ArcWorld® 50/50S and 52/52S
SYSTEM MANUAL

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

For Your Safety

Robots generally have requirements which are different from other manufacturing equipment, such as larger working areas, high-speed operation, rapid arm movements, etc., which can pose safety hazards.

Read and understand the instruction manuals and related documents, and observe all precautions in order to avoid the risk of injury to personnel and damage to equipment.

Carelessness contributes to serious accidents in the work area.

It is the user’s responsibility to ensure that all local, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions are met and followed.

DANGER

• Teaching, operations, and maintenance of the Robot must conform to:
  – Industrial Safety and Health Law
  – Order for Enforcement of the Industrial Safety and Health Law
  – Industrial Safety and Health Regulations
  – Technical Standards for Electrical Facilities

Other related laws and regulations are:
  – Occupational Safety and Health Act in USA
  – Factory Act (Gewerbeordnung) in Germany
  – Health and Safety at Work, etc. Act in UK
  – EC Machinery Directive 2006/42/EC

• Prepare:
  – SAFETY WORK REGULATIONS
    based on concrete policies for safety management complying with related laws and regulations.

• Observe:
  – JIS B 8433-1: 2015 “Robots for industrial environments-Safety requirements” (ISO 10218-1: 2011) for safe operation of the robot. (JIS B 8433 is for Japan only)

• Reinforce:
  – SAFETY MANAGEMENT SYSTEM
    by designating authorized operators and safety managers for the Robot, as well as giving continuing safety education and training.

• Teaching, operation, and maintenance of the Robot are specified as “Hazardous Operations” in the Industrial Safety and Health Act (for Japan only).
  Personnel engaged in these operations must receive special training offered by YASKAWA.
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.

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.

DANGER

• Personnel engaged in operation, maintenance, or management of the Robot must receive required training before using the Robot. For more information on training, contact Customer Support.

• Make sure to have and follow all manuals, read them thoroughly and understand the contents of them.

Confirm that you have all required manuals. If any of the manuals are missing, contact Customer Support.

• Read and understand these instructions thoroughly before installing, operating, or maintaining the Robot.

Any matter not described in this manual must be regarded as “prohibited” or “improper”.

WARNING

• Safe operation of this equipment is the user’s 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.

Not following all national codes, safety standards and local codes can result in death or serious injury

• 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

Not providing additional safety measures as required can result in death or serious injury.

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

If safety equipment does not operate properly death or serious injury can result.

CAUTION

• Only trained personnel familiar with the operation, manuals, electrical design, and interconnections of this equipment should program, or maintain the system.

Any personnel involved with the operation of the equipment must understand potential dangers of operation.

NOTICE

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

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

• Some operations require standard passwords and while others require special passwords.

• If a manual is damaged or lost, contact Customer Support to order a new copy. Make sure to tell Customer Support the Part Number listed on the front cover.
Notes for Safe Operation

Read this manual carefully before installing, operating, maintaining, or inspecting the system.

In this instruction, Safe Operations are classified as “DANGER”, “WARNING”, “CAUTION” or “NOTICE”.

- **DANGER**: Indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury.

- **WARNING**: Indicates a potentially hazardous situation which, if not avoided, MAY result in death or serious injury.

- **CAUTION**: Indicates a hazardous situation, which if not avoided, MAY result in minor to moderate injury.

- **CAUTION**: Indicates a situation which if not avoided may result in equipment damage.

- **NOTICE**: Indicates practices not related to personal injury.

**NOTICE**

To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as “DANGER”, “WARNING” or “CAUTION”.
**ArcWorld Explanation of Safety Labels**

The following labels are attached to the ArcWorld. Always follow these safety labels.

*Fig. : ArcWorld Label Locations*

1. **Collaborative Motion Label**
   
   Collaboration is a special type of operation between a person and Robot sharing a common workspace.

2. **Robot Labels**
   
   Refer to Robot Documentation for details.
183574-1CD

ArcWorld 50/50S and 52/52S

Safety
ArcWorld Explanation of Safety Labels

3 High Voltage Label

This label indicates that hazardous voltages are present and there is a danger of getting electrical shock.

4 Controller Labels

Refer to Controller Documentation for details.

5 Power Supply Labels

Refer to Manufacturer’s Power Supply Documentation for details.

6 Fuse Use Label

CAUTION
TO REDUCE THE RISK OF FIRE, REPLACE ONLY WITH FUSES OF SAME TYPE AND RATING

This label advises to replace fuses with the same type and rating.

7 Manipulator and Controller Same Order Number

This label is a reminder when installing the ArcWorld to make sure that the Manipulator and Controller have the same Order Number.

8 Arc Flash Hazard Label

WARNING
Arc Flash Hazard
Appropriate PPE Required
Do not operate controls or open covers without appropriate personal protective equipment. Failure to comply may result in injury or death.

This label is supplied to inform to use appropriate personal protective equipment.
Safety
ArcWorld Explanation of Safety Labels

⑨ Securely Lock Door Latches

![Label Image]

This label is supplied to remind users to have doors securely latched before applying power.

⑩ High Voltage Lockout/Tagout

![Label Image]

Use a device to ensure that power remains off while repairs or adjustments are being made.
Installation and Wiring Safety

Review the Robot and Controller Instructions for details on installation and wiring.

In planning installation, adapt an easy to observe arrangement to ensure safety. Take safety into consideration when planning the installation. Observe the following when installing the Robot:

**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 motion of the Robot's arm.
- Any person who programs, teaches, operates, maintains or repairs the included system MUST be trained and demonstrates competence to safely perform assigned tasks.
  Failure to observe these safety precautions may result in death or serious injury from unexpected movements.

**WARNING**

- Run the piping, wiring, and cables for the Controller, Robot, Positioner control panel, peripheral devices, etc. in a pit so that they are not stepped on by personnel or run over by a forklift.

Failure to observe this Warning may cause personnel to trip over exposed piping, wiring, or a cables, which may result in personal injury. Additionally it may also cause damage to piping, wiring, or cables, and unexpected movement of the Robot, which may result in personal injury and/or equipment damage.
CAUTION

- Make sure all covers and shields are installed correctly before operating.
  - Some drawings in this manual may have protective covers or shields removed to show details.

Not having all covers and shields installed correctly can result in injury.

- When installing the Robot system, avoid interference with buildings, structures, utilities, other machines.

Not avoiding these items may create trapping or pinch points.

- Do not make unauthorized modifications.

Unauthorized modifications can result in injury or equipment damage and will void the warranty.

- Inspect:
  - For problems with movement
  - Damages to external wires

Repair any problems immediately and perform all necessary procedures. If problems are not repaired or procedures are not fixed unexpected results can occur causing injury.

NOTICE

- If supplying a supplementary audible means for Robot operation, it shall exceed the ambient noise at the end-use of the application.

- Any changes or additions to the applicable information as provided by the manufacturer is to be provided by the party that makes the change or addition to the Robot system
Ensure Safety

**DANGER**

- When the power supplies of the Robot and Controller are turned ON at start-up, be sure to confirm the following:
  - Safety protection devices such as the E-STOP circuit, door interlocks, etc. operate normally.
  - Each axis operates normally in TEACH mode.
  - Robot operates normally at the speed limit or less in the TEACH mode. (Speed limit: 250 mm/s at the TCP or the flange)
  - The teaching function and the playback function operate normally.
- The Robot may stop movements while waiting for a condition to be satisfied during operation. Once meeting the condition, the Robot starts movement causing a danger that will cause death or severe injury.
- Make sure to clearly indicate when the Robot is in operation:
  - Use a pilot lamp and/or an audible alert or
  - The Robot stops operation if the operator comes close.
- Install a safety fence around the Robot to prevent any accidental contact with the Robot when power is applied.
  - Display a warning sign stating “Off-Limits During Operation” at the entrance of the safety fence.
  - The gate of the safety fence must be equipped with a safety interlock to turn the servo power OFF when the gate opens.
  - Make sure interlocks operate properly before use.
- For areas not enclosed by safety fences, use a photoelectric sensor, a safety light curtain, etc. to make sure that the Robot stops its operation if the operator enters its operating range.

Failure to observe this Danger notice will result in death or serious injury due to contact with the Robot.
All personnel working with the Robot (safety administration, installation, operation, and maintenance personnel) must always be prepared and “Safety First” minded, to ensure the safety of all personnel.

**WARNING**

- In the vicinity of the area where the Robot is installed, avoid any dangerous actions, such as entering the Robot's operating range without due care.

Failure to observe this instruction may cause contact with the Robot or peripheral equipment, which may result in death or serious injury.

- Strictly observe the safety precautions and signs in the factory, such as “Flammable”, “High Voltage”, “Danger”, “Off-limits to Unauthorized Personnel”.

Failure to observe this instruction may result in death or serious injury do to fire, electric shock, caused by contact with the Robot or other equipment.

- Strictly observe the following precautions about clothing:
  - Always wear approved work clothes (no loose-fitting clothes).
  - To prevent mis-operation, do not wear gloves when operating the Robot.
  - Do not allow underwear, shirts, or neckties hang out from the work clothes.
  - Do not wear accessories, such as earrings, rings, or necklaces.
  - Always wear protective safety equipment, such as hard hats, safety shoes (with slip-proof soles), face shields, safety glasses, and gloves as necessary.

Failure to observe this instruction may result in death or serious injury.

- The following must be understood and strictly observed by all personnel as rules:
  - Unauthorized personnel other than the operator must not approach the area where the Robot is installed.

Failure to observe this instruction may cause contact with the Robot, Controller, control panel, workpiece, or Positioner, etc., may result in death or serious injury.
**WARNING**

- Turn OFF servo power before operating.
  - Press the EMERGENCY STOP button to turn off SERVO POWER. When servo power is OFF, the SERVO ON LED on the Programming Pendant is OFF.

If the EMERGENCY STOP button(s) do not work correctly, death or serious injury may result. Do not use if the EMERGENCY STOP button does not perform correctly.

*Fig. : EMERGENCY STOP Button*

- Clear the cell of all items which could interfere with the operation before releasing the EMERGENCY STOP button.

Death or serious injury may result from unintentional or unexpected motion.

*Fig. : Release of EMERGENCY STOP Button*

- Make sure no person is in the operating range and the operator is in a safe location before:
  - Turning ON power to the Controller
  - Moving the Robot with the Programming Pendant
  - Running the system in the TEACH mode
  - Performing automatic operations

Death or serious injury may result if a person enters the operating range during operation. Immediately press an EMERGENCY STOP button whenever there is a problem.
CAUTION

- All operators, programmers, maintenance personnel, supervisors, and anyone working near the system must be 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:
  - Place system in E-STOP mode whenever it is not in use.
  - Use lockout/tagout procedures during equipment maintenance in accordance with ANSI/RIA R15.06-2012, section 4.2.5, Sources of Energy. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).
  - Only trained personnel familiar with the operation of this equipment, the operator's manuals, the system equipment, and options and accessories can operate equipment.

Improper operation can result in personal injury and/or damage to the equipment.

- If the light in the operator's working space is not bright enough, provide the space with appropriate lighting.

CAUTION

- Store industrial tools, etc. in a safe location outside the Robot's operating range.

If an industrial tool, etc. is left unattended on the Robot, on a fixture, or on the floor, etc., the Robot may come in contact with the industrial tool left unattended, which may result in damage to the Robot and/or the fixture.
Operation Safety

**DANGER**

- Personnel engaged in teaching or inspection, etc. of the Robot must receive special training required by applicable laws and regulations.

- While performing inspection and maintenance, wiring, or attaching a tool to the Robot, etc., make sure to turn OFF the power supply of the Controller and the tool, and keep the switch of the power supply locked so that unauthorized personnel cannot turn ON the power supply.

In addition, display a warning sign stating “Energizing Prohibited”.

Turning ON the power supply without due care during inspection and maintenance, etc., may cause electric shock or unexpected movement of the Robot, which may result in personal injury.

- Use the Robot only within the specifications described in the manuals for the Robot.

Failure to observe this instruction may result in personal injury and/or equipment damage.

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

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

- Before operating the Robot, make sure the servo power is turned OFF by performing the following operations. When the servo power is turned OFF, the SERVO ON LED on the Programming Pendant is turned OFF.
  - Press the EMERGENCY STOP buttons on the front door of the Controller, on the Programming Pendant, on the external control device, etc.
  - Disconnect the safety plug of the safety fence. (when in the PLAY mode or REMOTE mode)

If operation of the Robot cannot be stopped in an emergency, personal injury and/or equipment damage may result.

- Make sure that all safety protection devices are activated before starting a job in the PLAY mode.
- Confirm that no person is present in the Robot's operating range and that the operator is in a safe location before:
  - Turning ON the Controller
  - Moving the Robot by using the Programming Pendant
  - Running the system in the TEACH mode
  - Performing automatic operations

Personal injury may result if a person enters the Robot's operating range during operation

- Immediately press an EMERGENCY STOP button whenever there is a problem.
WARNING

• Read “Safety” of the Controller instructions before operating.
  Not reading and understanding chapter 1 of the Controller instruction can result in death or serious injury.

• Read and understand all Warning Labels before operating.
  Not reading and understanding all Warning Labels can result in death or serious injury.

• Confirm that no person is present in the P-point maximum envelope of the Robot before:
  – Turning on the power for the Controller.
  – Moving the Robot with the Programming Pendant.
  – Running the system in the TEACH mode.
  – Performing automatic operations.

  Injury may result if anyone enters the working envelope of the Robot during operation. Always press an EMERGENCY STOP button immediately if there are problems.

• Observe the following when performing teaching operation within the operating range:
  – Lockout by putting a lockout device on the safety fence when going into the area enclosed by the safety fence.
  – Display a sign that operations are being performed so no other person closes the safety fence.
  – View from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Always keep in mind emergency response measures against unexpected movement toward a person.
  – Ensure a safe place to retreat in case of emergency.

  Failure to observe this precautions may cause improper or unintended movement, which may result in personal injury.

• Maintenance and inspection must be performed by specified personnel.

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

• Contact Customer Support for disassembly or repairs.

  Not contacting Customer Support can result in electrical shock or injury.
Robot Cells have Collaborative Motion functionality:

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

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

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

---

CAUTION

- Do not operate the Robot when a [COOLING FAN2 ERROR] appears on the Programming Pendant.

If operation continues with a warning message, equipment damage can occur.

- During high speed continuous operation Robot temperature may rise quickly depending on ambient temperature and operation pattern.

If a warning message displays stop operations or equipment damage may occur.

- Monitor warning messages on the Programming Pendant.

Not monitoring warning messages may cause equipment damage.

- Refer to the Controller Concurrent I/O manual for details on the signal output.

Not referring to Controller Concurrent I/O manual can result in equipment damage.
Maintenance Safety

WARNING

• Make sure equipment has no potentially hazardous conditions.
  – area is clean and free of water, oil, debris, etc.
  – all safeguards are in place.
  – all safety equipment work correctly. Repair or replace any non-functioning safety equipment immediately.
  – Check the EMERGENCY STOP button(s) for proper operation before programming. The equipment must be in E-STOP mode when not in use.

If a hazardous condition is present death or serious injury may occur.

• Use care when modifying software.
  – The equipment allows modifications to the software for maximum performance.

All modifications made to the software will change the way the equipment operates and may cause death or serious injury, as well as damage parts of the system.

• Make sure all modifications did not make create a hazardous or dangerous condition in all modes.

All modifications made to the software will change the way the equipment operates and may cause death or serious injury, as well as damage parts of the system.

• Disconnect and lockout/tagout all sources of energy before making modifications or connections.

Not disconnecting and doing lockout/tagout of all sources of energy can result in death or serious injury.

• Read and understand all maintenance procedures before completing procedures.

Not reading and understanding maintenance procedure may result in death or serious injury.
Safety
Notes for Moving and Transferring the Robot

CAUTION

• Do not modify the Controller.
  Making modifications without written permission from YASKAWA will void the warranty.

• 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.

• Use proper replacement parts only.
  Not using proper replacement parts can cause damage to equipment.

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

Notes for Moving and Transferring the Robot

DANGER

• When relocating, transferring, or selling the Robot, make sure that the Robot is always accompanied by its manuals so that all users have access to necessary manuals.
  See the Bill of Material for a list of the manuals.

  If any of them is missing, contact Customer Support. The telephone numbers of our offices are listed on the back cover of this manual.

• If a warning label on the Robot or the Controller is dirty and unreadable, clean the label to make it clearly readable. If a warning label has come off, put the label back in place. Note that some local laws and regulations may prohibit equipment operation if safety labels are not in place.
  Contact Customer Support if you require new warning labels.

• After the Robot is relocated, inspection by Customer Support is recommended.
  If installation or wiring of a device is incorrect, personal injury and/or equipment damage may result.
## Definition of Terms Used Often in This Manual

The Robot is the YASKAWA industrial robot product.

The Robot usually consists of a Robot, Controller, Programming Pendant, and 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>YRC1000 controller</td>
<td>Controller</td>
</tr>
<tr>
<td>YRC1000 Programming Pendant</td>
<td>Programming Pendant</td>
</tr>
<tr>
<td>ArcWorld 50/50S and 52/52S Manipulator</td>
<td>Robot</td>
</tr>
<tr>
<td>Cable between the Robot and the Controller</td>
<td>Robot cable</td>
</tr>
<tr>
<td>Positioner</td>
<td>Positioner</td>
</tr>
</tbody>
</table>

Descriptions of the Programming Pendant keys, buttons, and displays are shown as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Pendant</td>
<td>Character Keys /Symbol Keys: The keys which have characters or symbols printed on them are denoted with [ ]. e.g. [ENTER]</td>
</tr>
<tr>
<td></td>
<td>Axis Keys /Numeric Keys: [Axis Key] and [Numeric Key] are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td></td>
<td>Keys pressed simultaneously: When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them, e.g. [SHIFT]+[COORD].</td>
</tr>
<tr>
<td></td>
<td>Mode Switch: Mode Switch can select three kinds of modes that are denoted as follows: REMOTE, PLAY or TEACH. (The switch names are denoted as symbols)</td>
</tr>
<tr>
<td></td>
<td>Button: The three buttons on the upper side of the Programming Pendant are denoted as follows: START, HOLD, or EMERGENCY STOP. (The button names are denoted as symbols)</td>
</tr>
<tr>
<td></td>
<td>Displays: The menu displayed in the Programming Pendant is denoted with { }. e.g. {JOB}</td>
</tr>
</tbody>
</table>
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 ® and TM are omitted.
Robot Disposal

**WARNING**

- Take precautionary measures to prevent the Robot from overturning, such as anchoring it firmly, etc., even when temporarily storing it before disposal.

Failure to observe this instruction may cause overturning of the Robot, which may result in personal injury.

**CAUTION**

- Do not modify the Robot or the Controller

Failure to observe this instruction can cause fire, mechanical failure, or malfunction, which may result in personal injury and/or equipment damage.

**NOTICE**

- When disposing of or recycling the Robot, follow the applicable national/local laws and regulations.
- This symbol is applicable in some locations.

The wheelie bin symbol on this product, manual or its packaging indicates that at the end of life the product should enter the recycling system. It must be disposed at an appropriate collection point for electrical and electronic equipment (EEE) and should not be put in the normal waste stream.
# Table of Contents

1 Introduction ..................................................................................................................................... 1-1

1.1 About This Document ........................................................................................................ 1-1

1.2 System Overview ............................................................................................................... 1-3

1.3 System Layout ................................................................................................................... 1-5

1.3.1 Robot Cell Assembly ............................................................................................ 1-5

1.3.2 Controller Base Assembly .................................................................................... 1-6

1.3.3 Optional Equipment .............................................................................................. 1-7

1.4 System Overview and Variations ....................................................................................... 1-9

1.4.1 System Teaching ................................................................................................ 1-10

1.4.2 System Operation ............................................................................................... 1-11

1.4.3 Key Safety Devices ............................................................................................ 1-13

1.4.3.1 Controller with a FSU: ........................................................................... 1-13

1.4.3.2 Safety Gate Interlock - tongue type: mechanical (qty 2): ...................... 1-13

1.4.3.3 One Operator Station per Workstation:................................................. 1-13

1.4.4 Safety Logic Implementation (all cells): .............................................................. 1-14

1.4.4.1 TEACH/PLAY mode .............................................................................. 1-14

1.4.4.2 TEACH mode ........................................................................................ 1-14

1.4.4.3 PLAY mode ........................................................................................... 1-15

1.5 Reference Documentation ............................................................................................... 1-22

1.6 Reference Table .............................................................................................................. 1-23

1.7 Customer Support Information ......................................................................................... 1-26

1.8 Quick Start Guide ............................................................................................................ 1-27

2 Equipment Description .................................................................................................................... 2-1

2.1 Robot Description .............................................................................................................. 2-1

2.2 Controller ........................................................................................................................... 2-1

2.2.1 Programming Pendant.......................................................................................... 2-2

2.3 Operator Station ................................................................................................................ 2-4

2.3.1 Operator Station — CYCLE START/CYCLE LATCHED .................................. 2-4

2.3.2 Operator Station — EMERGENCY STOP ....................................................... 2-5

2.3.3 Operator Station — POSITIONER AUTO/MANUAL .................................. 2-5

2.4 Work Stations .................................................................................................................... 2-6

2.4.1 Stationary Weld Tables ...................................................................................... 2-6

2.4.2 MH185 Headstock (ArcWorld 50S/52S Only) .................................................. 2-6
# Table of Contents

2.5 Welding Equipment............................................................................................................2-7
  2.5.1 Welding Power Sources .......................................................................................2-7
  2.5.2 Wire Feeder..........................................................................................................2-7
  2.5.3 GMAW Torch........................................................................................................2-7

2.6 Safety Features..................................................................................................................2-8
  2.6.1 Welding Arc Protection .........................................................................................2-8
  2.6.2 Safety Fencing (Standard)....................................................................................2-8
    2.6.2.1 Safety Fencing (Option) ...........................................................................2-8
  2.6.3 Emergency Stop (E-STOP) ..................................................................................2-9
  2.6.4 Programming Pendant's Enable Device ...............................................................2-9
  2.6.5 Emergency Braking System .................................................................................2-9
  2.6.6 Interlocked Work-cell Access Door.......................................................................2-9

3 Installation.......................................................................................................................................3-1

  3.1 Required Materials.............................................................................................................3-1
    3.1.1 Customer-supplied Items......................................................................................3-1
    3.1.2 Recommended List of Hand Tools and Equipment..................................................3-2

  3.2 Site Preparation .................................................................................................................3-3

  3.3 Removal of System Components from Shipping Skids .....................................................3-8

  3.4 Installing the System Components ....................................................................................3-9
    3.4.1 Door Latch Alignment .........................................................................................3-10
    3.4.2 Installing the Arc Curtains...................................................................................3-11
    3.4.3 Installing the Auxiliary Equipment.......................................................................3-11

  3.5 Cable Connections...........................................................................................................3-12
    3.5.1 Connection to Earth Ground ..................................................................................3-12
    3.5.2 Connection to Local Electrical Service ................................................................3-13
      3.5.2.1 Controller........................................................................................................3-14
      3.5.2.2 Welding Power Source ..................................................................................3-14

  3.6 Safety/Operation Check...................................................................................................3-15

  3.7 Installation of Tooling and Fixtures ..................................................................................3-16
# Table of Contents

4 Operation ........................................................................................................................................ 4-1

4.1 Programming ..................................................................................................................... 4-1

4.2 Daily Operation .................................................................................................................. 4-2

4.2.1 Start-up Procedure ............................................................................................... 4-2

4.2.2 Robot HOME Position .......................................................................................... 4-2

4.2.3 Control Master Job ............................................................................................... 4-3

4.2.4 Operation Cycle .................................................................................................... 4-3

4.2.5 Shutdown ............................................................................................................. 4-4

4.3 System Recovery............................................................................................................... 4-5

4.3.1 Alarms and Errors................................................................................................. 4-5

4.3.1.1 Error Messages....................................................................................... 4-5

4.3.1.2 Minor Alarms ........................................................................................... 4-5

4.3.1.3 Major Alarms ........................................................................................... 4-5

4.3.2 E-STOP Recovery ................................................................................................ 4-6

4.3.3 Shock Sensor Recovery....................................................................................... 4-6

5 Maintenance ................................................................................................................................... 5-1

6 Alarms and Messages .................................................................................................................... 6-1

6.1 Alarms Based on Barrier Door Operation ........................................................................... 6-1

6.2 Alarms Based on Functional Safety Unit Conditions ......................................................... 6-2

6.3 Cell Messages ................................................................................................................... 6-3

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

7.1 Robot Spare Parts ............................................................................................................. 7-1

7.2 Positioner Spare Parts ....................................................................................................... 7-1

7.3 ArcWorld Door Spare Parts ............................................................................................... 7-2

Appendix A .......................................................................................................................................A-1

A.1 Checklist............................................................................................................................A-1

Appendix B .......................................................................................................................................B-1

B.1 Glossary ............................................................................................................................B-1
1 Introduction

The ArcWorld is part of the YASKAWA family of standardized arc welding solutions. It is a fully integrated welding system, and is supported from wire to weld by YASKAWA.

1.1 About This Document

This system manual provides a “first look” and overview of the complete ArcWorld. Read and understand this manual before moving on to the more detailed documentation that is included with the ArcWorld. Although basic in content, this manual is intended for personnel who have received operator training from YASKAWA and are familiar with the operation of this particular system. For more detailed information on any specific component or peripheral, review the full documentation package that is included (refer to section 1.5).

NOTICE

This manual documents a standard system. If the system is custom or modified, use this manual in conjunction with the drawings, schematics, and part listings (Bill of Material) for the specific system. The drawings, schematics, and parts listing are included in the documentation package supplied with the system.

This system manual contains the following sections:

Chapter 1 “Introduction”

This section provides general information about the ArcWorld, a list of reference documents, and customer support contact information.

Chapter 2 “Equipment Description”

This section provides a description of the major components of the ArcWorld.

Chapter 3 “Installation”

This section provides installation procedures for the ArcWorld.

Chapter 4 “Operation”

This section provides an overview of ArcWorld operation, including start-up, loading, normal operations, fault recovery, and system shutdown.

Chapter 5 “Maintenance”

This section provides preventive maintenance requirements for certain components of the ArcWorld system.

Chapter 6 “Alarms and Messages”

This section contains information on alarms that are generated by the Controller ladder.
Chapter 7 “Spare Parts”

This section gives a list of recommended spare parts.

Appendix A

This Appendix includes a checklist for start-up and after maintenance.

Appendix B

This Appendix is a glossary of definitions used in the industry.
1.2 System Overview

The ArcWorld provides a complete arc-welding solution in a standardized configuration (see Fig. 1.3). The system is designed around a Robot, Controller, welding power source, and one or two work stations, Station 1 and/or Station 2.

<table>
<thead>
<tr>
<th>Table 1-1: ArcWorld General Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller</td>
</tr>
<tr>
<td>Robot</td>
</tr>
<tr>
<td>Work Stations</td>
</tr>
<tr>
<td>Positioner</td>
</tr>
<tr>
<td>Stationary Tables</td>
</tr>
<tr>
<td>Fencing</td>
</tr>
<tr>
<td>Access Doors</td>
</tr>
<tr>
<td>Safety Barrier Doors</td>
</tr>
<tr>
<td>Approximate Weight of ArcWorld Cell Assembly</td>
</tr>
<tr>
<td>Dimensions of ArcWorld Cell Assembly</td>
</tr>
<tr>
<td>Input Voltages</td>
</tr>
<tr>
<td>Phases</td>
</tr>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Full Load Current</td>
</tr>
<tr>
<td>Amp Rating of Largest Motor</td>
</tr>
<tr>
<td>Short Circuit Current Rating</td>
</tr>
<tr>
<td>External Axis Speed in TEACH Mode</td>
</tr>
</tbody>
</table>

a) The approximate weight does not account for any optional equipment. Refer to the appropriate equipment manual for additional weights.

The ArcWorld features a total safety environment that meets or exceeds the requirements of the ANSI/RIA R15.06-2012 Robot Safety standard and is designed to safeguard both personnel and equipment. Heavy-gauge, wire-mesh safety fencing prevents unintended entry of personnel into the work cell while it is in operation. Arc curtains cover the wire-mesh fencing to decrease the amount of arc radiation that escapes the work cell during welding operations. Two dual-channel access doors, one on each side of the cell, allow convenient access to equipment while providing a safety interlock to disable all equipment should either access door be opened while the Robot is active.
Each station also includes a heavy duty, motor driven safety barrier located in front of each station to protect the operator from weld flash or other debris and prevents entry into the Robot work area during Robot operation. Robot travel is limited by the Functional Safety Unit.

Safeguards for the system complement the operation while protecting people that will program, operate, and/or provide maintenance. Possible hazards from the risk assessment process determines needed safeguards and interlocks. While the system design safeguards the support staff, it does not protect against misuse. Misuse of the system includes, but is not limited to, climbing over/under barriers, climbing over/under interlocked doors, or disabling/bypassing system interlocks.

During the installation and commissioning process the end user must ensure tooling and other equipment do not cause additional hazards. This evaluation ensures that the system will provide safe and reliable operation. The Risk Assessment document should be reviewed before installation of the system and prior to operation. Any changes and additions to the system require a full review of the Risk Assessment document.
1.3 System Layout

The ArcWorld has two main assemblies: the Robot cell assembly and the Controller base assembly.

1.3.1 Robot Cell Assembly

The Robot cell assembly is fully enclosed by safety fencing and interlocking doors. The interlocking barrier doors allow the operator to load parts at one station while the Robot is welding at the other station. The Functional Safety Unit (FSU) supplies logic for providing a safety zone that prevents the Robot from entering an open/occupied station.

Fig. 1-1: Robot Cell Assembly

The Robot cell assembly includes the following major components (see Fig. 1-1 for location):

- Robot
- One or two Barrier Doors/work stations
- Headstock drive assemblies (Positioner) (AW50S and AW52S only)
- One or two Operator Stations
- Welding Equipment:
  - Welding torch
  - Wire feeder
  - Torch mounts
- Safety Fencing
  - Heavy-gauge, wire-mesh safety fencing (Optional solid panels available)
  - Arc curtains (covers the safety fencing)
- Two interlocked Work-Cell Access Doors
1.3.2 Controller Base Assembly

The Controller Base Assembly includes the Top Hat and Interface, Control Enclosure Assembly, Controller, Accessories/Air Panel, Welding Power Supply, optional Transformer, and a Power Distribution Enclosure. (see Fig. 1.2 for the location of these components).

Fig. 1-2: Controller Base Assembly

- Top Hat and Interface
  - FSU Relay Board
  - Power Distribution Terminals
  - Eight port Ethernet Switch
  - Machine Safety Board
  - External Axis Connection(s)
  - Master Fuse Module

- Control Enclosure Assembly

- YRC1000 Controller

- Accessories/Air Panel
  - Pneumatic Filter/Regulator
  - Air Manifold
  - Valve Assemblies
  - Weld Accessories
  - 110V GFCI Receptacle (Optional)

- Welding Power Supply

- Transformer (Optional)
1.3.3 Optional Equipment

The following optional equipment is available for the ArcWorld:

- **Stationary Tables: (AW50 and AW52 Only)**
  This table provides a place to position parts.

- **Torch Cleaner**
  This stand-alone device uses a pneumatic motor with a reamer to clean the torch nozzle.

- **Wire Cutter**
  Automatically cuts welding wire to a desired length. A programmed path brings the welding wire into the cutter jaw. Using a Robot output signal, the pneumatic device will shear off the wire, leaving a clean edge at the programmed stick-out length. A specific length of wire is used for touch sensing on the Robot system.

- **Water-cooled Torch (with water circulator)**
  Reduces torch temperature and prevents the system from overheating.

- **TouchSense™**
  The Touch Sensing function enables the Robot to find the welding joint.

- **ComArc™**
  Seam tracking functions by weaving the welding wire in the joint and sensing the current at each stroke of the weaving motion. If the detected current at each stroke is not the same, the Robot will correct its path in a direction required to make the current the same.

- **Digital Gas Flow Gauge**
  Provides a readout and diagnostic for the shielding gas to confirm if flow is present. This sends a digital signal to the Controller to trigger an alarm when detecting a low flow.

- **Beacon Light**
  Visual indicator of cell status and audible alert if an alarm occurs. Colors indicate status conditions. Fence or post mounting is available for most cells and typically is located in the front of the cell, near the operator stations.

- **Tip Change Request (Buttons only, no box)**
  This is a standalone “Operator Station” with the buttons and indicators to complement the tip change process. This is available for compact cells where the Robot can move towards access or station door to allow the operator to access the torch to do the tip change.

- **Enabling Device for Second Cell Occupant**
  Enabling device with holster allows additional personnel to enter the workcell.

- **Wire Spool Mount**
  A bracket and cover to support cabling and mounting of a 30 lb spool to the Robot. Also provided is conduit between the spool and wirefeeder.

- **Wire Delivery Kit for Bulk Wire**
  This kit includes brackets and conduit to attach to a customer provided bulk spool.
1 Introduction
1.3 System Layout

- **No Wire Sensor**
  Provides feedback from each wire conduit/delivery system when there is no wire present.

- **Exhaust Hood**
  Ideal solution for capturing fumes before they can spread throughout a facility, and ensuring regulatory compliance.

  YASKAWA has worked with RoboVent to provide pre-engineered customized hoods that match each ArcWorld. Specific ventilation requirements require discussions with RoboVent.
1.4 System Overview and Variations

The ArcWorld cell is designed to accommodate a single Robot and includes one or two part loading stations which are guarded by up/down barrier doors.

- ArcWorld 50, ArcWorld 52
  - Each station will be empty or an optional flat table can be added.
  (The customer will supply their own fixtures in either case.)

- ArcWorld 50S, ArcWorld 52S
  - Each station includes a Positioner.

The cell is designed for arc welding applications where the Controller and a welding power source are located in the Controller base assembly. The cell has an interlocked door to allow access for teaching and adjustments when it is not in operation. Each of the work stations includes a physical barrier with a dual channel interlock to determine when the door is fully closed.

Each work station includes an operator station with a [Cycle Start] push button, “Auto/Manual” selector switch, and an EMERGENCY STOP button. The operator stations are normally installed on the right side of each work station.

Access to either station is guarded by a barrier door. When the barrier door is open, the Robot is restricted from entering the corresponding station through logic in the FSU. Additionally, if a Positioner is included at that station, then “stand still monitoring” using the Axis Speed Monitor function will be active. This will create an E-STOP condition if any headstock motion occurs.

*Fig. 1-3: ArcWorld*
1.4.1 System Teaching

**WARNING**

- Review the Risk Assessment prior to any interactions with the Work-Cell.

Failure to observe this warning may result in death or serious injury.

All systems are programmable by entering the interlocked work-cell access doors on either side of the cell or by viewing inside the cell from the exterior, through an open barrier door.

1. Set the mode switch on the Programming Pendant to TEACH.

**NOTICE**

Placing the mode switch in the TEACH position limits all Robot and external axes speeds to 250 mm/sec and allows the position of the Interlocked Work-Cell Access Door to be open or closed.

**CAUTION**

- Avoid trip hazards (cables or other structures within the cell) while programming.

Not avoiding trip hazards may result in minor to moderate injury.

2. Turn Robot servo motors on by pressing and holding the “Enable Device” on the Programming Pendant.

3. Set the mode switch to PLAY when done with teaching.
1.4.2 System Operation

**WARNING**

- Check all programs, safety functions, and cell interactions before operating in an automatic operation.

Failure to observe this warning may result in death or serious injury.

Place the ArcWorld into automatic operation by completing the following:

1. Close the interlocked work-cell access door.
2. Select the {MASTER} job on the Programming Pendant.
3. Press the [SERVO ON] button on the Programming Pendant.
4. From the Main Menu choose {JOB} then {AUTO}.
5. Press the [START] button on the Programming Pendant to begin the execution of the {MASTER} job.

Normal cell production begins with the assumption that the Robot is in the home position. FSU Zones and Axis Range Limits ensure that the Robot operates in areas that are clear of potential human presence.

- If the cell is an ArcWorld 50S or ArcWorld 52S:
  When a station is open (or not fully closed) the dual channel safety switch in the barrier door reports this condition to the FSU which puts the system into “Standstill Monitoring” mode. This prevents the headstock at the corresponding station from moving.

  - If motion of the headstock is detected the entire system will go into an E-STOP condition and can only be recovered after the source of the fault is addressed.
  - If the Robot enters a station that is open while in PLAY mode, the entire cell goes into an E-STOP condition. Recovery from this E-STOP condition can be done by closing the barrier door (via I/O or cycle start button) or changing to TEACH mode and jogging the Robot out of this station.

- If anything obstructs the movement of the door, a barrier door control fault occurs and triggers a Controller alarm.
When pressing the [Cycle Start] button, successful door closure latches this station in for queuing of work. The Robot will approach this station immediately if no work is currently being performed.

- If work is occurring in the other station, the "Cycle Start Latched" light will illuminate green. It will turn off once the cycle begins. Assuming there are no faults or issues during the production of the part, the Robot will return to a safe position when the cycle is complete.

The Robot's MASTER job waits for cycle start inputs and will call jobs based on the [Cycle Start] button pressed. This job also controls the frequency of torch cleaning if that option is included in the cell.

The CLEAN job can only be called while the station 1 barrier door remains closed.
1.4.3 Key Safety Devices

1.4.3.1 Controller with a FSU:

- Dual channel Programming Pendant EMERGENCY STOP button
- Dual channel Programming Pendant “Enable Device”
- “TEACH/PLAY” mode input to FSU
  - Logic mapped from Machine Safety to FSU.
- Functional Safety Unit (FSU) - one per Robot
  - Limits Robot access as follows:
    - Complete perimeter access granted in TEACH mode.
    - Three axis limits are defined per Robot depending on barrier door status in PLAY mode.
      - Station 1 valid/allowed (barrier door 2 not closed)
      - Station 2 valid/allowed (barrier door 1 not closed)
      - Allowed in only rear of cell (barrier door 1 and 2 not closed).
    - If AW50S or AW52S - the FSU manages when the external axes in the system are in “Standstill Monitoring” based on the barrier door open status inputs
      - Station 1’s Positioner must be stationary if Station 1’s barrier door is not fully closed
      - Station 2’s Positioner must be stationary if Station 2’s barrier door is not fully closed

1.4.3.2 Safety Gate Interlock - tongue type: mechanical (qty 2):

- Dual channel dry contact outputs

1.4.3.3 One Operator Station per Workstation:

- Green “CYCLE START/CYCLE LATCHED” button/light - single channel with illumination
- Black “AUTO/MANUAL” selector switch - single channel
- Red “EMERGENCY STOP” button - dual channel with illumination
1.4.4 Safety Logic Implementation (all cells):

1.4.4.1 TEACH/PLAY mode

Disabling the FSU function can be difficult, especially when the Robot violates a defined Robot range or some other corrective action needs to be taken. Disabling the FSU function requires the “Safety mode” password. Then all of those functions have to be re-enabled before PLAY mode production can begin. To eliminate these issues and expedite the steps to a remedy, PLAY mode status is a condition for many of the FSU files, while changing to TEACH mode will let a user quickly escape the violating condition. **Putting the system in TEACH mode is often a first step to bypass or recover from many of the FSU’s monitoring functions.** The next thing to do is to move the Robot or barrier door into a condition that allows the cell to resume operation safely.

In TEACH mode, the Robot is limited to motions within the cell. This perimeter definition is in a Range Limiting file to match the cell fencing.

1.4.4.2 TEACH mode

In TEACH mode a “R1 Teach Zone” has been established for the purpose of ensuring that the Robot remains within the confines of the work cell. Since TEACH mode is already limiting the speed to 250 mm/sec, no additional safeguards will be taken. In TEACH mode, “Standstill Monitoring” on the headstock(s) is also disabled so that the programmer can jog and teach the Positioners.

*Fig. 1-4: Teach Zone - Access within Perimeter of Safe Guards (Fence and Doors)*
1.4.4.3 PLAY mode

In PLAY mode, a combination of FSU-based “Robot Range Limiting” and “Stop Position Monitoring” ensures safe operation of the cell.

The FSU-based “Stop Position Monitoring” function is used to ensure that the appropriate headstock remains stationary in PLAY mode anytime the barrier door at the corresponding station is open or not fully closed. The Robot is also restricted from entering the station until the barrier door at the station is closed. This Robot motion restriction is enforced by the “Robot Range Limit” function.

Also in PLAY mode, the Controller monitors that the Safety Gate is closed, ensuring that someone is not accessing the work cell. The Safety Gate dual contacts are wired directly into the Machine Safety Unit's dedicated inputs.

- Robot 1 - Robot Range Limit Files
  - Robot Range Limits: Five zones define the Robot's access. Using FSU logic these zones prevent or grant access to the Robot based on TEACH/PLAY conditions and barrier door status.

**NOTICE**

Some numeric values in the screen shots that follow may not represent actual values for your system. The general shape and theory of operation remain constant. Consult YASKAWA for specific system configurations.
1 Introduction
1.4 System Overview and Variations

– Robot Range Settings:
  
  • Zone 1 - Teach access allowed. Door position does not matter. Access doors can be open. Positioner can be rotated.
  
  • Zone 2 - Access Allowed when both Station 1 and 2 barrier doors are open.
• **Zone 3** - Station 1 Access Allowed when Station 2 barrier door is open. (Station 1 closed).

• **Zone 4** - Station 2 Access Allowed when Station 1 barrier door is open. (Station 2 closed).
• Zone 5 - Access allowed when Station 1 and 2 are closed.

• Axis Speed Monitor (Stop Monitor) Files: (ArcWorld 52S only)
  – Axis Speed Monitor Files Used (aka Standstill Monitoring):
    Always enabled. Results are evaluated in the safety logic circuit
- **Station#1 Stopped**: Headstock in Station 1 has motion monitored to 0.2 degrees of motion (allows some variance when installing parts / fixture.)

- **Station#2 Stopped**: Headstock in Station 2 has motion monitored to 0.2 degrees of motion (allows some variance when installing parts / fixture.)
1 Introduction
1.4 System Overview and Variations

• Safety Logic Circuit:
  – 52S shown

<table>
<thead>
<tr>
<th>Input</th>
<th>Logic</th>
<th>Output</th>
<th>Timer</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>H terminated</td>
<td>01</td>
<td>MG-OUT1</td>
<td>Station 1 Door</td>
</tr>
<tr>
<td>002</td>
<td>H terminated</td>
<td>02</td>
<td>MG-OUT2</td>
<td>Station 2 Door</td>
</tr>
<tr>
<td>003</td>
<td>PLA2</td>
<td>03</td>
<td>MG-OUT3</td>
<td>IN PLAY MODE</td>
</tr>
<tr>
<td>004</td>
<td>PRES</td>
<td>AND</td>
<td>E3ESP</td>
<td>R020</td>
</tr>
<tr>
<td>005</td>
<td>R021</td>
<td>AND</td>
<td>W3-OUT1</td>
<td>R021</td>
</tr>
<tr>
<td>006</td>
<td>R022</td>
<td>AND</td>
<td>R022</td>
<td>R022</td>
</tr>
<tr>
<td>007</td>
<td>R023</td>
<td>AND</td>
<td>R023</td>
<td>R023</td>
</tr>
<tr>
<td>008</td>
<td>R024</td>
<td>AND</td>
<td>R024</td>
<td>R024</td>
</tr>
<tr>
<td>009</td>
<td>R025</td>
<td>AND</td>
<td>R025</td>
<td>R025</td>
</tr>
<tr>
<td>010</td>
<td>R026</td>
<td>AND</td>
<td>R026</td>
<td>R026</td>
</tr>
<tr>
<td>011</td>
<td>R027</td>
<td>AND</td>
<td>R027</td>
<td>R027</td>
</tr>
<tr>
<td>012</td>
<td>R028</td>
<td>AND</td>
<td>R028</td>
<td>R028</td>
</tr>
<tr>
<td>013</td>
<td>R029</td>
<td>AND</td>
<td>R029</td>
<td>R029</td>
</tr>
<tr>
<td>014</td>
<td>R030</td>
<td>AND</td>
<td>R030</td>
<td>R030</td>
</tr>
<tr>
<td>015</td>
<td>R031</td>
<td>AND</td>
<td>R031</td>
<td>R031</td>
</tr>
<tr>
<td>016</td>
<td>R032</td>
<td>AND</td>
<td>R032</td>
<td>R032</td>
</tr>
</tbody>
</table>

• Tooling Power Outputs
  – The FSU breakout card is configured with logic to control tooling power at Station 1 and Station 2. The tooling power outputs will be energized in these conditions:
    • Any EMERGENCY STOP button is NOT pressed
    • Corresponding barrier door is fully closed (door is determined to be completely down with safety sensor detecting this condition)

  – Safety Logic Circuit Ext Signal Allocation (AW52S Shown)
1 Introduction

1.4 System Overview and Variations

- Safety Logic Circuit Signal Display Setup
1.5 Reference Documentation

For additional information on individual components of the ArcWorld 50/50S/52/52S system, refer to the following documentation that is included with the system:

- AR1440 Manipulator Manual (P/N 178958-1CD)
- AR1440 Manipulator Maintenance Manual (P/N 179319-1CD)
- Brake Release Manual (P/N 179330-1CD)
- YRC1000 Read First!! Safety Requirements (P/N 179526-1CD)
- YRC1000 Controller Instructions (P/N 178642-1CD)
- YRC1000 General Operator’s Manual (P/N 178645-1CD)
- YRC1000 Maintenance Manual (P/N 178643-1CD)
- YRC1000 Alarm Codes Manual (P/N 178644-1CD)
- Operator’s Manual for Arc Welding (P/N 178646-1CD)
- Concurrent I/O Manual (P/N 178648-1CD)
- MH(T)-Series SIGMA-5 Positioner Manual (P/N 168961-1CD)
- YRC1000 TCP Function (P/N 178668-1CD)
- YRC1000 Independent/Coordinated Control Function Manual (P/N 178660-1CD)
- INFORM User’s Manual (P/N 178649-1CD)
- Functional Safety Operation Manual (P/N 178949-1CD)
- Motoman Lagging Supplement (186835-1CD)
- Vendor manuals for system components not manufactured by YASKAWA
## 1.6 Reference Table

The table below provides location(s) for various operations.

Table 1-2: Reference Table

<table>
<thead>
<tr>
<th>Description</th>
<th>Manual/Chapter</th>
<th>Handling</th>
<th>Installation &amp; Commissioning</th>
<th>Start-up</th>
<th>System Information</th>
<th>Use of System</th>
<th>Maintenance</th>
<th>Decommissioning</th>
<th>Emergency Situations</th>
<th>Robot Specific Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Information</td>
<td>Manipulator &amp; Controller Chap 3, Positioner Chap 2</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass Value(s)</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center of Gravity, Lifting</td>
<td>Positioner &amp; Manipulator Chap 2</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Anchoring</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Vibration Dampening</td>
<td>Positioner Chap 2, Manipulator Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly &amp; Mounting Condition</td>
<td>Positioner Chap 2, Manipulator Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Needed for Maintenance</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Connecting Power</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Waste Removal</td>
<td>Controller Chap 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective Measures by Users</td>
<td>Throughout Manuals</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Initial Checks</td>
<td>ArcWorld Chap 3 &amp; 4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of system, fittings, and protective devices</td>
<td>ArcWorld Chap 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of Applications</td>
<td>ArcWorld Chap 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Function Perform Correctly</td>
<td>ArcWorld Chap 3 &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controller Functions, Operator Panels, Programming Pendants and Enabling Devices</td>
<td>ArcWorld Chap 2 &amp; 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawings and Diagrams</td>
<td>Throughout Manuals and Included Outside Manuals</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazards and Measuring Methods</td>
<td>Throughout Manuals</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Technical Documents concerning Electrical Equipment</td>
<td>Included Outside Manuals</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Documents of Complying with Mandatory Requirements</td>
<td>Included Outside Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Modifications Made to Protective Equipment</td>
<td>Drawings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Analysis</td>
<td>Documents Included</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Energy Loss, Human Interventions</td>
<td>ArcWorld Chap 2 &amp; 4</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
### 1.6 Reference Table

<table>
<thead>
<tr>
<th>Description</th>
<th>Manual/Chapter</th>
<th>Handling</th>
<th>Installation &amp; Commissioning</th>
<th>Start-up</th>
<th>System Information</th>
<th>Use of System</th>
<th>Maintenance</th>
<th>Decommissioning</th>
<th>Emergency Situations</th>
<th>Robot Specific Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance and Intended Life</td>
<td>ArcWorld Chap 5</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface Requirements</td>
<td>ArcWorld Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic Limiting Zones</td>
<td>ArcWorld Chap 2 &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Risks that Can Not be Eliminated</td>
<td>Throughout Manuals</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Risks with Certain Applications</td>
<td>Throughout Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreseeable Misuse</td>
<td>Throughout Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Flow</td>
<td>Manipulator Chap 4</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intended Use</td>
<td>ArcWorld Chap 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Residual Risk for Various Tasks</td>
<td>Throughout Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span of Control</td>
<td>ArcWorld Chap 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Description of Manual Controls</td>
<td>ArcWorld Chap 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settings and Adjustments</td>
<td>ArcWorld Chap 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Modes and Means for Stopping</td>
<td>ArcWorld Chap 2 &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fault ID, Repair, and Restarting</td>
<td>ArcWorld Chap 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Personal Protective Equipment</td>
<td>Throughout Manuals</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Test and Examination After Changing Components</td>
<td>ArcWorld Chap 3 &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Instructions for Disconnecting Pendants</td>
<td>Controller Chap 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Instructions for Fault and Emergency Recovery</td>
<td>ArcWorld Chap 4 &amp; 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Training Requirements</td>
<td>ArcWorld Chap 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Drawings and Diagrams allowing Maintenance Carry Out Task</td>
<td>Throughout Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information to Replace Safety Devices</td>
<td>ArcWorld Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Contact Information</td>
<td>ArcWorld Chap 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dismantling</td>
<td>Manipulator Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Emergency Situations</td>
<td>ArcWorld Chap 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Raising and Lowering Speed Using Pendant</td>
<td>Controller Chap 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Information on Limiting Device</td>
<td>ArcWorld Chap 2 &amp; 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Information on Operating and Enabling Devices</td>
<td>ArcWorld Chap 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Description</td>
<td>Manual/Chapter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopping Time and Distance</td>
<td>Drawings; Positioner Chap 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specifications for Fluids</td>
<td>Manipulator Chap 9, Positioner Chap 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limits for Range of Motion</td>
<td>ArcWorld Chap 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relevant Standards</td>
<td>Included Outside Manuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction on Synchronized Motion</td>
<td>ArcWorld Chap 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programmed Limits</td>
<td>Controller Chap 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robot Suitable for Integration</td>
<td>Documents Included</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- ✔ = Included
- ✓ = Reference
1.7 Customer Support Information

If assistance is needed with any aspect of the ArcWorld 50/50S/52/52S system, please contact Customer Support at the following 24-hour telephone number:

(937) 847-3200

For routine technical inquiries, Customer Support can be contacted at the following e-mail address:

techsupport@motoman.com

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

NOTICE

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

Please have the following information ready before calling:

- System
  - ArcWorld 50/50S/52/52S

- Robot
  - AR1440

- Positioner (AW 50S or 52S only)
  - MH185

- Primary Application
  - Arc Welding

- Controller
  - YRC1000

- 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
1 Introduction

1.8 Quick Start Guide

WARNING

Anyone working with the ArcWorld is responsible for reading and understanding all included documents. This Quick Start Guide is just a basic outline of the setup of the ArcWorld.

<table>
<thead>
<tr>
<th>PHASE 1</th>
<th>PREPARATION (PRE-ARRIVAL)</th>
<th>Preliminary Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ArcWorld System Manual Sec 2.6, 3, 3.1</td>
<td>ISO 10218-2:2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 2</th>
<th>RECEIVE ARCWORLD CELL</th>
<th>PREPARE FOR POWER CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controller Inst. Sec. 3.1</td>
<td>ArcWorld System Manual Chap 3.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 3</th>
<th>INSTALL ARCWORLD CELL</th>
<th>MOUNTING SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controller Inst. Sec. 3.1</td>
<td>ArcWorld System Manual Sec 3.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 4</th>
<th>SYSTEM VERIFICATION</th>
<th>TOOLING SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controller Read First Alarm</td>
<td>Controller Inst. Sec 5.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 5</th>
<th>INSTALL AND VERIFY ARC WELDING TOOLS</th>
<th>COMPRESSED AIR SUPPLY (IF USED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May be provided with the system - Customer Specific</td>
<td>Controller Inst. Sec 2.6, 3, 3.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRAINING</th>
<th>CONTACT YASKAWA Academy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phone: 937-347-3307</td>
</tr>
<tr>
<td></td>
<td>Email: <a href="mailto:training@motoman.com">training@motoman.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 5</th>
<th>INSTALL AND VERIFY ARC WELDING TOOLS</th>
<th>CONFIRM RISK ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May be provided with the system - Customer Specific</td>
<td>ArcWorld System Manual Sec 2.6, 3, 3.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 5</th>
<th>INSTALL AND VERIFY ARC WELDING TOOLS</th>
<th>COMPRESSED AIR SUPPLY (IF USED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May be provided with the system - Customer Specific</td>
<td>ISO 10218-2:2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 5</th>
<th>INSTALL AND VERIFY ARC WELDING TOOLS</th>
<th>COMPRESSED AIR SUPPLY (IF USED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May be provided with the system - Customer Specific</td>
<td>ANSI/RIA 15.06-2012</td>
</tr>
</tbody>
</table>

1-27
### PHASE 6
**TEST OPERATION OF BARRIER DOORS**

<table>
<thead>
<tr>
<th>SET TO TEACH MODE TOGGLE CYCLE START STATION 1</th>
<th>SET TO TEACH MODE TOGGLE CYCLE START STATION 2 (52 OR 52S ONLY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcWorld System Manual Sec 1.3, 2.3, 2.6.3</td>
<td>ArcWorld System Manual Sec 1.3, 2.3, 2.6.3</td>
</tr>
</tbody>
</table>

### PHASE 7
**TEST OPERATION OF THE CELL**

<table>
<thead>
<tr>
<th>STEP THROUGH PROVIDED MASTER JOB</th>
<th>CREATE NEW JOB &amp; TEACH POINTS</th>
<th>TEST &amp; CHECK STEPS</th>
<th>PLAYBACK JOB</th>
<th>STOP JOB</th>
<th>RUN MASTER JOB</th>
</tr>
</thead>
</table>

- Controller Operator's Manual Sec 1.1.1
- Controller Operator's Manual Sec 1.1.3
- Controller Operator's Manual Sec 1.1.2
- Controller General Operator's Manual Sec 4.3
- Controller General Operator's Manual Chap 4
- Controller General Operator's Manual Sec 3.3
- ArcWorld System Manual Sec 1.3.2, 2.3, 4.2
2 Equipment Description

2.1 Robot Description

The ArcWorld 50/50S/52/52S system includes an AR1440 six-axis Robot. This Robot is specifically designed for arc-welding applications. The Robot has a payload capacity of 12 kg, a horizontal reach of 1430 mm (56.30in.) and a relative positioning accuracy of ±0.06 mm.

The AR1440 Robot has an internal cabling design that provides high flexibility and streamlines its profile, thus allowing access into confined spaces. The Robot's B-axis (Pitch/Yaw) features an expanded range of motion that improves circumferential welding on cylindrical work pieces. The T-axis (Twist) can rotate the welding torch ±210 degrees without cable interference.

The Robot’s S-axis rotation is physically limited by hard stops located in the base. For more information, refer to the Robot Manual that came with the ArcWorld documentation package (see section 1.5).

2.2 Controller

The Controller, shown in Fig. 2-1, features a Windows® CE Programming Pendant with a color touch screen, high-speed processing, built-in Ethernet, and robust PC architecture. The Controller easily handles multiple tasks and can control up to 72 axes, (including Robots and external axes) and input/output (I/O) devices. Advanced Robot Motion (ARM) control provides high-performance path accuracy and vibration control.

The Controller coordinates the operation of the ArcWorld. It controls the Robot movement, processes input and output signals, and provides the signals to operate the welding system.

For more information on the Controller, refer to the Controller Manual that is included with the ArcWorld documentation package (see section 1.5).

Figure 2-1: Controller
2.2.1 Programming Pendant

The Programming Pendant (see Fig. 2-2) is the primary means for programmer/operator interaction with the ArcWorld. The pendant features a Windows® CE operating system and displays information on a 640 X 480 pixels color LCD touch-screen. It also incorporates a SD card slot and USB port for program backups.

The Programming Pendant provides icon-driven system programming. It features a menu-driven interface to simplify operator interaction with the Robot. Most operator controls are located on the Programming Pendant. This allows remote installation of the Controller. By using the Programming Pendant, the operator can teach the Robot’s motion, perform programming, editing, maintenance, and diagnostic functions, and enable or disable Operator Station control of the ArcWorld. For more detailed information on the pendant’s programming keys, programming and display functions, refer to the Operator’s Manual for Arc Welding that is included with the ArcWorld documentation package (see section 1.5).

Figure 2-2: Programming Pendant

![Programming Pendant Diagram]

- **Start button**
- **Hold button**
- **Mode switch**
- **EMERGENCY STOP Button**
- **SD card slot**
- **PAGE key**
- **USB connector**
- **SELECT key**
- **Cursor key**
- **Axis keys**
- **Manual speed keys**
- **Enable Device**
  - Located on the back of the programming pendant.
  - Lightly squeeze this switch to turn the power ON.
  - Firmly squeeze this switch to turn the power OFF.
- **ENTER key**
- **MOTION TYPE key**
- **Numeric keys / Function keys**
  - Press these keys to enter numbers.
  - These keys are also used as function keys.
  - When inputting instructions, etc., these keys are automatically switched from numeric keys to function keys.
2 Equipment Description

2.2 Controller

NOTICE

- The Programming Pendant’s LCD display goes dark after a few minutes of inactivity. Press any key to restore the screen.
- Placing the Programming Pendant’s mode switch to REMOTE transfers control of the ArcWorld to the Operator Station.
- Refer to the Programming Pendant instructions for more details.
2.3 Operator Station

The Operator Station (see Fig. 2-3) is located on the front right post (AW50/50S) and right and left posts (AW52/52S).

See Fig. 1.3 for the location of the Operator Stations in relation to the other components of the ArcWorld. The following paragraphs describe the controls on the Operator Stations.

To enable the operator station turn the Programming Pendant mode switch to REMOTE.

Figure 2-3: Operator Station

2.3.1 Operator Station — CYCLE START/CYCLE LATCHED

CAUTION

- Do not alter the Control Master job.

Altering the Control Master job may result in minor to moderate injury or damage to the equipment.

The operation of the [CYCLE START/CYCLE LATCHED] button is dependent on the structure of the Control Master job. The green [CYCLE START/CYCLE LATCHED] button initiates a job cycle when the robot is in HOME position. If the [CYCLE START/CYCLE LATCHED] button is pressed while the robot is outside HOME position, the Cycle Start command does not execute until the robot returns to HOME position.

The “CYCLE LATCHED” lamp illuminates when the [CYCLE START/CYCLE LATCHED] button is pressed during operation. When the lamp is illuminated, the Positioner will sweep and the robot will begin to weld immediately after the current job cycle is complete. It is not necessary to wait for the robot to finish welding and return to HOME position before pressing the [CYCLE START/CYCLE LATCHED] button. Pressing this button while the robot is still in motion latches the Cycle Start command into the controller.
2.3.2 Operator Station — EMERGENCY STOP

Pressing the Operator Station’s EMERGENCY STOP button initiates an E-STOP condition. Refer to section 2.6.3 for information on the E-STOP condition and the procedures for recovering from it.

2.3.3 Operator Station — POSITIONER AUTO/MANUAL

The POSITIONER AUTO/MANUAL selector switch is used to select automatic or manual mode for the Positioner. When the selector switch is in the AUTO position, the Robot welds parts immediately after the barrier door closes. In MANUAL mode, the Positioner rotates, but the Robot does not weld parts - this mode is useful to verify that the door operation is occurring properly.

NOTICE

The POSITIONER AUTO/MANUAL command depends upon the structure of the Control Master job.
2.4 Work Stations

Each ArcWorld 50 Series work cell comes with support posts for either weld table or MH-series headstock mounting. Table 2-3 shows the optional weld tables and headstocks available for each work cell. YASKAWA does not supply weld tables with any standard cell.

Table 2-3: Work Cell Options

<table>
<thead>
<tr>
<th>System</th>
<th>Weld Table</th>
<th>MH-series Headstock</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcWorld 50</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>ArcWorld 50S</td>
<td>NA</td>
<td>1</td>
</tr>
<tr>
<td>ArcWorld 52</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>ArcWorld 52S</td>
<td>NA</td>
<td>2</td>
</tr>
</tbody>
</table>

2.4.1 Stationary Weld Tables

Optional weld tables are available to secure production parts using customer-supplied tooling fixtures. See Table 2-4.

Table 2-4: Weld Table Specifications

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Fixture Rating</td>
<td>Each optional table can support up to 300 kg.</td>
</tr>
<tr>
<td>Weld Current Rating</td>
<td>600 amperes at 100% duty cycle</td>
</tr>
</tbody>
</table>

NOTICE

In high humidity areas, the weld table tooling plates may rust or corrode. Use surface protection to prevent corrosion of unpainted tooling surfaces.

2.4.2 MH185 Headstock (ArcWorld 50S/52S Only)

The MH185 Headstock drive assembly provides precision-controlled rotary motion and can be mounted in any orientation. The standard configuration utilizes an AC servo motor, a high-ratio gear reducer with integral output bearing, faceplate, and a cast iron housing. Each Headstock also includes one weld ground brush rated at 400 amps. An optional second brush is available.

For detailed Positioner specifications for the MH185 headstock, including a parts lists breakdown, refer to the MH-series Positioner Manual with MotoMount and Drive Assemblies (see section 1.5 “Reference Documentation” on page 1-22”).

NOTICE

In high humidity areas, use surface protection to prevent corrosion of the tooling plates.
2.5 Welding Equipment

In its standard configuration, the ArcWorld includes a welding power source, wire feeder, torch, and torch mount for the Robot. Other optional equipment may also be included with the ArcWorld (refer to section 1.3.3).

2.5.1 Welding Power Sources

YASKAWA offers various brands and types of welding power sources. The welding power source supplied with the ArcWorld depends on the customer’s specific application and preference. For information on the welding power source supplied with the ArcWorld, refer to the welding power source manual that is included with the system documentation package (see section 1.5).

2.5.2 Wire Feeder

Welding systems typically include a wire feeder. YASKAWA mounts it on the robot’s upper arm. Most wire feeders also have an electronically controlled gas valve that provides features such as purge, pre-flow and post-flow. Interchangeable feed rolls are used to accommodate different wire gauges and types. For additional information on how the wire feeder is mounted to the Robot’s upper arm, including allowable load and installation position, refer to the wire feeder documentation that is included with the ArcWorld documentation package (see section 1.5).

2.5.3 GMAW Torch

The ArcWorld uses either an air-cooled or water-cooled Robot-specific GMAW torch. These are heavy-duty torches designed for quick replacement with a minimum of Robot reprogramming. The GMAW torch is installed in a mount at the end of the Robot’s wrist flange. The torch mount provides multi-dimensional impact (collision) detection to protect the Robot, torch, fixture, Positioner, and work piece from damage in the event of a collision. Any collision triggers an E-STOP condition (refer to section 4.3.2).

For applications that use the optional water-cooled torch, the ArcWorld includes a water circulator kit. For additional information on the torches that are supplied with the system, refer to the vendor documentation that is included with the documentation package (see section 1.5).
2.6 Safety Features

The ArcWorld 50 Series system includes a total safety environment. When all standard safety precautions are taken, the equipment helps to ensure safe operation of the robotic cell. The ANSI/RIA R15.06-2012 Robot Safety Standard stipulates that the user is responsible for safeguarding.

**NOTICE**

Users are responsible for determining whether the provided safeguards are adequate for plant conditions. Users must also ensure that all safeguards are maintained in working order.

2.6.1 Welding Arc Protection

**DANGER**

- Never look directly at the welding arc without protective eye wear.

Although safety fence arc curtains block the radiation of ultraviolet light, looking directly at the welding arc without protective eye wear can cause severe eye damage or blindness.

One by-product of the welding arc is an intense level of ultraviolet light. The ultraviolet light radiates outward in all directions from the weld point whenever an arc is established. If not attenuated, the radiated ultraviolet light can present a health risk to personnel near the welding arc.

The arc curtains block most of the ultraviolet light radiation that escapes the work cell and protects other personnel who are nearby.

2.6.2 Safety Fencing (Standard)

The heavy-gauge, welded wire safety fencing that is provided with the ArcWorld encloses the entire work cell. It forms a physical barrier that prevents personnel from entering the work area during automatic operation.

2.6.2.1 Safety Fencing (Option)

The cell can also be configured with solid panel fencing as an upgrade. This will block more of the ultraviolet light radiation that could escape from the work environment and also forms a physical barrier that prevents personnel from entering the work area during automatic operation.
2.6.3 Emergency Stop (E-STOP)

E-STOP is a primary safety feature of the ArcWorld. A work-cell access door interlock, Robot welding torch impact (collision) detection circuitry (refer to section 2.5.3), and [EMERGENCY STOP] buttons can trigger an E-STOP condition. An E-STOP condition immediately de-energizes the control system and activates the Robot emergency braking system (refer to section 2.6.5). The [EMERGENCY STOP] buttons are used for an intentional shutdown of the ArcWorld and are installed at the following locations:

- Programming Pendant
- Operator Stations

To resume operation after an E-STOP condition shutdown, the operator must clear and reset the action that caused the E-STOP condition (refer to section 4.3.2).

2.6.4 Programming Pendant’s Enable Device

The Enable Device is part of the Programming Pendant and provides a safety feature that controls servo power while the system is in TEACH mode (see Fig. 2-2). When pressed in, this switch allows the operator to enable servo power. Should the operator release the switch or grasp it too tightly however, servo power is immediately disabled, thus preventing further Robot movement. For detailed information about the operation of the ENABLE Device, refer to the Controller Operator’s Manual for Arc Welding that is included with the documentation package (see section 1.5).

2.6.5 Emergency Braking System

The Robot incorporates a braking system that protects personnel from injury and prevents equipment damage if servo power is removed. Upon loss of servo power, the brake system activates to hold all Robot axes in place. The brake system has a feature that allows the operator to release the brake of a specific Robot axis, even if drive power is disabled. Brake release is accomplished with the Programming Pendant. Refer to the Manual Brake Release Manual included with the documentation package (see section 1.5).

2.6.6 Interlocked Work-cell Access Door

The work-cell access door features a safety interlock (see Fig. 1.3). Any attempt to open the access door while the Robots are in PLAY mode triggers an E-STOP condition (refer to section 2.6.3).
3 Installation

3.1 Required Materials

Two to three qualified technicians can install the ArcWorld in a reasonable amount of time. Always comply with all the safety instructions and precautions given throughout this manual.

The instructions given in this section are general guidelines for installing the ArcWorld system. Refer to the system drawings for more specific installation information.

### 3.1.1 Customer-supplied Items

- Shielding gas for the welding torches
- Local electrical service
- Earth ground wires for the Robot and the Controller assembly
- Earth ground rods and/or buried copper sheeting (quantity and placement depth as required to achieve specified resistance-to-ground reading of 100 ohms or less)
- Chemical (optional) to increase conductivity of soil in the vicinity of the earth ground system
- Welding wire
- Clean, dry air supply (for torch tender or wire cutter options):  
  - Flow Rate: 0.425 m³/min (15 cfm)  
  - Pressure: 620 kPa, gauge (90 psi, gauge)
- Forklift

---

**CAUTION**

- Only qualified personnel who are familiar with the installation and setup are to install the ArcWorld.
- Handle all system components with care.

The ArcWorld is not extremely fragile, but it is a sophisticated system that can be damaged by rough handling.

**NOTICE**

The customer must supply all anchoring hardware for the ArcWorld. Refer to the Motoman Lagging Supplement for suggestions for anchoring hardware and foundation specifications.
3 Installation
3.1 Required Materials

• Special anchor bolts and drill bits (refer to Motoman Lagging Supplement for suggested anchoring.)

3.1.2 Recommended List of Hand Tools and Equipment

• Safety glasses
• Face shield
• Gloves (heavy-duty leather recommended)
• Levels (short and long)
• Ratchet handle (with 3/4-inch hex socket)
• Adjustable wrenches (large and small)
• Hammer drill with appropriate concrete bits
• Phillips and flat-blade screwdrivers
• Hammers (dead-blow, steel, and non-marring)
• Socket sets (SAE and Metric)
• Air-impact gun (with 3/4-inch hex socket)
• Open-end wrench sets (SAE and metric)
• Hex key wrench sets (SAE and metric)
### 3.2 Site Preparation

**WARNING**

- During installation planning, allow sufficient room for access to the work-cell doors and system components that are exterior to the work cell.

Failure to observe this warning could result in injury to personnel during system operation and maintenance.

To prepare the site, proceed as follows:

1. Clear the floor and overhead space as needed for the ArcWorld (see Fig. 3-1(a) through Fig. 3-2(d). Allow an additional 1.2 m to 1.5 m on all sides of the work cell to provide the clearances needed for installation.

2. Gather all customer-supplied items and required tools (refer to section 3.1).

*Fig. 3-1(a): Plan View Overhead View (AW50 and AW50S)*
Fig. 3-1(b): Plan View Front View (AW50 and AW50S)

Fig. 3-1(c): Plan View P-Point Envelope (AW50 and AW50S)
Fig. 3-1(d): Plan View Positioner (AW50S)

Fig. 3-2(a): Plan View Overhead View (AW52 and AW52S)
3 Installation

3.2 Site Preparation

Fig. 3-2(b): Plan View Front View (AW52 and AW52S)

Fig. 3-2(c): Plan View P-Point Envelope (AW52 and AW52S)
3 Installation

3.2 Site Preparation

Fig. 3-2(d): Plan View Positioner (AW52S)

Fig. 3-3: ArcWorld Tables

ARCWORLD 50

ARCWORLD 50S

ARCWORLD 52

ARCWORLD 52S
3.3 Removal of System Components from Shipping Skids

The ArcWorld components are attached to wooden shipping skids at the factory, prior to shipment. The customer is responsible for removing the shipping skids and inspecting the components for shipping damage.

**NOTICE**

If there is any equipment damage, notify the shipping contractor as soon as possible.

1. Unbolt the ArcWorld components from the shipping skids using a 3/4-inch hex socket (see Fig. 3-4).

*Figure 3-4: Typical Stabilizing Screw and Removal of A Shipping Lag Bolt*

*NOTE* – An air-powered tool is not required for removal of the shipping bolts, as these fasteners can be removed with ordinary hand tools. However, the air-powered tool does make quick work of the task.

2. Discard or recycle the shipping skids and other shipping materials.
3.4 Installing the System Components

**WARNING**

- Make sure handling equipment can lift 340 kg (750 lbs), approximate weight of the Controller Base Assembly.

Injury to personnel and damage to equipment can occur if rating of handling equipment is not at least 340 kg (750 lbs).

1. Inspect cell, fence, Robot, torch, and associated components for shipping damage.

**NOTICE**

Notify the shipper immediately if there is any equipment damage.

Fig. 3-5: Cell Assembly

2. Place the cell assembly base and Controller base according to the system prints.

3. Attach all cables as shown in the system diagram.

4. Once components are correctly installed, anchor each component securely in place (refer to the Motoman Lagging Supplement for suggestions).
3.4.1 **Door Latch Alignment**

Adjust the location of the door latch as necessary to provide smooth operation of the door assembly. A #14 spanner bit is provided to loosen and adjust the location of the latch assembly. Shims can also be placed beneath the fence posts to make gross adjustments. See Fig. 3-6 for latch adjustments.

**NOTICE**

For Lockout/Tagout of the door interlock switch:

- insert supplied key into interlock switch.
- place lock on key.

*Fig. 3-6: Door Latch Alignment*
### 3.4.2 Installing the Arc Curtains

**WARNING**

- Do not install the arc curtains until the cell walls are secure. Unsecured cell walls can fall and injure personnel and damage equipment.

The arc curtains may be shipped in an accessories box. Unfold arc curtains and install one curtain on inside of each cell wall section.

### 3.4.3 Installing the Auxiliary Equipment

The Controller, welder, and main service disconnect are typically installed at the factory. However, if installation is required, proceed as follows:

1. Unbolt the auxiliary equipment from the shipping skid.
2. Carefully remove plastic wrapping and cardboard from Controller and welder.
3. Inspect for any shipping damage.

**WARNING**

- Make sure handling equipment can lift 150 kg (330 lbs), approximate weight of the Controller. Injury to personnel and damage to equipment can occur if rating of handling equipment is not at least 150 kg (330 lbs).

4. Using a forklift, lift the Controller and remove from shipping skid.
5. Using the system drawings, place the Controller and welder next to the cell.
6. Once components are correctly installed, anchor each component securely in place (refer to the Motoman Lagging Supplement for anchor suggestions).
3.5 Cable Connections

After components are level and securely in place, the cables should be unwrapped from around the equipment and installed according to the cable diagram included in the system drawing package. Each cable connection is clearly identified for ease of installation.

3.5.1 Connection to Earth Ground

### WARNING

Do not use the ArcWorld unless specified components are connected to a low-resistance earth ground. Do not connect the earth ground wire with the wires for the electric power source, welder, etc. The low-resistance earth ground must be a “dedicated” ground that is a direct connection between a component and the earth ground point.

Operator injury or death, as well as equipment damage, may result from an inadequate or defective earth ground system.

The Robot and Controller must be connected to a low-resistance earth ground. If a ground stake is used, it should be driven at least 2.43 m into the soil. The soil surrounding the ground stake should be treated with a chemical that increases the soil conductivity in the vicinity of the stake. This is often referred to as a “low-resistance earth ground” and may require more than a single driven ground rod, depending on soil conditions. Multiple ground rods (bonded together) or even a bonded network of buried copper sheeting (plus conduction-enhancing chemicals) may be required, depending on local soil conditions. In any event, the “low-resistance earth ground” must indicate a resistance of **100 ohms or less** (when measured directly between grounded equipment and the earth ground system). Be advised that specialized measuring equipment is usually required to get an accurate “resistance-to-ground” reading. Consult a specialist in this field, if required.

### NOTICE

The customer shall supply all wires associated with the earth ground. The customer is responsible for establishing the correct gauge of all wires associated with the earth ground and maintaining an adequate earth ground (measured resistance of 100 ohms or less).

Connect the Robots and Controller assembly to the earth ground as follows:

1. Connect one end of an earth ground wire to the lug marked EARTH GROUND on the connector panel of Robot R1. Connect the other end of the earth ground wire to the low-resistance earth ground.

See *Fig. 1-1 "Robot Cell Assembly" on page 1-5* for the location of Robot.
2. Connect one end of an earth ground wire to the COMMON GROUND BUS BAR located inside the Controller. Connect the other end of the earth ground wire to the low-resistance earth ground.

Fig. 3-7: Grounding Method

3.5.2 Connection to Local Electrical Service

**WARNING**

- Local electrical service connection to the ArcWorld must be performed by a qualified, licensed electrician.

Electrical and grounding connections must comply with the National Electrical Code (NEC), as well as all local electrical codes. Not complying with regulations may result in death or serious injury.

**NOTICE**

Unless otherwise noted, the ArcWorld system is configured for three-phase 480 VAC primary power. For additional information, refer to the electrical drawings and schematics that are included with the system documentation package (see section 1.5 “Reference Documentation” on page 1-22).

After all the system components have been properly installed, connect local electrical service to the Controller and welding power source (refer to section 3.5.2.1 and section 3.5.2.2).
3 Installation
3.5 Cable Connections

3.5.2.1 Controller
For detailed electrical service connection procedures for the Controller, refer to the Controller Manual and ArcWorld drawings and schematics that are included with the system documentation package (see section 1.5).

3.5.2.2 Welding Power Source
Refer to the welding power source documentation and ArcWorld drawings and schematics for electrical service connection procedures and diagrams for the welding power source.
3.6 Safety/Operation Check

Before installing the tooling and fixtures for the application, take a few minutes to perform the following safety/operation check:

1. Ensure that all shipping brackets and material are removed from the system.
2. Check the security and integrity of all cable connections.
3. Ensure that the work-cell sliding access doors close and the door interlocks engage properly.
4. Verify the correct settings for the welding power source (refer to the welding power source documentation that is included with the ArcWorld).
5. Verify that local electrical service complies with the power requirements for the ArcWorld system.
6. Verify that local electrical service is correctly wired into the Controller assembly and the welding power source (refer to section 3.5 “Cable Connections”).

7. Rotate the Controller main power switch to ON (see Fig. 2-1).

**CAUTION**

- Only qualified, trained personnel who are familiar with the ArcWorld should perform the power-up sequence.

Failure to comply with this CAUTION may result in injury to personnel and damage to equipment.

8. Check for correct operation of all EMERGENCY STOP buttons (refer to section 2.6.3).

**WARNING**

- Before operating the Robot, verify that each EMERGENCY STOP button disables servo power when activated (pushed in).
  - Each EMERGENCY STOP button must immediately stop the Robot and Positioner movement when activated.

If any of the EMERGENCY STOP buttons do not work correctly death or serious injury may occur.

9. Check for correct operation of the system HOLD button on the Programming Pendant. Refer to the Operator’s Manual for Arc Welding for more information on the pendant’s HOLD button (see section 1.5).

10. Check for correct action of the work-cell access door safety interlock.

11. Turn the Controller main power switch to OFF after completion of the safety/operation check.
3.7 Installation of Tooling and Fixtures

The ArcWorld is now ready for attachment of tooling fixtures to the table(s) or Positioner. YASKAWA recommends assigning this task to personnel who are familiar with the ArcWorld operation and setup. After installation of the tooling and fixtures, test the Positioner for correct operation. Refer to the Positioner manual for instructions on how to test the Positioner for correct operation (see section 1.5).

NOTICE

• The customer will supply all tooling and fixtures for the Positioner.
• YASKAWA recommends using a corrosion/rust preventive compound on tooling and fixtures located in a high-humidity environment.
4 Operation

4.1 Programming

This section provides a brief overview of the operating procedures and precautions for your ArcWorld 50 Series system. For more detailed operating information, refer to the specific component manuals that are part of the ArcWorld 50 Series system documentation package (see section 1.5 “Reference Documentation” on page 1-22).

The ArcWorld 50 system is a single station welding cell that uses an AR1440 robot to weld parts. When the robot completes the welding process, it returns to HOME (Safe) position. The operator then unloads the welded parts and loads new parts for processing. Once the new parts have been loaded and the door closed, the operator can initiate another cycle from the Operator Station.

The ArcWorld 52 is a two station welding cell. The ArcWorld 52 uses an AR1440 robot to weld parts on one station while the operator loads the other station with parts. When the robot completes the welding process, it returns to the HOME (Safe) position. The operator can then initiate another cycle from the Operator Station. This moves the robot to the next station, where the robot begins another welding cycle.

4.1 Programming

The operation of this system is programming dependent. The following operating instructions are based on one possible configuration of this system. The system configuration and job structure may differ slightly from that presented here however, basic operation will remain the same. For additional programming procedures and information, refer to the Controller documentation included with the ArcWorld system documentation package (see section 1.5).

Any changes made to the system configuration and/or job structure will alter the operation of the system. YASKAWA recommends not modifying the original jobs and system configuration of the ArcWorld. If it is determined that the original jobs or system configuration needs to be modified, make a backup first. Store the original backup in a known and safe location. Do not modify it. Modifications must be performed by trained and experienced personnel who are familiar with the operation of the ArcWorld. If there are any questions concerning the configuration of the system, please contact Customer Support (refer to section 1.7).
4 Operation

4.2 Daily Operation

The procedures below represent the typical operating sequence from power-up to shutdown. The basic operating procedures may vary depending on the situation.

- Perform the start-up procedure (see section 4.2.1).
- Move the Robot to HOME position (see section 4.2.2).
- Select the Control Master job (see section 4.2.3).
- Perform an operation cycle (see section 4.2.4).
- Perform the shutdown procedure (see section 4.2.5).

4.2.1 Start-up Procedure

To start up the ArcWorld cell from a power-off condition, proceed as follows:

1. Rotate the Controller’s main power ON-OFF switch to ON (Fig. 2-1).
2. Set the power ON-OFF switch on the welding power source to ON.
3. Open the regulator valve for the welding gas supply.
4. Make sure that the work-cell access doors are closed and operating properly and the door safety interlocks are engaged.
5. Make sure that all EMERGENCY STOP buttons are released. EMERGENCY STOP buttons are installed at the following locations:
   - Programming Pendant
   - Operator Station(s)
7. Place the Robot in HOME position (refer to section 4.2.2).

4.2.2 Robot HOME Position

To move the Robot to HOME position:

1. Select TEACH mode on the Programming Pendant.
2. Select MAIN MENU on the Programming Pendant’s touch screen.
4. Select {SELECT JOB} on the Programming Pendant’s touch screen (a job list appears on the screen).
5. Use the navigation cursor key to move the cursor to SAFE job and then press {SELECT} (the job appears on the display screen).
6. Turn servo power ON by pressing SERVO ON and holding the Enable Device in the center position.
7. Use the [FWD] button on the Programming Pendant to move the Robot to HOME position.
4.2 Daily Operation

4.2.3 Control Master Job

With the system powered up and in TEACH mode, call up the Control Master job:

1. Select {JOB} on the Programming Pendant’s touch screen.
2. Select {CTRL MASTER} on the Programming Pendant’s touch screen.
3. Press {SELECT} twice to activate the Control Master job.
4. On the Programming Pendant turn the mode switch to PLAY.
5. Press the (SERVO ON) button on the Programming Pendant.
6. Press the START button on the Programming Pendant (the Control Master job cycles, waiting for a CYCLE START/CYCLE LATCHED input from the Operator Station).
7. Transfer control to the Operator Station by selecting REMOTE on the Programming Pendant’s mode switch.

The ArcWorld work cell is now ready for operation.

4.2.4 Operation Cycle

The following is the typical sequence of operation for the ArcWorld two station work cell after start-up:

1. The operator loads the fixture in Station 1 with the parts to be welded.
2. At the Operator Station, the operator presses the green [CYCLE START/CYCLE LATCHED] button for Station 1. The safety barrier door closes, and the Robot moves to Station 1 to perform the welding program.
3. While the Robot is welding, the operator moves to Station 2 and starts loading the next group of parts to be welded.
4. When the welding program in Station 1 is complete, the Robot returns to the HOME (Safe) position, and the safety barrier door opens automatically.

NOTICE

Control of the Positioner uses collaborative motion between the Robot and the Positioner external axis.
Collaborative motion is active when jogging the tooling axis, loading, or unloading parts.
4 Operation
4.2 Daily Operation

5. When Station 2 is ready, the operator moves to the Operator Station, and presses the [CYCLE START/CYCLE LATCHED] button. The safety barrier door closes, and the robot moves to Station 2 to perform the welding program.

NOTICE
If the robot is still welding at the opposite station when the [CYCLE START/CYCLE LATCHED] button is pressed, the robot will finish and then proceed to the other station automatically (see section 2.3.1).

6. The operator moves to Station 1, removes the welded parts, replaces them with non-welded parts, and the process continues.

4.2.5 Shutdown
Use the following procedure to perform a normal shutdown of the ArcWorld:

1. Make sure that the robot is in HOME position.
2. Turn off the system servo power by pressing the EMERGENCY STOP button at the Operator Station or Programming Pendant.
3. Select TEACH mode on the Programming Pendant.
4. Rotate the Controller’s main power switch to OFF (see Fig. 2-1).
5. Set the welding power source’s power ON-OFF switch to OFF.
6. Close the regulator valve for the welding gas supply.

The ArcWorld is now shut down.
4.3 System Recovery

When a system error or alarm occurs, it needs to be cleared in order to return to normal operation. The paragraphs below describe the different types of alarms and errors that might be encountered and how to clear them.

4.3.1 Alarms and Errors

Alarms and errors will stop the program. The three levels of alarms and errors are as follows:

- Error Messages
- Minor Alarms
- Major Alarms

For more detailed information on alarm and error recovery, refer to the Controller and Robot documentation that is included with the documentation package (see section 1.5). Cell specific alarms are available in chapter 6 “Alarms and Messages”.

4.3.1.1 Error Messages

Error messages are usually the result of simple, easily cleared operation errors. One example of this type of error is pressing the START button when the robot is not in PLAY mode. Clear errors of this type by pressing the CANCEL button on the Programming Pendant.

4.3.1.2 Minor Alarms

Minor alarms usually involve programming errors. Clear alarms of this type by pressing the [CANCEL] button on the Programming Pendant.

4.3.1.3 Major Alarms

Clear alarms of this type by cycling the Controller power in accordance with the following steps:

1. Rotate the Controller power ON-OFF switch to OFF (see Fig. 2-1).
2. Allow the Controller power ON-OFF switch to remain in the OFF position for approximately 10 seconds.
3. Rotate the Controller power ON-OFF switch back to ON.
4.3 System Recovery

4.3.2 E-STOP Recovery

An E-STOP condition is triggered by any of the following:

- An EMERGENCY STOP button is activated.
- A work-cell access door is opened while the robot is not in TEACH mode.
- A welding torch collision triggers a shock sensor output (refer to section 4.3.3).

If an E-STOP condition is triggered, restart the ArcWorld as follows:

1. Press the [SERVO ON] button on the Programming Pendant.
2. Select the REMOTE mode on the Programming Pendant’s mode switch to transfer control of the system to the Operator Station.
3. Press the green [CYCLE START/CYCLE LATCHED] button on the Operator Station.

The ArcWorld is now ready to continue operation.

4.3.3 Shock Sensor Recovery

The ArcWorld welding package includes a torch mount for the Robot. This mount protects the torch from damage in case of an impact (collision). A slight deflection of the torch activates a SHOCK SENSOR signal that triggers an E-STOP condition. To clear the E-STOP condition, override the shock sensor and move the robot clear of the impact. Refer to the following procedure to override the shock sensor:

1. Press MAIN MENU on the Programming Pendant.
2. Use the Programming Pendant cursor key to select the ROBOT icon, then press [SELECT].
3. Use the Programming Pendant cursor key to select OVERRUN-S SENSOR, then press the [SELECT] key.
4. Select [RELEASE] to release the shock sensor.
5. Turn servo power ON by pressing the servo ON/READY. Then hold the Enable device in the middle position.

CAUTION

- Always reactivate the Shock Sensor before continuing system operation.

The Robot can be damaged if the Shock Sensor Override Switch remains in the “Override” position.

CAUTION

If an E-STOP condition occurs while the Positioner is rotating, the Positioner will complete the rotation when the ArcWorld is restarted.
4.3 System Recovery

6. Move the robot clear of the impact position.

The ArcWorld is now ready to continue operation.
5 Maintenance

Maintenance must be performed by authorized personnel who are familiar with the ArcWorld. Make sure to read and understand the documentation for a particular component before doing repairs or maintenance. Make sure to understand the maintenance procedures, have the proper tools at hand, comply with all safety instructions and precautions given throughout this manual and follow all local and federal regulations.

The maintenance intervals given in Table 5-1 are recommendations only. Adjust the frequency and level to suit the specific equipment schedules and shop environment.

For periodic maintenance procedures and schedules for the individual components of the ArcWorld, refer to the documentation that is included (refer to section 1.5).

---

**CAUTION**

- Use only YASKAWA-specified antifreeze if the system uses a water-cooled torch.

Do not use automotive antifreeze. It typically contains additives that can clog the small cooling ports in the torch and damage sealing gaskets in the water circulator pump.

---

**Table 5-1: Periodic Maintenance**

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>COMPONENT</th>
<th>PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Water Circulator (optional)</td>
<td>Check level of coolant/antifreeze. If necessary, add a mixture of YASKAWA coolant/antifreeze and distilled water. Mix antifreeze and distilled water in proportions shown on the antifreeze container.</td>
</tr>
<tr>
<td></td>
<td>All safety related items – work-cell door interlocks, EMERGENCY STOP buttons, arc curtains, etc.</td>
<td>Check physical condition of each safety item and ensure that it is working correctly.</td>
</tr>
<tr>
<td></td>
<td>Gas and Water Hoses</td>
<td>Inspect hoses for damage and replace as required.</td>
</tr>
<tr>
<td>Weekly</td>
<td>ArcWorld</td>
<td>Remove accumulated dirt, grease, and debris from inside and outside the work cell.</td>
</tr>
<tr>
<td>Every Six Months</td>
<td>System Components Common Equipment Base (optional)</td>
<td>Check the integrity and security of anchor hardware in accordance with Hilti® documentation. Check the torque of hold-down nuts in accordance with Hilti® documentation.</td>
</tr>
</tbody>
</table>
6 Alarms and Messages

This section contains information on alarms that are generated by the Controller. Cause and resolution of each alarm are presented to help with troubleshooting. For additional help contact Customer Support.

6.1 Alarms Based on Barrier Door Operation

Many of the alarm text below are for Station 1 (ST1). These alarms may also occur for Station 2, in that case the alarm text will show “ST2” instead of “ST1”.

Table 6-1: Barrier Door Alarms

<table>
<thead>
<tr>
<th>Alarm Text</th>
<th>Alarm Cause</th>
<th>Suggested Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST1 Barrier Fault Occurred</td>
<td>Some sort of alarm in the VFD which provides motion to the door.</td>
<td>- Press corresponding general output to reset the VFD.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Station 1 = OUT #2027</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Station 2 = OUT #2059</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some alarms can only be cleared by cycling power to the control drive. These are not typical.</td>
</tr>
<tr>
<td>ST1 Door Overtime Flt</td>
<td>Door was moving longer than 4.0 seconds. The total door cycle time is expected to be under 3.0 seconds.</td>
<td>Check for mechanical failure of the door, or failures in Raised or Lower switches.</td>
</tr>
<tr>
<td>ST1 Door Raised Not On</td>
<td>Door was moving up longer than 5 seconds and the “Door Raised” switch never engaged.</td>
<td>Investigate Door Raised proximity switch. Check for proper operation in Manual mode. Verify cabling.</td>
</tr>
<tr>
<td>ST1 Door Raised Not Off</td>
<td>Door was moving down longer than 5 seconds and the “Door Raised” switch stayed on.</td>
<td>Investigate Door Raised proximity switch. Check for proper operation in Manual mode. Verify cabling.</td>
</tr>
<tr>
<td>ST1 Door Lowered Not On</td>
<td>Door was moving down longer than 5 seconds and the “Door Lowered” switch never engaged.</td>
<td>Investigate Door Lowered proximity switch. Check for proper operation in Manual mode. Verify cabling.</td>
</tr>
<tr>
<td>ST1 Door Lowered Not Off</td>
<td>Door was moving up longer than 5 seconds and the “Door Lowered” switch stayed on.</td>
<td>Investigate Door Lowered proximity switch. Check for proper operation in Manual mode. Verify cabling.</td>
</tr>
</tbody>
</table>

1 Inputs to Reference:
- ST1 Door Lowered = IN #2019
- ST1 Door Raised = IN #2020
- ST1 Door Fault (VFD) = IN #2030
- ST2 Door Lowered = IN #2051
- ST2 Door Raised = IN #2052
- ST2 Door Fault (VFD) = IN #2062
### 6.2 Alarms Based on Functional Safety Unit Conditions

#### Table 6-2: Functional Safety Unit Alarms

<table>
<thead>
<tr>
<th>Alarm Text</th>
<th>Alarm Cause</th>
<th>Suggested Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS CRITICAL FSU FUNCT DISABLED</td>
<td>The Functional Safety Unit has several files which need to be enabled to ensure safe operation of the cell. The Functional Safety Unit uses one the “Robot Range Limit” files to control or limit the range of robot motion based on several conditions.</td>
<td>In TEACH mode - Robot Range Limit File #1 will be active, if someone changed the logic or other setting, this alarm could occur. Under normal operation this file is activated by Signal condition, which is a “TEACH/PLAY” mode input.</td>
</tr>
</tbody>
</table>

In PLAY mode - with Station 1 barrier door closed and Station 2 barrier door open, Robot Range Limit File #3 will be active, if someone changed the logic or other setting, this alarm could occur. Under normal operation this file is activated by the safety proximity signals from each barrier door. If the safety proximity is not activating properly this alarm may also occur falsely.

In PLAY mode - with Station 2 barrier door closed and Station 1 barrier door open, Robot Range Limit File #4 will be active, if someone changed the logic or other setting, this alarm could occur. Under normal operation this file is activated by the safety proximity signals from each barrier door. If the safety proximity is not activating properly this alarm may also occur falsely.

---

1 Reference cell drawings (183196-1 and 183197-1) and barrier drawings (183272-1 and 183272-2) for physical locations of each sensor.
6 Alarms and Messages
6.3 Cell Messages

Table 6-3: Cell Messages

<table>
<thead>
<tr>
<th>Message Text</th>
<th>Message Cause</th>
<th>Suggested Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROBOT RANGE FILE 1-5 DISABLED</td>
<td>After “SYS CRITICAL FSU” type alarm occurs, this message will follow, which helps point towards the specific feature to examine.</td>
<td>Check the menu: SAFETY FUNC. &gt; ROBOT RANGE LIMIT and verify that all Files 1 through 6 are setup per section 1.4.4</td>
</tr>
<tr>
<td>ROBOT RANGE FILE #5 DISABLED</td>
<td>After “SYS CRITICAL FSU” type alarm occurs, this message will follow, which helps point towards the specific feature to examine.</td>
<td>Check the menu: SAFETY FUNC. &gt; ROBOT RANGE LIMIT and verify that File 5 is setup per section 1.4.4</td>
</tr>
</tbody>
</table>
7  Spare Parts

7.1  Robot Spare Parts

Maintenance of the ArcWorld cell and its associated components should be performed only by authorized personnel who are familiar with the design, construction, and operation of the system. When exchanging failed parts be sure to understand the procedure and risks, have the proper tools, and observe all applicable safety precautions.

<table>
<thead>
<tr>
<th>WARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ensure that servo power is OFF and observe standard lockout/tagout practices before performing the following procedures.</td>
</tr>
<tr>
<td>Not removing servo power may result in death or serious injury.</td>
</tr>
</tbody>
</table>

When a part malfunctions, it is helpful to have replacement parts in stock for quick replacement. YASKAWA recommends the parts in the following sections be kept on hand.

7.1  Robot Spare Parts


7.2  Positioner Spare Parts

For a AW50S or AW52S cell, reference the Positioner Manual for spare part recommendations relative to the Positioner. See section 1.5 “Reference Documentation” on page 1-22 for manual details.
7.3 ArcWorld Door Spare Parts

Each ArcWorld is supplied with an interface panel that is mounted within one of the auxiliary enclosures. Recommended spare parts include:

*Table 7-4: Recommended Spare Parts for the Electrical Interface*

<table>
<thead>
<tr>
<th>Component</th>
<th>YASKAWA Part Number</th>
<th>Recommended Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Amp Fuse 24VDC</td>
<td>149593-1</td>
<td>2</td>
</tr>
<tr>
<td>2 Amp Fuse 24VDC</td>
<td>703039-1</td>
<td>2</td>
</tr>
<tr>
<td>1.6 Amp Fuse 24VDC</td>
<td>703039-8</td>
<td>2</td>
</tr>
<tr>
<td>1 Amp Fuse 24VDC</td>
<td>703093-3</td>
<td>2</td>
</tr>
<tr>
<td>2.5 Amp Fuse, Radial Leads</td>
<td>174327-1</td>
<td>6</td>
</tr>
<tr>
<td>6.3 Amp Fuse, Radial Leads</td>
<td>174327-3</td>
<td>4</td>
</tr>
<tr>
<td>315 mA Fuse, Radial Leads</td>
<td>174327-2</td>
<td>8</td>
</tr>
<tr>
<td>1 Amp, CC Class Fuse</td>
<td>130295-3</td>
<td>3</td>
</tr>
<tr>
<td>2 Amp, CC Class Fuse, Time Delay</td>
<td>183600-2</td>
<td>6</td>
</tr>
<tr>
<td>15 Amp, CC Class Fuse, Time Delay</td>
<td>180653-4</td>
<td>3</td>
</tr>
<tr>
<td>Relay, Mini</td>
<td>184204-1</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix A

A.1 Checklist

Since our customer is very important to us we include a checklist to use before start-ups and after maintenance for convenience and safety.

<table>
<thead>
<tr>
<th>BEFORE APPLYING POWER</th>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Check Mounting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Installation Section in all Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Power</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Connections, Controller Manual)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Ground</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Grounding in all Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Operation and Vendor Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Air</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Robot and Vendor Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Gas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Operation and Vendor Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Interlocks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Work Cells in all Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Limiting Devices/Software</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Limits in all Manuals)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Installation in Controller Manual)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Version</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Refer to Confirmation of Software Version)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other Items to Check Before Applying Power
(Vendor or Integrator Supplied)

|                                                       |           |            |
|                                                       |           |            |
|                                                       |           |            |
|                                                       |           |            |
|                                                       |           |            |
|                                                       |           |            |
## Appendix A

### A.1 Checklist

<table>
<thead>
<tr>
<th>After Applying Power</th>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Check Control Switches</strong> (Refer to Operator Station, Controller Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Axis Move and are Restricted</strong> (Refer to Basic Specifications, Robot Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check EMERGENCY STOP(s)</strong> (Refer to E-STOP in all Manual(s))</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check External Power Disconnect</strong> (Refer to Turning OFF The Power Supply, Controller Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check TEACH Mode</strong> (Refer to TEACH Mode, Controller Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Playback Mode</strong> (Refer to PLAY Mode, Controller Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Environment</strong> (Refer to Location in Robot Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Safeguards</strong> (Refer to Safeguards in all Manuals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check Manual Mode</strong> (Refer to Manual Mode in Operations Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Check PLAY Mode</strong> (Refer to Automatic Mode in Operations Manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other Items to Check After Applying Power</strong> (Vendor or Integrator Supplied)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Appendix A

## A.1 Checklist

<table>
<thead>
<tr>
<th>DOCUMENTATION INCLUDED</th>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Drawings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modifications Made to Original Protective Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End Effector Load Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructions on Synchronized Motion (More than one piece of moving synchronized equipment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programmed Limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborative Operation Declaration (Robot is suitable for integration that includes requirements met and types of operation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance Documents (ANSI, ISO, RIA, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Documents to Include (Vendor or Integrator Supplied) (Vendor Manuals, Supplier Certifications, Compliance Documents, etc.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### MARKINGS INCLUDED ON EQUIPMENT

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Business Name, Address, Info
- Machinery Designation and Type
- Year Built
- Explosive Proof
- **Order Number** *(Serial Number)*

### Other Markings on Equipment

*Vendor Machine Designation, Type, Serial No, Version, etc.*

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OTHER ITEMS

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>Checked By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

B.1 Glossary

3

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

A

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

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

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

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

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

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

Arm
An interconnected set of links and powered joints comprising a Robot 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 Robot
A Robot 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 Robot system and allows translation and rotary motion.

Articulation
Describes a jointed device, such as a jointed Robot. 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.

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.

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

B.1 Glossary

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.

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 Robot
A Cartesian Robot 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 Robot-arm degrees of freedom are defined by Cartesian Coordinates. This describes motions that are east-west, north-south and up-down, as well as rotary motions to change orientation.
Category 3 (Cat3)
Category 3 (Cat 3) means that the safety related parts of the control system will be designed so that:

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

Caution
Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.

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 by means of feedback information. As a Robot is in action, its sensors continually communicate information to the Controller, which is used to further guide the Robot within the given task. Many sensors are used to feed back information about the Robot’s placement, speed, torque, applied forces, as well as the placement of a targeted moving object, etc. See "Feedback".
Collaborative Robot
Term used to describe a robot system designed to operate in one or more of the four collaborative modes.
- "Safety Monitored Stop"
- "Hand Guiding"
- "Speed and Separation Monitoring"
- "Power and Force Limiting (PFL)"

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

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

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

Compliant Robot
A robot that performs tasks, with respect to external forces, by modifying its motions in a manner that minimizes those forces. The indicated or allowed motion is accomplished through lateral (horizontal), axial (vertical) or rotational compliance.

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

Contact Sensor
A device that detects the presence of an object or measures the amount of applied force or torque applied on the object through physical contact with it. Contact sensing can be used to determine location, identity, and orientation of work pieces.

Continuous Path
Describes the process where by a robot is controlled over the entire path traversed, as opposed to a point-to-point method of traversal. This is used when the trajectory of the end-effector is most important to provide a smooth movement, such as in spray painting etc. See "Point-to-Point".

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

Control Command
An instruction fed to the robot by means of the human-to-machine input device. See Pendant (Teaching). This command is received by the Controller system and is interpreted. Then, the proper instruction is fed to the robot's actuators, which enable it to react to the initial command. Many times, the command must be interpreted with the use of logic units and specific algorithms. See "Input Devices" and "Instruction Cycle".
Appendix B
B.1 Glossary

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, a start button, or a selector switch. (R15.06)

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

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

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

Controller System
The 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 contains the programs, data, algorithms; logic analysis, and various other processing activities, which enable it to perform. See "Robot".

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

Central Processing Unit (CPU)
The Central Processing Unit (CPU) is the main circuit board and processor of the Controller.

Cubic Interference Area
This area is a rectangular parallelepiped, which is parallel to the base coordinate, robot coordinate or user coordinate. The Controller judges whether the current position of the Robot’s TCP is inside or outside this area, and outputs this status as a signal.

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

Cyclic Coordinate System
A coordinate system that defines the position of any point in terms of an angular dimension, a radial dimension and a height from a reference plane. These three dimensions specify a point on a cylinder.
Cyclo Drive
A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major (larger) axis.

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

D

Danger
Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

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

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

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

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

Drive
A speed (gear) reducer to convert high speed low torque to low speed high torque. See "Harmonic Drive", "Cyclo Drive" and "Rotary Vector Drive (RV)".

Drop Delivery
A method of introducing an object to the workplace by gravity. Usually, a chute or container is so placed that, when work on the part is finished, it will fall or drop into a chute or onto a conveyor with little or no transport by the robot.

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

E

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)
Appendix B
B.1 Glossary

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 Robot 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 Robot will attempt to achieve at the end of a path of motion. The end of the distal link.

Error
The difference between the actual response of a robot and a command issued.

Expandability
Being able to add resources to the system, such as memory, larger hard drive, new I/O card, etc.

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

Feedback
The return of information from a Robot or sensor to the processor of the robot to provide self-correcting control of the Robot. See “Feedback Control” and “Feedback Sensor”.
Feedback Control
A type of system control obtained when information from a Robot or sensor is returned to the Controller in order to obtain a desired robot effect. See "Feedback", "Closed-loop" and "Feedback Sensor".

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

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

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

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

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

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

Frame
A coordinate system used to determine a position and orientation of an object in space, as well as the robot's position within its model.

Functional Safety Unit (FSU)
The Functional Safety Unit (FSU) is a component of the 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 Robot and tool's position, speed and posture.

Gantry
An adjustable hoisting machine that slides along a fixed platform or track, either raised or at ground level along the X, Y, Z axes.
Appendix B
B.1 Glossary

Gantry Robot
A robot which has three degrees of freedom along the X, Y and Z coordinate system. Usually consists of a spooling system (used as a crane), which when reeled or unreeled provides the up and down motion along the Z axis. The spool can slide from left to right along a shaft which provides movement along the Z axis. The spool and shaft can move forward and back along tracks which provide movement along the Y axis. Usually used to position its end effector over a desired object and pick it up.

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.

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.
B.1 Glossary

Home Position
A known and fixed location on the basic coordinate axis of the Robot where it comes to rest, or to an indicated zero position for each axis. This position is unique for each model of Robot. On 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 Robot 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 Robot, and a 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 Controller. See "Command Position".

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

Integrate
To fit together different subsystems, such as robots and other automation devices, or at least different versions of subsystems in the same control shell.
B.1 Glossary

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 Robots or the Robot and peripheral device. The areas can be set up to 64 areas. Three types of methods to use each interference area are as follows: Cubic Interference, Outside of Cubic Area and Axis Interference.

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

ISO
International Organization for Standardization

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

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

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

J

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

JOB
JOB is the YASKAWA name for a robot program created using YASKAWA’s INFORM robot programming language. Typically, a JOB consists of instructions that tell the Controller what to do and data that the program uses when it is running.
Appendix B
B.1 Glossary

**Joint**
A part of the Robot system, which allows a rotation and/or translational degree of freedom of a link of end-effector.

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

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

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

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

**K**

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

**L**

**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.
Appendix B

B.1 Glossary

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 Robot, 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.

M

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

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

Manual Mode
See "TEACH Mode".

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

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.
Appendix B
B.1 Glossary

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

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

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

**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 Robot.

**Motor**
See "Servo Motor".

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

**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.
Appendix B
B.1 Glossary

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

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

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

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

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

**PAM Function – Position Adjustment by Manual**
Position Adjustment by Manual allows position adjustment by simple operations while observing the motion of the Robot, and without stopping the Robot. 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 Robot 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**
See "Programming Pendant"
Pendant Teaching
The mapping and recording of the position and orientation of a robot and/or Robot system as the robot is manually moved in increments from an initial state along a path to a final goal state. The position and orientation of each critical point (joints, robot base, etc.) is recorded and stored in a database for each taught position the robot passes through on its path toward its final goal. The robot may now repeat the path on its own by following the path stored in the database.

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

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

Pick and Place Cycle
The amount of time it takes for a Robot 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 Robot arm. See “Roll” and “Yaw”.

PLAY Mode
After a robot is programmed in TEACH mode, the Controller can be switched to PLAY mode to execute the robot program. In PLAY mode, the robot program is played back. This is the mode in which robots are used in production.
Appendix B
B.1 Glossary

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. Mode 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
Robot motion in which a limited number of points along a projected path of motion is specified. The Robot moves from point to point rather than a continuous smooth path.

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

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

Position Level
The position level is the degree of approximation of the Robot 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 Robot 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.

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

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

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

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

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

**Range of Motion**
The full movement potential of the robot.

**Reach**
The volume of space (envelope), which a robot's end-effector can reach in at least one orientation.
Appendix B
B.1 Glossary

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

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

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

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

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

Repeatability
A measure of how close an arm can repeatedly obtain a taught position. For instance: once a Robot is manually placed in a particular location and this location is resolved by the Robot, the repeatability specifies how accurately the Robot 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.
Appendix B

B.1 Glossary

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 Robot 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, Robot and end-effector. See "Manipulator", "Controller" and "End-effector".

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

Robot Integrator
See "Integrator".

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

Robot Range Limit Monitoring
Monitors the Robot 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 Robot arm. See "Pitch" and "Yaw".

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

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

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

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

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

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

SCARA Robot
A cylindrical robot, having two parallel rotary joints (horizontally articulated) and provides compliance in one selected plane. (ISO 8373)

NOTICE
SCARA derives from Selectively Compliant Arm for Robotic Assembly

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

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

Sensor
Instruments used as input devices for robots, which enable it to determine aspects regarding the robot's environment, as well as the robot's own positioning. Sensors respond to physical stimuli (such as heat, light, sound, pressure, magnetism and motion), and they transmit the resulting signal or data for providing a measurement, operating a control or both. (R15.06)
Appendix B
B.1 Glossary

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

**Servo Control**
The process by which the control system of the robot checks if the attained pose of the robot corresponds to the pose specified by the motion planning with required performance and safety criteria. (ISO 8373)

**Servo Motor**
An electrical power mechanism used to effect motion or maintains position of the robot (for example, a motor which converts electrical energy to effect motion of the robot) (R15.07). The motor responds to a signal received from the control system and often incorporates an encoder to provide feedback to the control loop.

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

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

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

**Shock Detection Function**
Shock detection is a function supported by the Controller that reduces the impact of a robot collision by stopping the Robot without any external sensor when the tool or the Robot 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"
Appendix B
B.1 Glossary

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

Softlimit Setting Function
The Softlimit Setting Function is a function to set the axis travel limit range of the Robot 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 Robot to complete a task without jerky motion.

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

Standstill Monitoring
Using the Axis Speed Monitor function will activate an E-STOP condition if a motion occurs.

Stop Position Monitoring
See "Standstill Monitoring"
System Integrator
See "Integrator"

T

Teach
To program a Robot arm by manually guiding it through a series of motions and recording the position in the Controller memory for playback.

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

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

Teach Pendant
See "Programming Pendant"

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

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

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

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

Tool & arm Interference
In a system with one Controller and multiple Robots, 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
B.1 Glossary

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 Robot have any contact with those of the other while moving, the Robots 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).

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 Robot 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.
Appendix B
B.1 Glossary

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.

Work Envelope
The set of all points which a Robot can reach without intrusion. Sometimes the shape of the work space, and the position of the Robot 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 Robot operations. It prevents interference with peripheral device by ensuring that the Robot is always within a set range as a precondition for operations such as starting the line. The Robot 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 Robot 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.
Appendix B
B.1 Glossary

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

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

Wrist
A set of rotary joints between the arm and the 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 Robot arm. Side to side motion at an axis. See "Roll" and "Pitch".

Z
ArcWorld® 50/50S and 52/52S
SYSTEM MANUAL

Specifications are subject to change without notice for ongoing product modifications and improvements.

YASKAWA ELECTRIC CORPORATION
2-1 Kurosakishiroishi, Yahatanishi-ku, Kitakyushu, 806-0004, Japan
Phone: +81-93-645-7703 Fax: +81-93-645-7802
http://www.yaskawa.co.jp

YASKAWA AMERICA, INC. (MOTOMAN ROBOTICS DIVISION)
100 Automation Way, Miamisburg, OH 45342, U.S.A.
Phone: +1-937-847-6200 Fax: +1-937-847-6277
http://www.motoman.com

YASKAWA EUROPE GmbH (ROBOTICS DIVISION)
Yaskawastrasse 1, 85391, Allershausen, Germany
Phone: +49-8166-90-100 Fax: +49-8166-90-103
http://www.yaskawa.eu

YASKAWA NORDIC AB
Verkstadsgatan 2, Box 504, SE-385 25 Torsas, Sweden
Phone: +46-480-417-600 Fax: +46-486-414-10
http://www.yaskawa.se

YASKAWA ELECTRIC (CHINA) CO., LTD
22F, One Corporate Avenue, No.222 Hubin Road, Huangpu District, Shanghai 200021, China
Phone: +86-21-5385-2200 Fax: +86-21-5385-3299
http://www.yaskawa.com.cn

YASKAWA SHOUGANG ROBOT CO., LTD.
No.7 Yongchang North Road, Beijing E&T Development Area, Beijing 100076, China
Phone: +86-10-6785-2858 Fax: +86-10-6785-2878
http://www.ysr-motoman.cn

YASKAWA ELECTRIC KOREA CORPORATION
35F, Three IFC, 10 Gukjegeumyung-ro, Yeongdeungpo-gu, Seoul, 07326, Korea
Phone: +82-2-784-7844 Fax: +82-2-784-8495
http://www.yaskawa.co.kr

YASKAWA ELECTRIC TAIWAN CORPORATION
12F, No.207, Sec. 3, Beishin Rd., Shindian District, New Taipei City 23143, Taiwan
Phone: +886-2-8913-1333 Fax: +886-2-8913-1513
http://www.yaskawa.com.tw

YASKAWA ASIA PACIFIC PTE. LTD.
30A Kallang Place, #06-01, 339213, Singapore
Phone: +65-6282-3003 Fax: +65-6289-3003
http://www.yaskawa.com.sg

YASKAWA ELECTRIC (THAILAND) CO., LTD.
59, 1st-5th Floor, Flourish Building, Soi Ratchadapisek 18, Ratchadapisek Road, Huaykwang, Bangkok 10310, Thailand
Phone: +66-2-017-0099 Fax: +66-2-017-0199
http://www.yaskawa.co.th

PT. YASKAWA ELECTRIC INDONESIA
Secure Building-Gedung B Lantai Dasar & Lantai 1 Jl. Raya Protokol Halim Perdanakusuma, Jakarta 13610, Indonesia
Phone: +62-21-2982-6470 Fax: +62-21-2982-6471
http://www.yaskawa.co.id

YASKAWA INDIA PRIVATE LIMITED (ROBOTICS DIVISION)
#426, Udyog Vihar Phase-IV, Gurgaon, Haryana 122016, India
Phone: +91-124-475-8500 Fax: +91-124-475-8542
http://www.yaskawaindia.in