



# HexGen® HEX500-350HL Hexapod Six-DOF Positioning System

## HARDWARE MANUAL

Revision 2.02



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## EU Declaration of Incorporation

**Manufacturer** Aerotech, Inc.  
101 Zeta Drive  
Pittsburgh, PA 15238-2811  
USA



herewith declares that the product:

**HEX500-350HL hexapod**

is intended to be incorporated into machinery to constitute machinery covered by the Directive 2006/42/EC as amended; and that the following harmonized European standards have been applied:

**EN ISO 12100:2010**

**Safety of Machinery - Basic concepts, general principles for design**

**EN 60204-1:2010**

**Safety of Machinery - Electrical equipment of machines - Part 1: General requirements**

and further more declares that

it is not allowed to put the equipment into service until the machinery into which it is to be incorporated or of which it is to be a component has been found and declared to be in conformity with the provisions of the Directive 2006/42/EC and with national implementing legislation, for example, as a whole, including the equipment referred to in this Declaration.

This is to certify that the aforementioned product is in accordance with the applicable requirements of the following directive(s):

**EU 2015/863**

**Directive, Restricted Substances (RoHS 3)**

**Authorized Representative:**

/ Jochen Jäger

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**Engineer Verifying Compliance**

/ Alex Weibel

Aerotech, Inc.  
101 Zeta Drive  
Pittsburgh, PA 15238-2811  
USA  
7/29/2024

**Date**

## UKCA Declaration of Incorporation

**Manufacturer**  
Aerotech, Inc.  
101 Zeta Drive  
Pittsburgh, PA 15238-2811  
USA



herewith declares that the product:

### **HEX500-350HL hexapod**

To which this declaration relates, meets the essential health and safety requirements and is in conformity with the relevant UK Legislation listed below:

#### **Supply of Machinery (Safety) Regulations 2008**

#### **Hazardous Substances in Electrical and Electronic Equipment Regulations 2012**

Using the relevant section of the following UK Designated Standards and other normative documents when installed in accordance with the installation instructions supplied by the manufacturer.

#### **EN ISO 12100:2010**

#### **Safety of Machinery - Basic concepts, general principles for design**

#### **EN 60204-1:2010**

#### **Safety of Machinery - Electrical equipment of machines - Part 1: General requirements**

and furthermore declares that it is not allowed to put the product into service until the machinery into which it is to be incorporated or of which it is to be a component has been found and declared to be in conformity with the provisions of the Supply of Machinery (Safety) Regulations 2008 UK Legislation and with national implementing legislation, for example, as a whole, including the equipment referred to in this Declaration.

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**Engineer Verifying Compliance**

/ Alex Weibel

Aerotech, Inc.  
101 Zeta Drive  
Pittsburgh, PA 15238-2811  
USA

**Date**

7/29/2024

## Safety Procedures and Warnings



**IMPORTANT:** This manual tells you how to carefully and correctly use and operate the hexapod.

- Read all parts of this manual before you install or operate the hexapod or before you do maintenance to your system.
- To prevent injury to you and damage to the equipment, obey the precautions in this manual.
- All specifications and illustrations are for reference only and were complete and accurate as of the release of this manual. To find the newest information about this product, refer to [www.aerotech.com](http://www.aerotech.com).

If you do not understand the information in this manual, contact Aerotech Global Technical Support.



**IMPORTANT:** This product has been designed for light industrial manufacturing or laboratory environments. If the product is used in a manner not specified by the manufacturer:

- The protection provided by the equipment could be impaired.
- The life expectancy of the product could be decreased.

Safety notes and symbols are placed throughout this manual to warn you of the potential risks at the moment of the safety note or if you fail to obey the safety note.



Shock/Electrocution Hazard



Pinch, Shear, or Crush Hazard



General/Conditional Awareness



Rotational Machinery Hazard



Hot Surface Hazard



Pinch/Entanglement Hazard



Magnetic Field Hazard



Trip Hazard



Heavy, Bulky Lifting Hazard



Appropriate Equipment Required



Pressure/Explosive Atmosphere Hazard



Electrostatic Discharge Hazard

A blue circle symbol is an action or tip that you should obey. Some examples include:



General tip



Read the manual/section



Wear personal protective equipment (PPE): Safety Glasses



If applicable, do not lift unassisted



Wear personal protective equipment (PPE): Gloves



Wear personal protective equipment (PPE): Hearing Protection



## Installation and Operation

To decrease the risk of damage to the equipment, you must obey the precautions that follow.



### **DANGER: General Hazard Warning!**

This product can produce high forces and move at velocities that could cause injury. The user is responsible for its safe operation. The following general equation is provided to assist with risk assessments in regards to contact and pinch points:

$$Pressure_{Max} \left[ \frac{N}{mm^2} \right] = \frac{Force_{Peak}[N]}{Area_{Contact}[mm^2]}$$



### **WARNING: General Hazard Warning!**

- Only trained operators should operate this equipment.
- All service and maintenance must be done by approved personnel.
- Use this product only in environments and operating conditions that are approved in this manual.
- Never install or operate equipment that appears to be damaged.
- Make sure that the product is securely mounted before you operate it.
- Use care when you move the hexapod or you could negatively affect the performance of it.



### **WARNING: Trip Hazard!**

Route, house, and secure all cables, duct work, air, or water lines. Failure to do so could introduce trip hazards around the system that could result in physical injury or could damage the equipment.

## Electrical Warnings

To decrease the risk of electrical shock, injury, death, and damage to the equipment, obey the precautions that follow.



### **DANGER: Electrical Shock Hazard!**

- Stage motor phase voltage levels could be hazardous live.
- Personnel are protected from hazardous voltages unless electrical interconnections, protective bonding (safety ground), or motor/stage enclosures are compromised.
- Do not connect or disconnect stage/motor interconnections while connected to a live electrical power source.
- Before you set up or do maintenance, disconnect electrical power.
- It is the responsibility of the End User/System Integrator to make sure that stages are properly connected and grounded per Engineering Standards and applicable safety requirements.
- It is the responsibility of the End User/System Integrator to configure the system drive or controller within the Aerotech motor/stage electrical and mechanical specifications.

## Motor-Related Warnings

Aerotech motors are capable of producing high forces and velocities. Obey all warnings and all applicable codes and standards when you operate a system that incorporates Aerotech motors.



### DANGER: Mechanical Hazard!

Personnel must be made aware of the mechanical hazards during set up or when you do service to the stage.



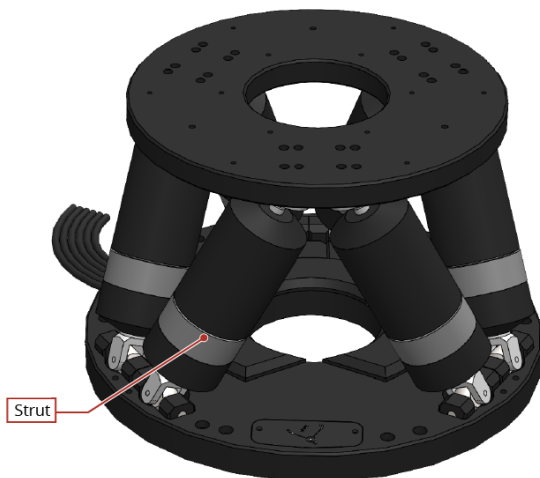
- Unintentional manual movement into the stage "end-of-travel" stops, could damage the stage or undo precision alignments.
- Stage movement could create pinch points, entanglement hazards, or rotational mechanical hazards.



### DANGER: Hot Surface Hazard!

- The stage/motor frame temperature could exceed 70°C in some applications.
- Do not touch the stage/motor frame while it is in operation.
- Wait until the stage/motor has cooled before you touch it.

Figure 1: Motor Location



**DANGER:** There is a motor housed in each strut. Misuse or carelessness could result in: Electric Shock, Burn, Pinch Point, Magnetic Field, and/or Explosive Atmosphere hazards.



### DANGER: Risk in Explosive Atmosphere!

- Standard Aerotech stage/motors are not rated for applications with explosive atmospheres such as airborne dust or combustible vapors.
- Do not operate stage/motors outside of Aerotech environmental specifications.



### DANGER: Magnetic Field Hazard!

Aerotech stage/motors contain magnets which can present a Magnetic Field Hazard.

- Do not disassemble a stage motor under any circumstances.
- Strong magnetic fields could interfere with external/internal medical devices.
- Strong magnetic fields could present mechanical hazards such as pinch points.

## Pinch Points

A pinch point is a mechanical hazard that can occur when there are exposed parts of the stage or system that can move. For example, the travel of a stage tabletop could expose the user to a pinch point between the tabletop and a strut. The images that follow will show you typical external and internal pinch point locations.

### **DANGER: Mechanical Hazard!**



- System travel can cause crush, shear, or pinch injuries.
- Only trained operators should operate this equipment.
- Do not put yourself in the travel path of machinery.
- Restrict access to all motor and stage parts
  - when the system moves under power (during normal operation, for example).
  - when the system is moved manually (during the installation process or when you do maintenance, for example).
- Motors are capable of very high speeds and acceleration rates.

**Figure 2: Typical Pinch Point Locations**



DANGER



PINCH POINT

**DANGER: PINCH HAZARD!** Due to the open-frame design, treat all areas exposed to the operator as possible pinch points. This includes at the struts, joints, and the stage table during travel.

## Handling and Storage



**IMPORTANT:** It is the responsibility of the customer to safely and carefully lift and move the hexapod.

- Be careful when you move or transport the hexapod.
- Retain the shipping materials for future use.
- Transport or store the hexapod in its protective packaging.



### **WARNING: Electrostatic Discharge (ESD) Sensitive Components!**

Wear an ESD wrist strap when you handle, install, or do service to the system assembly.

You could damage the power supply or drives if you fail to observe the correct ESD practices.

Inspect the shipping container for any evidence of shipping damage. If any damage exists, notify the shipping carrier immediately.

Remove the packing list from the shipping container. Make sure that all the items specified on the packing list are contained within the package.

The documentation for the hexapod is on the included installation device. The documents include manuals, interconnection drawings, and other documentation pertaining to the system. Save this information for future reference.

## Unpacking and Handling

It is the responsibility of the customer to safely and carefully lift and move the hexapod.



**IMPORTANT:** All electronic equipment and instrumentation is wrapped in antistatic material and packaged with desiccant. Ensure that the antistatic material is not damaged during unpacking.



**DANGER: Lifting Hazard!** Use care when you move the hexapod or you could negatively affect the performance of it.

- Use the correct lifting techniques, mechanical assistance, or additional help to lift or move this product.
- Make sure that all moving parts are secure before you move the hexapod. Unsecured moving parts could shift and cause injury or damage to the equipment.
- **Do NOT use the struts or joints as lift points.**
- **Do not manually lift and move the HEX500-350HL.**
- Do not use the cables to lift or move the hexapod.
- If the hexapod is heavy, a single person lift could cause injury. Use assistance when you lift or move it.
  - Refer to [Section 2.1](#) for dimensions
  - Refer to [Section 1.2](#) for mass specifications.

Carefully remove the hexapod from its protective shipping container.

- Use lifting straps fed through the lifting rings of the shipping brackets (refer to [Figure 3](#)).
- If necessary, use a cart, dolly, or similar device to move the stage to a new location.
- Gently set the hexapod on a smooth, flat, and clean surface.
- Use compressed nitrogen or clean, dry, oil-free air to remove any dust or debris that has collected during shipping.

- Let the hexapod stabilize at room temperature for at least 12 hours to make sure that all of the alignments, preloads, and tolerances are the same as they were when they were tested at Aerotech.
- Remove the shipping brackets before you operate the hexapod. Retain them for future use.

Each HEX500-350HL has a label that lists the system part number and serial number. These numbers are necessary to maintain or update system hardware and software. Locate this label and record the information for later reference.

### Shipping Brackets

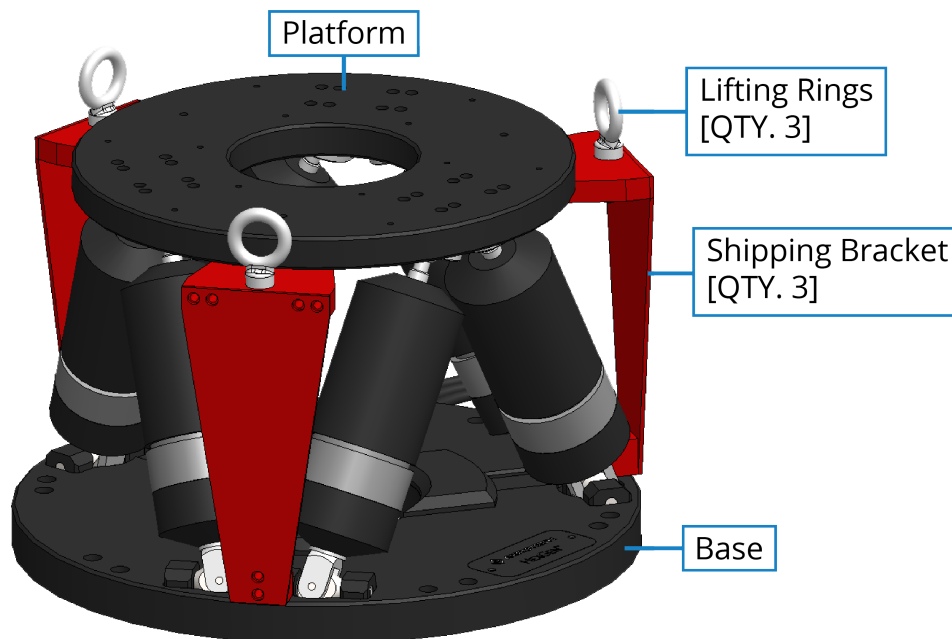
Red, anodized aluminum shipping brackets have been installed to prevent unwanted motion and potential damage that could occur during shipment. You must remove the brackets before the HEX500-350HL can be operated. Retain the brackets and hardware for future use.



#### **DANGER: Mechanical Hazard!**

- The product can move manually without electrical power connected.
- When the shipping brackets are removed, the operator could be exposed to pinch points.

**Figure 3: Lifting and Shipping Brackets**



### Storage

Store the hexapod in the original shipping container. If the original packaging included ESD protective packaging, make sure to store the hexapod in it. The storage location must be dry, free of dust, free of vibrations, and flat.

Refer to [Section 1.1. Environmental Specifications](#)

## Chapter 1: Overview

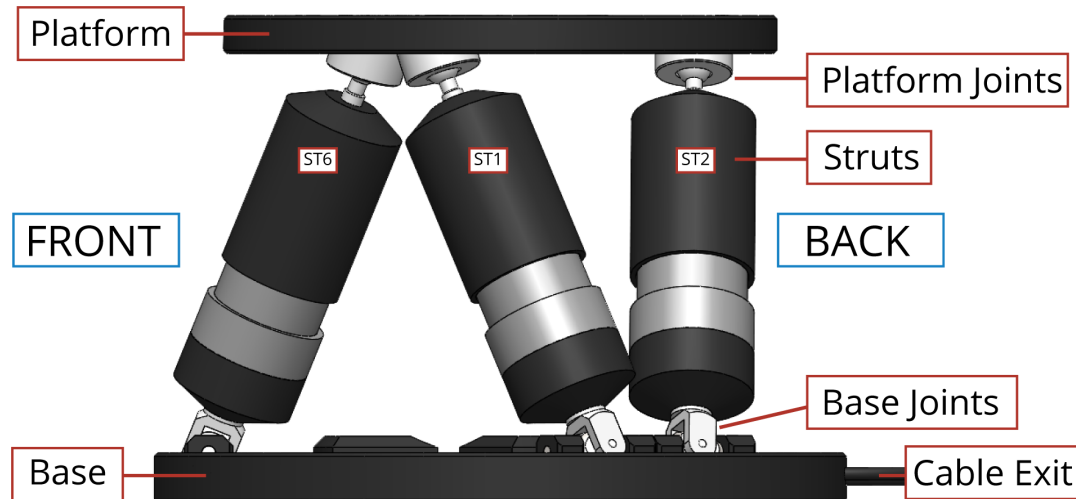
The **base** of a hexapod has a flat mounting surface on the bottom and holds electronics for the hexapod. The base should be mounted to a flat, rigid mounting surface (refer to [Section 2.2](#)). The **base joints** allow the attached strut to pivot from the base.

The **platform** is the moving plate of a hexapod. The threaded holes on the top surface are designed to hold customer equipment (refer to [Section 2.3](#)). The **platform joints** allow the attached strut to pivot from the platform.

The six **struts** of a hexapod change length in order to control the position of the platform. The struts attach only to the joints of the base and platform.

The **cables** exit out of the back of the base. These six cables connect the hexapod to the controller (refer to the [Section 3.2](#)).

**Figure 1-1: HEX500-350HL Callouts**



**Table 1-1: Model Options**

HexGen® HEX500-350HL Hexapod 6-DOF Positioning System	
HEX500-350HL	Six degree-of-freedom hexapod positioning system; 500 mm diameter base; 300 mm height at mid-travel; high-load capacity version
<b>Feedback (Required)</b>	
-E2	Incremental encoders
-E3	Absolute encoders
<b>Performance Grade (Optional)</b>	
-PL3	Base performance
-PL4	Ultra high-accuracy performance
<b>Customization</b>	
Additional customization may be available (Vacuum preparation, custom geometry, etc.). Contact Aerotech for details.	

## 1.1. Environmental Specifications



**WARNING:** Use this product only in environments and operating conditions that are approved in this manual.

**Table 1-2: Environmental Specifications**

<b>Ambient Temperature</b>	Operating: 10 °C to 35° C (50 °F to 95 °F) Deviation in temperature can result in performance degradation.
	Storage: 0 °C to 40 °C (32 °F to 104 °F) in original shipping packaging
<b>Humidity</b>	Operating: 20% to 60% RH
	Storage: 10% to 70% RH, non-condensing in original packaging. The machine should be packaged with desiccant if it is to be stored for an extended time.
<b>Altitude</b>	Operating: 0 m to 2,000 m (0 ft to 6,562 ft) above sea level
	Contact Aerotech if your specific application involves use above 2,000 m or below sea level.
<b>Vibration</b>	Use the system in a low vibration environment. Excessive floor or acoustical vibration can affect system performance. Contact Aerotech for information regarding your specific application.
<b>Protection Rating</b>	Not suited for dusty or wet environments (IP30 equivalent ingress protection rating).
<b>Use</b>	Indoor use only.

### 1.1.1. Accuracy and Temperature Effects

Aerotech products are designed for and built in a 20 °C environment. Moderate temperature changes will affect the accuracy while extreme temperature changes could cause damage to the machine. At a minimum, the environmental temperature must be controlled to within 1 °C per hour to ensure the safety of the hexapod. The severity of temperature effects on all specifications depends on many different environmental conditions, including how the hexapod is mounted. Contact the factory for more details.



## 1.2. Basic Specifications

**Table 1-3: HEX500-350HL Series Specifications**

			X	Y	Z	A (θ <sub>x</sub> )	B (θ <sub>y</sub> )	C (θ <sub>z</sub> )
Travel <sup>(1)</sup>			100 mm	110 mm	54 mm	22°	22°	40°
Axis Positioning Accuracy <sup>(2,3)</sup>	Full Travel	Standard (-PL3)	±4 μm	±4 μm	±3 μm	±50 μrad (±10.3 arc-sec)	±50 μrad (±10.3 arc-sec)	±25 μrad (±5.2 arc-sec)
		ULTRA (-PL4)	±1 μm	±1 μm	±0.75 μm	±10 μrad (±2.1 arc-sec)	±10 μrad (±2.1 arc-sec)	±5 μrad (±1.0 arc-sec)
	Limited Travel <sup>(7)</sup>	Standard (-PL3)	±1.25 μm			±12.5 μrad (±2.6 arc-sec)	±12.5 μrad (±2.6 arc-sec)	±7.5 μrad (±1.5 arc-sec)
		ULTRA (-PL4)	±0.75 μm	±0.75 μm	±0.5 μm	±5 μrad (±1.0 arc-sec)	±5 μrad (±1.0 arc-sec)	±2.5 μrad (±0.5 arc-sec)
Resolution (Minimum Incremental Motion)			20 nm			0.2 μrad (0.04 arc sec)		
Bidirectional Repeatability, pk-pk <sup>(3)</sup>			±0.6 μm	±0.6 μm	±0.35 μm	±1 μrad (±0.2 arc sec)		
Unidirectional Repeatability, pk-pk			±0.25 μm	±0.25 μm	±0.15 μm	±0.5 μrad (±0.1 arc sec)		
Maximum Speed <sup>(4)</sup>			50 mm/s	50 mm/s	25 mm/s	10 °/s	10 °/s	20 °/s
Load Capacity, All Positions <sup>(5)</sup>		Vertical	200 kg (Push); 120 kg (Pull)					
		Horizontal	35 kg					
Holding Capacity, De-Energized <sup>(6)</sup>			165 kg					
Stage Mass			49 kg					
Material			Anodized Aluminum Platform and Base; Steel Used in Joints and Inside Struts					
<p>1. Travels are mutually-exclusive. Consult the <a href="#">HexGen® Hexapod Sizer</a> on the Aerotech website for detailed workspace sizing.</p> <p>2. Measured with single-axis moves at a height of 50 mm above the moving platform. Results can be payload and workpoint dependent.</p> <p>3. X, Y, Z performance certified as standard. X, Y, Z, A, B, C performance certified with -PL4.</p> <p>4. Requires the selection of an appropriate amplifier with sufficient voltage and current.</p> <p>5. Centered loading (refer to <a href="#">Section 2.3</a>).</p> <p>6. Horizontal base plate, centered loading (refer to <a href="#">Section 2.3</a>).</p> <p>7. Over any 20 mm (X, Y, Z) or 5° (A, B, C)</p>								

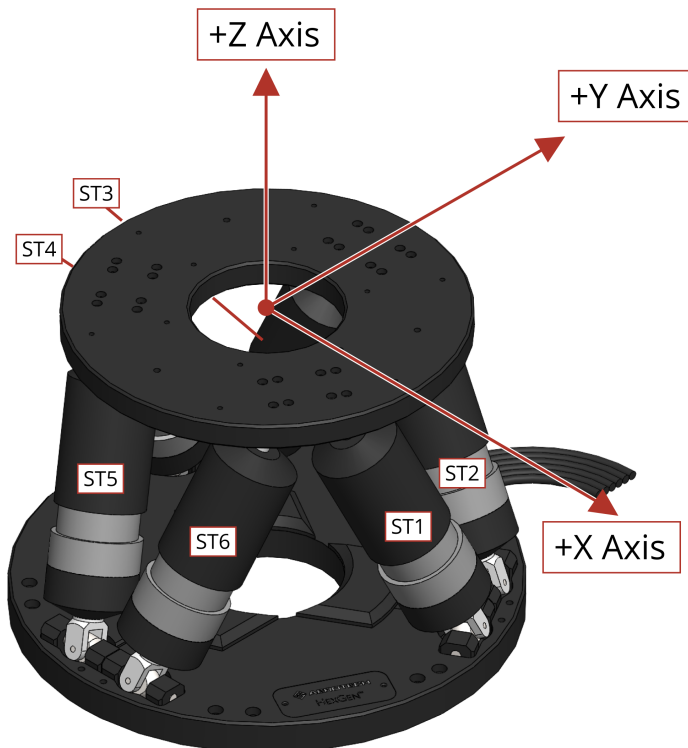
## 1.3. Understanding Basic HEX500-350HL Operation

### 1.3.1. Hexapod Axes

The hexapod platform can be actuated in six degrees of freedom by changing the lengths of the six struts that connect the platform to the base. Since the axes of motion are not obvious from the mechanics of the hexapod, the axis convention is outlined below. These axes can be used to orient the hexapod in the global workspace. Refer to the HexGen<sup>®</sup> Programming Guide for more information about controlling hexapod motion. To get a copy of this guide, go to the [Resources](#) section of [www.aerotech.com](http://www.aerotech.com). Select the **Manuals and Help Files** tab. Then download **Hexapod Programming User Guide** from the **User Guides** category.

The six axes include 3 translational axes, X, Y, and Z, and 3 rotational axes, A, B, and C. As shown in the overview, the cables exit out of the back of the base. The positive direction of the X axis goes to the right when looking at the front of the hexapod, and the Z axis goes up vertically. The Y axis goes toward the back of the hexapod. Rotational axes are oriented in the same direction as the translational axes, and positive rotation is clockwise when looking in the direction of the axis. The A axis rotates about the X axis, B rotates about the Y axis, and C rotates about Z. The control software enables the user to customize the coordinate system with certain restrictions. Please refer to the HexGen Programming guide for details regarding coordinate system manipulation.

**Figure 1-2: Axis Orientation**



### 1.3.2. Strut Limits and Hexapod Range

Limits on the strut keep the strut within the useable travel range. When any strut has reached the end of travel in either direction, an error will occur in the controller. Because the ranges of the hexapod axes are interdependent, the limits of the hexapod axes are not constant, and the range of motion of a hexapod cannot be concisely described. Refer to [Section 1.2](#) for the independent travel of each hexapod axis and the strut travel. If a strut limit is triggered, the hexapod is out of range. In this case, follow the directions of the controller to return the hexapod to a position within the range of motion. Refer to the HexGen<sup>®</sup> Programming Guide for more information.

### 1.3.3. Homing

When the incremental encoder option (-E3) is ordered, the struts must each be homed in order for the hexapod to be controlled. Knowledge of the initial condition is necessary for the inverse kinematic calculations to be accurate. The home sequence involves moving each strut to its shortest position and then returning to the center of travel. Be sure that there are no crash conditions before homing. Refer to the HexGen® Programming Guide for more information about initializing a hexapod.

If the absolute encoder option (-E2) has been ordered, there is no need to home the hexapod.

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## Chapter 2: Mechanical Specifications and Installation

**IMPORTANT:** This manual tells you how to carefully and correctly use and operate the hexapod.

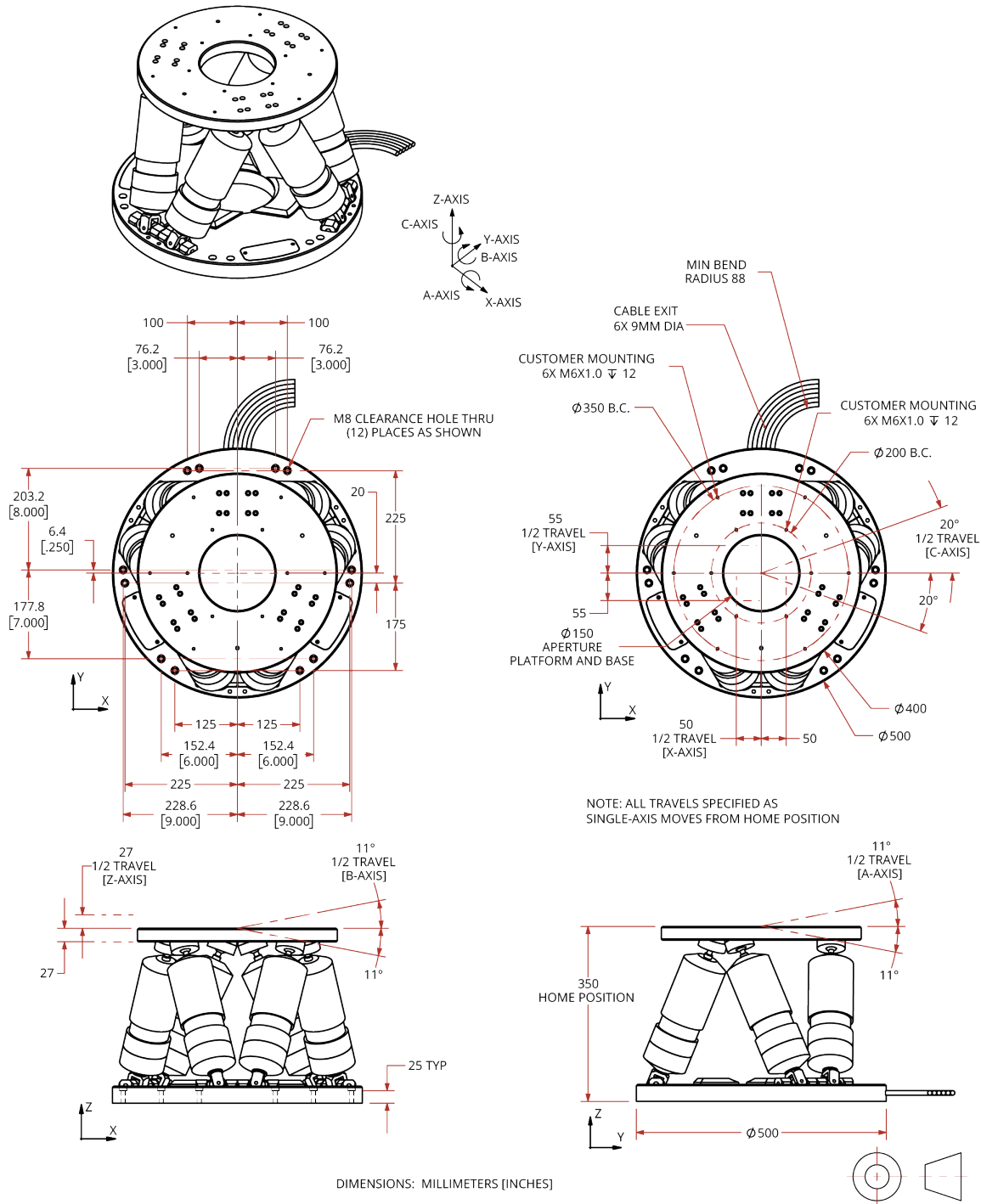


- Read all parts of this manual before you install or operate the hexapod or before you do maintenance to your system.
- To prevent injury to you and damage to the equipment, obey the precautions in this manual.
- All specifications and illustrations are for reference only and were complete and accurate as of the release of this manual. To find the newest information about this product, refer to [www.aerotech.com](http://www.aerotech.com).

If you do not understand the information in this manual, contact Aerotech Global Technical Support.

## 2.1. Dimensions

Figure 2-1: HEX500-350HL Dimensions



## 2.2. Securing the Hexapod to the Mounting Surface

**DANGER: Mechanical Hazard!**

Personnel must be made aware of the mechanical hazards during set up or when you do service to the stage.

- Do not manually move the hexapod if it is connected to a power source.
- The stage must be mounted securely. Improper mounting can result in injury and damage to the equipment.
- When you move the tabletop manually to do maintenance, this could expose the operator to pinch points. Refer to [Pinch Points](#) on [Page 12](#).

The mounting surface must be flat and have adequate stiffness to achieve the maximum performance from the hexapod. When it is mounted to a non-flat surface, the stage can be distorted while the mounting screws are tightened. This distortion will decrease overall accuracy. Adjustments to the mounting surface must be done before the stage is secured.

Inspect the mounting surface for dirt or unwanted residue and clean if necessary. Use precision flatstones on the mounting surface to remove any burrs or high spots. Clean the mounting surface with a lint-free cloth and acetone or isopropyl alcohol and allow the cleaning solvent to completely dry. Gently place the stage on the mounting surface.



**IMPORTANT:** The hexapod is precision machined and verified for flatness at the factory.

- Do not machine the hexapod housing. If you must machine a surface to achieve a required flatness, machine the mating mounting surface.
- Keep the use of shims to a minimum when you mount the hexapod to the mounting surface. The use of shims could reduce the rigidity of the system.



**IMPORTANT:** To maintain accuracy, the mounting surface must be flat to within 0.0127 mm over the contact area.

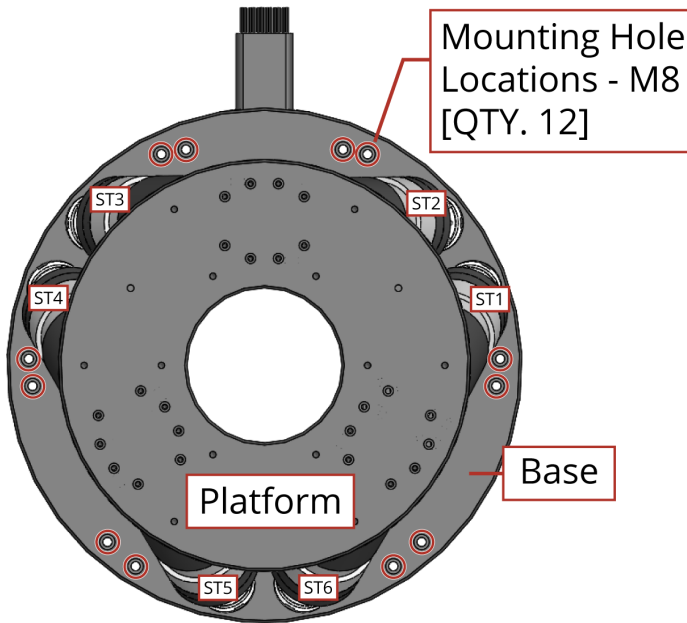
A minimum of six M8 mounting screws are required to mount the hexapod to the mounting surface. Refer to [Figure 2-2](#) or [Section 2.1. Dimensions](#) for mounting locations and [Table 2-1](#) for tightening torque values.

Tightening torque values for the mounting hardware are dependent on the properties of the surface to which the stage is being mounted. Values provided in [Table 2-1](#) are typical values and may not be accurate for your mounting surface. Refer to [Section 2.1](#) for specific model mounting locations and dimensions.

**Table 2-1: Hexapod to Mounting Surface Hardware**

Mounting Hardware	Typical Screw Torque
M8 SHCS (12 places)	17 N·m

**Figure 2-2: Mounting Hole Locations**





## 2.3. Attaching the Payload to the HEX500-350HL

Inspect the mounting surface for dirt or unwanted residue and clean if necessary. Clean the mounting surface with a lint free cloth and isopropyl alcohol and allow the cleaning solvent to completely dry.

Aerotech recommends that customers use a representative payload during start-up to prevent accidental damage to the stage and the payload. Proceed with the electrical installation and test the motion control system in accordance with the system documentation. Document all results for future reference. For information on electrical installation refer to [Chapter 3](#) and the documentation delivered with the stage.

The payload must be flat, rigid, and comparable to the stage in quality to maintain optimum performance.



**IMPORTANT:** For valid system performance, the mounting interface should be flat within 0.0127 mm over the contact area.

Loads should be mounted close to the center of the hexapod, if possible, to reduce offset loading. The maximum load is based on the distance from the payload's center of mass to the center of the platform's mounting surface. External forces to the payload or hexapod platform should be considered when determining the maximum payload. Add process forces to the mass of the payload when determining the total applied force.

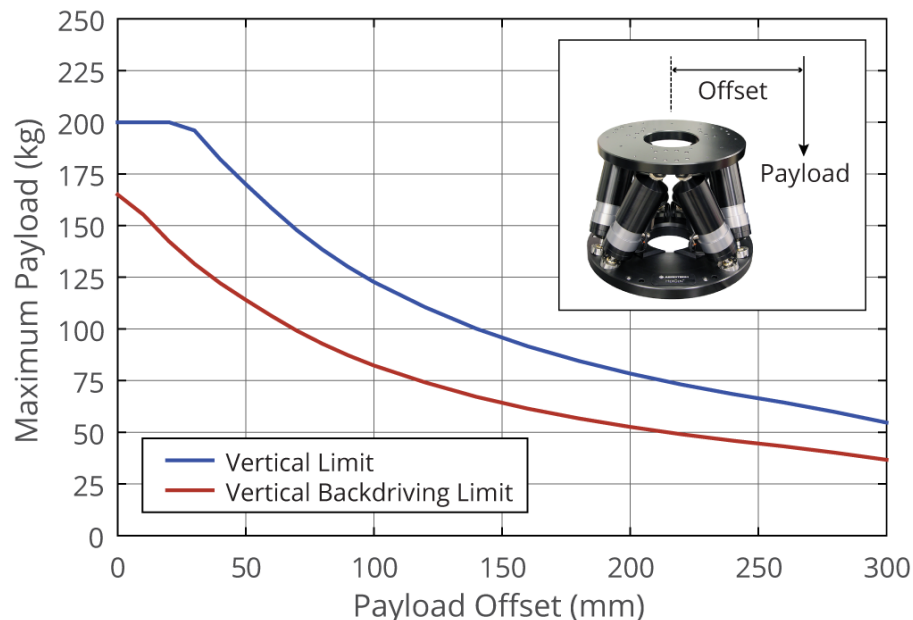
HexGen<sup>®</sup> hexapods can be mounted to a horizontal surface or a vertical surface. The orientation will also be critical in determining the load capacity. A horizontal mounting surface is recommended for maximum payload capabilities. Refer to the load curves that follow for allowable loading as a function of orientation and load offset.



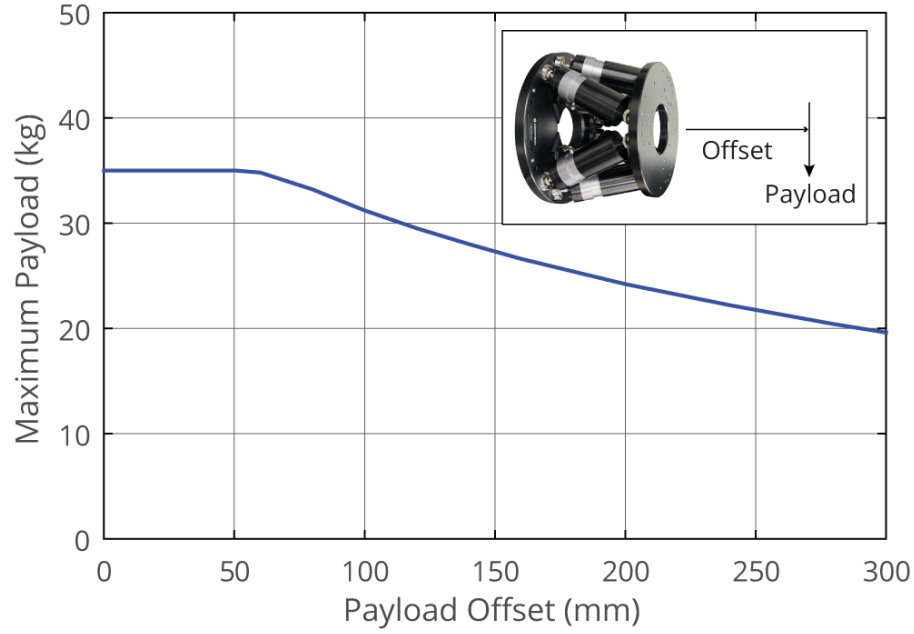
**IMPORTANT:** HexGen<sup>®</sup> hexapods can backdrive under some vertical loads. Refer to the graphs that follow for more information.

You should avoid backdriving the struts into the hardstops and limits while attaching the payload. The best practice is to only attach the payload while the hexapod is at home and the shipping clamps are installed or the hexapod is enabled.

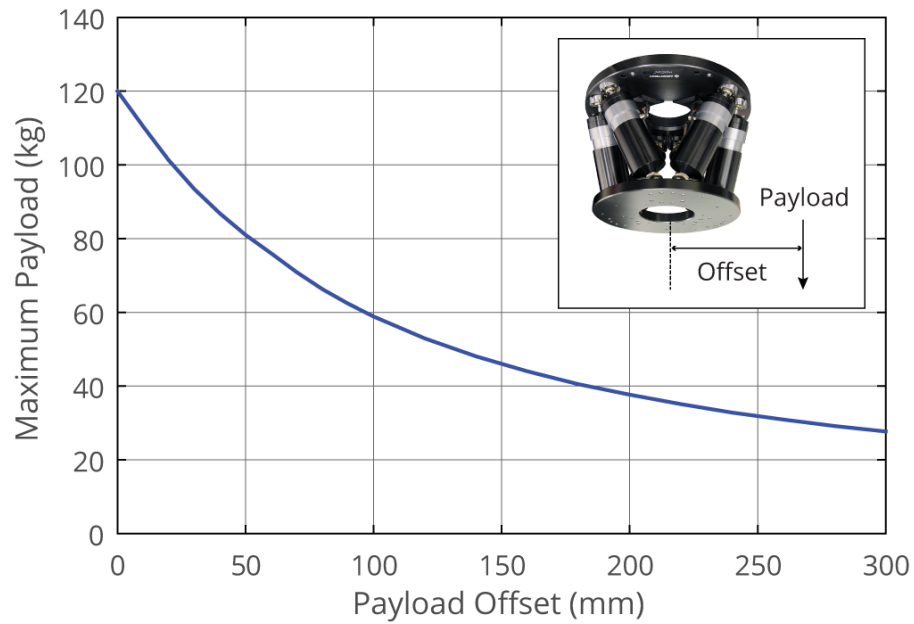
**Figure 2-3: HEX500-350HL Vertical Load Capabilities**



**Figure 2-4: HEX500-350HL Horizontal Load Capabilities**



**Figure 2-5: HEX500-350HL Inverted Load Capabilities**



## Chapter 3: Electrical Specifications and Installation

### **DANGER: Electrical Shock Hazard!**



- Restrict operator access to the base and tabletop while the system is connected to a power source.
- Stage motor phase voltage levels could be hazardous live.
- Personnel are protected from hazardous voltages unless electrical interconnections, protective bonding (safety ground), or motor/stage enclosures are compromised.
- Do not connect or disconnect stage/motor interconnections while connected to a live electrical power source.
- Before you set up or do maintenance, disconnect electrical power.
- It is the responsibility of the End User/System Integrator to make sure that stages are properly connected and grounded per Engineering Standards and applicable safety requirements.
- It is the responsibility of the End User/System Integrator to configure the system drive or controller within the Aerotech motor/stage electrical and mechanical specifications.

### **WARNING: General Hazard Warning!**



Applications that require access to the HEX500-350HL must be restricted to qualified and trained personnel. The system integrator or qualified installer is responsible for determining and meeting all safety and compliance requirements when they integrate the HEX500-350HL into a completed system. Failure to do so could expose the operator to electrical or mechanical hazards.

Electrical installation requirements will depend on the ordered product options. Installation instructions in this section are for Aerotech products equipped with standard Aerotech motors intended for use with an Aerotech motion control system. Contact Aerotech for further information on products that are otherwise configured.

Aerotech motion control systems are adjusted at the factory for optimum performance. When the HEX500-350HL is part of a complete Aerotech motion control system, setup should only require that you connect the hexapod to the appropriate drive chassis with the cables provided. Labels on the system components should indicate the appropriate connections.

If system level integration was purchased, an electrical drawing that shows the system interconnects has been supplied with the system (separate from this documentation).

The electrical wiring from the motor and encoder are integrated at the factory. Refer to the sections that follow for standard motor wiring and connector pinouts.



**IMPORTANT:** Refer to the controller documentation to adjust servo gains for optimum velocity and position stability.

### 3.1. Motor and Feedback Connectors



**DANGER:** To decrease the risk of electrical shock, injury, death, and damage to the equipment, obey the precautions that follow.

- Before you do maintenance to the equipment, disconnect the electrical power.
- Before you connect wires to this product, disconnect the electrical power.
- The stage controller must provide over-current and over-speed protection.
- Restrict access to the hexapod when it is connected to a power source.
- It is the responsibility of the system integrator or qualified installer to determine and meet all safety and compliance requirements when they integrate the HEX500-350HL into a completed system.

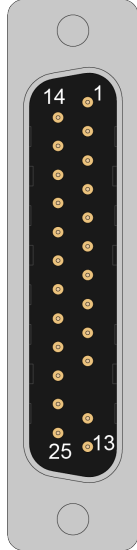


**IMPORTANT:** The protective ground connection must be properly installed to minimize the possibility of electric shock.

- Make sure that all components are grounded correctly and that they obey the local electrical safety requirements.
- The protective ground connection of the HEX500-350HL provides motor frame ground protection only.
- Additional grounding and safety precautions are required for applications requiring access to the stage while it is energized.

If the HEX500-350HL is built with standard Aerotech motors and encoders, it will arrive from the factory completely wired and assembled.

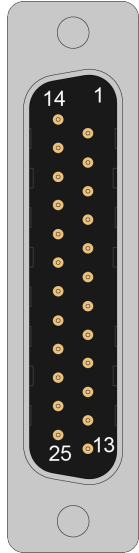
**Table 3-1: -E2 Option Motor and Feedback Pinout**

Pin	Description	Connector
Case	Shield Connection	
1	Over-Temperature Thermistor Sensor	
2	COS- (Encoder Cosine-)	
3	SIN- (Encoder Sine-)	
4	CLK- (Absolute Encoder Clock-)	
5	Common	
6	Common	
7	DATA- (Absolute Encoder Data-)	
8	Reserved	
9	Reserved	
10	Hall Effect Sensor (Phase C)	
11	Key (to make sure that the correct cable is plugged into the correct jack)	
12	Hall Effect Sensor (Phase A)	
13	Hall Effect Sensor (Phase B)	
14	COS+ (Encoder Cosine+)	
15	SIN+ (Encoder Sine+)	
16	CLK+ (Absolute Encoder Clock+)	
17	5V Power Supply Input	
18	Stage ID	
19	DATA+ (Absolute Encoder Data+)	
20	Reserved	
21	Reserved	
22	Hall Effect sensor, phase A	
23	Hall Effect sensor, phase B	
24	Frame Ground	
25	Motor Phase C	

**Table 3-2: Mating Connector Part Numbers**

Mating Connector	Aerotech P/N	Third Party P/N
25-Socket D-Connector	ECK00300	FCI DB25S064TLF
Backshell	ECK00656	Amphenol 17E-1726-2

**Table 3-3: -E3 Option Motor and Feedback Pinout**

Pin	Description	Connector
Case	Shield Connection	
1	Key (to make sure that the correct cable is plugged into the correct jack)	
2	COS- (Encoder Cosine-)	
3	SIN- (Encoder Sine-)	
4	MRK- (Encoder Marker-)	
5	Common ground	
6	Common ground	
7	-/CCW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine negative” or “machine counter-clockwise” direction.)	
8	Hall Effect Sensor (Phase A)	
9	Hall Effect Sensor (Phase C)	
10	Frame Ground	
11	Motor Phase A	
12	Motor Phase B	
13	Motor Phase C	
14	COS+ (Encoder Cosine+)	
15	SIN+ (Encoder Sine+)	
16	MRK+ (Encoder Marker+)	
17	5V Power Supply Input	
18	Reserved	
19	+/CW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine positive” or “machine clockwise” direction.)	
20	Over-Temperature Thermistor Sensor	
21	Hall Effect Sensor (Phase B)	
22	Frame Ground	
23	Motor Phase A	
24	Motor Phase B	
25	Motor Phase C	

**Table 3-4: Mating Connector Part Numbers**

Mating Connector	Aerotech P/N	Third Party P/N
25-Socket D-Connector	ECK00300	FCI DB25S064TLF
Backshell	ECK00656	Amphenol 17E-1726-2

### 3.2. Motor and Feedback Wiring



**DANGER:** To decrease the risk of electrical shock, injury, death, and damage to the equipment, obey the precautions that follow.

- Make sure that all components are grounded correctly and that they obey the local electrical safety requirements.
- It is the responsibility of the system integrator or qualified installer to determine and meet all safety and compliance requirements when they integrate the HEX500-350HL into a completed system.
- Restrict access to the hexapod when it is connected to a power source.

Shielded cables are required for the motor and feedback connections.

**Figure 3-1: Motor and Feedback Wiring (-E2 Connector)**

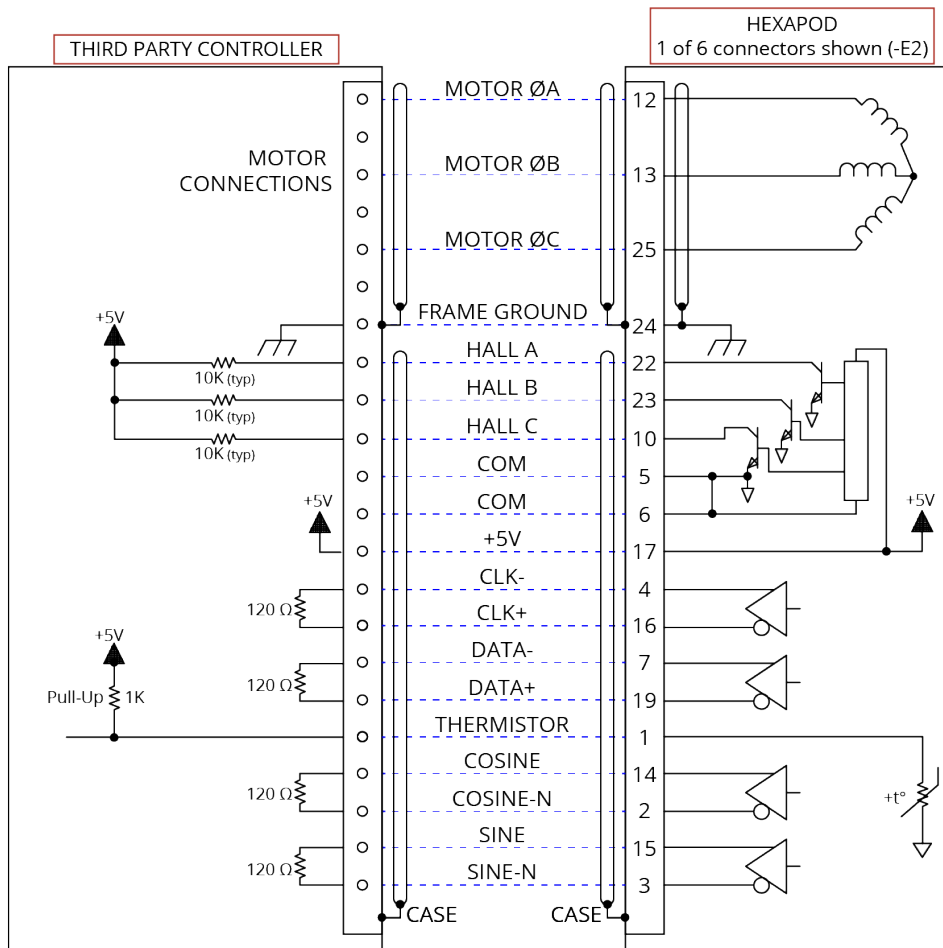
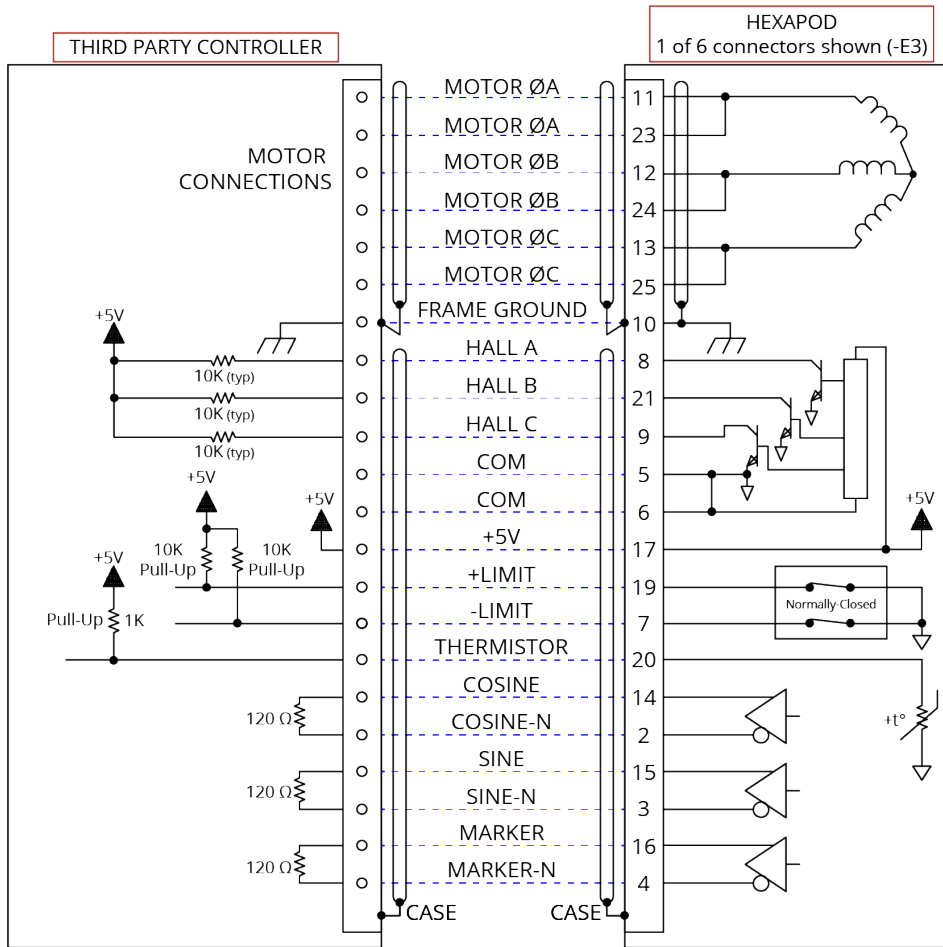


Figure 3-2: Motor and Feedback Wiring (-E3 Connector)





### 3.3. Motor and Feedback Specifications

**Table 3-5: Hall-Effect Sensor Specifications**

	Specifications
Supply Voltage	5 V $\pm$ 5%
Supply Current	50 mA
Output Type	Open Collector
Output Voltage	24 V max (pull up)
Output Current	5 mA (sinking)

**Table 3-6: Thermistor Specifications**

	Specifications
Polarity	Logic "0" (no fault)
	Logic "1" (over-temperature fault)
Cold Resistance	$\sim$ 100 $\Omega$
Hot Resistance	$\sim$ 10 K
<b>Note:</b> 1K pull-up to +5V recommended.	

**Table 3-7: Encoder Specifications**

	Specifications
Supply Voltage	5 V $\pm$ 10%
Supply Current	-E2 425 mA
	-E3 175 mA
Output Signals	-E2 <b>Sinusoidal Type (Incremental Rotary Encoder):</b> 1 V <sub>pk-pk</sub> into 120 $\Omega$ load (differential signals SIN+, SIN-, COS+, and COS-) <b>Serial Output (Absolute Linear Encoder):</b> Biss C (unidirectional)
	-E3 <b>Sinusoidal Type (Incremental Rotary Encoder):</b> 1 V <sub>pk-pk</sub> into 120 $\Omega$ load (differential signals SIN+, SIN-, COS+, and COS-)

**Table 3-8: Rotary Encoder Resolution**

	Fundamental Signal Period
Fundamental Resolution	3,600 Lines/Rev

**Table 3-9: Linear Encoder Resolution (-E2 Option)**

	Fundamental Signal Period
Fundamental Resolution	1 nm

**Table 3-10: Limit Switch Specifications**

	Specifications
Supply Voltage	5 V $\pm$ 5%
Supply Current	25 mA
Output Type	Open Collector
Output Voltage	5 V
Output Current	10 mA (sinking)
Output Polarity	Normally Closed (NC)
	<ul style="list-style-type: none"> <li>Sinks current to ground (Logic "0") when not in limit</li> <li>High impedance (Logic "1") when in limit</li> <li>Requires external pull-up to +5 V (10 k<math>\Omega</math> recommended)</li> </ul>
<b>Note:</b> If the HEX500-350HL is driven beyond the electrical limit, it will encounter a mechanical stop. Impacting the mechanical stop could cause damage to the stage even at low speeds.	

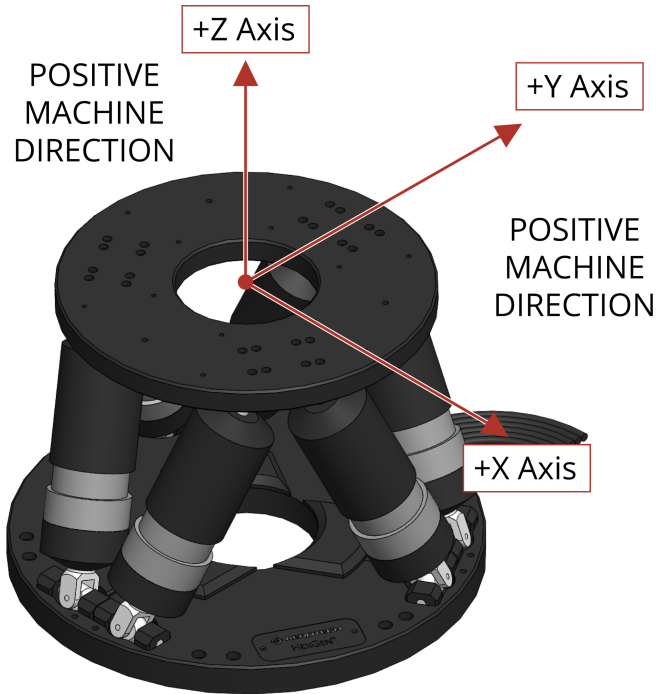
**Table 3-11: HEX500-350HL Motor Specifications**

		S-76-35
<b>Performance Specifications</b>		
Stall Torque, Cont.	N·m	0.48
Peak Torque	N·m	0.72
<b>Electrical Specifications</b>		
BEMF Const., line-line, Max	$V_{pk}/krpm$	29.1
Continuous Current, Stall	A	2.0
Peak Current, Stall	A	8.0
Torque Constant	N·m/A	0.24
Motor Constant	$N·m/\sqrt{W}$	0.075
Resistance, 25 °C, line-line	$\Omega$	10.5
Inductance, line-line	mH	1.40
Maximum Bus Voltage	VDC	80
Thermal Resistance	°C/W	1.83
Number of Poles	--	14
<p>(1) All performance and electrical specifications have a tolerance of <math>\pm 10\%</math>.</p> <p>(2) Values shown at 75 °C temperature rise above a 25 °C ambient temperature, with housed motor mounted to a 250x250x6 mm<sup>3</sup> aluminum heat sink.</p> <p>(3) Peak torque assumes correct rms current; consult Aerotech.</p> <p>(4) Torque constant and motor constant specified at stall.</p> <p>(5) All Aerotech motors and amplifiers are rated using vector amplitude values. For sinusoidal signals, use sine wave peak value.</p>		

### 3.4. Machine Direction

Aerotech stages are configured to have positive and negative "machine" directions. The machine direction defines the phasing of the feedback and motor signals and is dictated by the hexapod wiring (refer to [Section 3.5](#) for Motor and Feedback phasing information). Programming direction of a stage is set by the controller that is used to move the stage. Programming direction is typically selectable in the controller, while machine direction is hardwired in the hexapod.

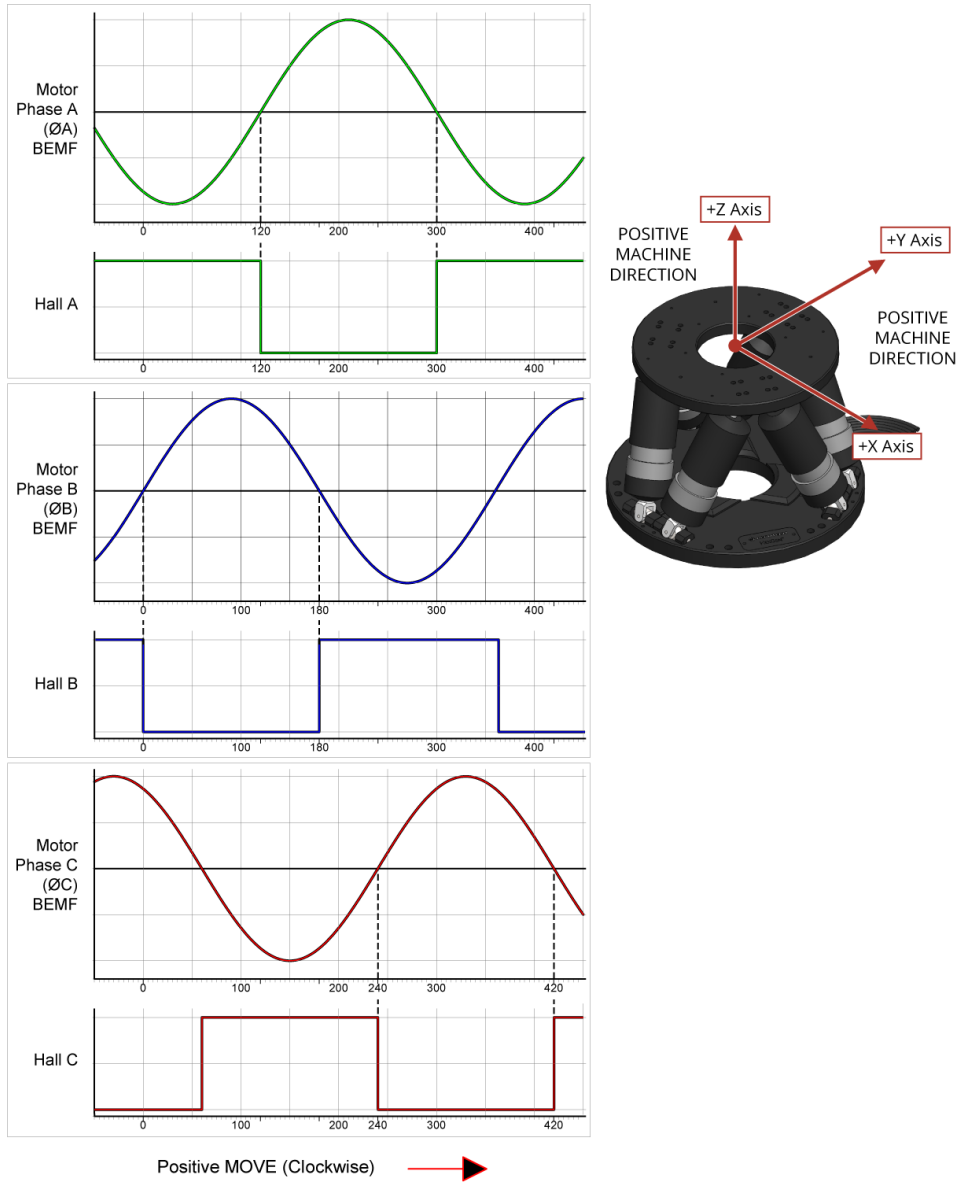
**Figure 3-3: Machine Direction**



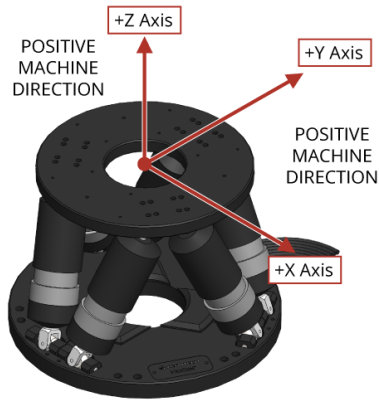
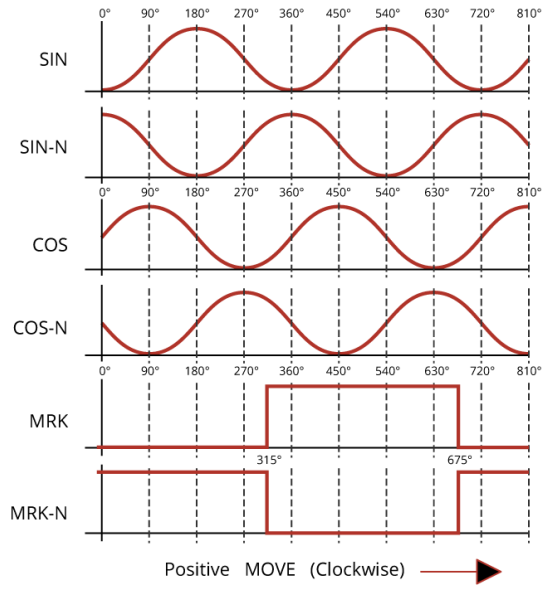
### 3.5. Feedback Phasing

Motor phase voltage is measured relative to the virtual wye common point.

**Figure 3-4: Hall Phasing**



**Figure 3-5: Encoder Phasing Reference Diagram (Standard)**



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## Chapter 4: Maintenance



**IMPORTANT:** Read the [Safety Procedures and Warnings](#) (on [Page 8](#)) before you do maintenance to the hexapod.



**DANGER:** To decrease the risk of electrical shock, injury, death, and damage to the equipment, obey the precautions that follow.

- All service and maintenance must be done by approved personnel.
- Before you do maintenance to the equipment, disconnect the electrical power.
- Before you connect wires to this product, disconnect the electrical power.
- Restrict access to the hexapod when it is connected to a power source.

### 4.1. Service and Inspection Schedule

Inspect and clean the HEX500-350HL once per month. A longer or shorter inspection interval may be required depending on the specific application, and conditions such as the duty cycle, speed, and environment.

Monthly inspections should include but not be limited to:

- Re-tighten loose connectors.
- Replace or repair damaged cables.
- Clean the HEX500-350HL and any components and cables as needed.
- Repair any damage before operating the HEX500-350HL.

## 4.2. Cleaning and Lubrication



**DANGER: Electrical Shock Hazard!** Before you do maintenance to the equipment, disconnect the electrical power.



**IMPORTANT:** Wear appropriate personal protective equipment (PPE) when you use cleaning solvents or lubricants.



**WARNING:** Do not scratch any bearing surfaces when you clean or lubricate the hexapod.

### Cleaning

Before you use a cleaning solvent on any part of the HEX500-350HL, blow away small particles and dust with nitrogen or, less preferably, clean, dry, compressed air.

Any external metal surface of the HEX500-350HL can be cleaned with isopropyl alcohol on a lint-free cloth.

### Lubrication

If the application process uses only a small portion of travel for most of the duty cycle, periodically drive the stage through full travel to redistribute the lubrication in the bearings. The motor is completely non-contact and requires no lubrication.

Only use the grease specified.

**Table 4-1: Grease Specifications**

Location	Grease
Ball Joints	Kluberplex BEM 34-132

### Lubrication Procedure for the Ball Joints



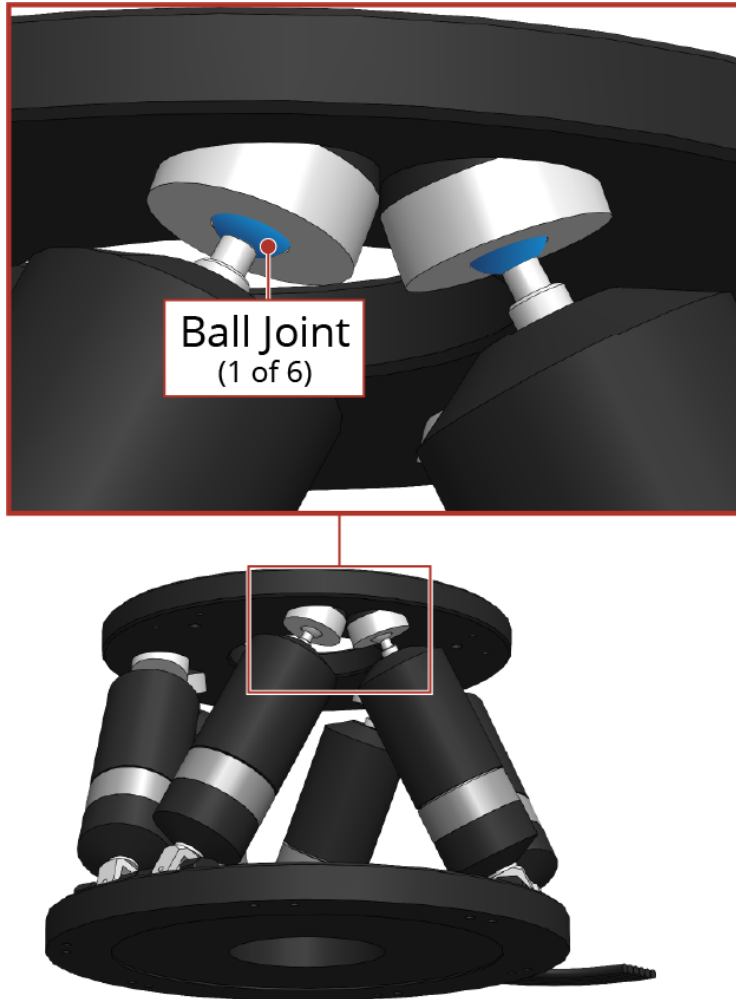
**IMPORTANT:** During the lubrication procedure, inspect the bearings for any damage or signs of wear.

Refer to [Figure 4-1](#) for the locations of the ball joints.

1. Remove power to the hexapod.
2. Remove any accumulated dust or debris.
3. Remove any dirty or dried lubricant from the joint.
  - Use a clean, lint-free cloth with a side-to-side motion.
  - Use a swab soaked in Isopropyl Alcohol to remove stubborn debris.
4. Clean the ball joints with a clean, lint-free cloth or swab.
5. Apply a thin, continuous film of lubricant to the ball joint. Aerotech recommends that you use a good quality, natural bristle artist's brush.
6. Restore power to the hexapod.
7. Drive the hexapod through a full range of motion to redistribute the lubricant.



Figure 4-1: Ball Joint Location



### 4.3. Troubleshooting

Table 4-2: Troubleshooting

Symptom	Possible Causes and Solutions
Strut will not move	<b>A Cable is Disconnected:</b> Check the cables for connections and damage.
	<b>Limit or Controller Fault:</b> Check the controller for faults. Refer to the controller and software documentation.
Strut moves uncontrollably	<b>Encoder Signal Connection or the Motor Signal Connection:</b> Check to make sure that the cable connections are secure. Refer to the <a href="#">Section 3.2. Motor and Feedback Wiring</a>
Axes are unstable or squeal	<b>Incorrect Gains:</b> Refer to controller documentation

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## Appendix A: Warranty and Field Service

Aerotech, Inc. warrants its products to be free from harmful defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products that are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, whether or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability on any claim for loss or damage arising out of the sale, resale, or use of any of its products shall in no event exceed the selling price of the unit.

THE EXPRESS WARRANTY SET FORTH HEREIN IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE. IN NO EVENT SHALL AEROTECH BE LIABLE FOR CONSEQUENTIAL OR SPECIAL DAMAGES.

### Return Products Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within thirty (30) days of shipment of incorrect material. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. A "Return Materials Authorization (RMA)" number must accompany any returned product(s). The RMA number may be obtained by calling an Aerotech service center or by submitting the appropriate request available on our website ([www.aerotech.com](http://www.aerotech.com)). Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than thirty (30) days after the issuance of a return authorization number will be subject to review.

Visit [Global Technical Support Portal](#) for the location of your nearest Aerotech Service center.

### Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an expedited method of return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

**Fixed Fee Repairs** - Products having fixed-fee pricing will require a valid purchase order or credit card particulars before any service work can begin.

**All Other Repairs** - After Aerotech's evaluation, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within thirty (30) days of notification will result in the product(s) being returned as is, at the buyer's expense.

Repair work is warranted for ninety (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

### Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

### On-site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site Field Service Representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

### On-site Non-Warranty Repair

If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site Field Service Representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

### Service Locations

<https://www.aerotech.com/contact-sales.aspx?mapState=showMap>

#### **USA, CANADA, MEXICO**

Aerotech, Inc.  
Global Headquarters

#### **CHINA**

Aerotech China  
Full-Service Subsidiary

#### **GERMANY**

Aerotech Germany  
Full-Service Subsidiary

#### **TAIWAN**

Aerotech Taiwan  
Full-Service Subsidiary

#### **UNITED KINGDOM**

Aerotech United Kingdom  
Full-Service Subsidiary

## Appendix B: Revision History

Revision	Description
2.02	<ul style="list-style-type: none"><li>updated link to the <a href="#">HexGen® Hexapod Sizer</a></li><li>specifications updated (<a href="#">Section 1.2.</a>)</li></ul>
2.01	<ul style="list-style-type: none"><li>General update/safety</li><li>Added UKCA Declaration of Incorporation</li></ul>
2.00	General update
1.01	Updated encoder specifications
1.00	New Manual

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