RM2-1555/2355 POSITIONER INSTRUCTIONS

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

MOTOMAN INSTRUCTIONS
MOTOMAN RM2-1555/2355 POSITIONER INSTRUCTIONS
CONTROLLER INSTRUCTIONS
CONTROLLER OPERATOR'S MANUAL
CONTROLLER MAINTENANCE MANUAL

The Controller operator's manual above correspond to specific usage. Be sure to use the appropriate manual.

Part Number: 166007-1CD
Revision: 18
Safety

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 Yaskawa Customer Support.

Notes for Safe Operation

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

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 Positioner 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 Positioner. 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 Positioner.
WARNING

- Before operating the Positioner, 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 Positioner during an emergency. The Positioner 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 Positioner. Then turn the servo power ON.

Injury may result from unintentional or unexpected Positioner motion.

Fig. : Release of EMERGENCY STOP

- Observe the following precautions when performing a teaching operation within the Positioner'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 Positioner from the front whenever possible.
  - Always follow the predetermined operating procedure.
  - Always keep in mind emergency response measures against the Positioner'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 Positioner, which may result in personal injury.

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

Personal injury may result if a person enters the Positioner'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 Positioner.
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 Positioner.
- 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 Positioner teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
  - Check for problems with Positioner 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 Positioner's work area, on the floor, or near fixtures.
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 Positioner’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”.
Explanation of Warning Labels

The following warning labels are attached to the Positioner:

Always follow the warnings on the labels. Also, an identification label with important information is placed on the body of the Positioner. Prior to operating the Positioner, confirm the contents.

**Fig. : Warning Label Locations**
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.
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).

Mechanical Safety Devices

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 buttons

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.
## Definition of Terms Used Often in This Manual

The MOTOMAN is the Yaskawa industrial robot product. The MOTOMAN usually consists of a Positioner, Controller, 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>DX200 Controller</td>
<td>Controller</td>
</tr>
<tr>
<td>YRC1000 Controller</td>
<td></td>
</tr>
<tr>
<td>Programming Pendant</td>
<td>Programming Pendant</td>
</tr>
<tr>
<td>RM2-1555 Positioner</td>
<td>Positioner</td>
</tr>
<tr>
<td>RM2-2355 Positioner</td>
<td></td>
</tr>
<tr>
<td>Any Manipulator</td>
<td>Manipulator</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</td>
</tr>
<tr>
<td></td>
<td>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>&quot;Axis Keys&quot; and &quot;Numeric Keys&quot; 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>Keys pressed simultaneously</td>
</tr>
<tr>
<td></td>
<td>When two keys are to be pressed simultaneously, the keys are shown with a &quot;+&quot; 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>
In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or bland names for each company or corporation. The indications of (R) and TM are omitted.
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 Yaskawa 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 Positioner.

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.
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1 Introduction

1.1 About This Document

This manual provides the following information:

- **Chapter 1 Introduction**
  Provides general information about the Manual, Positioner and its components.

- **Chapter 2 Installation**
  This chapter provides installation procedures.

- **Chapter 3 Power Connections**
  This chapter provides information concerning wiring and cable installation.

- **Chapter 4 Basic Specifications**
  Provides general specifications that may be required during installation and setup.

- **Chapter 5 Load Specifications and Jig Mounting**
  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**
  This appendix provides performance charts for the Positioner.

- **Appendix B**
  This appendix contains the Illustrated Parts List (IPL). The IPL provides detailed views (with part numbers).

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

The Positioner can be used with a variety of applications that require precise parts movement. Typically, the Positioner is integrated with a Manipulator and a Controller in a work cell arrangement.

The Positioner is a two station headstock/tailstock (HS/TS) Positioner. Because of certain operational dynamics, this type of Positioner is often referred to as a “Ferris wheel” Positioner.

The main (sweep) axis and both tooling plate (orbital) axes are rotated by individual SIGMA 5 servomotors (working through gear reduction units) that are controlled by circuitry in the Controller.

All three axes can be driven simultaneously during a sweep motion. In addition, movement of the Positioner can be coordinated with Manipulator motion to allow complex jobs such as the welding of circumferential joints.

*Fig. 1-1: Positioner Assembly*

The Headstock Drive Assembly, Headstock Swing Arm, and the Arc Shield Assembly rotate around a main (sweep) axis and are limited in rotation by hardstops located on the tooling drive swing arm.
If the system does not have FSU Dual “in position” switches are mounted in the headstock housing (see Fig. 1-2). These provide switch closures, as a backup to encoder data, to indicate to safety circuitry whether or not the swingarm assemblies are in the correct and safe position after a Positioner sweep.

Fig. 1-2: Main (Sweep) Axis — Side-A, Side-B “In Position” Safety Switches
A tooling plate multiple angle control feature allows the programmer to define the angle of the tooling presented to the operator (with a resolution of 6 degrees over 30 degrees). This improves load station ergonomics and part tacking (see Fig. 1-3).

Fig. 1-3: Tooling (Orbital) Axis “S” — Tooling Plate Multiple Angle Control Components

All Positioner tooling plates are fitted with the MotoMount™ flexible tool mounting system as the tooling interface (see Fig. 1-1 “Positioner Assembly” on page 1-2 and Fig. 1-3).

Each AC servomotor incorporates a small Lithium-Ion “keep alive” battery pack that maintains servo positioning data in memory, should the main cables between the Positioner and Controller be disconnected. This battery pack is a part of each cable assembly (internal to the Positioner) that connects each AC servomotor to its associated multi-pin plug on the Positioner base (see Fig. 6.2 “Battery Pack Replacement” on page 6-4). These battery packs have a very long life. However, if they drop below a certain charge level, a “low battery” indication appears on the Programming Pendant LCD display screen.

Refer to Table 4-1 “Positioner Technical Specifications” on page 4-1.
1.3 Positioner Configuration

The Positioner assembly is available in two configurations (1555 or 2355). The main (sweep) axis AC servomotor and tooling (orbital) axis AC servomotors are located on the headstock swingarm of the Positioner. This configuration, along with other proprietary features, endow the Positioner with an exceptional Total Index Time (refer to Table 4-1 “Positioner Technical Specifications” on page 4-1 for a complete listing of specifications).

1.4 Welding Ground System

The Positioner incorporates spring-loaded carbon brushes to connect each tooling plate to the welding ground system. A group of four carbon brushes contact the Positioner side of each tooling plate. The negative (–) ground cable to the welding power source is connected to a ground block located inside the Positioner headstock swingarm assembly.

1.5 Major Components

The RM2-1555/2355 Positioner includes the following major components;

• One tooling drive housing assembly (headstock),
• One main drive housing assembly (tailstock)
• Wedge block on either the headstock or tailstock assembly (if equipped)
• One main (sweep) axis SIGMA 5 servomotor (and associated gear reduction unit)
• Two tooling (orbital) axes SIGMA 5 servomotors (and associated gear reduction units)
• One arc screen
• Two Positioner-to-Controller interconnect cables
• One assembly kit for the Controller (servo packs, etc.)

1.5.1 Optional Equipment

This manual documents a standard Positioner assembly. If the Positioner assembly is modified or incorporates optional equipment, refer to the Engineering Drawing Package and associated Bill of Materials (BOM) in addition to this manual. The Engineering Drawing Package and BOM are included with the Positioner shipment. Please refer to those documents, along with this manual, when troubleshooting or provisioning spare parts for the Positioner assembly.
1.6 Reference Documentation

For additional information on individual components of the RM2-1555/2355 Positioner system, refer to the following documentation that is included with the system:

- **Manipulator**
  - Manipulator Instructions
  - Manipulator Maintenance

- **Positioner Manual**
  - RM2-1555/2355 Positioner Manual (166007-1CD)
  - MHTH Headstock Instructions (152568-1CD)

- **Controller Manual**
  - READ FIRST Safety Requirements
  - Instructions
  - Maintenance Manual
  - Operator's Manual for the application
  - Controller Concurrent I/O Manual
  - INFORM User’s Manual

- Vendor manuals for system components not manufactured by Motoman
1.7 Customer Support Information

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

*(937) 847-3200*

For routine technical inquiries, feel free to contact Customer Support at the following e-mail 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 your inquiry.

**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 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**

Please 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:

- **Positioner**: RM2-1555/2355 Positioner
- **Manipulator**
- **Controller**
- **Application**
- **Software Version**: Access this information on the Programming Pendant’s LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - {VERSION}
- **Serial Number**: Located on the Positioner data plate
- **Sales Order Number**: Located on the Positioner data plate
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 serious injury or death.

CAUTION

• Installation of the Positioner is to be completed by qualified personnel.
  – These components are not fragile, but should still be handled with care.
Handling the Positioner 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.

Standard delivery includes the following items (information for the content of optional goods is given separately):

2.1.1 Major Components

The Positioner includes the following major components—

- One headstock swingarm assembly
- One tailstock swingarm assembly
- One main (sweep) axis SIGMA 5 servomotor drive (and associated gear reduction unit)
- Two tooling (orbital) axes SIGMA 5 servomotors (and associated gear reduction units)
- One spreader beam/arc screen
- Two Positioner-to-Controller interconnect cables
- Shipping bracket/ lifting bracket

2.1.2 Optional Equipment

This manual documents a standard Motoman Positioner assembly. If Positioner assembly is modified or incorporates optional equipment, refer to the Engineering Drawing Package and associated Bill of Materials (BOM) in addition to this manual. The Engineering Drawing Package and BOM are included with the Positioner shipment. Please refer to those documents, along with this manual, when troubleshooting or provisioning spare parts for the Positioner assembly.

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
- Wire Rope
- Self Leveling Laser
- Spreader Beam
- Forklift and/or Overhead Crane
- Open-end wrench set
- Wrench sets (Standard and Metric)
- Hammer drill with appropriate concrete bits
2.3 Positioner Installation

**CAUTION**

- Do not start operating the Positioner or turn ON power before firmly anchoring.

The Positioner may overturn and cause injury or damage if Positioner is not firmly anchored.

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 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.

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 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
- 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 by reviewing Fig. 2-1 and Table 4-1 "Positioner Technical Specifications" on page 4-1 and any other additional documentation as required.

**Fig. 2-1: Mounting the Positioner to the Floor**
2.3.2 Shipping Bolts and Bracket

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.

**NOTICE**

Notify shipping agent immediately if there is any shipping damage.

*Fig. 2-2: Shipping Bolt Removal*

The Positioner is provided with shipping bolts and nuts, (*Fig. 2-2* "Shipping Bolt Removal").

Extend the M20 leveling bolts to a point approximately 6.35 mm below the headstock and tailstock frames to the leveling bolt plate. See *Fig. 2-3*.

*Fig. 2-3: Setting Leveling Bolts*
2.3.3 Transporting Method

**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.

**CAUTION**

- Avoid excessive vibration or shock during transportation. The system consists of precision components.
  Failure to observe this caution may adversely affect the performance.
- Do not ship or move Positioner in or around plant without shipping brackets and alignment bar installed.
  Failure to observe this caution may cause damage to the system.

The Positioner can be transported by either:
- overhead crane (section 2.3.3.1)
- two forklifts (section 2.3.3.2)
2.3.3.1 Using an Overhead Crane

**CAUTION**

- Make sure eyebolts are securely fastened on Positioner.
- Use a wire rope strong enough to withstand the weight of the Positioner. The weight of the Positioner is approximately 4800kg including the set-up/shipping brackets.
- Mount the shipping bolts and brackets before transporting the Positioner.

Avoid exerting force on the motors when transporting the Positioner. To avoid injury, be careful when using transporting equipment.

1. Thread wire ropes through the attached M20 eyebolts on the Positioner headstock and tailstock.
2. Attach the wire ropes to the spreader beam.
3. Make sure the Positioner is in the shipping position and the shipping bracket is installed.
4. Lift the Positioner in the posture shown in Fig. 2-4.

*Fig. 2-4: Transporting the Positioner (Crane or Hoist)*
2.3.3.2 Using Forklifts

Two forklifts can be used with the forklift pockets when the Positioner is in the shipping position and with the shipping brackets installed. Make sure the Positioner is in the fixed position with the shipping brackets before transporting per Fig. 2-5.

*Fig. 2-5: Transporting the Positioner (Forklift)*
2.3.4 Mounting Procedures for the Positioner

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.

Mount the Positioner firmly on a baseplate or foundation strong enough to support the Positioner and withstand repulsion forces in acceleration and deceleration.

Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Positioner.
2.3.4.1 Setting Headstock

1. Place leveling bolt plates under each M20 leveling bolt so that the leveling bolts do not rest on the concrete.

   • There should be approximately 6.35mm between the top of the leveling bolt plate and the underside of the headstock. See Fig. 2-6 as a reference only.

   **Fig. 2-6: Headstock Installation on Floor.**

2. Place a machinists' level on the front of the machined surface of the Headstock (without the overhead rail attachment if supplied).

   **Fig. 2-7: Headstock Machined Surface**

---

**NOTICE**

This elevation is just a starting point, and is not a final requirement.
3. Adjust the leveling bolts so the top of the headstock frame is level in both the “X” and “Y” direction within 0.5°.
   • It is best to use three leveling bolts with the fourth leveling bolt retracted to adjust the level.
   • After the top of the headstock is level, the fourth leveling bolt can be turned down to just contact the leveling bolt plate.

4. Lag the two outer most holes of the headstock column to the floor.

2.3.4.2 Setting Tailstock

1. Place leveling bolt plates under each M20 leveling bolt so the bolts do not rest on the concrete.
   • There should be 6.35mm between the top of the leveling bolt plate and the underside of the tailstock frame.

Fig. 2-8: Tailstock Installation on Floor.

2. Remove the shipping brackets (qty 2) that are attached between the tailstock and the Z-beam frame.

3. Place a level on top of the tailstock (without the overhead rail attachment if supplied).

4. Adjust the leveling bolts so the top of the tailstock frame is level in both “X” and “Y” direction within 0.5°.
   • It is best to use three leveling bolts with the fourth leveling bolt retracted to adjust the level.
   • After the top of the tailstock is level, turn down the fourth leveling bolt to just contact the leveling bolt plate.

5. Measure the distance between the tailstock to the headstock at the points in Fig. 2-9 and ensure the distance between these points are within 3.175mm.

NOTICE

This elevation is just a starting point, and is not a final requirement.
Fig. 2-9: Distance between points on Tailstock and Headstock
6. Check the elevation of the headstock to tailstock using a self leveling laser.

**NOTICE**

The Z-beam dowel pin is the recommended reference. The laser should hit both dowel pins at the same elevation.

7. Verify that the headstock is parallel to the tailstock by using the laser from the headstock column machined plate making sure it hits the same spot on the tailstock column.

2.3.4.3 Mounting the Positioner on the Floor

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. When the thickness of the concrete floor is 200mm or more, the Positioner can be fixed directly to the floor see “Robotic Equipment Installation and Lagging Requirements” and “Equipment Anchoring” for more details.

Before mounting the Positioner on the floor, check the flatness, cracks, etc. of the floor. If there are any cracks on the floor, they should be repaired before installation. Any thickness less than 200mm is insufficient for mounting, even if the floor is concrete. Use striker plates to prevent the leveling bolts from embedding into the concrete.

**CAUTION**

- 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.

Head and tailstock column location should be checked for squareness using a cross measuring method and using a level to determine that they are parallel with each other vertically.
### Robotic Equipment Installation and Lagging Requirements

- The customer is responsible for reviewing the data in “Equipment Anchoring” to determine all equipment lagging requirements.

- The customer is responsible for determining the adequacy of the foundation in the area where the equipment will be located.

- If the foundation is found to be inadequate for the proposed equipment, the customer will be responsible for installing or subcontracting the installation of a suitable foundation for the equipment.

- Upon receipt of the equipment, the customer is responsible for supplying the recommended lagging required based on section “Equipment Anchoring”. The customer is responsible for providing the labor and material for installing the lagging per recommendations.

### Equipment Anchoring

- The Customer or designated Contractor shall provide and install all required Hilti Anchors or equivalent.

- For the applications listed with Kwik Bolt II Expansion type Anchors, other proposed manufacturers’ strength characteristics must meet the equivalent Hilti strength characteristics.

- Stud anchors shall extend above the Nut no more than 25mm.

- The Customer or designated contractor shall use a minimum of 5/8” HVA Chemical Style anchors when choosing anchors for the equipment being installed.

- The customer or designated contractor shall use the approved anchors of the lengths consistent with the minimum 5/8” HVA Chemical Style anchor.

- The Hilti HVA Chemical Style anchors specified are Standard HAS Rod Material ASTM Type A36 as a minimum for Mechanical Properties required. Standard HAS-E Rod Material ISO 898 Class 5.8 or Super HAS Rod Material ASTM A193, Grade B7 may be substituted as required.

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**NOTICE**

The data in this document is to assist in the installation of equipment. Before installing any equipment evaluate the floor to determine if it is within the requirements of the equipment.
2.4 Customer-Supplied Tooling Fixtures

The RM2-1555/2355 Positioner is equipped with a MotoMount™ tool mounting system (see Fig. 1-1 “Positioner Assembly” on page 1-2). MotoMount is a flexible tool mounting system for headstock / tailstock style Positioners, such as the RM2-1555/2355 Positioner. MotoMount provides improved part presentation repeatability compared to traditional hard-mounted systems.

The MotoMount system also minimizes headstock / tailstock bearing loads induced by tooling and headstock / tailstock misalignment (up to a maximum of ±2 degrees), transmitting only the predictable moment loads resulting from simple beam loading.

For additional information on the correct use and care of the MotoMount tool mounting system, contact Customer Support. (Refer to section 1.7 “Customer Support Information” on page 1-7).

**NOTICE**

The customer shall supply all tooling fixtures for the Positioner.

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

**WARNING**

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

**CAUTION**

- The Positioner system should be installed by qualified personnel who are familiar with the installation and setup. Failure to observe this caution may cause injury or damage.
- Do not install or operate a Positioner that is damaged or lacks parts. Failure to observe this caution may cause injury or damage.

**CAUTION**

- Before turning ON the power, check to be sure that all shipping bolts and brackets are removed. Failure to observe this caution may cause in damage to the major driving parts.

To insure safety, be sure to install safeguarding. It prevents unforeseen accidents with personnel and damage to equipment. The following is quoted for information and guidance. Positioner homing procedure and Manipulator to Positioner calibration can now be performed.
2. Installation

2.5 Installation of Safeguarding

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.
3 Power Connections

3.1 Electrical Connections

### WARNING

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

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

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

#### 3.1.1 Grounding

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

### 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.

*Fig. 3-1: Grounding Method*
3.2 **Cable Connection**

There are two cables used to connect the Positioner to the Controller; a power cable and an encoder cable. Connect these cables to the Positioner base connectors and the Controller respectively. Refer to Fig. 3-2 and Fig. 3-3 for connection between the Positioner and the Controller.

3.2.1 **Connection to the Positioner**

Before connecting the cables to the Positioner, check the numbers on both the cables and Positioner base connectors. Connect each cable adjusting the cable connector positions to the main key positions of the Positioner, and then tighten the nut until it clicks.

3.2.2 **Connection to the Controller**

Before connecting the cables to the Controller, check the numbers on both the cables and controller connectors. Connect each cable adjusting the cable connector positions to the main key positions of the Positioner, and then tighten the nut until it clicks.

Connect the power cable to the Controller. Check the numbers on both the cable and the relay connectors before connecting.

Connect the encoder cable to the Controller. Check the numbers on both the cable and the relay connector before connection.

*Fig. 3-2: Connection between the RM2-1555/2355 Positioner and the Controller*

*Fig. 3-3: Connection between Positioner and Controller (Positioner Side)*
3.2.3 Shop Air Connections

The shop air connections is used to operate the valves of the Positioner. Air pressure for the Positioner should be between 75 to 120psi. to operate the Positioner assembly efficiently.
4 Basic Specifications

4.1 Basic Specifications List

**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>
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<th>SPECIFICATION</th>
<th>UNITS</th>
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## Basic Specifications

### 4.1 Basic Specifications List

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<th>RM2-2355</th>
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4.2 Part Names and Working Axes

Fig. 4-1: Part Names and Working Axes

4.3 Mounting Dimensions

Fig. 4-2: Mounting Dimensions (swingarms removed for clarity)
4.4 Dimensions and Working Envelope

Fig. 4-3: RM2-1555 Dimensions and Working Envelope

Fig. 4-4: RM2-2355 Dimensions and Working Envelope
5 Load Specifications and Jig Mounting

5.1 Details of Fixture Mounting

The fixture mounting dimensions are shown in the figures below. It is a requirement that the fixture be located with the 16mm dowel and attached with four M12 bolts (10.9 or 8.8 grade).

Fig. 5-1: Details of Jig Mounting Face

5.2 Fixture Specifications

- Tool and part weight MUST not exceed rated Positioner capacity.
- Length of fixture to be a nominal of ±1mm.
- Diameter of fixture not to exceed:
  - RM2-1555 - 1524mm
  - RM2-2355 - 1778mm
6 Maintenance and Troubleshooting

**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.
- Do not remove the motor or release the brake.

Failure to observe these cautions may result in injury from unexpected turning of the table.

**NOTICE**

The motor and reducer are not recommended for field service. The unit should be returned for repairs of these components.
### 6.1 Inspection Interval

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

**Table 6-1: Periodic Maintenance for Positioner**

<table>
<thead>
<tr>
<th>Inspection Item</th>
<th>Frequency</th>
<th>Inspection Operation</th>
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<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 Yaskawa Customer Support. Refer to section 1.7 “Customer Support Information” on page 1-7.</td>
</tr>
<tr>
<td>S1 Gear and Pinion Axis</td>
<td>Weekly&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Grease with Yaskawa P/N 180144-1, Mobil CM-P, Lithium Complex. Apply grease with a grease gun thru the grease fitting on the bottom. Apply three squeezes of grease gun lever (approximately 4g). In TEACH mode rotate the Gear/Reducer pinion 180 degrees and apply grease to the grease fitting that is located on bottom.</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>
</tbody>
</table>
| Positioner Axis Motor Connectors     | • 1,000 H  
• 6,000 H  
• 12,000 H | Check for loose connections. tighten if necessary. |
| Position Axis Speed Reducer and Gear | 6,000 H   | Grease with Yaskawa P/N 132412-1, Molywhite RE00 |
| Positioner Axis Speed Reducer and Gear | 12,000 H | Grease with Yaskawa P/N 132412-1, Molywhite RE00 |
| Limit Switch Actuator for Positioner Axis | • 6,000 H  
• 12,000 H | Check for damage and looseness. Tighten and check the actuator movement. |
| Tailstock Main Sweep Axis Bearing    | Monthly   | 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). |
| Motomount Bearing                    | Monthly   | Grease with Yaskawa P/N 180144-1, Mobil CM-P, Lithium Complex. Apply grease with a grease gun thru the grease fitting. Apply 10 squeezes of the grease gun lever (approximately 1.25g x 10). |

<sup>a</sup> The S1 Gear and Pinion Axis needs to be lubricated when setting up for the first time. Refer to section 6.3.3.2 “Lubricating for the First Time”.

---

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NOTICE

The inspection intervals depend 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 Customer Support.

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>Slewling S1 Gear and Pinion Axis, tailstock swingarm main axis bearing and motomount bearing.</td>
</tr>
<tr>
<td>3</td>
<td>Gadus S2 V220 2</td>
<td>132177-1</td>
<td>Slewling bearing raceway.</td>
</tr>
</tbody>
</table>
6.2 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 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. 6-1: Battery Pack*
6.3 Grease Replenishment/Exchange for Speed Reducers

**WARNING**

- Follow all necessary safety procedures as described in this manual and all state and federal procedures and regulations.

Not following all necessary safety procedures may result in serious injury.

6.3.1 Main Axis

1. Rotate the B side to the operator, until S1 motor is in the up position. The vent is located in the upper most surface of the S1 motor bracket.

2. With the drive pinion in the upper most position remove one of the three set screws from the face of the drive pinion.

3. Remove the button head screw above the motor flange and install the M6 grease fitting.

4. Pump grease through the reducer from the motor side and vented on the gear side.

5. Reseal.

6.3.2 Tooling Axes

1. Remove the button head screws in the vent located in the flat surface at the top of the drive assembly.

2. Install M6 grease fitting in the faceplate and pump grease through the reducer.

3. Reseal.

6.3.3 Gear and Pinion Lubrication

6.3.3.1 Gear and Pinion Teeth Lubrication

If the Positioner is retrofitted with the optional remote main axis kit, the lubrication process will vary from standard method. For convenience, the main axis lubrication grease fittings are moved from the main axis motor cover to the top of the headstock column as shown below which allows main axis lubrication while running. Pump grease into each fitting as the Positioner turns clockwise or counterclockwise as indicated in the label.

*Fig. 6-2: Optional Remote Main Axis Kit Lubrication Fittings*
6.3.3.2 Lubricating for the First Time

1. Turn the Positioner so the S1 gear and pinion cover is pointing down.
2. Remove the S1-axis motor cover, by removing four M6 screws, washers, and lock washers. See Fig. 6-3.

Fig. 6-3: S1-axis Motor Cover Removal

CAUTION

- Make sure the grease hose outlets are in aligned with the center of the gear.

Not having the grease hose alignment correct may cause the gear and pinion to wear out prematurely.

3. Check the alignment of the grease hose outlets. The hose outlets should be aligned with the center of the gear as shown in Fig. 6-4. If the alignment of the grease hose outlet is not aligned with the gear, loosen the hose clamp by loosening the screw and adjust as required.

Fig. 6-4: Alignment of Grease Nozzles looking from underneath
4. Tighten the hose clamp screws and inspect hoses for kinks or damages.

5. Insert Mobil CM-P, Lithium Complex (part number 180144-1) into the two grease fittings by squeezing the lever of a standard grease gun until grease comes out the hose outlets at the gears. Ensure grease comes out the grease hose outlets and there is no damage to the grease fittings, or hoses.

6. Reinstall the S1-axis motor cover by reinstalling the screws and washers to 12.2 Nm removed from step 2.

6.3.3.3 Weekly Lubrication

1. Turn the Positioner so the S1 gear and pinion cover is pointing down.  
   *Fig. 6-5: S1 Gear and Pinion Cover Pointing Down*

2. Wipe off any old grease from the grease fittings. See *Fig. 6-5* for location of grease fittings.

3. Apply Mobil CM-P, Lithium Complex (part number 180144-1) with a grease gun thru the grease fitting on bottom. Squeeze the grease gun lever three times (approximately 1.25g x 2.)

4. In Teach Mode rotate the S1 gear and pinion 180 degrees and repeat step 3.
6.3.4 Tailstock Lubrication

The lubrication of the swingarm main axis bearing and the motomount axis bearing are required to be lubricated monthly.

6.3.4.1 Swingarm Main Swing Axis

1. Remove the four M5 screws holding the tailstock swingarm center cover in place and slide cover out.

*Fig. 6-6: Removing Swingarm Center Cover, Looking Down View*

2. Apply Mobil CM-P grease to the grease fitting by using a standard grease gun and pressing the lever 10 times (1.25g x 10).

*Fig. 6-7: Tailstock Swingarm Center Cover Opening*

3. Replace the tailstock swingarm center cover and four M5 screws tightening the screws to 7.2Nm removed in step 1.
6.4 General Cleaning

The RM2-1555/2355 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.

6.5 SIGMA 5 Servomotors

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 1.7 “Customer Support Information” on page 1-7).

6.6 Servo Pack

The servo pack (located in the Controller) does not require customer maintenance. If suspecting a problem with the servo pack, contact Customer Support (refer to section 1.7 “Customer Support Information” on page 1-7).
6.7 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 (see section 1-2 “System Overview” on page 1-3). 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 Customer Support (refer to section 1.7 “Customer Support Information” on page 1-7).

6.7.1 Setting (Sweep) Axis Backlash.

The Axis Backlash is a measurement of free movement of the gears. Yaskawa recommends using Customer Support to set the Axis Backlash.

**NOTICE**

Positioner’s assembled from August 2018 and later no longer have shims for adjusting the backlash.

To adjust the backlash on Positioner’s assembled from August 2018 and later an adjustment tool will need to be purchased. The adjustment tool part number is 185367-1.

The backlash between the drive pinion and the ring gear needs to be set at 0.110mm to 0.140mm. The actual measurement is the free movement of the gears.
6.7 Main (Sweep) Axis Reduction Gear Unit (RV–320E–X)

6.7.1.1 Positioner Assembled from August 2018 or later

Required Tools:

- Dial Test Indicator
- Rags
- M12 Guide Pins x2
- Backlash Adjustment Tool
- Impact Wrench
- Torque Wrench
- M16 Socket Drive
- Marker

1. Locate the three dots on the drive pinion and the three ring gear teeth and mark. See Fig. 6-9

*Fig. 6-9: Marking Dots and Teeth*

[Image of three dots on pinion and highlighted gear teeth]

**NOTICE**

When marking the ring gear teeth align tooth with the middle dot on the drive pinion and align the left and right dot of the pinion with the spaces next to the middle tooth on the gear

2. Insert four base screws tight enough to hold ring gear in place.

*Fig. 6-10: Four base Screws*
3. Install two M12 guide pins onto the ring gear.

*Fig. 6-11: Installing Guide Pins*

4. Wipe grease off the gear teeth.
5. Attach the test indicator ensuring the tip of the test indicator is parallel to the ring gear.

*Fig. 6-12: Placing Test Indicator Parallel to the Ring Gear*

**NOTICE**

Refer to the Test Indicator instructions concerning use and measuring tips.
6. Retract the bottom bolt of the backlash adjustment tool and place inside the headstock with “Other” in the up position and tighten the upper bolt till it stays in place.

Fig. 6-13: Attach Backlash Adjustment Tool Placement

7. Rotate the Ring Gear clockwise and counterclockwise using guide pins ensuring the test indicator reads between 0.110mm and 0.140mm.

8. Torque the four screws holding the ring gear in place to 255Nm. Refer to Fig. 6-10.

9. Repeat step 7.

10. Install the rest of the M16 screws for the ring gear and torque to 255Nm.

**NOTICE**

If the reading of the test indicator reads:

– above the required readings the upper bolt of the adjustment tool needs to be extended.

– below the required readings, remove the backlash adjustment tool and repeat step 6 and step 7.

If the reading of the test indicator is not between 0.110mm and 0.140mm loosen up the four screws holding the ring gear in place and repeat step 6 through step 8.
6.7.1.2 Positioner Assembled before August 2018

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.
6.8 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 (see Fig. 1-1 “Positioner Assembly” on page 1-2). 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 Customer Support (refer to section 1.7 “Customer Support Information” on page 1-7).

6.9 Main (Swing) Axis Hardstops

The Positioner incorporates two buffered hardstops that are welded to the Tooling Drive Swingarm Assembly. The hardstops provide a positive stop for the Tailstock Tooling Drive Swingarm Assembly (and thus the Arc Shield and Main Axis Swingarm Assembly) during a sweep cycle. The tailstock hardstop is fixed while the headstock is adjustable. The adjustable hardstops must be set at the final installation process and are located on the headstock. Refer to section 6.12.1 “Positioner Home Position”.
6.10 Welding Ground System

6.10.1 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.

6.10.2 Ground Brush Replacement

Ground Brush Removal Procedure –

1. Remove all hazardous energies from the Positioner and other system components.

**NOTICE**

Each ground brush is enclosed in a box-shaped brush holder that is attached to a mounting plate. The brush holder incorporates a spring tensioner device that holds the ground brush, under spring tension, against the rear of the tooling plate when locked into position.

2. Release the spring tensioner by squeezing together both of the black levers that are visible on each brush holder. While squeezing the levers together, pull out and away from the brush holder. This should produce the ground brush.

3. Each ground brush has two braided copper leads that connect to silver-plated, high current quick disconnect posts on the ground brush mounting plate. After the ground brush is free and clear of the brush holder, use a flat blade screwdriver or needle nose pliers to disconnect each of the braided copper brush leads from the quick disconnect posts.
6.10.3 Ground Brush Installation

1. Connect braided copper brush cables (from the new brush) to the quick disconnect posts on the ground brush mounting plate.

   NOTICE

   This is a good time to check the cleanliness and condition of the quick disconnect posts. If dirt or grease buildup is noticed on the posts, clean them. Use a small bristle brush (toothbrush size) and compressed air.

2. Make sure that the spring tensioner in the brush holder is released and pulled as far back as possible.

3. Insert the new brush into the brush holder and push forward as far as possible.

4. Lock the new brush into position by squeezing together the black tensioner levers and pushing the tensioner forward into the brush holder until it “clicks” into the locked position.

6.10.4 Inspection of Welding Ground Connections

Inspect all welding ground cable connections for cleanliness and security.

   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.
6.11 AC Servomotor Encoder Back-Up Battery

The main (sweep) axis and tooling (orbital) axes SIGMA 5 servomotors all incorporate an external Lithium-Ion “keep alive” battery pack that maintains encoder positioning data in system memory, should the main cables between the Positioner and Controller be disconnected.

The “keep alive” batteries have a long life in this particular application. However, should one or more of these batteries drop below a certain charge level, an indicator will appear on the Programming Pendant display screen, indicating the need for battery renewal.

To replace a depleted encoder “keep alive” battery pack, gain access to the encoder plug on the applicable SIGMA 5 servomotor, locate the depleted battery pack, and replace it with a new battery pack of the same type.
6.12 Positioner Home Position

- **Home Position Definition:**
  S1 with Side B at Manipulator & Side A at Operator
  S2 Tooling Down (At Operator Side)
  S3 Tooling Up (At Manipulator Side)

6.12.1 Adjusting the Hardstops

Shock absorbing hardstops prevent the Positioner from rotating a full 360°. It is important that both the headstock and tailstock swingarms strike the hardstop shock absorbers at approximately the same time. Standard Positioner's use wedge blocks to secure the operating side in place while loading and unloading heavy parts on the operator side. It is important that both the tailstock and headstock hardstops come in full contact, leaving no gaps. If one hardstop is higher than the other the wedge blocks will jam the lock when releasing. Adjust the headstock hardstop as needed to make sure both hardstops are at the same height."

To adjust the hardstops, proceed as follows:

1. Loosen the M16 bolts attaching the adjustable hardstop plates on the headstock swing arm.

   ![Headstock Hardstops](image)

2. Rotate the square head adjusting screw to allow the hardstop to move away from the fixed component. This allows the tailstock hardstop to contact first during motion.

   **NOTICE**
   To hold the headstock in position one of the M16 may need to be snugged.

3. Jog S1 axis into the Positioner hardstop with the B-side of the Manipulator. Increment the Positioner against the hardstop on the tailstock side until the holding torque is 20%. Record the value into the "S1 Home" position.
4. Adjust the hardstop plate on the headstock by loosening the jam nut and rotating the square head adjusting screw. (Loosen the M16 bolts that were snugged in step 2). Torque increases to 35-45% during this process. Snug the M16 bolts holding the hardstop on the swing arm and rotate to a position that allows access for tightening the remaining M16 bolts. Lock the adjusting screw with jam nut.

5. Rotate the Positioner back to the B-side position, observing torque is between 45-50%. Adjust the position with the Programming Pendant (if required) and reset the home position. See setting the Home Position in the Controller manual.

**NOTICE**

Once the home position is set, if the FSU is enabled, a message will appear directing to flash reset the FSU in MAINTENANCE mode. This reset can be postponed until instructed later in the homing procedure.

6. Repeat the above steps to set the A-side except set the value to S1 A-SIDE @ RBT Position.

7. Jog Positioner to both the A and B sides checking the holding torque values. Adjust the “A” position as required until holding torque is between 45-50%. It requires several cycles on both sides for confirmation.

**NOTICE**

Anytime the holding torque value changes on side “B” the holding torque value on side “A” needs to be adjusted.

---

**Table 6-3: Jog Positioner to both A & B sides checking the holding torque values.**

**EX Position Variable Settings**

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>DX Variable</th>
<th>YRC Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 A-SIDE @ RBT</td>
<td>EX040</td>
<td>EX100</td>
<td>-180.000°</td>
<td>S1 A-Side at Manipulator (Value may change after homing)</td>
</tr>
<tr>
<td>S1 B-SIDE @ RBT</td>
<td>EX050</td>
<td>EX106</td>
<td>0.000°</td>
<td>S1 B-Side at Manipulator</td>
</tr>
</tbody>
</table>

**a** S1 A-SIDE @ RBT variable value will vary from Positioner-to-Positioner and gives results of homing routine. The results should have a value of 179.5° and 180.5° for proper FSU operation.
6.12.2 Setting S3 Tooling at Manipulator

1. Using the Programming Pendant, place the robotic system into MANAGEMENT mode.
2. Jog S3 tooling vertical (90 degrees from level).
3. Install the plastic homing pin (see Fig. 6-15) in the back side of the faceplate into the homing pin hole. (see Fig. 6-16).

Fig. 6-15: Homing Pin Details

Fig. 6-16: Tooling Plate Home (Zero) Position

CAUTION

- Do Not Jog the S3-axis too far.
  Jogging the axis too far will bend the pin causing an inaccuracy. Slowly jog the axis in reverse until the pin is straight and still touching the edge of structure.

4. Slowly jog S3-axis until homing pin just touches stationary edge of structure.
5. Press (TOP MENU) on the Programming Pendant.
6. Cursor to {ROBOT} and press [SELECT].
7. Cursor to {HOME POSITION} and press [SELECT].
8. Press [PAGE OVER] to {S3} (indicated in top right corner of Programming Pendant display panel).
9. Press [SELECT].
10. Cursor to (YES), press [SELECT].
   The tooling plate is now reset to zero.
11. Remove the homing pin from the tooling plate.

**Table 6-4: Jog Positioner Variable to Set S3 “Level Home”**

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>DX Variable</th>
<th>YRC Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S3 Home Pin to Level Home</td>
<td>EX060</td>
<td>EX112</td>
<td>98.000°</td>
<td>S3 Homing Pin to “Level Home”</td>
</tr>
<tr>
<td>S3 Level Home to Home Pin</td>
<td>EX061</td>
<td>EX113</td>
<td>-98.000°</td>
<td>S3 “Level Home” to Homing Pin</td>
</tr>
</tbody>
</table>

13. Once at the S3 Level Home to Home Pin Variable, Re-home the S3 axis by modifying the home position.
6.12.3 Setting S2 Tooling at Manipulator

1. Using the Programming Pendant, place the Manipulator system into MANAGEMENT mode.
2. Jog S2 tooling vertical (90 degrees from level).
3. Install the plastic homing pin (see Fig. 6-15) in the back side of the faceplate into the homing pin hole (see Fig. 6-16).

**CAUTION**

- Do Not Jog the S2-axis too far.
  Jogging the axis too far will bend the pin causing an inaccuracy. Slowly jog the axis in reverse until the pin is straight and still touching the edge of structure.

4. Slowly jog S2-axis until homing pin just touches stationary edge of structure.
5. Press (TOP MENU) on the Programming Pendant.
6. Cursor to {ROBOT} and press [SELECT].
7. Cursor to {HOME POSITION} and press [SELECT].
8. Press [PAGE OVER] to {S2} (indicated in top right corner of Programming Pendant display panel).
9. Press [SELECT].
10. Cursor to {YES}, press [SELECT].

**NOTICE**

Once the home position is set, and the FSU is enabled, a message will appear directing to flash reset the FSU in Maintenance mode. This reset can be postponed until instructed later in the homing procedure.

11. Remove the homing pin from the tooling plate.

*Table 6-5: Jog Positioner variable to set S2 “Level Home”*  

<table>
<thead>
<tr>
<th>EX Position Variable Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable Name</strong></td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>S2 Home Pin to Level Home</td>
</tr>
<tr>
<td>S2 Level Home to Home Pin</td>
</tr>
</tbody>
</table>

13. Once at the S2 Home Pin to “Level Home” Variable, re-home the S2 axis by modifying the home position.
14. If the FSU is enabled, reset the FSU in Maintenance Mode.
6.13 Setting Wedge Locks *(Optional)*

**NOTICE**

- This section is included for Positioner’s that include wedge locks.
- Before setting the wedge locks ensure the hardstops are set correctly. See section 6.9 for more information concerning hardstops.

Wedge Locks are located on the headstock and the tailstock swing arm.

6.13.1 Setting Wedge Lock Regulators

1. Remove the Positioner Main Drive Housing Cover.
2. Loosen the Extend and Retract air regulator locks.

*Fig. 6-17: Wedge Lock Regulators*

3. Disconnect the control cable to the regulators.
4. Set the Retract and Extend regulators per *Table 6-6*.

**NOTICE**

The bottom of the regulator sets the Retract pressure and the top of the valve sets the Extend pressure.

*Table 6-6: Extend and Retract Wedge Lock Pressure*

<table>
<thead>
<tr>
<th>Shop Air (psi)</th>
<th>Extend (psi)</th>
<th>Retract (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 +</td>
<td>Not Recommended</td>
<td>Not Recommended</td>
</tr>
<tr>
<td>90 - 120</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>75 - 90</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>75 -</td>
<td>Not Recommended</td>
<td>Not Recommended</td>
</tr>
</tbody>
</table>

5. Operate the valves using the buttons on the valves observing the pressure to ensure a three times differential in pressure. See *Table 6-6*. 
6.13.2 Adjusting Wedge Gap

1. Loosen the two bolts on front of the cylinder of the headstock swingarm.

Fig. 6-18: Positioner Wedge Locks

2. Move the wedge locks in using the buttons on the valves.
3. Loosen the two back bolts on the cylinder.
4. Align wedge cylinder from front to back ensuring there is no light showing at the bottom of the wedge.
5. Tighten the two bolts on front of the cylinder.
6. Manually move the wedge locks in using the buttons on the valve.
7. Tighten the two bolts on the back on the cylinder.
8. Tighten the regulator nuts to lock regulators.
9. Check operation to ensure wedge block works correctly manually.
10. Repeat step 2 through step 9 with the tailstock swingarm by removing the wedge lock access covers first.
11. Reconnect the Control Cable to the regulators.

NOTICE

- The front bolts are the bolts seen looking from the view of the headstock Housing Cover.
- Figure 6-18 is shown with out covers for reference only.
6.13.3 Set Reed Sensor

6.13.3.1 Extended Sensor
1. Unlock the reed sensor on the cylinder.
2. Move sensor until sensor goes off and then back just enough to have the sensor light.
3. Lock sensor in place.

6.13.3.2 Retract Sensor
1. Unlock the sensor on the cylinder.
2. Move sensor to the middle of stroke and tighten.
3. Lock sensor in place.
6.14 Troubleshooting

6.14.1 Positioner

Table 6-7: 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 temperature</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>Motor surface is dirty</td>
<td></td>
<td>Clean motor surface.</td>
</tr>
<tr>
<td>Motor overloaded</td>
<td></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>Positioner misaligned</td>
<td>Realign Headstock/tailstock (see Section 2.3.4, &quot;Mounting Procedures for the Positioner&quot;)</td>
</tr>
<tr>
<td></td>
<td>Noisy bearing</td>
<td>Check alignment, noise of bearing, lubrication. Call 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>

6.14.2 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

Table 7-1: Spare Parts for the RM2-1555/2355 Positioner

<table>
<thead>
<tr>
<th>Rank</th>
<th>Part No’s.</th>
<th>Name</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>For speed reducer of each axis.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>180144-1</td>
<td>Mobil CM-P, Lithium Complex Grease</td>
<td>-</td>
<td>Slewling S1 Gear and Pinion Axis, tailstock swingarm main axis bearing, and motomount bearing.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>132177-*</td>
<td>Gadus S2 V220 2</td>
<td>-</td>
<td>Slewling bearing raceway.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>479348-2</td>
<td>Battery Pack</td>
<td>1</td>
<td>3</td>
<td>Backup</td>
</tr>
<tr>
<td>A</td>
<td>144370-1</td>
<td>Weld Ground Brush Post</td>
<td>4</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>144372-1</td>
<td>Weld Ground Brush Holder</td>
<td>4</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>144371-1</td>
<td>Brush</td>
<td>4</td>
<td>1</td>
<td>For Positioner</td>
</tr>
<tr>
<td>A</td>
<td>185367-1</td>
<td>Adjustment Tool^a</td>
<td>1</td>
<td>1</td>
<td>For adjusting backlash</td>
</tr>
</tbody>
</table>

^a The Adjustment Tool is required for Positioner assembled August 2018 or later.

NOTICE

To replace parts in Rank B or Rank C, contact Customer Support. (Refer to section 1.7 “Customer Support Information” on page 1-7).

To order spare parts or replacement parts for the Positioner, contact Customer Support. (Refer to section 1.7 “Customer Support Information” on page 1-7).

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>30</td>
<td>2390</td>
<td>2661</td>
</tr>
<tr>
<td>60</td>
<td>480</td>
<td>549</td>
</tr>
<tr>
<td>90</td>
<td>350</td>
<td>415</td>
</tr>
<tr>
<td>120</td>
<td>261</td>
<td>314</td>
</tr>
<tr>
<td>150</td>
<td>2059</td>
<td>2749</td>
</tr>
<tr>
<td>180</td>
<td>1830</td>
<td>2077</td>
</tr>
<tr>
<td>200</td>
<td>1599</td>
<td>1841</td>
</tr>
<tr>
<td>220</td>
<td>1499</td>
<td>1682</td>
</tr>
<tr>
<td>240</td>
<td>1399</td>
<td>1511</td>
</tr>
<tr>
<td>260</td>
<td>1299</td>
<td>1355</td>
</tr>
<tr>
<td>280</td>
<td>1199</td>
<td>1200</td>
</tr>
<tr>
<td>300</td>
<td>1099</td>
<td>1077</td>
</tr>
</tbody>
</table>

Maximum Bearing Moment (N*m) = 7056

<table>
<thead>
<tr>
<th>Load CG Overhang (from Tooling Plate)</th>
<th>Rated W (kgf)</th>
<th>Max W (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1240</td>
<td>1690</td>
</tr>
<tr>
<td>60</td>
<td>1296</td>
<td>1840</td>
</tr>
<tr>
<td>90</td>
<td>1690</td>
<td>2130</td>
</tr>
<tr>
<td>120</td>
<td>1840</td>
<td>2380</td>
</tr>
<tr>
<td>150</td>
<td>1990</td>
<td>2530</td>
</tr>
<tr>
<td>180</td>
<td>2140</td>
<td>2670</td>
</tr>
<tr>
<td>200</td>
<td>2290</td>
<td>2810</td>
</tr>
<tr>
<td>220</td>
<td>2440</td>
<td>3040</td>
</tr>
<tr>
<td>240</td>
<td>2590</td>
<td>3170</td>
</tr>
<tr>
<td>260</td>
<td>2740</td>
<td>3290</td>
</tr>
<tr>
<td>280</td>
<td>2890</td>
<td>3420</td>
</tr>
<tr>
<td>300</td>
<td>3040</td>
<td>3550</td>
</tr>
</tbody>
</table>

Note: HTS Applications assume 1/2 load on headstock @ 50 mm, using MotoMount.
1) Rated load based upon 50% maximum bearing moment.
2) Maximum load based upon 75% maximum bearing moment.

<table>
<thead>
<tr>
<th>Reflected Ratio</th>
<th>Jl/Jm</th>
</tr>
</thead>
<tbody>
<tr>
<td>672</td>
<td>2.3</td>
</tr>
<tr>
<td>747</td>
<td>2.76</td>
</tr>
<tr>
<td>822</td>
<td>3</td>
</tr>
<tr>
<td>889</td>
<td>3.29</td>
</tr>
<tr>
<td>955</td>
<td>3.5</td>
</tr>
<tr>
<td>1021</td>
<td>3.75</td>
</tr>
<tr>
<td>1088</td>
<td>4</td>
</tr>
<tr>
<td>1155</td>
<td>4.25</td>
</tr>
<tr>
<td>1221</td>
<td>4.5</td>
</tr>
<tr>
<td>1297</td>
<td>4.75</td>
</tr>
<tr>
<td>1373</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: Maximum recommend inertia ratio is 5.
B.1 Illustrated Parts List

The Illustrated Parts List contains illustrations (exploded views) and associated parts list tables that show detail parts of a particular component, assembly, or subassembly.

B.1.1 General

The Illustrated Parts Lists (IPL) identifies, describes, and illustrates detail parts of the Positioner's included in this manual is an illustration and table for each of the different Positioner's. The illustrations included are:

- Fig. B-1 "Major Assemblies — RM2-1555 and 2355 (Built Before August 2018)"
- Fig. B-2 "Housing Assembly, Swingarm Headstock Main Drive (Built Before August 2018)"
- Fig. B-3 "Housing, Headstock Swingarm (Built Before August 2018)"
- Fig. B-4 "Main Sweep Drive Assembly (Built Before August 2018)"
- Fig. B-5 "Tailstock Swingarm Housing (Built Before August 2018)"
- Fig. B-6(a) "Major Assemblies — RM2-1555 and 2355 (Built after August 2018)"
- Fig. B-6(b) "Headstock Swingarm (Built after August 2018)"
- Fig. B-6(c) "Tailstock Assembly (Built After August 2018)"
- Fig. B-7 "Headstock Main Drive Swing Arm Assembly (Built after August 2018)"
- Fig. B-8 "Slip-Ring Kit Assembly"
- Fig. B-9 "Cylinder Assy, Headstock, 100mm Stroke (Wedge Block) (If Equipped)"
- Fig. B-10 "Cylinder Assy, Tailstock, 75mm Stroke (Wedge Block) (If Equipped)"

B.1.2 Purpose

The IPL provides parts identification and descriptive information for use in provisioning, purchasing, storing, and issuing spare parts.

B.1.3 IPL Layout

The IPL is arranged so that the illustration (exploded view) for an assembly appears directly above the parts list table for that illustration. When this is not possible, due to a large illustration or an extensive parts list table, the parts list table is listed on the facing page. This format always attempts to present the illustration and its associated parts list table to the reader in one view, regardless of viewing format (PDF or printed).
B.1.4 Item Categories Not Included in the IPL

The following item categories are not included in the IPL –

- Standard hardware items (attaching parts) such as nuts, screws, washers, etc. These are commercially available to the customer.
- Bulk items and consumables such as wire, cable, sleeving, tubing, certain fluids, etc. These are commercially available to the customer.
- Permanently attached parts that lose their identity because they are welded, soldered, riveted, etc., to other parts, assemblies, or sub-assemblies.

B.1.5 Parts List Table Structure

Each figure’s parts list table contains the following data columns –

- **FIGURE AND ITEM NUMBER**
  An entry in this column gives the item number for a part shown in the associated illustration (exploded view). The item number listed in this column is the same as the item number shown on the illustration. Item numbers on the illustration are identified by a circled number and leader line that points to the particular part (item) on the illustration.

- **PART NUMBER**
  An entry in this column gives the part number for an item. Refer to this number when ordering or referencing the part.

- **DESCRIPTION**
  An entry in this column gives the description (nomenclature) for an item number or part number.

- **QTY**
  An entry in this column gives the total quantity of an item or part number required for an assembly or subassembly in which the part appears. The quantity given in this column may or may not be the total quantity required for the complete end item. The letters “REF” in this column indicate a reference to the top assembly in the figure.

---

**NOTICE**

Items not shown in the illustrations are indicated by a dash (–) prefix to the item number. An example could include a right-hand (RH) part that is otherwise identical to the illustrated left-hand (LH) part.
B.1.6 Positioner's Built Before August 2018

Fig. B-1: Major Assemblies — RM2-1555 and 2355 (Built Before August 2018)
### Table B-1: Major Assemblies — RM2-1555 and 2355 (Built Before August 2018)

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RM2-1555</td>
<td>RM2-2355</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>164222-1</td>
<td>HOUSING ASSY, SWING, HEADSTOCK</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>163898-1</td>
<td>163899-1</td>
<td>ARM ASSY, SWING, HEADSTOCK,</td>
</tr>
<tr>
<td>3</td>
<td>163902-1</td>
<td>163903-1</td>
<td>ARM ASSY, SWING, TAILSTOCK</td>
</tr>
<tr>
<td>4</td>
<td>164350-1</td>
<td></td>
<td>HOUSING ASSY, TAILSTOCK</td>
</tr>
<tr>
<td>5</td>
<td>3.0M</td>
<td>164218-1</td>
<td>BEAM, Z-SPREADER</td>
</tr>
<tr>
<td></td>
<td>3.5M</td>
<td>164218-5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0M</td>
<td>164219-2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>131274-4</td>
<td></td>
<td>SCREW, HHC, M6X40</td>
</tr>
<tr>
<td>7</td>
<td>132049-1</td>
<td></td>
<td>WASHER, CONICAL SPRING, GTS 16</td>
</tr>
<tr>
<td>8</td>
<td>132652-9</td>
<td></td>
<td>PIN, DOWEL, M20X40</td>
</tr>
<tr>
<td>9</td>
<td>3.0M</td>
<td>148102-4</td>
<td>SCREW, SHC, M6X16</td>
</tr>
<tr>
<td></td>
<td>3.5M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. B-2: Housing Assembly, Swingarm Headstock Main Drive (Built Before August 2018)

Table B-2: Housing Assembly, Swingarm Headstock Main Drive (Built Before August 2018)

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>164522-1</td>
<td>SPACER, GEAR BEARING</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>142278-3</td>
<td>PIN, DOWEL, M16X40</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>164371-1</td>
<td>DRIVE ASSY, HEADSTOCK</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>166206-1</td>
<td>COVER, ACCESS</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>166340-1</td>
<td>COVER MAIN DRIVE</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>130556-2</td>
<td>WASHER, SPRING</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>130532-15</td>
<td>SCREW, SHC, M16X60</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>471075-1</td>
<td>WASHER, CONICAL SPRING, M12</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>472303-16</td>
<td>SCREW, SHC, M12X90</td>
<td>24</td>
</tr>
<tr>
<td>11</td>
<td>164222-1</td>
<td>CYLINDER ASSY, HEADSTOCK (WEDGE BLOCK)</td>
<td>1</td>
</tr>
</tbody>
</table>
Fig. B-3: Housing, Headstock Swingarm (Built Before August 2018)
### B.1 Illustrated Parts List

**Table B-3: Housing, Headstock Swingarm (Built Before August 2018)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>RM2-1555: 140786-3</td>
<td>BEARING, SLEWING</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>130532-12: 130532-6</td>
<td>SCREW, SCH, M16</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>130556-2</td>
<td>WASHER, SPRING</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>164344-1</td>
<td>ACTUATOR, A-B POSITION</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>132652-9</td>
<td>PIN DOWEL, M20X40</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>167173-1</td>
<td>SPACER, ACTUATOR, SWITCH</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>130532-15</td>
<td>SCREW, SCHC, M16X60</td>
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<tr>
<td>12</td>
<td>163890-1</td>
<td>DRIVE ASSY, MAIN SWEEP AXIS</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>130533-18</td>
<td>SCREW, SCH M20X2.5X100</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>147177-1</td>
<td>WASHER, CONICAL SPRING M20</td>
<td>8</td>
</tr>
<tr>
<td>15</td>
<td>165175-1</td>
<td>SHIM, 0.0100”</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>165175-2</td>
<td>SHIM, 0.0050”</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>130533-19</td>
<td>SCREW, SCH M20X2.5X100</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>166338-1</td>
<td>COVER, GEAR HEADSTOCK</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>148102-4</td>
<td>SCREW, SCHC, M16X16</td>
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<td>SCREW, BHSC, M6X12</td>
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<td>21</td>
<td>166342-1</td>
<td>WIPER, RUBBER, HEADSTOCK</td>
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<td>22</td>
<td>167170-1</td>
<td>BLOCK, STOP, RH ADJUSTABLE</td>
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</tr>
<tr>
<td>23</td>
<td>167171-1</td>
<td>BLOCK, STOP, LH ADJUSTABLE</td>
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</tr>
<tr>
<td>24</td>
<td>167119-1</td>
<td>PLATE, SLIDE ADJUSTMENT, WEDGE</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>152712-1</td>
<td>WASHER, BELLEVILLE, .505” ID X 1” OD</td>
<td>32</td>
</tr>
<tr>
<td>28</td>
<td>167168-1</td>
<td>PLATE, STOP, RH, FIXED</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>167172-1</td>
<td>SCREW, SET M16-2X100</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>167169-1</td>
<td>PLATE, STOP, LH, FIXED</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>130440-9</td>
<td>NUT, HEX, FULL, M16</td>
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</tr>
<tr>
<td>32</td>
<td>167172-2</td>
<td>SCREW, SET, SQ HEAD, M16-2X60</td>
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</tr>
<tr>
<td>33</td>
<td>130532-3</td>
<td>SCREW, SCHC, M16X40</td>
<td>14</td>
</tr>
<tr>
<td>34</td>
<td>132049-1</td>
<td>WASHER, CONICAL SPRING GTS16</td>
<td>18</td>
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<td>35</td>
<td>130532-5</td>
<td>SCREW, SCHC, M16X50</td>
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</tr>
<tr>
<td>36</td>
<td>407249-4</td>
<td>SCREW, SCHC, M6X16</td>
<td>12</td>
</tr>
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</table>
Fig. B-4: Main Sweep Drive Assembly (Built Before August 2018)
### Table B-4: Main Sweep Drive Assembly (Built Before August 2018)

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>163837-1</td>
<td>BRACKET, MAIN DRIVE</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>130425-2</td>
<td>SCREW, BHSC, M6X10</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>470602-1</td>
<td>WASHER, CONICAL, SPRING M6</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>133937-3</td>
<td>FITTING, ZERK M6X1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>163877-1</td>
<td>GEAR ASSY, INPUT, MAIN DRIVE</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>479297-3</td>
<td>SCREW, SHCS M10X20</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>470541-1</td>
<td>WASHER, CONICAL, SPRING M10</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>151592-7</td>
<td>REDUCER, RV</td>
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Fig. B-5: Tailstock Swingarm Housing (Built Before August 2018)
### Table B-5: Tailstock Swingarm Housing Assembly (Built Before August 2018)

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<td>SLIP-RING KIT, ETHERNET WITH AIR</td>
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B.1.7 Positioner’s Built After August 2018

Fig. B-6(a): Major Assemblies — RM2-1555 and 2355 (Built after August 2018)
Fig. B-6(b): Headstock Swingarm (Built after August 2018)
Fig. B-6(c): Tailstock Assembly (Built After August 2018)
Table B-6: Major Assemblies — RM2-1555 and 2355 (Built after August 2018)

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## Appendix B

### B.1 Illustrated Parts List

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Fig. B-7: Headstock Main Drive Swing Arm Assembly (Built after August 2018)
### Appendix B

**B.1 Illustrated Parts List**

#### Table B-7: Headstock Main Drive Swing Arm Assembly (Built after August 2018)

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### Illustrated Parts List

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B.1.8 Accessories

Fig. B-8: Slip-Ring Kit Assembly

SLIP-RING ASSEMBLY TYP BOTH SIDES (REFERENCE ONLY)

PNEUMATIC HOSE & FITTINGS FOR SLIP-RINGS
LOCATED IN TAILSTOCK SWINGARM
(1555 SWINGARM SHOWN)

FROM FILTER/REGULATOR (SIZES VARY)
FITTINGS AND AIR HOSE INCLUDED WITH POSITIONER
### Table B-8: Slip-Ring Kit Assembly

<table>
<thead>
<tr>
<th>Item</th>
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<tr>
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<td>CONNECTOR, TEE, DEVICE NET</td>
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Fig. B-9: Cylinder Assy, Headstock, 100mm Stroke (Wedge Block) (If Equipped)
### Table B-9: Cylinder Assy, Headstock, 100mm Stroke (Wedge Block)

<table>
<thead>
<tr>
<th>Item</th>
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<td>WASHER, LOCK, M10</td>
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Fig. B-10: Cylinder Assy, Tailstock, 75mm Stroke (Wedge Block) (If Equipped)
### Table B-10: Cylinder Assy, Tailstock, 75mm Stroke (Wedge Block)

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<thead>
<tr>
<th>ITEM NO.</th>
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</tbody>
</table>
Appendix C

C.1 Glossary

3

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.

A

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.
Appendix C
C.1 Glossary

C

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”.
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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.
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C.1 Glossary

Continuous Path
Describes the process where by 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.

D

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)".
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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.
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**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.
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C.1   Glossary

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.

G

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".

H

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.
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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.
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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.

J

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.
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**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.
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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.

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.
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**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.
C.1 Glossary

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 $= 10^{-7} < 10^{-6}$. 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 $= 10^{-8} < 10^{-7}$. 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.
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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.
**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.
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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 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.
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**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.
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**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.
C.1 Glossary

**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.
C.1 Glossary

**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".
- **Z**