MOTOMAN-MH900 INSTRUCTIONS

TYPE:
YR-MH00900-A00 (STANDARD SPECIFICATION)

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

MOTOMAN INSTRUCTIONS
MOTOMAN-MH900 INSTRUCTIONS
DX200 INSTRUCTIONS
DX200 OPERATOR’S MANUAL (for each purpose)
DX200 MAINTENANCE MANUAL

Part Number: 180929-1CD
Revision: 2
MANDATORY

- This instruction manual is intended to explain mainly on the mechanical part of the Robot 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 Robot.

- General items related to safety are listed in Chapter 1: Safety of the Controller Instructions. To ensure correct and safe operation, carefully read the Controller Instructions before reading this manual.

CAUTION

- Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure all covers and shields are replaced 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 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 Customer Support 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.

- YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product's warranty.
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.
Notes for Safe Operation

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

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

DANGER
Indicates an imminent hazardous situation which, if not avoided, could result in death or serious injury to personnel.

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to personnel and damage to equipment. It may also be used to alert against unsafe practices.

MANDATORY
Always be sure to follow explicitly the items listed under this heading.

PROHIBITED
Must never be performed.

Even items described as “CAUTION” may result in a serious accident in some situations.

At any rate, be sure to follow these important items.

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

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 Customer Support.
- 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 Robot's arm.
WARNING

• Before operating the Robot, 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 (E-Stop) circuit cannot stop the Robot during an emergency. The Robot 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 Robot. Then turn the servo power ON.

Injury may result from unintentional or unexpected Robot motion.

Fig. : Release of EMERGENCY STOP button

• Observe the following precautions when performing teaching operations within the P-point maximum envelope of the Robot:
  – Be sure to use a lockout device to the safeguarding when going inside. Also, display the sign that the operation is being performed inside the safeguarding and make sure no one closes the safeguarding.
  – View the Robot from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Keep in mind the emergency response measures against the Robot’s unexpected motion toward you.
  – Ensure that you have a safe place to retreat in case of emergency.

Improper or unintended Robot operation may result in injury.

• Confirm that no person is present in the P-point maximum envelope of the Robot and that you are in a safe location before:
  – Turning ON the power for the Controller.
  – Moving the Robot with the Programming Pendant.
  – Running the system in the check mode.
  – Performing automatic operations.

Injury may result if anyone enters the P-point maximum envelope of the Robot during operation. Always press an EMERGENCY STOP button immediately if there is a problem.
Definition of Terms Used Often in This Manual

The MOTOMAN is the YASKAWA industrial robot product.

The MOTOMAN usually consists of the Robot, the Controller, the Programming Pendant, and the Robot 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>DX200 Programming Pendant</td>
<td>Programming Pendant</td>
</tr>
<tr>
<td>MH900 Manipulator</td>
<td>Robot</td>
</tr>
<tr>
<td>Cable between the Robot and the Controller</td>
<td>Robot Cable</td>
</tr>
</tbody>
</table>

Description of the Operation Procedure

In the explanation of the operation procedure, the expression “Select • • •” means that the cursor is moved to the object item and the SELECT key is pressed, or that the item is directly selected by touching the screen.

Registered Trademark

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.

CAUTION

- Perform the following inspection procedures prior to conducting Robot teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
  - Check for problems in Robot 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 Robot's work area, on the floor, or near fixtures.
- Read and understand the Explanation of Warning Labels in the Controller Instructions before operating the Robot:
Explanation of Warning Labels

The following warning labels are attached to the Robot. Always follow the warnings on the labels. Also, an identification label with important information is placed on the body of the Robot. Prior to operating the Robot, confirm the contents.

Fig. : Warning Label Locations
Warning Label A

Must label of the motor, and do not release the brake. Failure to observe this caution may result in injury from unexpected turning of the manipulator arm. Please contact your Yaskawa representative.

Nameplate

YASKAWA
MODEL
MOTOR
TYPE
PAYLOAD
MASS
ORDER NO.
DATE
SERIAL NO.

YASKAWA AMERICA, INC.,
100 AUTOMATION WAY
MIAMISBURG, OH 45342
MADE IN USA

Warning Label B

Do not enter robot work area.

Warning Label C

Moving parts may cause injury

Warning Label D

Do not use side fork pockets for transporting manipulator. Use fork pockets for bracket transporting only. Failure to comply can result in death or serious injury.
Safeguarding Tips

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 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

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:

• Safety barriers

• Door interlocks

• EMERGENCY STOP button(s) located on operator station

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

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 EMERGENCY STOP button on the operator station for proper operation before programming. The equipment must be placed in 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 a standard passwords and some require special passwords.
- The equipment allows modifications of the software for maximum performance. Care must be taken when making these 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.
**Maintenance Safety**

Turn the power OFF and 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.

**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 Notes.

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

If you need assistance with any aspect of your MH900 system, please contact Customer Support at the following 24-hour telephone number:

(937) 847-3200

For routine technical inquiries, you can also 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 your issue, along with complete contact information. Please allow approximately 24 to 36 hours for a response to your inquiry.

Please use e-mail for routine inquiries only. If you have an urgent or emergency need for service, replacement parts, or information, you must contact Customer Support at the telephone number shown above.

Please have the following information ready before you call Customer Support:

• System  MH900
• Primary Application
• Controller  DX200
• Software Version  Access this information on the Programming Pendant's LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - {VERSION}
• Robot Serial Number  Located on the robot data plate
• Robot Sales Order Number  Located on the Controller data plate
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1 Product Confirmation

1.1 Contents Confirmation

Confirm the contents of the delivery when the product arrives.

A standard delivery includes the following items. (A separate list includes additional items.):

- Robot
- Lifting bracket for Robot
- Controller
- Programming Pendant
- Robot cables
  (8 cables between the Controller and the Robot)
- Reference manuals (packaged with the Controller)

1.2 Optional Accessories

The following accessories may be available:

<table>
<thead>
<tr>
<th>Kit Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeroing Kit</td>
<td>180437-1</td>
</tr>
<tr>
<td>Bypass Kit</td>
<td>182715-1</td>
</tr>
<tr>
<td>Limit Switch Kit, S-Axis</td>
<td>182716-1</td>
</tr>
<tr>
<td>Limit Switch Kit, L-Axis</td>
<td>182717-1</td>
</tr>
<tr>
<td>Limit Switch Kit, U-Axis</td>
<td>182718-1</td>
</tr>
</tbody>
</table>

1.3 Reference Documentation

For additional information on individual components of the MH900, refer to the following documentation included with the system:

- YASKAWA Maintenance Manual for the MH900 (P/N 180930)
- YASKAWA Maintenance Manual for the DX200 (P/N 183986)
- YASKAWA Instructions Manual for the DX200 (P/N 182582)
- YASKAWA Operator’s Manual for this configuration/application of the DX200
- Vendor manuals for system components not manufactured by YASKAWA
1.4 Order Number Confirmation

![CAUTION]

* Confirm that the Manipulator and the Controller have the same order number. Take special care when installing more than one Robot.

If the numbers do not match, Robots may not perform as expected and cause injury or damage.

Check that the order number of the Robot corresponds to the order number of the Controller. The order number is located on a label as shown in Fig. 1-1 “Location of Order Number Labels”.

Fig. 1-1: Location of Order Number Labels

(a) Controller (Isometric View)

(b) Manipulator (Side View)

Check that the manipulator and the DX200 have the same order number.
1.5 Quick Start Guide

**WARNING**

This Quick Start Guide is for reference only. Read and understand all included documents before working with the DX200 Controller and the MH900 Robot. Failure to follow this instruction may result in severe personal injury.

### PHASE 1
**PREPARATION (PRE-ARRIVAL)**
- PRELIMINARY RISK ASSESSMENT
  - Manip. Instr. Sec 3.1, 3.6
  - ISO 10218-2:2011
  - ANSI/RIA 15.6-2012
- DETERMINE LOCATION FOR INSTALL
  - Manip. Instr. Sec 3.2, 3.3, 3.6, 5.4
  - Contr. Instr. Sec 3.2, 3.3
- PREPARATION FOR INSTALLATION
  - Manip. Instr. Sec 3.4, 3.5, 3.7
  - Contr. Instr. Sec 4.1, 4.2
- MOUNTING SPECIFICATIONS
  - Manip. Instr. Sec 3.8, 5.3
  - Contr. Instr. Chap 3
  - Contact YASKAWA for Mounting Options
- TOOLING SPECIFICATIONS
  - Manip. Instr. Sec 5.1, 5.7
  - Chap 6
- COMPRESSED AIR SUPPLY (IF USED)
  - Manip. Instr. Sec 6.2
  - Sales Order
- TRAINING
  - Contact YASKAWA Academy:
    - Phone: 937-847-3307
    - Email: training@motoman.com
- PHASE 1 Complete: □

### PHASE 2
**RECEIVE CONTROLLER AND ROBOT**
- TRANSPORTATION POSITION
  - Manip. Instr. Sec 2, 2.1
  - Contr. Instr. Sec 3.1
- RECEIVE SHIPPING SKID
  - Manip. Instr. Sec 2.2
- INVENTORY & INSPECT EQUIPMENT
  - Manip. Instr. Sec 1.1, 1.2
  - Contr. Instr. Sec 2.1
  - Sales Order
- VERIFY ORDER RECEIVED
  - Manip. Instr. Sec 1.3
  - Contr. Instr. Sec 2.2
  - Sales Order
- READ & UNDERSTAND ALL SAFETY & INCLUDED DOCUMENTATION
  - READ FIRST!! DX200 (FSU)
  - Manip. & Contr. Instr. (All Safety Sections)
- PREPARE FOR HANDLING & TRANSPORTATION OF EQUIPMENT TO WORKSPACE
  - Manip. Instr. Sec 1.3
  - Contr. Instr. Chap 4
- PREPARE FOR HANDLING & TRANSPORTATION OF EQUIPMENT TO WORKSPACE
  - Manip. Instr. Chap 2
  - Contr. Instr. Chap 3
- PHASE 2 Complete: □

### PHASE 3
**INSTALL CONTROLLER**
- TAG OUT POWER
  - Company Procedures
  - Government Regulations
  - Contr. Instr. Chap 4
- TRANSPORT CONTROLLER TO WORKSPACE
  - Contr. Instr. Sec 3.1
- MOUNT DX200 CONTROLLER
  - Contr. Instr. Sec 3.4
- CONNECT PRIMARY POWER & GROUND
  - Company Procedures
  - Government Regulations
  - Contr. Instr. Chap 4
- CONNECT DX200 PENDANT TO CONTROLLER
  - Contr. Instr. Sec 4.3.5
- PHASE 3 Complete: □

### PHASE 4
**INSTALL ROBOT ARM**
- TRANSPORT MH900 ROBOT
  - Manip. Instr. Chap 2 & Sec 3.7
- INSTALL AUX. SAFETY EQUIPMENT (IF REQUIRED)
  - Contr. Instr. Sec 3.1
- MOUNT MH900 ROBOT
  - Manip. Instr. Sec 3.8
- ATTACH GROUNDS
  - Contr. Instr. Sec 4, 4.1
- ATTACH ROBOT CABLES TO CONTROLLER
  - Contr. Instr. Sec 4.2
  - Contr. Instr. Sec 4.3.3, 4.3.4
- ATTACH AIR LINE (IF USED)
  - Manip. Instr. Sec 6.2
- REVIEW INSTALLATION CHECKLIST
  - Contr. Instr. Chap 3
  - Manip. Instr. Sec 3.9
- PHASE 4 Complete: □

### PHASE 5
**SYSTEM VERIFICATION**
- VERIFY POWER INSTALLATION FOR DX200 & MH900
  - Manip. Instr. Sec 4.3
  - Contr. Instr. Chap 4
- PRESS E-STOP, CLOSE DX200 DOOR, & CLEAR WORKSPACE AREA
  - Contr. Instr. Sec 5.3.1
- TAG IN POWER SUPPLY
  - Company Procedures
  - Government Regulations
- TURN ON MAIN POWER SUPPLY & CONTROLLER
  - Contr. Instr. Sec 5.1
  - DX200 Read First Alarm
- TEST SERVOS & E-STOPS
  - Contr. Instr. Sec 5.2
- PHASE 5 Complete: □

### PHASE 6
**INSTALL AND VERIFY TOOLING**
- MECHANICAL INSTALLATION OF TOOL
  - Manip. Instr. Sec 5.7, 8.1
  - Contr. Instr. Sec 4.3.6
- ELECTRICAL INSTALLATION OF TOOL
  - Contr. Instr. Sec 6.2
- ENTER TOOL SETTINGS ON DX200 PENDANT
  - Contr. Instr. Sec 8.3
- SET HOME POSITIONS
  - Contr. Instr. Sec 8, 8.1, 8.2
- CONFIRM RISK ASSESSMENT
  - Manip. Instr. Sec 3, 3.1, 3.6
  - ISO 10218-2:2011
  - ANSI/RIA 15.6-2012
- PHASE 6 Complete: □
## PHASE 7
**SIMPLE PICK & PLACE**

<table>
<thead>
<tr>
<th>CREATE NEW JOB &amp; TEACH POINTS</th>
<th>ADDITION OF I/O &amp; SIMPLE INFORM COMMANDS</th>
<th>TEST &amp; CHECK STEPS</th>
<th>PLAYBACK JOB</th>
<th>STOP JOB</th>
<th>MH900 QUICK START COMPLETE!</th>
</tr>
</thead>
</table>

- The Quick Start Procedure for MH900 is Complete. Techniques for Increased Functionality & Safety Can Now Be Added.

**PHASE 7 Complete**

- □
2 Transporting

WARNING

- Use moving/rigging equipment that can handle the Robot and the Controller mounted on a 4710mm x 2540mm (15.5ft x 8.5ft) shipping skid.
- The weight of the equipment and the skid is approximately 13000kg (28600lb). The weight of the Robot only is 10288kg (22680lb).
- The skid containing the Robot can be moved by forklift from the side with a properly-sized forklift.
- Do not move the Robot by forklift unless it is attached to the skid.
- Allow only authorized personnel to operate the crane.

Failure to observe this instruction may result in death or serious injury from unexpected moving/rigging equipment movement.

CAUTION

- Make sure there is no external force on the arm or motor when using transporting equipment other than a crane.

Failure to observe this instruction can result in minor to moderate injury.

NOTE

- Avoid excessive vibration and/or shock during transporting equipment.
- The system consists of precision components, so failure to observe this instruction may adversely affect performance.
- Remove shipping bolts and brackets before turning ON power.
- Store shipping bolts and brackets for future use.
2.1 Preparing to Transport the Robot

2.1.1 Robot Transporting Position

The Robot is factory-shipped in the transporting position. Always place the Robot in the transporting position before moving. Refer to Table 2-1, Fig. 2-1 and Table 2-2.

Table 2-1: Factory Setting/Transport Position: Angle & Pulse of Axes

<table>
<thead>
<tr>
<th>Axis</th>
<th>S</th>
<th>L</th>
<th>U</th>
<th>R</th>
<th>B</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>0°</td>
<td>-60°</td>
<td>0°</td>
<td>0°</td>
<td>-90°</td>
<td>0°</td>
</tr>
<tr>
<td>Pulse</td>
<td>0</td>
<td>390708</td>
<td>0</td>
<td>0</td>
<td>493292</td>
<td>0</td>
</tr>
</tbody>
</table>

2.1.2 Shipping Bolts and Brackets

The Robot comes with shipping hardware and brackets. Make sure shipping hardware and brackets are installed before transporting the Robot. As Fig. 2-1 “Transporting Position” illustrates, the brackets are called out by name, and hardware items are called out by letter. Both the brackets and the hardware are yellow in color. A listing of the hardware position, hardware type, and quantity is in Table 2-2.

Table 2-2: Shipping Hardware and Brackets

<table>
<thead>
<tr>
<th>Hardware Position</th>
<th>Hardware Type</th>
<th>Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hexagon socket head cap screw M20 x 70mm with Type 2 Conical Washer</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>(Tensile strength: 1200N/mm² or more)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Hexagon socket head cap screw M20 x 100mm with Type 2 Conical Washer</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(Tensile strength: 1200N/mm² or more)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Hexagon socket head cap screw M16 x 40mm with Type 2 Conical Washer</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(Tensile strength: 1200N/mm² or more)</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Hexagon head nut M30</td>
<td>2</td>
</tr>
</tbody>
</table>
2 Transporting
2.1 Preparing to Transport the Robot

2.1.3 Center of Gravity Details
Refer to the following paragraphs for center of gravity information.

2.1.3.1 Center of Gravity - Robot
Refer to Fig. 2-2 for the Robot’s center of gravity information in order to correctly position the overhead crane and chain sling before transporting the Robot.

Fig. 2-2: Center of Gravity - Robot
2.1.3.2 Center of Gravity - Robot on Shipping Skid

Refer to Fig. 2-3 for the Robot/Shipping Skid assembly’s center of gravity information. The shipping skid may be transported by overhead crane and chain sling, or by fork truck.

Before transporting the Robot mounted on the shipping skid, use the center of gravity information to calculate the correct position of the overhead crane and chain sling, or the size and load capacity of the fork truck.

*Fig. 2-3: Center of Gravity - Robot on Skid*
2.2 Moving the Shipping Skid

- The MH900 assembly will arrive on a shipping skid as shown in Fig. 2-4 Moving Shipping Skid Using Side Fork Pockets.
- All items are strapped down and the Robot is bolted to the shipping skid.

1. Clear a path to the installation location and the surrounding area.

2. If needed, place the Robot in the Transporting Position (Fig. 2-1) and install the shipping bolts and brackets described in section 2.1.2 “Shipping Bolts and Brackets”.
- The Robot is factory-shipped in the Transporting Position.

3. Move shipping skid to the installation location, using either side fork pockets or side hoist rings ONLY.
- The shipping skid may be moved from the side with a properly-sized forklift.
- If lifting the shipping skid from above using hoist rings (Fig. 2-5):
  a) use an adjustable four-chain sling at least 15ft (180000mm) long and able to support the shipping skid.
  b) Use a crane to lift the chain sling.

Fig. 2-4: Moving Shipping Skid Using Side Fork Pockets
Fig. 2-5: Moving the Shipping Skid Using Hoist Rings
3 Installation

WARNING

- Install safeguarding as needed.
Failure to observe this instruction may result in serious injury.
- Make sure Robot tool or workpiece does not reach the wall, safeguarding, or Controller when extending arm is fully extended.
Failure to observe this instruction may result in serious injury.
- Do not start the Robot or even turn ON the power before it is firmly anchored.
The Robot may overturn and cause serious injury.

CAUTION

- Do not install or operate a Robot with damage or missing parts.
Failure to observe this instruction may cause injury.
- Referring to Fig. 3-6 make sure to remove the shipping bolts and brackets before turning ON power.
Failure to observe this instruction may result in damage to the driving parts.
- Keep the foundation flatness to 0.5mm or less.
Failure to observe this instruction may cause the Robot shape to deform and compromise its functional ability.
3.1 Required Tools

**WARNING**

- To lift the custom shipping assembly, use moving/rigging equipment that can handle a 4710mm x 2540mm (15.5ft x 8.5ft) shipping skid that weighs approximately 13000kg (28600lb).
- To lift the Robot only, use moving/rigging equipment that can lift 10288kg (22680lb).

Failure to observe this instruction may result in death or serious injury from unexpected moving/rigging equipment movement.

Supply the following tools for installation.

- Robot Lifting Bracket (Fig. 3-6 on page 3-10): part number 180563-1
- 4572mm (15ft) Chain Sling
- **For lifting Robot only:** Crane capable of lifting 10288kg (22680lbs) MINIMUM (combined weight of the Robot and Robot Lifting Bracket)
- **For lifting custom shipping assembly:** Moving/rigging equipment capable of lifting 13000kg (28600lb) MINIMUM (combined weight of custom shipping skid, Robot, moving bracket and Controller)
- 12x M20 SHC Class 12.9 bolts; minimum length 100mm
- 12x M20 heavy load conical spring washers
- 675Nm torque wrench
- Socket key sets for removing shipping brackets
3.2 Common Installation Mistakes

The following table lists actions to take for common installation mistakes.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Actions to Take</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor is not properly strengthened for MH900 weight</td>
<td>Follow recommended installation procedures in this document, and the recommended procedures from a structural engineer. Prepare the floor in advance, following the recommended floor specifications in section 3.8 “Install the Robot Assembly” on page 3-12.</td>
</tr>
<tr>
<td>Lifting equipment is insufficient to move Robot assembly or Robot</td>
<td>Read the hazard notifications in chapter 2 “Transporting” on page 2-1 and follow the instructions in section 2.1 “Preparing to Transport the Robot” on page 2-2. Use recommended unpacking equipment. Obtain equipment well in advance of installation.</td>
</tr>
<tr>
<td>Robot collides with other parts in facility</td>
<td>Refer to Fig. 5-3 “Dimensions and P-Point Maximum Envelope” on page 5-5. Allow enough clear space around the Robot installation site to avoid collisions between the Robot and other equipment.</td>
</tr>
<tr>
<td>Robot incorrectly mounted</td>
<td>Refer to Fig. 5-2 “Robot Base Dimensions” on page 5-4. The Robot base hole pattern is not symmetrical; the Robot base can be set in only one position. Rotate the Robot base until the base hole pattern of the Robot matches the anchor rod pattern.</td>
</tr>
<tr>
<td>Robot mounting bolts not properly torqued</td>
<td>Use proper equipment to torque the bolts to 675Nm.</td>
</tr>
<tr>
<td>Shipping brackets have not been removed from the Robot</td>
<td>Remove the shipping brackets, rod and hardware (Fig. ” on page 3-10).</td>
</tr>
</tbody>
</table>
3.3 Environmental Resistance Protection Class

- Main Part of Robot conforms to IP30
- Wrist Part of Robot conforms to IP67

3.4 Environmental Conditions

Satisfy the following environmental conditions:

- Ambient temperature: 0° to +45°C
- Humidity: 20 to 80%RH (non-condensing)
- No exposure to water, oil, or dust
- No corrosive gases or liquids, or explosive gases or liquids
- No large electrical noise (plasma)
- No excessive shock or vibration (4.9m/s² [0.5G] or less)

3.4.1 Robot Clearance Requirements

Make sure there are no obstructions that would prevent the Robot from being placed in the Transporting Position after installation (Fig. 2.1 “Preparing to Transport the Robot” on page 2-2). The Robot must be placed in the transporting position if it is ever moved to another site.
3.5 Foundation Requirements

**WARNING**

- The following illustration is for reference only. The customer is responsible for constructing the foundation required to withstand maximum repulsion forces of the Robot. REFER TO THE STRUCTURAL DRAWINGS FOR REFERENCE INFORMATION. YASKAWA DOES NOT SUPPLY SPECIFIC INSTALLATION REQUIREMENTS.

Failure to observe this instruction may cause injury.

Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Robot per Table 3-2 and Fig. 3-1.

- The floor must be strong enough to support the Robot.
- The floor must be concrete and a minimum of 813mm (2ft-8in) thick. Refer to the structural drawings.
- The floor must be level, and flatness for installation must be 0.5mm or less.
- The floor must be free of all cracks, etc.

### 3.5.1 Robot Repulsion Force and Torque Values

**Table 3-2: Robot Repulsion Force and Torque Values**

<table>
<thead>
<tr>
<th></th>
<th>Horizontal rotation</th>
<th>Vertical rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Repulsion force $F_H$</td>
<td>Torque $M_H$</td>
</tr>
<tr>
<td><strong>Emergency Stop</strong></td>
<td>16610N (1694kgf)</td>
<td>88200N•m (8994kgf•m)</td>
</tr>
<tr>
<td><strong>Acceleration/Deceleration</strong></td>
<td>4984N (508kgf)</td>
<td>26460N•m (2698kgf•m)</td>
</tr>
</tbody>
</table>
3.6 Constructing the Foundation

**CAUTION**

- The following illustrations are for reference only. The customer is responsible for constructing the foundation required to withstand maximum repulsion forces of the Robot. REFER TO THE STRUCTURAL DRAWINGS FOR REFERENCE INFORMATION. YASKAWA DOES NOT SUPPLY SPECIFIC INSTALLATION REQUIREMENTS.

Failure to observe this instruction may cause injury.

Construct a solid foundation with the appropriate thickness to withstand maximum repulsion forces of the Robot.

- Make sure the floor is strong enough to support the Robot.
- The floor must be concrete and a minimum of 813mm (2ft-8in) thick. Refer to the structural drawings.
- Use M20 bolts or anchor rods to secure the Robot to the floor.
- Before mounting the Robot, make sure the floor is level. Repair all cracks, etc.
3.6.1 Constructing the Floor-Mounted Robot Foundation

Refer to the following illustration for a representation of the foundation for the floor-mounted Robot. This illustration is for reference only.

Fig. 3-2: Foundation Requirements, Floor Mount-Plan View

![Foundation Requirements, Floor Mount-Plan View](image)

Fig. 3-3: Foundation Requirements, Floor Mount-Section View

![Foundation Requirements, Floor Mount-Section View](image)
3.6.2 Constructing the Baseplate-Mounted Robot Foundation

Refer to the following illustration for a representation of the foundation baseplate-mounted Robot. This information is for reference only.

Fig. 3-4: Foundation Requirements, Baseplate Mount-Plan View

Fig. 3-5: Foundation Requirements, Baseplate Mount-Section View
3.7 Installation Preparation

1. Make sure the flatness for installation is 0.5mm or less.

2. Make sure the foundations are prepared per section 3.6.1 “Constructing the Floor-Mounted Robot Foundation” on page 3-7 or section 3.6.2 “Constructing the Baseplate-Mounted Robot Foundation” on page 3-8.

3. Obtain necessary moving/rigging equipment.

3.8 Install the Robot Assembly

**DANGER**

- Always use a chain sling attached to the Moving Bracket (Fig. 3-6) to lift the Robot. Do not lift the Moving Bracket/Robot assembly with a fork truck. Do not transport the Moving Bracket with a fork truck unless the Moving Bracket is NOT mounted on the Robot.

Failure to observe these safety precautions may result in death or serious injury if the Moving Bracket/Robot assembly falls off the fork truck or causes the fork truck to tip.

**NOTE**

Before moving the Robot:
- Make sure shackles and chain sling:
  - will support at least 10288kg (22680lb).
  - are only for transporting Robot.
  - are secure.
- Make sure shipping bolts and brackets for transporting the Robot are securely in place.

1. Make sure all items have been delivered. Refer to section 1.1 “Contents Confirmation” on page 1-1.

2. Remove the straps from all items.

3. Move Controller and Robot cables to their install locations.

4. Attach the Controller to the mounting base with M12 hardware (provided with Controller).

5. Remove and save the Robot-to-shipping skid attachment bolts for shipping purposes.

6. Attach a four-chain sling to the Moving Bracket (Fig. 3-6 “Lift Robot with Chain Sling” on page 3-10). Make sure the sling is at least 15ft (4572mm) long and able to support the Robot.

7. Adjust chain sling until the Robot is level when lifted.

8. Use a crane to lift the chain sling. Do not move the Robot by forklift.

9. Use M20 bolts to secure the Robot to the floor or to the baseplate.
10. Remove all shipping hardware and brackets. Refer to Fig. 3-6 "Lift Robot with Chain Sling" and Table 3-3 "Shipping Hardware and Brackets".

11. Save hardware, brackets and empty skid for future relocation.

Table 3-3: Shipping Hardware and Brackets

<table>
<thead>
<tr>
<th>Hardware Position</th>
<th>Hardware Type</th>
<th>Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hexagon socket head cap screw M20 x 70mm with Type 2 Conical Washer (Tensile strength: 1200N/mm² or more)</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>Hexagon socket head cap screw M20 x 100mm with Type 2 Conical Washer (Tensile strength: 1200N/mm² or more)</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Hexagon socket head cap screw M16 x 40mm with Type 2 Conical Washer (Tensile strength: 1200N/mm² or more)</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>Hexagon head nut M30</td>
<td>2</td>
</tr>
</tbody>
</table>
3.8 Install the Robot Assembly

3.8.1 Mounting Robot to the Floor

**WARNING**

- The following illustration is for reference only. The customer is responsible for constructing the foundation required to withstand maximum repulsion forces of the Robot. REFER TO THE STRUCTURAL DRAWINGS FOR REFERENCE INFORMATION. YASKAWA DOES NOT SUPPLY SPECIFIC INSTALLATION REQUIREMENTS.

Failure to observe this instruction may cause injury.

**NOTE**

- During Installation:
  - Keep the foundation flatness to 0.5mm or less.
  - If the flatness is more than 0.5mm, the Robot shape can deform and compromise its ability to function correctly.

1. Before mounting the Robot, make sure the floor is level, and repair all cracks, etc.

2. Use M20 bolts or anchor rods to secure the Robot to the floor.

*Fig. 3-7: Robot Typical Floor Mounting*
3.8 Install the Robot Assembly

3.8.2 Mounting Robot and Baseplate to the Floor

**WARNING**

- The following illustration is for reference only. The customer is responsible for constructing the foundation required to withstand maximum repulsion forces of the Robot. REFER TO THE STRUCTURAL DRAWINGS FOR REFERENCE INFORMATION. YASKAWA DOES NOT SUPPLY SPECIFIC INSTALLATION REQUIREMENTS.

Failure to observe this instruction may cause injury.

1. Anchor the baseplate firmly to the floor.
   - The baseplate should have enough rigidity, which is 76mm (3in.) or more in thickness.
   - The size of the anchor bolt recommended for the baseplate fixation is M24 or more.

2. Attach the Robot base to the baseplate.
   - The Robot base has 12 mounting holes. Secure the Robot to the baseplate using 12 M20 socket head cap screws, and twelve M20 washers made of 1045 steel, with an outer diameter of 40mm and a minimum thickness of 3mm. (Tensile strength: 1200N/mm² or more) (recommend: 80mm long).
   - Tighten the bolts with a tightening torque of 675N•m (68.8kgf•m).

*Fig. 3-8: Mounting the Robot on the Baseplate*
3.9 Installation of Safeguarding

To insure safety, install safeguarding. Safeguarding helps prevent accidents to personnel and damage to equipment. Refer to "Responsibility for Safeguarding (ISO 10218)" below for information and guidance.

**Responsibility for Safeguarding (ISO 10218)**

The user of a Robot or robot system is to make sure safeguarding is in accordance with Chapter 6, 7, and 8 of this standard. The degree of safeguarding, includes any redundancies, corresponds directly to the type and level of hazard present. Safeguards may include safeguarding devices, barriers, interlock barriers, perimeter guarding, awareness barriers, awareness signals and more.
### 3.10 Checklist After Installation

After installation double-check to make sure each item in *Table 3-4 Installation Completion Checklist* is complete, then add date and initials.

*Table 3-4: Installation Completion Checklist*

<table>
<thead>
<tr>
<th>Date</th>
<th>Initials</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All shipping brackets (usually painted yellow) have been removed from the Robot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Robot is fully mounted with proper flooring support.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Controller is fully mounted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional equipment is fully mounted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optional cables (air lines, I/O, Fieldbus, etc.) are fully connected if needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controller and main power are located out of Robot area of operation and follow necessary safety regulations (OSHA, etc.).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robot area of operation is clear of all obstacles OR any limits to the area of operation are identified to anyone operating the robot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All safeguarding has been installed.</td>
</tr>
</tbody>
</table>
4 Wiring

**WARNING**

- Ground resistance must be 100Ω or less.
- Turn the primary power supply OFF, and put up a warning sign before wiring. (ex. DO NOT TURN THE POWER ON.)

Failure to observe these instructions may result in fire or electric shock.

- Allow only authorized or certified personnel to do the wiring.

Failure to observe this instruction may result in fire or electric shock.
4.1 Grounding

Follow electrical installation standards and wiring regulations for grounding. YASKAWA recommends using 8.0mm² (8awg) or larger.

Refer to Fig. 4-1 “Grounding Method” to connect the ground line directly to the Robot.

- Never share this wire with any other grounding lines or grounding electrodes for any other electric power, motor power, welding devices, etc.
- When using metal ducts, metallic conduits, or distributing racks, lay grounding cable in accordance with electrical installation standards.

Fig. 4-1: Grounding Method
4.2 Robot Cable Connections

The Robot comes with eight Robot cables: one encoder cable (Fig. 4-2(a)), six power cables (Fig. 4-2(b)) and one brake cable.

In this manual, connection location identifies which cable to use.

Fig. 4-2(a): Robot Encoder Cable (1BC)

Table 4-1: Robot Encoder Cable (1BC) Part Numbers

<table>
<thead>
<tr>
<th>166312-*</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4M (157in.)</td>
</tr>
<tr>
<td>2</td>
<td>5M (196in.)</td>
</tr>
<tr>
<td>3</td>
<td>7M (275in.)</td>
</tr>
<tr>
<td>4</td>
<td>10M (393in.)</td>
</tr>
<tr>
<td>5</td>
<td>15M (708in.)</td>
</tr>
<tr>
<td>6</td>
<td>20M (787in.)</td>
</tr>
<tr>
<td>7</td>
<td>25M (984in.)</td>
</tr>
<tr>
<td>8</td>
<td>30M (1181in.)</td>
</tr>
</tbody>
</table>
Fig. 4-2(b): Robot Power Cables

![Diagram of Robot Power Cables]

Table 4-2(a): Robot Power Cable (*BC) Part Numbers

<table>
<thead>
<tr>
<th>Connector Location on Robot</th>
<th>Connector Location on Controller</th>
<th>Part Number&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>2BC</td>
<td>X21</td>
<td>178444-*</td>
</tr>
<tr>
<td>3BC</td>
<td>X22</td>
<td>178445-*</td>
</tr>
<tr>
<td>4BC</td>
<td>X23</td>
<td>178446-*</td>
</tr>
<tr>
<td>5BC</td>
<td>X24</td>
<td>178447-*</td>
</tr>
<tr>
<td>6BC</td>
<td>X25</td>
<td>178448-*</td>
</tr>
<tr>
<td>7BC</td>
<td>X26</td>
<td>178449-*</td>
</tr>
</tbody>
</table>

1 Indicates part number for cable length see Table 4-2(b).

Table 4-2(b): Power Cable Last Number of Part Number

<table>
<thead>
<tr>
<th>Part Number&lt;sup&gt;*&lt;/sup&gt;</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4M (157in.)</td>
</tr>
<tr>
<td>2</td>
<td>5M (196in.)</td>
</tr>
<tr>
<td>3</td>
<td>7M (275in.)</td>
</tr>
<tr>
<td>4</td>
<td>10M (393in.)</td>
</tr>
<tr>
<td>5</td>
<td>15M (708in.)</td>
</tr>
<tr>
<td>6</td>
<td>20M (787in.)</td>
</tr>
<tr>
<td>7</td>
<td>25M (984in.)</td>
</tr>
<tr>
<td>8</td>
<td>30M (1181in.)</td>
</tr>
</tbody>
</table>
4 Wiring
4.2 Robot Cable Connections

Fig. 4-3(a): Robot Brake Cable (8BC)

Table 4-3: Robot Brake Cable (8BC) Part Numbers

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4M (157in.)</td>
</tr>
<tr>
<td>2</td>
<td>5M (196in)</td>
</tr>
<tr>
<td>3</td>
<td>7M (275in)</td>
</tr>
<tr>
<td>4</td>
<td>10M (393in)</td>
</tr>
<tr>
<td>5</td>
<td>15M (708in)</td>
</tr>
<tr>
<td>6</td>
<td>20M (787in)</td>
</tr>
<tr>
<td>7</td>
<td>25M (984in)</td>
</tr>
<tr>
<td>8</td>
<td>30M (1181in)</td>
</tr>
</tbody>
</table>
4.2 Robot Cable Connections

4.2.1 Connection to the Robot

1. Verify the numbers on the Robot 2BC power cable with the connector number on the Robot by referring to Fig. 4-4(a) below, and Fig. 4-2(b) “Robot Power Cables” on page 4-4.

Fig. 4-4(a): Robot Cable Connectors (Robot Side)

2. Align holes and pins between 2BC cable connector and the Robot and attach. Refer to Fig. 4-2(b) “Robot Power Cables” on page 4-4.

- Align the main key position of the Robot and install cable by referring to Fig. 4-2(a) “Robot Encoder Cable (1BC)” on page 4-3 and Fig. 4-4(a), above.

**NOTE** Make sure to press the levers until they click in place.

3. Repeat step 1 and step 2 with the rest of the Robot cables in the following order; 3BC, 4BC, 5BC, 6BC, 7BC, 8BC, and 1BC.
4.2.2 Connection to the Controller

To connect the Robot to the Controller, refer to the Instructions Manual listed in section 1.3 “Reference Documentation” on page 1-1.

4.3 Checklist Before Applying Power

After installation, before applying power, double-check to make sure each item in Table 4-4 “Checklist Before Applying Power” is complete, then add date and initials.

Table 4-4: Checklist Before Applying Power

<table>
<thead>
<tr>
<th>Date</th>
<th>Initials</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Robot and Controller are grounded.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional Equipment is grounded as needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cables from Robot to Controller are connected correctly (Cables have unique locating pins and should only fit in one connector.).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Each motor on the Robot (six total) have a brake, encoder, and power cable fully connected.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robot to Controller cables are clean and organized inside the work area (no tripping hazards, out of Robot reach, etc.).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robot to Controller cables are not frayed or damaged in any way.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robot internal harness cables are not frayed or damaged in any way.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All cables have protection as needed (cable sleeves, wire ways, cable protectors for walkways, etc.).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controller is fully connected to main power.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Main power to the Controller is 208V.</td>
</tr>
</tbody>
</table>
## 5 Basic Specifications

### 5.1 Basic Specifications

*Table 5-1: Basic Specifications* 

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Configuration</strong></td>
<td>Vertically Articulated</td>
</tr>
<tr>
<td><strong>Degree of Freedom</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Payload</strong></td>
<td>900kg</td>
</tr>
<tr>
<td><strong>Repeatability</strong></td>
<td>±0.5mm</td>
</tr>
<tr>
<td><strong>Maximum Reach</strong></td>
<td></td>
</tr>
<tr>
<td>Maximum End Effector Vertical Reach</td>
<td>4709mm from robot vertical 0</td>
</tr>
<tr>
<td>Maximum End Effector Horizontal Reach</td>
<td>Radius of 4683mm from robot horizontal center</td>
</tr>
<tr>
<td><strong>Shipping Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>MH900 height in shipping position</td>
<td>2902mm</td>
</tr>
<tr>
<td>MH900 height in shipping position, mounted on shipping skid</td>
<td>3158mm</td>
</tr>
<tr>
<td><strong>Motion Range</strong></td>
<td></td>
</tr>
<tr>
<td>S-axis (turning)</td>
<td>-165° ~ +165°</td>
</tr>
<tr>
<td>L-axis (lower arm)</td>
<td>-60° ~ +100°</td>
</tr>
<tr>
<td>U-axis (upper arm)</td>
<td>-130° ~ +35°</td>
</tr>
<tr>
<td>R-axis (wrist roll)</td>
<td>-360° ~ +360°</td>
</tr>
<tr>
<td>B-axis (wrist pitch/yaw)</td>
<td>-120° ~ +120°</td>
</tr>
<tr>
<td>T-axis (wrist twist)</td>
<td>-360° ~ +360°</td>
</tr>
<tr>
<td><strong>Maximum Speed</strong></td>
<td></td>
</tr>
<tr>
<td>S-axis</td>
<td>0.79rad/s, 45°/s</td>
</tr>
<tr>
<td>L-axis</td>
<td>0.52rad/s, 30°/s</td>
</tr>
<tr>
<td>U-axis</td>
<td>0.52rad/s, 30°/s</td>
</tr>
<tr>
<td>R-axis</td>
<td>0.63rad/s, 36°/s</td>
</tr>
<tr>
<td>B-axis</td>
<td>0.65rad/s, 37°/s</td>
</tr>
<tr>
<td>T-axis</td>
<td>1.22rad/s, 70°/s</td>
</tr>
<tr>
<td><strong>Allowable Moment</strong></td>
<td></td>
</tr>
<tr>
<td>R-axis</td>
<td>14700N•m (1500kgf•m)</td>
</tr>
<tr>
<td>B-axis</td>
<td>14700N•m (1500kgf•m)</td>
</tr>
<tr>
<td>T-axis</td>
<td>4900N•m (500kgf•m)</td>
</tr>
<tr>
<td><strong>Allowable Inertia (GD²/4)</strong></td>
<td></td>
</tr>
<tr>
<td>R-axis</td>
<td>3000kg•m²</td>
</tr>
<tr>
<td>B-axis</td>
<td>3000kg•m²</td>
</tr>
<tr>
<td>T-axis</td>
<td>2200kg•m²</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td>Approximately 10000kg</td>
</tr>
<tr>
<td><strong>Protective Structure</strong></td>
<td>Main part of the Robot: IP30 or equivalent</td>
</tr>
<tr>
<td></td>
<td>Wrist axis only: IP67 or equivalent</td>
</tr>
<tr>
<td><strong>Ambient Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>0 to 45°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>20 to 80%RH (non-condensing)</td>
</tr>
<tr>
<td>Vibration Acceleration</td>
<td>Less than 4.9m/s² (0.5G)</td>
</tr>
<tr>
<td>Others</td>
<td>Free from corrosive gasses or liquids, or explosive gasses</td>
</tr>
<tr>
<td></td>
<td>Free from water, oil, or dust</td>
</tr>
<tr>
<td></td>
<td>Free from excessive electrical noise (plasma)</td>
</tr>
<tr>
<td><strong>Power Capacity</strong></td>
<td>35.0kVA</td>
</tr>
<tr>
<td><strong>Noise</strong></td>
<td>70dB</td>
</tr>
</tbody>
</table>

1 This table uses SI units. However, gravitational units are in parentheses.
2 Conforms to ISO9283
3 Depending on the operation position, it may not reach the maximum speed of each axis.
4 Refer to section 5.7 “Allowable Load for Wrist Axis and Wrist Flange” on page 5-11 for details on the permissible moment of inertia.
5 Conforms to ISO6926
   1. Measurements are with a Robot using the maximum load and maximum speed.
   2. Measurement are:
      - between 1.2m and 1.5m above the ground.
      - 400mm away from the P-point maximum envelope.
5.2 Part Names and Working Axes

Fig. 5-1: Part Names and Working Axes
5.3 Robot Base Dimensions

Fig. 5-2: Robot Base Dimensions

MH900
5.4 Dimensions and P-Point Maximum Envelope

Fig. 5-3: Dimensions and P-Point Maximum Envelope
5.5 Stopping Distance and Times for S-, L- and U-Axes

5.5.1 General Information

- The stopping distance is an angle traveled by the Robot from the moment when the stop signal is activated until the Robot comes to a complete standstill.
- The stopping time is a time elapsed from the moment that the stop signal is activated until the Robot comes to a complete standstill.
- The data that are given for the main axes S, L and U are the maximum displacement.
- Superposed axes motions may result in longer stopping distance.
- Stopping distance and stopping time are measured in accordance with ISO 10218-1, Annex B.
- Stop categories: According to IEC60204-1
  - Stop category 0
  - Stop category 1

- The values specified for Stop category 0 are the reference values that are determined by tests and simulations. The actual stopping distance and stopping time may differ.

5.5.2 Definition of Use

- Load: Rated load weight and load on an arm
- Speed: Operating speed of the Robot
- Extension: Distance between the rotation center and the P-point of each axis

5.5.3 Stopping Distance and Time for Stop Category 0: S-, L- and U-Axes

Measurement Conditions

- Load: Maximum load
- Speed: Maximum speed
- Posture: Maximum inertia generation posture

<table>
<thead>
<tr>
<th>Axis</th>
<th>Stopping distance (deg)</th>
<th>Stopping time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-axis</td>
<td>15.6</td>
<td>0.950</td>
</tr>
<tr>
<td>L-axis</td>
<td>13.0</td>
<td>0.590</td>
</tr>
<tr>
<td>U-axis</td>
<td>14.7</td>
<td>0.810</td>
</tr>
</tbody>
</table>
5 Basic Specifications
5.5 Stopping Distance and Times for S-, L- and U-Axes

5.5.4 Stop Category 1: Stopping Distance and Time for Stop Category 1: S-, L-, and U Axes

5.5.4.1 Extension

Refer to Fig. 5-4 “S-Axis Extension”, Fig. 5-5 “L-Axis Extension” and Fig. 5-6 “U-Axis Extension” for each axis arm extension.

The 100% Extension Length of the S-Axis is 4683mm.

Fig. 5-4: S-Axis Extension

The 100% Extension Length of the L-Axis is 4183mm.

Fig. 5-5: L-Axis Extension

The 100% Extension Length of the U Axis is 2505mm.

Fig. 5-6: U-Axis Extension
5.5.4.2 Stopping Distance and Time for Stop Category 1: S-axis

*Fig. 5-7: Stopping Distance and Time for Stop Category 1: S-Axis*

---

**Stop Category 1, Extension 100%**

- **Stop Category 1, Extension 66%**

- **Stop Category 1, Extension 33%**

---

**Load 100%**

**Load 66%**

**Load 33%**

---

5 Basic Specifications

5.5 Stopping Distance and Times for S-, L- and U-Axes
5.5.4.3 Stopping Distance and Time for Stop Category 1: L-axis

Fig. 5-8: Stopping Distance and Time for Stop Category 1: L-Axis

5.5.4.4 Stopping Distance and Time for Stop Category 1: U-axis

Fig. 5-9: Stopping Distance and Time for Stop Category 1: U-Axis
5.6 Alterable Operating Range

Modifications to the S-Axis operating range with the operating conditions in Table 5-3 “S-Axis Operating Range”. If a modification is necessary, contact Customer Support.

* The interval between stoppers must be a minimum of 72°.

**Fig. 5-10: Alterable Operating Ranges**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications*</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-axis Operating Range</td>
<td>-165° to +165° (standard)</td>
</tr>
<tr>
<td></td>
<td>* (-144° to +144°)</td>
</tr>
<tr>
<td></td>
<td>-132° to +132°</td>
</tr>
<tr>
<td></td>
<td>-120° to +120°</td>
</tr>
<tr>
<td></td>
<td>-108° to +108°</td>
</tr>
<tr>
<td></td>
<td>-96° to +96°</td>
</tr>
<tr>
<td></td>
<td>-84° to +84°</td>
</tr>
<tr>
<td></td>
<td>-72° to +72°</td>
</tr>
<tr>
<td></td>
<td>-60° to +60°</td>
</tr>
<tr>
<td></td>
<td>-48° to +48°</td>
</tr>
<tr>
<td></td>
<td>-36° to +36°</td>
</tr>
<tr>
<td></td>
<td>* (-15° to +15°)</td>
</tr>
</tbody>
</table>

*The interval between stoppers must be a minimum of 72°.*

If any other operating ranges are needed, contact Customer Support.
5.7 Allowable Load for Wrist Axis and Wrist Flange

5.7.1 Allowable Wrist Load

The allowable wrist load including the weight of the gripper is 900kg maximum. If applying force to the wrist instead of the load, force on R, B, and T axes are to be within the values in Table 5-4 “Moment and Total Moment of Inertia”. Contact Customer Support for further information or assistance.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Moment N•m (kgf•m)(^1)</th>
<th>GD(^2)/4 Total Moment of Inertia kg•m(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-axis</td>
<td>14700 (1500)</td>
<td>3000</td>
</tr>
<tr>
<td>B-axis</td>
<td>14700 (1500)</td>
<td>3000</td>
</tr>
<tr>
<td>T-axis</td>
<td>4900 (500)</td>
<td>2200</td>
</tr>
</tbody>
</table>

1 ( ): Gravitational unit

When the volume load is small, refer to the moment arm rating in Fig. 5-11 “Moment Arm Rating”.

Calculate the allowable total moment of inertia when the moment is at the maximum. Contact Customer Support beforehand when only creating moment of inertia; the load moment is small while the moment of inertia is large or the load mass combines with an outside force.
5.7.2 Wrist Flange

The wrist flange dimensions are in Fig. 6-2 “Wrist Flange”. YASKAWA recommends attaching the mount inside the fittings to see the alignment marks. Fitting depth of the inside fitting must be 9mm or less, and outside fitting 12mm or less.

*Fig. 5-2: Wrist Flange*

Wash off anti-corrosive paint (yellow color) on the wrist flange surface with thinner or light oil before mounting the tools.
6 System Application

6.1 Peripheral Equipment Mounts

When attaching peripheral equipment to the U-arm, follow conditions in Table 6-1 and Fig. 6-1.

Table 6-1: Constraint for Attaching

<table>
<thead>
<tr>
<th>Application</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Cable Processing</td>
<td>Load mass max is 900kg max. including wrist load.</td>
</tr>
<tr>
<td>B Cable Processing</td>
<td>50kg max.</td>
</tr>
<tr>
<td>C Valve Load</td>
<td>49N•m (5kgf•m) max. for moment increase amount of upper arm</td>
</tr>
<tr>
<td>D Others</td>
<td>550kg max.</td>
</tr>
</tbody>
</table>

Fig. 6-1: Installing Peripheral Equipment
6.2 Internal User I/O Wiring Harness and Air Lines

The Robot incorporates valve cables (0.5mm\(^2\) × 6 wires, and 0.3mm\(^2\) × 12 wires) and one airline for the drive of peripheral devices mounting on the upper arm per Table 6-2 and Fig. 6-2.

See Fig. 6-3 “Details of the Connector Pin Numbers” on page 6-3 for connector pin assignments for user wiring.

Table 6-2: Internal User I/O Wiring Harness and Air Lines

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal user I/O wiring harness</td>
<td>0.5mm(^2) × 6 wires 0.3mm(^2) × 12 wires (See “Pin details for internal user I/O wiring harness” below.)</td>
<td>0.5mm(^2) : 5.8A or less per wire 0.3mm(^2) : 3.0A or less per wire (Total current should be 21A or less.)</td>
</tr>
<tr>
<td>Air Line</td>
<td>Inside diameter: 12.0mm(^2) × 1 hose</td>
<td>490kPa (5kgf/cm(^2))</td>
</tr>
</tbody>
</table>

Fig. 6-2: Connectors for Internal I/O Wiring Harness and Air Lines
Fig. 6.3: Details of the Connector Pin Numbers

WIRE SIDE SHOWN

S1-1
S1-2
S1-3
S1-4
S1-5
S1-6
S1-7
S1-8
S1-9
S1-10
S1-11
S1-12
S1-13
S1-14
S1-15
S1-16
S1-17
S1-18
S1-19
S1-20
S1-21
S1-22
S1-23
S1-24

USER I/O
7 Electrical Equipment Specification

7.1 Limit Switch

The interference limit switches are part of a safety system that limits the operating range of the Robot along the S-, L- and U-Axes. The switches sense the presence/absence of mechanical limit markers (flags) installed on the Robot.

When a limit switch activates, power is removed from the Robot, causing the Robot to make an emergency stop. Refer to section 8.9 “Overrun/Tool Shock Sensor Releasing” in “DX200 INSTRUCTIONS” for releasing the status of this overrun.

The limit switches are optional, and serve as a back-up to the encoder for sensing the Robot’s position. Either the encoder, or a limit switch will trigger an alarm, and send a signal that will interrupt the power supply to the Robot.

7.1.1 Specification of Limit Switch

The S-, L- and U-Axes limit switches are set to the maximum operating range limit before shipping.

7.1.2 Location of Limit Switches

Limit switches mount to the S-, L- and U-Axes on the Robot per the limit switch specification. Refer to Fig. 7-1 “Location of Limit Switches”.

The locations of the mechanical limit markers (flags) at S-, L- and U-Axes are changeable. They are factory-mounted per the limit switch specifications.

The positions of the mechanical limits (mechanical stoppers) at S-, L- and U-Axes are changeable. They are factory-mounted per the mechanical limits specifications.
Fig. 7-1: Location of Limit Switches

- U-axis overrun limit switch
- L-axis overrun limit switch
- S-axis overrun limit switch
7.1.3 Setting of Operation Range

7.1.3.1 S-Axis Operation Range

Using the S-axis limit switch adjust the operating range using Table 5-3 “S-Axis Operating Range” on page 5-10.

7.1.3.2 L-Axis Operation Range

Using the L-axis limit switch, adjust the L-axis operating range by setting any angle within -61° to +101° and Fig. 7-2 “L-Axis Overrun Limit Switch Setting Range”.

Fig. 7-2: L-Axis Overrun Limit Switch Setting Range
7.1.3.3 Setting Range of LU-Axes Interference Angle

L- and U-Axes interference limit switches check the interference angle of the L- and U-Axes.

Set the operating range of the U-axis to any angle within -65° to +70° as the interference angle with L-axis. See Fig. 7-3 “LU-Axes Interference Angle”.

*Fig. 7-3: LU-Axes Interference Angle*
8 Maintenance and Inspection

8.1 Inspection Schedule

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. Inspection intervals are in six levels. Conduct periodical inspections according to the inspection schedule in Table 8-1 “Inspection Items”.

Classifications for inspections in Table 9-1 are:

- **User**: Operations performed by authorized personnel.
- **Trained**: Operations performed by trained personnel
- **Service**: Operations performed by service company personnel.

- The inspection interval must be based on the servo power supply on time.

For axes which are used very frequently (in handling applications, etc.), it is recommended that inspections be conducted at shorter Intervals. Contact Customer Support.

---

**DANGER**

- Specified personnel are to perform maintenance and inspections. Failure to observe this instruction may result in electric shock or injury.
- For disassembly or repair, contact Customer Support.
- 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 Robot's arm.

**WARNING**

- Turn the main power supply OFF and put up a warning sign before doing maintenance or inspections.

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

**CAUTION**

- Connect the battery pack before removing detection connector during maintenance and inspections.

Failure to observe this instruction may result in the loss of home position data.
### Table 8-1: Inspection Items (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>Items</th>
<th>Schedule</th>
<th>Method</th>
<th>Operation</th>
<th>Inspection Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
<td>1000H Cycle</td>
<td>6000H Cycle</td>
<td>12000H Cycle</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Visual, Aural</td>
<td>Check for damage that will affect operation. Listen for noises.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>Visual</td>
<td>Check alignment mark accordance at the home position.</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>Visual</td>
<td>Check for damage and deterioration of leads.</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Visual</td>
<td>Check for grease leakage.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Wrench</td>
<td>Tighten loose bolts. Replace if necessary.</td>
<td>●</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Phillips screwdriver, wrench</td>
<td>Tighten loose bolts. Replace if necessary.</td>
<td>●</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Manual</td>
<td>Check for loose connectors and tighten if necessary.</td>
<td>●</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Manual</td>
<td>Check for loose connectors and tighten if necessary.</td>
<td>●</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Grease Gun</td>
<td>Supply grease. See section 8.3.10.</td>
<td>●</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Visual, multimeter</td>
<td>Check for conduction between the main connector of connector base and each connector with manually shaking the wire. Check for wear of protective spring.</td>
<td>●</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>Replace.</td>
<td>●</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Visual Manual</td>
<td>Check for a backlash of the bearing by moving the LU-Axes back and forth, and up and down. Supply grease.</td>
<td>●</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease (6000H cycle). Replace grease (12000H cycle). See section 8.3.2.</td>
<td>●</td>
</tr>
</tbody>
</table>
Table 8-1: Inspection Items (Sheet 2 of 2)

<table>
<thead>
<tr>
<th>Items 1)</th>
<th>Schedule</th>
<th>Method</th>
<th>Operation</th>
<th>Inspection Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
<td>1000H Cycle</td>
<td>6000H Cycle</td>
<td>12000H Cycle</td>
</tr>
<tr>
<td>14 LU-axis speed reducer</td>
<td>●</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). Replace grease 5) (12000H cycle). See section 8.3.4 and section 8.3.5.</td>
</tr>
<tr>
<td>15 RBT-axis gear</td>
<td>●</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). Replace grease 5) (12000H cycle). See section 8.3.5.</td>
</tr>
<tr>
<td>16 R-axis speed reducer</td>
<td>●</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). Replace grease 5) (12000H cycle). See section 8.3.6.</td>
</tr>
<tr>
<td>17 BT-axis speed reducer and gear</td>
<td>●</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). Replace grease 5) (12000H cycle). See section 8.3.7 and section 8.3.8.</td>
</tr>
<tr>
<td>18 U-axis cross roller bearing</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). See section 8.3.8.</td>
<td>●</td>
</tr>
<tr>
<td>19 S-Axis cross roller bearing</td>
<td>●</td>
<td>Grease Gun</td>
<td>Check for malfunction. (Replace if necessary.) Supply grease 5) (6000H cycle). See section 8.3.8.</td>
<td>●</td>
</tr>
<tr>
<td>20 Overhaul</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Inspection No. correspond to the numbers in Fig. 8-1 “Inspection Parts and Inspection Numbers”.
2) The occurrence of a grease leakage indicates the possibility that grease has seeped into the motor. This can cause a motor breakdown. Contact Customer Support.
3) When checking for conduction with multimeter, connect the battery pack to “BAT” and “OBT” of connectors on the motor side for each axis, then remove connectors on the detector side for each axis from the motor. Not following the above may result in the loss of the home position. (Refer to section 8.4 “Notes for Maintenance”.)
4) Replace internal cables (for S-, L-, U-, R-, B- and T-Axes) at 24000H inspection.
5) For grease, refer to Table 8-1 “Inspection Items”.

Table 8-1: Inspection Items (Sheet 2 of 2)
8 Maintenance and Inspection
8.1 Inspection Schedule

Table 8-2: Inspection Parts and Grease Used

<table>
<thead>
<tr>
<th>No.</th>
<th>Grease Used</th>
<th>Inspected Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>13,14,15,16,17,19</td>
<td>Molywhite RE No. 00</td>
<td>All axis speed reducers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B- and T-Axes gears</td>
</tr>
<tr>
<td>9,11,18,19</td>
<td>Gadus Grease</td>
<td>U-axis cross roller bearing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tapered roller bearing in the link part</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L-axis balancer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S-axis cross roller bearing</td>
</tr>
</tbody>
</table>

The numbers in the above table correspond to the numbers in Table 8-1 “Inspection Items”.

Fig. 8-1: Inspection Parts and Inspection Numbers
8.2 Notes on Maintenance Procedures

8.2.1 Battery Pack Replacement

See Fig. 8-2 “Battery Pack Location” on page 8-6 for battery pack locations. The lithium battery’s lifetime is:

- 10 years when the battery’s ambient temperature is 40°C (104°F) or less,
- 4.1 years when the battery’s ambient temperature is 50°C (122°F) or less, and
- 1.5 years when the battery’s ambient temperature is 60°C (140°F) or less.

When the lithium battery is used for backup, its lifetime is:

- About 100 days with a fully-charged battery.
- About 6 days with a half-charged battery.

If the battery alarm occurs in the Controller, replace the battery packs according to the following:

1. Supply power to, and fully charge the battery.
   In 24 hours, the battery charges to a level that allows backup operation. Completing a full charge requires about 120 hours (5 days).
2. Turn the Controller main power supply OFF.
3. Remove the plate fixing screws and the plate from the connector base, and pull the battery pack out to replace with a new battery pack.
4. Remove the battery pack from the battery holder.
5. Connect the new battery pack to the unoccupied connector on the board. See Fig. 8-3 “Battery Connection” on page 8-6.
6. Remove the old battery pack from the board.

**CAUTION**

- Remove the old battery pack after connecting the new battery pack.
Failure to observe this instruction will cause the encoder absolute data to disappear.

7. Mount the new battery pack to the holder.
8. Reinstall the plate.

**CAUTION**

- Do not allow plate to pinch the cables when reinstalling the plate.
Failure to observe this instruction may cause the pressure of the plate to break wires in the cables.
8.2.2 Signal Cable Bypass/Replacement Kit

The Robot cable for the encoder and brake contains six signal cables; one for each motor on the Robot. The Signal Cable Replacement Kit allows each signal cable to be replaced separately. Once a signal cable is replaced, only the motor connected to the replaced signal cable needs to be re-referenced.
8.3 Grease Replenishment/Exchange

8.3.1 Notes on Grease Replenishment/Exchange Procedures

Make sure to follow the instructions listed below during grease replenishment/exchange. Failure to observe the following notes may result in damage to motor and speed reducer.

**CAUTION**

- Do not add grease without removing the plug/screw from the grease exhaust port. Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted. Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

- Fill the hose on the grease inlet with grease before injecting grease. Failure to observe this instruction may result in air leaking into the speed reducer.

- Use a grease pump to inject grease. Set air supply pressure to the grease pump at 0.3MPa or less, and the grease injection rate at 8g/s or less. Failure to observe this instruction may result in grease leaking due to seal damage.

8.3.2 Grease Replenishment Quick Reference

The following table lists all grease replenishment amounts.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Replenishment</th>
<th>First Supply Amount</th>
<th>Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>R, B, and T Motor Mount (one grease cavity)</td>
<td>7000g</td>
<td>13700g</td>
<td>Approximately 7000g</td>
</tr>
<tr>
<td>Upper Arm</td>
<td>3100g</td>
<td>6200g</td>
<td>Approximately 3100g</td>
</tr>
<tr>
<td>S Speed Reducer and Gear</td>
<td>12200g</td>
<td>24400g</td>
<td>Approximately 12200g</td>
</tr>
<tr>
<td>L Speed Reducer</td>
<td>8000g</td>
<td>15800g</td>
<td>Approximately 8000g</td>
</tr>
<tr>
<td>U Speed Reducer</td>
<td>9000g</td>
<td>17900g</td>
<td>Approximately 9000g</td>
</tr>
<tr>
<td>R Speed Reducer</td>
<td>3000g</td>
<td>6200g</td>
<td>Approximately 3000g</td>
</tr>
<tr>
<td>B and T Speed Reducer and Gear (same grease cavity)</td>
<td>1200g</td>
<td>2400g</td>
<td>Approximately 1200g</td>
</tr>
</tbody>
</table>
8.3.3 Grease Replenishment/Exchange for S-axis Speed Reducer and Gear

*Fig. 8-4: S-axis Speed Reducer and Gear Diagram*
8.3 Grease Replenishment/Exchange

8.3.3.1 S-Axis Speed Reducer and Gear Grease Replenishment

(Refer to Fig. 8-4 “S-axis Speed Reducer and Gear Diagram”.)

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not add grease without removing the plug/screw from the grease exhaust port.</td>
</tr>
<tr>
<td>Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.</td>
</tr>
<tr>
<td>• Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.</td>
</tr>
<tr>
<td>Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.</td>
</tr>
</tbody>
</table>

1. Remove the hexagon socket head plug 3/8 BSPT from the grease exhaust port.
2. Remove the hexagon socket head plug 3/8 BSPT from the grease inlet and install a grease zerk 3/8 BSPT.
3. Inject grease into the grease inlet using a grease gun. (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 12200g (24400g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less
4. Move the S-axis for a few minutes to discharge excess grease.
5. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).
6. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

<table>
<thead>
<tr>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not install plug into exhaust port while grease is being exhausted.</td>
</tr>
<tr>
<td>Failure to observe this instruction may cause grease to leak inside the motor and cause damage.</td>
</tr>
</tbody>
</table>
8.3 Grease Replenishment/Exchange

8.3.3.2 S-Axis Speed Reducer and Gear Grease Exchange

(Refer to Fig. 8-4 “S-axis Speed Reducer and Gear Diagram”.)

**CAUTION**

- Do not add grease without removing the plug/screw from the grease exhaust port.
  
  Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.
  
  Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

1. Remove the hexagon socket head plug 3/8BSPT from the grease exhaust port.

2. Remove the hexagon socket head plug 3/8 BSPT from the grease inlet and install a grease zerk 3/8 BSPT.

3. Inject grease into the grease inlet using a grease gun.

   (The grease zerk is delivered with the Robot.)

   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 12200g
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

4. The grease exchange is complete when new grease appears in the grease exhaust port.

   Distinguish new grease from the old grease by color.

5. Move the S-axis for a few minutes to discharge excess grease.

6. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

7. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

**NOTE**

- Do not install plug into exhaust port while grease is being exhausted.

  Failure to observe this instruction may cause grease to leak inside the motor and cause damage.
8.3.4 Grease Replenishment/Exchange for L-and U-Axes Speed Reducer

Fig. 8-5: L-and U-Axes Speed Reducer Diagram

8.3.4.1 L-and U-Axes Speed Reducer Grease Replenishment

(Refer to Fig. 8-5 "L-and U-Axes Speed Reducer Diagram").

CAUTION

- Do not add grease without removing the plug/screw from the grease exhaust port.

Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.

Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

1. Remove the hexagon socket head plugs 1/8 BSPT from the grease exhaust port.

2. Remove the hexagon socket head plugs 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.

3. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: L-Axis approx. 8000g (15800g for the 1st supply)
     U-Axis approx. 9000g (17900g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

4. Move the L-and U-Axes for a few minutes to discharge excess grease.

5. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
8 Maintenance and Inspection

8.3 Grease Replenishment/Exchange

6. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

8.3.4.2 L-and U-Axes Speed Reducer Grease Exchange

(Refer to Fig. 8-5 “L-and U-Axes Speed Reducer Diagram”.)

CAUTION

- Do not add grease without removing the plug/screw from the grease exhaust port.
- Do not install a joint, a hose, etc. to the grease exhaust port.

Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

1. Remove the hexagon socket head plugs 1/8 BSPT from the grease exhaust port.
2. Remove the hexagon socket head plugs 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.
3. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: L-Axis approx. 8000g (15800g for the 1st supply)
     U-Axis approx. 9000g (17900g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less
4. The grease exchange is complete when new grease appears in the grease exhaust port.
   Distinguish new grease from the old grease by color.
5. Move the L-and U-Axes for a few minutes to discharge excess grease.
6. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
7. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
8.3.5 Grease Replenishment/Exchange for RBT-Axes Gear

*Fig. 8-6: RBT-Axes Gear Diagram*

![Diagram of RBT-Axes Gear](image)

8.3.5.1 RBT-Axes Gear Grease Replenishment

(Refer to *Fig. 8-6 “RBT-Axes Gear Diagram”*.)

**CAUTION**

- Do not add grease without removing the plug/screw from the grease exhaust port.
  
  Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.
  
  Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

1. Remove the hexagon socket head plugs 3/8 BSPT from the grease exhaust port.

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.

3. Inject grease into the grease inlet using a grease gun.
   
   (The grease zerk is delivered with the Robot.)

   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 7000g
     (13700g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

4. Move the R-, B-, and T-Axes for a few minutes to discharge excess grease.
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8.3 Grease Replenishment/Exchange

5. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

6. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

8.3.5.2 Grease Exchange
(Refer to Fig. 8-6 “RBT-Axes Gear Diagram”.)

1. Remove the hexagon socket head plugs 3/8 BSPT from the grease exhaust port.

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.

3. Inject grease into the grease inlet using a grease gun. (The grease zerk is delivered with the Robot.)
   
   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 7000g
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

4. The grease exchange is complete when new grease appears in the grease exhaust port. Distinguish new grease from the old grease by color.

5. Move the RBT-Axes for a few minutes to discharge excess grease.

**NOTE**

- Do not install plug into exhaust port while grease is being exhausted.

Failure to observe this instruction may cause grease to leak inside the motor and cause damage.

**CAUTION**

- Do not add grease without removing the plug/screw from the grease exhaust port.

Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.

Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.
6. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

7. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

**NOTE**

- Do not install plug into exhaust port while grease is being exhausted.
  - Grease may leak inside the motor and cause damage.

### 8.3.6 Grease Replenishment/Exchange for R-axis Speed Reducer

Fig. 8-7: R-axis Speed Reducer Diagram

8.3.6.1 Grease Replenishment

(Refer to Fig. 8-7 “R-axis Speed Reducer Diagram”)

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not add grease without removing the plug/screw from the grease exhaust port. Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.</td>
</tr>
<tr>
<td>• Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted. Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.</td>
</tr>
</tbody>
</table>

1. Remove the hexagon socket head plugs 3/8 BSPT from the grease exhaust port.

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.
8.3 Grease Replenishment/Exchange

3. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: 3000g
     (6200g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

4. Move the R-axis for a few minutes to discharge excess grease.

5. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

6. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

8.3.6.2 Grease Exchange

(Refer to Fig. 8-7 "R-axis Speed Reducer Diagram").

**CAUTION**

- Do not install plug into exhaust port while grease is being exhausted.
  Grease may leak inside the motor and cause damage.

- Do not add grease without removing the plug/screw from the grease exhaust port.
  Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.
  Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

1. Remove the hexagon socket head plugs 3/8 BSPT from the grease exhaust port.

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.

3. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 3000g
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less
4. The grease exchange is complete when new grease appears in the grease exhaust port. Distinguish new grease from the old grease by color.

5. Move the R-axis for a few minutes to discharge excess grease.

6. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

7. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 23N•m (2.4kgf•m).

**NOTE**

Do not install plug into exhaust port while grease is being exhausted.

Grease may leak inside the motor and cause damage.

8.3.7 Grease Replenishment/Exchange for B-axis and T-Axis Speed Reducers and Gear

*Fig. 8-8: B-axis and T-axis Speed Reducers and Gear Diagram*
8.3.7.1 Grease Replenishment

(Refer to Fig. 8-8 “B-axis and T-axis Speed Reducers and Gear Diagram”.)

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not add grease without removing the plug/screw from the grease exhaust port.</td>
</tr>
<tr>
<td>Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.</td>
</tr>
<tr>
<td>• Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.</td>
</tr>
<tr>
<td>Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.</td>
</tr>
</tbody>
</table>

1. Remove the hexagon socket head plugs 1/8 BSPT from the grease exhaust port.
2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.
3. Inject grease into the grease inlet using a grease gun. (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: 1200g (2400g for the 1st supply)
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less
4. Move the B-axis and T-axis for a few minutes to discharge excess grease.
5. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
6. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

<table>
<thead>
<tr>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not install plug into exhaust port while grease is being exhausted.</td>
</tr>
<tr>
<td>Grease may leak inside the motor and cause damage.</td>
</tr>
</tbody>
</table>
8.3 Grease Replenishment/Exchange

8.3.7.2 Grease Exchange

(Refer to Fig. 8-8 “B-axis and T-axis Speed Reducers and Gear Diagram”.)

**CAUTION**

- Do not add grease without removing the plug/screw from the grease exhaust port.

Failure to observe this instruction will cause grease to leak inside the motor and may cause an oil seal on the speed reducer to come off, which may damage the motor. Make sure to remove the plug/screw.

- Do not install a joint, a hose, etc. to the grease exhaust port while grease is being exhausted.

Failure to observe this instruction may result in damage to the motor due to the loss of an oil seal.

7. Remove the hexagon socket head plugs 1/8 BSPT from the grease exhaust port.

8. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.

9. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   - Grease type: Molywhite RE No. 00
   - Amount of grease: approx. 1200g
   - Air supply pressure of grease pump: 0.3MPa or less
   - Grease injection rate: 8g/s or less

10. The grease exchange is complete when new grease appears in the grease exhaust port. Distinguish new grease from the old grease by color.

11. Move the B-axis and T-axis for a few minutes to discharge excess grease.

12. Wipe the discharged grease with a cloth, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

13. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

**NOTE**

- Do not install plug into exhaust port while grease is being exhausted.

Grease may leak inside the motor and cause damage.
8.3.8 Grease Replenishment for U-axis Cross Roller Bearing

Fig. 8-9: U-axis Cross Roller Bearing Diagram

1. Remove the hexagon socket head plug 1/8 BSPT from the exhaust port.
2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet and install a grease zerk A-1/8 BSPT.
3. Inject grease into the grease inlet using a grease gun.
   (The grease zerk is delivered with the Robot.)
   
   – Grease type: Gadus Grease
   – Amount of grease: 19cc

   **NOTE** Do not inject excessive grease into the grease inlets. The exhaust port is for air flow.

4. Reinstall the plug into the exhaust port. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
5. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).
8.3.9 Grease Replenishment for Tapered Roller Bearing in the Link Part

Fig. 8-10: Link Part Diagram

1. Remove the hexagon socket head plug 1/8 BSPT from the exhaust port of each link part (6 places: 3 places × both sides). (Refer to Fig. 8-10 “Link Part Diagram”.)

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet of each link part and install the grease zerk A-1/8 BSPT. (The grease zerk comes with the Robot.)

3. Inject grease using a grease gun.
   - Grease type: Gadus Grease
   - Amount of grease: 6cc (12cc for the 1st supply)

4. Reinstall the plug into the exhaust port of each link. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

5. Remove the grease zerk from the grease inlet, and reinstall the plug. Before installing the plug, apply Three Bond 1206C on the thread part of the plug. Then tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m).

The exhaust port is for air flow.

Do not inject excessive grease into the grease inlets.
8.3.10 Grease Replenishment for Balancer Link Part

Fig. 8-11: Balancer Link Part

1. Remove the hexagon socket head plug 1/8 BSPT from the exhaust port of Link1. Remove the hexagon socket head plug 1/8 BSPT (2 places) from the exhaust port of Link2. (Refer to Fig. 8-11 "Balancer Link Part").

2. Remove the hexagon socket head plug 1/8 BSPT from the grease inlet.

3. Install a grease zerk A-1/8 BSPT on the grease inlet. (The grease zerk is delivered with the Robot.)

4. Inject grease using a grease gun.
   - Grease type: Gadus Grease
   - Amount of grease: approx. 5cc (10cc for the 1st supply)

5. Remove the grease zerk from the grease inlet and reinstall the plug. Tighten the plug with a tightening torque of 4.9N•m (0.5kgf•m). (Apply Three Bond 1206C to thread part of the plug.)

6. Reinstall the plug on the exhaust port of the Link1. Reinstall the plugs (2 places) on the exhaust port of the Link2. Tighten the screw/plugs with a tightening torque of 4.9N•m (0.5kgf•m). (Apply ThreeBond 1206C to thread part of the screw/plugs.)
8.4 Notes for Maintenance

- While performing maintenance such as replacing a wire harness in the Robot, the encoder connector may require removal. In this case, connect the battery pack to the battery backup connector before removing the encoder connector.

**NOTE**

Removing the encoder connector without connecting the battery pack causes the loss of encoder absolute data. Refer to Fig. 8-12 “Battery Pack Connection for Motor” for the battery connection.

The connectors for the battery pack connection attach to the main body of motors. Connect the battery pack according to the following steps.

1. Remove the cap attached to the battery backup connector of the motor.
2. Connect the battery pack (HW9470917-A) for motors to the battery backup connector. (With the battery pack connected to the battery backup connector, remove the encoder connector and perform the maintenance.)
3. After maintenance, confirm all connections of connectors and remove the battery pack connection cable for the motor and battery pack.
4. Reinstall the attached cap to the battery backup connector of the motor.

**NOTE**

Do not remove the battery pack in the connector base. Removing the battery pack will cause the loss of encoder absolute data.

*Fig. 8-12: Battery Pack Connection for Motor*

![Battery Pack Connection Diagram](image_url)
9  Recommended Spare Parts

YASKAWA recommends keeping the following parts and components in stock as spare parts for the MOTOMAN-MH900. Refer to Table 9-1 “Spare Parts for the MOTOMAN-MH900” on page 9-2.

When preparing lead wires for a wire harness in the Robot, etc., check the serial number and contact Customer Support.

YASKAWA does not guarantee product performance when using spare parts from another 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

NOTE  To replace parts in Rank B or Rank C, contact Customer Support.
### Table 9-1: Spare Parts for the MOTOMAN-MH900

<table>
<thead>
<tr>
<th>Rank</th>
<th>Call Out</th>
<th>Name</th>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Qty</th>
<th>Qty per Unit</th>
<th>Remarks</th>
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</thead>
<tbody>
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<td>A</td>
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<td>Battery Pack</td>
<td>HW9470917-A</td>
<td>YASKAWA</td>
<td>1</td>
<td>1</td>
<td>For S-, L- and U-Axes</td>
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<tr>
<td>A</td>
<td>12</td>
<td>Battery Pack</td>
<td>HW0470360-A 164675-1</td>
<td>YASKAWA</td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>Liquid Gasket</td>
<td>ThreeBond 1206C</td>
<td>ThreeBond Co.,Ltd.</td>
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<td>1</td>
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<tr>
<td>A</td>
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<td>Grease</td>
<td>Molywhite RE No. 00</td>
<td>YASKAWA</td>
<td>37gal</td>
<td>-</td>
<td>For all axes speed reducers and wrist units</td>
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<tr>
<td>A</td>
<td>5</td>
<td>Grease</td>
<td>Gadus Grease 2</td>
<td>Showa Shell Sekiyu K.K.</td>
<td>16kg</td>
<td>-</td>
<td>For tapered roller bearing</td>
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<tr>
<td>B</td>
<td>6</td>
<td>Replacement Kit for S-axis Speed Reducer</td>
<td>182728-1</td>
<td>YASKAWA</td>
<td>1</td>
<td>1</td>
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<tr>
<td>B</td>
<td>7</td>
<td>Replacement Kit for L-axis Speed Reducer</td>
<td>182729-1</td>
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<td>B</td>
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<tr>
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<td>3</td>
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10 Parts List

10.1 Robot Arm Assembly

Fig. 10-1(a): Robot Arm, MH900
Fig. 10-1(b): Hardware Pkg, Robot, Arm, MH900

EXPLoded DETAIL K
SAME AT LINK B

HARDWARE PACKAGE
HARDWARE SHOWN AS
ZERK FITTINGS

SAME ON BOTH SIDES
OPP SIDE USE ITEM 48

L-ARM YOKE AND BALANCER CLEVIS SHOWN
1.5
### Table 10-1: Manipulator Arm Assembly (Sheet 1 of 5)

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<td>BASE ASSY,MH900</td>
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<td>BALANCER ASSY,SPRING,MH900</td>
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<td>5</td>
<td>1</td>
<td>178531-1</td>
<td>ARM ASSY,L-ARM,MH900</td>
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### Table 10-1: Manipulator Arm Assembly (Sheet 2 of 5)

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<td>PLATE,RETAINER,BEARING SHAFT,A/B LINK PIVOT,MH900</td>
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<td>178362-1</td>
<td>TUBE,GUIDE,MIDDLE CABLE,S-AXIS GEAR CASE,MH900</td>
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<td>FLANGE,GUIDE TUBE,CABLE EXIT,S-AXIS GEAR CASE,MH900</td>
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<td>SHAFT,BEARING,SPRING BALANCER HOUSING,MH900</td>
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Table 10-1: Manipulator Arm Assembly  (Sheet 3 of 5)

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Table 10-1: Manipulator Arm Assembly  (Sheet 4 of 5)

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<tr>
<td>427</td>
<td>22</td>
<td>479281-105</td>
<td>FITTING, PLUG, 1/8 BSPT, BLACK</td>
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<td>428</td>
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<td>162873-4</td>
<td>PLUG, VENT, GREASE, 3/8 BSPT, PRESSURE RELIEF AT 1-5 PSI</td>
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<tr>
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<td>PLUG, VENT, GREASE, 1/8 BSPT, PRESSURE RELIEF AT 1-5 PSI</td>
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<td>433</td>
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<td>479297-3</td>
<td>SCREW, SHC, M10X20, CLASS 12.9,</td>
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10.2 S-Axis Unit

Fig. 10-2: S-Axis Unit

HARDWARE PACKAGE

[Diagram of S-Axis Unit with labeled parts]
### Table 10-2: S-Axis Unit (1) (Sheet 1 of 2)

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<thead>
<tr>
<th>Item</th>
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<td>178526-1</td>
<td>BASE ASSY, MH900 [S-AXIS UNIT]</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>178379-1</td>
<td>COVER, BASE, BOTTOM, MH900</td>
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<td>HOUSING, CAST, S-AXIS BASE, MH900</td>
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<tr>
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<tr>
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<tr>
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<td>SEAL, O-RING, 419.3mm ID X 5.7</td>
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<td>HARDWARE PKG, BASE ASSY, MH900</td>
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### Table 10-2: S-Axis Unit (1) (Sheet 2 of 2)

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<tr>
<td>409</td>
<td>4</td>
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<tr>
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10.3 L-Axis Unit

Fig. 10-3: L-Axis Unit
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<td>178101-1</td>
<td>HOUSING, CAST, L-ARM, MH900</td>
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<td>FLANGE, CAST, YOKE, L-ARM TO SPRING BALANCER CLEVIS, MH900</td>
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<tr>
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<td>10</td>
<td>407249-5</td>
<td>SCREW, SHC, M6 X 20</td>
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10.4 Drive Assembly U-Axis Unit

Fig. 10-4: Drive Assembly U-Axis Unit

- U-Nut Included With RV Reducer
- Spacer Included With RV Reducer
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<td>76</td>
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<td>180542-1</td>
<td>WASHER, FLAT, M30, 56 OD X 31 ID X 5 THK, RV-1500E, MH900</td>
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</table>
10.5 Balancer Unit

Fig. 10-5: Balancer Unit

HARDWARE SHOWN AS

SUBASSEMBLY A
1:4

SUBASSEMBLY B
1:4

SUBASSEMBLY C
1:4

SUBASSEMBLY D
1:4

SUBASSEMBLY E
1:4

HARDWARE PACKAGE

HARDWARE SHOWN AS
### Table 10-5: Balancer Unit (Sheet 1 of 2)

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<td>FLANGE, MACHINED, SPRING BALANCER CAP END, MH900</td>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
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<td>SPRING, COMPRESSION, BALANCER, OUTER LH, 342 OD X 44 WIRE DIA X 668 FL</td>
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<td>ROD, SPRING BALANCER, MH900</td>
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<td>FLANGE, WELDMENT, SPRING BALANCER MIDDLE, MH900</td>
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<td>FLANGE, WELDMENT, SPRING BALANCER HEAD END, MH900</td>
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### Table 10-5: Balancer Unit (Sheet 2 of 2)

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<td>SCREW, SHC, M10X45, CLASS 12.9</td>
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</table>
10.6 U-Arm Assembly

Fig. 10-6(a): U-Arm Assembly

HARDWARE PACKAGE

HARDWARE SHOWN AS

XXXX (QTY)
Fig. 10-6(b): U-Axis Unit Sub Assemblies

SUBASSEMBLY A

SUBASSEMBLY B

SUBASSEMBLY C

SUBASSEMBLY D

SUBASSEMBLY E

SUBASSEMBLY F

Parts List

10.6 U-Arm Assembly
Fig. 10-6(c): R-Axis Unit
Fig. 10-6(d): R-Axis Unit Sub Assemblies
Fig. 10-6(e): R-, B- and T-Axes Unit

HARDWARE PACKAGE

HARDWARE SHOWN AS
### Table 10-6: U-Arm Assembly (Sheet 1 of 4)

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### Table 10-6: U-Arm Assembly (Sheet 2 of 4)

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### Table 10-6: U-Arm Assembly (Sheet 3 of 4)

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### Table 10-6: U-Arm Assembly (Sheet 4 of 4)

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10.7 Wrist Unit 178523 PAGE 8

Fig. 10-7: Wrist Unit
HARDWARE PACKAGE

HARDWARE SHOWN AS
400 (QTY)

6008410 (33)
6008410 (32)
6008410 (32)
6008410 (6)
6008414 (12)
6008414 (12)
6008414 (6)
6008414 (6)
6008414 (6)
6008414 (6)
6008414 (6)
6008414 (6)

B1 SUBASSEMBLY

B2 SUBASSEMBLY
Fig. 10-7(a): Wrist Unit Subassemblies 178523 PAGE 9

T1 Subassembly

Collar, Included with Reducer
U-Nut, Included with Reducer

T2 Subassembly

T3 Subassembly

T4 Subassembly

Collar, Included with Reducer
U-Nut, Included with Reducer
### Table 10-7: Wrist Unit Assembly (Sheet 1 of 4)

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### Table 10-7: Wrist Unit Assembly (Sheet 2 of 4)

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Appendix A Glossary

A.1 Glossary

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.

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.

Arm
An interconnected set of links and powered joints comprising a robot Manipulator that supports and/or moves a wrist and hand or end-effector through space. The arm itself does not include the end-effector. See "Manipulator", "End-effector" and "Wrist".

Articulated Manipulator
A Manipulator with an arm that is broken into sections (links) by one or more joints. Each of the joints represents a degree of freedom in the Manipulator system and allows translation and rotary motion.
Appendix A Glossary

B

**Articulation**
Describes a jointed device, such as a jointed Manipulator. The joints provide rotation about a vertical axis, and elevation out of the horizontal plane. This allows a robot to be capable of reaching into confined spaces.

**Assembly Robot**
A robot designed specifically for mating, fitting, or otherwise assembling various parts or components into completed products. Primarily used for grasping parts and mating or fitting them together, such as in assembly line production.

**Automatic Measurement Function**
For optimal robot motion, the mass properties of the end-effector should be specified. These properties can be derived from a CAD model of the tool. The Automatic Measurement Function is an alternative to a CAD model, and it uses the robot arm itself to measure the tool properties. With this function, the user can register the load of tool, the position of the tools center of gravity and the moment of inertia at the center of gravity.

**Automatic Mode**
See "Play Mode".

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

**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.

**B**

**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 robots or devices as positions defined in Base Coordinates will be the same for all robots and devices.

**Base Link**
The stationary base structure of a robot arm that supports the first joint.

**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.

**Bypass Kit**
Hardware that allows individual encoder and/or brake signal cables (enclosed in the Manipulator cable) to be replaced separately. Used to replace a failed encoder or a brake cable.
Appendix A 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.

**Carousel**
A rotating platform that delivers objects to a robot and serves as an object queuing system. This carousel delivers the objects, or work pieces, to the loading/unloading station of the robot.

**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 robot 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.
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C

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

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

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

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

Clamping
The maximum permissible force acting on a body region, resulting from a robot 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 robot Manipulator by means of feedback information. As a Manipulator is in action, its sensors continually communicate information to the robot's 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.

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.

Connector Panel
A junction plate that allows the Manipulator cables to connect to the robot’s internal harness. See "Internal Harness".
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 robot's 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 Operator Handle
Power switch on the Controller. Turns on the Controller and provides power to the robot.

Controller System
The robot 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"
Manipulator

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D

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, robot coordinate or user coordinate. The YRC1000 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.

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", "Cylindrical Topology" and "Rotary Vector Drive (RV)".
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E

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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F

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 gauges. 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.
Manipulator

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G

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

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

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

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

Hand Guiding
Collaborative feature that allows an operator to hand guide the robot to a desired position. This task can be achieved by utilizing additional external hardware mounted directly to the robot or by a robot specifically designed to support this feature. Both solutions will require elements of functional safety to be utilized. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.

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.
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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.

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.
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**Integrate**
To fit together different subsystems, such as robots and other automation devices, or at least different versions of subsystems in the same control shell.

**Integrator**
A company that provides value added services that results in creation of automation solutions by combining a robot and other automation and controls equipment to create an automation solution for end users.

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

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

**Internal Harness**
Collection of cables bundled inside the main body of the Manipulator. The cables run from the base of the robot to each motor.

**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 YASKAWA name for a robot program created using YASKAWA’s INFORM robot programming language. Typically, a JOB consists of instructions that tell the robot 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.
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Ladle Gripper
An end-effector, which acts as a scoop. It is commonly used to scoop up liquids, transfer it to a mold and pour the liquid into the mold. Common for handling molten metal under hazardous conditions. See "End-effector".

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.

Lifting Bracket
A lifting fixture factory-shipped installed on the Manipulator. It contains hoist rings used for lifting by a chain sling. The lifting bracket is not rated for lifting by forklift. It must be lifted by chain sling only.

Limit Switch
Prevents the Manipulator from moving past overrun positions. Provided for the S, L, and U axes.

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.

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.

Links
The static material, which connects the joints of an arm together. Thereby a kinematical chain is formed. In a human body, the links are the bones.

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 usually consisting 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 Manipulator may be controlled by an operator, a programmable electronic Controller or any logic system (for example cam device, wired, etc.) (ISO 8373)
See "Arm", "Wrist" and "End-effector"

Manipulator Cables
A collection of cables that connect the base of the robot to the Controller through the connector panel.

Manual Mode
See "Teach Mode".

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

Material Processing Robot
A robot designed and programmed so that it can machine, cut, form or change the shape, function or properties of materials it handles between the time the materials are first grasped and the time they are released in a manufacturing process.

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 teach 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.

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

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

Motor
See "Servo Motor".
**Manipulator**

**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.

**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)

**Operator Handle, Controller**
Power switch on the Controller. Turns on the Controller and provides power to the robot.

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

**Optical Proximity Sensors**
Robot sensors which measure visible or invisible light reflected from an object to determine distance. Lasers are used for greater accuracy.

**Orientation**
The angle formed by the major axis of an object relative to a reference axis. It must be defined relative to a three dimensional coordinate system. Angular position of an object with respect to the robot’s reference system. See "Roll", "Pitch" and "Yaw".

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

P

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 [Teach 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.

Pendant Teaching
The mapping and recording of the position and orientation of a robot and/or Manipulator system as the robot is manually moved in increments from an initial state along a path to a final goal state. The position and orientation of each critical point (joints, robot base, etc.) is recorded and stored in a database for each taught position the robot passes through on its path toward its final goal. The robot may now repeat the path on its own by following the path stored in the database.

Performance Level d (PLd)
ISO Performance Level (PL) “d” means that the average probability of dangerous failure per hour of the safety related parts of the control system falls within = 10^-7 to < 10^-6. Additionally, other factors such as proper installation, maintenance and protection against environmental factors also apply. This is the minimum performance level specified in ISO 10218-2 section 5.2.2, unless a risk assessment would allow a lower value to be used.
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Manipulator

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

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

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

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

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

Play Mode
After a robot is programmed in Teach Mode, the robot 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.

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.
Appendix A Glossary

**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.

**Power and Force Limiting (PFL)**
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 determine if any additional safeguarding is necessary to mitigate risks within the robot system.

**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.
Appendix A Glossary

Q

**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.

Q

**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

R

**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".
Appendix A Glossary

R

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 teach pendant). During this mode, the use of the teach pendant is disabled.

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

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

Revolute Joint
The joints of a robot, which are capable of rotary motion.

Risk Assessment
The process of evaluating the intended use of a machine or system for foreseeable hazards and then determining the level of risk involved for the tasks identified.

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

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

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 “Cylindrical Topology” 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.
Appendix A Glossary

S

**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 YASKAWA robot 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" and "Servo-system".
Appendix A Glossary

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".

Shipping Brackets
A collection of parts used as a back-up safety assembly to the motor brake. Locks the robot in place during transport.

Shipping Skid
A custom-made platform used to ship the Manipulator and the Controller. It is included with the shipping assembly.

Shock Detection Function
Shock detection is a function supported by the YASKAWA robot 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.

Shoulder
The first or second axis of a robot is sometimes referred to as a shoulder axis as it somewhat resembles a human shoulder. This is often used in describing humanoid or dual-arm systems such as the YASKAWA Motoman® SDA10D.

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.

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
Appendix A Glossary

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 which may be parabolic in shape. A spline motion may also accomplish a free form curve with mixtures of circular and parabolic shapes.

System Integrator
See "Integrator".

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 robot Controller mode in which a robot Manipulator is programmed by manually guiding it through a series of motions and recording the position in the robot 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
A hand-held control box, which is used by an operator to remotely guide a robot through the motions of its tasks. The motions are recorded by the robot control system for future playback. Modern industrial robots come with Programming Pendants, which not only allow robot teaching, but also support full feature robot programming and safety user interface.
Appendix A Glossary

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 robot arm, such as a hand, gripper, welding torch, screwdriver, etc. See "Arm", "Gripper" and "End-effector".

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

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

Tool Against Tool
Interference is checked by using a cylinder that is slightly larger than the arm or tool. A sphere is placed on both ends of the cylinder. If the cylinder and spheres of one Manipulator have any contact with those of the other while moving, the Manipulators stop because interference was detected.

Tool Center Point (TCP)
The Tool Center Point (TCP) defines the tip of the current tool as defined relative to the tool flange. For example, for a welding robot, the TCP will generally be defined at the tip of the welding gun. After defining and configuring the TCP, the robot motion will be defined relative to this frame (i.e., rotation in the Rx direction would cause rotation around the X-axis and positions will be taught in this frame).

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

Tool Coordinates
When the tool attached to the robot 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 robot (relative to the base frame).
Appendix A Glossary

**Manipulator**

**Touch Sensor**
Sensing device, sometimes used with the robot's hand or gripper, which senses physical contact with an object, thus giving the robot an artificial sense of touch. The sensors respond to contact forces that arise between themselves and solid objects.

**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 robot's control system.

**Uptime**
A period of time in which a robot or production line is operating or available to operate, as opposed to downtime.

**User Coordinate Setting**
User coordinates are defined by three points that have been taught to the Manipulator through axis operations. These three defining points are ORG, XX, and XY, as shown in the diagram below. These three points of positional data are registered in a user coordinate file. ORG is the home position, and XX is a point on the X-axis. XY is a point on the Y-axis side of the user coordinates that has been taught, and the directions of Y- and Z-axes are determined by point XY.

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

**Vacuum Cup Hand**
An end-effector for a robot arm which is used to grasp light to moderate weight objects, using suction, for manipulation. Such objects may include glass, plastic; etc. Commonly used because of its virtues of reduced object slide slipping while within the grasp of the vacuum cup. See "End-effector".

**Vision Guided**
Control system where the trajectory of the robot is altered in response to input from a vision system.

**Vision Sensor**
A sensor that identifies the shape, location, orientation, or dimensions of an object through visual feedback, such as a television camera.
Warning
Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury. Hazards identified by the signal word WARNING present a lesser degree of risk of injury or death than those identified by the signal word DANGER.

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

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

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

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

Workspace
The volume of space within which the robot can perform given tasks.

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

World Model
A three dimensional representation of the robot's work environment, including objects and their position and orientation in this environment, which is stored in robot memory. As objects are sensed within the environment the robot's 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 robot 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 "Arm", "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

Zeroing Kit
Hardware and sensor mounted to robot. Automatically restores the home position data for the Manipulator.
MOTOMAN-MH900
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