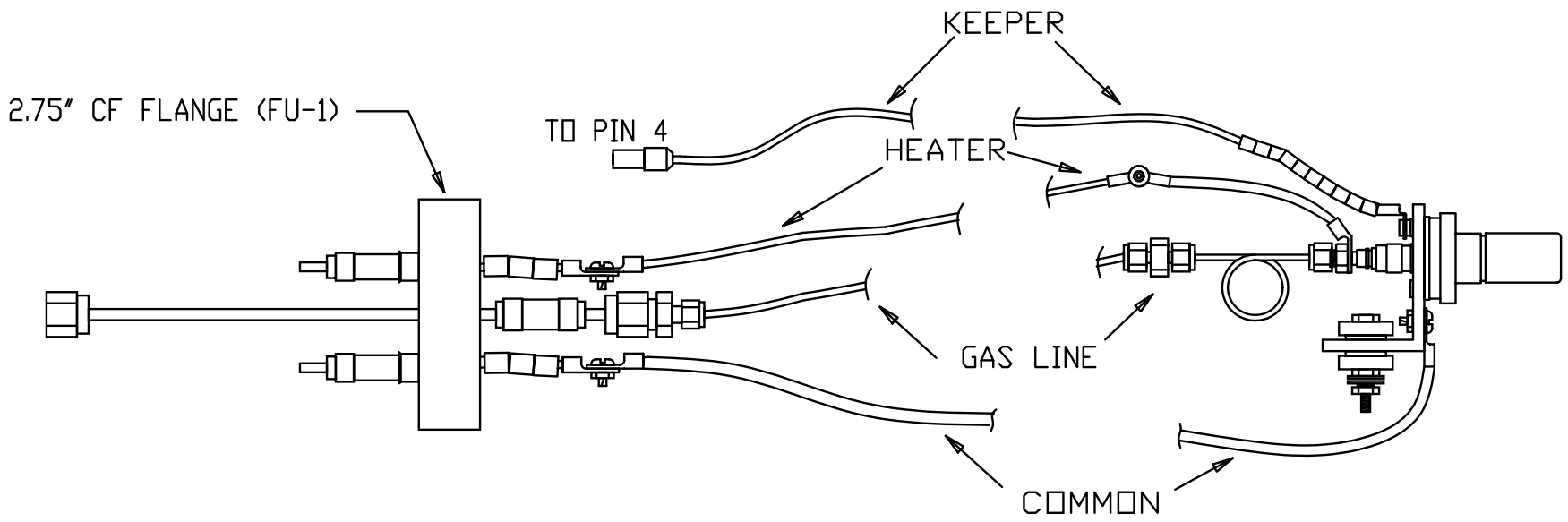


Fig. 5 Flange Connections

2.4 NORMAL OPERATION

The front panel of the HWPES-250 PS is shown in Fig. 3.

2.4.1 Start Sequence

Once the connections to TB1 and the HWPES-250 have been made, and the HWPES-250 is under a vacuum and purged and prepared for use as described elsewhere in this manual, the HWPES-250 PS rocker switch may be turned to the on position. After turning the unit on, the starting light will start to glow a dull yellow, which will gradually increase in intensity. After about three minutes, the HWPES-250 will start which will be indicated on the HWPES-250 PS by the green ready light illuminating, and the yellow starting light diminishing in intensity after a delay of several seconds.

2.4.2 Automatic Restarts

With the HWPES-250 on, the HWPES-250 PS will automatically maintain stable HWPES-250 operation, and also automatically initiate a restart sequence if the HWPES-250 unit should go out.

2.5 OFF-NORMAL OPERATION

Certain conditions may result in operation of the HWPES-250 PS which does not follow the normal start and run sequencing behavior.

2.5.1 Plasma Instabilities

During initial set-up of the HWPES-250 PS and HWPES-250 in a new application, inadequate plasma grounding around the HWPES-250 unit, and/or general instabilities in the plasma load being fed by the HWPES-250, may result in voltage transients which shut down the HWPES-250 PS. This behavior will be noted by the HWPES-250 going out and both the green ready and the yellow starting LED's being off (if the yellow starting LED is on alone that indicates that the HWPES-250 has gone out and that the HWPES-250 PS has initiated an automatic restart sequence). If both LED's are off, it will be necessary to turn off the HWPES-250 PS rocker switch (middle position), wait five

minutes as the HWPES-250 PS internally resets itself, and then turn back on the HWPES-250 PS. Upon turning the HWPES-250 PS on, the unit will initiate a restart sequence of the HWPES-250.

2.5.2 Self-Cleaning Operating Mode

Serious contamination of the HWPES-250 will cause the HWPES-250 PS to automatically oscillate between the starting and ready modes as the HWPES-250 PS cleans the HWPES-250 unit. This cleaning may or may not be successful depending up the severity of the contamination. Working gas flow rates may have to be increased to ensure stable operation of the HWPES-250. A successful self-cleaning operation will be signaled by establishment of steady HWPES-250 operation. While some contamination can be corrected by this automatic self-cleaning action, the lifetime of the HWPES-250 unit may be reduced.

2.6 MAINTENANCE

The HWPES-250 PS requires no maintenance. There are no user serviceable components within the HWPES-250 PS.

3.0 HWPES-250 MOUNTING UNIT HWPES-250 MU

3.1 GENERAL DESCRIPTION

The HWPES-250 MU has been designed specifically to support many vacuum chamber application environments. Figures 4 and 5 show a range of options which are available with the HWPES-250 MU, and how these various components work together to achieve different user operational configurations. These options include a gas flow isolator, HWPES-250 GFI 125, for electrically isolating the user gas supply from the potentials of the HWPES-250 system, a remote mounting kit, HWPES-250 RM, for physically attaching the HWPES-250 to a user supplied remote mounting bracket, a power cabling kit, HWPES-250 PC-24, for supplying power to a remotely mounted HWPES-250 unit, and an enclosed extraction electrode heat shield kit, HWPES-250 HS, for mitigating radiative heat transfer from the HWPES-250.

As a general guideline, rough treatment of the HWPES-250 MU and its various accessory components may result in part breakage.

3.2 INSTALLATION

The HWPES-250 MU will have been provided with no vacuum flange (MU-0) or either a 2.75" CF flange mount HWPES-250 MU-1, or a KF40 flange mount HWPES-250 MU-2.

3.2.1 Unpacking

The HWPES-250 is provided with the enclosed extraction electrode packaged in a sealed plastic bag and should not be opened until the HWPES-250 is ready to be installed into the vacuum facility. Similarly, any options such as the HWPES-250 RM, PC 24, and HWPES-250 HS will be included in this package. The user desired vacuum flange configuration, HWPES-250 MU-1 or HWPES-250 MU-2 is in a separate package. The flange may be fitted with optional components such as a GFI 125.

3.2.2 Making Mechanical and Electrical Connections

Assembly of the optional components to the vacuum flange may be performed as per the drawings contained in Figs. 4 and 5. Connections made too tight will bend parts and potentially break delicate insulators. This is especially true of the Swagelok connection at the rear of the HWPES-250 unit. No 1/16” gas line is provided for remote mounting applications of the HWPES-250 since the line length is dependent on the user application. It is very important to thoroughly clean and outgas any 1/16” gas line that is connected to the HWPES-250 unit. The 1/16” Swagelok nut supplied should be first swaged to the user 1/16” Swagelok union supplied for this purpose as a swaging tool. The 1/16” gas line, with swaged nut attached, can then be connected to the rear of the HWPES-250 unit.

When it is time to attach the HWPES-250 to the flange, the HWPES-250 must not be clamped or held mechanically to assist in making or breaking this Swagelok connection. Use of hand wrenches is adequate, with the 1/16” Swagelok connection tightened to a fit just barely snug or finger tight only. However, the atmosphere

Swagelok gas line fittings should be made tight, as per the manufacturers recommended pull-up on these gas fittings, to avoid any ambient air leakage problems into the gas feed lines. These latter fittings must be tightened with care to avoid part breakage.

It is strongly advisable to provide stress relief for the HWPES-250 GFI 125 to avoid breakage caused from gas lines exerting twisting and shearing forces on this component. It is highly recommended that the user gas flow system be manufactured from clean, stainless steel tubing of a small diameter to mitigate the formation of undue flow line mechanical stresses. A further benefit of using stainless steel tubing is that the slight porosity and air leakage inherent with non-metallic tubing is eliminated.

3.2.3 Enclosed Extraction Electrode Alignment

The HWPES-250 comes with the enclosed extraction electrode assembled to the HWPES-250 and the electrode gap and their respective orifices already aligned. Reliable operation of the HWPES-250 is not critically dependent on the alignment of these parts. If it becomes necessary to separate the HWPES-250 from its enclosed extraction electrode, the parts should be reassembled so that the downstream orifices of these two units are aligned such that the 0.100" dia. orifice in the enclosed extraction electrode is outside the circle defined by the 0.040" dia. orifice in the HWPES-250. Similarly, the gap between these two orifices should be in the range of 0.040 - 0.060".

3.2.4 Additional Shielding

Plasma grounding requirements will depend on the end use process configuration. In many applications it will be necessary to shield portions of the HWPES-250 and the mounting unit from the surrounding plasma environment to prevent arcing and extraneous plasma current paths in the process chamber. The degree of shielding required will vary. Similarly, for certain applications, the process chamber may be a significant source of sputtered material. Such material can coat exposed insulator surfaces on the HWPES-250, and its mounting components, causing short circuit current paths that can affect the operating stability of the HWPES-250. Where appropriate, sputter shielding should be used to prevent the accumulation of conducting sputtered films on insulator surfaces exposed to the process chamber.

Heat shielding may also be required around the HWPES-250 to prevent undue heat from reaching temperature sensitive hardware in the process chamber. Although the heat radiated from the HWPES-250 is significantly less than from heated filaments, additional heat shielding may be desired beyond that provided with the unit. With care, additional user supplied heat shields may be incorporated in the general vicinity of the HWPES-250.

3.2.5 Gas Feed Line Electrical Isolation

Use of the HWPES-250 GFI 125 is highly recommended to provide gas line electrical isolation between the voltages on the HWPES-250 and the user gas feed delivery system. If gas line electrical isolation is not provided by the GFI 125, or by a similar product, the common point of the HWPES-250 will be at the same potential as the gas feed system. Under these conditions, direct attachment to a grounded gas feed system will create a potential electrical ground loop in the HWPES-250 PS, and other user power supplies, which may be connected to the HWPES-250.

4.0 HeatWave Labs Hollow Cathode Products

Available 250 Series Hollow Cathode Components:

Part Number	Model Number	Description
101366	HWPES-250	Hollow Cathode Plasma Electron Emitter
101369-01	HWPES-250 MU-0	Mounting Unit without vacuum flange
101369-02	HWPES-250 MU-1	Mounting Unit, 2.75" CF Flange
101369-03	HWPES-250 MU-2	Mounting Unit, KF40 Flange
101368	HWPES-250 PS	Start and Standby Power System
101369-04	HWPES-250 WH	Wiring Harness
101369-05	HWPES-250 RM	Remote Mount
101369-06	HWPES-250 PC-24	Remote Power Cable, 24"
101369-07	HWPES-250 GFI 125	Gas Flow Electrical Isolator
101369-08	HWPES-250 HS	Extraction Electrode Heat Shield
101369-09	HWPES-250 SR	Feed Line Strain Relief

Note that 375 series and the 500 series hollow cathode components are available upon request as special order items. The hollow cathodes range in electron emission capability and in size according to their series number. A 250 series unit will provide 0-10 A of continuous emission. A 375 series unit will provide 0-25A of continuous emission, and a 500 series unit will provide 0-50 A of continuous emission.