

 **Flow**

MACH 2C SERIES

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Mach 2c Series

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Introduction

The information in this manual will help you become familiar with your new Flow International (FLOW) equipment. It was compiled from the most current information available at the time of publication and is intended to cover the most common configurations.

Safety

All operating personnel and service technicians must read and follow the procedures in this manual and in all manuals provided with the equipment, to avoid creating unsafe conditions, or risking damage to the equipment.

The comprehensive list of safety precautions in Chapter 2 must be followed to ensure safe operation of the equipment. These precautions must be reviewed and understood by operating and maintenance personnel before installing, operating, or servicing the equipment. The high-pressure waterjet system is a powerful cutting tool and must always be treated with respect.

Manual MS-2281, European Safety, is also provided as part of the equipment documentation.

Warnings, cautions, & notes

Before operating the equipment, please read, thoroughly understand, and follow all warnings, cautions, and notes that appear in this manual. They are defined as follows:

WARNING

Highlights an operating or service procedure or condition that can result in death or serious injury to personnel.

CAUTION

Highlights an operating or service procedure or condition that can lead to impaired system operation or equipment damage.

Note: Highlights an operating or service procedure or condition that is essential for efficient operation and service.

CHAPTER 1

Equipment Description

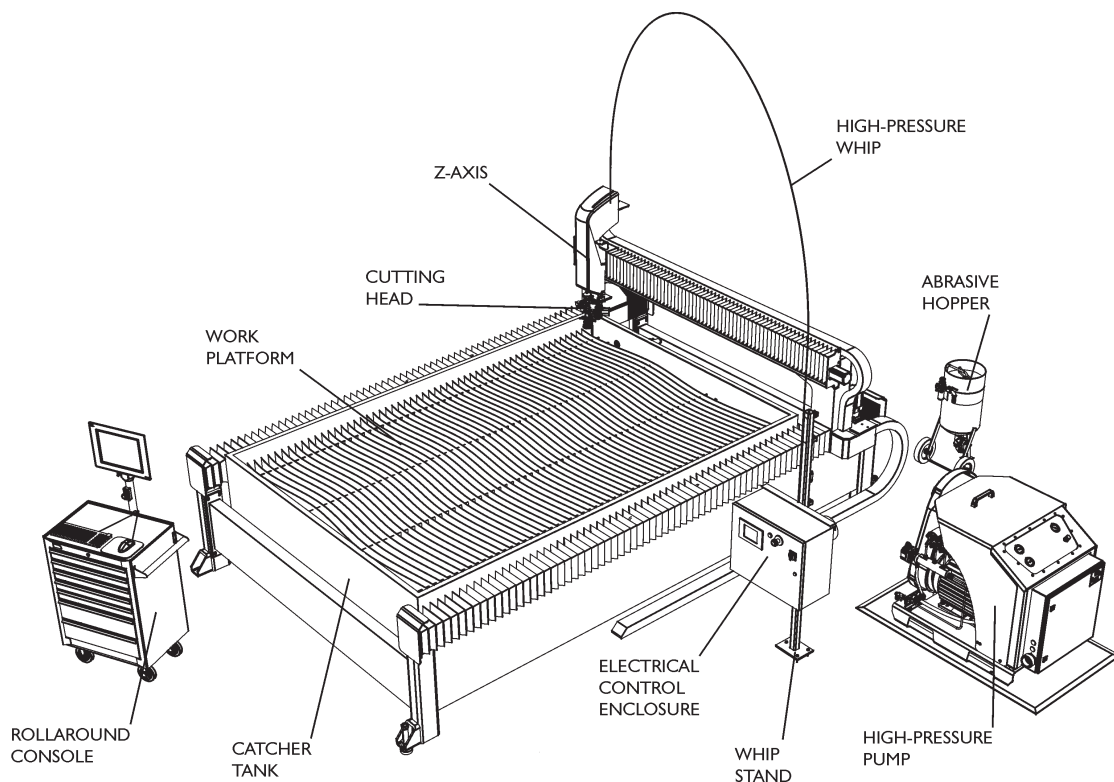
The Mach 2c Series systems combine a gantry design cutting table with a PASER® 4 abrasivejet, ultrahigh-pressure pump, and PC-based controller into a production-ready machine tool. Quick and simple part programming using FlowPATH and FlowCUT generates machine motion from a standard DXF (CAD) file.

System components

X-Y motion system

The Mach 2c uses a helical rack drive system to drive the base axis (Y), and ballscrews for the other axes (X and Z). Features of the X-Y system include:

- Anti-skew software for accurate bridge movement.
- Base, bridge, and vertical axes have recirculating ball, linear bearings, and hardened precision ground ways.
- Environmental protection package designed for abrasivejet applications.



End effector

The Mach 2c Series system is available with a couple cutting head options. Cutting heads are described in the listed manuals.

- M-398, PASER 4
- M-386, Dynamic Waterjet

PC-based controller

- Refer to the integrated help guides in the FlowMaster® software for programming and operation information.

Ultrahigh-pressure pumps

There are three pumps available for the Mach 2c. Refer to listed manual for complete information.

Intensifier pump

60,000 psi (4140 bar)

- M-287, 7X pump
- M-387, 30SA pump

Direct drive pump

55,000 psi (3792 bar)

- M-416, HyPlex Prime

Abrasivejet system

The abrasivejet system includes an abrasive delivery hopper and a cutting head.

The abrasive delivery hopper is available as an integrated hopper with no external controls, or a standalone unit with external controls.

The abrasive level switch on an integrated hopper is monitored through the software.

- Refer to the PASER 4 manual for complete information.

Catcher tank

The catcher tank supports the cutting envelope surface. The levelness of the tank and the water in the tank is important to maintain consistent cutting quality.

Note: Use caution when handling materials around the machine to prevent damage to the base rail bellows.

Light curtain safety device

The Mach 2c Series systems operating in Europe can be equipped with a light curtain to maintain a safety perimeter around the machine and to comply with CE requirements.

Control system

The Mach 2c uses state-of-the-art digital electronics that provide power and control functionality for the entire system. This system meets or exceeds IP65 environmental protection and European specifications.

Digital drive system

The cutting head moves in X, Y and Z directions. The Y-direction is parallel to the base rail, the X-direction is parallel to the bridge.

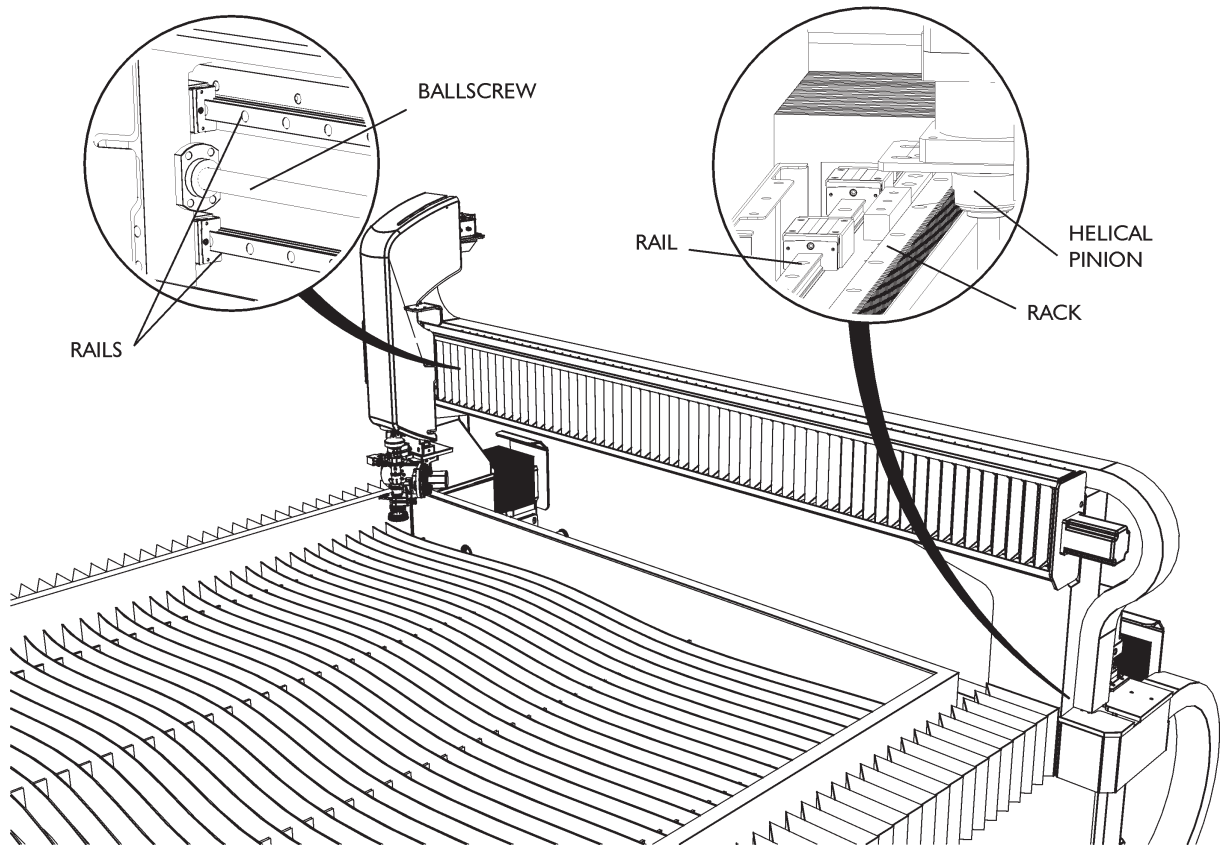
- The Y-motion is generated by moving the bridge on the linear units (buses) mounted in parallel.
- The X- and Z-axes are driven via a conventional ballscrew system.

The axes must be homed before use, and the Z,A,B axis needs to be homed before the X,Y. Refer to the integrated help in the FlowMaster software.

Helical rack and pinion drive system

The Mach 2c uses a helical rack-and-pinion system to provide linear motion on the Y-axis.

See the Maintenance chapter in this manual for lubrication requirements.



System specifications

<i>Table size</i>	<i>2020</i>	<i>2031</i>	<i>2030</i>
System size			
Bridge axis travel	2.1 m	2.1 m	2.1 m
Base axis travel	2.1 m	3.15 m	4.1 m
Z-axis travel	152 mm (6 in.)	152 mm (6 in.)	152 mm (6 in.)
Speed			
Max. traverse speed	800 ipm (20 m/min)		
Max. cutting speed	500 ipm (127 m/min)		
Accuracy			
Linear accuracy	+/- 0.005 in. (0.1 mm)		
Repeatability	+/- 0.002 in. (0.05 mm)		
Drive system			
Drive motor	Two-phase brushless servo motor		
Drive structure	Bridge: Ballscrew with linear rail Base: Helical rack & pinion with linear rail		
Catcher tank			
Work envelope	2 x 2 m	2 x 3.1 m	2 x 4 m
Max. loading capacity	68 Kg (150 lb/ft ²)		

Optional equipment

The following options are available for the Mach 2c system. Refer to the listed manuals for complete information.

Final Filter

- M-360

UltraPierce Vacuum Assist

- M-307

Dynamic Contour Follower

- M-379

Notes

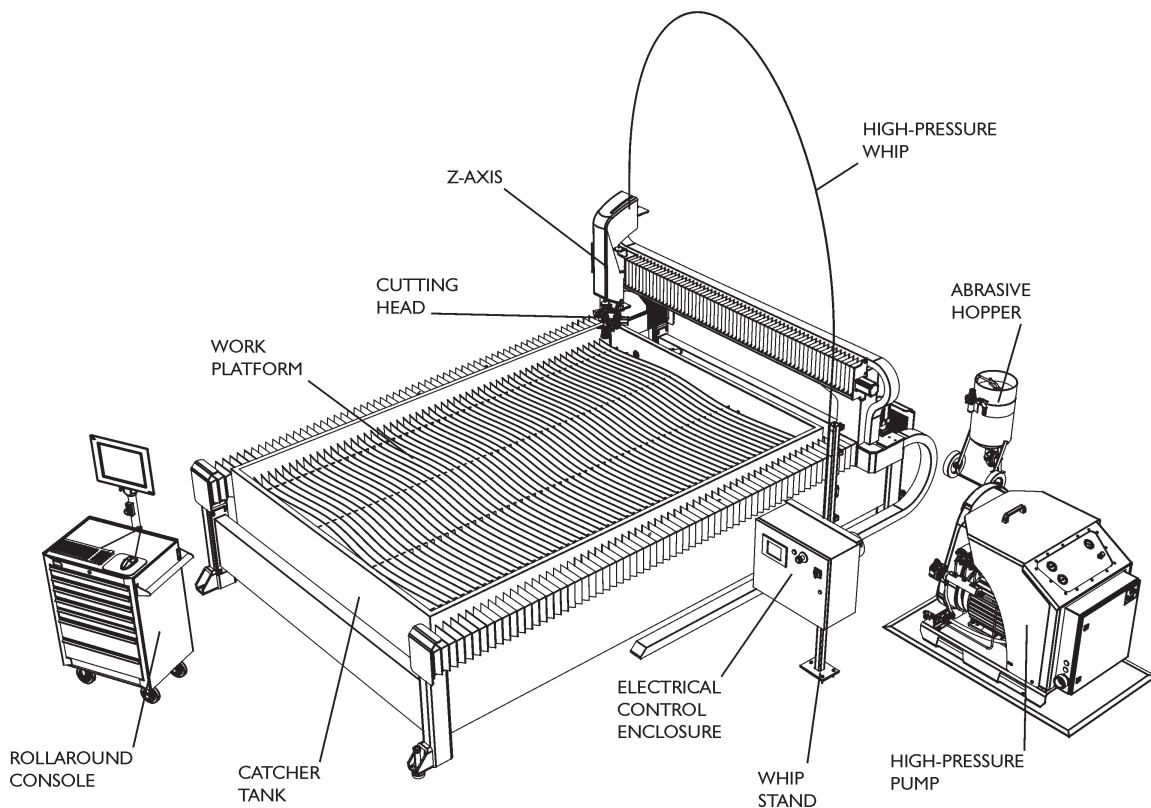
CHAPTER 2

Facility Requirements

Environment

The Mach 2c system is designed only for factory or shop use.

Ambient temperature	60° to 100°F (15.5° to 38°C)
Relative humidity	Up to 90% @ 100°F (38°C) non-condensing
Airborne dust/contaminants	Minimal
Radio frequency interference	Minimal
Lighting	Adequate to operate & service the equipment



Utility connections

- Flow recommends that you install manual on/off valves in the high-pressure, inlet water, and cooling water lines. Locate valves as close as possible to the pump interface connection to make them easier to service.
- Coolant water lines must be non-corrosive pipe or rubber hose. Rubber hose (per SAE Standard 20R1, 30R1, or equivalent) is recommended.
- Cutting water lines (from the filtering system to the intensifier pump) must be as short as possible and must be PVC, copper, or equivalent. Do not use galvanized iron piping—it will introduce minerals to the water, which will shorten orifice life.

Ethernet connection

An Ethernet port to connect the machine to a network is provided at the base of the electrical enclosure (labeled J7).

It is important that an Ethernet cable from the switchgear to the machine interface box be no longer than 250 ft. If a longer run is necessary, the customer needs to provide a switch close to the interface box to amplify the signal. If these conditions are not met, it may not be possible to connect the machine to the customer's network, and will negatively affect Flow's ability to support the machine via VPN.

Oil requirements

Refer to individual pump manuals for information on checking oil for moisture and changing oil. Use an oil that does not contain anti-wear additives. Other manufacturer's equivalents can be used:

	60K intensifier pump	HyPlex Prime pump
Recommended oil	Shell Tellus S2M 46 or equivalent	Shell Morlina 100 Hydraulic Oil
Kinematic viscosity	310 SSU @ 100°F (38°C)	100 SSU @ 104°F (40°C)
Reservoir capacity	30SA: 35 gal (133 L) 7X: 27 gal (102L)	2.0 qt (1.9 liter)
Container size needed for service	30SA: 38 gal (144 L) 7X: 28 gal (106 L)	3.5 qt (3.3 liter)
Filtration	2 microns, continuous flow	N/A
Cooling	Oil-to-water heat exchanger	N/A
Optimum oil temperature	105°F (40.5°C)	105°F (40.5°C)

Water requirements

The intensifier pump requires two sources of water: cutting and cooling. Also required are three water drain lines for coolant, leakage, and bleed-down water. Leakage and bleed-down water drain lines may be plumbed together when necessary. Leakage drain must be separate where local regulations do not permit oil in drains. Specific requirements are defined below.

The direct drive pump requires only one source of water.

Cooling water (to heat exchanger)

For intensifier pumps only

Dual heat exchangers regulate heat build-up in the hydraulic oil. Optimum hydraulic oil temperature is 105°F (40.5°C). Tap water is routed first to a heat exchanger in the pump case drain line, then to a heat exchanger in the intensifier return line.

A thermostatically controlled cooling water flow control valve designed for partially open operation is installed in the line to regulate the water flow for maximum water conservation.

Water flow must be sufficient to ensure that the hydraulic oil reservoir temperature is always maintained below 110°F (43°C). Cooling water flow rate is typically 3 gpm (11 lpm) per 50 hp at an inlet water temperature of 60°F (15°C).

Water with low levels of minerals and acid will maximize heat transfer efficiency and heat exchanger life.

Cutting water

Water quality

Waterjet systems perform better with soft water. A water quality test kit is provided with new systems, and is available from Flow. It is recommended that water be tested once a year.

CAUTION

A high concentration of dissolved solids in the inlet water (especially silicates and calcium) can reduce waterjet nozzle life. If water quality is poor and filtration will not correct it, the customer must add additional water treatment equipment. Contact Flow Technical Service for more information.

Flow recommends the use of a water softener to pre-treat the cutting water. Systems should be sized for 150% of your pump capacity, and should match your intended maximum duty cycle.

Water pressure

Refer to pump manual for minimum required inlet water flow rate.

Water flow rate

The minimum inlet water flow rate must be equal to 1.5 times the maximum output flow rate. Specific pump flow rates can be found in the pump manual.

Drain requirements

Intensifier pump

Cooling water drain

Cooling water leaving the intensifier pump is considered waste water. This water can be routed to a waste water recovery system, a recirculation system, or a drain—whichever is most applicable for the installation. If the water is reused for cooling, a commercial water cooling system can be used.

If the cooling water is routed directly to a waste water drain, you must have a minimum drain capacity of 5 gpm (19 lpm).

Bleed-down water

When the pump is shut down, the bleed-down valve exhausts high-pressure water through the BLEED DOWN WATER port on the bulkhead. This can be connected to the same drain as the catcher overflow, if required.

Leakage drain (oil or water)

The pump has a drip pan to collect oil/water leakage from the intensifier seals. Leakage is usually negligible; however, the drain line is sized to accommodate the worst case (if the bleed-down valve opens) of 10 gpm (38 lpm).

Do not connect the leakage water drain to the coolant water drain line or any other pressurized drain system.

HyPlex Prime pump

The HyPlex Prime pump requires a single drain line with a maximum drain capacity of 0.9 gpm for a 30 hp pump or 1.5 gpm for at 50 hp pump.

Catcher tank

The catcher tank has a single overflow drain at the rear of the tank that is adjustable for desired water level. Typically, the flow rate will be less than 1 gpm or less, but a facility drain should be sized to handle intermittent flows of 5 gpm.

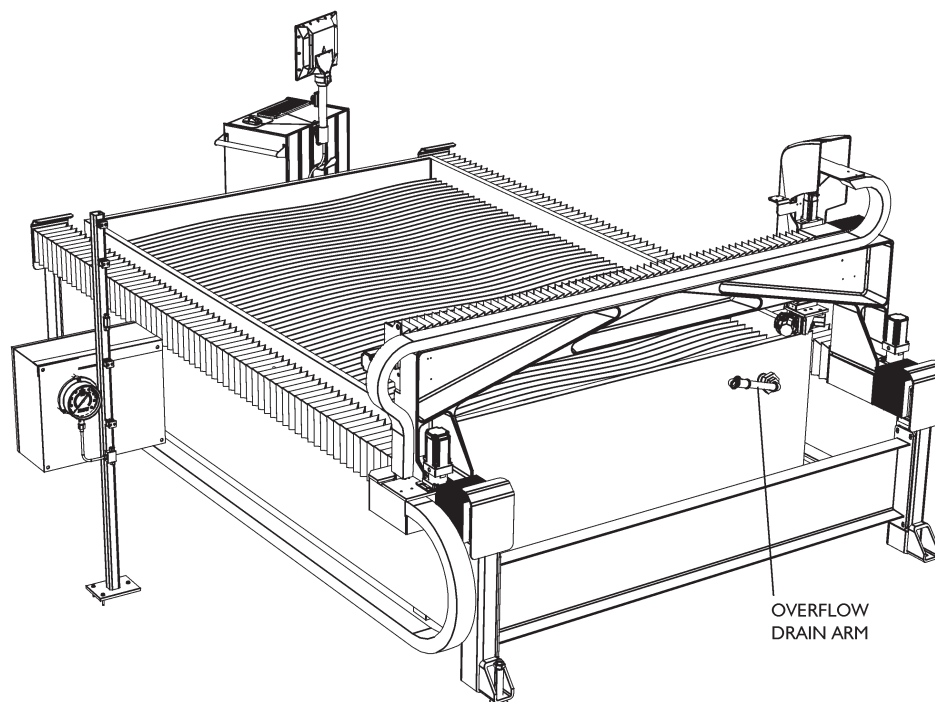
Overflow from the catcher tank can be routed to an optional 3-tier waste water recovery system, a recirculation system, or a drain.

CAUTION

Water from the catcher tank overflow outlet can contain variable amounts of abrasive particulate.

Water level adjustment

The water level of the catcher tank is adjusted by moving the drain arm up or down. The optimum water level for most cutting applications is just above the slats in the catcher tank.



OVERFLOW
DRAIN ARM

Air requirements

Three air lines are required to supply the end effector, the abrasive hopper, and the high-pressure water pump (if a direct drive pump is used). Additional lines may be necessary for optional equipment. The air must be dry and filtered to 10 microns at 90 psi.

- With mobile components, make sure air lines are supported and are long enough to provide adequate travel.
- Make sure all air lines are connected to the air source and the component, and all couplings are correctly installed and clamped.
- Inspect the entire length of air lines for cracks, breaks, kinks, or sharp bends.

End effector

The following elements of the end effector require sequenced airflow from the control station and abrasive metering valves. Refer to the listed manuals for complete information

PASER 4

- M-398, PASER 4

Dynamic Waterjet

- M-385, Dynamic Waterjet for Mach b Series and Mach c Series

Ultrahigh-pressure pumps

Intensifier pumps

- M-287, 7X pump
- M-387, 30SA pump

HyPlex Prime pump

The HyPlex Prime pump requires sequenced airflow from the control station. Refer to the manual for complete information

- M-416, HyPlex® Prime Pump

High-pressure tubing

Refer to the Small High-Pressure Components manual (M-127) that shipped with your system for more information on high-pressure tubing, components, and related service.

High-pressure tubing certified for operation at 60,000 psi (4140 bar) must be used with the following pumps:

- 7X pump
- 30SA pump
- HyPlex Prime pump

Starting the system after installation

After initial installation, and whenever you perform major service on the intensifier pump, you must follow a standard startup procedure when putting the equipment back into service. This procedure provides checks to make sure the pump is correctly reassembled.

Procedures for starting the high-pressure pump can be found in the pump manual.

- M-287, 7X pump
- M-387, 30SA pump
- M-416, HyPlex Prime pump

Before starting any Flow equipment:

- Be sure you know how to stop it.
- Read the manuals, get training from an experienced operator, and review the safety precautions.
- Follow a written checklist that includes an inspection for needed or ongoing service, damaged or missing parts, leaks, or anything that could make the equipment unsafe to operate.
- Make sure doors and covers are in place.
- Call out “START-UP” to let anyone in the area know the equipment will be starting up.
- Stand in a place that is protected by safety devices and within reach of an emergency stop switch.

WARNING
NEVER operate an intensifier pump with uncertified parts—this can cause explosive separation of parts and serious bodily injury. Contact Flow or seek professional installation assistance.

All operators and service personnel must review the safety precautions in this manual before starting the equipment.

Routine operation

- Routine operating instructions are located in Chapter 4 of this manual.

CHAPTER 3

Safety

The comprehensive list of safety precautions in this manual, in European safety manual MS-2281, and in all Flow equipment manuals provided with this system must be followed to ensure safe operation of the equipment. The equipment must only be used, serviced, and repaired by persons who are familiar with the operating instructions and the service procedures provided in this and other Flow manuals.

These precautions must be read and understood by everyone operating and maintaining the equipment—before they start working with the equipment.

In addition to adhering to the safety rules in this manual, all applicable local safety agency rules (including OSHA, state, and national) must be adhered to.

Applicable plant general safety precautions must also be followed.

The user shall practice and promote safety at all times to avoid potential injuries and unnecessary production shutdowns.

Safety precautions

FLOW designed your high-pressure waterjet cutting system and related equipment with safety in mind. Throughout the manual, safety precautions and warnings for specific operations are highlighted. Safety precautions are also posted on the equipment. The operator and service personnel shall pay particular attention to these precautions at all times.

Operators of a high-pressure waterjet cutting system must treat the system as they would treat any high-speed cutting tool. Although the waterjet may appear harmless, it is a high-energy cutting tool capable of cutting many nonmetallic materials such as composites, plastics, and wood products. Misuse of this equipment or carelessness in its application can be extremely hazardous to operating personnel. Always treat the waterjet cutting system with respect.

The label shown is available in two sizes:

- Part # 006317-1
3.75 x 6 in.
(95 x 152 mm)
- Part #009837-1
1.8 x 3 in.
(46 x 76 mm)



Warnings, cautions, and notes

Service procedures in the waterjet manuals include safety warnings, cautions, and notes that must be read, understood, and adhered to. These are specific categories of safety notices, and are defined as follows:

WARNING
Highlights an operating condition or service procedure that can result in death or serious injury.

CAUTION
Highlights an operating condition or service procedure that can lead to impaired system operation or equipment damage.

Note: Highlights an operating or service procedure or condition that is considered essential for efficient operation and service.

Safety tips

- Do not let the waterjet stream touch any part of your body.
- Do not point the waterjet at anyone.
- Take the system out of service during maintenance. The controls shall be locked and marked with a warning sign.
- All personnel working on or around the equipment shall pay particular attention to all warning signs and notices posted in the plant and on the equipment.
- Protective guards, shields, and covers must be in place on the equipment at all times.
- First aid facilities shall be provided in convenient locations throughout the plant. These locations must be known by all personnel.
- The work area around the equipment shall be clean and free of debris. Oil spillage results in slippery floors and must be removed immediately.
- Any conditions that could result in injury must be reported to the plant supervisor without delay.
- Safety shoes, glasses, and hearing protection must be worn by all personnel working around the equipment. Do not wear dangling jewelry (such as rings, watches, or necklaces) when working around any equipment that has moving parts.

Mechanical system

- Don't start the system unless you know how to stop it.
- Never maintain, service, or clean around the equipment while it is operating.
- Using the wrong tools can result in injury or costly damage to the equipment.
- Never climb on or around the equipment on makeshift devices. Use only approved catwalks, ladders, or platforms.
- Do not exceed specified pressure settings for pneumatic or hydraulic components. Exceeding these limits can cause serious injury to personnel or equipment damage.
- Shield and bundle equipment hoses and cables so they do not obstruct the operator's freedom of movement.
- Be alert at all times when working around the equipment.
- Clear all tools, parts, and rags from any moving parts after servicing the equipment.

Electrical system

- Only properly trained personnel shall perform electrical or electronic troubleshooting and servicing.
- Always assume that power is ON in all electrical systems. Always check and lock out the main power switches before servicing the equipment. Post a sign, "Maintenance in Progress—Do Not Energize."
- Live electrical circuits are present in the control console whenever the master disconnect is on, regardless of whether the EMERGENCY STOP is engaged.
- Disconnect circuit breakers and lock them in the OFF position before servicing the electrical system. If this isn't possible, have someone stand by to prevent anyone from powering up the system.
- Be especially careful when servicing the power system in a damp environment.
- Never alter or bypass protective interlocks or devices unless specifically instructed to do so, and only if all precautions are followed.
- Give capacitors enough time to discharge. If this isn't possible, carefully discharge them manually.
- Do not use jumper wires across fuses or fuse holders.
- Make sure all tools are well insulated.
- Use only proper test apparatus; check it regularly to make sure it works properly.
- Use caution when connecting a test probe to test points.
- All replacement wires shall conform to the manufacturer's specifications, including color coding, wire numbers, and size.
- Close the control panel doors or junction box covers after servicing.

Waterjet cutting system

- High-pressure water can remain in the system for an extended time after shutting down the high-pressure water source. System pressure can be relieved by opening any valve downstream of the outlet valve.
- Always bleed down the system pressure before servicing any part of the system.
- Do not touch weep holes with your bare hands or try to stop water by plugging the holes.
- The waterjet stream is a knife. Do not put anything in its path that you do not intend to cut.

- Wear a face shield whenever required by the operating instructions.
- Do not remove protective shields from high-pressure tubing. If shields are removed for servicing, they must be replaced before starting the system.
- Torque all fittings to the manufacturer's specifications.
- Stepping or leaning on high-pressure water tubing can break connections and cause leaks.
- High-pressure fittings, valves, and tubing must be certified for 60,000 psi (4138 bar) for 60K systems and 87,000 psi (6000 bar) for Hyperjet systems. Do not substitute when making alterations or additions to the high-pressure water system.
- Do not alter or eliminate stress relief tubing coils.
- Follow the tubing manufacturer's recommendations for high-pressure tube bending radii.
- Do not exceed specified operating pressures for high-pressure components.
- Follow the manufacturer's recommendations for servicing the equipment, and use only original manufacturer replacement parts.
- Follow the manufacturer's system startup procedure to ensure safe operation.
- Use care when lifting equipment covers during operation.

High-pressure waterjet cleaning tools

- Turn off equipment and relieve water pressure before replacing nozzles, tips, or bits.
- Hang a sign on the power supply control panel warning that the equipment is being serviced and is not available for use until servicing is complete.
- Replace all protective covers and shielding on equipment before operation.
- Check for leakage after nozzle or tip replacement and correct immediately.
- Use only Flow manufactured or approved waterjet nozzles, cleaning tips, and drilling or cutting bits.

Protective clothing

Workers operating hand-held, high-pressure waterjet cutting or cleaning equipment and those working nearby should wear protective clothing and safety devices as described in this section. Flow recommends that work-site safety personnel approve all safety equipment and clothing for everyone working around waterjet cutting equipment.

Eye protection



- At a minimum, operators must wear safety glasses with side shields and a visor, or goggles and a visor, to guard against spray and flying debris.
- All eye protection shall meet appropriate ANSI requirements for that type of eye protection.
- Some states and countries have their own eye protection rules that must be followed.

Head protection



- Helmets must be worn at all times by all personnel within the work area. Helmet material must withstand mechanical shock to 10 G in 8 ms without fracturing.

Hand protection



- Operator must wear gloves at all times. Leather gloves are preferred.

Foot protection



- Safety footwear with steel toe-caps 0.02-in. (5 mm) thick (minimum) must be worn. The toe cap must cover at least 30% of the footwear length.
- For some applications, footwear must be equipped with metatarsal guards to provide instep protection.

Hearing protection



- Operators and other personnel exposed to noise levels of more than 90 dBa for more than 1 hour must wear suitable ear protection. Ear plugs and muffs are usually adequate.

Body protection

- Waterproof garments only protect the operator from spray and flying debris. They do NOT deflect direct jet impact.

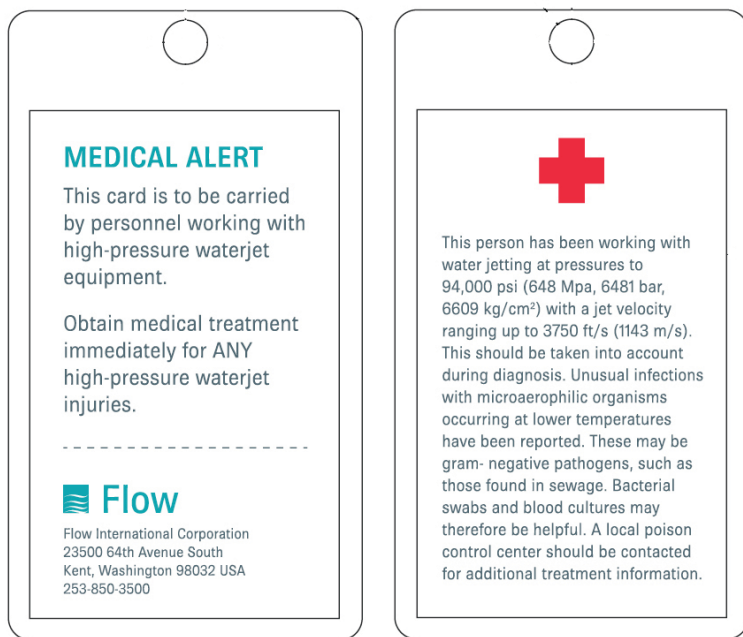
WARNING
NEVER point a waterjet cutting or cleaning tool at yourself or at any person. Do not aim a waterjet tool at anything you do not intend to cut.

Emergency medical information

Anyone who incurs equipment-related injuries while operating high-pressure water equipment should be given immediate hospital attention. It is vital that medical personnel have information about this type of injury. Therefore, all waterjet operating personnel should carry a waterproof emergency medical tag or card that describes their work and the nature of injuries inherent in using waterjet cutting devices.

The card illustrated below can be purchased from Flow (P/N A-8466). It is also available in French, German, Italian, and Spanish. Simply order part number A-8466F, G, I, P, or S.

The tag or card should contain the information in the sample below.



Light curtain safety barrier (optional)

When installed on machines, light curtain safety barriers must be operational at all times, except when the machine is shut down for maintenance.

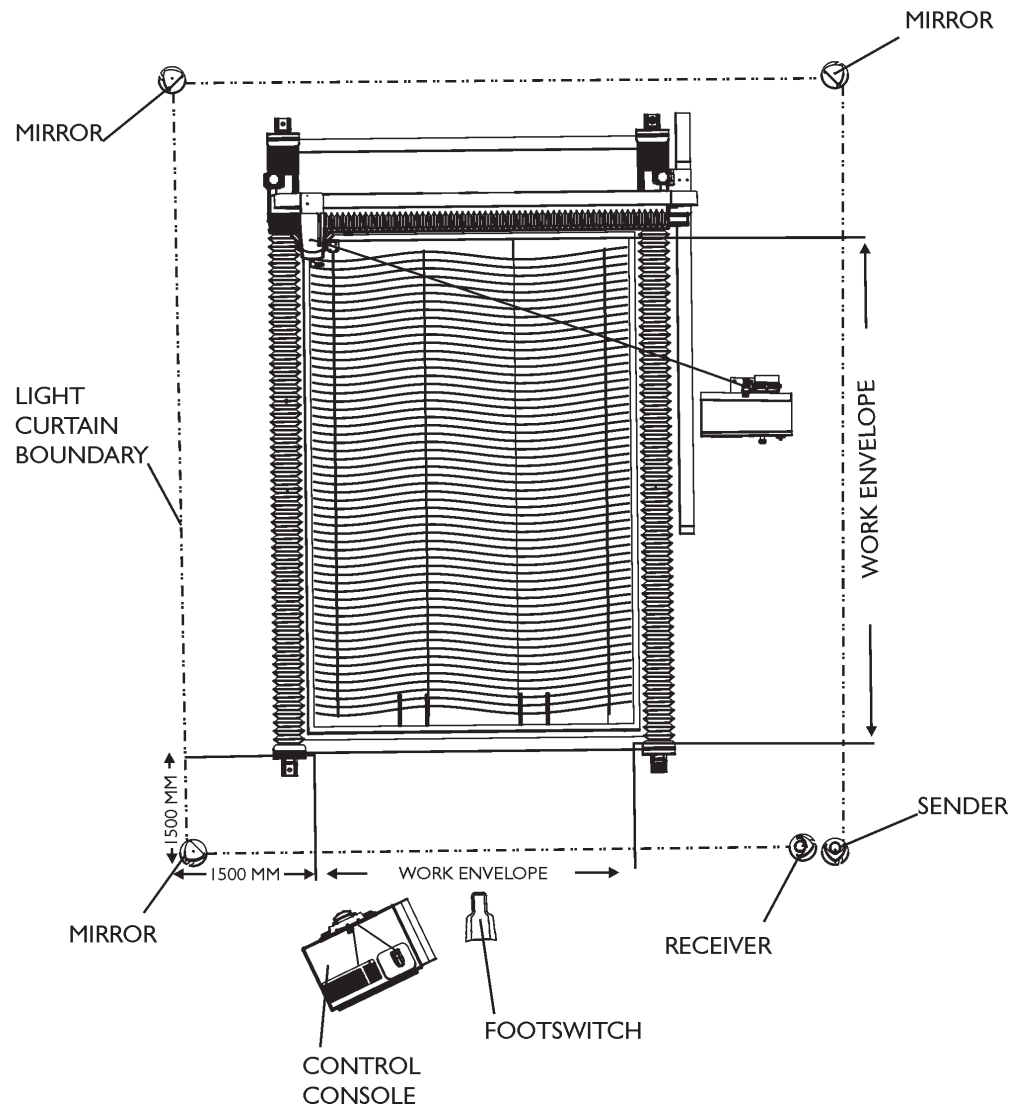
An illustration to show placement of the light curtain system is on the following page.

- The proper function of safety equipment must be inspected at least once a year; local ordinances may require more frequent inspections.
- When the sensor is crossed or otherwise activated, the machine is automatically switched into setup mode and the following actions are carried out:
 - An error message stops any automatic program that may be running
 - All traveling axes stop, or speed is reduced to 2m/min
 - The water valve of the cutting head is closed
 - The high-pressure pump is shut off and the high-pressure line system is depressurized

Before use

- Only use the system when all drive units are functioning correctly, the safety equipment is installed and operational, and the E-Stop is working correctly.
- All protective guards, shields, and covers must be in place on the equipment at all times. If removed for maintenance or service, lock and tag the main disconnect switch so the equipment cannot be accidentally started.

Light curtain installation



Notes

Operation

Operating instructions

The Mach 2c system and ultrahigh-pressure pump are operated from the FlowMaster PC controller. A pump operation button on the FlowMaster RUN MACHINE screen is used for starting and stopping the pump. Select HIGH PRESSURE or LOW PRESSURE for the dual-pressure feature.

Before starting any Flow equipment:

- Be sure you know how to stop it.
- Read the manuals, get training from an experienced operator, and review the safety precautions.
- Follow a written checklist that includes an inspection for needed or ongoing service, damaged or missing parts, leaks, or anything that could make the equipment unsafe to operate.
- Make sure doors and covers are in place.
- Call out “START-UP” to let anyone in the area know the equipment will be starting up.
- Stand in a place that is protected by safety devices and within reach of an emergency stop switch.

WARNING
NEVER operate an intensifier pump with uncertified parts—this can cause explosive separation of parts and serious bodily injury. Contact Flow or seek professional installation assistance.

All operators and service personnel must review the safety precautions in this manual before starting the equipment.

Starting the pump

After initial installation, and whenever you perform major service on the intensifier pump, you must follow the pump startup procedure when putting the equipment back into service. This procedure provides checks to make sure the pump has been correctly re-assembled.

Procedures for starting the high-pressure pump can be found in the pump manual:

- M-287, 7X pump
- M-387, 30SA pump
- M-416, HyPlex Prime pump

Coordinate systems

The system keeps track of the cutting head position in terms of XYZ, also known as Cartesian coordinates.

On the Mach 2c system, the coordinate system is oriented as follows:

X Axis (*bridge*)

- Jog with left/right arrow keys
- +X is to the right.

Y Axis (*base*)

- Jog with up/down arrow keys
- +Y is toward the back

Z Axis (*vertical*)

- Jog with PgUP/PgDN keys
- +Z is up and away from the sheet being cut

System operation

The ultrahigh-pressure pump is operated from the FlowMaster PC controller. Refer to the integrated Help guides in the FlowMaster software for programming and operation information.

A pump operation button on the FlowMaster RUN MACHINE screen is used for starting and stopping the pump. Select HIGH PRESSURE or LOW PRESSURE for the dual-pressure feature.

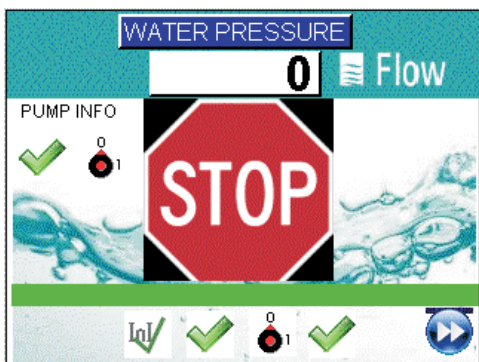
Machine startup

To start the machine from a "cold start" (no power), make sure that main air and main water supplies are turned on to the machine, then follow these steps:

1. Turn on main power switch located on the front of the electrical enclosure. If there is an additional disconnect on the wall that feeds power to the machine, make sure this is turned on as well.
2. Disengage all E-stop switches.
3. When the display has booted up to the basic "ready" screen, push the POWER ON button on the electrical enclosure to provide power to the controllers. The button will illuminate when the pump Safety PLC is functioning.
4. Wait for the motor drives to initialize. The progress bar will change from red to green. The display will indicate that the motor drives are initialized but not enabled, and the pump is available but not enabled.

CAUTION

Do not start FlowCUT until the enclosure display status bar is fully green and three check marks appear at the bottom of the screen. Software errors can occur if the motor drives have not fully initialized.



5. Log in to the computer on the rollaround console using the following user name and password:

User name: flow

Password: password

Note: These are permanent. DO NOT change the user name or password at any time.

6. Start FlowCUT by double-clicking the FlowCUT icon on the screen.
7. Load a part file (ORD file) and set the proper Jet Setup and material/thickness properties.
8. Click the **run Machine** button. You will hear a click as the motors drives are enabled, and the drive enable status indicator on the enclosure display will turn green.
9. Home the machine (see *Homing the machine on the next page*).



CAUTION

The machine must be homed after each startup. Failure to do so will result in inaccurately cut parts or damage to material.

The machine is ready for use.

Machine shutdown

Shut down the machine if it will not be run for an extended period of time (overnight, for example). To shut down the machine normally, follow these steps:

1. Save any part files that are open in FlowCUT.
2. Jog the machine manually so that the X and Y axes are near the HOME position (X0, Y0). This is not a necessary step, but it will make it more convenient to HOME the machine next time you start up the machine.
Manually jog the Z-axis to its highest position off of the cutting surface.
3. Exit FlowCUT and shut down Windows®.
4. Engage the E-stop button on the electrical enclosure.
5. Turn off the power switch on the electrical enclosure.

Homing the machine

The motor drives on the Mach 2c do not retain positional information when the machine is powered down. The machine must be homed each time the machine is started to establish proper position.

To save time, the gantry bridge may be jogged manually near the Home position by using the keyboard arrow keys.

CAUTION

The machine must be homed after each startup. Failure to do so will result in inaccurately cut parts or damage to material.

Soft limits are set after the machine has been homed. Use caution when jogging the machine before it has been homed as it is possible to crash the machine.

1. In FlowCUT, click the **Home Z,A,B-axis** button to home the Z-axis and A- and B-axis motors.



2. Click the **Home X,Y-axes button**, then select "Go to machine home" from the list and click OK. The machine will move to the front left corner of the work envelope.



Note: The machine uses hard stops in the homing process. It is not unusual to hear a metallic knocking noise when the hard stops have been reached.

Running the pump

Intensifier pump

When the machine is in position to start a cut, click on the PUMP ON button. The intensifier pump will not start immediately; first the booster pump turns on to charge the system. After approximately 5 seconds, the pump starts and begins ramping up to pressure. The pump uses an electronic proportional control valve to automatically ramp up hydraulic pressure. The digital high-pressure gauge on the FlowCUT screen indicates the amount of water pressure in the system.

When the system reaches the desired operating pressure (60,000 psi/4140 bar) you can begin cutting.

Click on the PUMP OFF button to turn off the pump. All system pressure is bled to 0 psi within one second of shutting down the pump.

HyPlex Prime pump

When the machine is in position to start a cut, click on the PUMP ON button. The HyPlex Prime pump will not start immediately; first the WATER ON solenoid energizes. After approximately 5 seconds, the HyPlex pump starts and begins ramping up to pressure. The pump uses an electronic proportional control valve to automatically ramp up high-pressure water. The digital high-pressure gauge on the FlowCUT screen indicates the amount of water pressure in the system.

When the system reaches the desired operating pressure (55,000 psi/3792 bar) you can begin cutting.

Click on the PUMP OFF button to turn off the pump. All system pressure is bled to 0 psi within one second of shutting down the pump.

Using dual pressure

Brittle materials, such as glass, stone, or composites, should be pierced at a lower operating pressure (such as 20,000 psi/1380 bar). To select high or low pressure, highlight either the HIGH PRESSURE or LOW PRESSURE box to the right of the PUMP on/off button.

The default setting is HIGH PRESSURE, which is usually set for the following operating pressures:

- HyPlex Prime | 55,000 psi (3792 bar)
- Intensifier pump | 60,000 psi (4140 bar)

Selecting LOW PRESSURE will lower the pressure, usually to 12,000–20,000 psi (828–1379 bar).

Use the LOW PRESSURE setting in conjunction with the FlowMaster PIERCE ALL HOLES FIRST function to pierce holes in a given program at low pressure before cutting.

Changing low-pressure or high-pressure setting (for intensifier pumps)

Use the Jet Setup screen in FlowCUT to enter low or high pressure.

E-stop reset

When an emergency stop (E-stop) has been engaged, machine motion stops, the pump is shut down, and power to the drive motors is removed.

There are two E-stops on the Mach 2c: one on the rollaround console and one on the electrical enclosure.

To reset an E-stop and restore function to the machine:

1. Make sure the danger or issue that prompted the emergency stop has been cleared.
2. Rotate the red E-stop button to disengage the E-stop.
3. Press the POWER ON button.
4. Clear errors in FlowSENSE diagnostic (see *Recovery from error*).

Recovering from an error

FlowCUT automatically monitors warning conditions while the machine is operating. A warning condition is indicated when the positional indicator on the Run Machine screen flashes.

FlowSENSE can then be used to identify the warning condition.

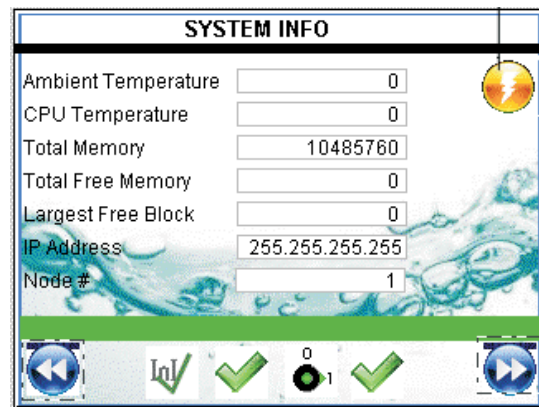
When an error message appears at the bottom of the Run Machine screen, click on **Show errors...** to open the Show Errors dialog box and see details of the error. Errors can be cleared by clicking the **Acknowledge errors** button.

Note: There are some errors that do not register and are not displayed in either the Run Machine screen or the Show Errors dialog box. Non-displayed errors can also be "acknowledged" and cleared by clicking the **Acknowledge errors** button in the Show Errors dialog box.

Warm restart

To restart the machine without cutting power to the machine, use the "warm restart" function on the control enclosure display.

1. Press the **Warm restart** button on the electrical enclosure display. Wait for the controller to power down and boot up.



2. Push the POWER ON button.
3. When the display has booted up to the basic "ready" screen, push the POWER ON button on the electrical enclosure to provide power to the controllers. The button will illuminate when the pump Safety PLC is functioning.
4. Wait for the motor drives to initialize. The progress bar will change from red to green. The display will indicate that the motor drives are initialized but not enabled, and the pump is available but not enabled.
6. Restart FlowCUT by double-clicking the FlowCUT icon on the screen.

CAUTION

Do not start FlowCUT until the enclosure display status bar is fully green and three check marks appear at the bottom of the screen. Software errors can occur if the motor drives have not fully initialized.

7. Load a part file (ORD file) and set the proper Jet Setup and material/thickness properties.
8. Click the **Run Machine** button. An audible click indicates that the motors drives are enabled. The drive enable status indicator on the enclosure display will turn green.
9. Home the machine (see *Homing the machine*).

CAUTION

The machine must be homed after each startup. Failure to do so will result in inaccurate parts or damage to material.

The machine is ready for use.

Operator control console

The operator control station (HMI) consists of a display screen, keyboard, mouse, and an emergency stop button. Individual functions are described in this section.

Features

Emergency stop (E-stop)

- The E-stop halts machine motion and shuts down the pump.
- It also removes 3-phase and 24VDC power from servo amplifiers and I/O circuits, but the Power On indicator will remain lit, and 24VDC power to the panel PC will not be interrupted.

Display monitor

- The monitor contains the PC that operates the FlowCUT software. It is not advisable to run other programs on this PC.

Keyboard and mouse

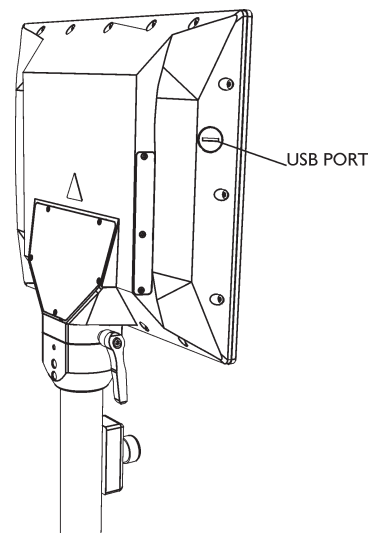
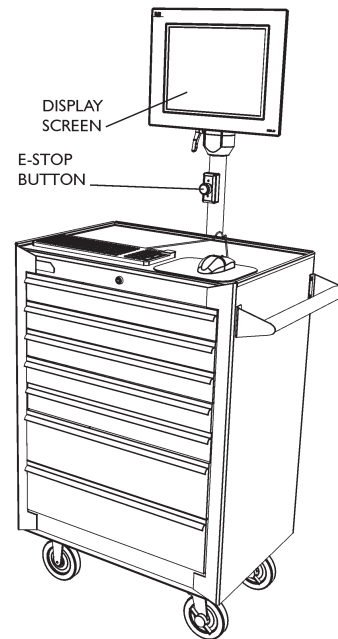
- Primary interface with the system

USB port

- Allows part files to be transferred via USB drive.

CAUTION

The USB port is vulnerable to debris and moisture while a drive is plugged in. After files have been transferred, remove the drive and cap the port with the supplied cover before cutting.



Control enclosure

The control enclosure houses the power junction for the machine and several system controls. Individual functions are described in this section

Features

Main power switch

- Allows power to be supplied from source power to the machine.

POWER ON button

- Powers up the enclosure display and initializes the drive motors.

Emergency stop (red mushroom switch)

- See description on previous page.

USB port

- Allows part files to be transferred via USB drive.

CAUTION

The USB port is vulnerable to debris and moisture while a drive is plugged in. After files have been transferred, remove the drive and cap the port with the supplied cover before cutting.

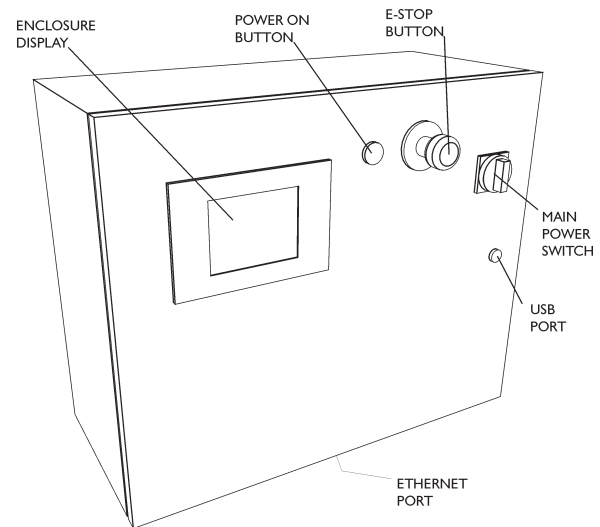
Ethernet connection

- The machine can be connected to a network to access remotely stored files. The Ethernet connection is located on the underside of the enclosure.

CAUTION

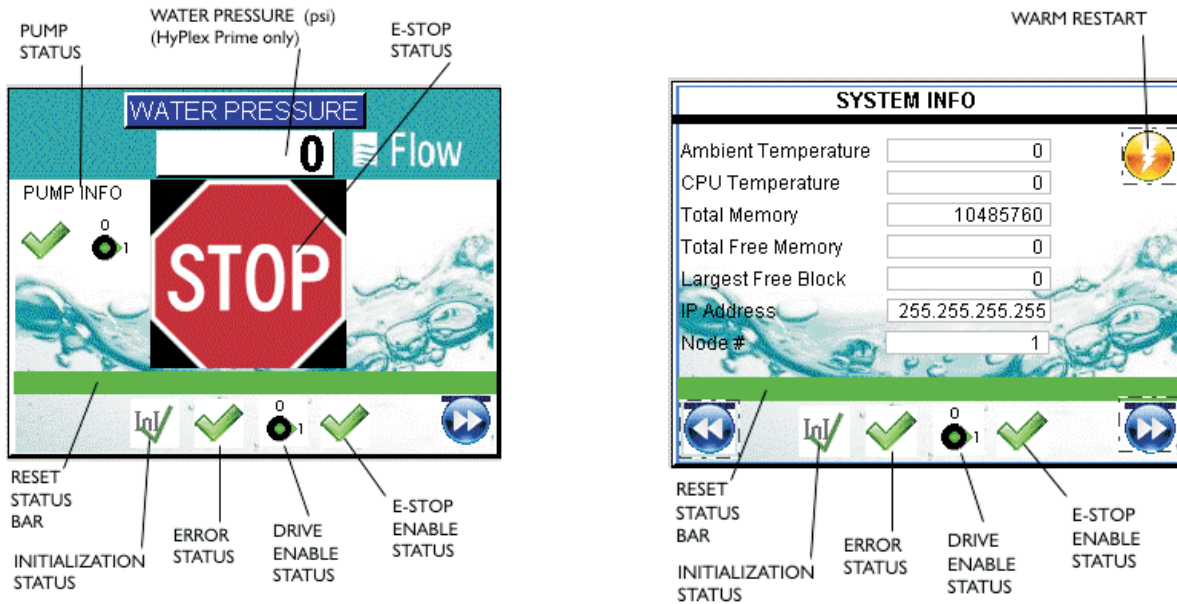
Always seal the Ethernet port to prevent moisture or debris from entering the port.

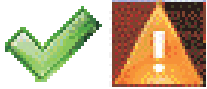



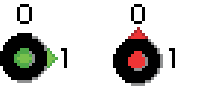



- The Ethernet connection establishes communication between the electrical enclosure display and the PC mounted on the rollaround console.
- The IP address associated with the machine can be found on the status screen on the electrical enclosure display.



Display

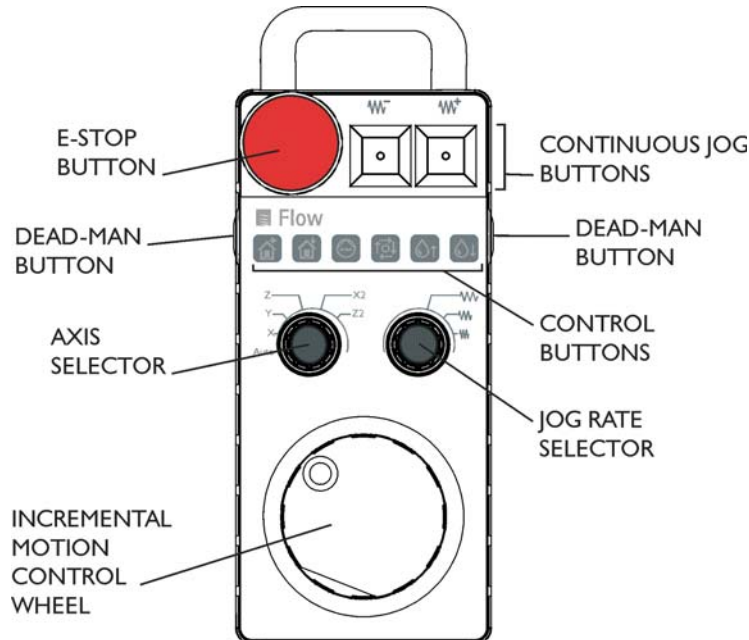
The touchscreen display on the control enclosure provides basic system information. Individual functions and indicators are described in this section.



	<p>Status indicators Power on Power off</p>		<p>Reset circulating arrows Indicates E-stop recovery in progress</p>
	<p>Drive initialization status Drive initialized Drive not initialized</p>		<p>Drive error Drive encoder values have not been loaded</p>
	<p>Drive enable status Drive enabled Drive disabled</p>		<p>"Warm restart" button Restarts the controller when pressed</p>
	<p>E-stop status Clear Engaged</p>		<p>Navigation buttons Selects next page on the display when pressed</p>

Remote jog pendant

The remote jog pendant allows the operator to move the X, Y, and Z axes independently, turn the pump on and off, start and stop a program, set user home, and control water level. While the pendant is selected, corresponding keyboard functionality is disabled.



Features

Motion control wheel

Controls movement on the selected axis based on jog rate. Turn clockwise for positive motion. Turn counter-clockwise for negative motion.

Axis selector

Selects the desired axis to control. Select "Auto" to enable the control buttons.

Jog rate selector

Selects the rate of motion for the motion control wheel. Choose between LOW, HIGH, and RAPID.

Control buttons

Selects functionality for user home, pump on/off, cycle start/stop, and water level control.

Dead-man buttons

Located on either side of the pendant, both buttons must be depressed to use the pendant.

Continuous jog buttons

Controls movement on the selected axis based on jog rate.

E-stop

The E-stop button is located at the upper left of the pendant. Push the button for emergency stop (or when directed to in a service procedure or operating sequence). When ready to reset the E-stop circuit, first turn the E-stop button clockwise to release.









Enabling the remote jog pendant

1. On the Run Machine screen of FlowCUT, click the Handheld operator panel button in the sidebar.
2. Press and hold the dead-man buttons on either side of the remote pendant. The pendant is now active.
3. **To jog an axis:** Select the desired axis and jog rate. Rotate the motion control wheel, or press the jog direction buttons to move the axis.
4. **To select a machine function:** Turn the axis selector to "Auto" and press the desired control button.



Click the Handheld operator button in the FlowCUT sidebar to return control to the keyboard.

Control buttons

	<p>Set Home When pressed, establishes the position of the cutting head as User Home position.</p>
	<p>Go to User Home Moves the cutting head to User Home position.</p>
	<p>Pump On/Off Turns the high-pressure pump on or off.</p>
	<p>Cycle Start/Stop Starts or stops a running NC program (This is a duplicate function of what can be done from within FlowCUT)</p>
	<p>Water Level Up two modes</p> <ul style="list-style-type: none"> • Hold mode: Press and hold to raise the water level in the catcher tank. Release when water reaches the desired level. • Latched mode: Tap button to raise water level for 10 seconds. Tap again to stop before factory-set timeframe is reached. <p>Note: If the tank level rises too high, water will siphon off through a drain in the corner of the tank.</p>
	<p>Water Level Down two modes</p> <ul style="list-style-type: none"> • Hold mode: Press and hold to lower the water level in the catcher tank. Release when water level reaches the desired level. • Latched mode: Tap button to lower water level for 20 seconds. Tap again to stop before factory-set timeframe is reached.
	<p>Jog direction Moves the machine along the selected axis in the direction (negative or positive) indicated.</p>
	<p>Jog rate selector There are three jog rates: Low, High, and Rapid. The jog rate setting determines the "resolution" of the motion control wheel.</p> <p style="padding-left: 40px;">Low = 1 micron (0.001 in.) High = 10 microns (0.001 in.) Rapid = 100 microns (0.01 in.)</p>

Maintenance & Troubleshooting

Maintenance

The preventive maintenance guidelines in this chapter are intended to be a guide, and are based on a 16-hour production day and 5-day production week, with the machine in a suitable environment. If the equipment is running more than this, perform maintenance more frequently. A customized maintenance program should be established for each machine, with a maintenance log book to record & monitor scheduled maintenance and other machine data.

Maintenance for other equipment

- Maintenance intervals and procedures for pumps, cutting heads, and other components are located in separate manuals. Manual numbers are listed in Chapter 1, Equipment Description.

Recommended cleaners

In the United States, the following cleaners are recommended:

Rails

- CRC Industries, Technical Grade 3-36, P/N 0300. Spray on light, even coat, and allow to penetrate dirt and grease. Wipe clean using a clean, lint free cloth. Repeated application may be necessary.

Bellows cover and painted surfaces

- Johnson Envy Instant Cleaner or equivalent. Spray foam evenly over surface. Wipe clean with cloth, sponge, or paper towel. Repeat as necessary.

Recommended lubricants

The Mach 2c X,Y table uses long-life lubricants, but needs to be manually greased annually.

Use the following lubricants for X,Y components.

For X,Y,Z ball nut and ball screw

- Mobilith SHC 220

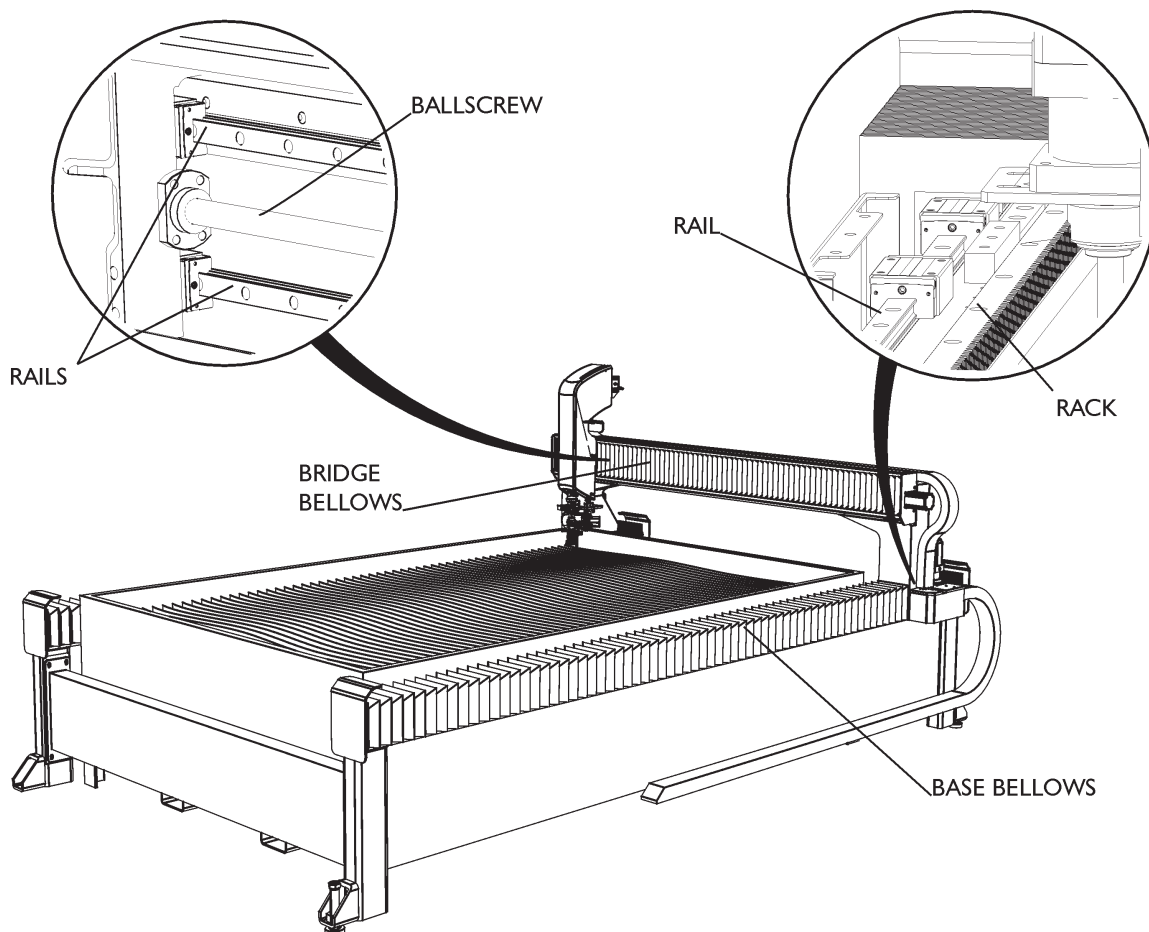
For X,Y,Z linear bearings

- Mobilith SHC 220

CAUTION

FLOW does not recommend using any other type of bearing grease. Mixing can cause the grease to solidify, reducing bearing life up to 75%.

Use only a hand-operated, low-volume grease gun when applying lubricants.



General maintenance intervals

Daily

- Clean all debris from machine and part holding/cutting fixtures.
- Check part clamp linkages, part clamps, locating pins, proximity switches, limit switches, and air/electrical lines on the part holding/cutting fixture. Repair or replace as needed.
- Make sure electrical enclosures and junction boxes are closed and secure.
- Individually activate all emergency stop devices, including E-stop buttons, and also floor sensor mats or light curtains (if installed). Check for proper operation and lock out any machine that has malfunctioning emergency stop devices.

Weekly

- Clean the bellows of the linear units with a soft brush.
- Check air hoses for holes; remove pressed-in chips with caution, check interfaces for tightness.
- Straighten any kinks in plastic air hoses, and replace defective parts.
- Check air hose unions for correct seating and make sure they seal tightly.
- Check pressure unit water separator for leaks; bleed down if necessary. Very frequent leakage is a sign that pressurized air is not dry enough, which can lead to system damage.
- Clean mirrors on light curtain stanchions, if equipped.

Monthly inspection

- Visually inspect all linear drive lead screws. Clean if necessary.
- Inspect compressed air system for leakage on all screwed unions and rigid conduits in the interior of the installation. Tighten as necessary; replace worn parts, including conduits.
- Inspect compressed air system valves for leaks.
- Clean filters by washing the filter cartridge in naphtha, and/or blowing it out against the flow direction of the compressed air.
- Check conduit connections on compressed air system cylinders. Retighten or insert new gaskets.

Annual inspection

- Lubricate all rail and way bearings.
- Remove all debris from equipment and clean thoroughly. Check all hoses, tubing, fittings, and electrical lines. Replace any worn or chafed lines.
- Check condition of wire ways, traveling cables, and cable track. Clean joints as necessary with compressed air.
- Clean all rails and ways thoroughly. Examine closely for any defect, damage, or excessive wear. Repair or replace as required.
- Check the general condition of the equipment. Repair or replace lamps, indicating gauges, and switches as required.

Lubrication

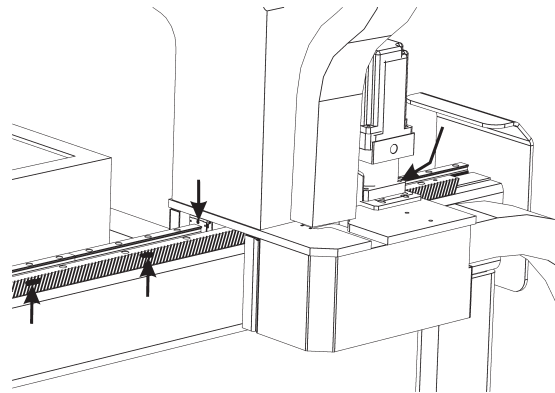
Moving parts on the Mach 2c must be manually lubricated with a synthetic lithium-based grease (see *Recommended lubricants*) on a periodic basis. Lubrication is recommended annually for typical daily operation; a demanding work environment (for example, two shifts/day or high-speed cutting) requires re-application of grease every six months.

Base axis (Y-axis)

Remove the bellows on each side of the bridge to access the four base-axis linear bearings (two per side) and grease fittings. Apply a moderate amount of grease in the fittings.

Remove old grease and accumulated dirt from the rack with a cloth rag. Apply a dollop of grease on the gear rack every 2 feet along its length. Jog the base axis back and forth at low speed to distribute the grease.

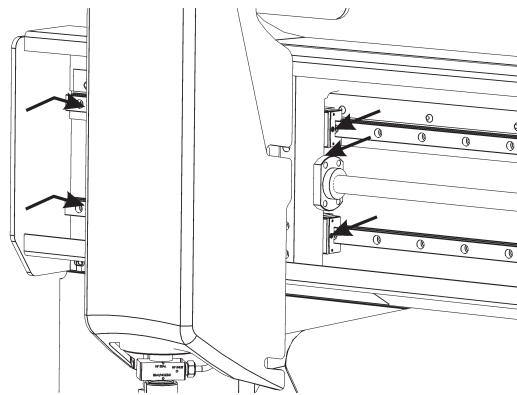
The electric motor and gearbox are sealed and lubed for life, and do not need regular attention.



Bridge axis (X-axis)

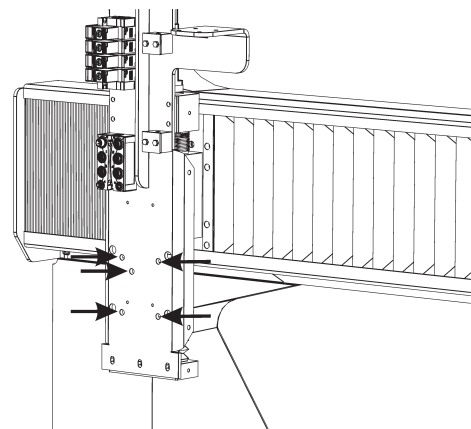
Remove the bridge bellows on each side of the Z-axis to access the four bridge-axis linear bearings and grease fittings. The ballnut has a flush-style grease fitting at the 12 o'clock position. Apply a moderate amount of grease in the fittings.

The ball bearing pillow blocks at each side of the bridge-axis ballscrew and the electric motor are sealed and lubed for life, and do not need regular attention.



Vertical axis (Z-axis)

Remove the plastic Z-axis cover and jog the Z-axis toward the catcher tank until the five access holes in the front plate align with the flush grease fittings in the actuator module. Apply a moderate amount of grease in the fittings.



Troubleshooting

You may experience conditions that are explained in the troubleshooting table that begins on the next page.

Additional troubleshooting tips

The following tips have been helpful in isolating less common system malfunctions and in correcting problems quickly.

- Listen to the machine and watch it operate. Learn to recognize the normal noises, temperature, and operating conditions. This will increase your ability to notice any unusual machine behavior.
- Keep a record of all service performed on the equipment. This will provide valuable information to help you stock spare parts and schedule maintenance.

Troubleshooting other equipment

Troubleshooting information for pumps, cutting heads, and other components is located in separate manuals. Manual numbers are listed in Chapter 1, Equipment Description

Software error		
"Application Error" occurs when using FlowMaster during start up	Machine must complete initialization before software can be used. Restart the machine and make sure the enclosure display status bar is fully green and three check marks appear at the bottom of the screen.	
X,Y movement		
X-axis is not true (perpendicular to Y-axis)	Contact FLOW Technical Service.	
X, Y axis locked in corner or will not jog	<ol style="list-style-type: none"> 1. Exit all programs. 2. Turn machine power off and wait 10 seconds. 3. Push or pull X or Y or both axes out of corner or current position about 6 in. 4. Turn power back on and wait for PC boot-up to complete. 5. Return to FlowCUT, select RUN MACHINE, and then home the machine. Jog the axis. If the problem is not fixed, contact FLOW Technical Service. 	
X- or Y-axis makes a rough binding noise	X- or Y-axis rails are not aligned Dirt or foreign objects on rack, ballscrew, or rails	Move carriage and feel or listen to where the binding occurs. Re-align the rails or rack/ballscrew. When correctly aligned, tighten the bolts.
Rough cuts are observed		
Incorrect clearance.	<ol style="list-style-type: none"> 1. Check the clearance between the pump/motor plate and the frame. 2. Make sure the machine frame is level and steady. 3. Make sure the catcher tank and grate are secure 4. Make sure your workpiece is secure. 	
Motor does not start		
Power not connected.	<ol style="list-style-type: none"> 1. Correct the power circuit. 2. Check fuses. 	
Loose connection.	Tighten any loose parts.	
Connector external wiring incorrect.	Refer to connection diagram and correct wiring.	
Motor disconnected.	Reconnect wiring or replace cable. Cable may be broken.	
Alarm tripped.	Reset motor amplifiers.	
Motor overheated		
Ambient temperature too high.	Reduce ambient temperature to 40°C (104°F) max.	
Motor surface dirty.	Clean dust and oil from motor surface.	
Overloaded.	Run under no load. If looks fine, look for mechanical binding.	
Abnormal noise		
Mechanical mounting incorrect	<ol style="list-style-type: none"> 1. Tighten mounting screws. 2. Center coupling. 3. Balance coupling. 	
Bearing defective	Check noise and vibration near bearing.	
Machine causing vibrations	Call Flow Technical Service.	

CHAPTER 6

Parts Lists & Engineering Drawings

Please note that drawings are provided for reference only. Drawings and part numbers can become obsolete as a part of Flow's ongoing product improvement. If part numbers are replaced by new numbers, Flow Customer Service will inform you when you order new parts.

X,Y assemblies

050787	Base assembly (2020)
049416	Base assembly (2030)
052101	Base assembly (2040)
049415	Bridge assembly

End effectors

051307	Conventional abrasive
051309	Dynamic Waterjet abrasive
042153	Water-only

Cutting heads

Refer to the following manuals for information on the installed cutting head:

- M-398, PASER® 4
- M-385, Dynamic Waterjet®
- M-307, Ultrapierce® Vacuum Assist (if equipped)

Electrical

050088	Electrical enclosure
050931	Electrical schematic
051980	Console assembly

Pneumatic

050087	Pneumatic drawing
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Catcher

052976	Catcher tank (2020)
052979	Catcher tank (2030)
052981	Catcher tank (2040)
713665	100 lb hopper
010693	500 lb hopper
012867	Abrasive supersack stand

Pumps

Refer to pump manual for information on pump.

High-pressure plumbing

B-7415-2	Standard plumbing package
051719	Whipstand and UHP whip

Kits

052146	Base installation kit
051823	CE label kit

Layout drawings

050811	2020
049641	2030
052159	2040

X,Y assemblies

050787-X Rev 02 Base assembly (2020)

See engineering drawing in this chapter.
050787-1 Right-hand base assembly
050787-2 Left-hand base assembly

049416-X Rev 03 Base assembly (2030)

See engineering drawing in this chapter.
049416-1 Right-hand base assembly
049416-2 Left-hand base assembly

052101-X Rev 02 Base assembly (2040)

See engineering drawing in this chapter.
052101-1 Right-hand base assembly
052101-2 Left-hand base assembly

049415-1 Rev 03 Bridge assembly

Electrical

050088-1 Rev A Electrical enclosure assembly

050931-DWG Rev A Electrical schematic

See engineering drawings in this chapter.

051980-1 Rev 01 Console assembly

#	Qty	Part #	Description
1	1	051608-1	Roll around controller
2	1	A-26073-1	Panel computer
3	1	A-19104-1-C	Hazard label

710649-5 Rev. J 5-point light curtain

See engineering drawings in this chapter.

Miscellaneous service parts

Tool kits

Specific tool kits are located in the pump manual shipped with your system.

A-2185 Blue Lubricant

Anti-galling compound for all threaded high-pressure connections.

A-4689 White Food Grade O-ring Lube

Use as a lubricant for all o-rings that come in contact with water.

200006 Parker Super O Ring Lube

Use as a lubricant for all o-rings that come in contact with hydraulic oil.

Notes

CHAPTER 7

Reference

MS-2266, Customer Support

MS-2281, European Safety Manual

Notes