



# MPS50SV Miniature Mechanical-Bearing Screw-Driven Lift Stage

## HARDWARE MANUAL

Revision 2.00



# GLOBAL TECHNICAL SUPPORT

Go to the [Global Technical Support Portal](#) for information and support about your Aerotech, Inc. products. The website supplies software, product manuals, Help files, training schedules, and PC-to-PC remote technical support. If necessary, you can complete Product Return (RMA) forms and get information about repairs and spare or replacement parts. To get help immediately, contact a service office or your sales representative. Include your customer order number in your email or have it available before you call.

This manual contains proprietary information and may not be reproduced, disclosed, or used in whole or in part without the express written permission of Aerotech, Inc. Product names mentioned herein are used for identification purposes only and may be trademarks of their respective companies.

Copyright © 2019-2025, Aerotech, Inc. | All rights reserved.

See the latest version of Aerotech's [Terms of Use](#), [Privacy Policy](#), and [Cookie Policy](#) online at [aerotech.com](http://aerotech.com).



## Table of Contents

<b>MPS50SV Miniature Mechanical-Bearing Screw-Driven Lift Stage</b>	<b>1</b>
Table of Contents	3
List of Figures	4
List of Tables	5
EU Declaration of Incorporation	6
UKCA Declaration of Incorporation	7
RoHS Conformity Declaration	8
Safety Procedures and Warnings	9
Installation and Operation	10
Electrical Warnings	11
Motor-Related Warnings	12
Pinch Points	13
Handling and Storage	14
<b>Chapter 1: Overview</b>	<b>17</b>
1.1. Environmental Specifications	18
1.2. Accuracy and Temperature Effects	18
1.3. Basic Specifications	19
1.4. Vacuum Operation	20
<b>Chapter 2: Installation</b>	<b>21</b>
2.1. Dimensions	21
2.2. Securing the Stage to the Mounting Surface	23
2.3. Attaching the Payload or Fixturing to the Stage	24
<b>Chapter 3: Electrical Installation</b>	<b>27</b>
3.1. Motor and Feedback Connectors	28
3.2. Motor and Feedback Wiring	33
3.3. Motor and Feedback Specifications	35
3.4. Limits, Marker, and Machine Direction	37
3.5. Motor and Feedback Phasing	38
<b>Chapter 4: Maintenance</b>	<b>39</b>
4.1. Service and Inspection Schedule	39
4.2. Cleaning and Lubrication	40
4.3. Troubleshooting	42
<b>Appendix A: Warranty and Field Service</b>	<b>43</b>
<b>Appendix B: Revision History</b>	<b>45</b>
<b>Index</b>	<b>47</b>

List of Figures

Figure 2-1: MPS50SV Dimensions .....21

Figure 2-2: MPS50SV Mounting Plate (-MP) Dimensions .....22

Figure 2-3: Stage Mounting Holes .....23

Figure 2-4: Cantilevered Load Capabilities .....25

Figure 2-5: Stage Orientations .....25

Figure 3-1: Motor and Feedback Wiring (-M1) .....33

Figure 3-2: Motor and Feedback Wiring (-M2) .....34

Figure 3-3: Machine Direction .....37

Figure 3-4: Encoder Phasing Reference Diagram (Standard/Square Wave) .....38

## List of Tables

Table 1-1: Model Numbers and Ordering Options .....	17
Table 1-2: Environmental Specifications .....	18
Table 1-3: MPS50SV Series Specifications .....	19
Table 2-1: Stage Mounting Surface Flatness Requirement .....	23
Table 2-2: Stage to Mounting Surface Hardware .....	23
Table 2-3: Payload Mounting Surface Flatness Requirement .....	24
Table 3-1: Motor and Feedback Connector Pinout (-M1) .....	29
Table 3-2: Mating Connector Part Numbers for the Stage Connector .....	29
Table 3-3: Motor and Feedback Connector Pinout (-M1 with -HV Option) .....	30
Table 3-4: Mating Connector Part Numbers for Vacuum Chamber DB25P Feed-Through Stage Connector .....	30
Table 3-5: Motor and Feedback Connector Pinout (-M2) .....	31
Table 3-6: Mating Connector Part Numbers for the Stage Connector .....	31
Table 3-7: Motor and Feedback Connector Pinout (-M2 with -HV Option) .....	32
Table 3-8: Mating Connector Part Numbers for Vacuum Chamber DB25P Feed-Through Stage Connector .....	32
Table 3-9: Encoder Specifications .....	35
Table 3-10: Encoder Resolution .....	35
Table 3-11: Limit Switch Specifications .....	35
Table 3-12: DC Motor Specifications .....	36
Table 3-13: Stepper Motor Specifications .....	36
Table 4-1: Troubleshooting .....	42



## EU Declaration of Incorporation

**Manufacturer:** Aerotech, Inc.  
**Address:** 101 Zeta Drive  
 Pittsburgh, PA 15238-2811  
 USA  
**Product:** MPS50SV - linear positioning stage  
**Models:** All

***This is to certify that the aforementioned product is in accordance with the applicable requirements of the following directive.***

2006/42/EC

*Machinery Directive (partially completed machinery)*

1.1 General Remarks

1.1.2 Principles of safety integration

1.1.5 Design of machinery to facilitate handling

1.2 Control Systems

1.2.1 Safety and reliability of control systems

1.3 Protection against mechanical hazards

1.3.1 Risk of loss of stability

1.3.2 Risk of breakup during operation

1.3.3 Risks due to falling or ejected objects

1.3.4 Risks due to surfaces, edges, or angles

1.5 Risks due to other hazards

1.5.4 Error of fitting

1.5.9 Vibrations

1.6 Maintenance

1.6.5 Cleaning of internal parts

1.7 Instructions

1.7.4.1 Instructions

***and that the following harmonized European standards have been applied:***

EN ISO 12100

*Safety of machinery – Basic concepts, general principles for design*

EN 60204-1:2018

*Safety of machinery – Electrical equipment of machines – Part 1: General requirements*


***and furthermore declares that***

**the equipment shall not be put 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.**

**Technical documentation showing compliance with this declaration in accordance with Annex VII part B will be provided in digital format upon request.**

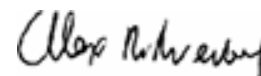
**Authorized  
Representative:**

Managing Director  
 Aerotech GmbH  
 Gustav-Weißkopf-Str. 18  
 90768 Fürth  
 Germany

  
 Jochen Jäger

**Engineer Verifying  
Compliance:**

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



Alex Weibel

Date: 3/26/2025



# AEROTECH UKCA Declaration of Incorporation

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

**herewith declares that the following Aerotech stage series:**

MPS50SV

**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

*Restricted Substances Directive*

**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

*Safety of machinery – Basic concepts, general principles for design*

EN 60204-1:2018


*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.**

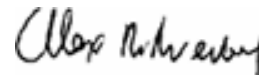
**Authorized Representative:**

Managing Director  
Aerotech Ltd.  
The Old Brick Kiln  
Ramsdell, Tadley  
Hampshire RG26 5PR  
UK

  
Simon Smith

**Engineer Verifying Compliance:**

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

  
Alex Weibel

Date: 3/26/2025



## RoHS Conformity Declaration

**Manufacturer:** Aerotech, Inc.  
**Address:** 101 Zeta Drive  
Pittsburgh, PA 15238-2811  
USA  
**Product:** MPS50SV - linear positioning stage  
**Models:** All

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

(EU) 2015/863 restriction of the use of hazardous substances (RoHS3)



## Safety Procedures and Warnings



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

- Read all parts of this manual before you install or operate the stage 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 stage 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 use or operate a stage or 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.



### **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

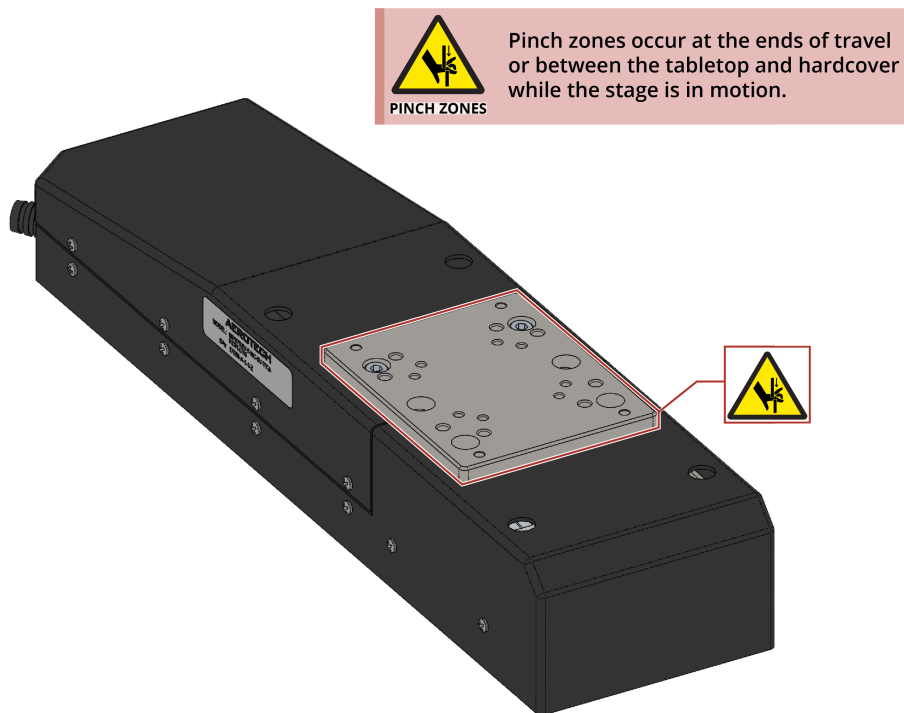
A pinch point is a mechanical hazard that can occur when there are exposed parts of the stage or system that can move. For example, the travel of a stage tabletop could expose the user to a pinch point between the tabletop and the stage housing. The images that follow will show you typical external and 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 1: Typical Pinch Point Locations**



## Handling and Storage



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

- Be careful when you move or transport the stage.
- Retain the shipping materials for future use.
- Transport or store the stage 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.

Failure to observe the correct ESD practices could cause ESD damage to stage electronics, system drives, and/or power supplies.

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 stage 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.

Each stage has a label listing the system part number and serial number. These numbers contain information necessary for maintenance or system hardware and software updates. Locate this label and record the information for later reference.

## Unpacking and Handling

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



**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 stage 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.
- Do not use the cables or the connectors to lift or move this product.
- Make sure that all moving parts are secure before you move the stage. Unsecured moving parts could shift and cause injury or damage to the equipment.
- If the stage is heavy, a single person lift could cause injury. Use assistance when you lift or move it.
  - Refer to [Section 2.1. Dimensions](#) for dimensions

Carefully remove the stage from its protective shipping container.

- Lift this product only by the base.
- For multi-axis assemblies, always lift the system by the lower axis.
- Use a cart, dolly, or similar device to move the stage to a new location.

Gently set the stage 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.

Before you operate the stage, let it stabilize at room temperature for at least 12 hours. This will ensure that all of the alignments, preloads, and tolerances are the same as they were when they were tested at Aerotech.

**Storage**

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

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

*This page intentionally left blank.*



## Chapter 1: Overview

**Table 1-1: Model Numbers and Ordering Options**

<b>MPS50SV Series Miniature Mechanical-Bearing Screw-Driven Lift Stage</b>	
<b>Travel</b>	
-5	5 mm travel
<b>Drive Screw (Required)</b>	
-BS	Precision-ground ball screw, 1 mm/rev
-LS	Precision-ground lead screw, 0.5 mm/rev
<b>Vacuum Preparation (Optional)</b>	
-HV	High vacuum preparation to $10^{-6}$ Torr
<b>Motor (Required)</b>	
-M1	DC Servomotor
-M2	Stepper motor
<b>Mounting Plate (Optional)</b>	
-MP	Optical table mounting plate
<b>Metrology (Required)</b>	
-PL0	No metrology performance plots
-PL1	Uncalibrated with performance plots
-PL2	Calibrated (HALAR) with performance plots
<b>Integration (Required)</b>	
-TAS	Test as system: Testing, integration, and documentation of a group of components as a complete system that will be used together.
-TAC	Test as components: Testing and integration of individual items as discrete components that ship together.

## 1.1. Environmental Specifications



**WARNING: General Hazard Warning!** Do not expose this product to environments or conditions outside of the listed specifications. You could damage the equipment if you exceed the environmental or operating specifications.



**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.

**Table 1-2: Environmental Specifications**

<b>Ambient Temperature</b>	Operating: 10 °C to 35 °C (50 °F to 95 °F)
	The optimal operating temperature is 20 °C $\pm$ 2 °C (68 °F $\pm$ 4 °F). If at any time the operating temperature deviates from 20 °C degradation in performance could occur.
	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 stage 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. 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 (IP00 equivalent ingress protection rating).
<b>Use</b>	Indoor use only

## 1.2. Accuracy and Temperature Effects

Aerotech products are designed for and built in a 20°C (68°F) environment. Temperature changes could cause a decrease in performance or permanent damage to the stage. At a minimum, the environmental temperature must be controlled to within 0.25°C per 24 hours to ensure the stage specifications are repeatable over an extended period of time. The severity of temperature effects on all specifications depends on many different environmental conditions, which include how the stage is mounted. Contact the factory for more details.

### 1.3. Basic Specifications

Specifications are for single-axis systems measured 25 mm above the tabletop; performance of multi-axis system depend upon the payload and workpoint. Consult the Aerotech factory for multi-axis or non-standard applications.

To ensure the achievement and repeatability of specifications over an extended period of time, environmental temperature must be controlled to within 0.25°C per 24 hours. Consult the Aerotech factory for more information.

**Table 1-3: MPS50SV Series Specifications**

			MPS50SV-5
Travel			5 mm
Accuracy	1.0 mm/rev Ball Screw	Standard	±2.5 μm
		Calibrated <sup>(1)</sup>	±1.0 μm
	0.5 mm/rev Lead Screw	Standard	±3.0 μm
		Calibrated <sup>(1)</sup>	±1.25 μm
Resolution (minimum incremental motion)			0.05 μm
Bidirectional Repeatability <sup>(1)</sup>	1.0 mm/rev Ball Screw		±0.75 μm
	0.5 mm/rev Lead Screw		±1.5 μm
Straightness			±3.0 μm
Wedge Ratio			6.82:1
Maximum Speed	1.0 mm/rev Ball Screw	DC Motor (-M1)	0.8 mm/s
		Stepper Motor (-M2)	0.15 mm/s
	0.5 mm/rev Lead Screw	DC Motor (-M1)	0.4 mm/s
		Stepper Motor (-M2)	0.1 mm/s
Load Capacity <sup>(2)</sup>			6 kg
Stage Mass			1.4 kg
Material			Stainless-Steel Carriage; Anodized Aluminum Body
(1) Requires an Aerotech controller.			
(2) Payload specifications are for a single-axis system.			

## 1.4. Vacuum Operation

Special preparations include:

- Parts are lubricated with vacuum-compatible lubricants.
- Materials, fasteners, and coatings are selected to be compatible with the specified level of vacuum.
- High-vacuum systems are designed to eliminate trapped volumes.
- Prior to assembly, stage parts are thoroughly cleaned in a clean environment.
- The stage is packaged in a special polyethylene bag.

### Vacuum Guidelines

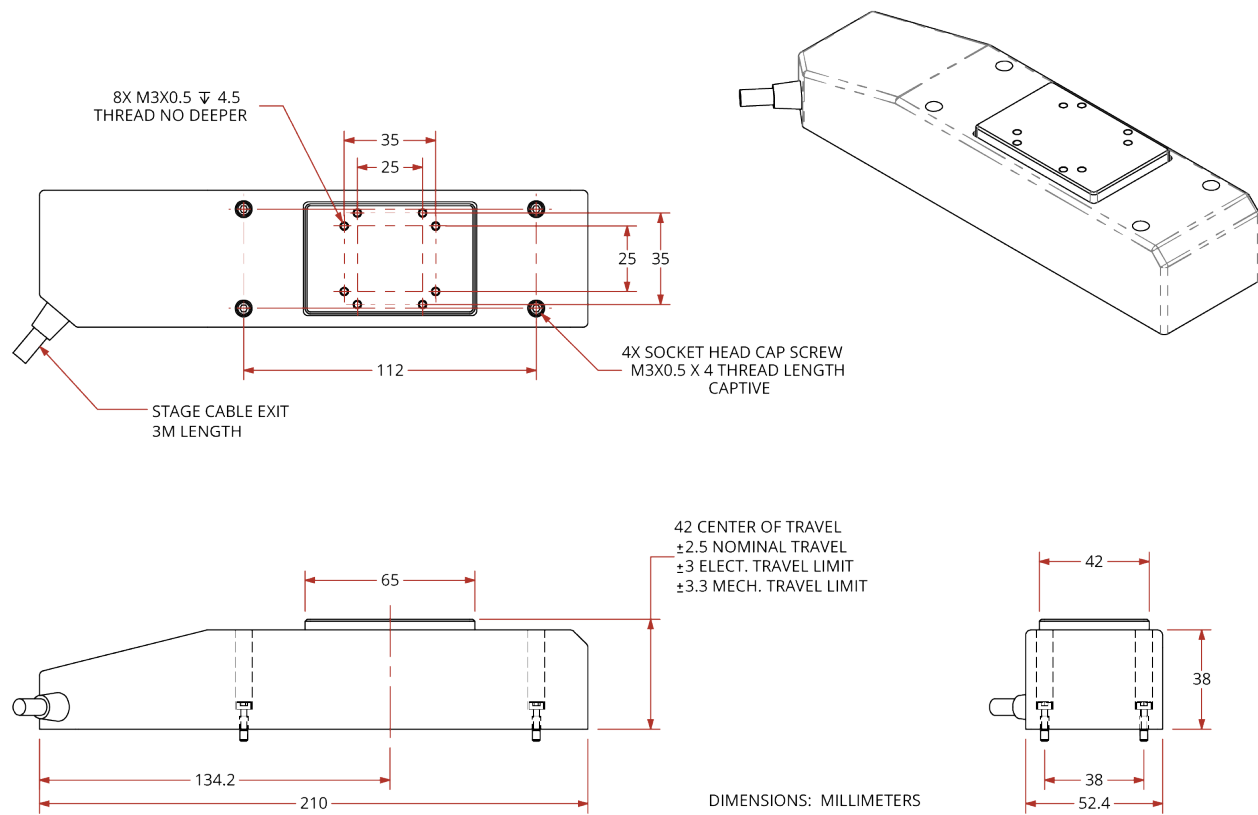
To ensure that the stage will continue to perform well in the vacuum environment, use the guidelines that follow (in addition to standard handling, installation, and lubrication guidelines outlined in this manual).

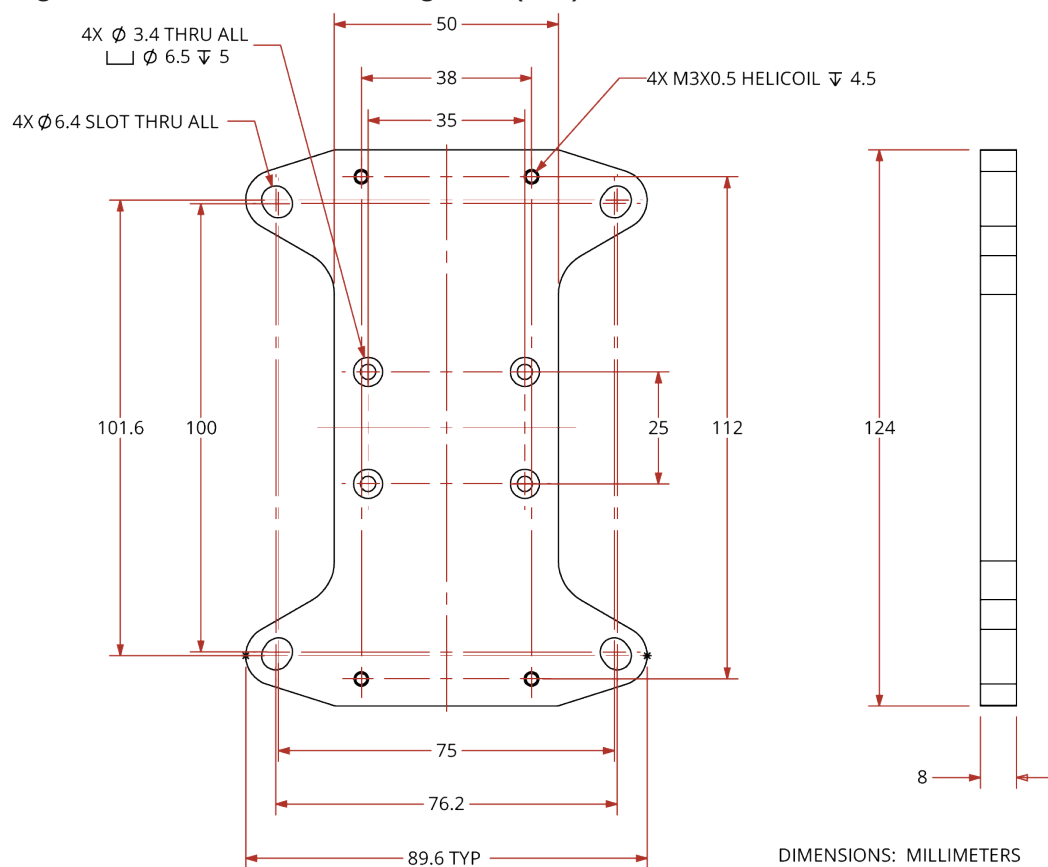
1. Do not remove the stage from its sealed bag until it is ready to use.
2. Always handle the stage in a clean environment and use powder-free polyethylene gloves to prevent any contaminants from adhering to the surface of the stage.
3. During installation, use cleaned, vented, stainless steel fasteners to secure the stage.
4. Reduced air pressure eliminates significant convective heat transfer. This, coupled with the viscous vacuum-compatible lubricants, could result in excessive motor operating temperatures. Because of this, consider all continuous torque ratings to be **40 to 60% lower** than the value specified for operation in normal atmospheric environment. Reduce motor usage accordingly.
5. We recommend that you use a small quantity of **Braycote® 602EF** grease or a compatible substitute of equal quality lubricant in vacuum applications.
6. To reduce outgassing during the initial pump-down to vacuum pressure, Aerotech recommends that you bake out vacuum systems when you first install them into the vacuum chamber. Bake the vacuum components at 60 °C for 24 to 48 hours to desorb water vapor from surfaces and degas polymers (such as cable insulation).

## Chapter 2: Installation

### 2.1. Dimensions

Figure 2-1: MPS50SV Dimensions



**Figure 2-2: MPS50SV Mounting Plate (-MP) Dimensions**

## 2.2. Securing the Stage 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 stage 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 13](#).

The mounting surface must be flat and have adequate stiffness to achieve the maximum performance from the stage. 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 stage is precision machined and verified for flatness at the factory.

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

**Table 2-1: Stage Mounting Surface Flatness Requirement**

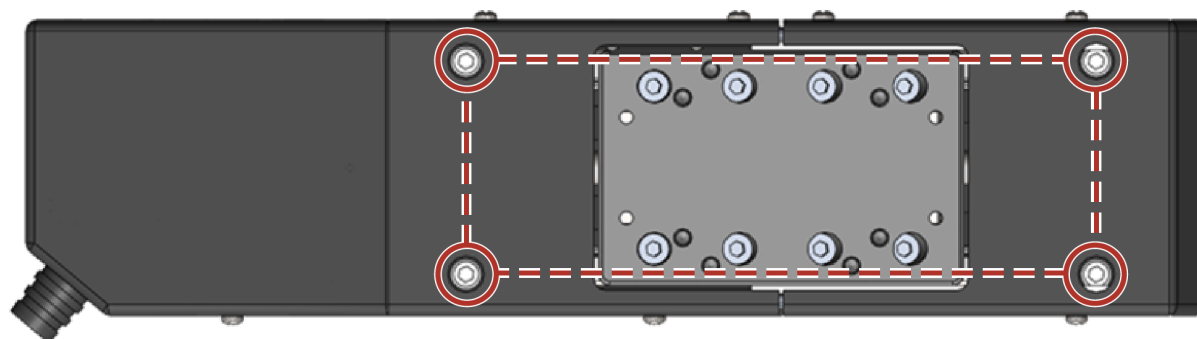
Stage	Flatness Requirement
All Frame Sizes	5 $\mu$ m

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 2-2](#) 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 2-2: Stage to Mounting Surface Hardware**

Mounting Hardware	Typical Screw Torque
M3 SHCS	0.9 N·m

**Figure 2-3: Stage Mounting Holes**



## 2.3. Attaching the Payload or Fixturing to the Stage

Inspect the mounting surface for dirt or unwanted residue and clean if necessary. 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.

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: Electrical Installation](#) and the documentation delivered with the stage.



**IMPORTANT:** If your MPS50SV was purchased with Aerotech controls, it could have been tuned with a representative payload based on the information provided at the time of order. If you start the MPS50SV without a payload, the servo gains provided by Aerotech with the shipment may not be appropriate and servo instability can occur. Refer to the controller help file for tuning assistance.

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

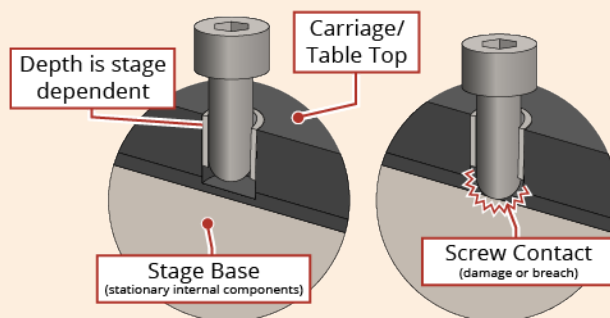
**Table 2-3: Payload Mounting Surface Flatness Requirement**

Stage Travel	Flatness Requirement
All Travels	5 $\mu$ m

### WARNING: General Hazard Warning!

Be careful when you attach the payload to the stage mounting surface.

- If a mounting screw extends through the carriage/table top, it can affect travel and damage the stage.
- Refer to the dimensions in [Section 2.1](#) for maximum allowable thread engagement.
- **Mounting Hole Cutaway:**

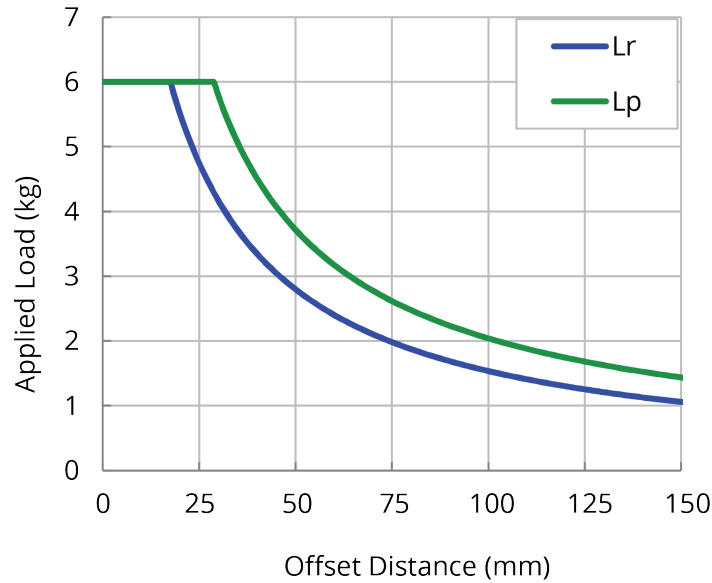


Applied loads should be symmetrically distributed whenever possible. The payload should be centered on the stage mounting surface and the entire stage should be centered on the support structure.

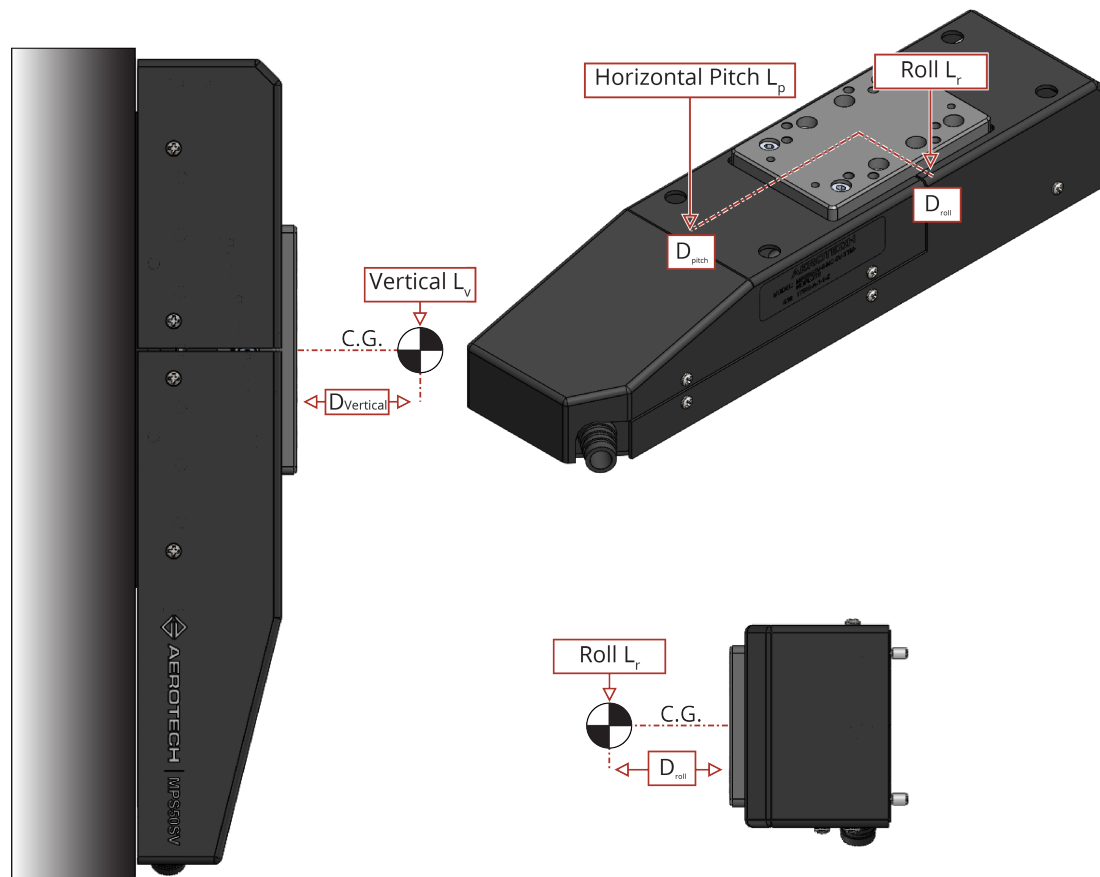


Refer to [Section 1.3](#) for maximum load carrying capacity specifications. If cantilevered loads are applied, refer to the graph that follows to find the maximum allowable load.

**Figure 2-4: Cantilevered Load Capabilities**



**Figure 2-5: Stage Orientations**



*This page intentionally left blank.*

## Chapter 3: Electrical Installation



### **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.



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

Applications that require access to the MPS50SV 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 MPS50SV 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 MPS50SV is part of a complete Aerotech motion control system, setup should only require that you connect the stage 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

Stages equipped with standard motors and encoders come from the factory completely wired and assembled.



**IMPORTANT:** Refer to the other documentation accompanying your Aerotech equipment. Call your Aerotech representative if there are any questions on system configuration.



**IMPORTANT:** If you are using standard Aerotech motors and cables, motor and encoder connection adjustments are not required.

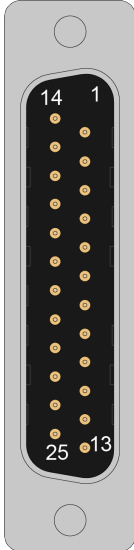
The protective ground connection of the MPS50SV provides motor frame ground protection only. Additional grounding and safety precautions are required for applications requiring access to the stage while it is energized. The System Integrator or qualified installer is responsible for determining and meeting all safety and compliance requirements necessary for the integration of this stage into the final application.



**DANGER: Electrical Shock Hazard!**

- The protective ground connection must be properly installed to minimize the possibility of electric shock.
- The stage controller must provide over-current and over-speed protection. Failure to do so could cause electric shock or damage to the equipment.

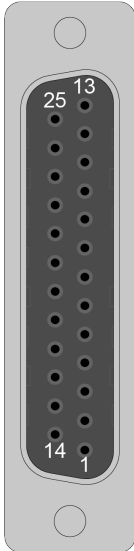
**Table 3-1: Motor and Feedback Connector Pinout (-M1)**

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	Reserved	
9	Reserved	
10	Motor -	
11	Motor +	
12	Reserved	
13	Reserved	
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	Reserved	
21	Reserved	
22	Motor -	
23	Motor +	
24	Reserved	
25	Reserved	

**Table 3-2: Mating Connector Part Numbers for the Stage Connector**

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: Motor and Feedback Connector Pinout (-M1 with -HV Option)**

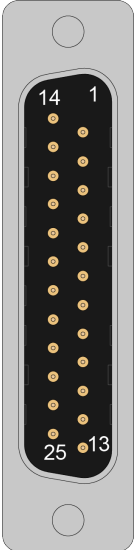
Pin	Description	Connector
Case	Shield Connection	
1	Reserved	
2	Reserved	
3	Motor +	
4	Motor -	
5	Reserved	
6	Reserved	
7	-/CCW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine negative” or “machine counter-clockwise” direction.)	
8	Common ground	
9	Common ground	
10	MRK- (Encoder Marker-)	
11	SIN- (Encoder Sine-)	
12	COS- (Encoder Cosine-)	
13	Reserved	
14	Reserved	
15	Reserved	
16	Motor +	
17	Motor -	
18	Reserved	
19	Reserved	
20	+/CW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine positive” or “machine clockwise” direction.)	
21	Reserved	
22	5V Power Supply Input	
23	MRK+ (Encoder Marker+)	
24	SIN+ (Encoder Sine+)	
25	COS+ (Encoder Cosine+)	

NOTE: Vacuum stages require a double-male bulkhead adapter (through the vacuum chamber wall) to mate to Aerotech standard cables.

**Table 3-4: Mating Connector Part Numbers for Vacuum Chamber DB25P Feed-Through Stage Connector**

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

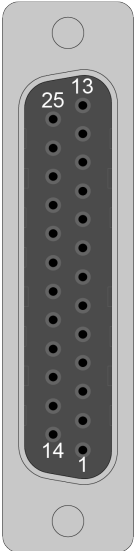
**Table 3-5: Motor and Feedback Connector Pinout (-M2)**

Pin	Description	Connector
Case	Shield Connection	
1	Key (to make sure that the correct cable is plugged into the correct jack)	
2	Reserved	
3	Reserved	
4	Reserved	
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	Reserved	
9	Reserved	
10	Motor Return/Frame Ground	
11	Motor Phase A	
12	Motor Phase B	
13	Reserved	
14	Reserved	
15	Reserved	
16	Reserved	
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	Reserved	
21	Reserved	
22	Motor Return/Frame Ground	
23	Motor Phase A	
24	Motor Phase B	
25	Reserved	

**Table 3-6: Mating Connector Part Numbers for the Stage Connector**

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

**Table 3-7: Motor and Feedback Connector Pinout (-M2 with -HV Option)**

Pin	Description	Connector
Case	Shield Connection	
1	Reserved	
2	Motor Phase B	
3	Motor Phase A	
4	Motor Return/Frame Ground	
5	Reserved	
6	Reserved	
7	-/CCW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine negative” or “machine counter-clockwise” direction.)	
8	Common ground	
9	Common ground	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Motor Phase B	
16	Motor Phase A	
17	Motor Return/Frame Ground	
18	Reserved	
19	Reserved	
20	+/CW LMT (End-of travel limit signal that indicates maximum permitted stage travel in the “machine positive” or “machine clockwise” direction.)	
21	Reserved	
22	5V Power Supply Input	
23	Reserved	
24	Reserved	
25	Reserved	

NOTE: Vacuum stages require a double-male bulkhead adapter (through the vacuum chamber wall) to mate to Aerotech standard cables.

**Table 3-8: Mating Connector Part Numbers for Vacuum Chamber DB25P Feed-Through Stage Connector**

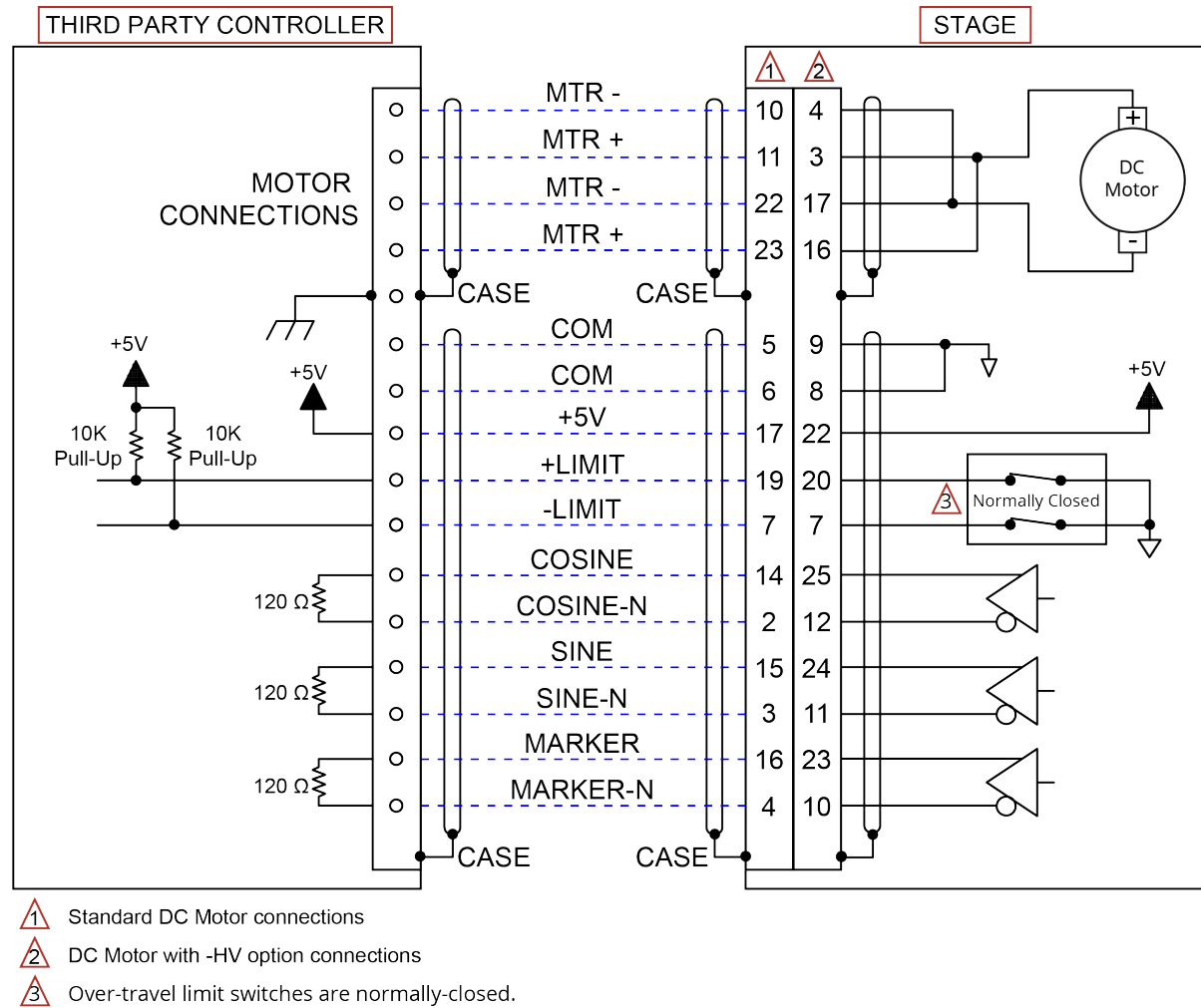
Mating Connector	Aerotech P/N	Third Party P/N
25-Socket D-Connector	ECK00300	FCI DB25S064TLF
Backshell	ECK00656	Amphenol 17E-1726-2

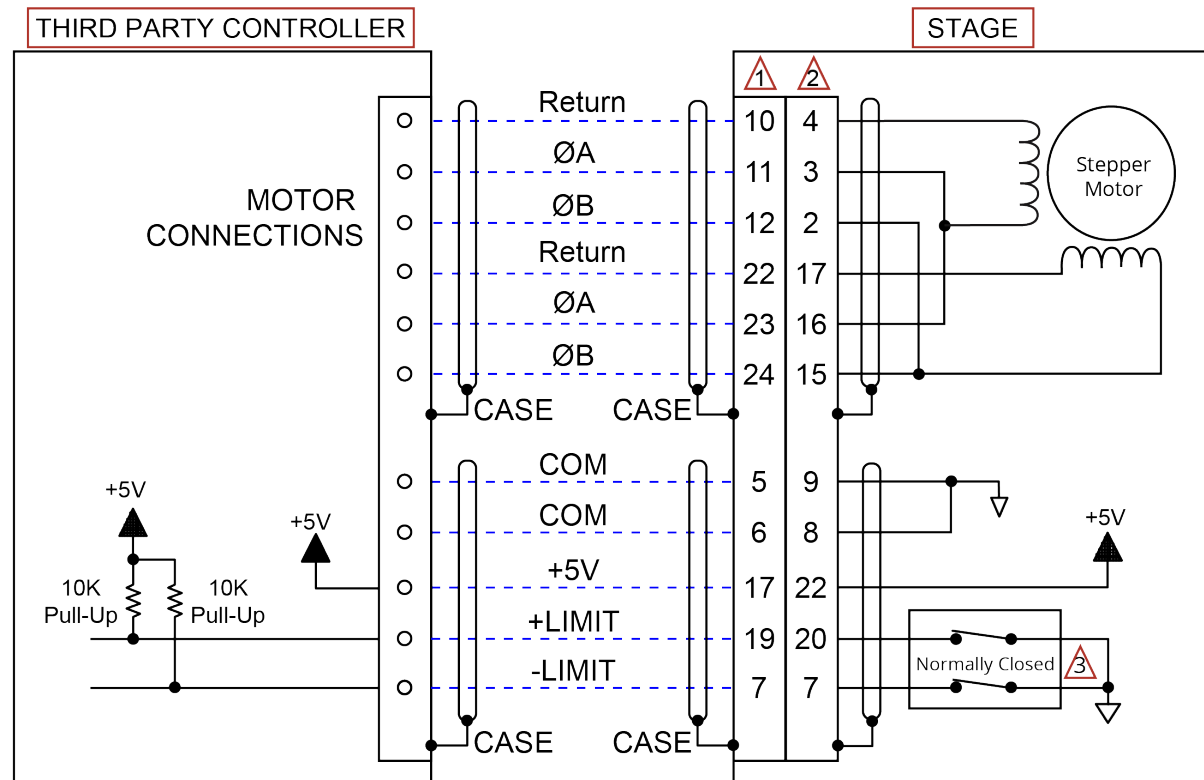


### 3.2. Motor and Feedback Wiring

Shielded cables are required for the motor and feedback connections.

**Figure 3-1: Motor and Feedback Wiring (-M1)**



**Figure 3-2: Motor and Feedback Wiring (-M2)**

### 3.3. Motor and Feedback Specifications

**Table 3-9: Encoder Specifications**

	Specification
Supply Voltage	5 V $\pm 5\%$
Supply Current	100 mA (typical)
Output Signals	<b>Digital Output (Incremental Encoder):</b> Digital encoder line-driver signals; RS422/485 compatible

**Table 3-10: Encoder Resolution**

		DC Motor (and -HV)	Stepper Motor (and -HV)
Feedback		512 lines/rev Rotary Encoder	N/A
Electronic Resolution	-BS	0.0051 $\mu\text{m}$	0.0071 $\mu\text{m}$ @ 480 steps/rev Motor Resolution
	-LS	0.0026 $\mu\text{m}$	0.0035 $\mu\text{m}$ @ 480 steps/rev Motor Resolution

**Table 3-11: Limit Switch Specifications**

	Specification
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 (Factory Configured)	<b>Normally Closed (NC)</b> <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>Electrical Limit Warnings:</b> If you set the electrical limits to an angle greater than the mechanical hard stop, the stage will hit the hard stop before it is able to safely stop at the electrical limit. If you set too much distance between the electrical limit and the hard stop, the stage travel could exceed the electrical limit. The stage could continue into the hard stop or do so the next time it is enabled.	

**Table 3-12: DC Motor Specifications**

	DC Motor (-M1)
Stall Torque, Continuous	0.0045 N·m
Peak Torque	0.0095 N·m
Maximum Speed	4200 rpm
Peak Current, Stall	0.40 A
Continuous Stall Current	0.19 A
Torque Constant	0.0263 N·m/A
Terminal Resistance	54.6 Ohm
BEMF Constant	2.76 V/krpm
Inductance	0.0012 H
Rotor Moment of Inertia	1.00E-07 kg·m <sup>2</sup>
Recommended Bus Voltage	24 V
Maximum Terminal Voltage	48 V
Motor Constant	0.0036 N·m/√w
Gear Ratio	676:49

**Table 3-13: Stepper Motor Specifications**

	Stepper Motor (-M2)
Stall Torque	0.0036 N·m
Rated Phase Current	0.15 A
Recommended Bus Voltage	24 V
Rotor Inertia	4.50E-08 kg·m <sup>2</sup>
Full Step Angle	15°
Phase Resistance	35 Ohm
Phase Inductance	0.0165 H
Maximum Speed	2600 rpm
Gear Ratio	2704:63

### 3.4. Limits, Marker, and Machine Direction

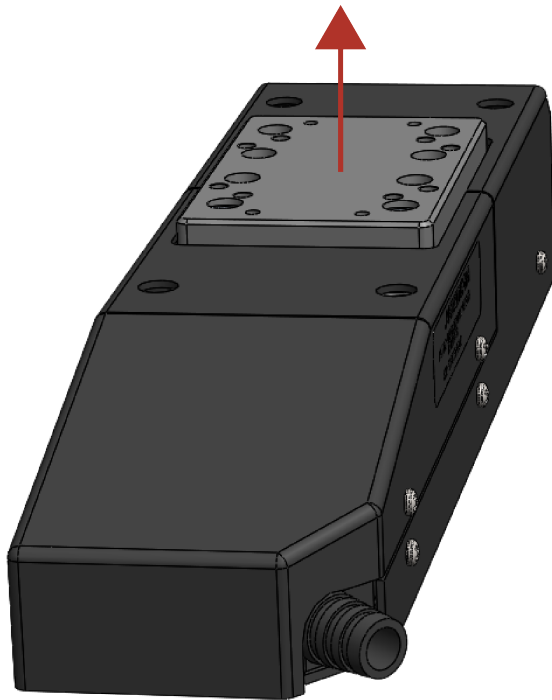
Aerotech stages are configured to have positive and negative "machine" directions. The machine direction defines the phasing of the feedback and motor signals and is dictated by the stage wiring (refer to [Section 3.2.](#)). Programming direction of a stage is set by the controller that is used to move the stage. Programming direction is typically selectable in the controller, while machine direction is hardwired in the stage. [Figure 3-3](#) shows the machine direction of MPS50SV stages.



**IMPORTANT:** Machine direction terminology is per Aerotech standards for linear motor systems and does not necessarily correspond to program direction.

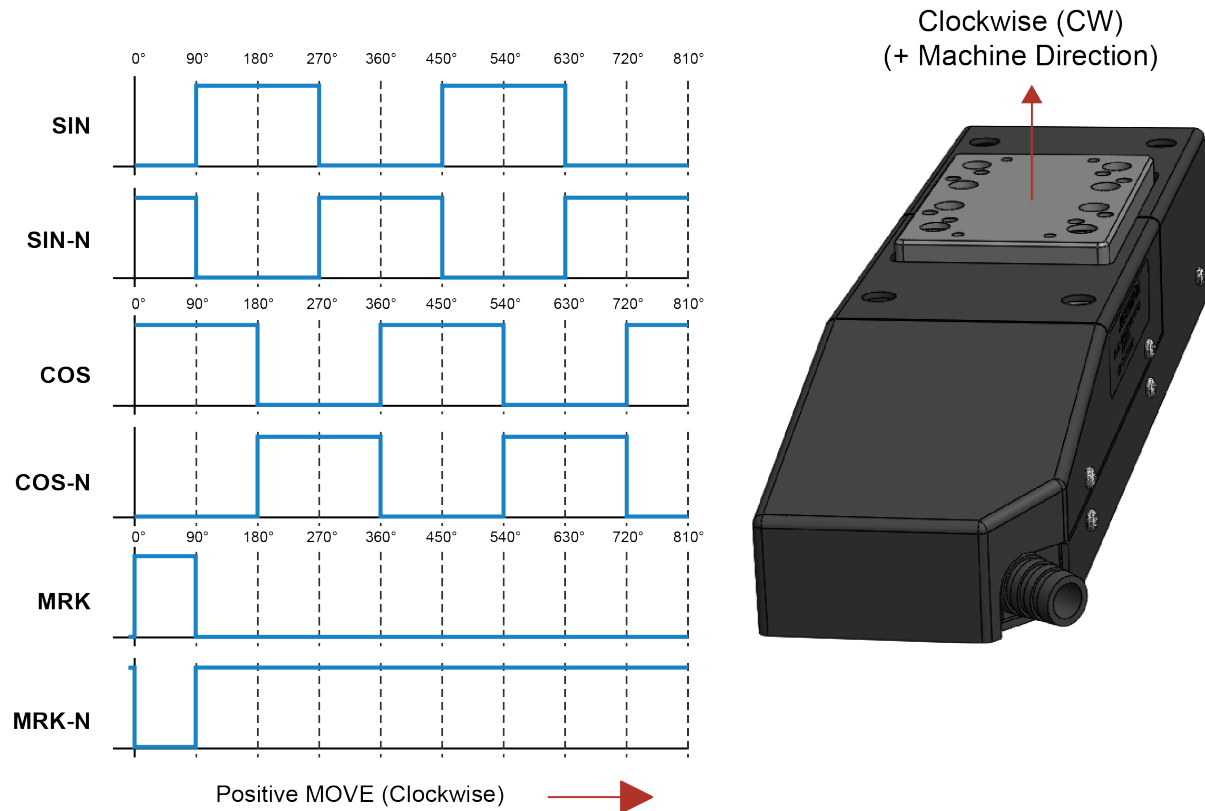
**Figure 3-3: Machine Direction**

Clockwise (CW)  
(Positive Machine Direction)



### 3.5. Motor and Feedback Phasing

Figure 3-4: Encoder Phasing Reference Diagram (Standard/Square Wave)



## Chapter 4: Maintenance



**IMPORTANT:** Read the [Safety Procedures and Warnings](#) (on [Page 9](#)) before you do maintenance to the stage.



**IMPORTANT:** Keep the bearing area free of foreign matter and moisture or the performance and life expectancy of the stage will be reduced.

### 4.1. Service and Inspection Schedule

Inspect the MPS50SV at least once per month. The need for a longer or shorter inspection interval will depend on the application and conditions, such as the duty cycle, speed, and environment.

The cleaning and lubrication interval depends on the conditions (duty cycle, speed, and the environment) in which the stage operates. In general, stages operating in a clean environment should be cleaned/lubricated annually. For stages operating under conditions involving excessive debris, stages should be cleaned/lubricated every six months. Use the inspection interval and operating conditions to determine if a shorter cleaning and lubrication interval is required.

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.

Monthly inspections should include but not be limited to:

- Visually inspect the stage and cables.
- Re-tighten loose connectors.
- Replace or repair damaged cables.
- Clean the MPS50SV and any components and cables as needed.
- Repair any damage before operating the MPS50SV.
- Inspect and perform an operational check on all safeguards and protective devices.

## 4.2. Cleaning and Lubrication



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



**DANGER: Mechanical Hazards!** When you move the tabletop manually to do maintenance, this could expose the operator to pinch points. Refer to [Pinch Points](#) on [Page 13](#).



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



**IMPORTANT:** In applications that have multiple stages bolted together to form multi-axis systems, the orthogonality can be lost if the stage tables of the support stages are loosened. Precision aligned stages should not be loosened or disassembled.

We recommend that you do not disassemble the stage beyond the instructions given in this manual. Proper assembly and calibration can only be done at the factory. Contact Aerotech for more information.

### Cleaning

When you clean components of the MPS50SV series stage:

1. Blow away small particles and dust with clean, dry, compressed air before you use a cleaning solvent on any part of the stage.
2. Use isopropyl alcohol on a lint-free cloth to clean any external metal surface of the MPS50SV. Harsher solvents, such as acetone, could damage the plastic, rubber, or precision components.



**WARNING: General Hazard Warning!** Make sure that all solvent has completely evaporated before you move the stage.



## Lubrication

For standard applications, use NSK LG2 grease on the precision rail guides and ball screw. For vacuum applications, refer to the vacuum guidelines in [Section 1.4](#) for the appropriate grease. Only use the specified grease as other greases may be incompatible.

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.



**IMPORTANT:** For high-speed applications (near maximum speed at a duty cycle of 50%, for example), frequent ball-screw maintenance with standard lubricants is required.



**IMPORTANT:** Removing the upper axis on an XY, XZ, or YZ system will alter a precision alignment. Do not remove the upper axis for lubrication and cleaning if possible.

## Lubrication Procedure

1. Drive the carriage to one end of travel, and remove power from the stage.
2. Remove the screws from the stage covers and remove the covers.
3. Blow off the interior of the stage with clean, dry compressed air or nitrogen.
4. Remove all dirty or dried lubricant from the drive screw and the precision rail guides. Use a small application of isopropyl alcohol with a clean, lint-free cloth or cotton swab.
5. Using a grease syringe, apply an approximate 2 mm diameter bead of lubricant to the drive screw threads and precision rail guides.
6. Manually move the carriage to the opposite end of travel. Then repeat Steps 2 through 4 for the opposite sides of the bearing rails.
7. Manually move the carriage through full travel three or more times to distribute the lubricant.
8. Repeat the grease application process three more times to reach the total replacement grease quantity.
9. Refasten the covers.
10. Restore power to the stage.

### 4.3. Troubleshooting

**Table 4-1: Troubleshooting**

Symptom	Possible Cause and Solution
Stage will not move	<ul style="list-style-type: none"><li>• In Limit condition. Check limits (refer to <a href="#">Chapter 3: Electrical Installation</a>) and refer to the Controller documentation for polarity and compatibility requirements (Example: voltage requirements).</li><li>• Controller trap or fault (refer to the Controller documentation).</li></ul>
Stage moves uncontrollably	<ul style="list-style-type: none"><li>• Encoder (sine and cosine) signal connections (refer to <a href="#">Chapter 3: Electrical Installation</a> and Controller documentation).</li><li>• Motor Connections (refer to <a href="#">Chapter 3: Electrical Installation</a> and the Controller documentation).</li></ul>
Stage oscillates or squeals	<ul style="list-style-type: none"><li>• Gains misadjusted (refer to the Controller documentation).</li><li>• Encoder signals (refer to the Controller documentation).</li></ul>

## 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	General Information
2.00	<ul style="list-style-type: none"><li>• Updated safety information</li><li>• Updated EU Declaration of Incorporation</li><li>• Added UKCA Declaration of Incorporation</li></ul>
1.00	New manual

Revision	General Information
2.00	<ul style="list-style-type: none"><li>• Updated safety information</li><li>• Updated EU Declaration of Incorporation</li><li>• Added UKCA Declaration of Incorporation</li></ul>
1.00	New manual

*This page intentionally left blank.*

# Index

			lubricant	
			vacuum	20
			Lubrication	41
<b>A</b>				
Accuracy and Temperature Effects	18		<b>M</b>	
Accuracy of the Ballscrew	18		Motor-Related Warnings	12
Altitude	18		mounting surface	
Ambient Temperature	18		cleaning	23-24
Attaching the Payload	24		securing stage	23
			multiaxis combinations	40
<b>B</b>				
Braycote® 602EF	20		<b>N</b>	
			NSK LG2 grease	41
<b>C</b>				
cleaning			<b>P</b>	
mounting surface	23-24		packing list	14
Cleaning	40		part number	14
cleaning solvent	40		Possible Cause	42
			Protection Rating	18
<b>D</b>			protective ground connection	28
Dimensions	21			
<b>E</b>			<b>S</b>	
Electrical Installation	27		serial number	14
Electrical Warnings	11		shims	23
Encoder Specifications	35		Solution	42
			solvents	40
<b>G</b>			Specifications	19
grease	20,41		Encoder	35
			Limit Switch	35
<b>H</b>			stabilizing stage	15
Handling	14		stage	
Humidity	18		distortion	23
			stabilizing	15
<b>I</b>			Storage	14
Inspection Schedule	39		Symptom	42
isopropyl alcohol	40		<b>T</b>	
<b>L</b>			Table of Contents	3
label	14		Temperature Effects	18
Limit Switch Specifications	35		Troubleshooting	42

**V**

vacuum guidelines	20
vacuum lubricant (Braycote 602EF)	20
Vacuum Operation	20
Vibration	18

**W**

Warnings	9
Warranty and Field Service	43