

ROBOCARVER[®]

SYSTEM MANUAL

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

MOTOMAN INSTRUCTIONS

MOTOMAN XXXXXX INSTRUCTIONS
DX100 INSTRUCTIONS
DX100 OPERATOR'S MANUAL
DX100 MAINTENANCE MANUAL

The DX100 operator's manual above corresponds to specific usage.
Be sure to use the appropriate manual.

Part Number: 159528-1CD
Revision: 0



YASKAWA

MANUAL NO.

159528-1CD 



MANDATORY

- This user guide provides an overview of the Yaskawa RoboCarver® system. It gives general information about the system, a description of its major components, and the procedures for installation, system operation, and preventive and repair maintenance. Be sure to read and understand this manual thoroughly before installing and operating the RoboCarver® system.
- General items related to safety are listed in Section 2 of the *DX100 Controller Manual*. To ensure correct and safe operation, carefully read the *DX100 Controller Manual* before reading this manual.
- 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 equipment. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the equipment. **NEVER ALLOW UNTRAINED PERSONNEL TO OPERATE, PROGRAM, OR REPAIR THE EQUIPMENT!**

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

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



CAUTION

- Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure that all covers and shields are replaced before operating this product.
- The drawings and photos in this manual are representative examples, and differences may exist between them and the delivered product.
- YASKAWA may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications. If such a modification is made, the manual number will also be revised.
- If your copy of the manual is damaged or lost, contact a YASKAWA representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.
- YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product's warranty.

Notes for Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the Yaskawa RoboCarver® system.

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



WARNING

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



CAUTION

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



MANDATORY

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



PROHIBITED

Must never be performed

Even items described as "CAUTION" may result in a serious accident in some situations. At any rate, be sure to follow these important items.



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



WARNING

- Before operating the manipulator, check that servo power is turned OFF by pressing the EMERGENCY STOP buttons on the operator station or Programming Pendant (refer to *Figure 1*). When servo power is turned OFF, the SERVO ON LED on the Programming Pendant is turned OFF.

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

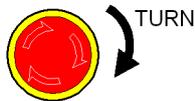
Figure 1: EMERGENCY STOP Button



- Release the EMERGENCY STOP button (refer to *Figure 2*). Once this button is released, clear the cell of all items which could interfere with the operation of the manipulator. Then turn servo power ON.

Injury may result from unintentional or unexpected manipulator motion.

Figure 2 : Release of EMERGENCY STOP Button



- Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator:
 - View the manipulator from the front whenever possible.
 - Always follow the predetermined operating procedure.
 - Ensure that you have a safe place to retreat to in case of emergency.

Improper or unintended manipulator operation may result in injury.

- Confirm that no person is present in the P-point maximum envelope of the manipulator and that you are in a safe location before:
 - Turning on the power for the DX100 controller.
 - Moving the manipulator with the Programming Pendant.
 - Running the system in the check mode.
 - Performing automatic operations.

Injury may result if anyone enters the P-point maximum envelope of the manipulator during operation. Always press an EMERGENCY STOP button immediately if there is a problem. The EMERGENCY STOP buttons are located on the operator station and on the Programming Pendant.



CAUTION

- Perform the following inspection procedures prior to conducting manipulator teaching. If problems are found, repair them immediately and be sure that all other necessary processing has been performed.
 - Check for problems in manipulator movement.
 - Check for damage to insulation and sheathing of external wires.
- Always return the Programming Pendant to the hook on the cabinet of the DX100 controller after use.

The Programming Pendant can be damaged if it is left in the manipulator's work area, on the floor, or near fixtures.

- Read and understand the Explanation of Warning Labels in the *DX100 Controller Manual* before operating the RoboCarver® system.

Definition of Terms Used Often in This Manual

The MOTOMAN manipulator is the YASKAWA industrial robot product.

The manipulator usually consists of the controller, the Programming Pendant, and supply cables.

In this manual, the equipment is designated as follows:

Equipment	Manual Designation
DX100 controller	DX100
DX100 Programming Pendant	Programming Pendant
Cable between the manipulator and the controller	Manipulator cable

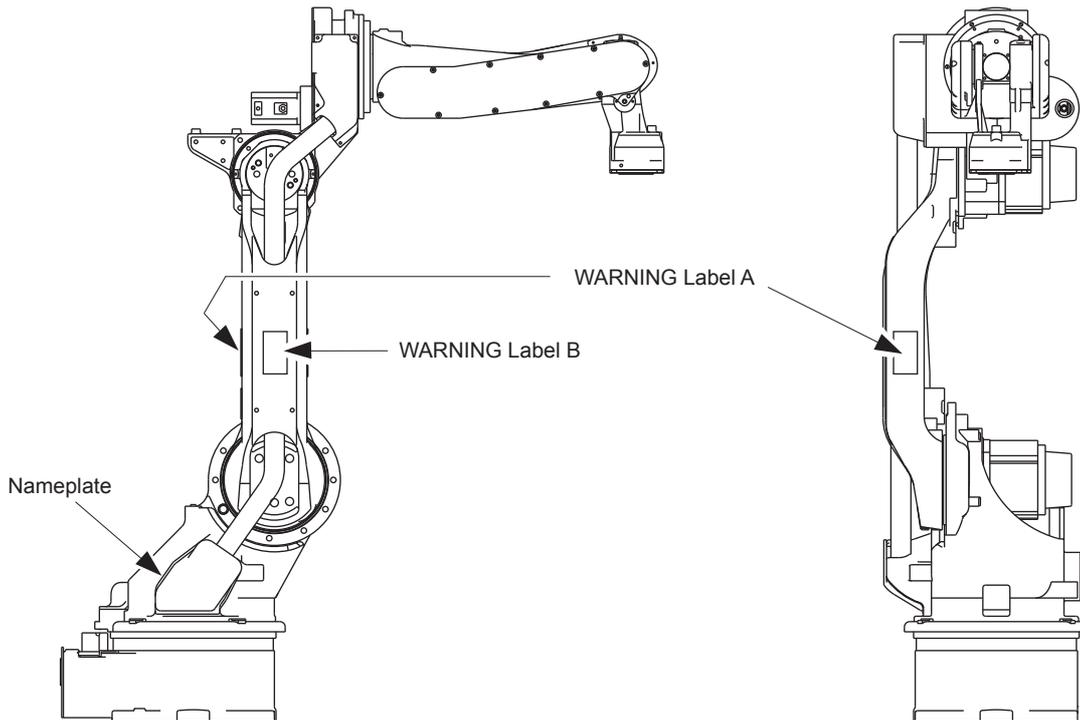
Explanation of Warning Labels

The following warning labels are attached to the RoboCarver® (refer to *Figure 3*).

Always follow the warnings on the labels.

Also, an identification label with important information is placed on the body of the RoboCarver®. Prior to operating the manipulator, confirm the contents.

Figure 3: Warning Labels Location



Nameplate:

MOTOMAN	
TYPE □□□□□□	
PAYLOAD □□ kg	MASS □□□ kg
ORDER NO. □□□□□□	DATE □□
SERIAL NO. □□□□□□	
YASKAWA ELECTRIC CORPORATION JAPAN	

WARNING Label A:



WARNING Label B:



Safeguarding Tips

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

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this equipment, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this equipment.
- Improper connections can damage the equipment. All connections must be made within the standard voltage and current ratings of the equipment.
- The system must be placed in Emergency Stop (E-Stop) mode whenever it is not in use.
- In accordance with ANSI/RIA R15.06-1999, 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).

Mechanical Safety Devices

The safe operation of this equipment 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 this equipment.

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

- Safety barriers
- Door interlocks
- Emergency stop palm buttons located on operator station

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

Programming, Operation, and Maintenance Safety

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

- Inspect the equipment to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Be sure that all safeguards are in place. Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.

- Check the E-Stop button on the operator station for proper operation before programming. The equipment must be 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 the controller unit can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to the controller unit. Making any changes without the written permission of Yaskawa will VOID YOUR WARRANTY!
- Some operations require standard passwords and some require special passwords. Special passwords are for Yaskawa use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.
- The equipment allows modifications of the software for maximum performance. Care must be taken when making these modifications. All modifications made to the software will change the way the equipment operates and can cause severe personal injury or death, as well as damage parts of the system. Double check all modifications under every mode of operation to ensure that you have not created hazards or dangerous situations.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Use proper replacement parts.
- Improper connections can damage the equipment. All connections must be made within the standard voltage and current ratings of the equipment.

Fire Safety

All locations where combustible materials are used or stored have the risk of fire. Fire can cause extensive damage, injury, and loss of life.

It is the purchaser's responsibility to provide a workspace for RoboCarver® that meets state and local occupancy classification requirements. This use classification may require certain design features such as automatic fire protection systems. The following are sample requirements:

- Locate fire extinguishers in the workspace.
- Provide access control. Limit access to authorized personnel only. Yaskawa recommends the placement of warning signs: "Authorized Personnel Only" where appropriate.
- Hazard communication: provide and properly indicate location of emergency exits per local codes.

Ignition sources must be controlled and eliminated where possible to reduce the risk of fire.

- Post hazard warning signs: “Danger, Combustible Dust May Be Present. No Smoking, No Sparks, No Open Flame.”
- All maintenance work that can produce heat or sparks must be done following standard hot work procedures.

Certain electrical circuits within this equipment are protected by fuses against over-current conditions. For continued protection against risk of fire, replace fuses only with the same type and rating specified.

Maintenance Safety

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

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

Combustible Dust Safety

Although the quantities of combustible dust from the foam carving operation are small, the dust is combustible and the accumulation of dust creates both a fire and a potential combustible dust deflagration hazard. There is no “de minimis” amount for combustible dust. Since there is a risk of fire or deflagration, National Fire Protection Association (NFPA) standards and Occupational Safety and Health Administration (OSHA) combustible dust requirements apply.

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. Yaskawa recommends that you review the following codes and standards for applicability to your project:

- Federal OSHA Combustible Dust National Emphasis Program requirements
- NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- NFPA 68: Standard on Explosion Protection by Deflagration Venting
- NFPA 69: Standard on Explosion Prevention Systems
- NFPA 77: Recommended Practice on Static Electricity
- NFPA 91: Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
- NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

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

- Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Improper operation can damage the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.
- 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. Check and test all changes at slow speed.
- All personnel involved with the operation of the carving equipment and anyone working near the unit must understand and comply with the requirements listed below:

Figure 3 includes reproductions of warning labels on the system. These labels are placed at entry points to the enclosure as shown in the system drawings.

To reduce explosion potential, do not permit dust to accumulate. Keep work areas clean and orderly.

Maintain material MSDS forms on site and ensure that all raw materials are correct and stored according to the manufacturer's recommendations.

Clean any accumulated dust. Do not allow accumulations greater than 1/8" in thickness.

Prevent dust spread by not allowing compressed air for cleaning.

Maintain records of housekeeping and maintenance activities.

Prevent dust spread by operating integral dust collection system to capture and control dust generated in the enclosure.



MANDATORY

All personnel involved with the operation of this foam carving equipment and anyone working near the equipment must understand and comply with the requirements listed below:

- Federal OSHA Combustible Dust National Emphasis Program requirements
- NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- NFPA 68: Standard on Explosion Protection by Deflagration Venting
- NFPA 69: Standard on Explosion Prevention Systems
- NFPA 77: Recommended Practice on Static Electricity
- NFPA 91: Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
- NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

Summary of Warning Information

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

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

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1 Introduction

1.1 About This Document

This system manual provides a “first look” and overview of the complete Yaskawa RoboCarver® system. You should read and understand this manual before moving on to the more detailed documentation that is included with your RoboCarver® system. Although basic in content, this manual is intended for personnel who have received operator training from Yaskawa and who are familiar with the operation of this particular Yaskawa system. For more detailed information on any specific component or peripheral of the RoboCarver® system, please review the full documentation package that is included with your RoboCarver® system (refer to *Section 1.3*).



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

This system manual contains the following sections:

Section 1 – Introduction

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

Section 2 – Equipment Description

This section provides a description of the major components of the RoboCarver® system.

Section 3 – Installation

This section provides installation procedures for the RoboCarver® system.

Section 4 – Operation

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

Section 5 – Maintenance

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

Section 6 – Anchoring

This section gives recommended anchoring hardware specifications and foundation requirements for all the equipment that is part of the RoboCarver® system.

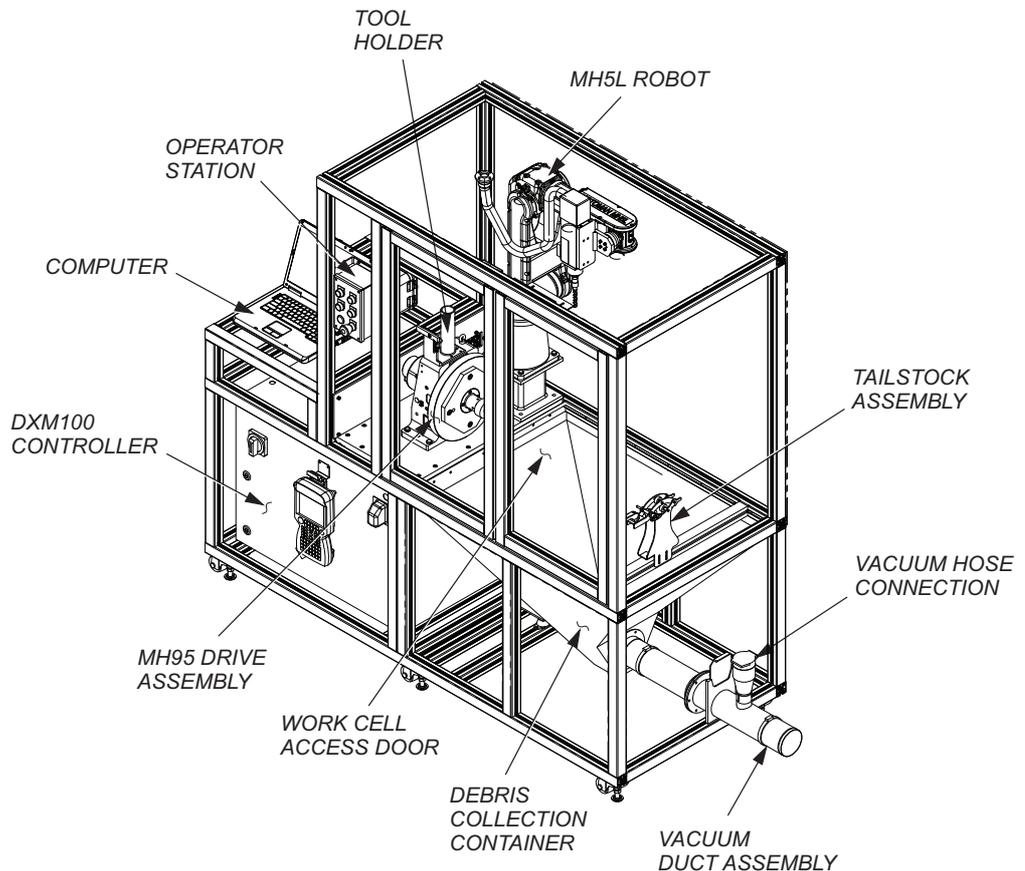
1.2 System Overview

The RoboCarver® system provides a complete multi-axis carving solution in a standardized configuration (see *Figure 1-1*). The RoboCarver® system is designed around the Yaskawa MH5L robot, DXM100 controller assembly, and MH95 headstock assembly. RoboCarver® is fully integrated with OMEGA® Tracer® software

The RoboCarver® system features a total safety environment that meets or exceeds the requirements of the ANSI/RIA R15.06 Robot Safety standard and is designed to safeguard both personnel and equipment. An extruded aluminum frame and transparent Lexan® polycarbonate shield panels provide a view of the RoboCarver® system in action, while preventing unauthorized access to the interior of the cell.

A differential pressure switch ensures that negative pressure is maintained during operation. A dual-interlocked access door at the front of the work cell provides convenient access to equipment while providing a safety interlock to disable all equipment should the access door be opened while the robot is active.

Figure 1-1: System Layout



1.2.1 System Layout

The RoboCarver® unit has been designed to accommodate standard building access points such as elevators, hallways, and doorways, making installation extremely flexible.

The MH5L manipulator (robot), MH95 headstock assembly, and DXM100 controller all share a common extruded aluminum frame for ease of installation and assurance of proper alignment between the robot and headstock/tailstock. The transparent Lexan® polycarbonate shield panels completely surround the RoboCarver® work cell.

1.2.2 Major Components

The RoboCarver® system includes the following major components:

- Motoman MH5L manipulator (robot)
- One DXM100 controller assembly
- One MH95 drive assembly and custom tailstock assembly
- One Programming Pendant (located on DXM100 controller)
- One Operator Station
- Panasonic ToughBook Computer
- Carving equipment:
 - Spindle
 - Tool
 - Tool wear sensor
- Safety equipment:
 - Heavy-gauge, extruded aluminum framing
 - Transparent Lexan® polycarbonate shield panels
 - Interlocked work-cell access door
 - Vacuum duct assembly
 - Interlocked differential pressure switch
- Software:
 - OMEGA Tracer
 - RoboCarver

1.3 Reference Documentation

For additional information on individual components of the RoboCarver® system, refer to the following documentation that is included with your system:

- Motoman *MH5L Manipulator Manual* (P/N 156483-1CD)
- Motoman *DX100 Controller Manual* (P/N 155494-1CD)
- Motoman *Maintenance Manual for DX100* (P/N 155492-1CD)
- Motoman *Operator's Manual for General* (P/N 155507-1CD)
- Motoman *DX100 Concurrent I/O Manual* (P/N 155491-1CD)
- Motoman *MH-Series Positioner Manual* (P/N bone-1CD)
- Motoman *Manual Brake Release Manual* (P/N 156239-1CD)
- Motoman *DX100 Independent/Coordinated Control Function Manual*
- Motoman *INFORM User's Manual* (P/N 155493-1CD)
- Vendor manuals for system components not manufactured by Motoman

1.4 Customer Support Information

If you need assistance with any aspect of your RoboCarver® 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:

techsupport@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.



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

Please have the following information ready before you call:

- | | |
|-----------------------|-------------|
| • System | RoboCarver® |
| • Robots | MH5L |
| • Positioner | MH95 |
| • Primary Application | Cutting |

RoboCarver®	1	Introduction
	1.4	Customer Support Information

- Controller DXM100
- 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 DX100 controller data plate

2 Equipment Description

2.1 Robot Description

The RoboCarver® system uses the Yaskawa MH5L six-axis robot. The MH5L robot is specifically designed for compact design applications with a small footprint and minimal floorspace. The MH5L robot has a payload capability of 5 kg and features a horizontal reach of 895 mm. The MH5L robot features a repeatability of ± 0.03 mm.

The MH5L robot feature an internal cabling design that provides high flexibility and streamlines the robot profile, thus allowing access into confined spaces. The robot's B-axis (Pitch/Yaw) features an expanded range of motion that improves circumferential cutting on cylindrical work pieces. The T-axis (Twist) can rotate the cutting tool ± 360 degrees without cable interference.

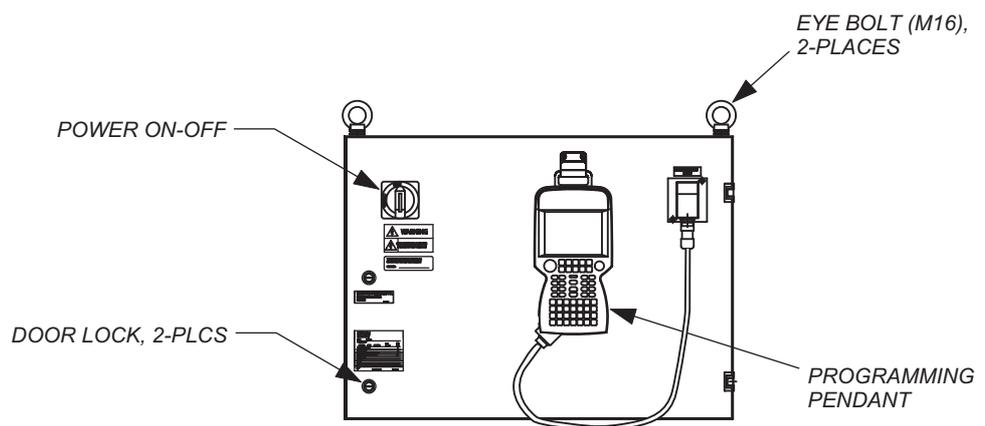
The robot's S-axis rotation is physically limited by hard stops located in the base of each robot. For more information, refer to the *MH5L Manipulator Manual* that came with your RoboCarver® system documentation package (see *Section 1.3*).

2.2 DXM100 Controller

The RoboCarver® system features a DXM100 controller (see *Figure 1-1* and *Figure 2-1*). In addition to controlling the movement of the robot, the DX100 controls the headstock and provides the signals necessary to operate the carving system.

The DX100 features an embedded real-time operating system (RTOS) and is programmed with the Motoman INFORM programming language. For more information on the DX100 controller, refer to DX100 Controller manual that came with your RoboCarver® system documentation package (see *Section 1.3*).

Figure 2-1: DXM100 Controller



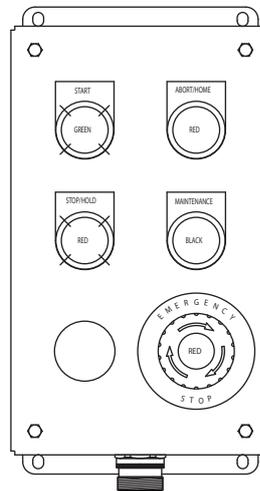


- The Programming Pendant's LCD display goes dark after a few minutes of inactivity. Press any key to restore the screen.
- Operator Station Enable or Disable is accomplished with the Programming Pendant's Mode Select Switch. To transfer control of the RoboCarver® system to the Operator Station, set the Mode Select Switch to REMOTE.

2.3 Operator Station

The Operator Station (see *Figure 2-3*) includes a NEMA enclosure mounted on the front panel. The following paragraphs describe the controls on the Operator Station.

Figure 2-3: Operator Station



2.3.1 START

Pressing the green START button starts the current, active job. The Programming Pendant's Mode Select Switch must be set to REMOTE and servo power must be ON for the START button to function.

2.3.2 ABORT/HOME

Pressing the red ABORT/HOME button stops all robot operation and returns the robot to the Home position.

2.3.3 STOP/HOLD

Pressing the red STOP/HOLD button stops robot operation and interrupts the job until the operator presses the green START button to resume operation. Operation resumes at the point in the program where the STOP/HOLD state was initiated.

2	Equipment Description
2.4	MH95 Drive Assembly

2.3.4 MAINTENANCE

Pressing the black MAINTENANCE button initiates the Maintenance job. The robot moves to the a maintenance position in which the carving tool is presented for inspection and or change out.

2.3.5 Emergency Stop (E-STOP)

Pressing the Operator Station's Emergency Stop (E-STOP) push button initiates an Emergency Stop (E-STOP). Refer to *chapter 2.6.2* for a discussion of the E-STOP function and the procedures for recovering the RoboCarver® system from the Emergency stop (E-STOP) condition.

2.4 MH95 Drive Assembly

The MH95 drive assembly provides programmable motion about a central axis with endless rotation. A faceplate adapter with ER40 collet provide for mounting customer supplied mandrel and part holder components. The MH95 drive assembly provides 105-kgf rated load with a speed of 23.8 rpm. The working envelope is a 24" (610 mm) Dia x 25" (635 mm) long cylinder.



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

The RoboCarver® system is capable of synchronized motion between various components depending on the job configuration. The robot can be synchronized with the drive assembly. For additional information on this type of independent control and coordinated motion, refer to the *DX100 Independent/Coordinated Control Function Manual* that is included with the RoboCarver® system documentation package (see *Section 1.3*).

For additional positioner information, including specifications, an illustrated parts list, load capabilities, and dimensions, refer to the *MH-SERIES SIGMA V POSITIONER* manual included with the RoboCarver® system documentation package (see *Section 1.3*).

2.5 Carving Equipment

In its standard configuration, the RoboCarver® system includes a robot mounted router spindle, cutting tool, OMEGA Tracer CAD/CAM software, and vacuum duct assembly. Optional equipment may also be included with your RoboCarver® system.

2.5.1 Router Spindle

The RoboCarver® features an RV55 spindle from Precision Drive Systems. The spindle motor draws fresh air from outside the enclosure to pressurize the motor enclosure and prevent entry of dust. For specific information, refer to the vendor manual included with your system documentation package (see *Section 1.3*).

RoboCarver®	2	Equipment Description
	2.6	Safety Features

2.5.2 Cutting Tool

The RoboCarver® includes a single end, 2 or 4 fluted, ball end mill. This end mill is designed to machine soft materials and is ideal for foam applications. The deep flutes prevent chip packing and the high helix angle provides shearing action and rapid chip evacuation. For specific information on the mill tool supplied with your RoboCarver® system, refer to the vendor documentation included with your system documentation package (see *Section 1.3*).

2.5.3 OMEGA Tracer CAD/CAM Software

The RoboCarver® system is fully integrated and compatible with the OMEGA Tracer software. For specific information on the OMEGA Tracer software, refer to the vendor manual included with your system documentation package (see *Section 1.3*).

2.5.4 Vacuum Duct Assembly

The RoboCarver® system is fully ready to be integrated with your facilities dust collection system. The system has been designed to collect debris in a debris collection container. A standard 4" vacuum connection pipe with gate is provided for connection with your facilities dust collection system. An additional vacuum cleaning tap is provided, designed to accept a 10' 1-1/4" diameter flex hose. For more information, refer to the system prints included with your system documentation package (see *Section 1.3*).

2.6 Safety Features

The RoboCarver® system includes a total safety environment. If you comply with all the safety instructions and precautions given throughout this manual, the safety equipment helps to ensure safe operation of the robot work cell.



Users are responsible for determining that the safeguards provided with the RoboCarver® system are adequate for their installation conditions. Users must also ensure that all safeguards are maintained in working order.

2.6.1 Safety Enclosure

An extruded aluminum frame and transparent Lexan® polycarbonate shield panels provide a view of the MotoCarver® system in action, and aids in the collection of combustible dust, while preventing unauthorized access to the interior of the cell.

A dual-interlocked access door at the front of the work cell provides convenient access to equipment while providing a safety interlock to disable all equipment should the access door be opened while the robot is active.

2.6.2 Emergency Stop (E-STOP)

Emergency Stop (E-STOP) is a primary safety feature of the RoboCarver® system. Both the work-cell access door interlock, and the E-STOP push 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 *chapter 2.6.4*). The E-STOP push buttons are used for an intentional shutdown of the RoboCarver® system and are installed at the following locations:

- Programming Pendant
- Operator Station

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

2.6.3 Programming Pendant's ENABLE Switch

The ENABLE switch is part of the Programming Pendant and provides a safety feature that controls servo power while the system is in TEACH mode (see *Figure 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 switch, refer to the DX100 *Operator's Manual for General Purpose* that is included with the RoboCarver® system documentation package (see *Section 1.3*).

2.6.4 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 incorporates 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 DX100 *Manual Brake Release* manual included with the RoboCarver® system documentation package (see *Section 1.3*).

2.6.5 Interlocked Work-cell Access Door

The work-cell access door features a safety interlock (see *Figure 1-1*). Any attempt to open the access door while the robot is in PLAY mode triggers an E-STOP condition (refer to *chapter 2.6.2*).

2.6.6 Interlocked Differential Pressure Switch

The work-cell enclosure features a differential pressure switch. If negative pressure is not maintained while the robot is in PLAY mode, a STOP/HOLD condition is triggered (refer to *chapter 2.3.3*).

3 Installation



CAUTION

- The RoboCarver® system should be installed by qualified personnel who are familiar with the installation and setup of a robotic system.
- Be sure to handle all system components with care. While the RoboCarver® system is not extremely fragile, it is a sophisticated robotic system that can be damaged by rough handling.

Two to three qualified technicians can install the RoboCarver® system in a reasonable amount of time. Always comply with all the safety instructions and precautions given throughout this manual during the installation process.

The instructions given in this section are general guidelines for installing the RoboCarver® system. Refer to your system drawings and relevant system component manuals for specific installation information (see *Section 1.3*).

3.1 System Requirements

All system components and most hardware items required for installation of the RoboCarver® system are included with your shipment. There are, however, some required items that the customer must supply, such as vacuum and dust collection system.

The environment in which RoboCarver® with filtration is installed should meet the following requirements:

- No electrical machines or devices within 65 feet that may produce high-frequency noise. Examples of such machinery include:
 - Arc welder
 - Resistance welder
 - High frequency drier
 - Electric discharge machine
- No Smoking

3.1.1 Dust Collection Requirements

The customer is responsible for providing an adequate vacuum and dust collection system to capture and convey dust away from the carving process.

3.1.2 Electrical Requirements



WARNING

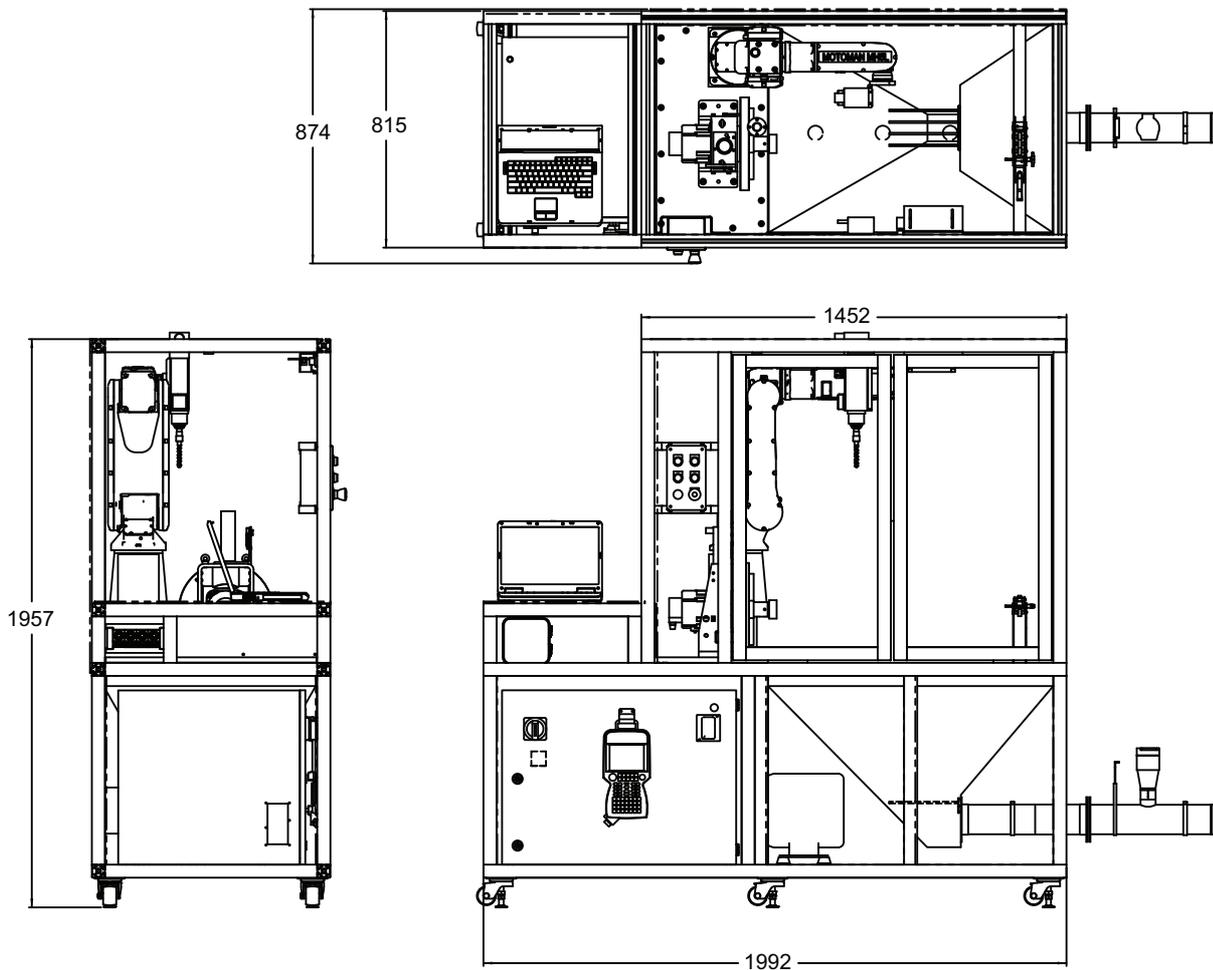
- Local electrical service connection to the RoboCarver® system must be performed by a qualified, licensed electrician. Electrical and grounding connections must comply with the National Electrical Code (NEC), as well as all state and local electrical codes.

Electrical Consumption	approx. 10.8 kVA
Current	10 Amps
Circuit	Dedicated and noise free
Voltage	220-240 VAC, single phase
Frequency	60 Hz [+/-1%]
Ground Requirements	Resistance, less than 1×10^6 Ohms
Temperature	5 to 40° C (41 to 104° F)
Humidity	10% to 80% RH (no condensation)

3.1.3 Weight and Space Requirements

The RoboCarver® unit must be installed on a flat surface capable of supporting 1250 kg (or approximately 2756 lbs). The surface must be level and stable. Allow an additional 1.2 - 1.5 m (4 to 5 ft.) on all sides of the system to provide clearance needed for installation and servicing.

Fig. 3-4: General System Dimensions



3.2 Unpacking the RoboCarver® Unit

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



If you notice any equipment damage, notify your shipping contractor as soon as possible.



WARNING

- Forklift truck operation should be performed only by licensed personnel. Never place any part of your body under a suspended load or move a suspended load over any part of another person's body. Careless handling may result in severe personal injury or death.

Unpack the RoboCarver® unit from the shipping container as follows:

1. Unbolt the RoboCarver® unit from the shipping pallet.
2. Discard or recycle the shipping skids and other shipping materials.



WARNING

- The RoboCarver® unit weighs approximately 1250 kg (2756 lbs). Ensure that your lifting device is rated to safely handle this load.

3. Using a forklift or overhead crane, lift the RoboCarver® unit from the shipping skid.

3.3 Installing the RoboCarver® Unit



WARNING

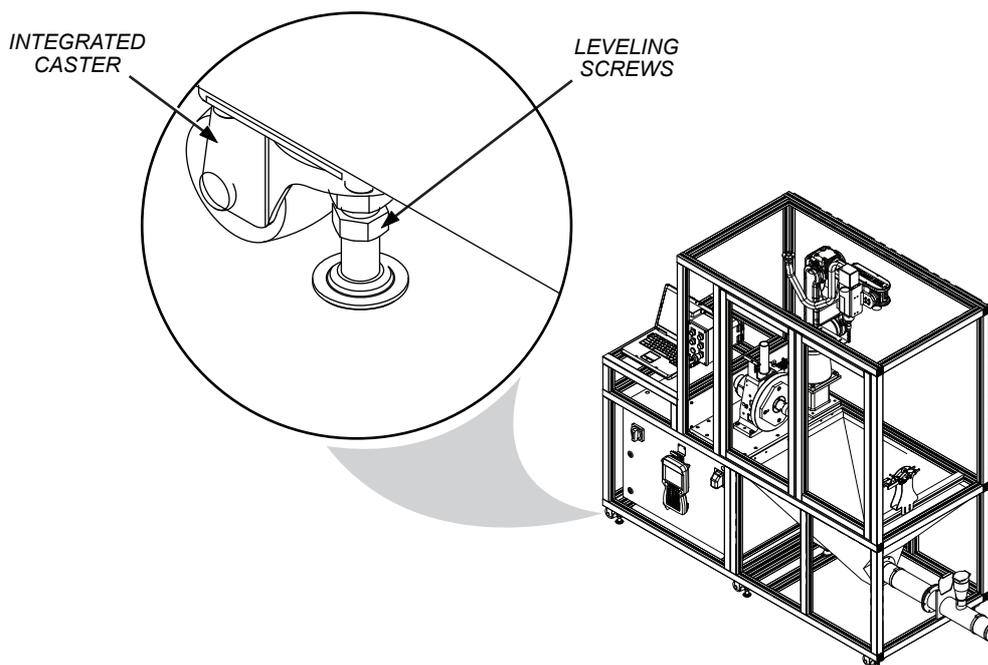
- The RoboCarver® unit weighs approximately 1250 kg (2756 lbs). Use caution when moving the RoboCarver® unit on inclines to avoid damage to the equipment or injury to personnel.

RoboCarver® has been designed to accommodate most building access points such as elevators, hallways, and doorways, making installation extremely flexible. However, some disassembly may be required to access locations with less than 36 inches of clearance. Integrated castors allow easy movement of the RoboCarver® unit by two to three people.

The RoboCarver® unit should be firmly fixed to the floor or foundation rigid enough to support the unit. The surface of the floor should be level and even. Integrated levelling pads are used to raise the unit off the casters and to provide proper level.

1. Raise the leveling screws high enough to provide adequate clearance for the integrated castors.

Fig. 3-5: Integrated Casters



2. Using the integrated castors, move the RoboCarver® unit into position. Allow an additional 1.2 - 1.5 m (4 to 5 ft) on all sides of the system to provide the clearance needed for installation and servicing.
3. Lower the leveling screws and raise the unit off the integrated castors to provide a stable and level installation.

3.3.1 Leveling the RoboCarver® Unit

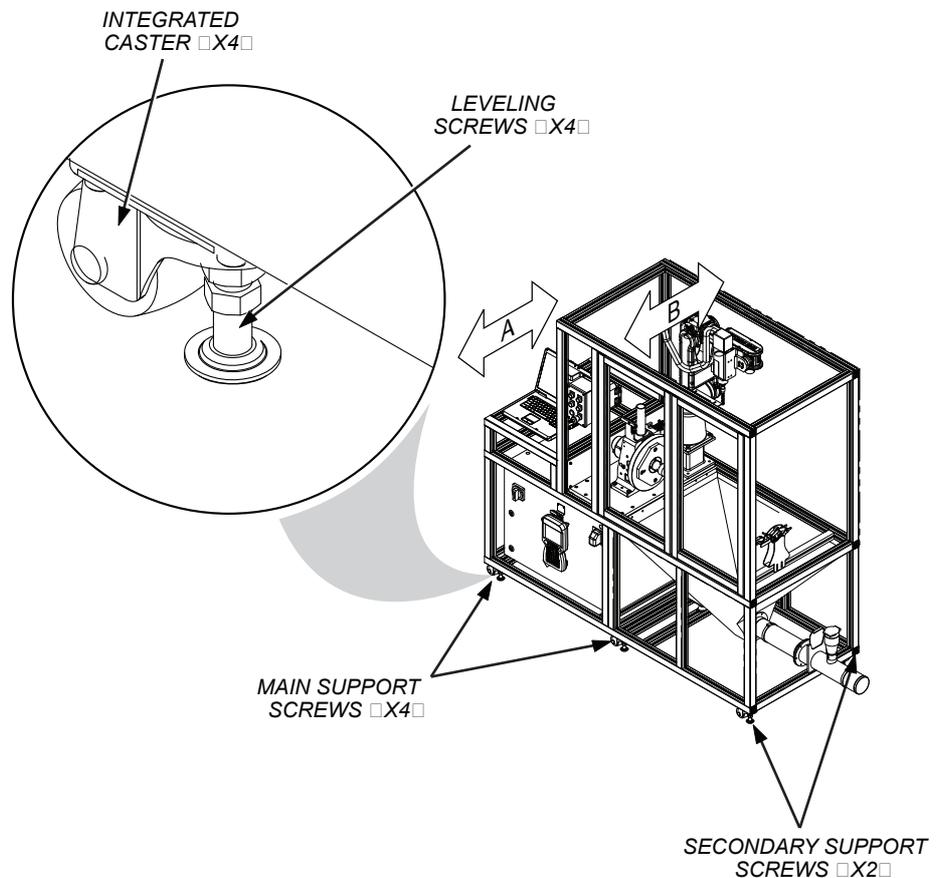
With the unit located in place, the unit must be properly leveled as required for your installation.

1. Place a spirit-level on the top center rear of the unit.
2. Adjust the left to right level using the left and middle (main support) leveling screws on the back of the unit.
3. Place a spirit-level on the left side of the unit (point A).
4. Adjust the front to back level using the main leveling screw on the front left corner.
5. Place a spirit-level in the middle of the unit (point B).
6. Adjust the front to back level using the main leveling screw in the middle of the unit.



The front panel must be removed to gain access to center-rear leveling screw.

7. With the unit level, lower the two secondary support screws, located on the right side of the unit, until they touch the ground and then turn an additional half turn.



3.4 Installing the Computer

The laptop computer is shipped in its original packaging. The computer power and communication cables remain routed within the RoboCarver® unit during shipping.

1. Unpack the computer from its shipping box.
2. Discard or recycle the shipping box and other packing materials.
3. Place the laptop computer on the laptop shelf.
4. Make all necessary power and communication cable connections according to vendor documentation provided.

3.5 Connection to Vacuum System (Customer Supplied)

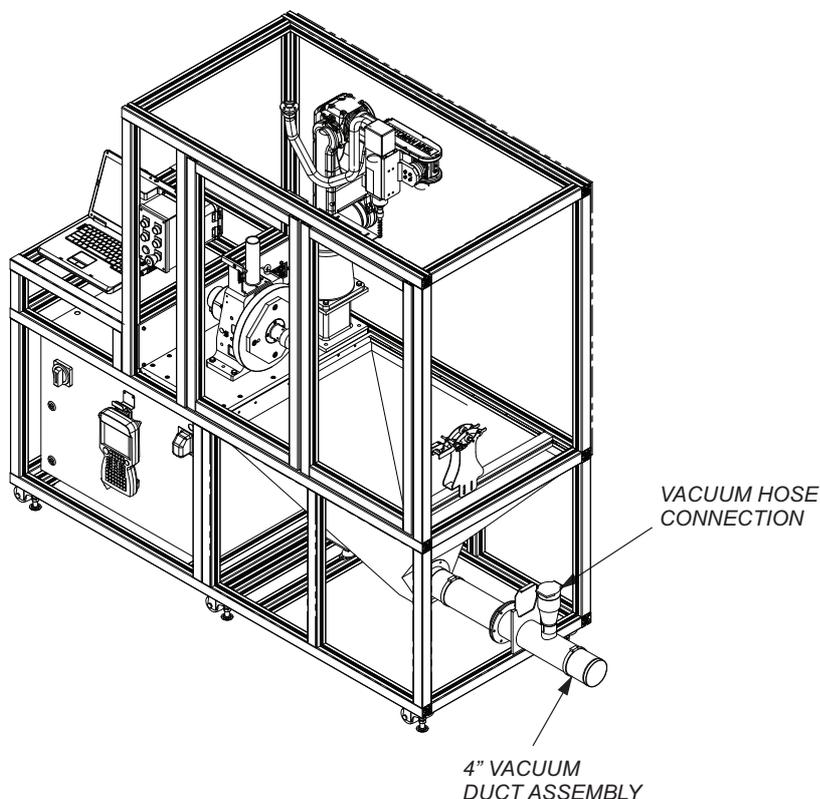


WARNING

Yaskawa assumes no liability for vacuum and dust collection. The customer is responsible for providing adequate vacuum and dust collection to capture and convey dust away from the carving process.

RoboCarver® includes an 4" duct assembly for connecting to your integral vacuum system. A vacuum cleaning tap is also included to aid in cleaning the enclosure. Customer must provide vacuum system with filtration.

Fig. 3-6: Vacuum System Connections



3.6 Connection to Local Electrical Service



WARNING

Local electrical service connection to the RoboCarver® system 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.



The RoboCarver® system is configured for single-phase 220/240V AC primary power. For additional information, refer to the electrical drawings and schematics that are included with your system documentation package (see *Section 1.3*).

After all the system components have been properly installed and interconnected, connect local electrical service to the RoboCarver®. The power line should connect directly to a power source known to be clear of erratic power loads, spikes, and electromagnetic interference. Power lines reserved for instrument use should have adequate reserve capacity. Normal loading should not exceed 50% of nominal capacity to allow for start up loads and the addition of new instruments.

1. Remove the back panel from behind the DXM100.
2. Open the front door of the DXM100.
 - a) Using a flathead screwdriver, rotate the door locks on the front of the DX100 (two places) 90 degrees clockwise.
 - b) Rotate the main power supply switch to the "OFF" position and open the door gently.
3. Confirm that the primary power supply is OFF.
4. Remove the cover on the upper right side of the back of the DX100.
5. Run the primary power supply cable from the cable clamp below the cover to the ACINXT terminal block.
6. Connect the cable to the ACINXT terminal block.
7. Connect a ground wire to the terminal block ACINXT to reduce noise and prevent electric shock. Perform grounding in accordance with all relevant local and national electrical codes.

3.7 Safety/Operation Check

Before installing the customer supplied part holder and mandrel fixtures for your application, take a few minutes to perform the following safety/operation check:

1. Check the security and integrity of all cable connections.
2. Ensure that the work-cell access door is closed and the door interlock is engaged.
3. Verify that local electrical service complies with the power requirements for your RoboCarver® system.



CAUTION

The RoboCarver® system is now ready for power-up. Qualified, trained personnel who are familiar with this system should perform the power-up sequence.

4. Set the power ON-OFF switch on the DXM100 controller to ON (see *Figure 2-1*).



WARNING

Before operating the robot, verify that each E-STOP push button disables servo power when activated (pushed in). Each E-STOP push button must immediately stop robot and positioner movement when activated (pushed in).

5. Check for correct operation of all E-STOP push buttons (refer to *Section 2.6.2*).
6. Check for correct operation of the system HOLD buttons on the Programming Pendant and Operator Station (ROBOT HOLD). Refer to the *Operator's Manual for General* for more information on the pendant's HOLD button (see *Section 1.3*). For more information on the Operator Station's STOP/HOLD and ABORT/HOME buttons (see *Section 2.3*).
7. Check for correct operation of the work-cell access door safety interlock.
8. Remove power from the RoboCarver® system after completion of the safety/operation check.

RoboCarver®	3	Installation
	3.8	Installation of Tooling and Fixtures

3.8 Installation of Tooling and Fixtures

Your RoboCarver® system is now ready for installation of the spindle and mandrel fixtures for your particular application. Personnel who are familiar with the operation of the RoboCarver® system should perform the installation. After tooling installation, test the headstock for correct operation. Refer to the positioner headstock manual for information on how to test that the positioner is operating correctly (see *Section 1.3*).



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

4 Operation

This section provides a brief overview of the operating procedures and precautions for your RoboCarver® system. For more detailed operating information, refer to the specific component manuals that are part of the RoboCarver® system documentation package (see *Section 1.3*).

The RoboCarver® system is a fully integrated robotic multi-axis carving CAD/CAM cell. A Yaskawa MH5L robot carves parts on a customer supplied part holder and mandrel mounted to an MH95 drive assembly. When the robot completes the carving process, it returns to HOME (Safe) position. The operator can then open the access door and remove the completed part, load a new part to be processed and press START to begin another carving 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. Your system configuration and job structure may differ slightly from that presented here; however, basic operation will be the same. For additional programming procedures and information, refer to the OMEGA Tracer documentation that is included with your RoboCarver® system documentation package (see *Section 1.3*).

Any changes made to your system configuration and/or job structure will alter the operation of the system. Yaskawa recommends that you **do not** modify the original programs and system configuration of your RoboCarver® system. **If you determine a need to modify the original programs and system configuration, make any modifications to a copy of the original. Keep the original as a backup. Do not modify the original.** Modifications must be performed by trained and experienced personnel who are familiar with the operation of the RoboCarver® system. If you have questions concerning the configuration of your system, please contact Motoman's 24-hour Customer Support (refer to *Section 1.4*).

4.2 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 the start-up procedure (refer to *Section 4.2.1*).
- Move the robot to HOME position (refer to *Section 4.2.2*).
- Select the Control Master job (refer to *Section 4.2.3*).
- Perform the operation cycle (refer to *Section 4.2.4*).
- Perform the shutdown procedure (refer to *Section 4.2.5*).

4.2.1 Start-up Procedure

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

1. If installed, switch the electrical service disconnect box to ON.



An electrical service disconnect box for the system shall be supplied (if desired) by the customer. It is not part of the RoboCarver® system shipment.

2. Set the power ON-OFF switch on the DXM100 controller to ON (see *Figure 2-1*).
3. Set the power ON-OFF switch on the laptop computer to ON.
4. Start the OMEGA Tracer software from the PC Start Menu or Desktop icon. The Tracer Start screen appears.
5. Make sure that the work-cell access door is closed and operating properly and the door safety interlock is engaged.
6. Make sure all E-STOP buttons are released. E-STOP buttons are installed at the following locations:
 - Programming Pendant
 - Operator Station
7. Select TEACH mode on the Programming Pendant.
8. 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.
3. Select JOB 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 in the ENABLE switch.
7. Use the FWD button on the Programming Pendant to jog the robot to HOME position.

4.2.3 Master Job

With the system powered up and in TEACH mode, call up the 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 Master job.
4. Select PLAY mode on the Programming Pendant (job playback operation is enabled).
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 input from the Operator Station).

7. Transfer control to the Operator Station by selecting REMOTE on the Programming Pendant's Mode Select Switch.

The RoboCarver® work cell is now ready for operation.

4.2.4 Operation Cycle

The following is the typical sequence of operation for the RoboCarver® work cell after start-up:



WARNING

- RoboCarver® shall not be operated if there is a dust accumulation greater than 1/8" in thickness at any location inside the enclosure.
- Do not operate RoboCarver® unless the integral vacuum system is operational and the differential pressure switch indicates that the vacuum system is operational.



CAUTION

- Take appropriate safety precautions to eliminate contact with dust in the enclosure. Wear suitable coveralls, a particulate mask, and safety goggles.

1. The operator opens the access door and loads the positioner drive assembly with the part to be carved.
2. The operator closes the access door and moves to the laptop computer.
3. The operator uses the OMEGA Tracer software to generate the appropriate programs for the part.
4. The operator presses the green START button on the Operator Station.
5. The robot begins to carve the part.
6. When the robot is finished carving, it returns to HOME position.
7. The operator presses the E-STOP button. The door unlocks, enabling the operator to unload the completed, carved parts.
8. The operator empties the dust collection hopper after each piece is completed.

4.2.5 Shutdown Procedure

Use the following procedure to perform a normal shutdown of the RoboCarver® system:

1. Make sure the robot is in HOME position.
2. Shut down the software applications and laptop in a safe manner.
3. Turn off the system servo power by pressing the E-STOP button on the Operator Station or Programming Pendant.
4. Select TEACH mode on the Programming Pendant.

5. Set the DXM100 controller power ON-OFF switch to the OFF position.
6. Switch the DX100 controller disconnect box (if installed) to OFF.



An electrical service disconnect box for the DX100 controller shall be supplied (if desired) by the customer. It is not part of the RoboCarver® system shipment.

The RoboCarver® system is now shut down.

4.3 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 might encounter and how to remedy them when you do.

4.3.1 Alarms and Errors

There are three levels of alarms and errors that will stop the program:

- Error messages
- Minor alarms
- Major alarms

For more detailed information on alarm and error recovery, refer to the maintenance and DX100 controller documentation that is included with your RoboCarver® system (refer to *Section 1.3*).

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 robots are 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

Major alarms usually involve hardware failures. Examples of this type of error include an overload condition and abnormal speed.

Clear alarms of this type by cycling the DX100 controller in accordance with the following steps:

1. Rotate the DX100 controller's power ON-OFF switch to OFF.
2. Allow the controller's power ON-OFF switch to remain in the OFF position for approximately 10 seconds.
3. Rotate the controller's power ON-OFF switch to ON.

4.3.2 E-STOP Recovery

An E-STOP (emergency stop) will occur under any of the following conditions:

RoboCarver®

-
- 4 Operation
 - 4.3 System Recovery
-

- An E-STOP button is pushed in (activated).
- The work-cell access door is opened while the robot is not in TEACH mode.

After an E-STOP condition occurs, restart the RoboCarver® system as follows:

1. To clear the E-STOP condition, perform any of the following actions that apply:
 - Release the activated E-STOP push button
 - Close the work-cell access door
2. Press the SERVO ON button on the Programming Pendant.
3. Select REMOTE mode on the Programming Pendant's Mode Select Switch to transfer control of the system to the Operator Station.
4. Press the green START button on the Operator Station.

The RoboCarver® system is now ready to continue operation.

5 Maintenance

Maintenance must be performed by authorized personnel who are familiar with the RoboCarver® system. Be sure to read and understand the documentation for a particular component before doing repair maintenance or preventive maintenance on that component. Be sure that you understand the maintenance procedures, have the proper tools at hand, and comply with all the safety instructions and precautions given throughout this manual.

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

For periodic maintenance procedures and schedules for the individual components of your RoboCarver® system, refer to the documentation that is included with your system documentation package (refer to *Section 1.3*).



CAUTION

- Maintenance procedures inside the machine enclosure may only be performed after the machine has been cleaned.
- Do not use compressed air to clean the carver. This will send dust into the bearing seals and the surrounding atmosphere.
- Yaskawa recommends wearing a particle mask/respirator during cleaning for protection against fine dust particles.

Table 5-1: Periodic Maintenance

FREQUENCY	COMPONENT	PROCEDURE
Daily (or on condition)	RoboCarver® Work Cell	Clean machine after each use. Brush down all accessible parts with a soft hand brush, and remove waste using integral vacuum system and vacuum cleaning tap and hose. Check for any damage to the interior and exterior of machine.
	All safeguard items – work-cell door interlocks, E-STOP push buttons, etc.	Check the physical condition of the safeguard item and ensure that it is working correctly.
One Month (or on condition)	RoboCarver® Work Cell	Remove accumulated debris, from inside and outside the work cell.

5.1 Cleaning

5.1.1 Cleaning the Clear Panels

1. Soften dirt by wiping with lukewarm water.
2. Gently remove dirt with a sponge or soft cloth and a solution of lukewarm water and ordinary household cleaner or mild soap.
3. Repeat the cleaning process, then dry the panel with a soft cloth.



- Do not scrub clear panels with brushes or instruments.
- Avoid contacting the surface with Butyl Cellosolve, Isopropanol, or any other solvents.
- Avoid any abrasives or cleaners of a highly alkaline nature.
- Test any cleaner on a small area of the carver prior to use.
- Solvent cleaners which state they are suitable for use on polycarbonates may not be safe for use on the clear panels.

5.1.2 Cleaning the RoboCarver® Interior

The interior shall be cleaned after every workpiece. This cleaning shall direct any accumulated dust into the vacuum dust collection system.



WARNING

- Do not use a conventional vacuum cleaner for cleaning machining waste.
- Do not use cleaning tools with steel parts for cleaning dust.
- Vigorous sweeping or blowing down with compressed air produces dust clouds and is not permitted.
- Yaskawa recommends wearing a particle mask/respirator during cleaning for protection against fine dust particles.

1. Close the vacuum connection pipe by loosening the wingnut and lowering the gate.
2. Open the cleaning tap cover and insert 10' flex hose.
3. Clean all surfaces in a manner that minimizes the generation of dust clouds.
4. Clean the coarse filter of all accumulated particles.
5. Remove and store the hose when complete.
6. Open the vacuum connection pipe by raising the gate and tightening the wingnut to keep gate open.

RoboCarver®	5	Maintenance
	5.1	Cleaning

5.1.3 Cleaning the Room

All employees working near RoboCarver® shall be trained on combustible dust hazards. The equipment must be maintained and operated in a manner that minimizes the escape of dust. The room where RoboCarver® is located should be checked daily for dust build up and cleaned as needed.

ROBOCARVER[®]

SYSTEM MANUAL

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MANUAL NO.

159258-1CD