Only personnel with proper training offered by Yaskawa should carry out the procedures described in this manual.

Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and retain for future reference.

MOTOMAN INSTRUCTIONS
MH3155 SIGMA-5 POSITIONER MANUAL
CONTROLLER INSTRUCTIONS
CONTROLLER OPERATOR’S MANUAL
CONTROLLER MAINTENANCE MANUAL
CONTROLLER ALARM CODES MANUALS
CONTROLLER COLLABORATIVE OPERATIONS MANUAL

The operator’s manual above corresponds to specific usage. Be sure to use the appropriate manual.

Part Number: 171246-1CD
Revision: 1
Summary of Warning Information

This manual is provided to help users establish safe conditions for operating the equipment. Specific considerations and precautions are also described in the manual, but appear in the form of Dangers, Warnings, Cautions, and Notice.

It is important that users operate the equipment in accordance with this instruction manual and any additional information which may be provided by Yaskawa. Address any questions regarding the safe and proper operation of the equipment to Customer Support.

Notes for Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the Manipulator.

In this manual, the Notes for Safe Operation are classified as “DANGER”, “WARNING”, “CAUTION”, or “NOTICE”.

**DANGER**

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Safety Signs identified by the signal word DANGER should be used sparingly and only for those situations presenting the most serious hazards.

**WARNING**

Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury. Hazards identified by the signal word WARNING present a lesser degree of risk of injury or death than those identified by the signal word DANGER.

**CAUTION**

Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury. It may also be used without the safety alert symbol as an alternative to “NOTICE”.

**NOTICE**

NOTICE is the preferred signal word to address practices not related to personal injury. The safety alert symbol should not be used with this signal word. As an alternative to “NOTICE”, the word “CAUTION” without the safety alert symbol may be used to indicate a message not related to personal injury.
Even items described as “CAUTION” may result in a serious accident in some situations.

**WARNING**

- This instruction manual is intended to explain mainly on the mechanical part of the Manipulator for the application to the actual operation and for proper maintenance and inspection. It describes on safety and handling, details on specifications, necessary items on maintenance and inspection, to explain operating instructions and maintenance procedures. Be sure to read and understand this instruction manual thoroughly before installing and operating the Manipulator. Any matter not described in this manual must be regarded as “prohibited” or “improper”.

- General information related to safety are described in Chapter 1. “Safety” of the Controller instructions. To ensure correct and safe operation, carefully read Chapter 1. “Safety” of the Controller INSTRUCTIONS.

- Do not remove the motor, and do not release the brake.

Failure to observe these safety precautions may result in death or serious injury from unexpected turning of the Manipulator's arm.
WARNING

- Before operating the Manipulator, check that servo power is turned OFF pressing the emergency stop buttons. When the servo power is turned OFF, the SERVO ON LED on the programming pendant is turned OFF.

Injury or damage to machinery may result if the emergency stop circuit cannot stop the Manipulator during an emergency. The Manipulator should not be used if the emergency stop buttons do not function.

*Fig. : Emergency Stop Button*

- Once the emergency stop button is released, clear the cell of all items which could interfere with the operation of the Manipulator. Then turn the servo power ON.

Injury may result from unintentional or unexpected Manipulator motion.

*Fig. : Release of Emergency Stop*

- Observe the following precautions when performing a teaching operation within the Manipulator's operating range:
  - Be sure to perform lockout by putting a lockout device on the safety fence when going into the area enclosed by the safety fence. In addition, the operator of the teaching operation must display the sign that the operation is being performed so that no other person closes the safety fence.
  - View the Manipulator from the front whenever possible.
  - Always follow the predetermined operating procedure.
  - Always keep in mind emergency response measures against the Manipulator's unexpected movement toward a person.
  - Ensure a safe place to retreat in case of emergency.

Failure to observe this instruction may cause improper or unintended movement of the Manipulator, which may result in personal injury.

- Confirm that no person is present in the Manipulator's operating range and that the operator is in a safe location before:
  - Turning ON the Controller power
  - Moving the Manipulator by using the programming pendant
  - Running the system in the check mode
  - Performing automatic operations

Personal injury may result if a person enters the Manipulator's operating range during operation. Immediately press an emergency stop button whenever there is a problem.

- Read and understand the Explanation of the Warning Labels before operating the Manipulator.
WARNING

• Maintenance and inspection must be performed by specified personnel.
Failure to observe this caution may result in electric shock or injury.

• For disassembly or repair, contact your Yaskawa representative

CAUTION

• Read and understand the Explanation of Warning Labels in the Controller instructions before operating the Manipulator.

• In some drawings in this manual, protective covers or shields are removed to show details. Make sure that all the covers or shields are installed in place before operating this product. The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.

Yaskawa is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids the product warranty.

• Perform the following inspection procedures prior to conducting Manipulator teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
  – Check for problems with Manipulator movement.
  – Check for damage to insulation and sheathing of external wires.

• Always return the programming pendant to the hook on the cabinet of the Controller after use.

• The programming pendant can be damaged if it is left in the Manipulator's work area, on the floor, or near fixtures.
Safety Notes for Safe Operation

**CAUTION**

This Robot Cell has Collaborative Motion functionality:

Collaboration is a special type of operation between a person and robot sharing a common workspace. The following are the guidelines for collaborative operation.

1. Used for pre-determined tasks.
2. Possible when all protective measures are active.
3. For robots with features specifically designed for collaborative operation.

   • The integrator shall include in the information for use the safeguards and mode selection required for collaborative operation.

---

**CAUTION**

• Always return the programming pendant to the hook on the cabinet of the Controller after use.

The programming pendant can be damaged if it is left in the Manipulator's work area, on the floor, or near fixtures.

---

**NOTICE**

• The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.

• Yaskawa may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications. If such modification is made, the manual number will also be revised.

• If your copy of the manual is damaged or lost, contact a Yaskawa representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.

• To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as “DANGER”, “WARNING” or “CAUTION”.
CAUTION

All operators, programmers, maintenance personnel, supervisors, and anyone working near the system must become familiar with the operation of this equipment.

Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this equipment should be permitted to program, or maintain the system. All personnel involved with the operation of the equipment must understand potential dangers of operation.

- Inspect the equipment to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Be sure that all safeguards are in place. Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Check the E-Stop button on the operator station for proper operation before programming. The equipment must be in Emergency Stop (E-Stop) mode whenever it is not in use.
- Back up all programs and jobs onto suitable media before program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.
- Any modifications to the Controller unit can cause severe personal injury or death, as well as damage to the robot. Do not make any modifications to the Controller unit. Making any changes without the written permission from Yaskawa will void the warranty.
- Some operations require standard passwords and some require special passwords.
- The equipment allows modifications to the software for maximum performance. Care must be taken when making modifications. All modifications made to the software will change the way the equipment operates and can cause severe personal injury or death, as well as damage parts of the system. Double check all modifications under every mode of operation to ensure that the changes have not created hazards or dangerous situations.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the Controller and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Use proper replacement parts.
- Improper connections can damage the equipment. All connections must be made within the standard voltage and current ratings of the equipment.
Safety
Safeguarding Tips

Safeguarding Tips

CAUTION

All operators, programmers, maintenance personnel, supervisors, and anyone working near the system must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. General safeguarding tips are as follows:

Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this equipment, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this equipment.

• Improper connections can damage the equipment. All connections must be made within the standard voltage and current ratings of the equipment.

• The system must be placed in Emergency Stop (E-Stop) mode whenever it is not in use.

• In accordance with ANSI/RIA R15.06-2012, section 4.2.5, Sources of Energy, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

CAUTION

The safe operation of this equipment is ultimately the users responsibility. The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06-2012 safety standards, and other local codes that may pertain to the installation and use of this equipment.

Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety equipment is provided as standard:

Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety equipment is provided as standard:

• Safety barriers

• Door interlocks

• Emergency stop palm buttons located on operator station

Check all safety equipment frequently for proper operation. Repair or replace any non-functioning safety equipment immediately.
Maintenance Safety

WARNING

- Turn the power OFF, disconnect and lockout/tagout all electrical circuits before making any modifications or connections.

Perform only the maintenance described in this manual. Maintenance other than specified in this manual should be performed only by Yaskawa-trained, qualified personnel.

National Safety Standard

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems (ANSI/RIA R15.06-2012). You can obtain this document from the Robotic Industries Association (RIA) at the following address:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
www.roboticsonline.com

Ultimately, well-trained personnel are the best safeguard against accidents and damage that can result from improper operation of the equipment. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the equipment.

NEVER ALLOW UNTRAINED PERSONNEL TO OPERATE, PROGRAM, OR REPAIR THE EQUIPMENT!

We recommend approved Yaskawa training courses for all personnel involved with the operation, programming, or repair of the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
# Safety

## Definition of Terms Used Often in This Manual

The MOTOMAN is the Yaskawa industrial robot product.

The MOTOMAN usually consists of the Manipulator, the Controller, the programming pendant, and supply cables.

In this manual, the equipment is designated as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller</td>
<td>Controller</td>
</tr>
<tr>
<td>Programming Pendant</td>
<td>Programming pendant</td>
</tr>
<tr>
<td>Cable between the Manipulator and the Controller</td>
<td>Manipulator cable</td>
</tr>
</tbody>
</table>

Descriptions of the programming pendant keys, buttons, and displays are shown as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Pendant</td>
<td>Character Keys</td>
</tr>
<tr>
<td></td>
<td>The keys which have characters printed on them are denoted with [ ]. ex. [ENTER]</td>
</tr>
<tr>
<td></td>
<td>Symbol Keys</td>
</tr>
<tr>
<td></td>
<td>The keys which have a symbol printed on them are not denoted with [ ] but depicted with a small picture. ex. PAGE key 📚 The Cursor is an exception, and a picture is not shown.</td>
</tr>
<tr>
<td></td>
<td>Axis Keys</td>
</tr>
<tr>
<td></td>
<td>“Axis Keys” and “Numeric Keys” are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td></td>
<td>Numeric Keys</td>
</tr>
<tr>
<td></td>
<td>“Axis Keys” and “Numeric Keys” are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td></td>
<td>Keys pressed simultaneously</td>
</tr>
<tr>
<td></td>
<td>When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them. ex. SHIFT key 🔄 +COORD key 🔄</td>
</tr>
<tr>
<td></td>
<td>Mode Key</td>
</tr>
<tr>
<td></td>
<td>Three kinds of modes that can be selected by the mode key are denoted as follows: REMOTE, PLAY, or TEACH</td>
</tr>
<tr>
<td></td>
<td>Button</td>
</tr>
<tr>
<td></td>
<td>Three buttons on the upper side of the programming pendant are denoted as follows: HOLD button, START button EMERGENCY STOP button</td>
</tr>
<tr>
<td></td>
<td>Displays</td>
</tr>
<tr>
<td></td>
<td>The menu displayed in the programming pendant is denoted with { }. ex. {JOB}</td>
</tr>
<tr>
<td></td>
<td>PC Keyboard</td>
</tr>
<tr>
<td></td>
<td>The name of the key is denoted ex. Ctrl key on the keyboard</td>
</tr>
</tbody>
</table>

## Registered Trademark

In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or brand names for each company or corporation. The indications of (R) and TM are omitted.
Table of Contents

1 Introduction ..................................................................................................................................... 1-1
   1.1 About this Document.......................................................................................................... 1-1
   1.2 System Overview .......................................................................................................... 1-2
       1.2.1 Headstock Positioner Assembly ........................................................................ 1-2
       1.2.2 Headstock and Tailstock Positioner Assembly ..................................................... 1-3
   1.3 Reference Documentation ................................................................................................. 1-3
   1.4 Customer Support Information........................................................................................... 1-4

2 Installation ................................................................................................................................... 2-1
   2.1 Contents Confirmation ....................................................................................................... 2-2
   2.2 Materials Required....................................................................................................... 2-2
       2.2.1 Customer-Supplied Items ..................................................................................... 2-2
       2.2.2 List of Tools .......................................................................................................... 2-2
   2.3 Positioner Installation .................................................................................................. 2-3
       2.3.1 Site Preparation.................................................................................................... 2-3
       2.3.2 Shipping Bolts....................................................................................................... 2-5
       2.3.3 Transporting.......................................................................................................... 2-6
       2.3.4 Mounting Positioner .............................................................................................. 2-7
   2.4 Tooling Fixture Installation ............................................................................................. 2-13
       2.4.1 Initial Installation ................................................................................................. 2-13
       2.4.2 Normal Installation .............................................................................................. 2-14
   2.5 Installation of Safeguarding ............................................................................................. 2-14
       2.5.1 Responsibility for Safeguarding (ISO10218) ...................................................... 2-14
   2.6 Final Alignment Check .................................................................................................... 2-14
       2.6.1 Horizontal Alignment........................................................................................... 2-15
       2.6.2 Vertical Alignment............................................................................................... 2-17
   2.7 Tooling Fixture Removal .................................................................................................. 2-19
   2.8 MotoMount Installation ................................................................................................... 2-20
       2.8.1 Preparation ......................................................................................................... 2-20
       2.8.2 Unpack and Assemble ........................................................................................ 2-20
       2.8.3 Securing MotoMount Drive Components onto Faceplate .................................. 2-22
       2.8.4 Retrofitting Tailstock Assembly ........................................................................... 2-22
Table of Contents

2.9 MotoMount Adjustments .................................................................................................. 2-23
  2.9.1 Allowable Misalignment ...................................................................................... 2-23
  2.9.2 Tooling Fixture Installation – MotoMount ............................................................. 2-24
  2.9.3 Tooling Fixture Removal ..................................................................................... 2-24
  2.9.4 Variable Tooling Size Accommodations ............................................................. 2-25

2.10 Conducting a Safety/Operation Check ........................................................................ 2-25

3 Wiring.................................................................................................................................... 3-1
  3.1 Grounding .................................................................................................................... 3-1
  3.2 Cable Connections ...................................................................................................... 3-1

4 Basic Specifications............................................................................................................ 4-1
  4.1 Positioner Assembly .................................................................................................. 4-1
    4.1.1 Positioner – Specifications .............................................................................. 4-1
  4.2 MotoMount™ ........................................................................................................... 4-3

5 Tooling Recommendations .................................................................................................. 5-1
  5.1 Headstock Only – Tooling Recommendations .......................................................... 5-1
    5.1.1 Customer-supplied Tooling Fixture .................................................................. 5-1
  5.2 Headstock/Tailstock with MotoMount ...................................................................... 5-3
    5.2.1 Customer-supplied Tooling Fixtures .................................................................. 5-3
    5.2.2 Multiple Tooling Fixtures .................................................................................. 5-3
    5.2.3 Specifications ...................................................................................................... 5-3

6 Maintenance and Troubleshooting..................................................................................... 6-1
  6.1 Maintenance Schedule ............................................................................................. 6-2
    6.1.1 General Cleaning ............................................................................................. 6-3
    6.1.2 Servomotor ...................................................................................................... 6-3
    6.1.3 Main (Sweep) Axis Reduction Gear Unit (RV–320E–X) ...................................... 6-3
    6.1.4 Setting (Sweep) Axis Backlash ....................................................................... 6-4
    6.1.5 Tooling Axis Reduction Gear Units (RV–320E) ................................................ 6-5
    6.1.6 Welding Ground System .................................................................................... 6-5
  6.2 Battery Pack Replacement .......................................................................................... 6-7
  6.3 Reset Headstock To Home Position .......................................................................... 6-8
    6.3.1 Homing ............................................................................................................. 6-8
# Table of Contents

6.4 Troubleshooting ............................................................................................................... 6-10
  6.4.1 Positioner ............................................................................................................. 6-10
  6.4.2 MotoMount .......................................................................................................... 6-10

7 Recommended Spare Parts .................................................................................................... 7-1

Appendix A ............................................................................................................................ A-1
  A.1 Performance Charts .................................................................................................... A-1
    A.1.1 Positioner Assembly .......................................................................................... A-1

Appendix B ............................................................................................................................ B-1
  B.1 Illustrated Parts list .................................................................................................... B-1
    B.1.1 Introduction ........................................................................................................ B-1
    B.1.2 Contents ............................................................................................................. B-1
    B.1.3 Parts List ........................................................................................................... B-1
    B.1.4 Symbols and Abbreviations ............................................................................. B-2

Appendix C ............................................................................................................................ C-1
  C.1 Glossary ...................................................................................................................... C-1
1 Introduction

1.1 About this Document

This manual provides the following information:

- **CHAPTER 1 – INTRODUCTION**
  Provides general information about the Positioner and components.

- **CHAPTER 2 – INSTALLATION**
  This chapter provides installation procedures.

- **CHAPTER 3 – WIRING**
  This chapter provides information concerning wiring and cable installation.

- **CHAPTER 4 – STANDARD SPECIFICATIONS**
  Provides general specifications that may be required during installation and setup.

- **CHAPTER 5 – TOOLING RECOMMENDATIONS**
  This chapter provides guidelines for customer-supplied tooling design.

- **CHAPTER 6 – MAINTENANCE AND TROUBLESHOOTING**
  This chapter provides preventive maintenance requirements and troubleshooting information.

- **CHAPTER 7 – RECOMMENDED SPARE PARTS**
  This chapter provides parts that is recommended to keep in stock.

- **APPENDIX A – PERFORMANCE CHARTS**
  This appendix provides performance charts for the MH3155 SIGMA-5 Positioner.

- **APPENDIX B – ILLUSTRATED PARTS LIST**
  This appendix contains the Illustrated Parts List (IPL). The IPL provides detailed views (with part numbers).

- **APPENDIX C – GLOSSARY**
  This appendix contains a list and terms that may be needed to know with this system.
1.2 System Overview

The MH3155 Positioner Assembly is available in two basic mechanical configurations:

- Headstock Positioner Assembly
- Headstock and Tailstock Positioner Assembly.

These assemblies are combined with the appropriate single or dual external axis control packages along with four meter cables to provide the complete Positioner kit. These assemblies do not have provisional safety switches that might be used to mute safeguarding. Therefore it is required that the Functional Safety Unit (FSU) be included in these assemblies.

1.2.1 Headstock Positioner Assembly

CAUTION

- If using your own Tailstock with a supplied Headstock assembly you must use the available MotoMount system from Yaskawa. Failure to do so will void the warranty.

The standard Headstock assembly provides precision controlled rotary motion utilizing an AC servo motor, a high ratio gear reducer with integral output bearing, faceplate, housing, and weld ground brushes. To ensure stability the Headstock is to be floor mounted or mounted to a machine base, as required for use in cantilevered stand-alone applications. The standard configuration provides:

- “Plug-and-Play” by using installation of the connectors on the housing for the motor control and safety circuits
- Leveling bolts

NOTICE

Suitable anchor bolts are required to work with the provided leveling bolts.

Fig. 1-1: MH3155 Headstock Positioner Assembly
1.2.2 Headstock and Tailstock Positioner Assembly

This Positioner Assembly integrates a Headstock (HS) with a Tailstock (TS) column and a MotoMount compliant tool mounting system. This system can be floor mounted or mounted to a machine base. The application determines the distance between the Headstock and Tailstock.

Fig. 1-2: Headstock and Tailstock Positioner Assembly

1.3 Reference Documentation

For additional information on individual components of the Positioner Assembly, refer to the following documentation that is included with the system:

- Motoman Manipulator Manuals
- Motoman Controller Manuals
- Motoman Operator's Manual for the application
- Motoman Controller Concurrent I/O Manual
- Vendor manuals for system components not manufactured by Yaskawa
1.4 Customer Support Information

If assistance is needed with any aspect of the system, please contact Customer Support at the following 24-hour telephone number:

(937) 847-3200

Customer Support also has an e-mail address for routine technical inquiries, to contact Customer Support through e-mail use the following address:

techsupport@motoman.com

When using e-mail to contact Customer Support, please provide a detailed description of the issue, along with complete contact information. Please allow approximately 24 to 36 hours for a response to the inquiry.

**DANGER**

- Maintenance and inspection must be performed by specified personnel.
  Failure to observe this caution may result in electric shock or injury.
- For disassembly or repair, contact your representative.
- Do not remove the motor, and do not release the brake.
  Failure to observe these safety precautions may result in death or serious injury from unexpected turning of the Manipulator's arm.

**NOTICE**

Use e-mail for routine inquiries only. If there is an urgent or emergency need for service, replacement parts, or information, contact Customer Support at the telephone number shown above.

Please have the following information ready before calling:

<table>
<thead>
<tr>
<th>Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioner</td>
<td>MH3155 SIGMA-5 Positioner</td>
</tr>
<tr>
<td>Software Version</td>
<td>Access this information on the Programming Pendant's LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - (VERSION)</td>
</tr>
<tr>
<td>Positioner Serial Number</td>
<td>Located on the Positioner data plate</td>
</tr>
<tr>
<td>Positioner Sales Order Number</td>
<td>Located on the Controller data plate</td>
</tr>
</tbody>
</table>
2 Installation

WARNING

• Sling applications and crane or forklift operations must be performed by authorized personnel only.

Failure to observe this caution may result in injury or damage.

• Never place any part of your body under a suspended load or move a suspended load over any part of another person's body.

A shifted or dropped load could result in serious injury or death.

• The Positioner must be installed by qualified personnel who are familiar with the installation and setup of this type of Positioner.

Failure to use a qualified personnel for installation and setup can result in serious injury or death.

• Always complete established safety procedures during installation of the Positioner.

Failure to use a qualified personnel and established safety procedures can result in severe injury or death.

CAUTION

• Installation of the MotoMount and the Positioner is not a task for the novice.

  – These components are not fragile, but should still be handled with care.

Rough handling can damage electronic components.

NOTICE

• These installation procedures are specifically developed for specially machine surface that enable these procedures to be successful.

• All anchoring hardware for the Positioner is supplied by the customer.

Refer to the “Robotic Equipment Installation and Lagging Requirements” and “Equipment Anchoring” as a reference.
2.1 Contents Confirmation

Confirm the contents of the delivery when the product arrives.

<table>
<thead>
<tr>
<th>NOTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notify shipping agent immediately if there is any shipping damage.</td>
</tr>
</tbody>
</table>

2.2 Materials Required

This section identifies customer-supplied items and tools required to complete installation.

2.2.1 Customer-Supplied Items

- Servo motion control unit
- Incoming power supply
- Two earth ground cables with two earth ground stakes

2.2.2 List of Tools

- Safety glasses
- Level
- Adjustable wrench set
- Hammer drill with appropriate concrete bits
- Forklift and/or overhead crane
- Open-end wrench set
- Wrench sets (standard and metric)
- Chalk String
2.3 Positioner Installation

**CAUTION**

- Do not start operating the Positioner or turn ON the power before it is firmly anchored.

The Positioner may overturn and cause injury or damage.

2.3.1 Site Preparation

**CAUTION**

- The floor should be strong enough to support the Positioner. Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Positioner. Make sure the thickness of the floor is 200mm or more because any thickness less than 200mm is insufficient for mounting, even if the floor is concrete. Before mounting the Positioner on the floor, check the flatness, cracks, etc. of the floor and repair before installing.

Shape of the Positioner may deform and its functional ability may be compromised.

- Make sure the floor flatness and level complies with ASTM E1155 code minimum values of $F_f$ of 20 and $F_l$ of 15.

If the flatness of the mounting face is insufficient, the shape of the Positioner may deform and its functional ability may be compromised.

- Consult with a licensed civil engineer if the strength or integrity of the floor is in question.

Not consulting a licensed civil engineer if there is any question concerning the strength or integrity of the floor can cause equipment damage.

Each Positioner assembly should be firmly mounted to a machine base or foundation rigid enough to withstand static and dynamic forces.
2.3.1.1 Location

**CAUTION**

• Install the Positioner in a location where the Positioner with a jig does not hit against anything such as the wall or the safeguarding.

Failure to observe this warning may result in injury or damage.

When the Positioner is installed, it is necessary to satisfy the following conditions:

• Ambient Temperature: 0° to +45°C
• Humidity: 20% to 80% RH (non-condensing)
• Free from dust, soot or water
• Free from corrosive gas or liquid, or explosive gas
2 Installation

2.3 Positioner Installation

• Free from excessive vibration (Vibration acceleration: 4.9m/s² [0.5G] or less)
• Free from large electrical noise (plasma)
• Make sure the flatness of the floor is within 10mm.
• Ensure appropriate space for equipment reviewing the Table 4-1 “Positioner Specifications” on page 4-1 and any other additional documentation as required.

2.3.2 Shipping Bolts

The Positioner is attached to a wooden shipping skid at the factory, prior to shipment to the customer. The customer is responsible for removing the Positioner from the shipping skid and inspecting for shipping damage.

Unbolt Headstock from the shipping skid using a 3/4-inch socket.

*Fig. 2-3: Unbolting Headstock from Shipping Skid*

NOTICE

Notify shipping contractor if there is any shipping damage.
2.3.3 Transporting

**WARNING**

- Sling applications and forklift operations must be performed by authorized personnel only.
  
  Failure to observe this caution may result in injury or damage.
  
- Never place any part of your body under a suspended load or move a suspended load over any part of another person's body.
  
  A shifted or dropped load could result in serious injury or death.

**CAUTION**

- Make sure the lifting device is rated for handling the weight of the equipment.
  
  - Refer to Table 4-1 “Positioner Specifications” on page 4-1 and any additional documentation included.
  
  If the handling equipment is not rated for handling the weight of the equipment damage can occur.
  
- Avoid excessive vibration or shock during transportation.
  
  - The system consists of precision components.
  
  Failure to observe this caution may adversely affect the performance.

To transport the Headstock remove the eight screws holding the top cover in place and remove. Once removed install the supplied eyebolts.
2.3.4 Mounting Positioner

2.3.4.1 Setting Headstock

Before proceeding, refer to the system layout drawings to ensure precise set up location.

*Fig. 2-4: Floor Mounting*
Refer to Fig. 2-5 and proceed as follows:

1. Use leveling bolt holes as a guide and transfer the hole locations to the concrete.

**CAUTION**

- The floor should be strong enough to support the Positioner. Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Positioner. Make sure the thickness of the floor is 200mm or more because any thickness less than 200mm is insufficient for mounting, even if the floor is concrete. Before mounting the Positioner on the floor, check the flatness, cracks, etc. of the floor and repair before installing.

Shape of the Positioner may deform and its functional ability may be compromised.

- Make sure the floor flatness and level complies with ASTM E1155 code minimum values of Ff of 20 and Fi of 15.

If the flatness of the mounting face is insufficient, the shape of the Positioner may deform and its functional ability may be compromised.

- Consult with a licensed civil engineer if the strength or integrity of the floor is in question.

Not consulting a licensed civil engineer if there is any question concerning the strength or integrity of the floor can cause equipment damage.

2. Install anchors per the manufactures instructions.
3. Install a leveling shim at each anchor location and reset the column assembly.
4. Screw each leveling bolt down until it just contacts the leveling shim and hand tighten the anchor bolts or nuts.

*Fig. 2-5: Leveling Hardware*
2.3.4.2 Leveling the Headstock

The Headstock must be leveled in two directions:

- Parallel to the faceplate
- Perpendicular to the faceplate.

Since it only takes three points to define a plane, use only three of the four leveling bolts to level the Positioner.

**NOTICE**

Make sure to use the same three leveling bolts throughout each process. The other leveling bolt will be used as an anchor.

Before proceeding, make sure that the Headstock is in the proper place. Make sure a leveling bolt, lock-nut, and leveling shim is installed in each column base hole.

- **To level the Headstock assembly axially, proceed as follows:**
  1. Place a level on top of the housing, perpendicular to the faceplate.
  2. Use the two leveling bolts beneath the faceplate (A and B), and a third beneath the motor (C) to level axially. If the faceplate side needs adjustment, A and B must be turned equally.

- **To level the Headstock assembly cross-axially, proceed as follows:**
  1. Place a level on top of the housing, parallel to the faceplate.
  2. Use the same three leveling bolts used above and adjust them until the level is balanced, adjusting B + C equally.
  3. Repeat the axial and cross-axial leveling steps until level readings are achieved in both directions.
  4. Drive the remaining leveling bolt down to leveling shim.
  5. Check level axially and cross-axially again. When level, tighten the anchor system (customer-supplied) to the specified torque.
  6. Tighten the four lock-nuts to the column base.
2.3.4.3 Setting Tailstock

**CAUTION**

- The floor should be strong enough to support the Positioner. Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Positioner. Make sure the thickness of the floor is 200mm or more because any thickness less than 200mm is insufficient for mounting, even if the floor is concrete. Before mounting the Positioner on the floor, check the flatness, cracks, etc. of the floor and repair before installing.

Shape of the Positioner may deform and its functional ability may be compromised.

- Make sure the floor flatness and level complies with ASTM E1155 code minimum values of Ff of 20 and FI of 15.

If the flatness of the mounting face is insufficient, the shape of the Positioner may deform and its functional ability may be compromised.

- Consult with a licensed civil engineer if the strength or integrity of the floor is in question.

Not consulting a licensed civil engineer if there is any question concerning the strength or integrity of the floor can cause equipment damage.

To set the Tailstock assembly onto a cell base or floor, proceed as follows:

1. Ensure the proper position for the Headstock assembly per system layout. The Headstock must permanently anchored to the floor/base.

2. Using a carpenter’s chalk string, strike a chalk line on the floor from the edge of the Headstock base towards location of the Tailstock.

![Fig. 2-6: Strike Chalk Line](image)

3. Position the Tailstock on the floor across from the Headstock.
2.3 Positioner Installation

4. Use the chalk line and the center line of each component as guides for placement of the Tailstock column on the floor.

**NOTICE**

Keeping the center line of each component aligned is not critical. However, the closer the bearings of both components are aligned with one another, the greater the degree of misalignment allowed with other system components.

5. To position the Tailstock accurately on the bearing center line, make two measurements from the Tailstock base to the chalk line and adjust the base as necessary.

*Fig. 2-7: Tailstock Placement*

---

2.3.4.4 Leveling Tailstock

The Tailstock must be leveled in two directions, axially and cross-axially. Since it only takes three points to define a plane, use only three of the four leveling bolts to level the system. It is important to consistently use the same three leveling bolts throughout each process. The fourth leveling bolt will be used as an anchor only.

Before proceeding, make sure that the Tailstock is in the proper location. Make sure a leveling bolt, lock-nut, and leveling shim is installed in each column base hole.

*Fig. 2-8: Leveling the Tailstock*
To level the Tailstock assembly axially, proceed as follows:
1. Place a level on top of the Tailstock column in the axial direction.
2. Use the leveling bolts A, B, and C to adjust the axial level. Adjust bolts A and B equally.

To level the Tailstock assembly cross-axially, proceed as follows:
1. Place a level on top of the Tailstock in the cross-axial direction.
2. Use the same three leveling bolts used above and adjust them until the level is balanced, adjusting B and C equally.
3. Repeat the axial and cross-axial leveling steps until level readings are achieved both directions.
4. Drive the fourth leveling bolt down to the leveling shim.
5. Check level axially and cross-axially again. When level, tighten the anchoring system (customer supplied) to the specified torque.
6. Tighten the four lock-nuts to the column base.

2.3.4.5 Allowable Misalignment

The flexibility of MotoMount allows for a misalignment between the Tailstock and the tooling fixture without affecting performance. A misalignment of 0.5 degrees is allowed. If the Tailstock is out of alignment more than 0.5 degrees, adjust the Tailstock using the Tailstock leveling bolts.

Fig. 2-9: Allowable Axial Leveling - Side View
2.4 Tooling Fixture Installation

2.4.1 Initial Installation

The initial tooling installation is required prior to the Headstock/Tailstock alignment procedure.

1. Make sure tooling mounting holes and locating pin are pointing up.

```
NOTICE
If tooling mounting holes and locating pin are not pointing up remove the MotoMount drive components and re-install in the proper orientation.
```

```
WARNING
• Make certain servo power is OFF for the remainder of the removal. Not making sure servo power is OFF can cause serious operator injury and/or equipment damage may result.
```

2. Use a suitable lifting device to position the tooling above the Headstock/Tailstock assemblies.

3. Slowly lower tooling fixture while aligning with the Headstock and Tailstock locating pins.

```
Fig. 2-10: Tooling Fixture Installation - Headstock/Tailstock
```

4. Continue lowering the tooling until the hoisting straps are loose.

5. Secure the tooling to the drive assembly with customer supplied M12, grade 8.8 (or better) bolts and hardened washers. Eight hardened washers are included with the MotoMount kit for this purpose.

6. Remove the hoisting straps.
2.4.2 Normal Installation

1. Jog the Headstock until MotoMount is horizontal. The tooling mounting holes and locating pin must be pointing up.

   ![WARNING]

   • Make certain servo power is OFF for the remainder of the removal. Not making sure servo power is OFF can cause serious operator injury and/or equipment damage may result.

2. Turn servo power OFF.

3. Use a suitable lifting device to position the tooling above the Headstock assembly.

4. Slowly lower one side of the tooling fixture onto the Headstock using the locating pin.

5. Install the M12 tool mounting bolts and washers onto the Headstock (customer-supplied grade 8.8 bolts), and torque the bolts to 76N•m.

2.5 Installation of Safeguarding

   ![WARNING]

   • Install all safeguarding. Failure to observe this warning may result in injury or damage.

To insure safety, be sure to install safeguarding. With the safeguards installed it helps prevent unforeseen accidents with personnel and damage to equipment. Quoted for information and guidance is section 2.5.1.

2.5.1 Responsibility for Safeguarding (ISO10218)

The user of a Manipulator or robot system ensures that safeguards are provided and used in accordance with Sections 6, 7 and 8 of this standard. The means and degree of safeguarding, including any redundancies, shall correspond directly to the type and level of hazard presented by the robot system consistent with the robot application. Safeguarding may include but not be limited to safeguarding devices, barriers, interlock barriers, perimeter guarding, awareness barriers, and awareness signals.

2.6 Final Alignment Check

The MotoMount system helps reduce the load on bearings due to tooling fixture misalignment with the Headstock and Tailstock. However, optimum performance is achieved when the alignment is as close as possible. Horizontal and vertical misalignment is possible. Both the horizontal and vertical alignment procedures require the measurement of the same gap on the MotoMount drive components. A tooling fixture must be installed to align the system.
2.6 Final Alignment Check

2.6.1 Horizontal Alignment

Check the horizontal alignment by measuring the gap (see Fig. 2-11 “Measurement Point for Horizontal Alignment, Bottom View ” on page 2-16) between the mounting fixture and mounting block. The measurement of this gap must not change more than 1 mm after the Headstock is rotated 180 degrees. To check the MotoMount’s horizontal alignment, proceed as follows:

1. Jog the Positioner until MotoMount is horizontal.

   **NOTICE**

   The alignment procedure may be easier if the weld ground cable is removed.

2. Using calipers, measure the alignment gap.

   **NOTICE**

   It is important to measure the alignment gap at the same location. This will ensure proper alignment.

3. Rotate the Positioner 180 degrees.

4. Measure the alignment gap at the second position. If the gaps differ by more than 1mm, the horizontal alignment must be adjusted. Use the following procedure to adjust horizontal alignment:

   a) Calculate the average gap between the two positions, by adding both measurements together and dividing by two.

   b) Loosen the bearing mounting bolts and move the Tailstock bearing housing towards the direction of the larger gap until the gap is at the average value.

   c) Ensure the bearing housing is perpendicular to the Tailstock adapter within 1/2 degree (a visual check with a square is acceptable).

   d) Repeat this process until the gap at both positions is within 1mm.

   **NOTICE**

   If moving the bearing housing cannot provide the desired results, the columns are out of basic alignment and must be repositioned.

   e) Tighten the bearing mounting bolts to 76N•m (56lbf-ft).
2 Installation

2.6 Final Alignment Check

Fig. 2-11: Measurement Point for Horizontal Alignment, Bottom View
2.6.2 Vertical Alignment

MotoMount must be at a vertical position to check the vertical alignment.

*Fig. 2-12: Vertical Position - Drive Bushing on Bottom*

The vertical alignment is checked by measuring the gap between the mounting fixture and mounting block. The measurement of this gap must not change more than 1mm after the Headstock is rotated 180 degrees.

To align MotoMount vertically, proceed as follows:

1. Jog the Positioner to vertical position until the drive bushing is at the bottom.
2. Using calipers, measure the alignment gap.
3. Rotate the Positioner 180 degrees until the drive bushing is at the top.
4. Measure the alignment gap at the second position. If the gaps are different by more than 1mm, the vertical alignment must be adjusted. Use the following procedure:
   a) Calculate the average gap between the two positions by adding both measurements together and dividing by two.
   b) If the first measurement (with drive bushing at the bottom) is greater than the second measurement, the Headstock must be raised until the gap is at the average gap value.

**NOTICE**

It is important to measure the alignment gap at the same location. This will ensure proper alignment.
2 Installation
2.6 Final Alignment Check

c) Raise the Headstock by making equal clockwise turns on the Headstock leveling bolts.

**NOTICE**

If the first measurement (with drive bushing at the bottom) is less than the second measurement, the Tailstock must be raised until the gap is at the average gap value. Raise the Tailstock by making equal clockwise turns on the Tailstock leveling bolts.

**Fig. 2-13: Vertical Position - Drive Busing on Top**

![Diagram of vertical position with drive bushing on top]

**NOTICE**

If multiple attempts fail to reduce the gap difference below 1 mm, contact Customer Support.

d) Recheck the alignment gap and verify that both gaps are within 1mm.

e) Recheck the horizontal alignment.

f) Insure ground cable is installed and properly secured.

g) When horizontal and vertical alignment is complete, ensure all bolts are tightened to the appropriate torque, including Tailstock bearing mounting bolts.
2.7 Tooling Fixture Removal

1. Jog the Headstock until the MotoMount is horizontal, with the tool mounting bolts and locating pin pointed up.

2. Turn servo power OFF.

3. Position a suitable lifting device and hoisting straps above the tooling. Attach the hoisting straps to the tooling fixture.

4. Remove the tool fixture mounting bolts and Tailstock bearing cap.

5. Slowly lift the tooling fixture off the Headstock/Tailstock assemblies.

**WARNING**

- Make certain servo power is OFF for the remainder of the removal. Not making sure servo power is OFF can cause serious operator injury and/or equipment damage may result.
2.8 MotoMount Installation

2.8.1 Preparation
Successful installation requires the MotoMount drive components be firmly mounted to the Headstock faceplate. Before installation, ensure the faceplate is clean and is not warped or deformed.

2.8.2 Unpack and Assemble
The MotoMount system will be shipped in a box with the following components (unless it is part of a larger system):

- MotoMount drive components
- Dowel pins (2)
- Mounting hardware
- Weld ground cable

Carefully remove plastic wrapping from components and inspect them for shipping damage.

**NOTICE**
Notify shipping contractor if there is any shipping damage.

2.8.2.1 Installing Fixture Dowel Pins
The dowel pins must be installed into the back of the mounting block before the assembly is mounted onto the faceplate. There are four holes in the back of the mounting block. See Fig. 2-14 to determine which holes to use for your application. If your Headstock faceplate does not have the matching dowel holes, it must be modified per the following template.

*Fig. 2-14: MotoMount Mounting Hole Pattern*
To install the dowel pins, proceed as follows:

**CAUTION**

- Handle the MotoMount components carefully. Not handling equipment carefully can result in equipment damage.

1. Use a small, 3mm thick metal spacer (a 1/8-in. thick washer will work) to transfer the press force from the mounting block to the fixture block.

2. Place the spacer between the mounting block and the fixture block so that it is located behind the appropriate dowel hole.

3. Use an arbor press to force the dowel pins into the appropriate dowel pin hole in the mounting block. It is important that the dowel pin is pressed in as far as possible.

4. Relocate the spacer behind the other dowel hole and install the second dowel pin.

5. After the dowel pins are inserted properly, remove the spacer.

The MotoMount drive components are now ready to install onto the faceplate.

*Fig. 2-15: Dowel Pin Installation*
2.8.3 Securing MotoMount Drive Components onto Faceplate

Use the previously inserted dowel pins to locate the exact position for the MotoMount drive components to the faceplate. To mount the fixture block onto the faceplate, proceed as follows:

1. Jog the face plate to the Home position.
2. Align the previously installed dowel pins with the proper holes in the faceplate and push fixture block in as far as possible.
3. Insert both mounting bolts through the fixture block and tighten into the faceplate holes. Torque bolts to 76N•m (56lbf-ft.).
4. Install the ground cable with one lug secured to the fixture block. Use the fixture block hole nearest to the drive bushing. The other lug is secured to the appropriate hole in the Headstock face plate.

Fig. 2-16: MotoMount Fixture Installation

2.8.4 Retrofitting Tailstock Assembly

Remove old Tailstock and replace with new.
2.9 MotoMount Adjustments

The MotoMount components are delivered assembled to the Headstock and Tailstock assemblies. See section 2.3.4.3 for installation of the Headstock and Tailstock assemblies.

Fig. 2-17: Nominal Center Position - Side View

2.9.1 Allowable Misalignment

The flexibility of MotoMount allows for misalignment between the Tailstock and the tooling fixture without affecting performance. A total misalignment (combined tooling and Headstock/Tailstock) up to two degrees, from top view is permissible. If misalignment exceeds two degrees, check tooling and/or position of Tailstock.

Fig. 2-18: Allowable Misalignment - Top View
### 2.9.2 Tooling Fixture Installation – MotoMount

Both the Headstock and Tailstock must be permanently anchored to the floor and leveled prior to installation of the tooling fixture.

1. Jog the Headstock until MotoMount is horizontal. The tooling mounting holes and locating pin must be pointing up.

   ![WARNING]
   
   * Make certain servo power is OFF for the remainder of the installation. Not ensuring servo power is OFF can result in serious operator injury and/or equipment damage.

2. Turn servo power OFF.

3. Use a suitable lifting device to position the tooling above the Headstock assembly.

4. Slowly lower one side of the tooling fixture onto the Headstock using the locating pin.

5. Install the M16 tool mounting bolts and washers onto the Headstock (customer-supplied grade 8.8 bolts), and torque the bolts to 190N•m (140lbf-ft). Hardened washers are recommended.

6. Slowly lower tooling fixture onto the Tailstock using the locating pin.

7. Install the M16 tool mounting bolts and washers onto the Tailstock (customer-supplied grade 8.8 bolts), and torque the bolts to 190N•m (140lbf-ft). Hardened washers are recommended.

8. Remove the hoisting straps.

### 2.9.3 Tooling Fixture Removal

1. Jog the Headstock until the MotoMount is horizontal, with the tool mounting bolts and locating pin pointed up.

   ![WARNING]
   
   * Make certain servo power is OFF for the remainder of the removal. Not ensuring servo power is OFF can result in serious operator injury and/or equipment damage.

2. Turn servo power OFF.

3. Position a suitable lifting device and hoisting straps above the tooling. Attach the hoisting straps to the tooling fixture.

4. Remove the tool fixture mounting bolts and Tailstock bearing cap.

5. Slowly lift the tooling fixture off the Headstock/Tailstock assemblies.
2.9.4 Variable Tooling Size Accommodations

The MotoMount system can adapt to small variations in tooling fixture lengths without changing the Tailstock performance or permanent location. Two steps can be taken to adjust the tooling fixture distance.

2.9.4.1 Changing Adapter Shaft Position

The preferred way to change the adapter shaft position is to simply slide the Tailstock adapter either way along the adapter shaft. If more adjustment is needed, loosen the four Tailstock bolts and slide the adapter shaft and the Tailstock adapter until a suitable position is acquired. These two processes do not effect MotoMount’s performance. It is important that a minimum distance is maintained between the Tailstock adapter and the top of the Tailstock column.

Fig. 2-19: Adapter Shaft Position

2.9.4.2 Reinstalling the Adapter Shaft

Once the new position for the adapter shaft is found, torque the Tailstock bolts to 350N•m (259lbf-ft.).

2.10 Conducting a Safety/Operation Check

Before operating either Positioner take a few minutes to perform a safety/operation check. To perform a safety/operation check, proceed as follows:

1. Check that all cable connections are tight.
2. Verify the Headstock and Tailstock are level and parallel.
3 Wiring

3.1 Grounding

Follow the local regulations and electrical installation standards for grounding. The recommended grounding wire size is 10ga (5.5mm²) or more.

WARNING

- Ground resistance must be 100 ohms or less.
Failure to observe this warning may result in fire or electrical shock.

- Before wiring make sure to turn OFF the primary power supply and put up a warning sign. (For example “DO NOT TURN ON THE POWER)
Failure to observe this warning may result in fire or electrical shock.

- Wiring must be performed by authorized or certified personnel.
Failure to observe this warning may result in fire or electrical shock.

NOTICE

Never use this line sharing with other ground lines or grounding electrodes for other electric power, motor power, welding devices, etc.
Where metal ducts, metallic conduits, or distributing racks are used for cable laying, ground in accordance with Electric Equipment Technical Standards.

3.2 Cable Connections

Do not connect the encoder, power, and ground cables until after the drive assembly is securely in place.

When the Positioner assembly is normally delivered with a Manipulator, and Controller Refer to the system manual and separate schematics and/or documentation specific to the system.
4 Basic Specifications

4.1 Positioner Assembly

The Positioner drive assembly consist of an AC servo motor and gear reducer with an integral output bearing mounted in a housing. Weld ground brushes are included as standard features. The drive assembly provides a programmable motion about the central axis, and endless rotation can be purchased as an option. Holes in the faceplate provide for mounting of the MotoMount drive components or parts fixtures in stand-alone (cantilevered) applications.

4.1.1 Positioner – Specifications

See Table 4-1 for the Positioner specifications.

CAUTION

- Do not operate outside the standard setup, without Yaskawa approval.

Working outside the standard setup may change E-Stop performance and void the warranty.

Table 4-1: Positioner Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit of Measure</th>
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<td>Rotation</td>
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<tr>
<td>Rated Load</td>
<td>kgf</td>
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<tr>
<td>Max MHT Load @ CG Off Center</td>
<td>kgf@mm</td>
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<tr>
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<td>180 Degree Sweep Time</td>
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<tr>
<td>Rated CG Off Center</td>
<td>mm</td>
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<tr>
<td>Rated CG Overhang</td>
<td>mm</td>
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<tr>
<td>Load @ 500 mm CG Overhang</td>
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<tr>
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<tr>
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<td>Nm</td>
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<tr>
<td>Rated Weld Current (Std/Optional)</td>
<td>Amps</td>
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<tr>
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<tr>
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<tr>
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**Table 4-1: Positioner Specifications (Continued)**

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<tr>
<td>Tailstock Dimensions</td>
<td>mm 1083 x 375 x 750</td>
</tr>
<tr>
<td>Tailstock Assy Weight</td>
<td>kg 142</td>
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</tbody>
</table>

* External axis default settings
4.2 MotoMount™

The MotoMount is a flexible tool fixture mounting system which improves tool repeatability and reduces loads on the Headstock/tailstock bearing systems. It accommodates for a combined Headstock/tailstock/tooling misalignment of up to two degrees.

A MotoMount is required for use with all Positioners. The MotoMount drive components are mounted onto the Headstock faceplate.

Fig. 4-20: MotoMount Layout
Installation of the tooling and fixtures should be performed by personnel who are familiar with the operation of this system. Tooling and fixtures are supplied by the customer.

There are two system configurations possible with the Positioner:

- Headstock Only
- Headstock and Tailstock with MotoMount.

To ensure optimal performance from the Positioner tooling system, Yaskawa makes the following recommendations for each configuration.

### 5.1 Headstock Only – Tooling Recommendations

The stand-alone Headstock assembly provides the only support for tooling and production parts. Proper tooling design directly affects the Headstock performance and longevity.

#### 5.1.1 Customer-supplied Tooling Fixture

The customer-supplied tooling hangs from the faceplate as it supports production parts for welding. Customers control/change the design of tooling fixtures to match the design of the production parts.

#### 5.1.1.1 Recommendations

To ensure optimum performance from the customer-supplied tooling fixture, please read the following recommendations:

- Use all bolt holes on the faceplate to mount the tooling fixture.
- Use the dowel pins.
5.1.2 Mounting Holes – Faceplate

**CAUTION**

To properly secure fixture, rated loads require the use of all M16 mounting holes.

The customer-supplied tooling must be designed to fit the Positioner faceplate mounting holes. See Fig. 5-21 for the faceplate mounting hole pattern.

*Fig. 5-21: Mounting Holes on Faceplate*
5.2 Headstock/Tailstock with MotoMount

5.2.1 Customer-supplied Tooling Fixtures

With MotoMount, the customer-supplied tooling fixture bridges the Headstock and tailstock together as it supports production parts for welding. Customer design their tooling fixtures to fit their specific needs. Modifications to existing tooling fixtures will be minimal as long it fits the current Headstock/tailstock configuration (retrofit application).

5.2.2 Multiple Tooling Fixtures

Some applications require multiple tooling fixtures that are switched in and out of the Positioner as production needs change. To prepare these extra fixtures to work with MotoMount, the following spare parts are needed:

- Bearing adapter
- Bearing

Contact Customer Support, to purchase these parts.

5.2.3 Specifications

To ensure that the customer-supplied tooling fixture fits properly to MotoMount, the following specifications must be met.

5.2.3.1 Parallelism

Inspect both mounting flanges for parallelism to one another. The combined angle of misalignment for both flanges should not exceed 1/2 degree (Fig. 5-22).

*Fig. 5-22: Tooling Fixture Inspection*
5.2.3.2 Hole Pattern on MotoMount

The tooling fixture flange that attaches to MotoMount must have the following hole pattern (Fig. 5-23).

*Fig. 5-23: Tooling Template - MotoMount*

5.2.3.3 Headstock Flange Specifications

*Fig. 5-24: Drive Component Clearance - MotoMount*
5.2.3.4 Tailstock Flange Specifications

*Fig. 5-25* shows the specifications for the tooling fixture flange that is secured to the MotoMount tailstock adapter.

*Fig. 5-25: Tailstock Adapter - MotoMount*

5.2.3.5 Auxiliary Mounting Holes – MotoMount

To further secure the tooling fixture, there are two auxiliary mounting holes *Fig. 5-26* on the face of the MotoMount tooling adapter. These auxiliary mounting holes are for added security only. Do not use the auxiliary mounting holes for the primary tooling support.

Center shaft clearance required on the tooling fixture when using auxiliary mounting holes on the Headstock are shown in *Fig. 5-24*. Center shaft clearance required when using auxiliary mounting holes on the tailstock are shown in *Fig. 5-26*.
6 Maintenance and Troubleshooting

Maintenance of the Positioner components should be performed only by authorized personnel who are familiar with the design and construction of this Positioner. The following procedures should be performed only as needed. Read through the instructions completely before performing any maintenance procedure. Be sure to understand the procedure, have the proper tools, and observe all applicable safety precautions.

**WARNING**

- Before maintenance or inspection, be sure to turn OFF the main power supply, and put up a warning sign. (ex. DO NOT TURN THE POWER ON.)

Failure to observe this warning may result in electric shock or injury.

**CAUTION**

- Maintenance and inspection must be performed by specified personnel.

Failure to observe this caution may result in electric shock or injury.

- For disassembly or repair, contact a Yaskawa representative.

Failure to observe this caution may result in electric shock or injury.

- Do not remove the motor or release the brake.

Failure to observe this caution may result in injury from unexpected turning of the Positioner.

**NOTICE**

The motor and reducer are not recommended for field service. The unit should be returned to Yaskawa Motoman for repairs to these components.
6 Maintenance and Troubleshooting

6.1 Maintenance Schedule

Proper maintenance is essential not only to assure that the equipment will be able to function for a long period, but also to prevent malfunctions and assure safe operation.

Table 6-1: Maintenance Schedule

<table>
<thead>
<tr>
<th>Inspection Item</th>
<th>Frequency</th>
<th>Inspection Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical damage</td>
<td>Daily</td>
<td>Check for physical damage; this indicates a load collision and is evidence of misuse.</td>
</tr>
<tr>
<td>Excessive or unusual noise</td>
<td>Daily</td>
<td>Listen for grinding, excessive or irregular noise. Contact Customer Support.</td>
</tr>
<tr>
<td>Motomount</td>
<td>Daily</td>
<td>Verify tooling bolts are tight.</td>
</tr>
<tr>
<td>Weld Brushes</td>
<td>Weekly</td>
<td>Check for dirt and ensure full contact with faceplate.</td>
</tr>
<tr>
<td>Cleaning</td>
<td>As required</td>
<td>Clean with dry cloth or compressed air.</td>
</tr>
<tr>
<td>Positioner Axis Motor Connectors</td>
<td>• 1,000 H</td>
<td>Check for loose connections. tighten if necessary.</td>
</tr>
<tr>
<td></td>
<td>• 6,000 H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 12,000 H</td>
<td></td>
</tr>
<tr>
<td>Position Axis Speed Reducer and Gear</td>
<td>6,000 H</td>
<td>Grease with Yaskawa P/N 132412-1, Molywhite RE00</td>
</tr>
<tr>
<td>Tailstock Main Sweep Axis Bearing</td>
<td>Monthly</td>
<td>Grease with Yaskawa P/N 180144-1, Mobil CM-P, Lithium Complex. Apply grease with a grease gun thru the two grease fittings on each side. Apply five squeezes of the grease gun lever (approximately 2@ 1.25g x 5).</td>
</tr>
<tr>
<td>Motomount Bearing</td>
<td>Monthly</td>
<td>Grease with Yaskawa P/N 180144-1, Mobil CM-P, Lithium Complex. Apply grease with a grease gun thru the two grease fittings on each side. Apply five squeezes of the grease gun lever (approximately 2@ 1.25g x 5).</td>
</tr>
</tbody>
</table>

NOTICE

The inspection interval depends on the total servo operation time.
For axes which are used very frequently other than arc welding, it is recommended that inspections be conducted at shorter intervals. Contact your Yaskawa representative.

Table 6-2: Inspection Parts and Grease Used

<table>
<thead>
<tr>
<th>No.</th>
<th>Grease Used</th>
<th>Yaskawa Part Number</th>
<th>Inspected Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moly-White RE00</td>
<td>132412-1</td>
<td>Speed reducers of all axes.</td>
</tr>
<tr>
<td>2</td>
<td>Mobil CM-P, Lithium Complex</td>
<td>180144-1</td>
<td>Tailstock swingarm main axis bearing and motomount bearing.</td>
</tr>
</tbody>
</table>
6 Maintenance and Troubleshooting

6.1 Maintenance Schedule

6.1.1 General Cleaning

The Positioner requires only occasional cleaning to remove dust and welding by-products. Use compressed air or vacuum, and a bristle brush (if required).

**NOTICE**

Yaskawa recommends application of a corrosion/rust preventive compound to tooling fixtures located in a high humidity environment.

6.1.2 Servomotor

The SIGMA 5 servomotors (1 sweep axis, 2 tooling plate axis) are sealed units and have no parts that need inspection or replacement on a regular basis. Do NOT disassemble a SIGMA 5 servomotor. If suspecting that the servomotor requires maintenance or overhaul, contact Customer Support (refer to section 1.4 “Customer Support Information” on page 1-4).

6.1.2.1 Battery Pack Replacement

If a battery alarm occurs in the Controller, replace the battery according to the following procedure.

**CAUTION**

- Do not remove power from the main power supply.

Removing the main power while removing the battery pack in the Positioner will cause the encoder to lose its memory.

1. Locate the battery that needs to be replaced.

**NOTICE**

The battery pack is attached to the motor located in the Headstock of the Positioner.

2. Remove the battery pack from the motor.

3. Remove the new battery pack into the Encoder Battery Pack assembly.

4. Install the new battery pack into the Encoder Battery Pack assembly.

5. Install the new battery pack into the motor.

6.1.3 Main (Sweep) Axis Reduction Gear Unit (RV–320E–X)

The main (sweep) axis Reduction Gear Unit (RV–320E–X) is located on the Main Drive Housing Assembly. This unit is sealed and contains no parts that need inspection or replacement on a regular basis. Do NOT disassemble the reduction gear unit or remove it from its associated AC servomotor. If suspecting the Reduction Gear Unit requires maintenance or an overhaul, contact Yaskawa Customer Support (refer to section 1.4 “Customer Support Information” on page 1-4).
6.1.4 Setting (Sweep) Axis Backlash

The backlash between the drive pinion and the ring gear needs to be set at 0.110mm to 0.140mm. Setting the backlash requires adding or removing shims under the sweep axis motor assembly. An indicator gauge needs to be positioned to measure the pitch line movement of the meshing gears. The actual measurement is the free movement of the gears.

Set the backlash at the high spots of both gears. The ring gear is marked with paint and 3 x 0's on the teeth, while the pinion is marked on the face with three center punch marks.

If tooling is present on the Positioner, rotate the Positioner to have the motor at the top (B side at operator) and block both sides to prevent movement. Position the first indicator to measure the pinion gear pitch line movement. Position a second indicator to the swing arm and touch the ring gear pitch line. With the teach pendant, rotate the S1 motor in single pulse mode, and measure the movement of the pinion gear until there is movement of the ring gear.

When backlash is set re-torque the bracket retaining bolts and re-check the lash. Torque of the retaining bolts to 490Nm.
6.1.5 Tooling Axis Reduction Gear Units (RV–320E)

Two Reduction Gear Units (RV–320E) are located in the Tooling Drive Swingarm Assembly, one for each tooling plate. These units are sealed and contain no parts that need inspection or replacement on a regular basis.

Do NOT disassemble the reduction gear unit or remove it from its associated AC servomotor. If suspecting the Reduction Gear Unit requires maintenance or an overhaul, contact Yaskawa Customer Support (refer to section 1.4 “Customer Support Information” on page 1-4).

6.1.6 Welding Ground System

6.1.6.1 Inspection and Cleaning of Carbon Brushes

Inspect the ground brushes where they contact the rear of tooling drive plates. Make sure that the contact area is clean and free of dust and welding by-products. Use compressed air and a small bristle brush to clean the ground brushes where they contact the tooling plates.

**NOTICE**

Always ensure that welding ground connections and brushes in the Positioner are clean and tight. If the ground points are not properly made and kept clean and secure, high welding currents can bypass the normal return path and, instead, pass through the drive components of the Positioner. This is especially hard on Positioner drive bearings when they are under load. High welding current, if allowed to pass through the drive components, can result in increased bearing wear and premature replacement.

6.1.6.2 Weld Ground Brush Replacement

To replace the grounding brush(s) proceed as follows:

1. Shut down cell using main disconnect.
2. Remove the back panel of the Headstock assembly.
3. Use a flathead screwdriver to disconnect the brush cable(s) from the ground post (*Fig. 6-1*).

*Fig. 6-1: Brush Cable Post*
4. Release the spring tensioner on the brush by squeezing both spring levers and pulling away from the faceplate.

5. Slide the old brush out of the housing and replace it with the new one.

*Fig. 6-2: Brush Assembly*

6. Squeeze the brush retaining spring and push the brush against the faceplate then release. The spring must hold the brush firmly against the face plate (*Fig. 6-2*).

7. Insert the ground cables onto the ground posts.

---

### CAUTION

- The weld ground brush must be held firmly and evenly against the faceplate. Uneven contact can subject the gear reducer bearing to weld current.

---

### NOTICE

Ground cable connections must be clean and tight. A loose or dirty connection can cause excess heat (high resistance connection) or arcing. Either of these conditions can damage the cable and cable connection point.
6.2 Battery Pack Replacement

**CAUTION**

- Do not remove power from the main power supply.

Removing the main power while removing the battery pack in the Positioner will cause the encoder to lose its memory.

1. Locate the battery that needs replaced.

**NOTICE**

The battery packs are attached to the three motors located in the swingarm of the Positioner.

2. Remove the battery pack from the motor.
3. Remove the new battery pack into the Encoder Battery Pack assembly.
4. Install the new battery pack into the Encoder Battery Pack assembly.
5. Install the new battery pack into the motor.

*Fig. 6-3: Battery Replacement*
6.3 Reset Headstock To Home Position

The home position on the drive assembly is set in the Controller by the operator. Any position of the Headstock can be programmed as home. The factory setting of home position is found using the alignment hole, an alignment tool, and the programming pendant.

Resetting of the home position is typically done before new tooling and fixturing is installed, or when the motor has been serviced.

6.3.1 Homing

The factory home position is located by aligning two homing pins after installing them into holes in the faceplate and housing. Once both pins are aligned, some minor programming with the programming pendant is required. To reset the Headstock, proceed as follows:

1. Make sure Manipulator(s) is in home position.
2. Locate the Headstock homing hole. Using the programming pendant in TEACH mode, jog the faceplate slowly until the faceplate homing hole is just below to the Headstock homing hole.
3. Install the faceplate homing pin through the faceplate homing hole in the faceplate. The pin may need to be tapped in with a hammer.
4. Install the Headstock homing pin through the Headstock homing hole in the Headstock. The pin may need to be tapped in with a hammer.
5. Slowly jog the faceplate until faceplate homing pin just touches the Headstock homing pin (Fig. 6-4) on the housing. If you go too far both pins will bend, causing an inaccuracy. Slowly jog the faceplate in reverse rotation until the both pins are straight and still touching each other.

Fig. 6-4: Home Position
6. Switch the Programming Pendant to MAINTENANCE mode and proceed:
   - Press [TOP MENU] key on programming pendant.
   - Cursor to ROBOT and press [SELECT].
   - Cursor to HOME POSITION and press [SELECT].
   - Press the [PAGE OVER] key to the desired station (indicated in the top right corner).
   - Make sure the Headstock is in the position that you want to teach as home and press [SELECT].
   - Cursor to (YES) and press [SELECT]. The Headstock is now reset to zero.

7. Remove both alignment pins from the faceplate Headstock.
6.4 Troubleshooting

6.4.1 Positioner

Table 6-3: Troubleshooting

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Probable Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor does not start</td>
<td>Loose connection</td>
<td>Check all wire connections.</td>
</tr>
<tr>
<td></td>
<td>Incorrect wiring</td>
<td>Check that system has been wired correctly.</td>
</tr>
<tr>
<td></td>
<td>Overload</td>
<td>Reduce load or reduce unbalanced load.</td>
</tr>
<tr>
<td>Unstable operation</td>
<td>Incorrect wiring</td>
<td>Inspect and correct wiring across motor terminals L1, L2, L3, and PE.</td>
</tr>
<tr>
<td>Motor overheats</td>
<td>Excessive ambient</td>
<td>Reduce ambient temperature below 40° C (104° F). Positioner has an operating range of 0 to 45° C (32 to 113°F).</td>
</tr>
<tr>
<td></td>
<td>temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor surface is dirty</td>
<td>Clean motor surface.</td>
</tr>
<tr>
<td></td>
<td>Motor overloaded</td>
<td>Reduce load or unbalanced load.</td>
</tr>
<tr>
<td>Unusual noise</td>
<td>Motor loosely mounted</td>
<td>Tighten mounting bolts.</td>
</tr>
<tr>
<td></td>
<td>Positioners misaligned</td>
<td>Realign Headstock/tailstock (see Section 2.3.4.4, “Leveling Tailstock”)</td>
</tr>
<tr>
<td></td>
<td>Noisy bearing</td>
<td>Check alignment, noise of bearing, lubrication. Call Yaskawa Motoman Customer Support.</td>
</tr>
<tr>
<td>Weld quality bad</td>
<td>Brushes misaligned</td>
<td>Remove brush(s) and reinstall them properly. Recheck as needed.</td>
</tr>
</tbody>
</table>

6.4.2 MotoMount

High duty cycles under heavy loads and/or dirty operating conditions may cause the drive bushing to wear. This may be indicated by an increase in the tooling position repeatability. Call Customer Support for details.
7 Recommended Spare Parts

It is recommended that the parts and components in the following table be kept in stock as spare parts for the Positioner. Product performance cannot be guaranteed when using spare parts from any company other than Yaskawa. The spare parts are ranked as follows:

- Rank A: Expendable and frequently replaced parts
- Rank B: Parts for which replacement may be necessary as a result of frequent operation
- Rank C: Drive Unit

**NOTICE**

To replace parts in Rank B or Rank C, contact Customer Support. (Refer to section 1.4 “Customer Support Information” on page 1-4).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Part No's</th>
<th>Component</th>
<th>Qty</th>
<th>Qty per Unit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>132412-1</td>
<td>Molywhite R00 Grease</td>
<td>-</td>
<td>16kg</td>
<td>For reducer of each axis</td>
</tr>
<tr>
<td>A</td>
<td>180144-1</td>
<td>Mobil CM-P, Lithium Complex Grease</td>
<td>-</td>
<td>14oz</td>
<td>For Tailstock swingarm</td>
</tr>
<tr>
<td>A</td>
<td>144370-1</td>
<td>Weld Ground Brush Post</td>
<td>1</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>144372-1</td>
<td>Weld Ground Brush Holder</td>
<td>1</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>144371-1</td>
<td>Brush</td>
<td>3</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>479348-2</td>
<td>Battery Assy, Backup</td>
<td>1</td>
<td>1</td>
<td>For Positioner</td>
</tr>
</tbody>
</table>

**NOTICE**

The motor and reducer are not recommended for field service. The unit should be returned to Yaskawa for repairs to these components.
Appendix A

A.1 Performance Charts

A.1.1 Positioner Assembly

<table>
<thead>
<tr>
<th>Load CG Offcenter (r [mm])</th>
<th>Rated W [kgf]</th>
<th>Max W [kgf]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2797</td>
<td>4105</td>
</tr>
<tr>
<td>1.0</td>
<td>2362</td>
<td>3385</td>
</tr>
<tr>
<td>1.5</td>
<td>2183</td>
<td>3214</td>
</tr>
<tr>
<td>2.0</td>
<td>1917</td>
<td>2886</td>
</tr>
<tr>
<td>2.5</td>
<td>1807</td>
<td>2710</td>
</tr>
<tr>
<td>3.0</td>
<td>1694</td>
<td>2480</td>
</tr>
<tr>
<td>3.5</td>
<td>1563</td>
<td>2234</td>
</tr>
<tr>
<td>4.0</td>
<td>1436</td>
<td>2104</td>
</tr>
<tr>
<td>4.5</td>
<td>1344</td>
<td>2035</td>
</tr>
<tr>
<td>5.0</td>
<td>1263</td>
<td>1905</td>
</tr>
<tr>
<td>5.5</td>
<td>1192</td>
<td>1785</td>
</tr>
<tr>
<td>6.0</td>
<td>1127</td>
<td>1691</td>
</tr>
<tr>
<td>6.5</td>
<td>1070</td>
<td>1625</td>
</tr>
<tr>
<td>7.0</td>
<td>1018</td>
<td>1557</td>
</tr>
<tr>
<td>7.5</td>
<td>971</td>
<td>1496</td>
</tr>
<tr>
<td>8.0</td>
<td>928</td>
<td>1442</td>
</tr>
<tr>
<td>8.5</td>
<td>889</td>
<td>1393</td>
</tr>
<tr>
<td>9.0</td>
<td>852</td>
<td>1351</td>
</tr>
</tbody>
</table>

Maximum Bearing Moment (N*m) = 20580

<table>
<thead>
<tr>
<th>Load CG Overhang (from Tooling Plate), D [mm]</th>
<th>Rated W [kgf]</th>
<th>Max W [kgf]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2977</td>
<td>4105</td>
</tr>
<tr>
<td>150</td>
<td>2362</td>
<td>3385</td>
</tr>
<tr>
<td>200</td>
<td>2183</td>
<td>3214</td>
</tr>
<tr>
<td>250</td>
<td>1917</td>
<td>2886</td>
</tr>
<tr>
<td>300</td>
<td>1807</td>
<td>2710</td>
</tr>
<tr>
<td>350</td>
<td>1694</td>
<td>2480</td>
</tr>
<tr>
<td>400</td>
<td>1563</td>
<td>2234</td>
</tr>
<tr>
<td>450</td>
<td>1436</td>
<td>2104</td>
</tr>
<tr>
<td>500</td>
<td>1344</td>
<td>2035</td>
</tr>
<tr>
<td>550</td>
<td>1263</td>
<td>1905</td>
</tr>
<tr>
<td>600</td>
<td>1192</td>
<td>1785</td>
</tr>
<tr>
<td>650</td>
<td>1127</td>
<td>1691</td>
</tr>
<tr>
<td>700</td>
<td>1070</td>
<td>1625</td>
</tr>
<tr>
<td>750</td>
<td>1018</td>
<td>1557</td>
</tr>
<tr>
<td>800</td>
<td>971</td>
<td>1496</td>
</tr>
<tr>
<td>850</td>
<td>928</td>
<td>1442</td>
</tr>
<tr>
<td>900</td>
<td>889</td>
<td>1393</td>
</tr>
<tr>
<td>950</td>
<td>852</td>
<td>1351</td>
</tr>
</tbody>
</table>

Note: HTS Applications assume 1/2 load on headstock @ 50 mm, using MotoMount.

2) Rated load based upon 50% maximum bearing moment.

3) Maximum load based upon 75% maximum bearing moment.

Reflected Ratio

<table>
<thead>
<tr>
<th>Load Inertia, Jm [kg*m²]</th>
<th>Jl/Jm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>1.25</td>
</tr>
<tr>
<td>5.0</td>
<td>2.5</td>
</tr>
<tr>
<td>10.0</td>
<td>5.0</td>
</tr>
<tr>
<td>20.0</td>
<td>10.0</td>
</tr>
<tr>
<td>40.0</td>
<td>20.0</td>
</tr>
<tr>
<td>80.0</td>
<td>40.0</td>
</tr>
</tbody>
</table>

Note: Maximum recommend inertia ratio is 5.
Appendix B

B.1 Illustrated Parts list

B.1.1 Introduction

This Illustrated Parts List identifies, describes, and illustrates detail parts of the main assemblies for the Positioner.

This list provides parts identification and descriptive information for use in provisioning, requesting, purchasing, storing, and issuing spare parts.

B.1.2 Contents

The parts list contains a breakdown of the equipment into detail parts. All parts of the equipment are listed except the following:

1. Standard hardware items (attaching parts) such as nuts, screws, washers, etc., which are available commercially.
2. Bulk items such as wire, cable, sleeving, tubing, etc., which are also commercially available.
3. Permanently attached parts which lose their identity by being welded, soldered, riveted, etc., to other parts, or assemblies.

B.1.3 Parts List

This form is divided into four columns as follows:

1. “Figure - Item Number” Column
   - This column lists the figure number of the illustration applicable to a particular parts list and also identifies each part in the list by an item number. These item numbers also appear on the illustration. Each item number on the illustration is connected to the part to which it pertains by a leader line and arrow. Thus, the figure and item numbering system ties the parts list to the illustrations and vice versa.

2. “Motoman Part Number” Column
   - All part numbers appearing in this column are Yaskawa part numbers.

3. “Description” Column
   - The item nomenclature appears in this column.

4. “QTY” Column
   - This column indicates the quantity of parts required for an assembly or subassembly in which the part appears. This column does not necessarily reflect the total used in the complete end item.
B.1.4 Symbols and Abbreviations

The following is a list of symbols and abbreviations used in the parts list.

- amp – ampere
- AC – alternating current
- cyl – cylinder
- DC – direct current
- fig – figure
- hex – hexagon
- ID – inside diameter
- in – inch
- m – meter
- mm – millimeter
- No– number
- psi – pounds per square inch
- v – voltage
Fig. B-1: Head Stock
# Appendix B

## B.1 Illustrated Parts List

<table>
<thead>
<tr>
<th>ITEM</th>
<th>P/N</th>
<th>DESCRIPTION</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>171222-1</td>
<td><strong>DRIVE ASSEMBLY, HEADSTOCK MH3155</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>171104-1</td>
<td>HOUSING, WELDMENT, HEADSTOCK ASSEMBLY, MH3155</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>133963-4</td>
<td>BOLT, EYE, M16, DIN580</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>146199-1</td>
<td>PLATE, FACE, 2000kg HEADSTOCK</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>130532-4</td>
<td>SCREW,SHC,M16X45</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>132049-1</td>
<td>WASHER, CONICAL SPRING, GTS16</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>169789-1</td>
<td>REDUCER,RV,RDS-320C-253</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>151843-1</td>
<td>HANGER, SUPPORT, CABLE</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>171139-1</td>
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Appendix B
B.1 Illustrated Parts list

*Fig. B-2: MotoMount™ Tailstock Components*
### Table B-2: MotoMount™ Tailstock Components

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<th>Item</th>
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Fig. B-3: MotoMount Components
### Table B-3: MotoMount Components

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Fig. B-4: Slip Ring Components
## B.1 Illustrated Parts list

### Table B-4: Slip Ring Kit Components

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C.1 Glossary

3D Graphic Display Function
The 3D Graphic Display Function (this will be called 3D Display Function) is that, a 3D model of the Manipulator is displayed on the programming pendant window, and the current value of the Manipulator can be confirmed. By using the multi-window function, the job's teaching position displayed in the job content can also be confirmed on the 3D display window. When the functional safety function is valid, the functional safety range can also be displayed.

Absolute Data (ABSO Data)
Absolute Data (ABSO Data) is a correction factor for data that establishes an indicated value of zero when the robot is at the predetermined Home (calibration position).

Accuracy
Accuracy is the measurement of the deviation between the command characteristic and the attained characteristic (R15.05-2), or the precision with which a computed or calculated robot position can be attained. Accuracy is normally worse than the arm's repeatability. Accuracy is not constant over the workspace, due to the effect of link kinematics.

Active Compliant Robot
An active compliant robot is one in which motion modification during the performance of a task is initiated by the control system. The induced motion modification is slight, but sufficient to facilitate the completion of a desired task.

Actual Position
The position or location of the tool control point. Note that this will not be exactly the same as the demand position, due to a multitude of unsensed errors, such as link deflection, transmission irregularity, tolerances in link lengths, etc.

Actuator
A power mechanism used to effect motion, or maintain position of the robot (for example, a motor which converts electrical energy to effect motion of the robot) (R15.07). The actuator responds to a signal received from the control system.
ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems
This standard provides guidelines for the manufacture and integration of Industrial Robots and Robot Systems with emphasis on their safe use, the importance of risk assessment and establishing personnel safety. This standard is a national adoption of the International Standards ISO 10218-1 and ISO 10218-2 for Industrial Robots and Robot Systems, and offers a global safety standard for the manufacture and integration of such systems.

ArcWorld
Robotic welding systems delivering flexible integrated robotics into the welding processes. ArcWorlds can be configured with multiple Manipulators, a heavy-duty Positioner or servo-controlled external axes for coordinated motion.

Automatic Mode
See "Play Mode".

Axis
A direction used to specify the Manipulator motion in a linear or rotary mode. (ISO 8373)

Axis Backlash
Play between drive train gears

Axis Interference
The Axis Interference Area is a function that judges the current position of each axis and outputs a signal based on whether the current position is within a predefined range.

Base
The stable platform to which an industrial robotic arm is attached.

Base Coordinate System
The Base Coordinate System (sometimes referred to as World Coordinate System) defines a common reference point for a cell or application. This is useful when using multiple Manipulators or devices as positions defined in Base Coordinates will be the same for all Manipulators and devices.

Burn-in
Burn-In is a robot testing procedure where all components of the robot are operated continuously for an extended period of time. This is done to test movement and movement programming of the robot at early stages to avoid malfunctions after deployment.
Computer Aided Design (CAD)
Computer Aided Design (CAD). Computer graphic applications designed to allow engineering of objects (or parts), which are to be manufactured. A computer is used as a tool to design schematics and produce blueprints, which enable the accurate production of the object. The CAD system enables the three dimensional drawings of basic figures, exact sizing and placement of components, making lines of specified length, width, or angle, as well as satisfying varying geometric shapes. This system also allows the designer to test a simulated part under different stresses, loads, etc.

Cartesian Coordinates
Cartesian Coordinates is a type of coordinate system that specifies the location of a point in two dimensional space by a pair of numerical numbers, which further specify the distance to fixed axes that are perpendicular to each other. In simple terms, an XY graph represents a two dimensional Cartesian Coordinate System. When a point is specified in a three dimensional space (XYZ graph), it constitutes a three dimensional Cartesian coordinate system. A robot’s TCP position is specified in a Cartesian Coordinate.

Cartesian Manipulator
A Cartesian Manipulator is a Manipulator arm with prismatic joints, which allows movement along one or more of the three-axes in the X, Y, Z coordinate system.

Cartesian Topology
A topology, which uses prismatic joints throughout, normally arranged to be perpendicular to each other.

Cartesian-coordinate Robot
A Cartesian-coordinate Robot is a robot whose Manipulator-arm degrees of freedom are defined by Cartesian Coordinates. This describes motions that are east-west, north-south and up-down, as well as rotary motions to change orientation.

Category 3 (Cat3)
Category 3 (Cat 3) means that the safety related parts of the control system will be designed so that:

• Single faults will not prevent the safety function from working correctly.
• Single faults will be detected at or before the next demand of the safety function.
• When a single fault does occur, a safe state shall be maintained until the detected fault is corrected.
• All reasonably foreseeable faults are detected.

Caution
Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury. It may also be used without the safety alert symbol as an alternative to “NOTICE”.

Centrifugal Force
When a body rotates about an axis other than one at it's center of mass, it exerts an outward radial force called centrifugal force upon the axis, which restrains it from moving in a straight tangential line. To offset this force, the robot must exert an opposing torque at the joint of rotation.

Circular Motion Type
A calculated path that the robot executes, and is circular in shape.

Clamp
An end-effector which serves as a pneumatic hand that controls the grasping and releasing of an object. Tactile, and feed-back force sensors are used to manage the applied force to the object by the clamp. See “End-effector”.

Clamping
The maximum permissible force acting on a body region, resulting from a Manipulator collision where the period of contact results in a plastic deformation of a person's soft tissue.

Clamping Force
When contact can cause a body part(s) to be clamped.

Closed-loop
Control achieved by a by means of feedback information. As a Manipulator is in action, its sensors continually communicate information to the Controller, which is used to further guide the Manipulator within the given task. Many sensors are used to feed back information about the Manipulator's placement, speed, torque, applied forces, as well as the placement of a targeted moving object, etc. See "Feedback".

Command Interpreter
A module or set of modules that determines what the received command means. The command is broken down into parts (parsed) and processed.

Command Position
The endpoint position of a robot motion that the Controller is trying to achieve.

Compliance
Displacement of a Manipulator in response to a force or torque. A high compliance means the Manipulator moves a good bit when it is stressed. This is called spongy or springy. Low compliance would be a stiff system when stressed.

Configuration
The arrangement of links created by a particular set of joint positions on the robot. Note that there may be several configurations resulting in the same endpoint position.

Contact Sensor
A device that detects the presence of an object or measures the amount of applied force or torque applied on the object through physical contact with it. Contact sensing can be used to determine location, identity, and orientation of work pieces.
Continuous Path
Describes the process where a robot is controlled over the entire path traversed, as opposed to a point-to-point method of traversal. This is used when the trajectory of the end-effector is most important to provide a smooth movement, such as in spray painting etc. See "Point-to-Point".

Control Algorithm
A monitor used to detect trajectory deviations in which sensors detect such deviations and torque applications are computed for the actuators.

Control Command
An instruction fed to the robot by means of the human-to-machine input device. See Pendant (Teaching). This command is received by the Controller system and is interpreted. Then, the proper instruction is fed to the robot's actuators, which enable it to react to the initial command. Many times, the command must be interpreted with the use of logic units and specific algorithms. See "Input Devices" and "Instruction Cycle".

Control Device
Any piece of control hardware providing a means for human intervention in the control of a robot or robot system, such as an EMERGENCY STOP button, a START button, or a selector switch. (R15.06)

Control Mode
The means by which instructions are communicated to the robot.

Controllability
The property of a system by which an input signal can take the system from an initial state to a desired state along a predictable path within a predetermined period of time.

Controller
An information processing device whose inputs are both the desired and measured position, velocity or other pertinent variables in a process and whose outputs are drive signals to a controlling motor or actuator. (R15.02)

Controller System
The control mechanism is usually a computer of some type, which is used to store data (both robot and work environment), and store and execute programs, which operate the robot. The Controller System contains the programs, data, algorithms; logic analysis, and various other processing activities, which enable it to perform. See "Robot".

Coordinate System or Frame
A Coordinate System (or Frame) defines a reference position and orientation from which a robot position can be measured. All robot positions are defined with reference to a Coordinate System. Yaskawa robots utilize the following Coordinate Systems:
- "Base Coordinate System"
- "Robot Coordinate System"
- "User Coordinate System"
- "Cartesian Coordinates"

Central Processing Unit (CPU)
The Central Processing Unit (CPU) is the main circuit board and processor of the Controller System.
Cubic Interference Area
This area is a rectangular parallelepiped, which is parallel to the base coordinate, Manipulator coordinate or user coordinate. The Controller judges whether the current position of the Manipulator’s TCP is inside or outside this area, and outputs this status as a signal.

Cycle
A single execution of a complete set of moves and functions contained within a robot program. (R15.05-2)

Cyclic Coordinate System
A coordinate system that defines the position of any point in terms of an angular dimension, a radial dimension and a height from a reference plane. These three dimensions specify a point on a cylinder.

Cyclo Drive
A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major (larger) axis.

Cylindrical Topology
A topology where the arm follows a radius of a horizontal circle, with a prismatic joint to raise or lower the circle. Not popular in industry.

Danger
Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Safety Signs identified by the signal word DANGER should be used sparingly and only for those situations presenting the most serious hazards.

Dead Man Switch
Deprecated term. See "Enabling Device".

Degrees of Freedom
The number of independent directions or joints of the robot (R15.07), which would allow the robot to move its end effector through the required sequence of motions. For arbitrary positioning, six degrees of freedom are needed: three for position (left-right, forward-backward and up-down), and three for orientation (yaw, pitch and roll).

Direct-drive
Joint actuation, including no transmission elements (i.e., the link is bolted onto the output of the motor.)

Downtime
A period of time, in which, a robot or production line is shut down, due to malfunction or failure. See "Uptime".

Drive
A speed (gear) reducer to convert high speed low torque to low speed high torque. See "Harmonic Drive", "Cyclo Drive" and "Rotary Vector Drive (RV)".
Drop Delivery
A method of introducing an object to the workplace by gravity. Usually, a chute or container is so placed that, when work on the part is finished, it will fall or drop into a chute or onto a conveyor with little or no transport by the robot.

Dynamics
The study of motion, the forces that cause the motion and the forces due to motion. The dynamics of a robot arm are very complicated as they result from the kinematical behavior of all masses within the arm's structure. The robot arm kinematics are complicated in themselves.

Emergency Stop
The operation of a circuit using hardware-based components that overrides all other robot controls, removes drive power from the robot actuators, and causes all moving parts to stop. (R15.06)

Enable Switch
See "Enabling Device".

Enabling Device
A manually operated device which when continuously activated, permits motion. Releasing the device shall stop robot motion and motion of associated equipment that may present a hazard. (R15.06)

Encoder
A feedback device in the robot Manipulator arm that provides current position (and orientation of the arm) data to the Controller. A beam of light passes through a rotating code disk that contains a precise pattern of opaque and transparent segments on its surface. Light that is transmitted through the disk strikes photo-detectors, which convert the light pattern to electrical signals. See "Feedback", "Closed-loop" and "Feedback Sensor".

Envelope
Is the range of movement available. This range is determined by the length of a robot's arm and the design of its axes. Each axis contributes its own range of motion.

EOAT
See "Gripper" or "End-effector".

End-effector
An accessory device or tool, specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot to perform its intended task. (Examples may include: gripper, spot weld gun, arc weld gun, spray point gun or any other application tools.) (R15.06)

Endpoint
The nominal commanded position that a Manipulator will attempt to achieve at the end of a path of motion. The end of the distal link.

Error
The difference between the actual response of a robot and a command issued.
Expandability
Being able to add resources to the system, such as memory, larger hard drive, new I/O card, etc.

External Force Limit
The threshold limit where the robot moves to or retains position, even when external forces are applied (provided that forces do not exceed limits that would cause an error).

Feedback
The return of information from a Manipulator or sensor to the processor of the robot to provide self-correcting control of the Manipulator. See "Feedback Control" and "Feedback Sensor".

Feedback Control
A type of system control obtained when information from a Manipulator or sensor is returned to the robot Controller in order to obtain a desired robot effect. See "Feedback", "Closed-loop" and "Feedback Sensor".

Feedback Sensor
A mechanism through which information from sensing devices is fed back to the robot's control unit. The information is utilized in the subsequent direction of the robot's motion. See "Closed-loop" and "Feedback Control".

Flexibility
The ability of a robot to perform a variety of different tasks.

Force Feedback
A sensing technique using electrical signals to control a robot end-effector during the task of the end-effector. Information is fed from the force sensors of the end-effector to the robot control unit during the particular task to enable enhanced operation of the end-effector. See "Feedback", "Feedback Sensor" and "Force Sensor".

Force Sensor
A sensor capable of measuring the forces and torque exerted by a robot and its wrist. Such sensors usually contain strain gages. The sensor provides information needed for force feedback. See "Force Feedback".

Forward Kinematic Solution
The calculation required to find the endpoint position, given the joint positions. For most robot topologies this is easier than finding the inverse kinematic solution.

Forward Kinematics
Computational procedures which determine where the end-effector of a robot is located in space. The procedures use mathematical algorithms along with joint sensors to determine its location.

Frame
A coordinate system used to determine a position and orientation of an object in space, as well as the robot's position within its model.
Functional Safety Unit (FSU)
The Functional Safety Unit (FSU) is a component of the Manipulator Controller that provides programmable safety functions that enable collaborative operation of the robot. As these safety functions are programmable, the FSU allows the minimization of nearby overall equipment footprint, as well as human accessible areas. The FSU consists of two parallel Central Processing Units (CPUs) run concurrently, thereby providing dual channel checking. In addition, the FSU acquires robot position from its encoders independently from the motion control system of the robot. Based on this feedback, the FSU monitors the Manipulator and tool’s position, speed and posture.

Gravity Loading
The force exerted downward, due to the weight of the robot arm and/or the load at the end of the arm. The force creates an error with respect to position accuracy of the end effector. A compensating force can be computed and applied bringing the arm back to the desired position.

Gripper
An end effector that is designed for seizing and holding (ISO 8373) and “grips” or grabs an object. It is attached to the last link of the arm. It may hold an object using several different methods, such as: applying pressure between its “fingers”, or may use magnetization or vacuum to hold the object, etc. See “End-effector”.

Hand
A clamp or gripper used as an end-effector to grasp objects. See “End-effector”, and “Gripper”.

Hardstop
Physical block that defines the movement stop positions

Harmonic Drive
Compact lightweight speed reducer that converts high speed low torque to low speed high torque. Usually found on the minor (smaller) axis.

Harness
Usually several wires, bundled together to deliver power and/or signal communications to/from devices. For example, the robot motors are connected to the Controller through a wire harness.

Hazardous Motion
Unintended/unexpected robot motion that may cause injury.

Headstock
Positioner column containing the driving mechanism

Hold
A stopping of all movements of a robot during its sequence, in which some power is maintained on the robot. For example, program execution stops, however power to the servo motors remain on, if restarting is desired.
Glossary

**Home Position**
A known and fixed location on the basic coordinate axis of the Manipulator where it comes to rest, or to an indicated zero position for each axis. This position is unique for each model of Manipulator. On Motoman® robots there are indicator marks that show the Home position for the respective axis.

**IEC**
International Electrotechnical Commission

**Inductive Sensor**
The class of proximity sensors, which has half of a ferrite core, whose coil is part of an oscillator circuit. When a metallic object enters this field, at some point, the object will absorb enough energy from the field to cause the oscillator to stop oscillating. This signifies that an object is present in a given proximity. See "Proximity Sensor".

**Industrial Robot**
A re-programmable multi-functional Manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks (R15.06). The principle components are: one or more arms that can move in several directions, a Manipulator, and a computer Controller that gives detailed movement instructions.

**INFORM**
The robot programming language for Yaskawa robots. INFORM language allows the robot user to: instruct the robot to use its basic capabilities to fulfill a defined set of expectations and also to describe to the robot, through a definition of parameters and conditions, what the expectations are in some given situations or scenarios. In simple terms, the INFORM programming language allows the user to instruct the robot on what to do, when to do it, where to do it and how to do it.

**Input Devices**
A variety of devices, which allow a human to machine interface. This allows the human to program, control, and simulate the robot. Such devices include programming pendant, computer keyboards, a mouse, joy-sticks, push buttons, operator panel, operator pedestal etc.

**Instruction**
A line of programming code that causes action from the system Controller. See "Command Position".

**Instruction Cycle**
The time it takes for a robot Controller system's cycle to decode a command or instruction before it is executed. The Instruction Cycle must be analyzed very closely by robotic programmers to enable speedy and proper reaction to varying commands.

**Integrate**
To fit together different subsystems, such as robots and other automation devices, or at least different versions of subsystems in the same control shell.
Integrator
A company that provides value added services that results in creation of automation solutions by combining a robot and other automation and controls equipment to create an automation solution for end users.

Intelligent Robot
A robot that can be programmed to make performance choices contingent on sensory inputs with little or no help from human intervention. See "Robot".

Interference Area
Interference Area is a function that prevents interference between multiple Manipulators or the Manipulator and peripheral device. The areas can be set up to 64 areas. Three types of methods to use each interference area are as follows: Cubic Interference, Outside of Cubic Area and Axis Interference.

Interpolation
The method by which endpoint paths are created. In general, to specify a motion a few knot points are defined before all the intermediate positions between them are calculated by mathematical interpolation. The interpolation algorithm used therefore has a dramatic effect of the quality of motion.

ISO
International Organization for Standardization

ISO 10218-1 Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots
A robot specific safety specification that addresses manufacturer requirements, functionality, required safety performance, hazards, protective measures and documentation for the robot itself.

ISO 10218-2 Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration
A companion document to ISO 10218-1. This safety specification provides guidance to both end users and robot integrators as it pertains to the safe design, Installation and commissioning of robot systems, as well as recommended procedures, safeguarding and information required for use.

ISO TS 15066(ANSI RIA 15.606): Robots and robotic devices - Collaborative robots
Provides detailed guidance not found in ISO 10218 parts 1 or 2 for the safe use of industrial robots operating collaboratively.

Jacobian matrix
The Jacobian matrix relates the rates of change of joint values with the rates of change of endpoint co-ordinates. Essentially it is a set of algorithm calculations that are processed to control the positioning of a robot.

JOB
JOB is the name for a robot program created using INFORM programming language. Typically, a JOB consists of instructions that tell the Controller what to do and data that the program uses when it is running.
Joint
A part of the Manipulator system, which allows a rotation and/or translational degree of freedom of a link of end-effector.

Joint Interpolated Motion
A method of coordinating the movement of the joints, such that all joints arrive at the desired location simultaneously. This method of servo control produces a predictable path regardless of speed and results in the fastest pick and place cycle time for a particular move.

Joint Motion Type
Also known as Point-to-Point Motion, Joint Motion Type is a method of path interpolation that commands the movement of the robot by moving each joint directly to the commanded position so that all axis arrive to the position at the same time. Although the path is predictable, it will not be linear.

Joint Space
a. Joint Space (or Joint Coordinates) is just a method of defining the position of the robot in terms of the value of each axis instead of as a TCP position. For example, the Home Position of a robot is often defined in Joint Space as each axis being at 0 degrees.
b. The set of joint positions.

Joints
The parts of the robot arm which actually bend or move.

K
Kinematics
The relationship between the motion of the endpoint of a robot and the motion of the joints. For a Cartesian Robot this is a set of simple linear functions (linear tracks that may be arranged in X, Y, Z directions), for a revolute topology (joints that rotate) however, the kinematics are much more complicated involving complicated combinations of trigonometry functions. The kinematics of an arm is normally split into forward and inverse solutions.

L
Laser
Acronym for Light Amplification by Stimulated Emission of Radiation. A device that produces a coherent monochromatic beam of light which is extremely narrow and focused but still within the visible light spectrum. This is commonly used as a non-contact sensor for robots. Robotic applications include: distance finding, identifying accurate locations, surface mapping, bar code scanning, cutting, welding etc.

Linear Interpolated Motion
Is a method of path interpolation that commands the movement of the robot by moving each joint in a coordinated motion so that all axis arrive to the position at the same time. The path of the Tool Control Point (TCP) is predictable and will be linear.
**Glossary**

**M**

**Linear Motion Type**
Is a method of path interpolation that commands the movement of the robot by moving each joint in a coordinated motion so that all axis arrive to the position at the same time. The path of the Tool Control Point (TCP) is predictable and will be linear.

**Link**
A rigid part of a Manipulator, which connects adjacent joints.

**Load Cycle Time**
A manufacturing or assembly line process term, which describes the complete time to unload the last work piece and load the next one.

**Magnetic Detectors**
Robot sensors that can sense the presence of ferromagnetic material. Solid-state detectors with appropriate amplification and processing can locate a metal object to a high degree of precision. See "Sensor".

**Manipulator**
A machine or robotic mechanism of which usually consists of a series of segments (jointed or sliding relative to one another) for the purpose of grasping and/or moving objects (pieces or tools), usually in several degrees of freedom. The control of the Manipulator may be by an operator, a programmable electronic Controller or any logic system (for example cam device, wired, etc.) (ISO 8373)
See "Wrist" and "End-effector"

**Manual Mode**
See "Teach Mode".

**Material Handling**
The process by which an industrial robotic arm transfers materials from one place to another.

**Mirror Shift Function**
With the Mirror Shift Function, a job is converted to the job in which the path is symmetrical to that of the original job. This conversion can be performed for the specified coordinate among the X-Y, X-Z or Y-Z coordinate of the robot coordinates and the user coordinates. The Mirror Shift Function is classified into the following three: the Pulse Mirror Shift Function, the Robot Coordinates Mirror Shift Function and the User Coordinates Mirror Shift Function.

**Mode Switch**
As per safety standards, an industrial robot has three distinct modes of operation. These are TEACH (also called Manual) and PLAY (also called Automatic) and REMOTE. Switching between these modes is performed using a key switch on the Programming Pendant and is called Mode Switch.

**Modularity**
The property of flexibility built into a robot and control system by assembling separate units, which can be easily joined to or arranged with other parts or units.
Glossary

N

Module
Self-contained component of a package. This component may contain sub-components known as sub-modules.

Motomount
Yaskawa proprietary mounting block allowing for limited play on multiple axis

Motion Axis
The line defining the axis of motion either linear or rotary segment of a Manipulator.

Motor
See “Servo Motor”.

Muting
While testing a robot program, the deactivation of any presence sensing safeguarding devices during the full robot cycle or a portion of the cycle.

N

Notice
NOTICE is the preferred signal word to address practices not related to personal injury. The safety alert symbol should not be used with this signal word. As an alternative to “NOTICE”, the word “CAUTION” without the safety alert symbol may be used to indicate a message not related to personal injury.

O

Off-line Programming
A programming method where the task program is defined on devices or computers separate from the robot for later input of programming information to the robot. (ISO 8373)b. A means of programming a robot while the robot is functioning. This becomes important in manufacturing and assembly line production due to keeping productivity high while the robot is being programmed for other tasks.

Operator
The person designated to start, monitor and stop the intended productive operation of a robot or robot system. An operator may also interface with a robot for productive purposes. (R15.06)

Optical Encoder
A detection sensor, which measures linear or rotary motion by detecting the movement of markings past a fixed beam of light. This can be used to count revolutions, identify parts, etc.

Optical Proximity Sensors
Robot sensors which measure visible or invisible light reflected from an object to determine distance. Lasers are used for greater accuracy.
Orientation
The angle formed by the major axis of an object relative to a reference axis. It must be defined relative to a three dimensional coordinate system. Angular position of an object with respect to the robot's reference system. See "Roll", "Pitch" and "Yaw".

Palletizing
The process of stacking packages (i.e., boxes, bags, containers, etc.) in an organized fashion on a pallet.

PAM Function – Position Adjustment by Manual
Position Adjustment by Manual allows position adjustment by simple operations while observing the motion of the Manipulator, and without stopping the Manipulator. Positions can be adjusted in both teach mode and play mode.

Parallel Shift Function
Parallel Shift refers to the shifting of an object from a fixed position in such a way that all points within the object move an equal distance. In the model for Parallel Shift shown in the following, the shift value can be defined as the distance L (three dimensional coordinate displacement). The Parallel Shift Function is relevant to the actual operation of the Manipulator because it can be used to reduce the amount of work involved in teaching by shifting a taught path (or position). In the example in the figure below, the taught position A is shifted in increments of the distance L (this is actually a three dimensional XYZ displacement that can be recognized by the robot).

Path
The continuous locus of positions (or points in three dimensional space) traversed by the tool center point and described in a specified coordinate system. (R15.05-2)

Payload - Maximum
The maximum mass that the robot can manipulate at a specified speed, acceleration/deceleration, center of gravity location (offset), and repeatability under continuous operation over a specified working space. Maximum payload is specified in kilograms. (R15.05-2)

Pendant [Programming Pendant]
See "Programming Pendant"

Pendant Teaching
The mapping and recording of the position and orientation of a robot and/ or Manipulator system as the robot is manually moved in increments from an initial state along a path to a final goal state. The position and orientation of each critical point (joints, robot base, etc.) is recorded and stored in a database for each taught position the robot passes through on its path toward its final goal. The robot may now repeat the path on its own by following the path stored in the database.
Performance Level d (PLd)
ISO Performance Level (PL) “d” means that the average probability of dangerous failure per hour of the safety related parts of the control system falls within $= 10^{-7}$ to $< 10^{-6}$. Additionally, other factors such as proper installation, maintenance and protection against environmental factors also apply. This is the minimum performance level specified in ISO 10218-2 section 5.2.2, unless a risk assessment would allow a lower value to be used.

Performance Level e (PLe)
ISO Performance Level (PL) “e” means that the average probability of dangerous failure per hour of the safety related parts of the control system falls within $= 10^{-8}$ to $< 10^{-7}$. Additionally, other factors such as proper installation, maintenance and protection against environmental factors also apply.

Pick and Place Cycle
The amount of time it takes for a Manipulator to pick up an object and place it in a desired location, then return to its rest position. This includes time during the acceleration and deceleration phases of a particular task. The robot movement is controlled from one point location in space to another in a Point-to-Point (PTP) motion system. Each point is programmed into the robot's control memory and then played back during the work cycle.

Pick-and-Place Task
A repetitive part transfer task composed of a picking action followed by a placing action.

Pinch Points
A pinch point is any point at which it is possible for a person or part of a person’s body to be caught between moving parts of a machine, or between the moving and stationary parts of a machine, or between material and any part of the machine. A pinch point does not have to cause injury to a limb or body part, although it might cause injury – it only has to trap or pinch the person to prevent them from escaping or removing the trapped part from the pinch point.

Pitch
Rotation of the end-effector in a vertical plane around the end of the robot Manipulator arm. See and "Yaw".

Pitch Line
Ideal line of the gear

Play Mode
After a robot is programmed in Teach Mode, the Controller can be switched to Play Mode to execute the robot program. In Play Mode, the robot program is played back. This is the mode in which robots are used in production.
Glossary

P

**Playback Operation**
Playback is the operation by which the taught job is played back. This function is used to decide where to resume the playback on the start operation after suspending the playback and moving the cursor or selecting other jobs. 0: Starts operation where the cursor is located in the job displayed at the moment. 1: The playback continuation window appears. Select “YES” and the playback resumes where the cursor has been located when the playback suspended. If “NO” is selected, the playback resumes where the cursor is located in the job displayed at the moment. Modes Switch on the programming pendant: PLAY – job is started up by [START] on the programming pendant and REMOTE job is started by a peripheral device (external start input).

**Point-to-Point**
Manipulator motion in which a limited number of points along a projected path of motion is specified. The Manipulator moves from point to point rather than a continuous smooth path.

**Pose**
Alternative term for robot configuration, which describes the linear and angular position. The linear position includes the azimuth, elevation and range of the object. The angular position includes the roll, pitch and yaw of the object. See “Roll”, "Pitch" and "Yaw".

**Position**
The definition of an object's location in 3D space, usually defined by a 3D coordinate system using X, Y and Z coordinates.

**Position Level**
The position level is the degree of approximation of the Manipulator to a taught position. The position level can be added to move instructions MOVJ (joint interpolation) and MOVL (linear interpolation). If the position level is not set, the precision depends on the operation speed. Setting an appropriate level moves the Manipulator in a path suitable to circumferential conditions and the workpiece.

**Position Variables**
Position Variables are used in a robot program (JOB) to define a location in 3D space, usually defined by a 3D coordinate system using X, Y and Z coordinates. As it is a variable, the value can change depending on conditions or on information passed to the JOB.

**Positioner**
Complete device used to position parts for welding

**Presence-sensing Safeguarding Device**
A device designed, constructed and installed to create a sensing field to detect an intrusion into such field by people, robots or objects. See "Sensor".
Programmable Logical Controller (PLC)
A solid-state control system, which has a user programmable memory for storage of instructions to implement specific functions such as: I/O control logic, timing, counting arithmetic and data manipulation. A PLC consists of a central processor, input/output interface, memory and programming device, which typically uses relay equivalent symbols. The PLC is purposely designed as an industrial control system, which may perform functions equivalent to a relay panel or a wired solid-state logic control system, and may be integrated into the robot control system.

Programmable Robot
A feature that allows a robot to be instructed to perform a sequence of steps and then to perform this sequence in a repetitive manner. It can then be reprogrammed to perform a different sequence of steps if desired.

Programming Pendant
A hand-held input device, linked to the control system with which a robot can be programmed or moved. (ISO 8373) This enables the human operator to stand in the most favorable position to observe, control and record the desired movements in the robot's memory.

Proximity Sensor
A non-contact sensing device used to sense when objects are a short distance away, and it can determine the distance of the object. Several types include: radio frequency, magnetic bridge, ultrasonic and photoelectric. Commonly used for: high speed counting, sensing metal objects, level control, reading coding marks and limit switches. See "Inductive Sensor".

Pulse Coordinates
Yaskawa robots define robot joint axes position in degrees for revolute joints. Pulse is also another way to specify robot joint position, and it does so in robot motor encoder pulse counts.

Quality Assurance (QA)
Describes the methods, policies and procedures necessary to conduct quality assurance testing during design, manufacturing and deliver phases of creating, reprogramming, or maintaining robots.

Quasi-static Clamping
A type of contact between a person and part of a robot system where the body part can be clamped between the moving part of the robot system & another fixed or moving part of the robot cell

Range of Motion
The full movement potential of the robot.

Reach
The volume of space (envelope), which a robot's end-effector can reach in at least one orientation.
Glossary

R

Real-time System
A computer system in which the computer is required to perform its tasks within the time restraints of some process simultaneously with the system it is assisting. The computer processes system data (input) from the sensors for the purpose of monitoring and computing system control parameters (outputs) required for the correct operation of a system or process. The computer is required to do its work fast enough to keep pace with an operator interacting with it through a terminal device (such as a screen or keyboard). The operator interacting with the computer has access, retrieval and storage capability through a database management system. System access allows the operator to intervene and alter the system's operation.

Record-playback Robot
A Manipulator for which the critical points along desired trajectories are stored in sequence by recording the actual values of the joint-position encoders of the robot as it is moved under operational control. To perform the task, these points are played back to the robot's servo-system. See "Servo-system".

Rectangular-Coordinate Robot
A robot whose Manipulator arm moves in linear motions along a set of Cartesian or rectangular axis in X, Y and Z directions. The shape of the work envelope forms a rectangular figure. See "Work Envelope".

Reliability
The probability or percentage of time that a device will function without failure over a specified time period or amount of usage (R15.02). Also called: the robot's uptime or the Mean Time Between Failure (MTBF).

Remanufacture
To upgrade or modify robots to the revised specifications of the manufacturer. (R15.06)

Remote Mode
Remote Mode is a type of Play Mode where the automatic execution of robot program is initiated from an external device (not the Programming Pendant). During this mode, the use of the Programming Pendant is disabled.

Repeatability
A measure of how close an arm can repeatedly obtain a taught position. For instance: once a Manipulator is manually placed in a particular location and this location is resolved by the robot, the repeatability specifies how accurately the Manipulator can return to that exact location. The degree of resolution within the robot control system determines the repeatability. In general, an arm's repeatability can never be better than its resolution. See "Teach" and "Accuracy".

Resolution
The amount of robot joint motion required for the position sensing to change by one count. Although the resolution of each joint feedback sensor is normally constant, the resolution of the endpoint in world coordinates is not constant for revolute arms, due to the non-linearity of the arm's kinematics.

Revolute Joint
The joints of a robot, which are capable of rotary motion.
Risk Assessment
The process of evaluating the intended use of a machine or system for foreseeable hazards and then determining the level of risk involved for the tasks identified.

Risk Mitigation
A secondary step in the risk assessment process that involves reducing the level of risk for the identified tasks, by applying risk reduction measures in order to eliminate or mitigate the hazards.

Robot
A re-programmable, multi-functional Manipulator designed to move material, parts, tools or specified devices through variable programmed motions for the performance of a variety of tasks. Common elements which make up a robot are: Controller, Manipulator and end-effector. See "Manipulator", "Controller" and "End-effector".

Robot Coordinate System
The Robot Coordinate System is defined in the base axis of a Robot, and points in the Robot Coordinate System will be relative to the base of the robot. Note that by default the Base Coordinate System and Robot Coordinate System are the same.

Robot Integrator
See "Integrator".

Robot Programming Language
An interface between a human user and a robot, which relates human commands to the robot.

Robot Range Limit Monitoring
Monitors the Manipulator arm or its tool to be in the designated safety area.

Robot Simulation
A method for emulating and predicting the behavior and the operation of a robotic system based on the model (i.e., computer graphics) of the physical system. (R15.07)

Roll
Rotation of the robot end effector in a plane perpendicular to the end of the Manipulator arm. See "Pitch" and "Yaw".

Rotary Joint
A joint which twists, swings or bends about an axis.

Rotary Vector Drive (RV)
A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major (larger) axis. See "Cyclo Drive" and "Harmonic Drive".

Rotational Motion
A joint which twists, swings or bends about an axis. An example of this is the elbow of a human arm.
Safeguard
A barrier guard, device or safety procedure designed for the protection of personnel. (R15.06)

Safety Integrity Level
Safety Integrity Level (SIL) is IEC’s method for determining the performance level of a safety system. SIL 2 corresponds to ISO Performance Level “d”, and SIL 3 corresponds to ISO Performance Level “e”. ISO 10218 allows for the use of either.

Safety Logic Circuit
The safety logic circuit monitors safety critical external devices such as the light curtains and FSU generated signals. The safety logic circuit is programmed via an intuitive user interface that is supported on the Yaskawa programming pendant. It enables to set up the logical operations, such as stopping the Manipulator or outputting a signal if the servos are on.

Safety Monitored Stop
Collaborative feature designed to allow safe human-robot interaction. Only when robot motion ceases can the human safety enter the collaborative workspace. Servos can remain energized in accordance with a category 2 stop in accordance with ISO 10218-1:2011, 5.4. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.

Second Home Position
Apart from the “home position” of the Manipulator, the second home position can be set up as a check point for absolute data. The initial value of the second home position is the home position (where all axes are at pulse 0). The second home position can be changed.

Security Mode
Levels of operator modes on the Controllers, include: Operation Mode, Edit Mode, Management Mode, Safety Mode and One Time Management mode.

Sensor
Instruments used as input devices for robots, which enable it to determine aspects regarding the robot's environment, as well as the robot's own positioning. Sensors respond to physical stimuli (such as heat, light, sound, pressure, magnetism and motion), and they transmit the resulting signal or data for providing a measurement, operating a control or both. (R15.06)

Sensory Feedback
Variable data measured by sensors and relayed to the Controller in a Closed-loop System. If the Controller receives feedback that lies outside an acceptable range, then an error has occurred. The Controller sends an error signal to the robot. The robot makes the necessary adjustments in accordance with the error signal.

Servo Control
The process by which the control system of the robot checks if the attained pose of the robot corresponds to the pose specified by the motion planning with required performance and safety criteria. (ISO 8373)
Servo Motor
An electrical power mechanism used to effect motion or maintains position of the robot (for example, a motor which converts electrical energy to effect motion of the robot) (R15.07). The motor responds to a signal received from the control system and often incorporates an encoder to provide feedback to the control loop.

Servo Pack
An alternating, current electrical power mechanism that is controlled through logic to convert electrical supply power that is in a sine wave form to a Pulse Width Modulated (PWM) square form, delivered to the motors for motor control: speed, direction, acceleration, deceleration and braking control.

Servo-controlled Robot
The control of a robot through the use of a Closed-loop Servo-system, in which the position of the robot axis is measured by feedback devices and is stored in the Controller's memory. See Closed-loop System and Servo-system.

Servo-system
A system in which the Controller issues commands to the motors, the motors drive the arm, and an encoder sensor measures the motor rotary motions and signals the amount of the motion back to the Controller. This process is continued many times per second until the arm is repositioned to the point requested. See “Servo-controlled Robot”

Shock Detection Function
Shock detection is a function supported by the Controller that reduces the impact of a robot collision by stopping the Manipulator without any external sensor when the tool or the Manipulator collide with a peripheral device.

SIL
See “Safety Integrity Level”

Simulation
A graphical computer program that represents the robot and its environment, which emulates the robot's behavior during a simulated run of the robot. This is used to determine a robot's behavior in certain situations, before actually commanding the robot to perform such tasks. Simulation items to consider are: the 3D modeling of the environment, kinematics emulation, path-planning emulation and simulation of sensors. See "Sensor", "Forward Kinematics" and "Robot".

Singularity
A configuration where two joints of the robot arm become co-axial (aligned along a common axis). In a singular configuration, smooth path following is normally impossible and the robot may lose control. The term originates from the behavior of the Jacobian matrix, which becomes singular (i.e., has no inverse) in these configurations.
Glossary

SLURBT
SLURBT are terms that Yaskawa Motoman uses to describe each axis of the robot for convenience. The definition of each value is as follows:
S – Swing or Swivel
L – Lower Arm
U – Upper Arm
R – Rotate
B – Bend
T – Twist

Softlimit Setting Function
The Softlimit Setting Function is a function to set the axis travel limit range of the Manipulator motion in software.

Speed and Separation Monitoring
Collaborative feature that allows both the operator and robot to work in proximity to one another by ensuring the robot will slow down and stop before a contact situation occurs. In order for this feature to be safely implemented, functional safety and additional detection hardware must be used. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.

Spline
A smooth, continuous function used to approximate a set of functions that are uniquely defined on a set of sub-intervals. The approximating function and the set of functions being approximated intersect at a sufficient number of points to insure a high degree of accuracy in the approximation. The purpose for the smooth function is to allow a robot Manipulator to complete a task without jerky motion.

Spline Motion Type
A calculated path that the robot executes-that may be parabolic in shape. A spline motion may also accomplish a free form curve with mixtures of circular and parabolic shapes.

Standstill Monitoring
Using the Axis Speed Monitor function will activate an emergency stop condition if a motion occurs.

Stop Position Monitoring
See "Standstill Monitoring"

Sweep Axis
Positioner axis that sweeps back and forth

Swing Arm
Casting or weldment attached headstock or tailstock column containing secondary axes

System Integrator
See "Integrator"

Tailstock
Positioner column containing the driven or idler side.
Teach
To program a Manipulator arm by manually guiding it through a series of motions and recording the position in the robot Controller memory for playback.

Teach Lock
While the Teach Lock is set, the mode of operation is tied to the Teach Mode and the machines cannot be played back using either [START] or external input. For safety purposes, always set the mode switch to “TEACH” before beginning to teach.

Teach Mode
A Controller mode in which a Manipulator is programmed by manually guiding it through a series of motions and recording the position in the Controller memory for playback. Industrial robots that do not have an active Power and Force Limiting Function require the use of a Three Position Enabling Device in Teach Mode.

Teach Pendant
See “Programming Pendant”

Teaching Window
Teaching Window is a user interface screen on the programming pendant. This window contains the JOB CONTENT window and teaching is conducted within this window. The JOB CONTENT window contains the following items: line numbers, cursor, instructions, additional items, comments, etc.

Through-beam
An object detection system used within a robot's imaging sensor system. A finely focused beam of light is mounted at one end and a detector at the other. When the beam of light is broken, an object is sensed.

Time Measuring Function
Time measuring function measures the execution time for the specified section in the job or the signal output time of the specified signal.

Tool
A term used loosely to define a working apparatus mounted to the end of the Manipulator arm, such as a hand, gripper, welding torch, screw driver, etc. See “Gripper” and “End-effector”.

Tool & arm Interference
In a system with one Controller and multiple Manipulators, the Tool & Arm Interference Check Function can be used to detect possible interference to avoid collision during operation. The following three patterns can be checked:

- Arm against arm
- Arm against tool
- Tool against tool

Tool against tool
Interference is checked by using a cylinder that is slightly larger than the arm or tool. A sphere is placed on both ends of the cylinder. If the cylinder and spheres of one Manipulator have any contact with those of the other while moving, the Manipulators stop because interference was detected.
**Tool Center Point (TCP)**
The Tool Center Point (TCP) defines the tip of the current tool as defined relative to the tool flange. For example, for a welding robot, the TCP will generally be defined at the tip of the welding gun. After defining and configuring the TCP, the robot motion will be defined relative to this frame (i.e., rotation in the Rx direction would cause rotation around the X-axis and positions will be taught in this frame.

**Tool Control Point**
See "Tool Center Point (TCP)"

**Tool Coordinates**
When the tool attached to the Manipulator moves, so does its tool coordinate system in reference to a fixed coordinate system, for example, world coordinates. In general, the tool coordinates do not align with the world XYZ coordinates.

**Tool Frame**
A coordinate system attached to the end-effector of a Manipulator (relative to the base frame).

**Total Index Time**
Sum of the main axis sweep time and the secondary axis sweep times

**Tooling Envelope**
Volume in which the tooling can be present when rotated on its own axis

**Tooling Fixture**
Tooling designed for the application to be mounted on a positioner axis where parts will be loaded and processed

**Tooling Plate**
Plate used to attach tooling to motomounts

**Tooling Sweep**
Time necessary to rotate tooling between positions

**Trajectory Generation (Calculation)**
The computation of motion functions that allow the movement of joints in a smooth controlled manner.

**Transducer**
A device that converts energy from one form to another. Generally, a device that converts an input signal into an output signal of a different form. It can also be thought of as a device which converts static signals detected in the environment (such as pressure) into an electrical signal that is sent to a Manipulator's control system.

**Uptime**
A period of time in which a robot or production line is operating or available to operate, as opposed to downtime.
User Coordinate Setting
User coordinates are defined by three points that have been taught to the Manipulator through axis operations. These three defining points are ORG, XX, and XY, as shown in the diagram below. These three points of positional data are registered in a user coordinate file. ORG is the home position, and XX is a point on the X-axis. XY is a point on the Y-axis side of the user coordinates that has been taught, and the directions of Y- and Z-axes are determined by point XY.

User Coordinate System
The User Coordinate System is any reference point that a user has defined for their application. This is often attached to an object such as a pallet and allows a user to teach points relative to this object. For example, a set of position could be taught relative to a User Coordinate System attached to a pallet and then easily transferred to a different User Coordinate System on another pallet. This allows for positions to be reused efficiently. See also, "User Coordinate Setting"

Vision Sensor
A sensor that identifies the shape, location, orientation, or dimensions of an object through visual feedback, such as a television camera.

Warning
Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury. Hazards identified by the signal word WARNING present a lesser degree of risk of injury or death than those identified by the signal word DANGER.

Work Envelope
The set of all points which a Manipulator can reach without intrusion. Sometimes the shape of the work space, and the position of the Manipulator itself can restrict the work envelope.

Work Envelope (Space)
The volume of space within which the robot can perform given tasks.

Work Home Position
The Work Home Position is a reference point for Manipulator operations. It prevents interference with peripheral device by ensuring that the Manipulator is always within a set range as a precondition for operations such as starting the line. The Manipulator can be moved to the set Work Home Position by operation from the programming pendant, or by signal input from an external device. When the Manipulator is in the vicinity of the Work Home Position, the Work Home Position signal turns ON.

Work Piece
Any part which is being worked, refined or manufactured prior to its becoming a finished product.

Workspace
The volume of space within which the robot can perform given tasks.
World Coordinates
A reference coordinate system in which the Manipulator arm moves in linear motions along a set of Cartesian or rectangular axes in X, Y, and Z directions. The shape of the work envelope forms a rectangular figure. See "Rectangular-Coordinate Robot".

World Model
A three dimensional representation of the robot's work environment, including objects and their position and orientation in this environment, which is stored in robot memory. As objects are sensed within the environment the Controller system continually updates the World Model. Robots use this World Model to aid in determining its actions in order to complete given tasks.

Wrist
A set of rotary joints between the arm and the Manipulator end-effector that allow the end-effector to be oriented to the work-piece. In most cases the wrist can have degrees of freedom which enable it to grasp an object with roll, pitch, and yaw orientation. See "End-effector", "Roll", "Pitch", "Yaw" and "Work Piece".

Wrist [Secondary Axis]
An interconnected set of links and powered joints between the arm and end-effector, which supports, positions and orientates the end effector. (ISO 8373)

X

Y

Yaw
Rotation of the end-effector in a horizontal plane around the end of the Manipulator arm. Side to side motion at an axis. See "Roll" and "Pitch".