



15150 25th Avenue North, Minneapolis, MN 55447-1981
 Phone 763-476-8600 Fax 763-476-4092
 For Service: MN 763-476-4191 IA 319-632-4288 NE 402-330-2323
 Visit us at: www.productivity.com Productivity is ISO 9001:2000 Certified

Productivity Inc®

Makino EDGE-2 PRE-INSTALLATION CHECKLIST – Rev 01/2009

Installation of your new Makino EDGE-2 can be smooth and rapid if preparations are made prior to the delivery of your machine. Any questions regarding machine installation should be directed to our service department for clarification. We hope this checklist will aid in a rapid installation of your new machine. **NOTE: The following must be completed prior to our service technician arriving to install your new machine.**

- Power Requirements for your machine: 30 Amp/3 phase/9kVa
 *Voltage of 200 to 480 at +/- 10% must be maintained. If not, an Automatic Voltage Regulator should be used. Proper voltage per machine specifications should be ready at machine site. **Do NOT power up the machine. See Makino Installation Manual for more information, or contact our Service Department with any questions.**
- Customer should furnish and have available the proper supply and types of lubricants required for machine operation.

ITEM	CAPACITY	FLUID TYPE
Dielectric Oil	52.8 Gal	IONO Plus+

You will need to have Dielectric Oil on hand for installation. Contact our Service Department for more information.

- Air lines should be routed to the machine location and operational for proper air pressure.

Clean, Dry Compressed Air of 70 psi. must be available; less than 40% relative humidity; In-line water trap recommended.

- Machine location should be planned to allow enough room for access panels to be opened and serviced with ease. A minimum of 36" is required around the machine for operator and maintenance access.
- Weight requirements should be checked to insure that the surface below the machine will have sufficient strength for support and stability. The machine must be set on a solid, sound and stable, steel bar-reinforced concrete slab poured directly on the grade. In general, the 6" concrete floor on industrial buildings is suitable for machine placement.
- **The EDGE-2 is best moved with a forklift. See Makino Installation Manual for lifting instructions. **NOTE 1: LIFTING EQUIPMENT, ROPES, SCHACKLES, LIFTING BARS, LIFTING BEAMS, ETC. ARE OPTIONAL EQUIPMENT AND ARE NOT PROVIDED WITH THE MACHINE. ITEMS MUST BE PURCHASED PRIOR TO MACHINE DELIVERY IF LIFTING WITH OVERHEAD/Crane. Upon arrival of your machine, uncrate and immediately check for visible damage.**

SHIPPING WEIGHT	SHIPPING DIMENSIONS OF MACHINE
8,377 # (Skidded/wrapped)	91" L x 91" W x 96" H (Skidded/wrapped)
See Makino Installation Manual for floor space requirements/dimensions – will vary depending upon the options you purchase.	

- **Remove as much preservative from the machine as possible without having to power up (tables – slides, pulleys, etc.). We recommend mineral spirits to clean. Apply oil when finished to prevent rust.**

PLEASE FORWARD THIS TO THE APPROPRIATE PERSON. THANK YOU.

INSTALLATION INFORMATION

METRIC

ENGLISH

Machine Tool (WxDxH).....	1625 mm x 1770 mm x 2290 mm	64" x 69.7" x 90.2"
Power Supply.....		Included
Dielectric Supply		Include
Machine Tool.....	3000 kg.....	6600 lbs
Power Supply		Included
Dielectric Unit		Included
Estimated Shipping Weight.....	3000 kg.....	6600 lbs

Transportation The EDGE2 is Shipped FOB Port of Entry in One Container weighing 6600 lbs. Air Ride Transportation is recommended.

Electrical 3 Phase Power is required with a ground of 100 ohms or less. Voltage of 200 to 480 at ±10% must be maintained. If not, an Automatic Voltage Regulator should be used.

Machine Amperage	Machine kVA
30	9
60	12

Dielectric Oil One drum (55 gallons) of Highly Refined Oil with a Minimum of PAH's similar to DM-244 or EDM-250 to minimize any health risks is required for installation.

Air Clean, Dry Compressed Air of 70 psi. must be available.

Specifications may be changed without prior notice to incorporate improvements resulting from ongoing R&D programs.

Makino EDGE2 Ram Electrical Discharge Machine with MGF Control

Pre-Installation Guide

This guide is intended for use by Makino customers and Makino employees and assigns for the safe operation and maintenance of Makino equipment.

This guide was developed through the combined efforts of:

Makino Documentation Group - Mason USA

MBS Associates (Lynne Hays)

Makino Customer Support

1st Release Date: July 20, 2000

Copyright © 2000 Makino, Inc. All Rights Reserved

- No part of this manual may be reproduced or transmitted by any means or in any form to parties other than which it is intended, without the expressed written permission of Makino.
- All specifications and designs may change without notice.

Every attempt was made to ensure that the information in this publication was correct at the time of printing. As specifications and designs change, Makino is not responsible for information that becomes incorrect or inaccurate after publication.

The following icons are used in this document. Safety and precautionary statements are presented as shown below.



A **DANGER** icon precedes each danger statement. A **DANGER** icon indicates an existing hazardous condition with a high probability of death or severe injury. Precautions must be taken immediately to prevent personal injury or death.



A **WARNING** icon proceeds each warning statement. A **WARNING** icon indicates a potentially hazardous situation with some probability of death or serious injury. Precautions must be taken immediately to prevent personal injury.



A **CAUTION** icon proceeds each caution statement. A **CAUTION** icon indicates a potentially hazardous situation with some probability of personal injury or damage to the machine. Precautions must be taken immediately to prevent personal injury or machine damage.

- Precautionary statements must be followed to prevent personal injury or damage to the machine.
- In addition, all safety requirements and guidelines found in Chapter 1 - Safety, the ANSI safety guidelines the Makino Safety Manual, shipped with the machine, and established company safety requirements and regulations must be followed. Taking personal responsibility for safety will prevent most accidents.

Notes are presented using the following icon format



A **NOTE** icon indicates information that expands on information given or indicates where additional information can be found. Notes are presented immediately following the applicable content.

A copy of the ANSI Safety Manual, ANSI document number ANSI B11.8 was shipped with the machine. If this manual was lost or misplaced, another copy can be obtained from Makino at no charge.

Write us at:
 Makino
 P.O. Box 8003
 7680 Innovation Way
 Mason Ohio, 54040-8003
 Attn: Information Services

Call or FAX us at:
 Phone: (513) 573-7200
 ask for Information Services
 FAX: (513) 573-7360
 Attn: Information Services

To contact Makino, for service after the sale:

Makino 7680 Innovation Way Mason, Ohio 45040 USA	
Technical Support Services	(888) Makino4 (625-4664)
Mon.-Fri. 7:00 a.m. to 8:00 p.m. Sat. 8:00 a.m. to 2:00 p.m. (Eastern Standard Time)	Fax: (513) 459-1825
Parts Express	(888) Makino1 (625-4661)
24 hours, 7 days a week	Fax: (888)-881-9289
Training Services	(888) Makino1 (625-4661)

The following acronyms and abbreviations are used in this document:

Term	Meaning
APC	Automatic Pallet Changer- work table (pallet) storage and exchange device
ATC	Automatic Tool Changer - tooling storage and exchange device
ccw	counterclockwise - direction of rotation
CNC	Computerized Numerical Control - control unit for machine tool system
cw	clockwise - direction of rotation
DEC	Deceleration - axis slow down for reference operations
DI	Dielectric (i.e. DI Fluid, DI unit)
EOB	End Of Block - program code at end of each block of data
E-Stop	Emergency Stop - machine condition halting all machine operation
FPB	Flexible Pendant Box - portable control and axis positioning device
FSE	Field Service Engineer - customer service technician
LS	Limit Switch - LS00 = limit switch 00
MDI	Manual Data Input - operating mode for direct input of NC data
MTC	Machine Tool Cabinet - Cabinet housing main machine electrics/electronics
NC	Numerical Control - input data (i.e. NC program)
PM	Preventive Maintenance - routine maintenance items and checks
S/G	Splash Guard - machining area enclosure
SOL	Solenoid - SOL01 = Solenoid 01

AVISO!

Las personas que no pueden leer o entender en Ingles deben mandar traducir este manual y solicitar entrenamiento antes de operar o mantener la maquina. Todos los que trabajen en esta maquina deberan saber como operarla con toda seguridad y en forma correcta para evitar un posible dano.

ATTENTION!

Les personnes ne sachant pas lire l'anglais devront se faire lire et expliquer le manuel avant d'utiliser ou de faire l'entretien de la machine. Toute personne travaillant sur la machine doit savoir comment l'utiliser sans danger et correctement afin d'eviter tout accident.

HINWEIS

Alle Personen die nur Teile des Handbuches oder kein Englisch verstehen, müssen sich dieses Handbuch erklären lassen, bevor sie die Maschine in Betrieb nehmen oder instandhalten. Alle Personen, die an der Maschine arbeiten, müssen zur Vermeidung von Verletzungen zur korrekten Handhabung angeleitet werden.

WARNING!

Persons unable to read English or do not understand any part of this guide, must have this guide read and explained to them before operating or maintaining the machine. Everyone working on the machine must know how to operate and maintain it safely and correctly to prevent possible serious injury.

CONTENTS

Chapter 1	Safety Precautions
Chapter 2	Specifications
Chapter 3	Installation Process Overview
Chapter 4	Pre-Delivery Preparations
Chapter 5	Machine Delivery
Appendix A	Conversion Factors

Chapter 1 Safety Precautions

For a Safe Working Environment

Makino EDGE2
Ram Electrical Discharge Machine
with MGF Control



Chapter 1

Safety Precautions

Contents

1.1 Overview	1 - 1
1.2 General Safety	1 - 1
1.2.1 Danger, Warning, Caution Statements and Symbols	1 - 2
1.2.2 Access to Information	1 - 4
1.2.3 Point-of-operation	1 - 4
1.2.4 Lockout/Tagout Procedure	1 - 5
1.3 Personal and Professional Safety	1 - 6
1.4 Equipment and Operation Safety	1 - 7
1.5 Environmental Safety	1 - 10
1.6 Lifting Safety	1 - 11
1.6.1 Slings	1 - 11
1.6.2 Chains	1 - 11
1.6.3 Hooks	1 - 12
1.6.4 Eye Bolts	1 - 12
1.6.5 Rings	1 - 12
1.6.6 Lifting the Machine or Components	1 - 13
1.6.7 Lifting Workpieces and Fixtures	1 - 13
1.7 Mechanical Maintenance Safety	1 - 14
1.8 Electrical Maintenance Safety	1 - 15
1.9 EDGE2 Ram Electrical Discharge Machine Safety	1 - 16
1.9.1 Fire Hazard and Prevention	1 - 16
1.9.1.1 EDM Fire Conditions	1 - 18
1.9.2 Machine Safety Features	1 - 20
1.9.3 Location of Emergency (E-Stop) Button	1 - 20
1.9.4 Location of Safety Labels	1 - 21
1.10 EDGE2 Equipment and Operation Safety	1 - 23

1.11 Installation Safety Instructions. 1 - 25

1.1 Overview

This chapter provides proven general safety guidelines that, if followed, promote a safer working environment. It also contains safety information specific to the EDGE2.

All machining centers have inherent hazards the manufacturer either designs out, guards against, or warns about. Even though the manufacturer has this responsibility, the machine user has ultimate responsibility to ensure that a safe working environment is maintained in and about the machining center. This includes, but is not limited to, allowing only properly trained and technically qualified personnel program, operate, and maintain the machining center.

It is Makino's policy and responsibility to design, manufacture, and market machining centers that are as reasonably safe as possible for their intended use.

1.2 General Safety

Safety precautions or requirements discussed in Makino guides or manuals do not supersede any safety requirements imposed by local, state, or federal governments. All government-imposed guidelines, i.e. OSHA (Occupational Safety and Health Administration), NEC (National Electric Code), NFC (National Fire Code), ANSI (American National Standard Institute) standards, shall take precedence.

To protect against injury or damage operate the machining center within the guidelines described in the provided documentation. Consider Makino's safety precautions supplemental to:

- Other Makino supplied guides or manuals related to programming, operation, and maintenance of this specific machining center.
- Your company's safety rules and regulations.
- All local, state, and federal regulations.

Your particular application may require additional safety measures to ensure proper operator safety.

Additional copies of any guide or manual provided with your Makino machining center may be purchased from Makino.

Prior To Installation, Operation, or Service,

Do NOT attempt to install, operate, or service this machining center until:

- You have read and understand the safety instructions contained in this guide.
- You have read and understand all Danger, Warning, and Caution safety labels attached to the machining center and its related equipment.
- You have read and understand all technical information, including the following sections of this safety chapter.

Questions Regarding Safe Operation

Before you operate this machine – contact your Makino service group for answers to any questions about safety and your Makino machine.

1.2.1 Danger, Warning, Caution Statements and Symbols

It is important that all employees recognize each safety symbol on the machine and understand the meaning of Danger, Warning, and Caution.

These safety labels must never be removed, covered, or painted over, and must be replaced if they are damaged, defaced, or become unreadable.





Table 1-1 presents the meaning of each safety statement. It is important that all employees recognize and understand the meaning of the safety symbols shown in Table 1-2.

The location of safety labels for specific hazards on the EDGE2 is described in [section 1.9.4](#).

TABLE 1-1 DEFINITION OF DANGER, WARNING, AND CAUTION STATEMENTS

Statement	Meaning
DANGER	DANGER is the most severe safety statement. This statement means that either severe personal injury or death may result if the instruction(s) is not followed.
WARNING	WARNING is the next level of safety statement. It indicates that if the instruction(s) is not followed severe personal injury could result.
CAUTION	A CAUTION is the least severe safety statement and indicates that if the instruction(s) is not followed damage to the equipment may result.

TABLE 1-2 SAFETY SYMBOL SHAPES AND THEIR MEANING

Symbol	Meaning
	A triangle or diamond shaped safety symbol indicates a hazard exists in the area or behind the enclosure where the symbol is placed. The symbol at left indicates an electrical shock hazard exists.
	A solid colored circle shaped safety symbol with an icon inside indicates the action shown by the icon is mandatory. The symbol at left indicates that safety glasses be worn.
	A square shaped safety symbol is used to convey information relative to the area where the symbol is placed. The symbol at left indicates the area is hot.
	A circle shaped safety symbol with a diagonal slash across the image indicates the action shown is prohibited in or around that area. The symbol at left indicates that smoking is not allowed in the area.

1.2.2 Access to Information

We strongly recommend that a copy of these safety instructions and all provided guides, manuals, and technical information be kept near the machine. This information should be organized for quick access and used by operators, maintenance, and other personnel with duties related to the machining center.

Access to this information:

- May save a life.
- Will prevent or reduce injury, mis-operation, and machining center damage.

In the event that parts of this information become damaged or unusable, replace them immediately.

1.2.3 Point-of-operation

“Point-of-operation” should be safeguarded to the greatest extent possible for all machining operations.

In addition to panel locks, interlocks, and guarding, certain areas of the machining center are color coded for safety. It is important that the original color and vividness of these areas be maintained.

Different operations or applications may make the general purpose safeguards unsuitable and require additional safeguards. You and your company are required to use special safeguards in these situations.

To assist in designing point-of-operation safeguards for specific machining center applications:

- OSHA has published a booklet called OSHA Publication No. 3067.
- Films regarding safety requirements for machine tools are available from ANSI and trade groups such as NMTBA (National Machine Tool Builders Association).

1.2.4 Lockout/Tagout Procedure

The machining center is powered by high voltage and other energy sources that represent potential hazards. To reduce the risk of injury or death establish, define, and practice a Lockout/Tagout procedure for the equipment in your facility.

Lockout/Tagout defines a minimum safe procedure to be followed by persons who might be confronted with unexpected energizing, start-up, or release of stored energy that could cause injury or death. At a minimum, all Lockout/Tagout procedures should include:



Electrical Shock Hazards Exist - Work Safely

Failure to turn the Main Power disconnect to the Off position, lock it out, and tag it could result in severe personal injury or death.

1. Set the machine's Main Power switch to the Off position.
2. Affix a **DO NOT START** tag with your name and department at, on, or near the machine's Main Power switch, until all repairs are complete.
3. Turn the Main Power disconnect to the Off position.
4. Install an industry approved lockout device through the Main Power disconnect handle.
5. Install a tamper-proof padlock onto the lockout device. All persons performing maintenance on the machine at the same time shall install their own padlock onto the lockout device.
6. Disconnect the main power of all power sources (i.e. electrical, air, hydraulic, etc.).

Use the Lockout/Tagout policy and procedures defined by your company. If no Lockout/Tagout procedure has been communicated to you, please ask your supervisor to provide and explain one or obtain copies of standards to develop and implement Lockout/Tagout in your plant.

- ANSI has issued a standard to assist in the design and development of a Lockout/Tagout policy. It is written as a guide to follow when determining the specific procedures and training necessary and appropriate to your plant operations.
 - Copies of the ANSI standard are available from ANSI at 1430 Broadway, New York, NY 10018, ask for: Standard ANSI Z244.1-1982, or as modified, for personal protection - Lockout/Tagout Of Energy Sources - Minimum Safety Requirements.

1.3 Personal and Professional Safety

General safety precautions should be practiced everyday, but never become common place. Safety is the responsibility of every person on the job site. In this regard, consider yourself responsible for safety in your workplace. No one is better positioned to eliminate or prevent unsafe conditions than you. Each employee should practice the following, regardless of their position, title, or labor grade:

- Approach and intercede anytime you witness unsafe procedures.
- Be prepared to report any condition which seems unsafe to your company's safety department or any supervisory or management staff. It could save lives. In particular report such things as:
 - Missing or defective guards and protective devices.
 - Leaks and spills of cutting fluid, lubricants, or any liquids.
 - Improperly stored chemicals or flammable materials and any unusual fumes.
 - Loose, worn, or broken flooring.
 - Slippery, broken, or unstable platforms.
 - Missing, broken, or unstable handrails.
- Avoid making sudden movements, loud noises, engaging in horseplay, or other activities that may prove distracting and result in an unsafe or dangerous work environment. Remember that around machinery, it only takes a second's inattention to result in personal injury or death.
- Observe and obey all signs posted on the machinery and its components and signs placed by your company, like:
 - NO SMOKING
 - SAFETY GLASSES MUST BE WORN WHILE OPERATING THIS MACHINE
 - DANGER - HIGH VOLTAGE, etc.
- Wear appropriate safety equipment as defined by OSHA, the equipment manufacturer, your company safety policy, or MSDS (Material Safety Data Sheet). Always wear approved eye protection and other safety equipment to meet the demands of current conditions while operating or working around the machining center.
- Clean up any oil or other liquid spills immediately.

- Obtain an MSDS for each chemical (such as cutting fluids, lubricating oils, greases, etc.) used on or around the machining center. Practice safe working habits and wear all protective equipment required. Know and understand the procedures to follow in the event:
 - Your skin is exposed to the chemical.
 - Your eyes are contacted by the chemical.
 - You ingested or inhaled the chemical.

1.4 Equipment and Operation Safety

We urge that all machining centers be operated, equipped, and cared for in strict compliance with all local, state, and federal safety regulations. The following safety requirements apply to all machinery and should be practiced in addition to machine specific safety guidelines.

- Do not neglect your responsibility to ensure that all machining centers are operated, maintained, and equipped with complete regard for operator safety.

Only qualified personnel, trained in safety and all machining center functions should be allowed to operate, maintain, or repair the machine.

To be considered qualified, all personnel whose duties are related to the operation, maintenance, or repair of the machining center should:

- Know the location and operation of the [**EMERGENCY**] (E-Stop) button.
- Study the related guides or manuals prior to attempting to operate, maintain, or repair the machine.
- Locate and understand all **Danger**, **Warning**, and **Caution** labels on the machining center and accessories.

Machining centers are designed for operation by one person at a time.

- Persons other than the designated operator should stay out of the area during operation.
- Unauthorized personnel may increase the potential for injury or damage due to inattentiveness.

Be sure to Always:

- Take steps to protect the machine tool and control cabinets from moisture and condensation. Moisture can damage electrical components, causing unwanted machine motion, leading to injury or machine damage.
- Maintain the exact original color and vividness of any machine areas that are color coded as safety precautions.
- Ensure that all shields and guards are in place and all covers, cabinet doors, and terminal boxes are closed prior to operation.
- Avoid accidentally bumping any machine controls, as this may cause unintended machine motion causing injury or machine damage.
- Be alert for loose, damaged, or worn parts on the machine and associated equipment. Immediately correct or report any loose items, noticeable change in operating noise, or any unusual machine action.
- Be aware of the machine and auxiliary components' moving members and range of movement which may create pinch points. Always be cautious of these areas. Avoid pinch points entirely during machine operation.
- Keep the machining center properly maintained. Perform maintenance at prescribed intervals, as described in the Mechanical Editions. Machining center maintenance should be performed only by authorized individuals.
- Check the level of each fluid reservoir periodically. Add fluids, if needed, as described in the Mechanical Editions. Use only recommended lubricants.
- Keep the machining center clean. Keep the work area clear of chips, rags, etc. Clean up any spilled or splashed fluid on the floor immediately. Cleaning should be performed at least daily.
- Double check the set up and workpiece before power up.
- Check all clamp bolts for tightness and verify the accuracy of all set ups before restarting machining operation.
- Use caution when handling workpieces after machining. Machining can produce sharp edges and, at times, considerable heat.

You should:

- Never wear loose-fitting clothing or accessories that may be entangled in machine components. In particular, never wear any of the following items when working in a shop environment:
 - Jewelry (rings, bracelets, watches, or necklaces) and accessories (necktie, scarf, or loose fitting belt)
 - Long hair (tie back and contain it under a hair net or cap)
- Never operate any machinery after taking strong medication, using nonprescription drugs, or consuming alcoholic beverages.
- Do not make modifications to the machine or associated equipment that may reduce the operational safety of the device such as:
 - Never paint, alter, deface, or remove any danger, warning, or caution label. (Replacement labels are available from Makino)
 - Never change or by-pass the location of the stroke limit dogs, limit switches, interlock circuitry, etc.
 - Never operate the machine with any safety device disabled or removed or any cover open or removed
- Do not allow yourself to become trapped or caught in pinch points:
 - Always be aware of a safe exit, when in or around any type of equipment. Know the travel limits of the machining center and always keep all body parts clear of moving components.
 - Never enter an area restricted by a barrier without first properly shutting down the equipment and locking out the power sources to prevent its restarting.
 - Never perform any set up, check the set up, or reach into the work area or across moving parts while the machine is in automatic operation.
 - Never change a workpiece or perform a manual operation on a workpiece while the machine is in automatic operation.
- Never activate or press any button or other operating control unless you are trained on the operation of that device, machine, or equipment.
- Never use compressed air to clean or blow chips or dirt off the table, workpiece, or the machining center.

1.5 Environmental Safety

Follow these specific practices when working at the machining center:

- The area around the machine should be well lighted, dry, and free from obstructions. Keep the area around the machine clean and in good order at all times.
- Equipment should not be operated during severe thunderstorms or other electrical disturbances.
- In the event of a power failure, turn the Main Power switch Off immediately. Leave the switch in the Off position until the power is fully restored and normal operations can safely be resumed.
- Never step on machine covers as they can become slippery during normal operation and are not designed to support your weight.
- Never perform grinding operations in the vicinity of the machining center. The dust created by grinding can contaminate components, cause premature wear, and cause inaccuracies or component failure.
- Never weld on parts mounted on or in the machine. Electrical currents associated with welding could cause bearing damage or explosions and result in serious injury or equipment damage.
- When a platform is placed around the machining center, it should be extremely sturdy, safe, and have anti-slip surfaces.
- Keep all flammable liquids away from the work area.

1.6 Lifting Safety

These lifting safety precautions must be followed by all persons responsible for lifting. This includes, but is not limited to, lifting machinery, machine components, and workpieces:

- All lifting equipment must be properly rated for the weight being lifted.
- All lifting equipment must be inspected on a regularly scheduled basis.
- Any lifting device found to be defective must be repaired in accordance with industry standards.
- Any lifting device that cannot be repaired must be destroyed.

1.6.1 Slings

Use nylon slings when lifting irregularly shaped objects and:

- Never exceed the lifting capacity of any sling.
- Protect slings with heavy padding when lifting objects with sharp edges.

1.6.2 Chains

Lifting chains must be stored properly to prevent damage when not in use.

When using chains:

- Never exceed the lifting capacity of any chain.
- Do not drag chains.
- Do not allow chains to become tangled or kinked.
- Never twist chains in an attempt to shorten their length. Use proper devices to shorten a chain's length.
- Use chains equipped with enclosed lifting hooks.

1.6.3 Hooks

When using hooks:

- Never exceed the lifting capacity of any lift hook.
- Do not repair lifting hooks.
- Destroy and discard bent lifting hooks.

1.6.4 Eye Bolts

To ensure a safe load carrying capacity:

- Never exceed the lifting capacity of any eye bolt.
- An eye bolt must be engaged to at least 90 percent of its threaded portion.
- Never weld or heat an eye bolt to a temperature in excess of 480° C (900° F). Heat exposure can change the physical properties of the stock and create an unsafe eye bolt.
- Never use an inch eye bolt in a metric thread or vice versa:
 - Use inch series thread eye bolts in inch series threads.
 - Use metric series thread eye bolts in metric series threads.
- Never use a painted or coated eye bolt as this may cover up defects.
- Discard and destroy any defective eye bolts.

1.6.5 Rings

When possible use a lifting ring or clevis instead of an eye bolt. Secure the lifting ring with the correct inch/metric series bolt.

- Never exceed the lifting capacity on any lifting ring or clevis.

1.6.6 Lifting the Machine or Components

Use only a lifting device and related equipment that is capacity rated to lift the total weight of the machining center (and shipping skid, if the skid is attached during lifting). Always follow the lifting instructions provided in the Pre-Installation Guide.

Before lifting, refer to shipping documents to obtain the weight of the machine or component being lifted. If the necessary weights cannot be determined, consult Makino. In addition:

- Only qualified riggers should perform machine lifting operations.
- Never place any portion of your body beneath a suspended object.
- Lift the machining center only at the designated lifting points.
- Never lift the machine higher than necessary.
- Always maintain the center of gravity by properly adjusting the leg lengths of the lifting device.

1.6.7 Lifting Workpieces and Fixtures

Always use a lifting device and related lifting equipment that is capacity rated for the workpiece or fixture being lifted.

- Never place hands, arms, feet, or any other portion of your body beneath a suspended workpiece fixture.
- Always maintain the center of gravity by properly adjusting the leg lengths of the lifting device.

1.7 Mechanical Maintenance Safety

Mechanical maintenance procedures for Makino machining centers should be performed by properly trained and technically qualified personnel. They should adhere to these specific practices when working with the machining center:

- Always perform Lockout/Tagout before removing any safety guard, cover, barrier, or any basic component of the machining center. See [section 1.2.4](#).
- Block vertical sliding members before disassembling any portion of their drive train.
- Be familiar with and adhere to safe lifting practices described in [section 1.6](#) before lifting the machine or components.
- Never return the machining center to production until all safety guards, covers, barriers, or other safety devices are reinstalled and confirmed operational.

Mechanical Maintenance Equipment

Mechanical maintenance personnel should:

- Keep all hand tools in good repair.
- Use each hand tool in a manner for which it is intended.
- Never use any hand tool that is defective, broken, or worn out.
- Keep alert with regard to nearby hazards.
- Do not use extenders in an effort to gain leverage; use a bigger tool.

1.8 Electrical Maintenance Safety

Electrical maintenance procedures for Makino machining centers must be performed by properly trained and technically qualified personnel. They should adhere to these specific practices when working with the machining center:

- Always perform Lockout/Tagout before working on electrical circuits. See [section 1.2.4](#).
- Use extreme care when troubleshooting with power On.
- With the power Off, identify and discharge any power retaining devices, such as capacitors, before starting any maintenance procedure within any electrical control cabinet.

Electrical Maintenance Equipment

Use only industry standard approved electrical testing equipment.

- Volt/Ohm Meters.
- Oscilloscopes.
- Static Ground Wrist Straps.

Machine Grounding

All Makino machining centers must be properly grounded at the time of installation.

- JIS class 3 grounding (resistance of 100 Ohms or less) is recommended.
- Proper grounding requires an isolated earth ground.
- Ground the machine in accordance with local, state, and federal regulations.

Machine Electrical Devices

Always replace defective electrical components, such as fuses, shunts, overloads, etc., with components of the same capacity and rating as the original equipment. If you are unsure of the correct electrical component or part, refer to the machine's electrical drawings or consult Makino.

1.9 EDGE2 Ram Electrical Discharge Machine Safety

In addition to safety precautions for all machining operations, Become familiar with the machine specific safety features listed below.

1.9.1 Fire Hazard and Prevention



Fire Hazard

RAM type EDM uses a dielectric fluid in the machining process. This fluid is flammable and may ignite, if improperly applied.

All Makino RAM machines are provided with the following fire related safety features:

1. Dielectric Temperature Detector – to immediately stops the machining process when the temperature of the dielectric fluid rises above a set value of 53°C.
2. Dielectric Level Detector – to immediately stops the machining process when the dielectric level falls below the set level. The set level must be at least 50mm above the workpiece.
3. Abnormal Machining Detector – stops the machining process if an arc occurs for an extended duration. During an arc the head retracts to clear the problem. If the head retracts beyond a specified distance, machining stops and an “abnormal machining” alarm is generated.
4. Automatic Fire Extinguisher – If the dielectric fluid catches fire a sensor detects the temperature rise and discharges the extinguishing agent into the work area. Additionally, all machine functions stop and an audible alarm sounds. To resume machining operations, you must change filters and dielectric fluid to remove the extinguishing agent. Do NOT remove or change the positions of the fire extinguisher sensor(s) or jet nozzle(s).

Be sure to Always:

- Keep all fire extinguishers fully maintained and operational and train all personnel in their proper use.
- Ensure the automatic fire extinguisher is fully operational. Perform a functional test at the prescribed intervals. Never operate the machine with the fire extinguisher testing knob in the "LOCK" position.
- Install additional fire extinguishers of a type for liquid applications in the work area.
- Fully ventilate the work area at all times.
- Pay attention to the mounting method of the electrode, workpiece and fixture so that electrical discharge does not occur near the surface of the dielectric.
- Monitor the machining process. Never leave the machine totally unattended for extended periods of time. Allocate workers in such a manner that necessary measures can be taken if a problem occurs or if a fire arises.
- Use only approved dielectric fluids.

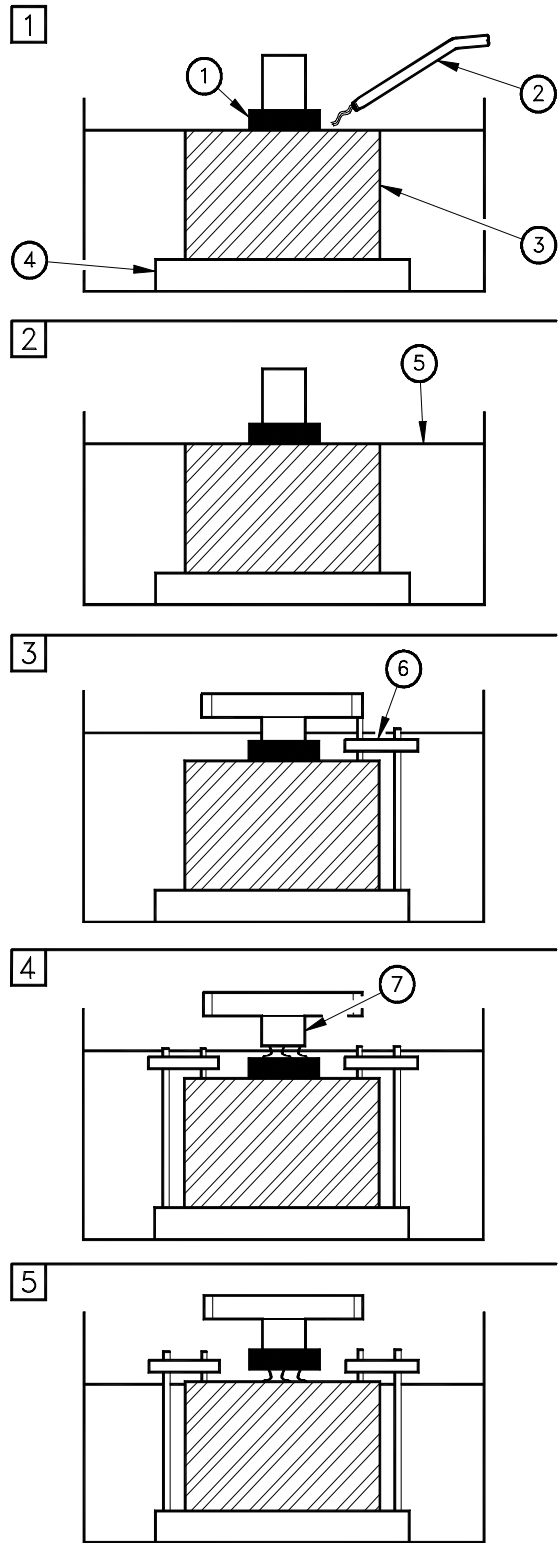
You Should Never:

- Never substitute any other flammable liquids, such as kerosene for dielectric fluid.
- Never use fire or heat sources such as heaters, welding machines or open flame, near the machine.
- Never machine with fluid only being jetted onto the workpiece.
- Never machine with less than 50mm of dielectric fluid covering the workpiece.

1.9.1.1 EDM Fire Conditions

The following conditions may result in fire during machining operations (Figure 1-1).

1. Fire hazard caused by spraying dielectric fluid onto workpiece. Workpiece should be submerged in the dielectric fluid to ensure safe burning.
2. Fire hazard from machining without enough dielectric fluid covering the workpiece. Dielectric level must be 50mm above the top of the workpiece.
3. Fire hazard from machine platen contacting a clamp. Ensure moving machine members will clear clamps, workpiece, and fixturing.
4. Fire hazard due to arcing between shank and electrode. This is caused if the electrode becomes loose or is improperly mounted.
5. Fire hazard due to carbon build up is caused by a combination of too little dielectric fluid covering the part and arcing.
6. Fire hazard can be caused by concave electrode shape (not shown), as gas can collect in cavity. Ensure a vent hole is drilled at the high point of the cavity.



17EDB50B001A

Legend

[1]	Electrode
[2]	Jet Nozzle
[3]	Workpiece
[4]	Table
[5]	Dielectric
[6]	Clamp
[7]	Shank

FIGURE 1-1 EDM FIRE CONDITIONS

1.9.2 Machine Safety Features

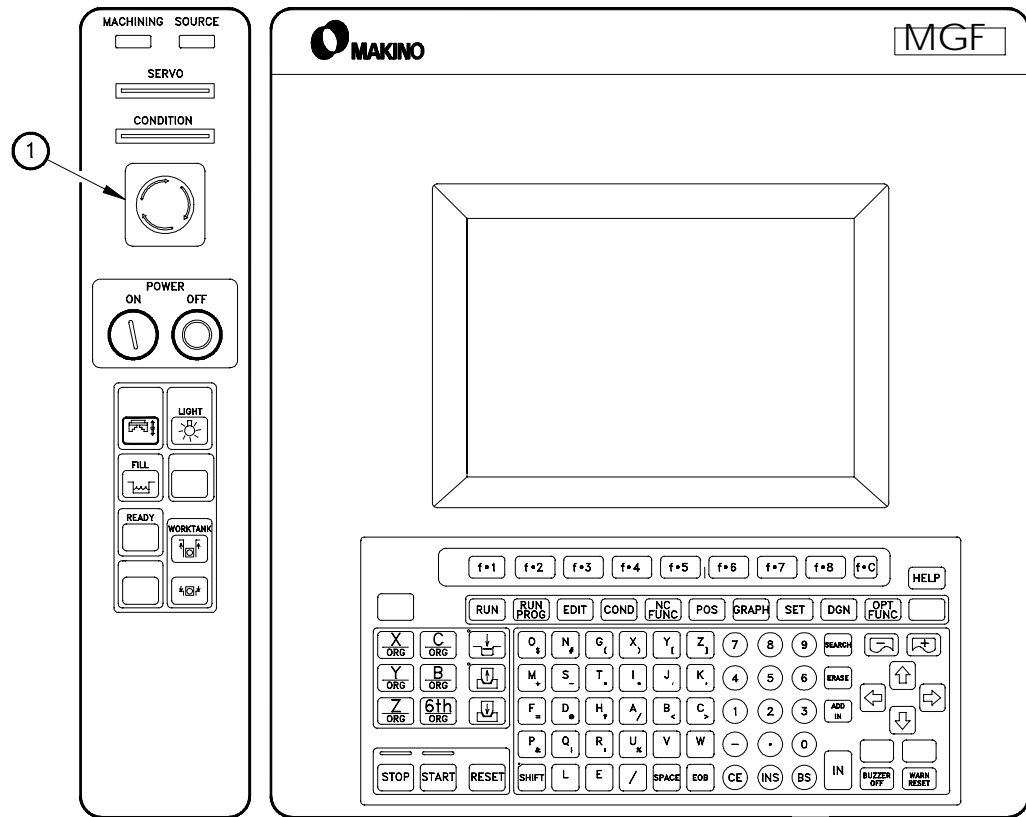
The EDGE2 provides the following safety features:

- [EMERGENCY] button, to immediately halt all machine functions.
- Automatic Fire Extinguisher and other fire related equipment, see [section 1.9.1 \(pg 1-16\)](#).

Descriptions, operational detail, and precautions related to these safety features are described in the Operation Guide.

1.9.3 Location of Emergency (E-Stop) Button

The [EMERGENCY] button [1] is on the Main operation panel (Figure 1-2).



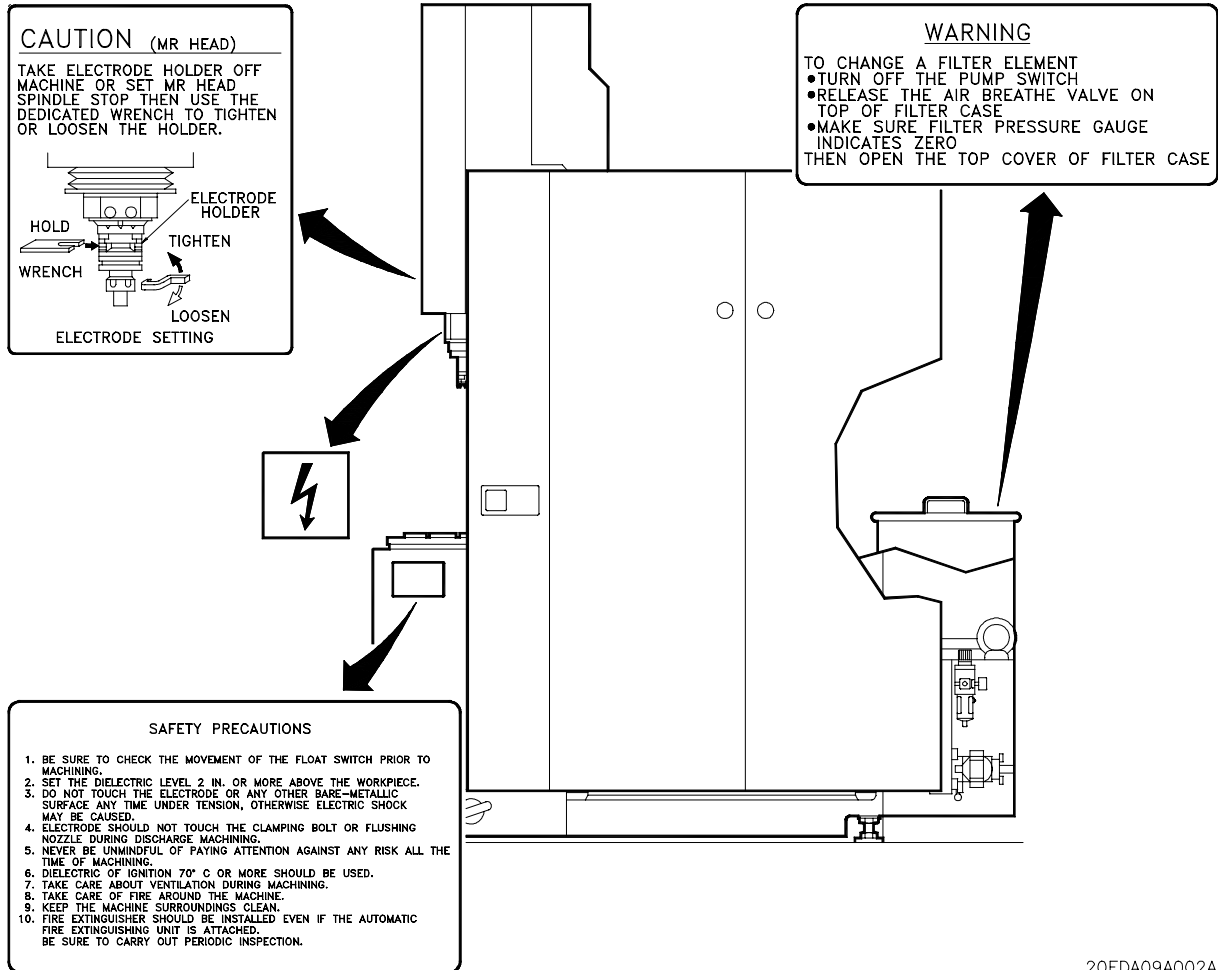
17EDB09A001A

FIGURE 1-2 EMERGENCY BUTTON LOCATION

1.9.4 Location of Safety Labels

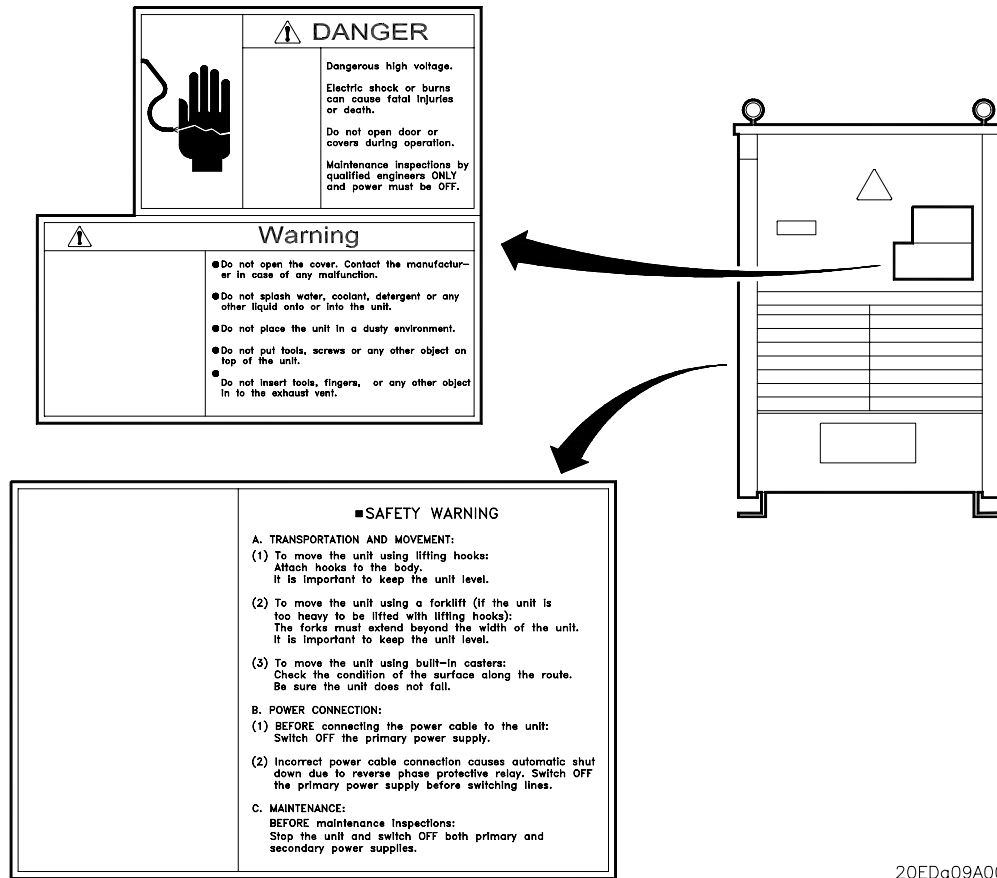
Labels attached to the machine at specific areas, identify safety risks and provide important instructions that must be read and followed.

- Machine safety labels (Figure 1-3)
- Oilmatic safety labels (Figure 1-4 (pg. 1-22))



20EDA09A002A

FIGURE 1-3 MACHINE SAFETY LABELS - RIGHT VIEW



20EDa09A001A

FIGURE 1-4 OILMATIC SAFETY LABELS

1.10 EDGE2 Equipment and Operation Safety

In addition to the general safety precautions in [section 1.2](#), adhere to these specific practices when working with the EDGE2.

Be sure to Always:

- Inspect all tool holders for nicks or other damage to ensure the accuracy of machining operations and prevent damage to the equipment.
- Check with the manufacturer to ensure proper and safe operation in a RAM EDM environment, of any accessory NOT specifically built, designed, or supplied by Makino.
- Use extreme caution when changing electrodes. Make sure that all electrodes are properly loaded and secured and that they will not come into undesirable contact with items in the work area during operation.
- Load or unload workpieces only when the machine is completely stopped and the control is in the STOP or RESET status.
- DRY RUN machining programs to verify that there is no chance of any interference between any machine parts, fixturing, and workpiece prior to unattended operation of the machine.
- Before moving the X, Y, or Z axes, make sure that there are no obstructions within the range of movement.
- Check the tightness of all clamping devices, fixture mounting, electrodes and tool holders prior to any machining operations. Be sure to verify the accuracy of the set up prior to automatic operations.

You should Never:

- Never use any device NOT specifically designed for use in an EDM environment. The dielectric fluid and electrical energies will cause damage to improperly designed devices.
- Never lay tools on the machine where they may interfere with machine movement or can become entangled with the work.
- Never exceed the machines specified maximum workpiece weight (500kg) or electrode weight (50kg).
- Never perform any set up work while the machine is in operation.

Working Inside the Machine

When working inside the machine be aware that axes and work tank operation are hazards that could result in serious injury or death. Therefore:

- Enter the machining area only when all machine motion is completely stopped and the control is in the STOP or RESET state.
- Remember injury can occur if any body parts are caught between top of the work tank and the workpiece or fixture or between work tank bottom and a platform or steps set near the machine.
- Ensure the Flexible Pendant Box cable does not interfere with the workpiece or fixture.
- Always place the Flexible Pendant Box to prevent accidental key activation resulting in unexpected machine movement.

Prior to Machining

- Check with the manufacturer of any accessory not designed, built, or supplied by Makino to ensure the device will operate properly and safely under the proposed operating conditions.
- Prior to unattended operation, prove out part programs to ensure clearance between machine parts, fixturing, and the workpiece.
- Before moving the axes, make sure there are no obstructions within the range of movement.
- Verify the accuracy of the set up prior to automatic operation. Check the tightness of all clamping devices, fixture mounting, etc.

Workpiece Handling Safety

These specific lifting safety precautions must be followed by all personnel responsible for lifting workpieces. In addition to the general lifting precautions in [section 1.6](#), adhere to these specific practices with the EDGE2:

- The EDGE2 has a maximum allowable table capacity of 500kg. Never exceed this weight limit.
- Use lifting equipment for heavy workpieces and other materials. Never attempt to lift anything beyond a reasonable weight without proper devices.
- Use care not to place fingers or hands where they may be pinched by the table or lower head while loading/unloading workpieces.

1.11 Installation Safety Instructions

The following information is related to installation of the machining center. Adhere strictly to the installation instructions provided in the Pre-Installation Guide:

- Review the general lifting safety rules in [section 1.6](#) and the specific procedures in the Pre-Installation Guide, prior to moving the machine.
- Review the general electrical safety rules in [section 1.8](#) and the specific procedures in the Pre-Installation Guide, prior to connecting power to the machining center.

Chapter 2 Specifications

Machine Unit and Control Specifications

Makino EDGE2
Ram Electrical Discharge Machine
with MGF Control



Chapter 2 Specifications

Contents

2.1 Overview	2 - 1
2.2 Installation Specifications	2 - 1
2.2.1 Layout Drawings	2 - 2
2.2.2 Foundations	2 - 5
2.3 General Information.....	2 - 6
2.3.1 Machine Environment	2 - 6
2.3.2 Machine Size	2 - 6
2.3.3 Electrical Power	2 - 7
2.3.4 Air	2 - 8
2.4 Unit Specifications.....	2 - 9
2.4.1 Head	2 - 9
2.4.1.1 C Axis (option)	2 - 10
2.4.2 Table	2 - 11
2.4.3 Axis Components (Spindle, Ram, Saddle)	2 - 12
2.4.4 Accuracy	2 - 12
2.4.5 ATC	2 - 14
2.4.5.1 Maximum Electrode Size	2 - 14
2.4.6 Dielectric Fluid Supply	2 - 15
2.4.6.1 Dielectric Fluid.....	2 - 16
2.4.7 Machining Power Source	2 - 17
2.5 Makino MGF Control	2 - 18
2.5.1 Operation Panel	2 - 18
2.5.2 Machine Communications	2 - 18
2.5.3 Operational Support	2 - 19
2.5.4 Maintenance and Safety	2 - 20
2.5.5 Controlled Axes and Coordinate System	2 - 20
2.5.6 Auxiliary Functions and Machining Conditions	2 - 21
2.5.7 Interpolation and Feeds	2 - 21
2.5.8 Programming	2 - 22

2.1 Overview

Makino's EDGE2 provides fully automated functional machine capabilities. Machine and MGF control specifications follow.



Information Subject to Change

Every effort was made to ensure the accuracy of the data presented in this chapter at the time of publication. Machine and control specifications are subject to change without prior notification.

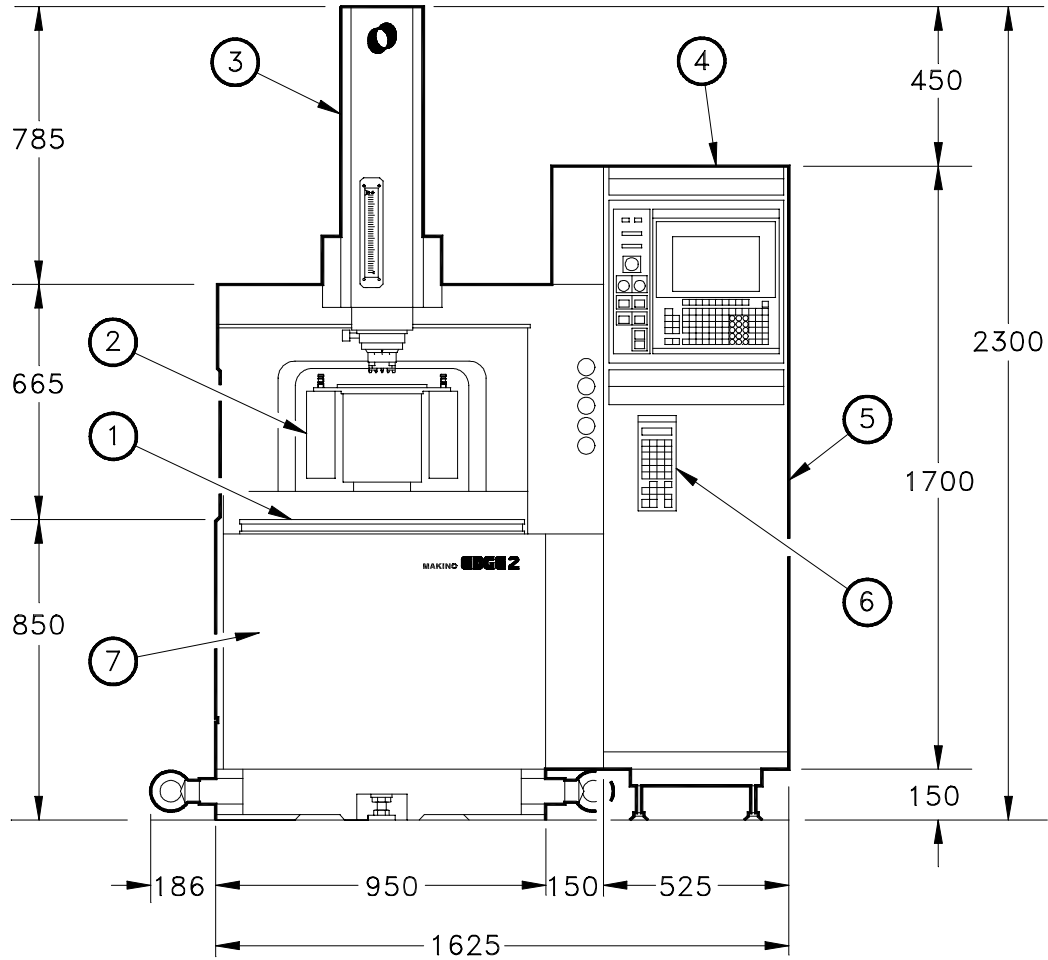
2.2 Installation Specifications

Dimensional and general arrangement drawings are included in this section to ensure proper machine site selection.

The machine tool should be placed with sufficient clearance to:

- Access the rear of the machine and all auxiliary components.
- Completely open all cabinet doors and panels.
- Prevent interference and potential pinch points of moving components with structural features (pillars, walls, etc.), other machines, their range of movement, or components.

2.2.1 Layout Drawings

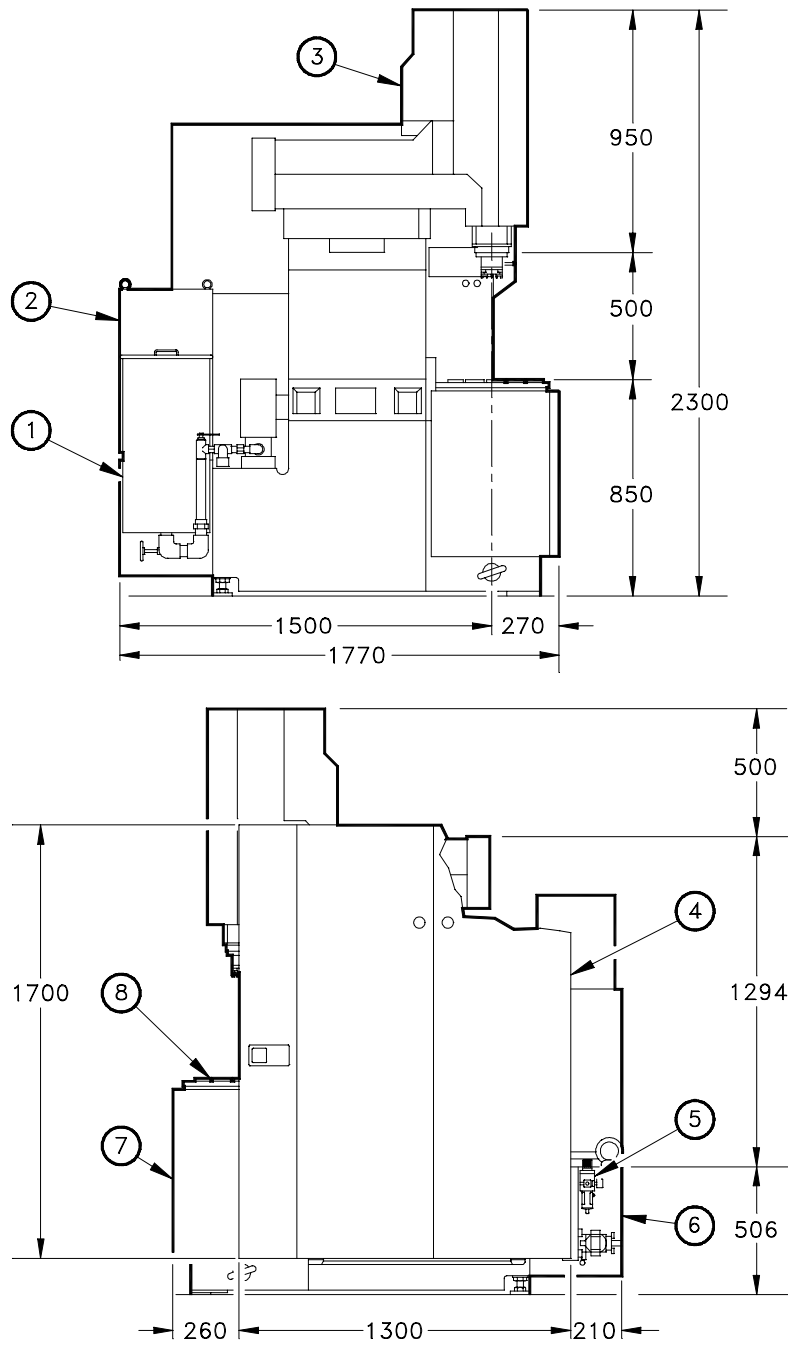


20EDA03A001A

Legend

[1] Work Table	[5] NC Unit
[2] ATC	[6] Flexible Pendant Panel
[3] Ram	[7] Work Tank
[4] Main Operation Panel	

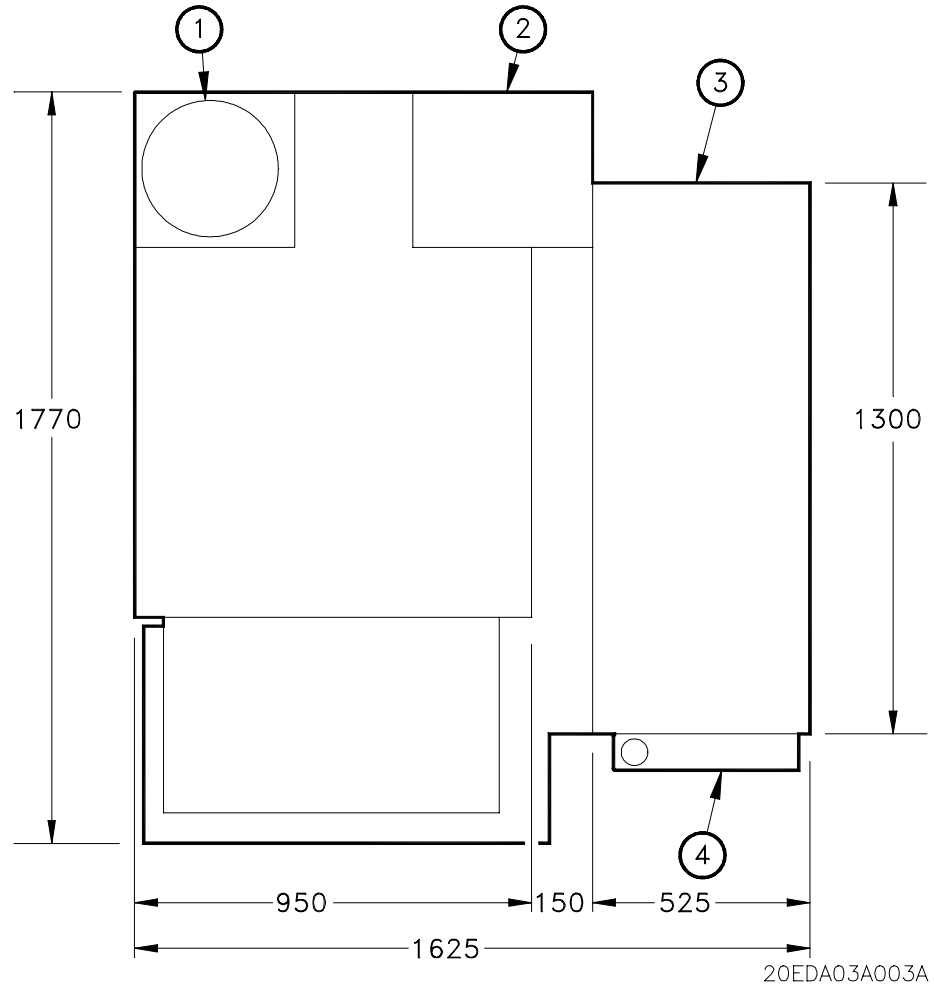
FIGURE 2-1 EDGE2 FRONT VIEW



Legend

[1] Dielectric Unit	[5] Air Filter Regulator
[2] Oilmatic	[6] Automatic Fire Extinguisher
[3] Ram	[7] Work Tank
[4] NC Unit	[8] Work Table

FIGURE 2-2 EDGE2 LEFT AND RIGHT VIEWS



Legend

[1] Dielectric Unit	[3] NC Unit
[2] Oilmatic	[4] Main Operation Panel

FIGURE 2-3 EDGE2 GENERAL ARRANGEMENT DRAWING

2.2.2 Foundations

The machine should be placed on a continuous concrete pad. The required floor space (including standard accessories) is 2225 × 2370mm for a standard machine. The required floor space increases with ATC or booster options.

- The recommended concrete thickness is 300mm.

2.3 General Information

This section contains general information on EDGE2 environment, machine size, power, and air requirements.

2.3.1 Machine Environment

The EDGE2 performance is directly affected by the environment. Table 2-1 lists key environmental specifications.

TABLE 2-1 EDGE2 ENVIRONMENTAL SPECIFICATIONS

Item	Specification
Ambient Temperature Range	10 – 35°C
Optimum Temperature	20±1°C
Maximum Relative Humidity	75% (no condensation)
Maximum Vibration	0.7m/s ²
EDGE2 Heat Release Rate 30A	5.3kW
EDGE2 Heat Release Rate 60A	7.1kW

In addition, protect the EDGE2 from:

- Dust, like that from grinding or polishing machines.
- Direct sunlight, excess air from ventilation systems, or any source that may affect the machine temperature.

2.3.2 Machine Size

Machine dimensions are listed in Table 2-2. External dimensions and floor plans are presented in [section 2.2.1](#).

TABLE 2-2 MACHINE DIMENSIONS

Item	Specification
Height	2290mm
Width	1625mm
Depth	1770mm
Weight (including NC unit and generator)	3000kg
Required Floor Space	2225x2370mm

2.3.3 Electrical Power

A 3-phase power source, with stable voltage regulation ($\pm 10\%$) and a JIS class 3 ground, of 10 ohms or less, must be provided.

The EDGE2 operates on 200/220VAC $\pm 10\%$, 50/60Hz $\pm 1\%$ connected to a terminal in the machine tool cabinet.

- A standard machine operates on 9kVa.

The customer must:

- Provide a properly sized service box for the machine. Use local code and Table 2-3 to assist in sizing the machine electrical service. Use the machine kVa rating when calculating machine electrical consumption.
- Ensure the electrical service voltages meet all requirements.
- Install an additional automatic voltage regulator if the required voltage cannot be maintained within $\pm 10\%$.
- Connect incoming electrical service at the Main Power switch.
- Provide a JIS class 3 ground of 100 ohms or less.

To convert kVa to amperage for service amperage:

$$kVa \times 1000 / 1.73 \times Voltage = amps$$

then take:

$$amps \times 125\% = Service$$

TABLE 2-3 MACHINE POWER REQUIREMENTS

Power Requirements	
Machine kVa Rating Standard 30amp	9kVa
Machine kVa Rating 60amp	12kVa
Source Voltage ($\pm 10\%$)	200-480VAC
Operating Voltage ($\pm 10\%$)	200-220VAC
Cycle ($\pm 1\%$)	50/60Hz

2.3.4 Air

Dry and clean compressed air at 0.6MPa must be available. The air supply line should be permanently piped.

- A pressure switch detects if air pressure drops below 0.3MPa and stops machine operation.

TABLE 2-4 AIR SPECIFICATIONS

Item	Specification
Standard machines	Pressure 0.6MPa
	Consumption 100 liter/min.
With MA Head	Pressure 0.6MPa
	Consumption 200 liter/min.
With ATC	Pressure 0.6MPa
	Consumption 200 liter/min.

2.4 Unit Specifications

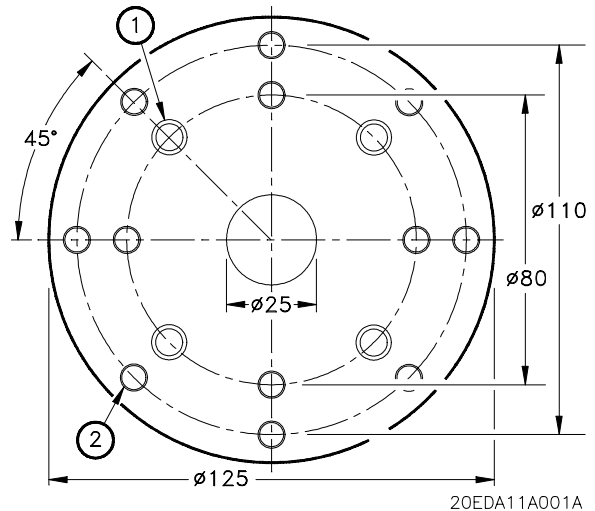
Specifications for each machine component follow. These specifications are presented to serve as a quick reference.

2.4.1 Head

The head can be purchased in several configurations. On standard heads the electrode is bolted directly to the platen. Figure 2-4 shows the platen bolt pattern.

Machines may also be purchased with a C axis (option) which comes with a chuck adapter.

- The C axis may be purchased with a 3R macro or Erowa rapid action chuck system



Legend

[1]	M10 x 1.50 TAP (4 Places)
[2]	M8 x 1.25 TAP (12 Places)

FIGURE 2-4 STANDARD PLATEN BOLT PATTERN

TABLE 2-5 HEAD SPECIFICATIONS

Item	Specification
Max Electrode Weight 3 Axis Orbiting	50kg
Max Weight Capacity of Chuck	40kg

2.4.1.1 C Axis (option)

The C axis is available in a MA or MR configuration (Table 2-6). The C axis allows programmable indexing of the head for positioning the electrode to a specific angle. The MA and MR heads also provide a rotary function for rotating the electrode.

- Refer to your sales order to confirm the head provided on your machine.

TABLE 2-6 SPECIFICATIONS FOR MA AND MR HEADS

Specification	Head Type	
	MA	MR
Speed (Rotary Function Selected)	10~1000rpm	0~10rpm
In Rotation (C-axis and Rotary Function)	30 amps	30 amps
Fixed (C-axis and Rotary Function)	30 amps	60 amps
Max. Electrode Weight in a Fixed Position	5kg	10kg
Max. Electrode Weight Using C-axis Positioning	10kg	15kg
Minimum Input Increment	0.001°	0.001°
Tooling Provisions Available	Erowa ITS or 3R Macro	

2.4.2 Table

Figure 2-5 shows table detail and Table 2-7 lists table specifications.

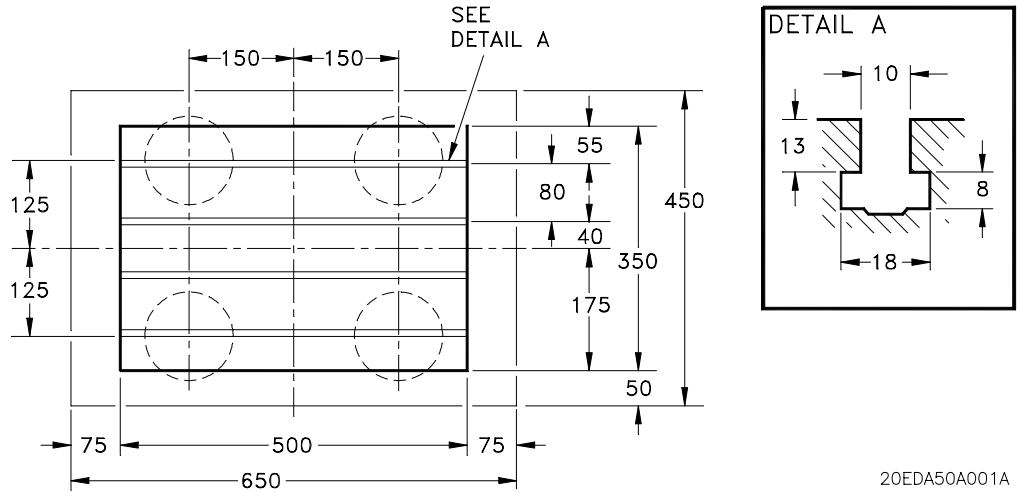


FIGURE 2-5 TABLE AND T-SLOT DETAILS

TABLE 2-7 TABLE SPECIFICATIONS

Item	Specification
Table Size	500x350mm
Number of T-Slots / Size	10mm x 4 rows
Maximum Workpiece Weight	500kg
Table Surface Height	840mm

2.4.3 Axis Components (Spindle, Ram, Saddle)

Table 2-8 lists work zone and machine travel specifications. Figure 2-6 shows axis configuration and work cube.

TABLE 2-8 AXIS COMPONENT SPECIFICATIONS

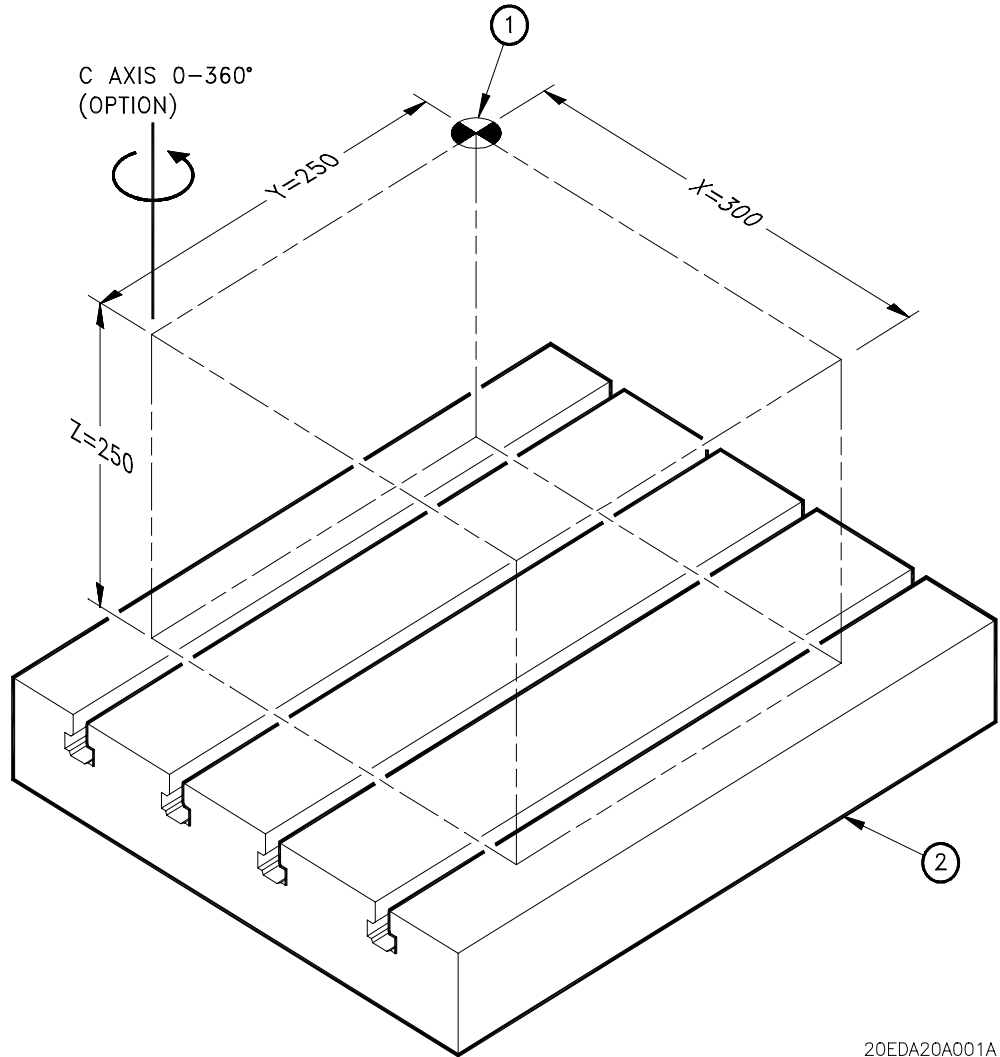
Item	Specification
X,Y Axis Travel	300x250mm
Z Axis Travel	250mm
Worktank Dimensions (WxDxH)	650x450x300mm
Platen to Table Distance Bottom Point	250mm
Chuck Face to Table Bottom Point	180mm
Table Size	500x350mm

2.4.4 Accuracy

Table 2-9 lists standard machine accuracy specifications. These accuracies are checked at the factory and require proper installation, foundation, environment, operation, and maintenance to be maintained or guaranteed.

TABLE 2-9 ACCURACY SPECIFICATIONS

Item	Specification
Static Load Positioning	± 5 microns [0.005mm]
Repeatability	± 2 microns [0.002mm]
Dynamic Machining	± 5 microns [0.005mm]
* Above accuracies can be guaranteed, when machine is installed, operated, and maintained under proper conditions.	



20EDA20A001A

Legend

[1]	Machine Reference
[2]	Table

FIGURE 2-6 AXIS CONFIGURATION AND WORK CUBE

2.4.5 ATC

An ATC (Automatic Tool Changer) provides several advantages in extending no or low-attendant machining, automatic multiple operations, and assigning spare tools for long job runs. The standard ATC is an A4 rack type with an A8, A16, or A24 carousel types available. Table 2-10 lists ATC specifications.

TABLE 2-10 ATC SPECIFICATIONS

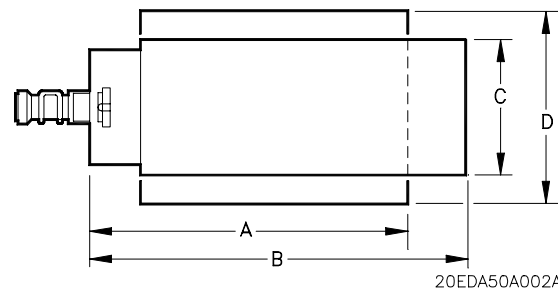
Item	Specification
Tool Selection	Random or Sequential
Tool Change Time	Approximately 45 Seconds
Max Electrode Weight by ATC	5kg

2.4.5.1 Maximum Electrode Size

Maximum electrode length and diameter (Figure 2-7) are limited by ATC size, chuck type, and work tank position.

Maximum electrode diameter varies by ATC size. Maximum electrode length varies with chuck type and work tank position. See Table 2-11.

- Maximum length is based on work tank in full up position.



Legend

[A] 230mm	[C] 60mm
[B] 250mm	[D] 80mm

FIGURE 2-7 ELECTRODE SIZE LIMITATIONS

TABLE 2-11 ELECTRODE LIMITATIONS BY ATC SIZE AND CHUCK TYPE

ATC Size	Maximum Length ¹		Maximum Diameter
	3R Macro	EROWA	
A4	230mm	250mm	80mm
A8	230mm	250mm	80mm
A16	230mm	250mm	60mm
A24	230mm	250mm	60mm

¹ Maximum length with work tank in full up position.

The maximum electrode length, shown in Figure 2-7, is for the work tank in full up position and is also affected by chuck type.

2.4.6 Dielectric Fluid Supply

The dielectric supply unit (DI unit) consists of an integrally designed tank, filters [1], and cooler unit.

This system filters machining sediments from the fluid and supplies clean fluid to the work tank for optimum machining. For increased accuracy, the cooler maintains fluid temperature within a set range of the machine temperature.

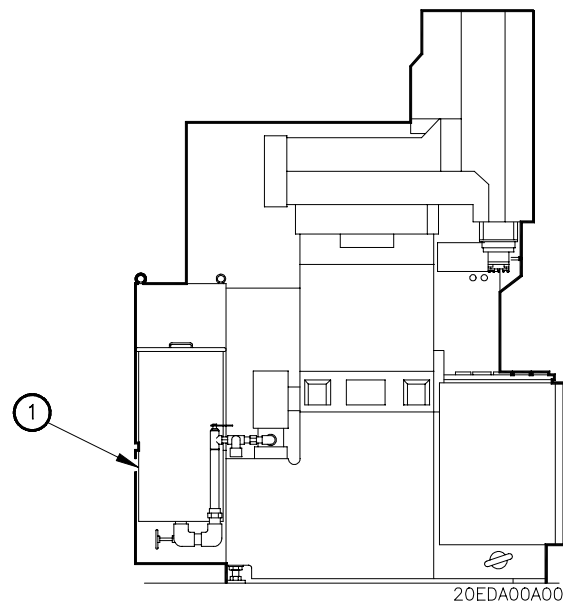


FIGURE 2-8 DI UNIT

TABLE 2-12 DIELECTRIC SUPPLY

Item	Specification
Fire Extinguisher	Automatic
Worktank	Vertical Slide System
Number of Pumps	1
Filtration	8 Micron × 2 Filters
Dielectric Refrigeration	Standard and Adjustable to ± 20°C
Max Worktank Level	250mm
Dielectric Reservoir Capacity	200 liter
Flushing - Pressure/ vacuum	2 Ports – 1.05kg/cm ²

2.4.6.1 Dielectric Fluid



Dielectric Fluids

1. Always use a highly refined oil with a minimum of PAH's. Use an oil similar to EDM-244 or EDM-250 to minimize any health risks.
2. Never use a dielectric fluid with a flash point under 70°C.

Dielectric fluid is used in the machining process and is required at time of installation and start up.

- The dielectric tank holds 200 liters.

There are three basic types of dielectric fluid, choose the type best suited to your work

1. Mineral Fluid – provides a concentrated electrical discharge and a removal rate 10 to 20% faster than synthetic fluids.
2. Synthetic Fluid – is recommended for machining with graphite and when using high current settings. Synthetics have less odor and better surface roughness than mineral fluids and promote longer filter life.
3. Intermediate Fluid – Provides performance characteristics between those of mineral and synthetic fluids.

2.4.7 Machining Power Source

Table 2-13 lists the machining power source specifications.

TABLE 2-13 MACHINING POWER SOURCE SPECIFICATIONS

Item	Specification
Circuit Type	Transistor Pulse
Maximum Machining Current	30A (60A optional)
Current Settings	90 Steps
Voltage Settings	8 Steps
OFF Intervals	256 Steps
Power Stabilizing Circuit	Standard
LL Generator Circuit	Standard
Power Unit Cooling	Forced Air
Machining Power Source	9kVa

2.5 Makino MGF Control

Standard MGF control configuration is listed below.

2.5.1 Operation Panel

Feature	Detail
Display Panel	10.4 inch Color display
	MDI (Manual Data Input) Function
	Operation Record Display
	Run Hour
	Dynamic Graphic Display
Routine Functions	Automatic Reference Return
	Measurement
	Return To Workpiece Zero Position
	Stored Stroke Limit

2.5.2 Machine Communications

Feature	Detail
I/O Communication Ports	RS-232C
	RS-227
3.5 type Floppy Disk Drive	2DD/2HD: 720kB/1.25MB, 1.44MB
NC Tape	1 inch, 8 bit EIA
EIA/ISO Recognition	Automatic

2.5.3 Operational Support

Feature	Detail
Operational Support Functions	Label Skip
	Single Block
	Program Stop – M0
	Optional Stop – M1
	End of Program
	Block Skip - /
	Dry Run
	Machine Lock
	Auxiliary Function Lock
	XY Axes Exchange
	Manual Absolute
	Automatic Return
	Workpiece Edge Positioning
	Hole Centering
	Corner Edge Positioning
	Groove Width Centering
	Plate Width Centering
	Cylinder Center Measurement
	Work Parallelism Measurement
	Automatic Measuring and Machining
Machining Time Estimation	
User Creation Screen	
Help Window	
Key Input Playback	
Manual Interrupt	
Automatic Operation Support	Process Skip and Additional Machining Function
	Approach Function
	Noncontact Point Search Function
	Automatic Power Cut Off Function

2.5.4 Maintenance and Safety

Feature	Detail
Maintenance and Safety	Emergency Stop
	Axis Overtravel Protection - 2 systems - Hard and Stored Stroke Limit
	Work Limit
	Diagnostic Function
	Regular Check Function
	Maintenance Function
	Parameter Output by Machine Number (G150)
	Machining Condition Output (G151)
	Machining Time Output (G152)
	Machining Status Record Output (G153)
	Data Backup (G154)

2.5.5 Controlled Axes and Coordinate System

Feature	Detail
Controlled Axes	5
	Simultaneous Control – 4
Coordinate Systems	Absolute or Incremental - G90, G91
	Reference Point Return - Manual, G28
	Return From Reference Point - G29
	Return To 2nd – 4th Reference Point - G30
	Coordinate System Setting - G92
	Machine Coordinate System Setting - G53
	Work Coordinate System Group – G500 – G509
	Work Coordinate System Selection - G54-G61
	Work Coordinate System Preset – G92
Relative Coordinate System Preset	

2.5.6 Auxiliary Functions and Machining Conditions

Feature	Detail
Auxiliary Functions	Machining (M17/M18)
	Work Tank Up/Down (M28/M29)
Machining Conditions	Selection: E4 digit (E0001 – E9999)
	Registered area: 600

2.5.7 Interpolation and Feeds

Feature	Detail
Interpolation	Rapid Positioning – Manual G0
	Linear Interpolation – Manual G1
	Circular Interpolation – G2 (CW), G3 (CCW)
	Taper Interpolation – G51 (left), G52 (right), G50(cancel)
	Taper Corner Tangential Interpolation – G24
	Spiral Interpolation – G25
	Taper Top/Bottom Same Radius – G49
	Vertical Irregular Shape Interpolation – G41/G42 P0, P1, P2
Feeds	Servo Feed by Machining Condition Setting
	F4 Digit Traverse
	Rapid Feed
	Jog Feed (High, Middle Low)
	Step Feed (Least Input Increment $\times 1$, $\times 10$)
	Incremental Feed
	Dwell – G4
	Automatic Acceleration/Deceleration
Axis Motion Overrides	Override Cancel
	F4 Digit Feed Override 0 – 200%

2.5.8 Programming

Feature	Detail
Storage	Memory – 369,000 characters (1000m of tape)
	Number of registrable programs – 9999
Methods	Standard CNC Language
	Minimum Input Increment – 0.001mm (0.0001mm) Standard or High Resolution (Parameter Selectable)
	Control Unit – 0.00005mm
	Maximum Programmable Increment - ± 99999.999 mm
	Sub-Programming – Nesting level: 9
	Programmable data input – G10
	Custom Macro: 33 Local and 200 Common Variables
	Decimal Point Programming
	Diameter Compensation 10x precision (inch)
Editing	Part Program editing
	Background editing
	Program Number Search
	Program Number Copy
	Program Number Division
	Program Number Collation
	Sequence Number Search
	Address and Word Search
	Error Search
	Execution Program Protection
Programming Support Functions	Inch/metric selection –G20-G21
	Circular Interpolation – by radius programming
	Parameter Call
	Modal Call
	Pseudo Command Call
	Scaling
	Rotation
	Rotation Copy
	Model Plan
	Sub Model
	Programless Cut Off
	Program Master Conversion
	Built In Automatic Programming
Z axis Position Management	

Chapter 3 Installation Process Overview

Makino EDGE2
Ram Electrical Discharge Machine
with MGF Control



Chapter 3
Installation Process Overview

Contents

3.1 Overview3 - 1

3.2 The Installation Process3 - 2

 3.2.1 Customer Installation Duties3 - 2

 3.2.2 FSE Installation and Set-up Duties3 - 3

 3.2.2.1 Machine Installation3 - 3

 3.2.2.2 On-site Training3 - 5

3.1 Overview

This chapter describes Makino's installation process and contains guidelines to prepare you for the delivery and installation of the EDGE2. It establishes clear expectations and responsibilities for all of us.

The success and efficiency of your installation rests, in large part, on your participation and involvement in the installation process.

Sixty days before the delivery of your Makino machine take time to:

- Review the information and requirements related to pre-installation
- Establish a time-line for completion of these items



Installation Process

Makino's installation process includes pre-installation duties to be performed by you. These duties are listed in [chapter 4](#) and [chapter 5](#).

3.2 The Installation Process

Makino developed a thorough process to ensure a consistent and professional installation. This process is designed to provide the maximum benefit from our FSE (Field Service Engineer) for set-up and alignment of the machine and proper training of your operator(s). Your participation and assistance are critical to an effective installation.

3.2.1 Customer Installation Duties

Makino asks that you be an active participant in the installation process. Your duties are listed below.

Makino recommends that you:

- Always use your unique RID (Request IDentification) number when contacting us, to encourage clear, efficient communication (with your sales order, Makino assigns a RID to track your machine installation).
- Read the pre-installation information in this Guide.
- Follow the instructions in [chapter 4](#) and [chapter 5](#). Use the worksheets provided in [chapter 4](#) to prepare for delivery and installation of the machining center.
- Complete each task in the Pre-Installation Checklist ([chapter 4](#)), to expedite the installation and ensure adequate time for training. Proper training during the installation provides the greatest return on your investment.
 - Fax or mail your completed Pre-Installation Checklist to Makino. This checklist is your request for installation services. The FSE reviews the checklist to confirm completion of customer tasks, prior to visiting your facility.
- Consider having:
 - Maintenance personnel available to the FSE during installation; this opportunity for exposure to the machine before the covers are on should not be missed.
 - Operators and Maintenance personnel (ideally two, maximum of four people) attend the Operation training.

3.2.2 FSE Installation and Set-up Duties

The Makino FSE is responsible for installing the machine and training your personnel. The FSE installation process should be completed in five working days.

These duties have a logical order and a built-in flexibility allowing the FSE to work around unexpected delays or problems and still complete the installation on time. The following steps may be completed in a different order.

- Some tasks duplicate items you already performed. This confirmation reduces the chance of error or accident.

3.2.2.1 Machine Installation

1. Initial Checks

- Check the foundation and placement.
- Check the machine for damage or other unacceptable conditions.
- Confirm cleanliness of machine components (i.e. anti-corrosive grease is removed). After start up the FSE assists in final cleaning.
- Verify receipt of all accessories.

2. Remove Shipping Locks

- Remove all axes and other component shipping locks and supports. You keep all locking and support devices in case the machine needs to be moved.
- Check all motor connections.

3. Power, Air, and Lubrication

- Verify source voltage, transformer connections, and tap settings.
- Confirm air is supplied at the proper pressure and volume.
- Supervise filling of reservoirs with the proper fluids.

4. Machine Set-up

- Verify machine level and correct, if needed.
- Connect peripheral devices (i.e. Oilmatic).
- Install unit anchors, if needed.

5. Power On
 - Ensure the machine is ready for power, BEFORE applying power.
 - After applying power, verify phase and confirm voltages are within the allowable range.
6. Checks and Adjustments
 - Install any required custom programs.
 - Check and confirm proper operation of all machine systems and functions (i.e. overtravel switches, spindle unclamp, etc.).
 - Verify operation of CNC (Computer Numerical Control) and machine parameters.
7. Finish Installation – Install any remaining covers and accessories.
8. On-site Training – Perform operation training, see [section 3.2.2.2](#).

3.2.2.2 On-site Training

Training is a major component in the proper installation of any equipment. Our experience shows that incomplete training can cause:

- Increased down time and avoidable machine damage.
- Increased frustration during the learning curve.
- Reduced utility and return on investment.

Makino partnered with local educational groups to develop an on-site training package to make your operator(s) comfortable, confident, and familiar with machine features and operation. This training is a “hands on, practical application, competency based,” educational model.

Training during set-up is broken into three categories (each training area is discussed below):

- Operator
- Operator Maintenance
- Options

Makino requests the following be considered, regarding on-site training:

- We strongly recommend that both the operator(s) and maintenance personnel are available for this training.
 - The job of maintenance is to “fix the machine,” even if the problem is not the “machine” itself. A working knowledge of machine operation and programming are powerful maintenance tools.
- To ensure consistency, have personnel from different shifts available so the material is covered once.
 - If scheduling does not allow this, notify the FSE, so the training timing can be adjusted to accommodate your needs.



Additional Training

Makino strongly recommends:

1. Operators/Programmers not familiar with this control model attend the appropriate training classes at Makino.
2. Maintenance personnel new to CNC or Makino machines and controls attend the appropriate training classes at Makino.
3. Companies interested in increasing their capabilities and production should review Makino’s formal learning opportunities.

Operator Training

This training is competency based and hands on with practical application in mind. To ensure its usability, all the information covered is cross-referenced to the Operation Guide.

This process requires machining a test part and involves basic programming, part set-up, program prove out, and operation. With assistance from the FSE, the part is developed in steps that reinforce earlier steps, and adds new ones. A final test part is given for the operators to complete by themselves.

The FSE covers:

- Machine Overview
 - Major machine components and control and function operations are explained, including checks and PM (Preventive Maintenance).
 - Proper procedures for power On and power Off, machine reference, tool changing, and basic alarm recovery are demonstrated.
 - Operation of the control panels and display are explained, demonstrated, and practiced.
- Job Set-up
 - Finding program zero and assigning work coordinate offsets is practiced.
 - Finding and assigning tool offsets is practiced.
 - Tool assignment is practiced.
- Control Operation
 - All screens and functions are explained and demonstrated. All common screens and their operation are practiced.
 - Program search, entry, and editing are explained and practiced.
 - MDI (Manual Data Input) operation is explained and performed.
 - Program Restart is performed and practiced.



Operator Training

1. This training can be modified, to some extent, to suit the needs of your personnel.
2. Specific questions will be answered on the spot when possible or referred to the appropriate personnel at your distributor or Makino.
3. Although FSEs are familiar with programming, they are not programming experts. The FSE can assist in preparing programs for training, answer programming questions, or refer you to an applications engineer, if needed. The FSE cannot set up your manufacturing process.

Operator Maintenance Training

This training is competency based and hands on with practical application in mind. To ensure its usability, all the information covered is cross-referenced to the appropriate guides.

The FSE covers:

1. Maintenance and Operation manuals for:
 - Safety precautions
 - Flexible Pendant Box operation
 - Machining precautions
 - PM (Preventive Maintenance)
2. Parts Manual layout and use are reviewed.



Operator Maintenance Training

1. This training can be modified, to some extent, to suit the needs of your personnel.
2. Questions will be answered on the spot when possible or referred to the appropriate personnel at your distributor or Makino.

Options Training

Machine options expand capability or provide additional utility, features, or functionality to the basic machine tool. Options training is left to the discretion of the FSE. Our experience shows that allowing the operator to become familiar with the basic machining center, prior to learning the options, is beneficial.

Due to the nature of available options, training is provided in different ways:

- Common options are trained at installation if the FSE is familiar with the option and believes your personnel can retain the additional training.
- Special or one of a kind options requiring additional or special training, are scheduled for a later date.
 - If you purchased a special option, check with your distributor to see if special training requirements exist. If so, make these arrangements now.

Chapter 4 Pre-Delivery Preparations

Makino EDGE2
Ram Electrical Discharge Machine
with MGF Control



Chapter 4 Pre-Delivery Preparations

Contents

4.1 Pre-Installation Preparations	4 - 1
4.2 Pre-Installation Checklist	4 - 4
4.2.1 Checklist Questions	4 - 4
4.2.2 Checklist Instructions	4 - 4
4.2.3 Completed Checklist Distribution	4 - 4
4.3 Selecting the Machine Location.	4 - 7
4.3.1 Access	4 - 7
4.3.2 Manufacturing Process	4 - 7
4.3.3 Environment	4 - 8
4.3.4 Foundation	4 - 9
4.4 Fixtures	4 - 9
4.5 Formal Training	4 - 10
4.5.1 Training Schedule	4 - 10

4.1 Pre-Installation Preparations

The Pre-Installation worksheet (Table 4-1 (pg. 4-2)) outlines key tasks in preparing for machine delivery and installation. The items checked in the “required” column must be completed for an efficient machine installation.

Use this Guide to accomplish these pre-installation tasks:

- Selecting machine location.
 - Access, environment, and foundation ([section 4.3 \(pg 4-7\)](#)).
 - Dimensional drawings for required floor space and clearances ([chapter 2](#)).
- Providing electrical service, air, water, and drainage requirements, described in [chapter 2](#) and detailed in this chapter.
- Unloading, moving, and leveling the machine ([chapter 5](#)).
- Preparing work holding devices for operator training and production start up ([section 4.4 \(pg 4-9\)](#)).

TABLE 4-1 PRE-INSTALLATION CHECK LIST

ACTION	Required	Not Required	Date Scheduled	Date Complete
MACHINE REQUIREMENTS				
Select machine site	<input checked="" type="checkbox"/>			
Ensure proper foundation ¹	<input checked="" type="checkbox"/>			
Check floor space requirements	<input checked="" type="checkbox"/>			
Check environment ²	<input checked="" type="checkbox"/>			
Ensure power, air, and water	<input checked="" type="checkbox"/>			
DELIVERY REQUIREMENTS				
Provide clearance from truck to machine location	<input checked="" type="checkbox"/>			
Plan for off loading	<input checked="" type="checkbox"/>			
Determine rigging requirements	<input checked="" type="checkbox"/>			
Establish installation duties	<input checked="" type="checkbox"/>			
MACHINING REQUIREMENTS				
Determine fixturing needs ³	<input checked="" type="checkbox"/>			
Identify job and workpieces				
Identify inspection equipment				
PERSONNEL REQUIREMENTS				
Select Operator(s)	<input checked="" type="checkbox"/>			
Select Programmer(s) and Maintenance personnel				
<p>1. Special foundations or environmental arrangements (if required) have long lead times. Proper does not necessarily mean a special foundation. Normal requirements are described in section 4.3.4.</p> <p>2. Environmental concerns related to machine location include temperature, humidity, and cleanliness. See section 4.3.3.</p> <p>3. Fixture design and manufacture typically require long lead times.</p>				

4.2 Pre-Installation Checklist

The Pre-Installation Checklist (on the following pages) is a customer request for installation services. To help ensure a smooth installation this Checklist allows Makino and your sales representative to know the status of your preparations and provide additional support where needed.

- It is necessary for you to complete or address the items on the Checklist prior to the arrival of the FSE.

In special cases and with prior approval, completion of all Checklist items is not mandatory; however, it is essential that Makino is informed of the status of your preparations prior to sending the FSE to your facility.

4.2.1 Checklist Questions

For questions or problems with any of the requirements on the Pre-installation Checklist or to inform us of your current status or a delay:

- Contact your distributor sales or service representative.
- Contact Makino Customer Support. Please provide your RID number to simplify service.

4.2.2 Checklist Instructions

The first page of the Checklist serves as the cover sheet. This information is required for us to serve you properly.

The Customer Contact is the individual our FSE should request at your facility. This person:

- Should be authorized to sign all installation paperwork.
- Should be available to arrange or coordinate any required assistance.
- Will become the first customer contact of record in our customer service database. Space is provided for additional contacts.

4.2.3 Completed Checklist Distribution

When the Checklist is complete:

- Retain the original for your records.
- Mail or fax a copy to your sales representative.
- Mail or fax a copy to Makino.



CUSTOMER SUPPORT

FAX: 513-459-1825

PRE-INSTALLATION CHECKLIST

TO: Customer Support

RE: Customer Request For Installation Services

Request ID _____

FROM:

COMPANY INFORMATION

Company name _____

Phone () - Fax () -

Customer Contact _____

Title Phone () -

2nd Contact _____

Title Phone () -

3rd Contact _____

Title Phone () -

Shipping Address Please complete to confirm the data in our records

Street _____

P.O. Box Suite #

City State

Zip Code

Billing Address Complete only if different from Shipping Address

Street _____

P.O. Box Suite #

City State

Zip Code

We will be ready on: _____

Signature Date

Fax Cover Sheet Number of pages to follow: 1.

Pre-Installation Checklist		page 2
		Request ID number
Machine Model: EDGE2	Control Type: MGF	Serial #

Please indicate the completion of the following items with a "Y" in the space provided. If there is a question or problem with any item listed below, it should be addressed immediately by contacting your distributor, sales representative, or Makino, **before** a Field Service Engineer is scheduled to supervise installation of the machine.

1. Packing list checked. Check that all parts, manuals, keys, tool kit, schematics, etc., have been received (in addition to immediately contacting Makino, note any discrepancies on a separate sheet and include with this document. Take pictures of any shipping damage).
2. Machine condition checked. The condition of the machine proper and all system components has been inspected for damage or other unacceptable conditions (in addition to immediately contacting Makino, note any discrepancies on a separate sheet, send to the shipper, and include with this document).
3. Machine placed on proper foundation clear of all obstructions and rough leveled.
4. Machine is clean. The machine, components, and accessories are unpacked, inspected, and cleaned (corrosion preventative and dirt removed by wiping with a safe, clean solvent).
5. Power cables are installed. 3-phase 240-480 VAC source voltage has been routed and connected to the main disconnect. **WARNING!** Do NOT apply power to the machine at this time (the FSE will verify proper wiring prior to power up).
6. Air is available. Permanent air lines should be run to the machine vicinity (if uncertain where to route the air line, please ensure that clean and dry air is available for a temporary connection for installation and training purposes).
7. Cutting fluid is available. Always use a highly refined oil with a minimum of PAH's. Do not fill the dielectric tank prior to the FSE's request.
8. Proper Earth Ground is connected. Earth Ground should be routed via any convenient path and attached to the machine's ground buss, inside the MTC (Machine Tool Cabinet).
9. Maintenance personnel selected and scheduled to assist the FSE with the installation (this is an excellent opportunity for exposure and learning. If required, riggers and millwrights are scheduled or available on short notice).
10. A precision level (0.0005in./ft.) is available for set-up. If not available, contact your distributor or sales representative (this equipment is required for proper periodic maintenance. Makino recommends this equipment be acquired, if not currently owned).
11.
 1. A part has been selected, and a part program is written and ready.
 2. Proper fixturing is ready.
12. Operators and Maintenance personnel selected and available for training.

4.3 Selecting the Machine Location

Key factors in selecting the machine location include:

- Access and required floor space.
- Your manufacturing process.
- Work and machine environment.
- Foundation.

Proper environment and foundation are of the utmost importance and more than any other factors, ensure machine accuracy and dependability.

Remember to ensure a path from the truck to the machine site that provides sufficient width, height, and swing clearance to accommodate your machine rigging and moving equipment. Failure to ensure sufficient moving room could result in delays and additional charges.

4.3.1 Access

The machine placement must have sufficient room for safe access around the machine and for all cabinet doors and panels to swing completely, see [chapter 2](#) for machine floor plan and dimensional drawings.

4.3.2 Manufacturing Process

Ideally the machine should be placed closest to the process it supports. This placement reduces handling costs and improves communication between process steps.

4.3.3 Environment

A sub-standard environment can cause control, machine, and component failures of all types.

Do NOT locate the machine:

- In direct sunlight.
- Near a source of heat.
- In a place subject to large temperature variation.
- Near a source of severe vibration, which may affect accuracy and alignments.
 - If the machine must be located in such an environment, we recommend a separate foundation with a 25mm expansion strip to absorb the vibration.
- Near a source of extreme metallic dust, like grinding machines.

The machine location should meet or allow for the following conditions:

- Dust-free, well-lighted, and free of temperature changes
 - Ambient temperature – 10 to 35°C, optimum 20±1°C.
 - Temperature fluctuation – less than 1°C/30 minutes.
 - Relative humidity – 35 to 75% (no condensation).
- Freely flowing air
- Available floor and bench space for storing raw and finished work-pieces, tooling, and inspection equipment
- Enough room for maintenance work. Adequate space around machine and clearance to fully open cabinet doors.
- Adequate and proper sized utilities are available: electrical power supply, clean, dry air supply, and water.
- Drainage for the overflow and tank cleaning drains with provisions for disposal of the used dielectric fluid.
- A foundation flat and strong enough to support the weight of the machine without appreciable deflection.

4.3.4 Foundation



To ensure machine accuracy and performance, customers must comply with all installation and foundation requirements. Failure to comply may void the accuracy portion of the warranty. Consistent accuracy can only be guaranteed on a reinforced concrete foundation that meets the minimum specifications for the machine.

A reinforced, isolated, concrete floor is the best foundation to minimize vibration and deflection (see [chapter 2](#) for detail on foundations, floorplans, and dimensional drawings).

- The concrete pad should be continuous, flat, and strong enough to support the weight of the machine without appreciable deflection.
- Do NOT place machine on separate sections of concrete.

As a rule of thumb, the foundation must meet the following specifications:

- Minimum ground resistance of 5 Ton/M²
- Minimum foundation thickness of 300mm
- Foundation should extend 300mm beyond the machine base.
- Level within 3.2mm/m

If the floor does not meet these specifications, a special foundation is needed to maintain machine level and alignment. If you are considering a special foundation, contact Makino.

When locating the machine on an upper floor of a building, be sure to:

- Consult a structural engineer for load bearing capacity.
- Consult Makino for acceptance or stipulations on this arrangement.

4.4 Fixtures

Fixtures typically require a long lead time. Address this issue before the delivery of the machine tool.

Consider design and manufacturing time, and coordinate completion with the delivery of the machine for a smooth transition into your production schedule.

4.5 Formal Training

In today's competitive marketplace it is good business to increase productivity in cost effective ways. Training is one of the best avenues to increasing productivity without increasing capacity.

Dollar for dollar your best investment is to properly train your people. Though often overlooked, training is most important after a major investment in new equipment or technology.

To assist our customers in getting the most out of their Makino machines, Makino provides formal classroom training at our facility in Mason, Ohio.

This is the time to look ahead and determine and schedule your training needs. Some courses provide the best benefit when attended before the arrival of the machine, and others after the machine has been in operation and the operator or programmer has developed a familiarity with the machine. This information is provided in the prerequisite area of each course description.

Course offerings designed to support our EDM customer's in:

- RAM Machine Operation and Applications
- WIRE Machine Operation and Applications
- Advanced EDM Applications Seminar

We also offer courses to support our Milling machine customers in:

- Basic CNC, Advanced CNC, and Conversational Programming
- Machine Options
- Machine Tool System Maintenance
- Die/Mold Process Training on high-speed machining

4.5.1 Training Schedule

Makino issues a training schedule throughout the year. A copy is available from your sales representative, distributor, or from Makino.

- The training schedule includes ALL information necessary for enrolling students, class dates, and information on hotel accommodations.
- In addition, special training can be arranged in most instances.

Contact your distributor for descriptions of the formal training courses related to the EDGE2.

Chapter 5 Machine Delivery

Makino EDGE2
Ram Electrical Discharge Machine
with MGF Control



Chapter 5 Machine Delivery

Contents

5.1 Overview	5 - 1
5.2 Inspect the Machine	5 - 2
5.3 Unloading, Lifting, and Moving	5 - 3
5.3.1 Lifting and Moving the Machine	5 - 4
5.4 Leveling	5 - 7
5.4.1 Check the Precision Level	5 - 7
5.4.2 Leveling the Machine	5 - 8
5.5 Initial Cleaning	5 - 10
5.6 Air Source	5 - 11
5.7 Power Source	5 - 13
5.7.1 Connecting Power to the Machine	5 - 13

5.1 Overview

This chapter describes how to receive, inspect, unload, move to site, level, clean, and connect piping and electrical power to the machine.

Performance of these duties:

- Ensures the smoothest and shortest installation time.
- Provides maximum training time for operator and maintenance personnel.



The Installation Process

Makino's Installation process includes Pre-Installation duties to be performed by you. These duties are described in this chapter and [chapter 4](#).

Makino customers must perform these duties to provide the maximum amount of time for proper machine setup and training. Your participation and assistance are critical to an effective installation.

5.2 Inspect the Machine

Inspection of the machine should begin when the driver removes the tarp and continue throughout the unpacking process.

To minimize the potential effects of shipping damage on your installation, follow these simple procedures.

Before Signing Shipper

1. Inspect the machine and all separate packages and containers for damage.
2. Check each item against the shipper and packing list for shortages.

When Signing Shipper

1. Write on the shipper – *Received subject to hidden and concealed damage*. Though rarely a factor, this precaution may protect your investment.
2. Sign your name.

After Signing the Shipper

1. Inspect all items as soon as possible.
 - Inspect each item in every box, crate, and carton.

Damage or Shortage is Found

If damage is discovered after releasing the driver (damage within crates is considered hidden damage):

1. Contact the carrier immediately.
 - A. File a claim with the carrier immediately.
 - B. Leave damaged material exactly as found and take photographs of the damage.
2. Contact Makino immediately with your name, company, machine type, and RID (Request IDentification) number.

5.3 Unloading, Lifting, and Moving

Unloading and moving the machine and its ancillary components to their final site is the customer's responsibility.

- Makino recommends that professional riggers unload the machine and ancillary components and move them to their final site.

After the initial checks for damage are complete:

1. Unload the machine and ancillary components from the truck.
 - Use an overhead crane, boom truck, or fork lift of sufficient capacity to lift the machine packing case and ancillary components off the truck.
2. Move the machine and the ancillary components to their location.
 - Verify there is adequate clearance and turning room to safely move the machine to its final site or the site where the packing case will be removed.
 - Use an overhead crane, boom truck, or fork lift of sufficient capacity to move the machine packing case and ancillary components.
 - Dollies, or rolling bars of sufficient capacity may also be used.
 - If dollies or rolling bars are used, some type of lifting equipment will be needed at the final site to lift the machine and remove the skid.

5.3.1 Lifting and Moving the Machine



Lifting and Moving Hazard

When lifting or moving the machine:

1. Make sure machine is balanced. Keep the machine level and lift or move gently.
2. Lift no higher than needed. Keep all body parts from under the machine.
3. Prevent impact with any nearby objects.
4. Do Not remove axis locks or move any axis. Axis locks will be removed by the FSE.

1. Verify the machine moving members - X and Y axes and ATC are securely retained by the yellow or orange painted shipping locks (Figure 5-1).

A. Y axis shipping lock is located on the left behind access plate [2].

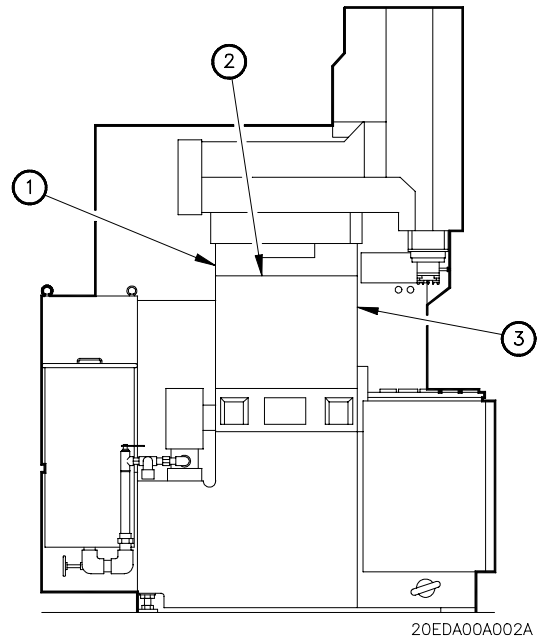
B. X axis shipping lock is located on the back behind access plate [1].

C. ATC shipping lock is viewed from the front.

2. Attach the lifting fixture to an overhead crane (Figure 5-2) and center it over the machine

3. Place the cable loops over the lifting bars, as shown in Figure 5-2.

4. Slowly raise the crane hook to remove slack in the cables, checking for interference with machine components. Use heavy pads or wood blocks at interference points. .



Legend

[1]	X Axis Shipping Lock
[2]	Y Axis Shipping Lock
[3]	ATC Shipping Lock

FIGURE 5-1 SHIPPING LOCKS



Rigging Detail

Makino machines are designed to be lifted by overhead crane. The required rigging is shipped with the machine. If using a fork lift BE SURE to approach from the machine side (Not the NC side).

5. Lift the machine and move to installation site.
6. Set 300mm blocking under the machine, near each leveling point.

7. Lower the machine onto blocking and install the NC unit leveling feet into the bottom of the cabinet. Run the leveling feet up to within 5mm of cabinet.
 - Leveling feet and machine leveling pads are shipped in the accessories crate or attached to the machine pallet.
8. Lift the machine and remove blocking.
9. Set the machine on the leveling bases.
10. Unhook the cables and move the crane away from the machine.
11. Rough level the machine.



Setting and Leveling Bases

1. When setting the machine, even temporarily, place leveling bases under the machine to prevent casting distortion.
2. If machine will sit for longer than 12 hours prior to its final setting, rough level the machine to 0.03mm/m (see [section 5.4 \(pg 5-6\)](#)).

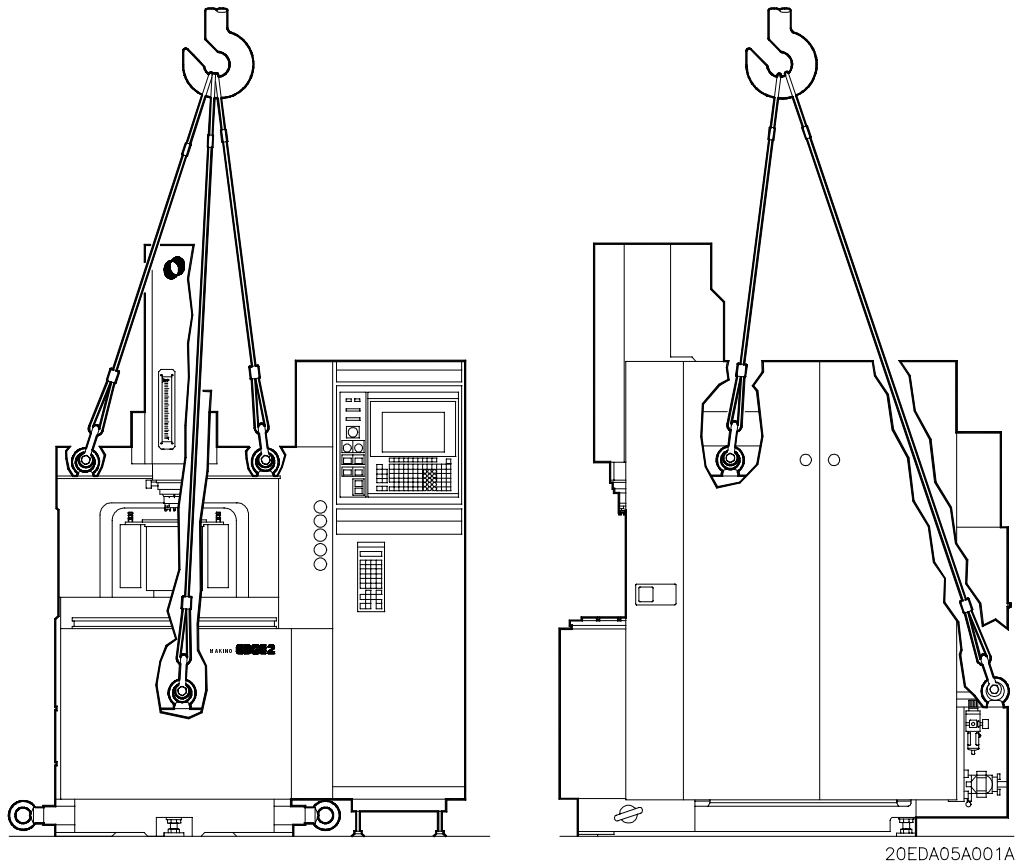


FIGURE 5-2 RIGGING AND LIFTING DETAIL

5.4 Leveling

Makino builds a highly rigid machine tool, and its accuracy depends on machine level. The importance of setting and maintaining proper machine level cannot be over-emphasized.

Rough leveling prevents a twist or other distortion from setting into the iron. Rough level the machine and leave it sit overnight to allow the iron to normalize before final leveling.

5.4.1 Check the Precision Level

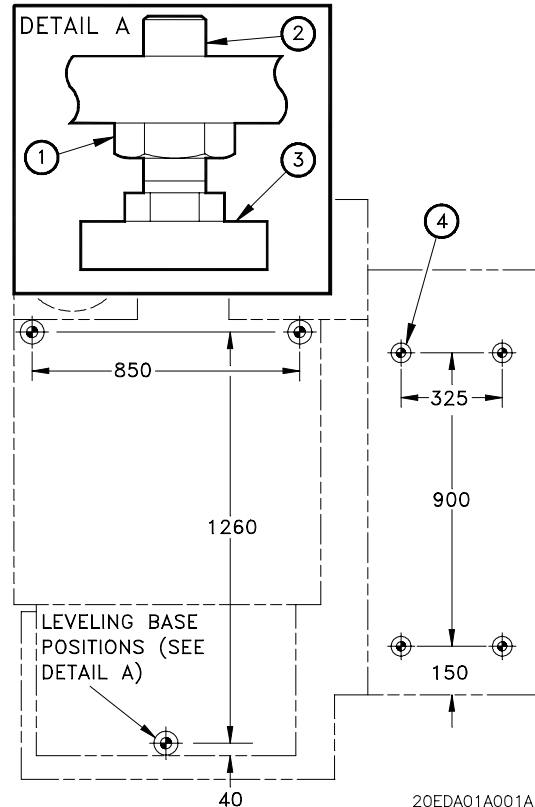
1. Place the level on a clean flat surface that is level enough to give a bubble reading that is not “bottomed” in the bezel.
2. Note the reading and rotate the level 180°.
 - If the reading is the same as the first (bubble is in the same place, on the same side of the bezel, from your viewing position), the level is accurate and repeatable.
3. If the reading is different, the level needs calibration.
4. Use the adjustment screws to calibrate and recheck the level.

5.4.2 Leveling the Machine

The EDGE2 uses a three point leveling system (Figure 5-3).

The leveling procedure described uses one level

1. Loosen the lock nut [1] on each leveling screw [2].
2. Set the level in the X axis plane, note the reading. Move to the Y axis plane, note the reading.
3. Adjust the leveling screws to obtain level.
4. Repeat the X and Y readings and level adjustments until the machine is level within 0.03mm.
5. Tighten the lock nut [1] on each leveling screw [2].
6. Run the NC leveling feet [4] down to touch the floor.
7. Double check X and Y axis plane readings.
8. Remove the level from the table.



Legend

[1]	Lock Nut
[2]	Leveling Screw
[3]	Leveling Plate
[4]	NC Leveling Feet

FIGURE 5-3 LEVELING POSITIONS

5.5 Initial Cleaning

A corrosion preventative is applied to the machined and sliding surfaces of the EDGE2 to prevent oxidation during shipping. This corrosion preventative must be removed prior to operating the machine.

- Use a clean, dry cloth and mineral spirits or another high flash-point, non-toxic solvent to remove the corrosion preventative. Clean only those areas of the machine you can reach without moving the axes.
- Wipe the machine surfaces dry with a clean, dry cloth. Do NOT use an air hose to dry the solvent. Pressurized air drives grit and dirt between bearing surfaces and causes premature wear.
- Lightly coat machined surfaces with way lubricant, to protect against oxidation. Periodic oiling of these surfaces will increase machine life.

The FSE will assist in the final cleaning after machine start up.

5.6 Air Source



Incoming Air Supply

Makino considers it the customer's responsibility to ensure that the air supply to the machine is both clean and dry. Supplied air must NOT exceed 40% relative humidity.

Connect the Air Supply

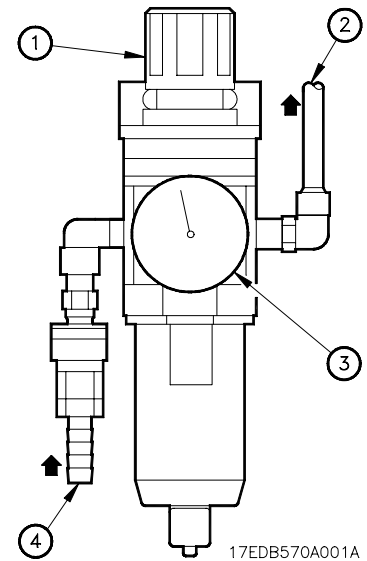
The air source is connected at the filter/regulator (Figure 5-4) located on the right rear of the machine.

1. Prepare an 8mm I.D. air supply hose with a female coupling.
2. Connect air supply hose to male inlet coupling.

Setting Standard Air Regulator

Adjust the filter/regulator to obtain an output pressure of 0.6MPa. To set the pressure:

1. Pull up on adjusting cap [1].
2. Rotate adjusting cap [1] (cw to increase or ccw to decrease), until pressure gage [3] reads 0.6MPa.
3. Push adjusting cap [1] down until it seats, locking the adjustment.



Legend

[1]	Adjusting Cap
[2]	Output to Machine
[3]	Pressure Gage
[4]	Input to Machine

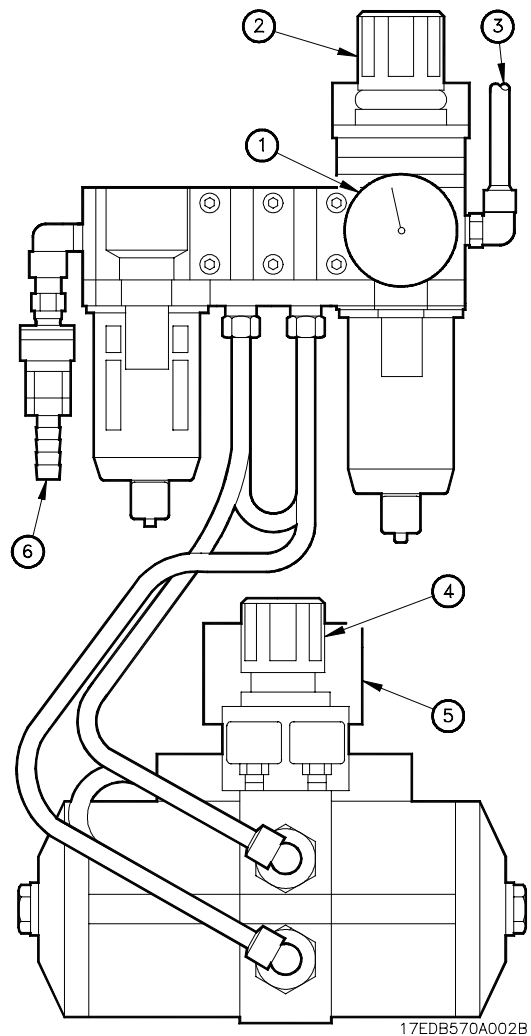
FIGURE 5-4 STANDARD AIR ADJUSTMENT

Setting Optional Air Booster

Adjust the filter/regulator to obtain an output pressure of 0.6MPa.

To set the pressure:

1. Unlock adjusting cap [2] and [4], by pulling up on the knobs.
2. Turn adjusting cap [4], until the outlet pressure gage [5] reads 0.7MPa.
 - Rotate adjusting cap cw to increase or ccw to decrease.
3. Turn adjusting caps [2] until pressure gage [1] reads 0.6MPa.
4. Push the adjusting caps down until they seats, locking the adjustment.



17EDB570A002B

Legend

[1]	Pressure Gage
[2]	Adjusting Cap
[3]	Output to Machine
[4]	Adjusting Cap
[5]	Outlet Pressure Gage
[6]	Input to Machine

FIGURE 5-5 BOOSTER AIR ADJUSTMENT

5.7 Power Source

A 3-phase power source with stable voltage ($\pm 10\%$) must be provided. The EDGE2 runs on 200Vac at 60Hz. A step down transformer accepts incoming power from 480Vac down to 240Vac and regulates voltage to 200Vac.

See [chapter 2](#) for machine power requirements (kVa ratings and calculating required service).

5.7.1 Connecting Power to the Machine



When Making Connections Ensure:

1. The power BUSS or main disconnect is Off, Locked Out, and Tagged.
2. The machine's Main Power switch is Off.
3. The proper size and type of cable is used (consult your electrical code).
4. The proper ground is provided.

To connect power from the shop power BUSS or disconnect to the machine Main Power switch:

1. Ensure the EDGE2 Main Power switch (CB1) is Off.
2. Ensure the facility power BUSS or disconnect is Off.
3. Perform Lockout/Tagout at the facility power BUSS or disconnect.
4. Ensure proper cable size and type are used (consult electrical code).
5. Ensure proper ground is provided (JIS class 3, 10 Ohm or less).
6. Open the NC door. Main Power switch (CB1) located in middle left.
7. Bring the power cable into NC through a cable inlet in the bottom and route the power cable to the top of CB1.

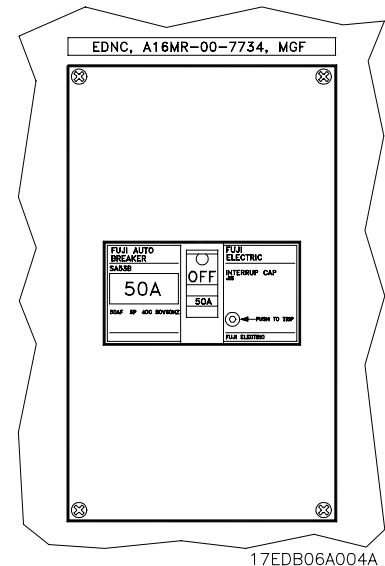


FIGURE 5-6 MAIN POWER SWITCH COVER

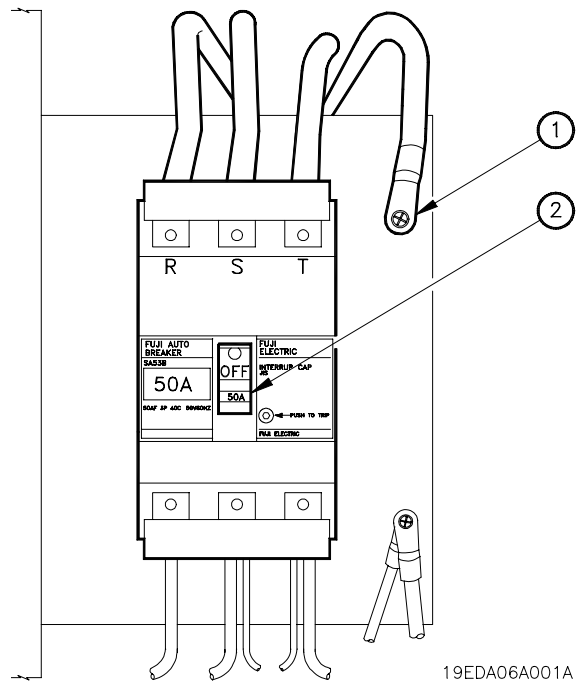
8. Connect incoming power at the top of CB1, terminals R, S, and T (Figure 5-7).
9. Connect the facility ground wire to earth ground (Figure 5-7).
10. Close the NC doors.



Do NOT Apply Power

Leave the power BUSS or disconnect Off, Locked Out and Tagged. The FSE will confirm connections, incoming voltage, and the transformer taps. Failure to observe this DANGER may result in serious damage or personal injury.

11. Do Not apply power at this time. Leave the power disconnect turned Off, Locked Out, and Tagged until the FSE requests that power be turned On.



19EDA06A001A

Legend

[1]	Ground
[2]	Main Power Switch

FIGURE 5-7 POWER CONNECTION TO CB1

Appendix A Conversion Factors

SI Metric System Basics and Inch-Metric Conversion Factors



Appendix A Conversion Factors

Contents

- A.1 Introduction A - 1
- A.2 Metric Basics A - 2
- A.3 Inch – Metric Conversions A - 6
- A.4 Electrical Consumption A - 11
- A.5 Conversion Factors for CNC A - 11

A.1 Introduction

Makino is a global company, which designs and produces its equipment in the metric system. Currently the JIS (Japanese Industrial Standard) is used, but the world market is driving toward the use of the SI (Systeme International d'Unites) standard.

- This appendix is presented as a reference for converting between metric and inch.

A.2 Metric Basics

The first Metric system was established in France after the French Revolution and several systems of metric units have been since developed and used. All metric systems are partially based on the International Metric Standards of the Meter and the Kilogram (or decimal multiples and sub-multiples of these standards).

In 1902 the MKS (meter-kilogram-second) system of units was adopted and in 1950, the *IEC* adopted the Ampere as a standard unit of measure resulting in the MKSA (meter, kilogram as a force, second and amp) system.

The Conference General des Poids et Mesures (CGPM) of 1954 added the Kelvin for temperature and the candela for luminous intensity. These changes led to the current metric system known as the Systeme International d'Unites (abbreviated in all languages as SI). The system is continuing to evolve, in 1971, the mole was added as a unit of quantity.

- Though most advanced industrial nations, use a metric system. Most countries are currently moving away from their system to the SI system.

All Metric systems are based on decimal arithmetic. This means that for each physical quantity, units of different sizes are formed by multiplying or dividing a single base value by powers of 10 (Table A-1).

- The metric system is a Base10 system of measurement.

The SI system is both universal and coherent.

- Universality is when there is only one unit for each physical quantity. In other systems energy may be expressed as; erg, calorie, kilogram meter, liter atmosphere or horsepower hour. Now it is given in joules.
- A system is coherent, when the product or quotient of any two unit quantities is the resultant quantity. (i.e. in a system with the foot as the unit of length, the square foot (not the acre) would be the unit for area.

In summary, the world is moving to the SI system of metric measurement. However, until this is complete we must be able to convert from other metric systems, the imperial and U.S. system of weights and measures, and measurements from other sciences.

TABLE A-1 MULTIPLES AND SUB MULTIPLES FOR METRIC UNITS

SI Metric Prefixes and Their Meaning			
Prefix	X Factor	Detail	Symbol
tera	10^{12}	Tera = 1,000,000,000,000 base units	T
giga	10^9	Giga = 1,000,000,000 base units	G
mega	10^6	Mega = 1,000,000 base units	M
kilo	10^3	kilo = 1000 base units	k
hecto	10^2	hecto = 100 base units	h
deka	10	deka = 10 base units	da
	1	1 SI base unit	
deci	10^{-1}	deci = 0.1 base unit	d
centi	10^{-2}	centi = 0.01 base unit	c
milli	10^{-3}	milli = 0.001 base unit	m
micro	10^{-6}	micro = 0.0000001 base unit	μ
nano	10^{-9}	nano = 0.0000000001 base unit	n
pico	10^{-12}	pico = 0.0000000000001 base unit	p
femto	10^{-15}	femto = 0.0000000000000001 base units	f
atto	10^{-18}	atto = 0.000000000000000001 base unit	a



More on Metrics

For more information on metrics, refer to the following publications:

MACHINERY HANDBOOK EDITION 24 published by Industrial Press Inc., 200 Madison Avenue, New York, NY 10016-4078

METRIC PRACTICE GUIDE, published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, A 19103

ISO INTERNATIONAL STANDARD 1000. This publication covers the rules for use of SI units, their multiples and sub multiples. It can be obtained from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036

The International System of Units, Special Publication 330 of the National Bureau of Standards – available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

Table A-2, presents the basic SI units. The physical quantity, unit name and unit symbol are listed.

Table A-3 presents SI units with special names. The unit name, physical quantity, derivation formula and unit symbol are listed.

Table A-4 presents SI units with complex names. The unit name, physical quantity, and unit symbol are listed.

TABLE A-2 BASIC (SI) METRIC UNITS

Basic SI base Units		
Unit Name	Physical Quantity	Unit Symbol
meter	Length	m
kilogram	Mass	kg
second	Time	s
ampere	Electric Current	A
degree kelvin	Thermodynamic Temperature	k
mole	Amount of Substance	mol
candela	Luminous Intensity	cd

TABLE A-3 SI METRIC UNITS WITH SPECIAL NAMES

SI Units with Special Names			
Unit Name	Physical Quantity	Formula	Unit Symbol
newton	Force	$N = \text{kg}\cdot\text{m}/\text{s}^2$	N
joule	Work, Energy, Quantity of Heat	$J = \text{N}\cdot\text{m}$	J
coulomb	Electric Charge	$C = \text{A}\cdot\text{s}$	C
volt	Electric Potential	$V = \text{W}/\text{A}$	V
farad	Electric Capacitance	$F = \text{C}/\text{V}$	F
ohm	Electric Resistance	$\Omega = \text{V}/\text{A}$	Ω
weber	Magnetic Flux	$\text{Wb} = \text{V s}$	Wb
henry	Inductance	$\text{H} = \text{V s}/\text{A}$	H
lumen	Luminous Flux	$\text{lm} = \text{cd sr}$	lm
lux	Illumination	$\text{lx} = \text{lm}/\text{m}^2$	lx
hertz	Frequency	$\text{Hz} = \text{cycle}/\text{s}$	Hz
pascal	Pressure	N/m^2	Pa
tesla	Magnetic Flux Density	Wb/m^2	T

TABLE A-4 SI METRIC UNITS WITH COMPLEX NAMES

SI Units with Complex Names		
Unit Name	Physical Quantity	Unit Symbol
square meter	Area	m^2
cubic meter	Volume	m^3
kilogram per cubic meter	Density (Mass Density)	kg/m^3
meter per second	Velocity	m/s
radian per minute	Angular Velocity	rad/s
newton per meter	Surface Tension	N/m
newton second per meter squared	Dynamic Viscosity	$\text{N s}/\text{m}^2$
meter squared per second	Kinematic Viscosity	m^2/s
	Diffusion Coefficient	
watt per meter degree kelvin	Thermal Conductivity	$\text{W}/(\text{m}^2/\text{s})$
volt per meter	Electric Field Strength	V/m
ampere per meter	Magnetic Field Strength	A/m
candela per square meter	Luminance	cd/m^2

A.3 Inch – Metric Conversions

Inch to metric conversion values follow. Most tables are set-up using multiplication and read from left to right so: $A \cdot B = C$ and $C \cdot D = A$. The common abbreviations are provided in parenthesis; e.g. Feet (ft, ').

- To simplify matters, you may prefer to learn one conversion factor and divide “back” to provide the conversion.

EXAMPLE: 0.3 inches \cdot 25.4 = 7.62 millimeters, conversely 7.62 millimeters \div 25.4 = 0.3 inches.

- For accuracy conversion factors are presented in its most accepted value. You need to think beyond the math, when converting form one system to the other. Watch for precision in addition to accuracy. The converted value should never be more precise than the original value. Know the acceptable tolerances in your field and ensure that converted measurements are appropriate.

EXAMPLE: When converting 50 square feet to square meters the result is 4.645 square meters. In most cases 4.6 square meters would be of adequate precision, especially if the 50 square feet was an approximation.

Use Table A-5 to find the required conversion table by measurement type.

TABLE A-5 CONVERSION REFERENCE TABLE

To convert	Reference
Length (Distance)	Table A-6 (pg. A-7)
Area	Table A-7 (pg. A-8)
Volume	Table A-8 (pg. A-9)
Mass (weight)	Table A-9 (pg. A-9)
Velocity and Flow	Table A-10 (pg. A-10)
Force and Force/Length	Table A-11 (pg. A-10)
Bending Moment or Torque	Table A-12 (pg. A-11)
Energy or Work	Table A-14 (pg. A-12)
Pressure	Table A-13 (pg. A-11)
Power	Table A-15 (pg. A-12)
Temperature	Table A-16 (pg. A-12)

TABLE A-6 LENGTH (DISTANCE) CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
------	---	------	---	--------	---	------	---	------

TABLE A-6 LENGTH (DISTANCE) CONVERSIONS

inch (in., ")	x	25.4	=	millimeter (mm)	x	.03937	=	in.
	x	2.54	=	centimeter (cm)	x	0.3937	=	
	x	0.0254	=	meter (m)	x	39.37	=	
foot (ft)	x	304.8	=	millimeter (mm)	x	0.00328	=	ft
	x	30.48	=	centimeter (cm)	x	0.0328	=	
	x	0.3048	=	meter (m)	x	3.280	=	
yard (yd)	x	0.9144	=	meter (m)	x	1.0936	=	yd

TABLE A-7 AREA CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
square inch (in. ² , sq in.)	x	645.16	=	square millimeter (mm ² , sq mm)	x	0.00155	=	in. ²
	x	6.4516	=	square centimeter (cm ² , sq cm)	x	0.1550	=	
	x	0.00064516	=	square meter (m ² , sq m)	x	1550.0	=	
square foot (ft ² , sq ft)	x	92,903.	=	square millimeter (mm ² , sq mm)	x	0.000010764	=	ft ²
	x	929.03	=	square centimeter (cm ² , sq cm)	x	0.0010764	=	
	x	0.92903	=	square meter (m ² , sq m)	x	10.764	=	
square yard (yd ² , sq yd)	x	0.8361	=	square meter (m ² , sq m)	x	1.196	=	yd ²

TABLE A-8 VOLUME (CAPACITY) CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
cubic inch (in. ³ , cu in.)	x	16,387	=	cubic millimeter (mm ³ , sq mm)	x	0.000061024	=	in. ³
	x	16.387	=	cubic centimeter (cc / cm ³)	x	0.061024	=	
	x	0.00001638	=	cubic meter (m ³ , sq m ³)	x	61,024	=	
cubic foot (ft ³ , cu ft)	x	0.028317	=	cubic meter (m ³ , sq m)	x	35.31466	=	ft ³
	x	28.31685	=	liter (L)	x	0.03531466	=	
cubic yard (yd ³ , sq yd)	x	0.76455	=	cubic meter (m ³ , sq m)	x	1.307951	=	yd ³
US gallon (gal)	x	0.003785	=	cubic meter (m ³ , sq m)	x	264.1720	=	US gal
	x	3.785412	=	liter (L)	x	0.2641720	=	
UK gallon (imp. gal)	x	0.004546	=	cubic meter (m ³ , sq m)	x	219.9692	=	Imp. gal
	x	4.546092	=	liter (L)	x	0.2199692	=	
quart (qt)	x	0.946	=	liter (L)	x	1.057	=	US qt

TABLE A-9 MASS (WEIGHT) CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
grain [advp 1/7000 lb]	x	0.0647989	=	gram (g)	x	15.43236	=	grain
ounce (oz) [advp]	x	28.34952	=	gram (g)	x	0.03527397	=	oz
	x	0.02834952	=	kilogram (kg)	x	35.27397	=	
pound (lb)	x	0.4535924	=	kilogram (kg)	x	2.204622	=	lb
short ton (st, t) [2000 lb]	x	907.1847	=	kilogram (kg)	x	0.0011023	=	t

TABLE A-10 VELOCITY AND FLOW CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
inch per minute (ipm, in./min.)	x	25.4	=	millimeter/minute (mm/min.)	x	0.03937008	=	ipm
	x	2.54	=	centimeter/minute (cm/min.)	x	0.3937008	=	
	x	0.0254	=	meter/minute (m/min.)	x	39.37008	=	
foot per minute (fpm, ft/min.)	x	0.3048	=	meter/minute (m/min.)	x	3.280840	=	fpm
US gallon/minute (gpm, gal/min.)	x	0.0037854	=	cubic meter/minute (meter ³ or m ³ /min.)	x	264.1720	=	gpm
	x	3.785412	=	liter/minute (liter/min., L/m)	x	0.264172	=	
UK gallon/minute (imp. gal/min.)	x	0.00454609	=	cubic meter/minute (meter ³ /min., m ³ / min.)	x	219.9692	=	imp. gal/ min.
cubic feet/minute (cfm, ft ³ /min.)	x	28.31685	=	liter/minute (liter/min., L/m)	x	0.03531466	=	cfm

TABLE A-11 FORCE AND FORCE/LENGTH CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
ounce-force (oz _f)	x	0.2780139	=	newton (N)	x	3.596942	=	oz _f
pound-force (lb _f)	x	4.448222	=	newton (N)	x	0.2248089	=	lb _f
pound/inch (lb/in)	x	175.1268	=	newton/meter (N/m)	x	0.005710148	=	lb/in.
pound/foot (lb/ft)	x	14.59390	=	newton/meter (N/m)	x	0.06852178	=	lb/ft
For working in kgf or kiloponds: newton x 0.1019716 = kgf and kgf x 9.806650 = newton.								

TABLE A-12 BENDING MOMENT OR TORQUE CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
ounce-inch (oz-in.)	x	7.061552	=	newton-millimeter (N-mm)	x	0.1416119	=	oz-in.
	x	0.00706155	=	newton-meter (N-m)	x	141.6119	=	
pound-foot (lb-ft)	x	1.355818	=	newton-meter (N-m)	x	0.7375621	=	lb-ft
For working in kg-m: newton-meter x 0.1019716 = kg-m and kg-m x 9.806650 = newton-meter.								

TABLE A-13 PRESSURE CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
atmosphere (atm) [14.6959 lb/in. ²]	x	101,325.0	=	pascal (Pa)	x	0.000009869	=	atm
bar	x	100,000.0	=	pascal (Pa)	x	0.00001	=	bar
	x	14.50377	=	pound/inch ² (lb/in. ²)	x	0.06894757	=	
	x	100,00.0	=	newton/meter ² (N/m ²)	x	0.00001	=	
pounds/inch ² (psi, lb/in. ²)	x	0.06894757	=	bar	x	14.50377	=	psi
	x	0.07030697	=	kilogram/ centimeter ² (kg/cm ²)	x	14.22334	=	
	x	0.00689475	=	newton/millimeter ² (N/mm ²)	x	145.0377	=	
	x	0.6994757	=	newton/centimeter ² (N/cm ²)	x	1.450377	=	
	x	6894.757	=	newton/meter ² (N/m ²)	x	0.000145037	=	
	x	6894.757	=	pascal (Pa)	x	0.000145037	=	

TABLE A-14 ENERGY AND WORK

Inch	X	This	=	Metric	X	This	=	Inch
British thermal unit (Btu)	x	1055.87	=	joule (J)	x	0.00094708	=	Btu
calorie (cal)	x	4.19002	=	joule (J)	x	0.2386623	=	cal
foot-pound (ft·lb)	x	1.355818	=	joule (J)	x	0.7375621	=	ft·lb
watt-hour (Wh)	x	3600.0	=		x	0.0002777	=	Wh

TABLE A-15 POWER CONVERSIONS

Inch	X	This	=	Metric	X	This	=	Inch
horsepower (hp) [550 ft·lb/s]	x	745.6999	=	watt (W)	x	0.001341022	=	hp
	x	0.7456999	=	kilowatt (kW)	x	1.341022	=	
horsepower [electric] (hp)	x	746.0	=	watt (W)	x	0.001340483	=	hp
horsepower (U.K.) (hp)	x	745.70	=	watt (W)	x	0.00341022	=	hp

TABLE A-16 TEMPERATURE CONVERSIONS

Convert	To	Use Formula
Fahrenheit (°F)	Celsius (°C)	$(°F - 32) \times 0.56 = °C$
	Kelvin (°K)	$(°F + 459.67) / 1.8 = °K$
Celsius (°C)	Fahrenheit (°F)	$(1.8 \times °C) + 32 = °F$
	Kelvin (°K)	$°C + 273.15 = °K$
Kelvin (°K)	Celsius (°C)	$°K - 273.15 = °C$
	Fahrenheit (°F)	$1.8 \times °K - 459.67$

A.4 Electrical Consumption

To ensure safe and consistent sizing of electrical power sources, use the formulas in Table A-4 to convert kVa to amps, then determine service size.

TABLE A-17 ELECTRICAL CONSUMPTION
FORMULAE

To Calculate	Use Formula
Amperage	$\frac{kVa \times 1000}{1.73 \times Voltage} = \text{amps}$
Service	$\text{amps} \times 125\% = \text{Service}$

A.5 Conversion Factors for CNC

CNC memory capacity is historically given in terms of tape length (meters or feet). Table A-18 presents the number of characters per inch, foot, meter and page.

TABLE A-18 TAPE TO MEMORY CONVERSIONS

No. of Characters	=	Tape length
10 characters	=	1 inch (25.4 millimeters)
120 characters	=	1 foot (0.305 meters)
383 characters	=	1 meter (3.281 feet (39.4"))
77 Characters	=	1 page (7.875 inches or 0.2 meters)

