Motoman NX100 Controller
FabWorld II Series
System Manual

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Chapter 1

Introduction

The FabWorld II Series system is part of the FabWorld family of standardized arc welding solutions. It is a fully integrated welding system, and is supported from wire to weld by Motoman, Inc.

1.1 About This Document

This manual is intended as an introduction and overview for personnel who have received operator training from Motoman, and who are familiar with operation of the FabWorld II Series work cells. For more detailed information, refer to the manuals listed in Section 1.3. This manual contains the following chapters:

CHAPTER 1 – INTRODUCTION
This section provides general information about the FabWorld II Series and its components, a list of reference documents, and customer support information.

CHAPTER 2 – SAFETY
This section provides information regarding the safe use and operation of the FabWorld II Series.

CHAPTER 3 – DESCRIPTION OF EQUIPMENT
This section provides a detailed description of the major components of the FabWorld II Series. This section also includes a table of component specifications.

CHAPTER 4 – INSTALLATION
This section provides instructions for set up and installation of the FabWorld II Series.

CHAPTER 5 – OPERATION
This section provides instructions for basic operation of the FabWorld II Series. This section also provides procedures for start-up, loading, normal operation, fault recovery, and shutdown.

CHAPTER 6 – MAINTENANCE
This section contains a table listing periodic maintenance requirements for the components of the FabWorld II Series work cell.

APPENDIX A – ANCHORING
This section contains a table listing recommended anchoring parts for the components of the FabWorld II Series work cell that require anchoring.
1.2 System Overview

The FabWorld II Series work cell provides a complete arc welding solution with multiple robot and station kit configurations. The system is designed around single or dual Motoman arc welding robots, and NX100 controllers, and includes a complete welding package. Two MHT-series positioners comprise the work stations and allow the robot(s) to weld in synchronous motion with each positioner. The cell can also be purchased with a stationary weld table instead of the headstock/tailstock combination. The cell also includes a full complement of safety features designed to protect both personnel and equipment. Dual robot systems feature single point of control of all axes from one programming pendant as required by ANSI/RIA 15.06-1999.

Figure 1 illustrates a typical system layout for the FabWorld II Series cell (dual robot feature shown).

Figure 1 System Layout - FabWorld II-Series

Note: This manual is for a standard Motoman system. If your system is a custom or modified system, please use the drawings and Bill of Material (BOM) provided with your system for troubleshooting and spares provisioning.

1.2.1 System Layout

The FabWorld II Series provides multiple configuration options for different application requirements. Several robot options are available for different applications and weld lengths. Single robot EA1400N or EA1900N cells are available as well as dual configurations. The robot manipulators are mounted on a common base providing ease of installation. Several MHT-series positioners are available, 500 or 1600 kg capacities to comprise the two work stations. Each positioner is equipped with Motoman’s patent-pending MotoMount flexible fixture system. Robot controllers and welding power sources share common bases outside the welding cell. The robotic cell is enclosed by safety fencing with an interlocking door. S-axis zone rings and light curtains provide reliable safeguarding. All
operator controls, including those on the controller and welding power supplies, are accessible from outside the safety fencing.

1.2.2 Major Components

The FabWorld II Series is made up of the following major components:

- Motoman EA-Series manipulators and NX100 controllers
- MHT-Series positioner
- Operator stations
- Welding equipment, including the following:
  - Welding power source
  - Welding torch (water-cooled or air-cooled)
  - Wire feeder
  - Applicable welding interface
  - Torch mount
- Safety equipment, including the following:
  - Safety fencing with arc curtains
  - Interlocked light curtains
  - Interlocked cell door

1.2.3 Optional Equipment

The following optional welding equipment is available for use with the FabWorld II Series system –

- Torch cleaner
- Wire cutter
- Water-cooled torch (w/ coolant circulator)
- Bulk wire dereeler, 454 kg
- ComArc™ (seam tracking)
- TouchSense™ (starting point detection)
- ToolSight® (auto verification of correct torch alignment)

1.3 Reference Documentation

For additional information refer to the following:

- Motoman EA1400N Manipulator Manual (P/N 149467-1)
- Motoman Independent/Coordinated Control Function Manual (P/N 149648-1)
- Motoman Inform II User's Manual (P/N 150078-1)
- Motoman EA1900N Manipulator Manual (P/N 149894-1)
- Motoman NX100 Controller Manual (P/N 149201-1)
- Motoman NX100 Maintenance Manual (P/N 150133-1)
- Motoman Operator's Manual for Arc Welding (P/N 149235-1)
• Motoman *Concurrent I/O Parameter Manual* (P/N 149230-1)
• Motoman *MH-Series Positioner Manual w/ MotoMount* (P/N 152763-1)
• Vendor manuals for system components not manufactured by Motoman

### 1.4 Customer Support Information

If you need assistance with any aspect of your FabWorld II Series system, please contact Motoman Customer Support at the following 24-hour telephone number –

```
937. 847. 3200
```

For routine technical inquiries, you can also contact Motoman Customer Support at the following e-mail address –

```
technicalsupport@motoman.com
```

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

*Note: Use e-mail for routine inquiries, only. If you have an urgent or emergency need for service, replacement parts, or information, please contact Motoman Customer Support at the telephone number shown above.*

Please have the following information ready before you call:

• Robot Type (EA1400N or EA1900N)
• Application Type (welding)
• System Type (FabWorld II Series)
• Software Version (access using MAIN MENU, SYSTEM INFO, VERSION on programming pendant)
• Robot Serial Number (located on back side of robot arm)
• Robot Sales Order Number (located on front door of NX100 controller)
Chapter 2

Safety

2.1 Introduction

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

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems (ANSI/RIA R15.06-1999). 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 robot system. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the robot cell. NEVER ALLOW UNTRAINED PERSONNEL TO OPERATE, PROGRAM, OR REPAIR THE ROBOT SYSTEM!

We recommend approved Motoman training courses for all personnel involved with the operation, programming, or repair of the robot system. This training is designed to familiarize personnel with the safe and correct operation of the robot system.
This safety section addresses the following:

- Standard Conventions (Section 2.2)
- General Safeguarding Tips (Section 2.3)
- Mechanical Safety Devices (Section 2.4)
- Installation Safety (Section 2.5)
- Programming, Operation, and Maintenance Safety (Section 2.6)

2.2 Important Advisory Information

Throughout this manual you will find advisory paragraphs (denoted by graphic symbols and bold typeface). All of these (except “NOTE”) direct the reader's attention to information and procedures that are essential to the safety of personnel or protection of equipment.

The type of information contained in the various advisories is described below. These are listed here in descending order of importance to the safety of personnel and protection of equipment.

**DANGER!**
Information appearing under the DANGER caption concerns the protection of personnel from an immediate and imminent hazards that, if not avoided, will result in immediate, serious personal injury or loss of life in addition to equipment damage.

**WARNING!**
Information appearing under the WARNING caption concerns the protection of personnel and equipment from potential hazards that can result in personal injury or loss of life in addition to equipment damage.

**CAUTION!**
Information appearing under the CAUTION caption concerns the protection of personnel and equipment, software, and data from hazards that can result in minor personal injury or equipment damage.

Note: Information appearing in a Note caption provides additional information that can be helpful in understanding the item being explained.

2.3 General Safeguarding Tips

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

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this robot system.
• Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the robot cell.

• Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).

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

• In accordance with ANSI/RIA R15.06-1999, section 4.2.5, Sources of Energy, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

2.4 Mechanical Safety Devices

The safe operation of the robot, positioner, auxiliary equipment, and system is ultimately 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 R15.06-1999 safety standards, and other local codes that may pertain to the installation and use of industrial equipment. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety equipment is provided as standard:

• Safety fences and barriers
• Light curtains and/or safety mats
• Door interlocks
• Emergency stop palm buttons located on operator station, robot controller, and programming pendant

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

2.5 Installation Safety

Safe installation is essential for protection of people and equipment. The following suggestions are intended to supplement, but not replace, existing federal, local, and state laws and regulations. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. Installation tips are as follows:

• Be sure that only qualified personnel familiar with national codes, local codes, and ANSI/RIA R15.06-1999 safety standards are permitted to install the equipment.
• Identify the work envelope of each robot with floor markings, signs, and barriers.
• Position all controllers outside the robot work envelope.
• Whenever possible, install safety fences to protect against unauthorized entry into the work envelope.
• Eliminate areas where personnel might get trapped between a moving robot and other equipment (pinch points).

• Provide sufficient room inside the work cell to permit safe teaching and maintenance procedures.

### 2.6 Programming, Operation, and Maintenance Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to program, operate, and maintain the system. All personnel involved with the operation of the equipment must understand potential dangers of operation.

• Inspect the robot and work envelope to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.

• Be sure that all safeguards are in place. Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.

• Do not enter the robot cell while it is in automatic operation. Be sure that only the person holding the programming pendant enters the work cell.

• Check the E-Stop button on the programming pendant for proper operation before programming. The robot must be placed in Emergency Stop (E-Stop) mode whenever it is not in use.

• Back up all programs and jobs onto suitable media before program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.

• Any modifications to PART 1, System Section, of the robot controller concurrent I/O program can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to PART 1, System Section. Making any changes without the written permission of Motoman will VOID YOUR WARRANTY!

• Some operations require standard passwords and some require special passwords. Special passwords are for Motoman use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.

• The robot controller allows modifications of PART 2, User Section, of the concurrent I/O program and modifications to controller parameters for maximum robot performance. Great care must be taken when making these modifications. All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot and other parts of the system. Double-check all modifications under every mode of robot operation to ensure that you have not created hazards or dangerous situations.

• Check and test any new or modified program at low speed for at least one full cycle.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Use proper replacement parts.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).
Chapter 3

Equipment Description

3.1 Robot Description

The Motoman six-axis EA1400N and EA1900N “Expert Arc” robots are specifically designed for arc welding applications. The EA1400N has a payload of 3 kg and features a horizontal reach of 1388 mm and a relative positioning accuracy of ±0.08 mm. The EA1900N has a payload of 3 kg and features a horizontal reach of 1904 mm and a relative positioning accuracy of ±0.08 mm. The EA-series robots have a patented internal cabling design that provides high flexibility and streamlines the robot profile, allowing access into confined spaces. Each robot’s B-axis features an expanded range of motion which improves circumferential welding on cylindrical work pieces. The T-axis can rotate the torch ±360 degrees without cable interference.

Each robot can be mounted on the floor, wall, or ceiling with minor modifications. For additional information, refer to the Manipulator Manual that is included with your system documentation package (refer to Section 1.3).

3.2 NX100 Controller

The FabWorld II Series features a NX100-DRC controller assembly that consists of one NX100 controller mated to an expansion cabinet (see Figure 2). This combination provides the same functionality of two full-size controllers, while reducing the overall width by 250 mm (when compared to two, full-size NX100 controllers). This configuration also reduces the cost to the customer by eliminating certain redundant components and circuit assemblies.

Through specific cable interconnections, the NX100-DRC is configured as controller R1 and controller R2 (see Figure 2). This configuration allows the two robots to operate as a dual system that takes advantage of all the unique functions available in a dual system configuration. With the FabWorld II Series, the full-size NX100 controller cabinet is designated R1, while the smaller, expansion cabinet is designated R2.

In addition to controlling the movement of the two robots, the NX100-DRC also controls the two welding power sources, the positioner, and provides the signals necessary to operate the two welding systems.
The NX100-DRC controller features an embedded real-time operating system (RTOS) and is programmed with the Motoman INFORM programming language.

**Figure 2** NX100-DRC Controller

### 3.3 Programming Pendant

The programming pendant (see Figure 3) is the primary user interface for the system and features a cross-shaped navigation cursor that reduces teaching time by 30 percent. The pendant has a 6.5-in. full color touch screen display (640 x 480 VGA), and provides a convenient CompactFlash® slot for easy memory back-ups. The system uses the INFORM III robot programming language and a menu-driven interface to simplify operator interaction with the robot.

Most operator controls are located on the pendant, allowing the control cabinet to be mounted remotely. By using the pendant, the operator can teach robot motion, and perform programming, editing, maintenance, and diagnostic functions. For detailed information on the pendant programming keys and display functions, please refer to the *NX100 Operator’s Manual for Arc Welding* that is included with your system documentation package (refer to Section 1.3).
Figure 3  NX100 Programming Pendant
3.4 Operator Station

The operator station (see Figure 4) includes a NEMA enclosure and fence mounting brackets. The following paragraphs describe the operator station controls.

![Operator Station Diagram]

**Figure 4** Operator Station

3.4.1 Start

The START button is connected to the robot external start input. The robot will start the current active job when START is pressed. The programming pendant must be set to REMOTE with servo power ON for the START button to work.

3.4.2 Servo On

The SERVO-ON push button turns servo power ON.

3.4.3 Alarm

The ALARM lamp lights red when the robot encounters an alarm condition.
3.4.4 **Cycle Start/Cycle Latched**

The operation of the CYCLE START/CYCLE LATCHED button is dependent on the structure of the Master job. Altering the Master job could result in injury to personnel or damage to the equipment. The green CYCLE START/CYCLE LATCHED button, initiates a positioner sweep cycle if the robot is in the Safe or Home position. If the CYCLE START/CYCLE LATCHED button is pressed while the robot is outside Home, the CYCLE START command is latched into the controller. Once the robot returns to Home, the CYCLE START command is executed and the positioner sweeps. A pulse instruction prevents the operator from holding the button down to continuously cycle the positioner.

3.4.5 **Joystick Control**

The joystick controls positioner rotation and user defined load positions. Moving the joystick to the right (FWD) indexes the positioner headstock in a clockwise direction at 30-degree intervals. Moving the joystick to the left (REV) indexes the positioner headstock in a counter-clockwise direction at 30-degree intervals. Moving the joystick forward (home) moves the positioner headstock to zero degrees (home position).

3.4.6 **Reset**

The RESET button is connected to the robot alarm reset input. A minor alarm or error condition is cleared when this button is pressed.

3.4.7 **Robot Hold**

The ROBOT HOLD button is a normally closed, momentarily actuated switch. Pressing ROBOT HOLD stops the operation of the manipulator until another START signal is sent. Operation resumes at the point in the program where the ROBOT HOLD state was initiated. Refer to the manipulator manual for more information.

3.4.8 **Emergency Stop (E-Stop)**

Pressing an E-Stop button or interrupting a door interlock stops all system operation. The operator station E-Stop, the robot E-Stop, and the sliding door interlocks are connected to a safety PLC and the Emergency Stop circuit. Brakes are applied to the robot and all servo power is removed from the system. The system E-Stop lights come on and all positioner motion is stopped.
3.5 **MHT-Series Positioners**

The MHT-series includes the MHT-500 and MHT-1600 positioners. These positioners include a headstock drive assembly, tailstock column, and the MotoMount™ tool mounting system. Part fixturing is mounted between the headstock and tailstock face plates.

Refer to the *MH-series Positioner Manual with MotoMount and Drive Assemblies* (P/N 152763-1) for MotoMount and MHT-500/MHT-1600 technical details.

The FabWorld II Series system is capable if true coordinated motion, where linear, circular, or spline motion can be coordinated between the robots and positioner. Coordinated motion allows the robots to weld while the positioner rotates the parts. For additional information on coordinated motion, refer to the *Independent/Coordinated Motion Manual* included with your system documentation package (refer to Section 1.3).

3.6 **Welding Equipment**

In its standard configuration, the FabWorld II Series system includes a welding power source, wire feeder, torch, and torch mount for each robot. Optional equipment-water circulator, Com-Arc unit, and torch tender for each robot - may also be included with your system.

3.6.1 **Wire Feeder**

The wire feeder mounts on the robot arm. This 4-roll wire feeder provides reliable wire feeding at rates up to 750 inches per minute (ipm). An integral gas valve provides fast gas response time. Interchangeable feed rolls are used to accommodate different types and sizes of wire.

3.6.2 **GMAW Torch**

The FabWorld II Series system can use a standard (air-cooled) or optional (water-cooled) robotic/automatic GMAW torch. These are heavy-duty torches designed for quick replacement and minimum robot reprogramming. The GMAW torch is installed at the end of the robot wrist.

3.6.3 **Power Sources**

Motoman offers several different power sources for use with the FabWorld II Series system, depending on the application. For more specific information, refer to the vendor manuals that are included with your system documentation package (refer to Section 1.3).
3.7 Safety Features

**WARNING!**
The ANSI/RIA R15.06-1999 Robot Safety Standard stipulates the user is responsible for safeguarding. Users are responsible for determining whether the provided safeguards are adequate for plant conditions. Users must also ensure that safeguards are maintained in working order.

The FabWorld II Series system includes a total safety environment. When all standard safety precautions are taken, the safety equipment helps to ensure safe operation of the robotic cell.

3.7.1 Arc Screen

**WARNING!**
Although the arc curtain blocks dangerous arc radiation, never look directly at the arc without protective eye wear!

The material used to cover the safety fencing of the entire robotic cell acts as an arc screen. This material reduces the amount of ultra-violet radiation that escapes from the robotic cell.

3.7.2 Fencing

The safety fencing provided with the FabWorld II Series system encloses the entire robotic work cell. It forms a physical barrier that prevents entry into the work cell during automatic operation.

3.7.3 Safety Light Curtains

The safety light curtains work in conjunction with the robot zone rings to help prevent serious injury to anyone entering a station safety zone while the robot is working in that area. In PLAY mode, if the robot is at station 1 and the operator steps into the station 1 safety zone, servo power is removed from the system and all positioner motion stops. Servo power can be re-applied and the operation resumed by pressing SERVO ON and START.

3.7.4 Emergency Stops (E-Stop)

In addition to the safety features described above, the FabWorld II Series incorporates strategically placed E-Stop push buttons actuators. When activated, they immediately stop all system operation. Brakes are applied to the robot and all servo power is removed from the system. The system E-Stop lights come on, and all positioner motion is stopped. The following is a list of E-Stop actuator locations:

- NX100 controller access door (see Figure 2)
- The programming pendant (see Figure 3)
- The operator station (see Figure 4)
3.7.5 ENABLE Switch

The ENABLE switch is a safety feature which controls servo power while the FabWorld II Series system is in TEACH mode. When pressed in, this switch allows the operator to turn servo power ON. However, should the operator release the switch or grasp it too tightly, servo power is immediately disabled, preventing further robot movement. For detailed information about the operation of the ENABLE switch, refer to the controller manual that is part of your system documentation package (refer to Section 1.3).

3.7.6 Brake Release

The robot brakes are designed to protect the robot and other system components from damage in event of a system or robot failure. The brake release is a safety feature that allows the operator to release the brake of a specific robot axis when drive power has been removed from the system. Use the programming pendant to access the brake release function. Refer to Section 5.3.4 for brake release procedures.

3.7.7 Interlocked Cell Door

A safety interlock on the cell entrance door prevents entry into the cell during PLAY mode. If the safety interlock is by-passed or otherwise defeated, brakes are applied to the robot, servo power is removed from the system, and all positioner motion is stopped.
Chapter 4
Installation

The FabWorld II Series system can be installed easily in just a short time. Follow established safety procedures at all times throughout the installation process. Failure to use safe work practices can result in damage to the equipment and injury to the workers.

CAUTION!
Installation of the FabWorld system is not a task for the novice. The FabWorld system is not fragile, but it is a highly sophisticated robotic system. Handle components with care. Rough handling can damage system electronic components.

4.1 Materials Required

All system hardware necessary for installing the FabWorld II Series system is included with the system. This section identifies customer-supplied items and tools required to complete installation.

4.1.1 Customer-Supplied Items

- Gas for welding torches
- Incoming power
- Two earth ground cables with two earth ground stakes
- Weld wire
- Incoming air supply: 0.04 cmm at 620.5 kPa (1.5 scfm at 90 psi) for torch tender or wire cutter options
- Stepladder
- Forklift and/or overhead crane
4.1.2 List of Tools

- Safety glasses
- Face shields
- Gloves
- Level
- Ratchet with 3/4 in. socket
- Adjustable wrench set
- Hammer drill with appropriate concrete bits
- Phillips and flat screwdrivers
- Hammer
- Socket set
- Forklift and/or overhead crane
- Air-impact gun with 3/4 in. socket
- Open-end wrench set
- Two socket-heads (Allen)
- Wrench sets (standard and metric)

4.2 Site Preparation

To prepare your site, proceed as follows:

1. Clear floor space needed for unit (refer to your specific system prints).

Note: To make installation easier, allow an additional 1.2 to 1.5 m on all sides of cell.

2. Gather all customer-supplied items and required tools listed in Section 4.1.

4.3 Installing the Robot/Positioner Common Base

The robot/positioner common base is shipped on a wooden shipping skid. To install the common base proceed as follows:

CAUTION!
Handle FabWorld system components carefully to avoid damage.

1. Unbolt the robot/positioner common base from the shipping skid using 3/4 in. socket.

WARNING!
The robot/positioner common base weighs approximately 1905 kg. Be sure your crane or forklift is capable of handling this much weight or damage to the equipment or injury to personnel can result.

1. Move the common base in position according to system drawings.
2. Carefully remove protective plastic wrapping from equipment.
3. Inspect equipment for shipping damage.

Note: Notify your shipping contractor if you notice any shipping damage.

4. Anchor common base securely in place (refer to Appendix A for anchor requirements).
4.3.1 Removing the Robot Shipping Bracket

**CAUTION!**

Failure to remove shipping brackets from robot before operating the FabWorld II Series may result in damage to the robot drive mechanisms.

A yellow bracket (see Figure 6) prevents the robot from moving during shipping. The bracket secures the lower arm assembly to the S-axis housing. After the robot is in place, remove the shipping bracket.

![Figure 5 Robot/Positioner Common Base](image)
4.3.2 Installing the Controller / Welder Base

The FabWorld II Series uses a separate controller base mounted on the outside of the system fencing. The common equipment base contains the robot controller, welder, service disconnect, and optional water circulator. To install the bases, proceed as follows:

1. Unbolt the base by removing four shipping bolts using a 3/4 in. socket.

**WARNING!**  
Each base weighs approximately 1600 kg. Be sure that your lifting device is capable of handling this much weight or damage to the equipment or injury to personnel can result.

2. Carefully remove plastic wrapping and cardboard from base.
3. Inspect base components for any shipping damage.

*Note: Notify your shipping contractor if you notice any shipping damage.*

4. Use a forklift to lift the base and remove wooden blocks.
5. Refer to your system drawings (supplied with the robot cell) to place the base in position.
6. Anchor the base securely in place (refer to Appendix A for anchor requirements).

4.4 Connecting the Cables

After components are level and securely in place, unwrap the cables and connect them according to the cable diagram included in the system drawing package. All cables are labeled to match the labels at the connection points. Using cable trays, route cables between system components.

**CAUTION!**  
Route wires in cable trays to avoid wire breakage and unnecessary interruption of cell operations.
4.4.1 Connecting the Earth Ground

Each robot and controller must each be connected to an earth ground. The ground stake must be driven a minimum of 2.43 m into the earth, and the earth must be treated with chemicals in order to reduce resistance to the ground stake. A maximum of 100 ohms ground resistance is recommended. Deeper ground stakes may be required depending on area soil conditions. To ground the robots and controller, proceed as follows:

**DANGER!**
Do not use the equipment if proper earth grounds cannot be provided. Equipment that is not grounded correctly can result in serious injury or death to personnel.

Note: If the robot and controller are within 4.57 m of each other, a common earth ground may be used. Otherwise, separate earth grounds must be used.

1. Connect one end of each robot earth ground cable to lug marked EARTH GROUND on base of robot.
2. Connect other end of robot earth ground cable to earth ground stake.
3. Connect one end of second earth ground cable to common ground bus bar inside the controller.
4. Connect other end of second earth ground cable to earth ground stake.

4.4.2 Connecting the Robot Cables

Two cables, 1BC and 2BC, connect each robot to the controller. The 1BC cable provides position feedback from the robot to the controller. The 2BC cable provides power to the robot servo motors.

To connect the robot cables, proceed as follows:

**CAUTION!**
Use care when attaching cable connectors to mating connectors on the robots and controllers. Do not use excessive force. Make sure that cable connectors are correctly aligned with mating connectors. The connectors are of the “multi-pin” type and are easily damaged if forced into position.

1. Unpack programming pendant and plug connector into receptacle on front door of controller.
2. Unpack two large black manipulator cables and route to controller and back of robot.
3. Connect one end of each cable (labelled 1BC and 2BC) to 1BC and 2BC connections on back of robot (see Figure 7). Connect other ends of 1BC and 2BC cables to the 1BC and 2BC connections on side of controller.
4.5 Installing the Safety Fencing

The fencing that makes up the welding cell protective walls is shipped on its own skid with all hardware needed for the installation.

**CAUTION!**
Be cautious when cutting the metal bands, and wear protective gloves. Metal bands are under tension and, when cut, may cause injury to anyone near the bands.

To install the fencing, proceed as follows:
1. Cut bands securing metal fencing and remove all items from skid.
2. Place fence components on floor around positioner according to system prints (see Figure 8).

**WARNING!**
At least two people are required for safe accomplishment of the remaining fence installation steps.

3. Connect and tighten fence posts to panels according to fence instructions.
4. Have an assistant hold the fencing in place while you attach each panel.
5. Measure to ensure that the cell walls are square (adjust as necessary).
6. Anchor the fence posts to the floor (refer to Appendix A for anchor requirements).
4.5.1 Installing the Arc Curtains

DANGER!
Do not install the arc curtains until after the cell walls have been secured. Unsecured cell walls can fall and injure personnel and damage equipment.

The arc curtains are shipped in an accessories box. To install the arc curtains:

1. Unfold arc curtains and install one curtain on inside of each cell wall section, using supplied wire ties and eyelets in curtain or Velcro depending on your design.

Note: The arc curtains are pre-cut to match the cell fencing. Each arc curtain bag contains documentation that includes the arc curtain’s dimensions. If necessary, these dimensions can be used to match the arc curtain to the correct cell fencing.

2. Make sure there are no gaps between arc curtains.
3. Install door panel arc curtain on inside of door panel using supplied wire ties and eyelets in curtain or velcro depending on your design.
4.6 Installing the Safety Light Curtains

There are two types of light curtains used on the FabWorld II Series system: floor-mounted and safety-fence mounted. One light curtain pair consists of a sender and a receiver (and associated cabling). All required light curtain pairs for the robot cell are typically shipped attached to the robot controller. To install the light curtains, proceed as follows:

1. Unpack light curtain components.
2. Carefully remove protective plastic wrapping.

*Note: Cable connections are typically left attached during shipping. If not, unpack the light curtain cables and connect them to the matching connectors on the light curtains and controller.*

3. The light curtain sender and receiver panels must be aligned properly. For exact alignment procedures, refer to the light curtain documentation that is supplied with the robot cell.
4. Identify the light curtains that are to be floor-mounted. Align the floor-mounted light curtains for proper operation, then anchor them to the floor (refer to Appendix A of this manual for anchor requirements). See Figure 1 and Figure 8 in this manual for the approximate attachment locations for the floor-mounted light curtains.
5. Identify the light curtains that will be mounted to the safety fencing. Align these light curtains for proper operation, then attach them to the safety fencing. See Figure 1 and Figure 8 in this manual for the approximate attachment locations for the safety fence-mounted light curtains.
6. Check the alignment of the light curtains again, after fence posts have been anchored. If necessary, readjust alignment and fastening of light curtains to ensure proper operation.

4.7 Installing the Operator Stations

The operator stations are shipped attached to the fencing. To install the operator stations, proceed as follows:

1. Carefully remove protective plastic wrapping from operator station.
2. Inspect operator station for shipping damage.

*Note: Notify your shipping contractor if you notice any shipping damage.*

3. Unpack operator station cables and route to controller.
4. Carefully engaging connectors, connect each cable according to the cable diagram included in the system drawing package.
4.8 Connecting Power

After all of the system components have been properly installed, connect the power to the FabWorld II Series.

DANGER!
Power must be connected only by a qualified electrician. Electrical and grounding connections must comply with applicable portions of the National Electrical Code and/or local electrical codes.

1. Install 3-phase power wiring to main service disconnect located on the controller base (and welder base for dual systems). Table 1 shows size and type of wire needed.
2. Make sure the service disconnect switch is set to the OFF position.
3. Route incoming power cable into disconnect box. Knock-out holes are provided.
4. Using a cord grip, secure incoming power cable to service disconnect housing.
5. Strip the three incoming power wires and secure them to the power disconnect connections inside. Use a phillips screwdriver to tighten.
6. Strip the ground wire and secure it to the ground lug inside the service disconnect box. A ring-tongue terminal will be needed. Nut and lock-washer are provided.
7. Turn service disconnect switch to the ON position.
8. Using a volt/ohm meter, verify incoming voltage and amperage values. Refer to label on service disconnect box and system prints for correct voltage.

Note: The FabWorld II Series is configured for 3-phase 460/480V AC, unless other voltage was requested. If other voltage is required for your plant, you must make the necessary modifications to the transformer. For more information, refer to the manipulator manual that came with your system.

Table 1 Incoming Power Specifications (Decal)

<table>
<thead>
<tr>
<th>Lug Data</th>
<th>60/75°C wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalog No.</td>
<td>TCAL14</td>
</tr>
</tbody>
</table>
| Wire Size | #14-7 Copper
#12-8 Aluminium |
| Torque | #14-7, 4.0 N•m (35 lb-in.) |
4.9 Conducting a Safety/Operation Check

Before installing tooling and/or fixtures for your application, take a few minutes to perform a safety/operation check. To conduct a safety/operation check:

1. Check that all three yellow shipping brackets have been removed from each robot Section 4.3.1.
2. Be sure safety light curtains are aligned correctly.
3. Check that cell door is closed and latched.
4. Check that all cable connections are tight.
5. Be sure welding power source is set correctly (see welding power source vendor's manual).
6. Verify incoming line power matches the input power specified on the front of the controller.

Your FabWorld II Series is now ready for power-up. The FabWorld system should be operated only by personnel who have received operator training from Motoman and who are familiar with the operation of this Motoman robot model. Turn the main power ON, and continue the safety/operation check.

7. Check all system E-Stops (pendant, operator station, breakaways, and controller door).
8. Check system Hold buttons.

4.10 Installation of Tooling and Fixtures

Your FabWorld II Series system is now ready for the installation of tooling and fixtures for your application. Installation of tooling and fixtures should be performed by personnel who are familiar with the operation of this system. Tooling and fixtures are supplied by the customer. After tooling is installed, test the positioner for proper operation.
Chapter 5
Operation

The FabWorld II Series is a fully integrated robotic arc welding cell. The Master job setup, and the sub-jobs programmed within it, determine how the system performs welding operation and other tasks. The robot(s) weld parts on the active station, while the operator loads or unloads parts on the opposite side. Once the robot(s) are finished with the welding process, they return to the Home position. The operator is then able to enter the safety zone and safely process the parts while the robot works at the opposite station.

The FabWorld II Series offers two workstations containing any combination of the following station kits: MHT-500 (500 kg capacity), and MHT-1600 (1600 kg capacity).

Note: All tooling and fixtures are supplied by the customer.

5.1 Programming

The operation of this system is programming dependent. The following operating instructions are based on one possible configuration of this system. Your system configuration and job structure may differ slightly from that presented here; however, basic operation will be the same. For additional programming instructions, refer to the NX100 Controller Manual that is supplied with your system.

Any changes made to your system configuration and/or job structure will alter the operation of this cell. Motoman recommends you do not modify the original jobs and system configuration that came with your system. If modifications need to be made, they should be made to copies of these jobs and not to the originals. Modifications should only be performed by personnel who have received operator training from Motoman, and who are familiar with the operation of this Motoman system. If you have questions concerning the configuration of your system please contact the 24 hour Service Hot-line, at (937) 847-3200 (refer to Section 1.4).

A major advantage of the FabWorld II Series system is its high degree of flexibility. The operator can fine tune the movement of both the robots and positioners according to parts configuration. The robots can be programmed to weld parts with the headstock stationary, or the robots and headstock can move simultaneously. The robots can be programmed to weld different seams on the same part and to move from part to part to continue welding.
With the NX100 programming pendant, you can develop a series of jobs for the robots. You can program the robots independently, the station axis independently, or the robots and station axis together. You must select the axis combination when first teaching the job (see Section 5.1.1). Motoman recommends programming the robots and station axis together to reduce the risk of interference.

Note: Refer to your system’s Independent/Coordinated Motion Manual (P/N 149648-1) for information on coordinated motion, selecting synchronization, group axes, and tooling calibration.

CAUTION!
Remember that only the Tool Center Point (TCP) location on the robot is recognized by the controller. Without careful programming, the robot arm can still damage other equipment.

5.1.1 Programming Specific Jobs

For more detailed information on programming user jobs, refer to Motoman Operator’s Manual for Arc Welding (P/N 149235-1).

You can program three types of moves:
- Rotation of headstock during air-cut moves
- Robot motion with headstock stationary
- Rotation of headstock during welding

The job you create may consist of a combination of the above. The first two types of moves assume a robot-plus-station group axis specification. The last type of move is called station synchronous and should be programmed with a station-plus-robot group axis specification with the station as the Master control device.

CAUTION!
Remember, only the Tool Center Point (TCP) location on the robot is recognized by the controller. Without careful programming, the robot arm could still damage other equipment.

Note: Refer to your system’s Independent/Coordinated Motion Manual (P/N 149648-1) for information on coordinated motion, selecting synchronization, group axes, and tooling calibration.
5.2 Daily Operation

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

- Perform Start-up Procedures (see Section 5.2.1).
- Move robot to Home position (see Section 5.2.2).
- Select master job (see Section 5.2.4).
- Perform Operation Cycle (see Section 5.2.5)
- Perform Shutdown Procedures (see Section 5.2.6)

5.2.1 Start-Up

To start the cell from a Power-Off condition, proceed as follows:
1. Make sure the enclosure door is closed and securely latched.
2. Turn ON main service disconnect switch.
3. Set MAIN POWER switch on R1 controller to ON.
4. Set INPUT POWER switch on welding power sources to ON.
5. Turn on welding gas supply.
6. Make sure E-Stop buttons on programming pendant and operator station are released.
7. Select TEACH mode on programming pendant; indicator light turns on.
8. Place robot(s) in Home position.

5.2.2 Robot Home Position

To place the robot(s) in the Home position, proceed as follows:
1. Select TEACH mode button on the programming pendant.
2. Press MAIN MENU on programming pendant.
3. Select JOB icon using cursor keys and press SELECT.
4. Cursor to SELECT JOB and press SELECT key.
5. Using cursor keys, move cursor to SAFE job and press SELECT.
6. Turn servo power ON by pressing SERVO ON, and holding in the ENABLE switch.
7. Using the INTERLOCK and FWD buttons on the programming pendant, jog the robot(s) to the Home position.
5.2.3 Safety Circuit Check

Test each of the following safety circuit items daily for proper operation. If any of these items do not work as instructed, contact Motoman service staff at (937) 847-3200 before operating the cell.

Gate Interlock
Open gate interlock while robot is in PLAY mode with servo power ON. Verify that servo power goes off.

Emergency Stop (E-Stop) Buttons
Press each E-Stop button with the robot in PLAY mode and the servo power ON. After each button is pressed, verify that servo power goes off and the programming pendant reads “Robot is Stopped.”

5.2.4 Starting the Master Job

With the system powered up and in TEACH mode:

1. Select the MAIN MENU key on the programming pendant touch screen.
2. Select JOB on the programming pendant touch screen.
3. Select CTRL MASTER on the programming pendant touch screen. Press SELECT twice to activate the Master job.
4. Select PLAY mode on programming pendant and press the PLAY ENABLE button on the controller door. Job playback operation is enabled.
5. Press SERVO ON button on the programming pendant.
6. Press START button on programming pendant. The Master job cycles, waiting for a Cycle Start input from operator station.

The FabWorld II Series cell is now ready for operation.

5.2.5 Perform Operation Cycle

The following is the typical sequence of operation for the FabWorld II Series cell after start-up:

1. Load fixture in station 1.
2. Step out of safety light curtain.
3. Press the CYCLE START button on the operator station. The CYCLE LATCHED light comes on and the robots begin welding parts.
4. While the robots are welding, the operator may load station 2.
5. When parts are loaded, press the CYCLE START button on operator station 2; the CYCLE LATCHED light comes on. When the robots are finished welding at station 1, they return to Home position (or if CYCLE LATCHED is active at station 2, the robots begin work at station 2), thus allowing the operator to process parts at station 1.
6. Unload welded parts from the station 1.

Note: Be sure to load the correct job before starting at first power up.
5.2.6 **Shutdown**

Use the following procedure to shut down the FabWorld II Series cell after operation is complete:

1. Make sure robots are in the Home position.
2. Turn off system servo power by pressing E-Stop button on operator station or programming pendant.
3. Select TEACH mode on the programming pendant.
4. Set the main service disconnect switch to the OFF position.
5. Close welding gas supply.

The FabWorld II Series cell is now shut down.

5.3 **System Recovery**

When a system error or alarm occurs, you must clear the error or alarm to return the system to normal operation. The paragraphs below describe the different types of alarms and errors you may encounter and how to remedy them when you do.

5.3.1 **Alarms and Errors**

Alarms and errors will cause the program to stop. There are three levels of alarms and errors: Error Messages, Minor Alarms, and Major Alarms. For more detailed information about alarm recovery, refer to the maintenance manual that came with your system.

5.3.1.1 **Error Messages**

These are simple errors such as pressing the START button when the robot is not in PLAY mode, or enabling the programming pendant when servo power is off. Clear these errors by pressing the CANCEL button on the programming pendant.

5.3.1.2 **Minor Alarms**

Minor alarms are usually programming errors. Minor alarms might occur if a circle has been programmed with fewer than three circular points, etc. Clear these errors by pressing the RESET (F5) soft key on the programming pendant.

5.3.1.3 **Major Alarms**

Major alarms are hardware failures. Major alarms might occur because of a servo tracking error or an abnormal speed and are usually associated with crashes. To clear these alarms, you must turn off the controller and then turn it on again.
5.3.2 E-Stop Recovery

An E-Stop can occur under any of the following conditions:

- Pressing E-Stop button on the operator station, programming pendant, or the controller door.
- Opening the cell door on robot enclosure when robot is not in TEACH mode.
- Stepping into light curtain when positioner is sweeping.
- Actuating shock sensor on torch mount.

To restart the FabWorld II Series cell after an E-Stop condition occurs, proceed as follows:

1. To clear E-Stop condition, perform any of the following actions that apply:
   - Release E-Stop button on operator station, programming pendant, or the controller door.
   - Close cell door.
   - Step out of safety curtain.
   - Clear Shock Sensor condition (refer to Section 5.3.3).

**CAUTION!**

If an emergency stop condition occurs while the positioner is sweeping, the positioner will continue the sweep when system is started again.

2. Press SERVO ON button on operator station or programming pendant.
3. Ensure robot is in remote mode.
4. Press START button on the operator station.

The FabWorld II Series cell is now ready to continue operation.
5.3.3 Shock Sensor Recovery

The FabWorld welding package includes a Motoman gun mount. This mount is designed to protect the torch from damage in case of a crash. A slight deflection of the torch activates a SHOCK SENSOR message which triggers an E-Stop condition. To clear the E-Stop condition, you must override the shock sensor and move the robot clear of the impact. To override the shock sensor, proceed as follows:

**CAUTION!**
Always remember to reactivate the Shock Sensor before continuing system operation. The robot can be crashed if the Shock Sensor Override Switch is left in the “Override” position.

1. Press MAIN MENU on programming pendant.
2. Select ROBOT icon using cursor keys and press SELECT.
3. Cursor to OVERRUN-S.SENSOR and press SELECT key.
4. Select RELEASE to release shock sensor.
5. Turn servo power ON by holding ENABLE switch on the programming pendant and pressing SERVO ON.

The FabWorld II Series cell is now ready to continue operation.

5.3.4 Brake Release

The robot brakes are designed to protect the robot and other system components from damage in the event of a system or robot failure and loss of drive power. If a system or robot failure occurs, it is often necessary to release the brakes on the robot to remove it from the crash site. To release the brakes, proceed as follows:

**WARNING!**
Releasing brakes can cause personal injury or machine damage. Make sure the axis to be released is properly supported BEFORE proceeding.

1. On the programming pendant, select TEACH mode and turn servo power OFF.
2. Select ROBOT on the programming pendant touch screen.
3. Select the MANUAL BRAKE RELEASE option. A Warning dialog appears.
4. Select YES in the warning dialog box.
5. Select the axis to be released using the cursor key.
6. Engage the ENABLE switch and press the Interlock and Select keys.
7. The brake for the selected axis releases.
NOTES
Chapter 6
Maintenance

Table 2 provides periodic maintenance items and intervals for the FabWorld II Series cell. The maintenance intervals listed here are intended as guidelines, only. You should adjust the frequency of maintenance to suit your specific work conditions.

For periodic maintenance procedures and schedules for the individual components of your FabWorld II Series, including the MH-Series positioners, refer to the manuals that are included with your system.

CAUTION!
Use only the antifreeze provided by Motoman. Automotive anti-freezes contain stop-leak additives that will clog small torch water-cooling ports and damage gaskets in water circulator pump.

Table 2  Periodic Maintenance

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Component</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Water Circulator</td>
<td>Check the fluid in the water circulator. Add fluid as required. Use only distilled water and approved antifreeze (Motoman P/N 131224-1).</td>
</tr>
<tr>
<td></td>
<td>(Water-cooled Torch Application only)</td>
<td></td>
</tr>
<tr>
<td>Monthly (or on condition)</td>
<td>Safety Circuits and Interlocks</td>
<td>Validate functionality</td>
</tr>
<tr>
<td></td>
<td>FabWorld Cell</td>
<td>Clean entire cell of dirt, grease, and debris.</td>
</tr>
</tbody>
</table>
NOTES
Appendix A

Anchoring

The purchaser must determine all anchoring and foundation requirements, and supply the appropriate anchoring hardware for their particular installation. Before installing the FabWorld II Series cell, refer to Table A.1 to determine the anchor and foundation requirements for all of the equipment used in your cell.

**WARNING!**

Do not mount robots directly to the floor without the indicated floor plate. Failure to follow floor plate requirements can result in severe damage or personal injury.

Table A.1 Minimum Recommended Equipment Anchor Requirements

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Minimum 'HILTI' Anchor Rod Diameter and Type</th>
<th>Minimum Floor Plate Requirements</th>
<th>Minimum Foundation Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robots: UP6, UP20, UP20-6, EA1400, EA1900</td>
<td>(4) 5/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>600mm x 600mm x 38.1mm</td>
<td>30&quot; x 30&quot; x 7&quot; thick, 4000 psi Reinforced Concrete</td>
</tr>
<tr>
<td>Robots: UP20M, UP50, SP80 (See Note 2)</td>
<td>(4) 7/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>900mm x 900mm x 50.8mm</td>
<td>60&quot; x 60&quot; x 9&quot; thick, 4000 psi Reinforced Concrete</td>
</tr>
<tr>
<td>Robots: UP120, UP130, UP165, SP100, SP160, SP250, SP400 (See Note 2)</td>
<td>(4) 7/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>1200mm x 1200mm x 50.8mm</td>
<td>72&quot; x 72&quot; x 9&quot; thick, 4000 psi Reinforced Concrete</td>
</tr>
<tr>
<td>Robots: UP200</td>
<td>(8) 7/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>1200mm x 1200mm x 50.8mm</td>
<td>72&quot; x 72&quot; x 9&quot; thick, 4000 psi Reinforced Concrete</td>
</tr>
</tbody>
</table>
### Table A.1 Minimum Recommended Equipment Anchor Requirements (Continued)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Minimum ‘HILTI’ Anchor Rod Diameter and Type</th>
<th>Minimum Floor Plate Requirements</th>
<th>Minimum Foundation Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robots: UP350, UP500, SK300X</td>
<td>(8) 7/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>1500mm x 1500mm x 50.8mm</td>
<td>72&quot; x 72&quot; x 9&quot; thick, 4000 psi Reinforced Concrete</td>
</tr>
<tr>
<td>Rotary Turntable Positioners:</td>
<td>5/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Trunnion Style Positioners:</td>
<td>7/8&quot; HVA Chemical Style anchor (See Note 3)</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Peripheral Equipment:</td>
<td>1/2&quot; Kwik Bolt II Style anchor (See Note 4)</td>
<td>Not Applicable</td>
<td>3&quot; min Thick or 1.3 Embedment Depth (whichever is larger), 4000 psi Reinforced Concrete</td>
</tr>
<tr>
<td>Cell Fence Posts:</td>
<td>3/8&quot; Kwik Bolt II Style anchor (See Note 4)</td>
<td>Not Applicable</td>
<td>3&quot; min Thick or 1.3 Embedment Depth (whichever is larger), 4000 psi Reinforced Concrete</td>
</tr>
</tbody>
</table>

Notes:
1. Minimum Robot Lagging Requirements are based on Maximum Repulsion Forces and Hilti Anchor Design Program V3.3b.
2. SP series robots require base plates and/or risers to be level within 2 degrees. Grout if necessary.
3. Reference source: *Hilti Product Technical Guide* Section 4.2.1 for hardware specifications or equivalent.
4. Reference source: *Hilti Product Technical Guide* Section 4.3.3 for hardware specifications or equivalent.
5. Robot manual requirements calling for cast-in anchors may be substituted with the recommendations listed.

**Contact Information –**
1-800-879-8000 (USA)  [http://us.hilti.com](http://us.hilti.com)
1-800-363-4458 (CAN)   [http://ca.hilti.com](http://ca.hilti.com)
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