



MODEL 509/539 ELECTRON BEAM SOURCE

INSTRUCTION MANUAL

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Current version of this manual can be found at
<https://telemark.com/uhv-e-beam-sources/ultra-compact-uhv-source/>

SAFETY WARNING

HIGH (POTENTIALLY LETHAL) VOLTAGES ARE PRESENT WITHIN EVAPORATION SYSTEM. GREAT CARE MUST BE EXERCISED WHEN PERFORMING MAINTENANCE.

HUMAN CONTACT WITH THE VOLTAGES CAN BE FATAL.

SHORT ALL HV FEEDTHRU CONNECTIONS WITH A GROUNDING HOOK.

DANGER – HIGH VOLTAGE

WARRANTY

Telemark products are warranted to be free of defects in materials and/or workmanship for a period of 12 months after shipment from the Telemark factory. This warranty is valid only for normal use, where regular maintenance has been performed. This warranty shall not apply if the product has been repaired or alterations made by anyone other than authorized Telemark service representatives, or if a malfunction or damage occurs through abuse, misuse, negligence, shipping damage, or other accident. No charge will be made for repairs covered by this warranty at a Telemark service facility. Telemark reserves the right to determine if the malfunction was caused by defective materials or workmanship. The customer will be responsible for freight charges to Telemark's service facility.

USER RESPONSIBILITY

The user is responsible for proper operation and ordinary maintenance of the equipment, following procedures described in this manual, including reference documents. Proper operation includes timely replacement of parts that are missing, broken, or plainly worn. If the user has a reasonable doubt about understanding the use or installation of a component, Telemark or your local representative should be called.

It is vitally important that the user properly install the equipment as described in Chapter 3 (Installation) of this manual, with particular attention to the correct grounding methods described.

The Warranty will be void if the equipment is improperly installed and/or properly grounded.

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1 UNPACKING

Your electron beam source is packed into a specially designed double strength box and surrounded with two and a half inches of rigid foam padding. Since packaging the source for safe shipment is otherwise difficult, please save the box in the event that the source ever needs to be returned for servicing. Telemark cannot be held liable for sources which are damaged in transit as a result of improper packaging.

Inside the box are the source and installation kit. The installation kit includes: a set of tools, a spare seal kit and an emitter rebuild kit. Please check the packaging list to make sure no damage has occurred in transit. Inspect the emitter assembly for alignment of the filament, anode plate and beam former. The source is ruggedly built and packaged tightly to prevent damage. In the event of any deficiencies, please report them to your vendor immediately. Also take care to read the warranty regarding the limits of Telemark's liabilities.

The finish on the metal parts of the source is the highest available. The source is assembled under clean conditions and sealed in a polyethylene bag for shipment.

2 DESCRIPTION

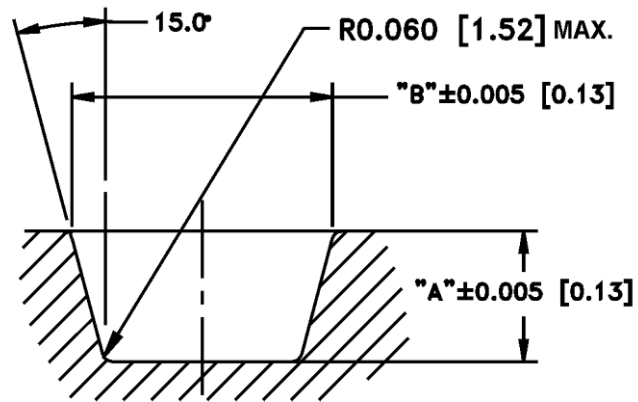
The electron beam source's most notable features:

Some models have crucibles that can be removed from above by simply removing the screws that hold them in place. This feature allows the crucible to be cleaned or replaced without removing the source from the vacuum chamber or disassembling the entire source. This process is described in the Servicing Manual.

The emitter assembly is a critical component in the operation of the electron beam source. The parts that make up the emitter assembly are manufactured to exacting standards. Telemark has developed several innovative changes to the emitter assembly which make it more reliable and easier to assemble.

The sweep coils are sealed in a water-cooled solid copper block or are sealed in a stainless steel can that is attached to a water-cooled solid copper block. This virtually eliminates the possibility of damaging the coils thermally or mechanically during normal production or handling. As long as proper water flow is maintained in the EB source and care is taken not to drop it, the coils should last indefinitely.

Other features, such as heavy-duty screws with Helicoil® inserts in the copper in all important fastening locations, reliable vacuum connections, and heavy-duty construction in general, are designed to make the source serviceable for years of production.



Standard Crucible

Figure 2-A Crucible Dimensions

Size	"A"		"B"	
	Inch	mm	Inch	Mm
4cc	.575	14.61	.885	22.48

3 SPECIFICATIONS

Specifications	509/539 EB Source
Electron Beam Deflection	270°
Power Rating	4 kW
High Voltage Range	-5 kV to -7 kV
Filament Power	Up to 575mA at 7kV
Water Requirements	2 gpm (min.) at 3 kW Input water temperature should be 60 F (15C) at a pressure of 60 psi (4.2 kg/cm2), using a 1/4" Line.
Crucible Volume	4cc
Bake-out Temperature	250°C

4 INSTALLATION

4.1 Required Components

See figure 4-A

The following is the minimum list of components required for setting up the source for safe operation.

- 1 High-voltage Feedthroughs** – Two high-voltage feedthroughs rated at 15 kV @ 70 amps. Bare copper straps are provided for use inside the chamber. Outside the chamber use #6 AWG copper wire with lugs for attaching feedthrough to transformer.
- 2 Tank Ground** – Use a solid copper strap or copper wire (#6 AWG or greater and up to seven strands, not copper braid) between tank and an 8 foot long copper clad steel grounding rod. Connections must be free of oxide and extremely tight.
- 3 Transformer Cover** – Mount filament (source) transformer as close to high-voltage feedthroughs as possible in the transformer box provided with the Telemark power supply.
- 4 Water Feedthrough** – For sources that do not come from the factory installed on flanges a water feedthrough is required. Use 3/8" O.D. x 1/16" wall 304 Stainless tubing and

weld into fittings provided with source and butt-weld to tubing dual water feedthrough. We do not recommend the use of bellows inside the chamber. Attach feedthrough tubing to 3/8" copper tubing outside chamber, use compression fittings or other means to make this connection.

- 5 Water Filter** – Use standard removable water filter on inlet. Position away from chamber so that it is completely accessible for servicing.
- 6 Blowout Valve** – Use three-way valve attached to air or nitrogen supply for blowout.
- 7 Flowmeter** – Use a flowmeter with an interlock switch on water outflow.
- 8 Interlocks** – Install interlocks for Vacuum, Tank, High Vacuum, and Water. Other interlocks should be installed using the Aux interlock input.

4.2 Setting Up

Note that it is important to never use mild steel for electron beam source mounting. This includes mounting plates, standoffs or source shutter hardware. Mild steel could affect the magnetic properties of the electron beam source resulting in poor performance or a deformed electron beam. The best material to use is non-magnetic 304 stainless steel.

Set the source level with the required offset from chamber centerline. The source is easiest to operate and observe in operation if placed facing forward and in front of the chamber centerline. The source may be mounted directly on a vacuum chamber baseplate, on stainless steel standoffs, a flange depending on the model and installation requirements. Custom designed mounting plates are available from the factory.

Good contact between the base of the electron beam source and the baseplate of the vacuum chamber is important to earth ground the source through the chamber baseplate.

A shutter should be mounted above and slightly behind the pocket. The shutter should obscure at least a one-hundred-degree cone above the pocket. A stainless disc makes a good, enduring shutter, provided it can be mounted ruggedly and detached easily for cleaning.

8 or 10 AWG copper wire is provided for the high voltage leads. These should be shortened to the smallest distance between source emitter and the feedthroughs, with a slight curve to allow for thermal expansion and contraction.

Interlocks should be installed, so that the breaking of any interlock turns off the source. See the note on high voltages below as to why this is important.

4.3 Grounding

Proper grounding is the single most important aspect of the installation of the E-beam. During arcing events, RF noise is generated that must be properly driven to ground to avoid interference/damage. For this reason, the E-beam ground must be separate from the electronics rack ground and ideally as short as possible. Improper grounding can lead to poor performance, interference with other equipment, damage to E-beam electronics or other equipment, or even shock potential.

Do not depend on water pipes for the system ground connection. Because of multiple joints and sealing compounds, water pipes typically do not make an earth ground. Keep in mind this is a high frequency as well as a DC ground.

Regardless of the method of grounding, the first point of connection for the ground cable/strap is always the E-beam chamber. There should be a specially designed ground bar welded to the chamber for this purpose. The strap, if used, should be "sandwiched" between two bars to ensure a broad area connection.

Connecting to Building Steel

The best method known for grounding the E-beam is to tie the ground bar to building steel as close as possible using the appropriate grounding strap (varies based on the distance - see details below). One must verify that the building steel has a good connection to ground for this to be a viable solution. Be sure to remove any paint, rust, etc from under the connection point to the building steel.

Because the connection is for an RF ground, surface area is more important than cross-sectional area. It is critical to have a wide surface area of connection between the grounding strap and the building steel.

Distance Between E-Beam Chamber and Grounding Point	Minimum Recommended Strap/Cable
< 10 Feet « 3 meters)	#6 Gauge or larger gauge copper cable
10-20 Feet (3-6 meters)	#4 Gauge or larger gauge copper cable
20-60 Feet (6-18 meters)	2 inch by .035 inch thick copper strap
> 60 Feet (> 18 meters)	Contact Telemark for recommendations

Table 4-1: Ground Strap Size

When in doubt, always go with the larger ground connection. You can never have too good of a connection!

Do not use braided wire. Be sure that the connection is made to clean metal.

The power supply is connected to ground using the HV cable's shield connection. The power supply may sustain major damage if power is applied before the ground is connected.

4.4 High Voltage

Use decals or other warning labels on the high voltage shield, at the front of the E-beam chamber and on the door to the room to provide warning that lethal voltages are present. Do not put any part of the body under a chamber while a source is running. Always use a grounding hook as a matter of habit before touching any potentially high voltage area, even when power supply is off. Always keep one hand in a pocket. Always maintain a respectful fear of high voltages: familiarity does not make high voltages safe.

4.5 Ground Connections

In addition to the critical building (earth) ground described above, there are 6 other ground leads that will be attached to the ground bar on the E-beam chamber:

1. Source Transformer Box - connected using 6 AWG gauge wire
2. E-beam power supply - connected using 6 AWG wire
3. Safety cover over high voltage feedthroughs - connected using 12 AWG gauge wire
4. Sweep controller - connected using 12 AWG gauge wire

5. TT-Controller - connected using 12 AWG gauge wire

6. Sweep cable ground connection - connected using 12 AWG gauge wire

There is not a required order for the above; simply connect each ground lead securely to an open ground lug location on the ground bar. Ensure connections are secure prior to turning on the power to the E-beam. Operating without one or more grounds properly connected may cause damage to equipment or even harm to the operator.

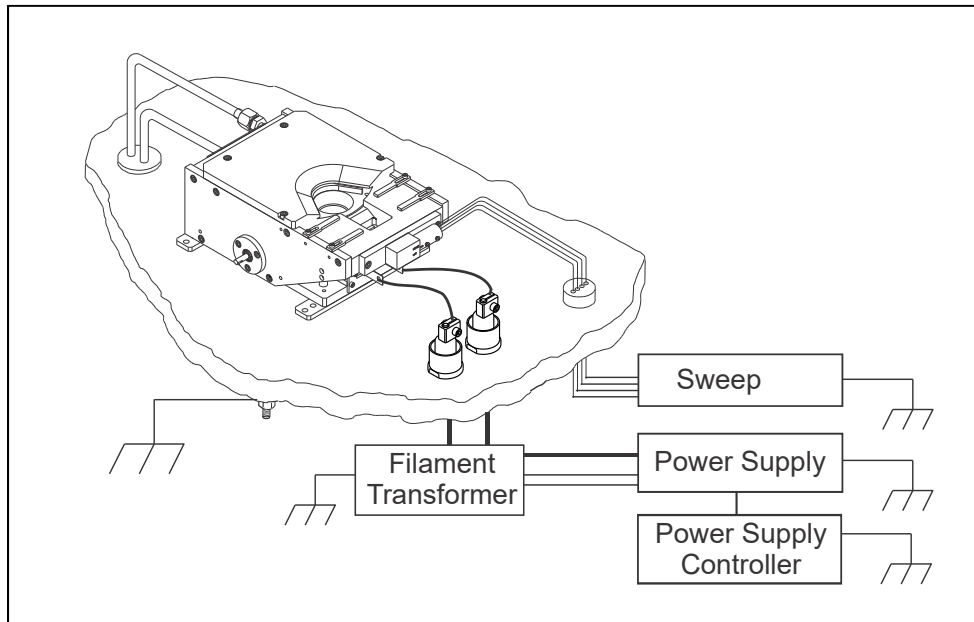


Figure 4-A Suggested Ground Installation

4.6 Two Source Installation

See Fig 4-B

To have a two-source installation work properly, a magnetic shunt bar must be placed between the two sources so that the magnetics of the sources do not interfere with the movement of positions of the dual electron beams. The shunt is usually a sandwich alternating between magnetic and non-magnetic metal with an air gap between each piece. Magnetic metals used are Mew metal or a mild steel .020 to .030 inch (0.50 to 0.75mm). Non-magnetic metals are non-magnetic stainless steel or copper .020 to .030 inch thick (0.50 to .75mm). One way of mounting the shunt to the magnet arms is with 304 stainless steel straps; other fastening methods may need to be used.

Sources must oppose each other for the sweep coils to work properly.

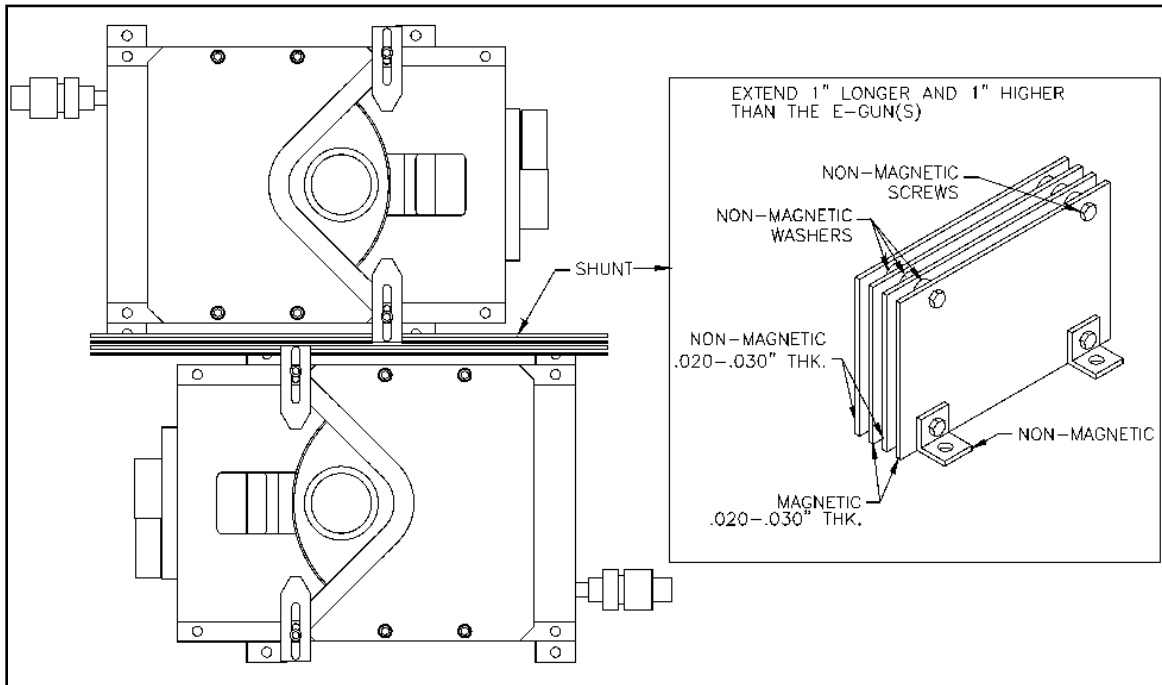


Figure 4-B Multi-Source Installation

5 OPERATION

5.1 General Operation – Startup

Load the crucible up to first rim with vacuum grade material. Make sure the view of the crucible is unobstructed from the view port when the chamber is closed. Welding glass (T9H is a convenient density) should be used when the beam intensity becomes too bright for direct viewing. (It is always a good idea to put a clean, removable piece of glass on the inside the chamber to prevent the port from being coated.) When the chamber is in operating range on the order of 1×10^{-5} torr or better, set the operation voltage, set the beam position to neutral, set the emission to zero, and reset the sweeps amplitude to zero.

When you are satisfied that conditions are optimal, turn on the power supply high voltage. Keeping an eye on the evaporant, very slowly turn up filament current. At around 100mA the beam should become apparent on the melt. If not, see the following paragraph. The beam should always be in the center of the crucible. As the emission is increased, the sweep pattern can be enlarged to cover the melt. After the ion gauge has stabilized and the material has stopped out-gassing and spitting, the shutter can be opened. After the required thickness level is reached, close the shutter, and reduce the emission to zero.

If the beam is not visible at 100mA of emission current, then adjust the beam position all the way in and then all the way out and from left to right. If the beam does not become visible at this time, do not under any circumstances try to increase the emission. Instead, turn off the source emission current and the high voltage. Check the longitudinal focus coil leads, be sure that they are not reversed, and go through the checklist under the section on troubleshooting.

5.2 General Operation – Shutdown

After terminating the final layer of the run sequence, turn down the filament current, turn off the high voltage, and allow the filament to cool for a few minutes before opening the chamber. The emitter assembly is surrounded by water-cooled components, so through radiation the filament will cool quickly. (A yellow oxide forms around the filament cavity if the vent is too fast.) Always use a grounding hook before working around high voltages.

Before removing the crucible for cleaning, make sure the water lines are blown out.

5.3 Adjusting the Electromagnetic Field

Position – The beam can be pulled towards the front of the crucible by:

- Reducing the high voltage (which also reduces beam intensity).
- Increasing the longitudinal coil current.
- Removing the shunt bar.
- Bringing the pole pieces farther in.

The beam can also be moved laterally by applying current to the lateral sweep coils.

Shape – As in the discussion above, the shape of the beam can be concentrated by bringing the pole pieces all the way in. In general, the beam shape is optimal for dielectrics if the pole pieces are two thirds of the way in, the shunt bar is added, and the accelerating voltage is around 6kV.

Intensity – The intensity of the beam is maximized by having the filament, beam former and anode plate aligned properly: see the service manual for your model electron beam source. If the intensity seems limited, the filament alignment should be checked – it may be warped, too far up, or even in backwards. The beam intensity is increased by turning up the filament current.

6

SERVICING

You should be particularly familiar with the removal and replacement of the crucible and the emitter, as these are the components most commonly removed for servicing.

CAUTION: MAKE SURE THAT A GROUNDING HOOK IS USED TO SHORT ALL HV CONNECTION BEFORE ANY WORK IS PERFORMED ON THE EMITTER ASSEMBLY.

6.1 Emitter Removal

Loosen the set screws holding the HV wire to the emitter assembly. The most convenient way to detach the emitter assembly is with a long handled Allen wrench since the emitter can be extremely hot. Remove the two screws on the front of the emitter.

6.2 Emitter Disassembly and Cleaning

You will need several things for the disassembly/cleaning process. Alcohol to help free the tight screws. Wire to string the metal parts of your emitter for cleaning. A bead-blaster to clean the parts. Wash and vapor dry the parts after bead-blasting. Some of your ceramics can also be cleaned in this fashion. Discard any cracked or broken ceramics.

6.3 Filament Replacement

To replace the filament in the emitter assembly it is necessary to locate and remove the two filament clamp set screws. CAUTION: If the screws seem tight, you can use alcohol to keep them from seizing. The filament alignment for the model 539 E beam source is identical to the model 509.

6.4 509/539 Emitter Rebuilding/Reassembly

See supplied drawings

PLEASE NOTE THE CRITICAL DIMENSIONS WITH NUMBERS IN CIRCLES BY THEM. THEY ARE NUMBERED ON ORDER OF IMPORTANCE FOR OPTIMUM PERFORMANCE. USE THE GAGES PROVIDED WITH THE E-BEAM SOURCE TO ACCURATELY MAKE ADJUSTMENTS.

If the emitter is disassembled, refer to figure 6-A. Ninety percent of system problems during production relate to the E-beam source emitter, so close attention to its assembly is of the utmost importance to trouble free runs. In particular, pay meticulous attention to the following:

- 1** Length of screws. All screws must be clean and of correct length. Tighten screws so that they are just snug. Do not overtighten screws going into or through ceramics. The ceramics will break, the resulting loss of ceramics can be both frustrating and expensive.
- 2** Relative position of anode (Main Block), beam former and filament must be precise to .005". Clearance between these three elements should be judged, based on performance, with a well calibrated, experienced eye. The E-beam source will only work properly if these clearances are properly maintained.
- 3** Leads to filament. The voltage through the filament is only 6 volts so filament clamps, leads and high voltage feedthroughs must all be snugged firmly, but not overtighten, to reduce resistance.
- 4** High voltage leads. Make sure high voltage leads clear all objects inside chamber by at least one inch.

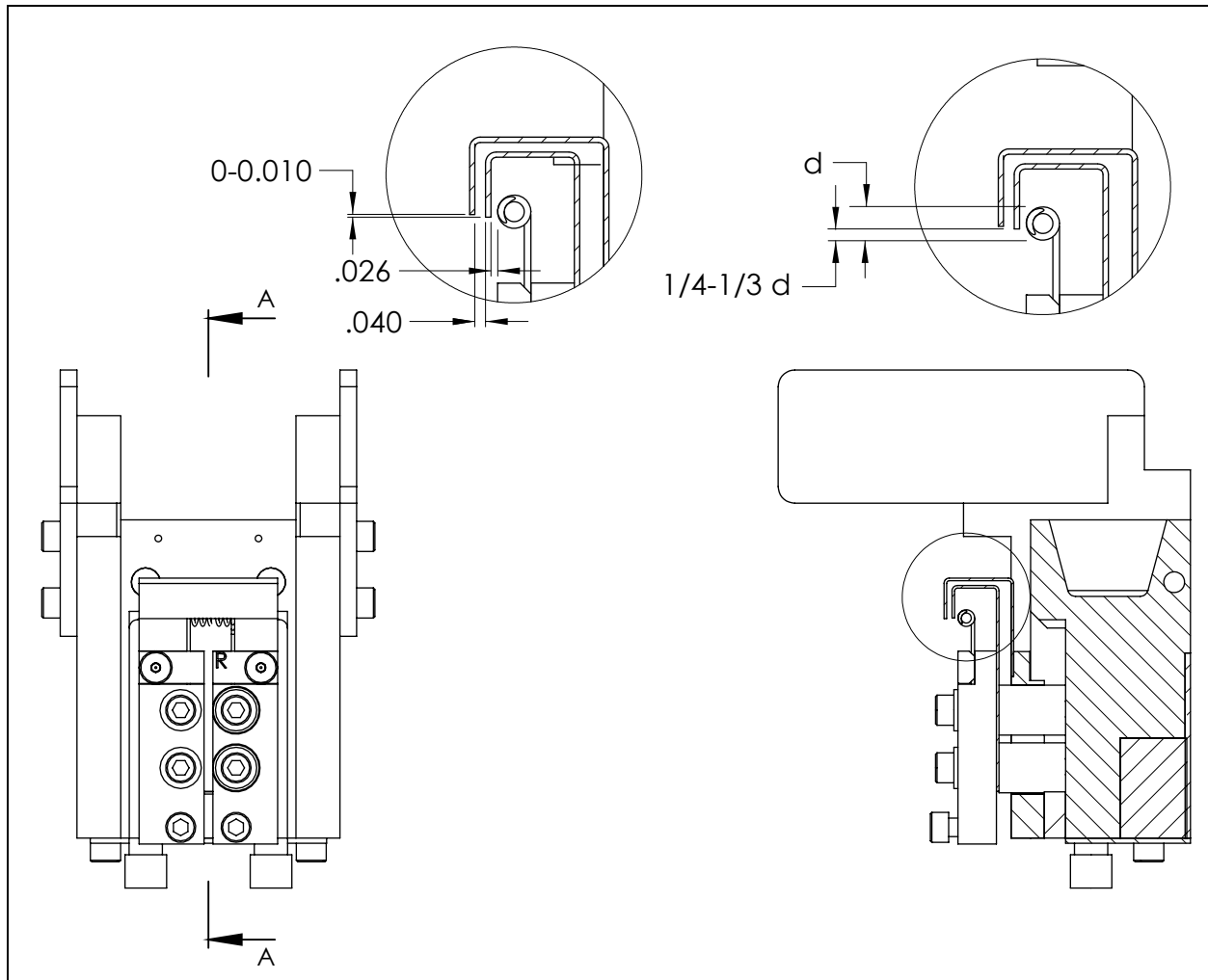


Figure 6-A 509/539 Emitter Adjustments

The following is the recommended step-by-step method rebuilding an emitter. Note that you should not tighten the screws all the way down until instructed to do so.

- 1** Remove the emitter from the E-beam source by removing the two screws on the front of the E-beam source.
- 2** Remove the broken or used filament by loosening the two set screws.
- 3** Check for damaged or coated ceramics, clean or replace as needed.
- 4** Put in a filament. Tighten the set screws.

- 5** The emitter is now installed in the E-beam source. Screw the emitter into the E-beam source. Do not tighten down the screws. Place a shim between the beam former and the anode. Press the beam former against the shim and tighten screw #2

- 6** Put the beam former on and tighten screw #1.

- 7** Check the tolerances now.

6.5 Quick Check

If necessary use following check list which is used on final Q.A. to make sure everything is in place.

Emitter Assembly	Filament location	
	Anode, beam former and filament parallel	
	#6-32 screws snugged	
	Resistance check	Filament continuity Emitter to ground
	Tightened firmly to HV leads	
Leak check	To 2×10^{-10} Std. ccs of helium	
Cleanliness	Beadblasting Flakes, dust, coating Fingerprints	
Waterline Fittings	Tight	

7 KITS AND ACCESSORIES

7.1 Installation Kit

The one of the following Installation Kits is shipped with the EB Source

509-0723-1 Installation Kit, 509

No.	Description	Quantity
271-4004-1	Four-In-One Screwdriver	1
271-4020-1	Wrench Kit	1
509-2000-1	Gasket Kit, 509	1
509-3039-1	HV Lead Kit, 12"	1
509-3700-1	Emitter Parts Kit, 509/539	1

539-0723-1 Installation Kit, 539

No.	Description	Quantity
271-4004-1	Four-In-One Screwdriver	1
271-4020-1	Wrench Kit	1
271-4030-1	Feeler Gauge Set	1
509-3039-1	HV Lead Kit, 12"	1
509-3700-1	Emitter Parts Kit, 509/539	1
539-2000-1	Seal Kit, 539	1
575-0800-1	Bearing Wrench	1
575-0801-1	Wrench, 1/4" combination, open end/12pt.	1

7.2 Accessories

Recommended parts:

- 1 Power Supply:** We recommend the ST or TT power supplies from Telemark. However, this source will work well with all available power supplies that meet the operating specifications of the electron beam source.

- 2 High Voltage Covers:** Install 2 HV covers for each EB source.

No.	Description
275-0212-2	HV Cover Assy. 2 Pass

- 3 Shutter:** For applications requiring a shutter install one of the following

No.	Description
275-0888-1	Shutter/Controller, 1" feedthrough
275-0888-2	Shutter/Controller, 1-1/4" feedthrough
275-0888-3	Shutter/Controller, CFF 2.75" feedthrough

- 4 Flowmeter.** Telemark part number 271-0831-1. This Model uses ¼" NPT fittings and is rated at 1-6 gpm adjustable.

- 5 High Feedthroughs.** Install one Dual Pass HV Feedthru for each EB source.

No.	Description
275-0019-2	Dual Pass HV Feedthru, CFF (10 AWG)

7.3 Rebuild Kits

509 Gasket Kit

509-2000-1

Gasket Kit, 509

No.	Description	Quantity
271-3500-1	Gasket, VCR 1/4"	2
271-3601-1	Gasket, CFF 2.75" Silver Plated	1

539 Seal Kit

539-2000-1 Gasket Kit, 539

No.	Description	Quantity
271-3500-1	Gasket, VCR 1/4"	2
271-3581-1	Gasket, CFF 1.33" Silver Plated	2
271-3601-1	Gasket, CFF 2.75" Silver Plated	2
271-3641-1	Gasket, CFF 6" Silver Plated	1

509/539 Emitter Parts Kits

509-3700-1 Emitter Parts Kit, 509

No.	Description	Quantity
223-0010-1	Ceramic Insulator	4
271-5003-1	Gloves, pr.	1
271-5985-2	Vented Screw, #2-56 X 1/8" SST Flat Head	2
271-6006-5	Vented Screw, #4-40 X 1/4" Hex Flat Head, Ti	2
271-6030-6	Vented Screw, #6-32 X 1/4" SST SHCS, SILVER	2
271-6065-5	Screw, #6-32 X 5/8" Ti, SHCS	4
271-6199-2	Set Screw, #6-32 X 1/2" SST	4
271-6242-1	Flat Washer, #6	6
273-0006-1	Insulator, Collar	4
509-0002-1	Filament, 5-1/2 Turn	5
509-0003-1	Anode	1
509-3004-1	Beam Former	1

8

TROUBLESHOOTING

This section should be read in conjunction with the section on assembling the emitter. Experience demonstrates that the emitter assembly causes ninety percent of system problems in production.

8.1 Power Problems

Problem: EMISSION CURRENT MUST BE TURNED TO HIGHER THAN NORMAL TO EVAPORATE.

Cause: Filament is badly warped or was put in backwards.

Correction: *Remove emitter assembly and replace filament.*

Problem: EMISSION GOES TO MAXIMUM WHEN THE HIGH VOLTAGE IS TURNED ON.

Cause: A flake of material (sometimes extremely small) may be shorting the filament block to the anode plate. This happens occasionally when heating brittle materials too fast.

Correction: *Remove emitter, and try to locate and remove flake.*

Problem: NO EMISSION CURRENT.

Cause 1: Filament is broken or leads need tightening

Correction: Replace filament or tighten connections.

Cause 2: Power supply filament control circuit is faulty. parallel

Correction: Fix power supply.

Problem: NO VOLTAGE.

Cause: System or source has high resistance ground

Correction: Check emitter, filament, and feedthroughs for shorts.

8.2 Beam Problems

Problem: NO BEAM VISIBLE IN CRUCIBLE AS CURRENT IS INCREASED.

Cause 1: The magnet was reversed when reassembling the source (this can have damaging affects on the EB source and chamber walls if emission current is increased too far while searching for beam).

Correction: Close down the system and reassemble the source with the magnet properly oriented.

Cause 2: The sweep unit may have a problem.

Correction: Check sweep for proper setup.

Problem: THE BEAM IS CENTERED TO THE FRONT OF THE CRUCIBLE, WITH NO COIL CURRENT.

Cause 1: The high voltage is below what the source was gaussed for.

Correction: Adjust the voltage so the beam is centered.

Cause 2: The magnet is too strong.

Correction: Place a shunt just behind the cover plate on the magnet arms to weaken the magnet.

Problem: THE BEAM CENTERED TO THE BACK OF THE CRUCIBLE, WITH NO COIL CURRENT.

Cause 1: The high voltage is above what the source was gaussed for.

Correction: *Adjust the voltage so the beam is centered.*

Cause 2: The magnet is too weak.

Correction: *Remove shunts. If still out of position, contact factory to have the source regaussed.*

Problem: THE BEAM DOES NOT HAVE THE DESIRED SHAPE.

Cause 1: The filament is warped or misaligned.

Correction: *Replace the filament.*

Cause 2: The pole pieces are either in or out too far.

Correction: *Adjust the pole pieces.*

Cause 3: The voltage is not set correctly causing the beam to spread out.

Correction: *Adjust the voltage.*

Problem: ARCING AND BLUE FLUORESCENCE OCCUR WHERE THE BEAM SHOULD BE.

Cause: The pressure is too high. There may be a water leak, the bleed valve may be wide open, or chamber seal may be broken.

Correction: *Shut off the bleed valve, check the source or water fittings for leaks, check the most recently opened chamber seals (such as the door) for clean surfaces. Mentally and, if necessary, physically leak check chamber.*

8.3 Rotation Problems

Possible problems with Quad-ring sealed Multi-Pocket Sources.

Problem: LOSS OF VACUUM WHEN THE CRUCIBLE IS ROTATED.

Cause: Water seal is letting water through.

Correction: *Install a new Quad-ring.*

Problem: THE CRUCIBLE IS DIFFICULT TO ROTATE.

Cause 1: The water seal is in need of lubrication.

Correction: Install a new Quad-ring.

Cause 2: The drive bearing is bad.

Correction: Check and replace bearing if needed.