
# HIGH FREQUENCY ELECTRODYNAMIC SHAKER

## PRODUCT MANUAL | MODEL 2025E-HF

THE MODAL SHOP
MTS SYSTEMS CORPORATION

modalshop.com | 513 351 9919

# HIGH FREQUENCY ELECTRODYNAMIC SHAKER

## MODEL 2025E-HF

### PRODUCT SUPPORT

For answers to questions about this product, consult this manual or the accessory manual. For additional product support, contact The Modal Shop at 800.860.4867 or 513.351.9919, 9 a.m. to 5 p.m. EST. If it is more convenient, fax your questions or comments to The Modal Shop at 513.458.2172 or email our technical staff at info@modalshop.com.

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Prior to the installation and use of this product, review all safety markings and instructions. The Modal Shop, Inc. equipment has been designed and manufactured for use in an industrial environment to be operated by trained, qualified personnel.

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**WARNING**: **Denotes a hazard that can cause injury.**

**Caution!** Denotes a hazard that can damage equipment or data.

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# 1. INTRODUCTION

Please review this manual carefully, as it contains important information regarding the safe and proper operation of the shaker.

The Modal Shop 2025E-HF High Frequency Shaker is a 13 lbf (111 N) sine-peak electrodynamic unit. The shaker is designed for general purpose vibration testing of small components and stress screening of electronic sub-assemblies. The shaker has an extended frequency range for use in calibration of accelerometers and general purpose high frequency testing.

The compact size of the 2025E-HF shaker (11 lb / 5 kg total) and large specimen mounting table surface (2.125" / 54 mm diameter) with multiple internally-threaded attachment points makes the shaker assembly ideally suited for such applications as production screening, accelerometer calibration and high frequency testing.

The armature suspension and guidance system's use of composite materials provides a high degree of lateral and rotational restraint while maintaining maximum compliance in the axis of motion to permit full 0.5" (12.7 mm) peak to peak displacement.

The 2025E-HF shaker body structure is designed to allow a variety of operating positions.  The shaker is mounted in a trunnion assembly to permit rotation of the thrust axis to any angle up to +90 degrees from the vertical. The shaker may be removed from the trunnion base and set on a horizontal surface or bolted to a mounting plate such that the thrust axis is parallel to the required vibration axis.

# 2. SPECIFICATIONS

The following are the performance and physical characteristics of the 2025E-HF shaker, assuming no amplifier or other system limitations. In the interest of constant product improvement, specifications are subject to change without notice.

| MODEL 2025E-HF SPECIFICATIONS | |
|---|---|
| **GENERAL** | |
| Rated output force: | |
| Sine force | 13 lbf (58 N) pk, natural air cooling |
| Random force | 8.0 lbf (35 N) RMS, natural air cooling |
| Shock force | 53 lbf (236 N) pk, 100 ms pulse |
| Displacement (Max) | 0.5 in (12.7 mm) pk-pk, continuous |
| Velocity (max) | 120 in/s (305 cm/s) pk |
| Acceleration (max) | 100 g pk, no load |
| | 150 g pk, resonance |
| | 300 g pk, shock pulse |
| Frequency range | DC – 14 kHz, bare table, full force<br>(usable to 20 kHz at reduced force) |
| **PHYSICAL CHARACTERISTICS** | |
| Moving element mass | 0.35 lb (0.159 kg) |
| Fundamental resonance, nominal | > 10 kHz |
| Rated armature current | 13 A RMS, natural air cooling |
| | 27 A RMS, with forced air cooling[1] |
| Specimen mounting | Four internally threaded mounting holes (6-32 UNC), on a 1.8 in (45.7 mm) bolt circle. On the center, a dual threaded mounting hole 10-32 UNF x 0.30 in (7.6 mm) deep and 6-32 UNC through. |
| Armature guidance and suspension system | Four internally damped lateral flexures with foreshortening compensation |
| Axial suspension stiffness, nominal | 15 lb/in (2.6 N/mm) |
| Stray magnetic field | <15 gauss at 1.0 in (25.4 mm) above table<br><15 gauss at 0.5 in (12.7 mm) from body |
| Shaker weight | 11 lb (5 kg), with trunnion |
| Shaker Dimensions, nominal | 4.25 in (108 mm) diameter<br>7.00 in (178 mm) height (with trunnion)<br>(See Outline Drawing section for details) |
| **ENVIRONMENTAL CONDITIONS** | |
| Ambient temperature | 40°F – 100 °F (4°C – 38 °C), < 85% RH |
| Force derating | Reduce 1% per 1 °F (0.56 °C) ambient air temperature greater than 100 °F (> 38 °C) |
| Altitude | < 6562 ft (2000 m) |

Notes:

[1] Minimum air flow required above 13 lbf output is 35 cfm at 6 in $H_2O$.

*The 2025E-HF is designed for continuous operation at 13 lbf (58N), sine pk max without the use of forced air cooling. However, prolonged operation of the shaker at near maximum levels without forced air cooling will result in increased temperature of the shaker. Undesirable heating of the armature mounting surface can be reduced by utilizing a cooling blower package.

# 3. INSTALLATION AND OPERATION

## 3.1 General

Installation of The Modal Shop 2025E-HF shaker involves unpacking, preparing the equipment and readying it for operation. This must be preceded by selection of an appropriate site and preparation of same. Before proceeding with the actual installation of the shaker, ensure that the site conforms to the needs of the equipment, and meets all the requirements for its proper operation.

## 3.2 Site Selection and Preparation

The location in which the modal shaker is to be installed should be one basically free of all airborne particles of foreign matter, but especially those that are of a ferromagnetic or other metallic nature. Consideration should be given to the vibration which will be introduced by the modal shaker to the mounting surface. The location should be chosen such that other equipment in the area (for example; a power amplifier on the same table) will not be adversely affected.

**WARNING: Consideration should also be given to the maximum sound pressure level produced during normal operation. This value is dependent upon the test frequencies and acceleration levels as well as the specimen and its mounting's acoustic characteristics. Sound pressure levels, which require the use of protective earpieces, can be present during testing. Sound pressure level should be measured or calculated by the equipment user; both at the operator's position in normal use and whatever point 3.2 ft (1 m) from the equipment has the highest sound pressure level. Hearing protection should be provided as necessary.**

A power amplifier and signal source will also be required for shaker operation.

If a cooling blower is desired for maximum shaker force performance, it should be installed and connected prior to start-up.

As for the modal shaker itself, the physical location of its installation is restricted only by the lengths of the various interconnecting cables and hoses. Position the shaker such that access to the cables and/or the hoses is not restricted.

## 3.3 Unpacking and Handling

At the time of arrival of the modal shaker, check the equipment against the packing list to make sure that the shipment is complete. Inspect all packages for shipping damage and check for loose, broken and/or damaged components.

In the event of shipping damage, notify the agent of the delivering carrier and obtain a full report of the irregularity. Have this signed by the agent before accepting the shipment.

## 3.4 Installation

The Model 2025E-HF Shaker is self-supporting and only requires sufficient room to allow connection of the drive cable, air hose (if used with a cooling package), accelerometer feedback cable and specimen mounting fixtures. Care should be taken to prevent conflicts or interference in the placement of these items. Ensure that there is not an accidental strain induced in the interconnecting cables or hose which could cause degradation in performance or a system failure.

The installation of the shaker is a simple process which only requires attention to a few details and can be accomplished as follows:

**Step 1** Place and position the shaker in the appropriately chosen site (see subsection 3.2).

**Step 2** Mounting Options:

Trunnion Mounting: A level mounting surface is desirable and the shaker trunnion should be securely mounted to prevent the shaker from bouncing or “wandering” during operation. Resilient mounting (vibration isolators vibration mat, etc.) is preferred where precision alignment is not required. If the trunnion must be hard mounted, the shaker can be removed from the trunnion base then reattached after the trunnion is mounted. To rotate the shaker’s thrust axis, loosen the trunnion mounting screws and rotate the shaker to the desired operating position. Tighten the mounting screws to lock the shaker into position.

Body Mounting: The shaker can be installed without its trunnion base by connecting the shaker body directly to the user’s test apparatus. Four ¼-20 UNC mounting holes are provided on the bottom of the shaker body.

Suspended: Turnbuckles or other means of suspension and adjustment may be attached by utilizing the holes in the bottom of the trunnion. This allows hanging the shaker in any position desired by adjusting the hangers.

**Step 3** If a cooling vacuum is to be used, a cooling hose should be connected between the blower and the hole located on the side of the shaker body, using appropriate hose adaptors. *Caution! Natural convection cooling is seriously impeded when a cooling vacuum is installed. If installed, the vacuum must be operating whenever the shaker is in use.*

**Step 4** The shaker drive cable should now be connected to the shaker and power amplifier. There are two wires in the cable which are to be connected as follows:

| Shaker Label | Amplifier Terminal Label |
|---|---|
| + | (O) OUT or SHAKER + |
| - | (R) RET or SHAKER - |

The two cable connections labeled “O” and “R” are the drive for the armature coil and should to be connected to the power amplifier as specified above to assure the proper phase/motion relationship of the shaker armature.

**WARNING: To prevent electrical shock, shut the system power amplifier off and disconnect its power cable to ensure that there is no power coming from the power amplifier before connecting the shaker drive cable terminals.**

Remove terminal cover, connect terminals and replace terminal cover.

**Step 5** With an appropriate signal source properly connected to the power amplifier, the shaker is now ready for operation.

**Input Signal**

The input signal (drive signal) for the shaker is provided by a signal source and power amplifier with sufficient output voltage and current capability to produce the required force output from the shaker. As a reference, the following are the nominal force vs. power requirements for the Model 2025E-HF shaker:

| **Force Rating** | **Power Amplifier Output** |
|---|---|
| 13 lbf pk | 12 A RMS, 20 V RMS, natural air cooling |
| 25 lbf pk | 24 A RMS, 40 V RMS, with 35 CFM at 6 in min vacuum |

Resonances in the specimen and mounting fixture can significantly affect the power requirements for a given test level, which would change these voltage/current relationships.

**WARNING: The shaker drive cable is provided with an inline fuse to protect the shaker from overheating due to overdrive conditions. Operation without the proper fuse protection and/or proper cooling conditions that results in armature coil failure due to overheating is not subject to warranty provisions! Make sure you know the drive current level during operation and do not exceed the above ratings.**

**Fuse Requirements**

The shaker drive cable fuse requirements are as follows:

- 12 A, 1 ¼ in, Fast Blow, 250V - shaker operation up to 13 lbf
- 25 A, 1 ¼ in, Fast Blow, 250V - shaker operation up to 25 lbf

**Cooling**

While in the process of performing the primary function of generating a vibratory force, the Model 2025E-HF shaker also dissipates, in the armature coil, an amount of heat related to the level of output force. The design of the armature coil, under natural convection cooling, permits the shaker to produce 13 lbf pk force, however, operation at force levels between 13 and 25 lbf pk on the 2025E-HF shaker requires the addition of an optional cooling package.

**WARNING: Shaker surface may become hot to the touch after prolonged use.**

## 3.5 Preoperational Procedure

Before actual use of the 2025E-HF shaker in a test application, it is recommended that a system vibration response signature be obtained. This procedure utilizes all of the system components; shaker, power amplifier, signal source and feedback accelerometer to observe the vibration waveform on an oscilloscope and verify proper shaker operation. Perform the following test:

**Step 1** Interconnect the shaker, power amplifier and signal source as detailed in the installation procedure.

**Step 2** Mount an accelerometer to the shaker armature and connect its output to an appropriate signal conditioning amplifier. In the case of calibration use, the reference accelerometer should be attached utilizing the #10-32 UNF hole in the center of the armature table.

**Step 3** Connect the output of the signal conditioning amplifier to an oscilloscope and adjust the signal level resolution for about (1.5 in to 2.5 in) 4 cm to 6 cm on the display.

**Step 4** With the system connected as described, adjust the sine wave signal source to obtain about 2 g peak response acceleration at approximately 100 Hz. Then, without changing the gain level, scan the frequency up and down (10 Hz to 10 kHz) and observe the acceleration waveform on the oscilloscope. Make note of changes in waveform distortion at specific frequencies.

It is necessary to be able to differentiate between normal and abnormal waveform distortion in order to identify potential problems or deterioration in shaker performance. Some waveform distortion is normal, such as the distortion which is seen at submultiples of the armature fundamental axial resonances. This distortion occurs when a small amount of harmonic distortion generated in the signal source and the system power amplifier are amplified by the major armature and accelerometer resonances.

A serious departure from the normal pattern of waveform distortion could indicate armature or suspension system misalignment or damage. It is highly recommended that a record be made of the armature fundamental resonance frequency and the waveform distortion when the shaker is received. This record can be used at a later date to differentiate between normal and abnormal distortion. A periodic check with this record will minimize troubleshooting time and can be used as a preventive maintenance check.

## 3.6 Load Attachment

The 2025E-HF shaker specimen mounting table surface is supplied with five tapped holes for load attachment. The best dynamic performance is obtained if all these attachment holes are used to secure the load (specimen and fixture). The 6-32 UNC hole in the center of table is recessed 0.35 in (8.9 mm) and a longer load attachment screw will be required in this position. In the case where the shaker is being used for calibration purposes, the hole in the center of the table is tapped for a 10-32 UNF x 0.30” deep for attachment of the reference accelerometer.

**Caution!** Do not drill additional holes in the specimen mounting table surface as this will weaken the table and may result in damage to the shaker.

The five #6-32 UNC screws used in mounting the specimen and fixtures to the shaker table should extend into the shaker mounting surface at least 0.38 in (9.7 mm) but no more than 0.75 in (19.0 mm) in the 4 outer holes. The center screw should extend 0.75 inches below the table surface. The screws should be tightened to between 13 and 18 in-lbf (1.47 and 2.03 N-m) or the manufacturer's recommended torque value for the particular class of fastener being used (whichever is lower). The armature table should be firmly gripped while fixture and specimen mounting screws are tightened to prevent a rotational movement of the armature which might cause damage to the internal armature guidance and suspension components.

Looseness or excessive compliance in any of the mechanical connections between the armature table and the load will cause erratic, uncontrolled test levels and spurious frequency components. Difficulties caused by such looseness can be detected by connecting an oscilloscope to the accelerometer output. Serious departure from a sinusoidal response and, more particularly, the addition of high frequency nonharmonic noise components superimposed on the waveform are nearly always an indication of decoupling between the shaker armature and fixture or fixture and specimen. Bolted connections within the fixture should be avoided if possible; welding or casting of fixtures is preferred.

Care must be exercised in locating the load over the armature table. The fixture height should be minimized to keep the center of gravity (CG) as close to the table surface as possible. Driving a complicated fixture/specimen assembly causes coupled modes of vibration which can only be reduced by rigorous attention to symmetry and careful alignment of the load over the thrust axis of the armature. Load attachment is a specialized problem which must be solved for each load configuration. The relative motion of the table and fixture with the specimen in place can be checked by a series of measurements taken with lightweight piezoelectric accelerometers.

### VERTICAL ORIENTATION

For vertical operation, the shaker should be positioned as close to true vertical as possible. This is especially important if the loads are heavy (greater than 1 lb / 0.454 kg) or if they have a high center of gravity. Off center loads will exert a torque on the armature suspension that can cause the armature coil to contact the shaker magnetic pole pieces causing damage to the armature. Damage can be caused by dynamic loading due to relatively small static imbalances and the customer is cautioned to look for any significant non-axial motion of the load and armature, and to correct the situation immediately.

This type of damage is caused by a combination of the relative size of the off-center load and the associated acceleration. The following can be used as a guide to approximate maximum off-center loads that can be tolerated by the 2025E-HF armature suspension.

$$X \leq 0.16/Wa$$

X = Armature axial center line to load CG offset distance in inches
W = Load weight in pounds
a = peak axial acceleration expected in g's

**Caution!** This equation should serve as a guide only and is not applicable under lateral resonant conditions.

The shaker flexure system support capabilities (axial suspension stiffness) should be considered before attaching a specimen and fixture to the mounting surface. The 2025E-HF armature suspension has been offset to allow full relative displacement with the armature displaced into the shaker approximately 0.06 in (1.5 mm) from its nominal unloaded position. This is equivalent to approximately 1 pound of weight (0.454 kg) with the shaker in the vertical position.

In order to obtain the full shaker stroke capability (0.50 in ± 0.25 in / 12.7 mm ± 6.4 mm) with a load greater than 1 pound (0.454 kg), the weight of the fixture and specimen must be externally supported. DC offset current to the armature coil may also be used to center the armature but the shaker AC performance will be reduced accordingly.

If less than the full shaker stroke capability is required for a test, a static deflection of the armature is permissible as long as the sum of the required vector displacement and the static deflection is less than 0.25 in (6.4 mm) from the neutral position.

### HORIZONTAL ORIENTATION

For horizontal operation, all of the concerns relative to vertical operation remain valid with an additional load carrying constraint. In addition to the axial off-center loading limitations, horizontal operation requires that the armature suspension counteract the torque applied by an over-hung test article due to its weight. If especially heavy or high center of gravity loads must be tested, additional load support should be used (slip table, linear bearings, "bungee" cords, etc.).

The following equation can be used as a guide to approximate maximum off-center loads (lateral) that can be tolerated by the 2025E-HF armature suspension.

$$X \leq (8/W) - 2$$

X = Armature mounting surface to load CG distance in inches
W = Load weight in pounds

## 3.7 Operation

The 2025E-HF shaker is designed to provide a force output proportional to the input drive current from a power amplifier and faithfully reproduce the waveform within its specified level and frequency bandwidth limits. It is important to note that the shaker and amplifier combination, whether operated by a manual or closed-loop control system, will react directly to an input, either intentional or accidental. Great care must be taken to avoid damage to the armature coil or suspension system. Damage can be caused by transients in the supply waveform or by exceeding the shaker's rated displacement and/or acceleration limits. To prevent such potential damage, please observe the following cautions during operation:

*Note: The 2025E-HF is designed for continuous operation at 13 lbf force (max) without the use of forced air cooling. However, prolonged operation of the shaker at near maximum levels will result in increased temperature of the shaker. Undesirable heating of the armature can be reduced by utilizing a cooling blower package.*

**Caution!** If the shaker is being controlled manually through the frequency range, approach the armature fundamental resonance frequency slowly while monitoring the acceleration level. Shaker armature resonances have a very large amplification factor and can force the acceleration level to exceed the shaker's acceleration limit.

**Caution!** Always reduce the power amplifier output to zero before switching the oscillator or control system to a different range. Switching before reducing the power amplifier gain to zero could result in a transient, which would exceed the shaker's acceleration or displacement limits.

**Caution!** Make sure that the maximum displacement is not exceeded at the low frequency end of the operating range. Exceeding the displacement will cause the armature assembly to strike its mechanical stop with an impact that could exceed the acceleration limit or break the armature coil bond.

**Caution!** Observe that the maximum armature current is not exceeded and that the proper cooling air flow is maintained since overheating and possible armature damage can occur. Refer to subsection 3.4 for rated armature current and cooling air flow specifications.

**WARNING: If the shaker is used in a manner not specified by the manufacturer, protection provided by the equipment may be impaired.**

**WARNING: Shaker surface may become hot to touch after prolonged use.**

# 4. PRINCIPLES OF OPERATION

## 4.1 Description

The 2025E-HF electrodynamic shaker incorporates a single ended magnet structure to provide the high-level magnetic field which surrounds the armature drive coil assembly. The armature assembly is suspended and centered in the magnetic gap by four composite material flexures. The flexures are attached to the shaker body through foreshortening flexures which maintain linear motion over the entire stroke.

The armature assembly consists of a cylindrical aluminum coil bonded to an aluminum armature table assembly to minimize the overall weight and maximize the structural stiffness. The armature coil is positioned around the center pole of the magnet assembly and is suspended in the air gap in the magnetic structure. The flexures provide axial support for the armature assembly as well as lateral and rotational restraint.

## 4.2 Theory of Operation

A shaker (vibration exciter) transforms electrical current into mechanical force for the purpose of vibration testing. A shaker is similar to a dynamic loudspeaker. It consists of a magnet structure and a moving coil. Force is generated in the moving coil by interaction between current flowing in the coil and the magnetic field in which the coil is placed. An alternating current in the coil will produce an alternating force and resultant motion at the same frequency in the coil.

The moving coil and the force-transmitting structure is called the armature. The armature is supported in the magnet structure or body by springs or flexures. This suspension allows movement of the armature normal to its mounting surface (i.e. parallel to its vibration axis).

The magnet structure is designed to provide extremely high flux densities in the coil gap and yet have low leakage flux density at the table. The high flux density provides a high ratio of force to current.

The force generated in the armature coil is always defined by the following equation:

$$F = K_1 \, BL \, I \, (2.54)^2$$

F = the force generated in the armature coil
$K_1$ = a physical constant (0.885 x 10-7 in English system of units)
B = the magnetic flux density (gauss) in the gap
L = the length of conductor (in inches) in the gap (coil circumference x number of coil turns)
I = the armature current

Thus the force-current ratio is constant for a particular shaker.

Whenever a conductor is moving in a magnetic field at the same time that current is flowing through the conductor, there is an interchange of power between the electric circuit and the mechanical system associated with the motion of the conductor. This is true in the case of a shaker. Neglecting the voltage drop across the electrical impedance of the armature coil due to the flow of current through it, a voltage will be generated in the coil that is directly proportional to the velocity of the coil.

$$E_B = K_2 \, BL \, v \, (2.54)^2$$

$E_B$ = the back-voltage generated in the coil
$K_2$ = a physical constant (10-8 in English system of units)
B = the magnetic flux density (gauss) in the gap
L = the length of conductor (inches) in the gap
v = the velocity of the armature coil (inches/seconds)

## 4.3 Formula

To effectively utilize the 2025E-HF shaker for specific vibration testing applications, it is useful to review the formulae which describe the physical principles of shaker operations. Some of these formulae define the payload capabilities of the shaker, while others describe the physical relationship between the operational parameters of Acceleration, Velocity and Displacement.

**Defining shaker payload capabilities**

$$F = M \cdot A$$

F = vector force, lbf / N
M = total moving mass (mass of shaker armature + mass of specimen + mass of the fixture), lb / kg
A = vector acceleration, gravity units ‘g’ / m/s$^2$ (note: 1 g = 9.80665 m/s$^2$)

Example:

Find the force required for a sine wave test of 15 g pk to be performed on a specimen of 0.2 lb and a fixture of 0.1 lb.

$$F = M \cdot A$$

F = (specimen mass + fixture mass + armature mass) • A
F = (0.2 + 0.1 + 0.35) lbs • 15 g pk
F = 0.65 lb • 15 g pk
→ F = 9.75 lbf pk

**Caution!** Although this calculation determines the force required, the maximum displacement and velocity must also be determined before proceeding with the test.

**Describing the relationships between Acceleration, Velocity & Displacement**

$$V = \pi f D$$

$$V = 61.44 g/f$$
$$g = 0.0511 f^2 D$$
$$g = 0.0162 V f$$

V = velocity in inches/second (in/s, peak)
D = displacement in inches (in, peak to peak)
f = frequency in (Hz)
g = acceleration in ‘g’ (gravity units)

All of the relationships for sine wave testing can be derived from the formulae shown.

**Defining the random acceleration levels**

$$g\ RMS = [\Delta f\ (g^2/Hz)]^{1/2}$$

$\Delta f$ = bandwidth ($f_2$-$f_1$), in Hz
$g^2/Hz$ = acceleration spectral density
g RMS = root mean square acceleration

This formula will provide the total Root Mean Square (RMS) acceleration level for a flat random spectrum. For shaped spectra, a more lengthy calculation is required.

# 5. MAINTENANCE

## 5.1 General

The Model 2025E-HF Shaker is designed to provide trouble-free service for long periods of time when operated within the performance limits set forth in Section 2 and in an environment which is free of excessive dust, metallic particles and other potentially harmful materials.

The only maintenance that should be performed on a routine basis, outside of replacement of worn or damaged components, is the cleaning of the air filter. Inspection of the shaker moving element (flexures, armature and wiring) can be performed if operational problems are suspected. The following procedures will aid in performing these inspection and routine maintenance functions:

**Caution!** Disconnect the shaker from the amplifier during maintenance procedures.

**WARNING: To prevent electrical shock, shut the system power amplifier off and disconnect its power cable to ensure that there is no power coming from the power amplifier before beginning maintenance procedures.**

## 5.2 Cleaning Air Filter

If the shaker is operated in a relatively dust-free environment, the air filter (located at the top of the shaker) and the cooling inlet screen (located on the bottom) should not need cleaning for a period of approximately 500 hours of operation. If cleaning is deemed necessary, please proceed as follows:

**Step 1** Using a small vacuum cleaner, adjusted for the minimum suction, gently vacuum the filter at the top of the shaker until it appears clean. Gradually increase the vacuum as required to obtain satisfactory results, being careful not to damage the filter membrane.

**Step 2** If satisfactory results cannot be obtained in this manner, the shaker housing will have to be removed and the filter cleaned by blowing through it with compressed air (see section 5.4 for cover removal procedure).

## 5.3 Inspecting Flexures, Armature and Wiring

Before disassembly of the shaker to locate a suspected operational problem, it is always a good idea to check the other system components such as: the power amplifier, signal generator or accelerometer and signal conditioning instrumentation for malfunctions since, historically, the largest majority of field problems have been traced to electronic component malfunctions rather than shaker mechanical problems.

Although the shaker moving element and suspension (flexures, armature, and wiring) should not require routine maintenance, an inspection to look for signs of wear, loose screws etc. is recommended if the housing is to be removed to clean the air filters or if an internal malfunction is suspected. To perform the inspection, please follow the procedure below:

**Step 1** Locate and remove the two "O-rings" which hold the air filter assembly to the circumference of the armature, being careful not to tear the filter material.

**Step 2** Locate and remove the three pan head machine screws which fasten the top cover to the shaker body. These screws are located on the circumference of the top cover at the transition to the shaker body.

**Step 3** Carefully remove the top cover assembly containing the air filter and carry to a location, away from the shaker, where there is a supply of compressed air. Also, remove filter plugs at shaker bottom plate.

**Step 4** Clean the air filter by carefully directing a stream of compressed air at the filter from the inside of the top cover assembly. Continue to clean in this manner until visual inspection, by holding the filter up to a light source indicating that the filter is clean.

**Step 5** Reinstall the top cover assembly by reverse order of the procedure steps 1 through 3.

*Note: Make sure that the filter material is properly set in the groove in the armature before installing the two "O-rings."*

## 5.4 Shaker Disassembly and Repair

There are three user replaceable subassemblies in the shaker. These are the armature, flexures and foreshortening flexure assembly. To remove the armature/flexure assembly for inspection or replacement see below.

The armature alignment can be checked and adjusted as follows:

**Step 1** Remove the housing as described in section 5.3.

**Step 2** Check for proper armature alignment by gently side-loading the armature. If the armature coil can be made to touch any part of the magnet structure, the foreshortening flexure assembly should be adjusted or replaced.

**Step 3** Using non-metallic alignment shims three places in the magnetic gap around the armature coil, re-align the armature in the magnetic gap by loosening the four #6 socket head cap screws, holding the copper compensation band and the four #10 socket head cap screws located at the periphery of the top plate (do not loosen the top plate hold down screws with low-profile heads or small hex nuts). Once the armature coil has been centered, and while the alignment shims are still in place in the magnetic gap around the armature coil, carefully re-tighten the four #10 screws to secure the armature position.

**Caution!** When making adjustments, it is important to be sure that the armature coil remain centered in the gap of the magnet structure. Non-metallic shims should be used for this purpose, and the concentricity should be maintained within 0.002 in.

**Step 4** Tighten the four #6 screws on the compensation band and the four #10 screws on the foreshortening assembly plate. Remove the alignment shims and recheck the alignment per step 2 above. Repeat steps 2 through 4 as required until proper clearance is obtained all around the armature coil.

**Step 5** Reassemble the shaker by reversing in the subsection of 5.4 step 3 and in the subsection of 5.3 steps 1 through 3.

The armature/flexure assembly can be removed and inspected or replaced as follows:

**Step 1** Remove the housing as described in section subsection of 5.3 steps 1 through 3.

**Step 2** Visually inspect the armature guidance system. Grasp the armature and slowly move it in and out to exercise the upper and lower flexures. Look for signs of cracks in the flexure material, loose or broken wiring connections, loose flexure fastening screws or problems with the foreshortening flexure assemblies.

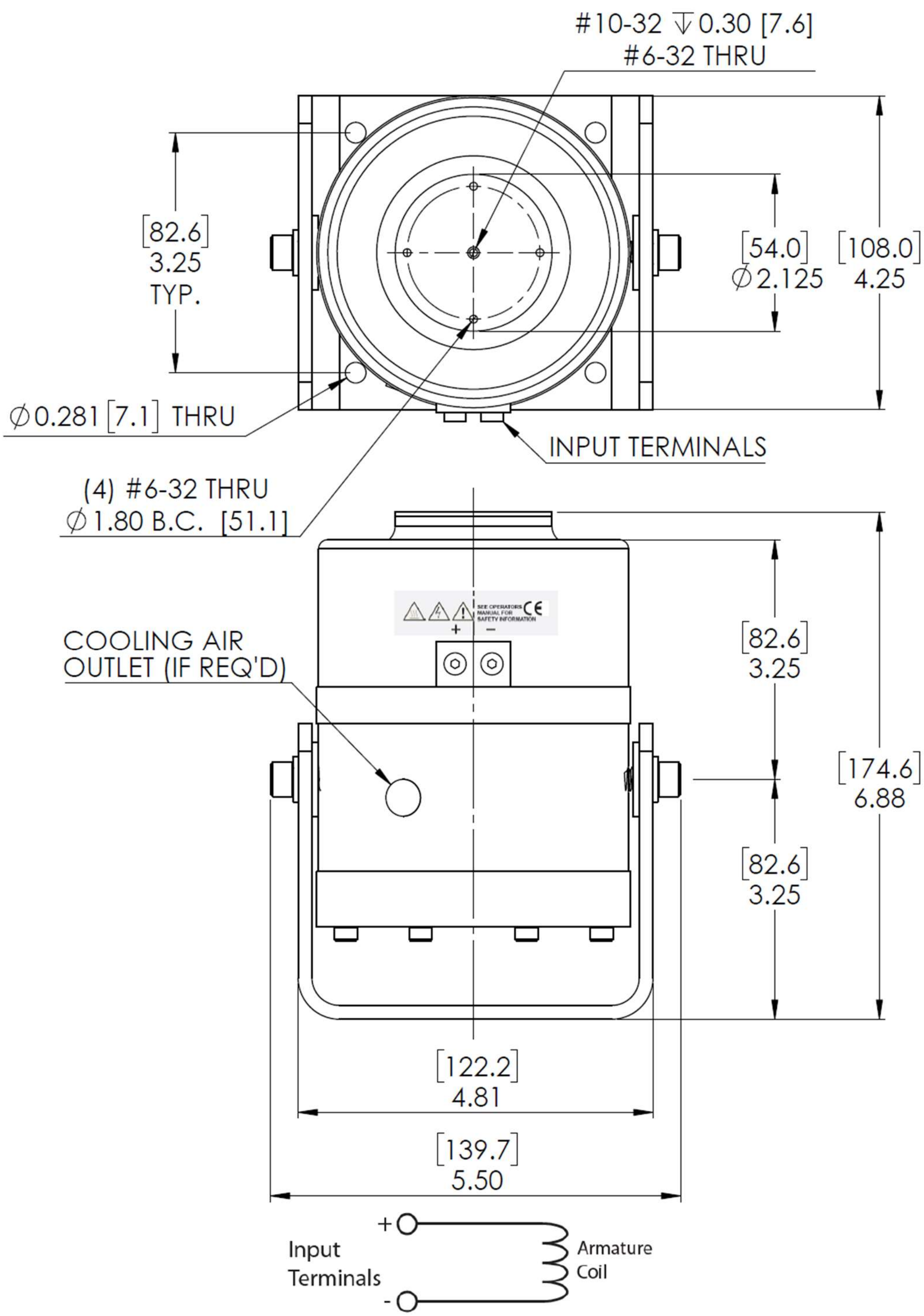
**Step 3** Remove the four #6 screws, holding the copper compensation band and the four #10 screws located at the periphery of the top plate (do not loosen the top plate hold down screws with low-profile heads or small hex nuts).

**Step 4** Gently pull the armature upward and out of the gap.

**Step 5** Install the existing or replacement armature/flexure assembly by pushing the coil gently into the magnetic gap and loosely install the four #10 and four #6 screws, following the alignment procedure outlined in subsection of 5.4 steps 3-5 above.

# 6. OUTLINE DRAWING

**2025E-HF High Frequency Electrodynamic Shaker (PD-5053)**



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