Hansvedt EDM

OWNER'S MANUAL

MS-4 FOREMAN
M-PULSE CNC
RAM EDM SYSTEM

HANSVEDT EDM DIVISION
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THE FOLLOWING INFORMATION IS NECESSARY WHEN CONTACTING THE FACTORY REGARDING YOUR MACHINE:

	MACHINE	POWER SUPPLY/CONTROL	BOOSTER
MODEL:	_____	_____	_____
SERIAL NO.:	_____	_____	_____
SOFTWARE VERSION:	_____		

Part No. MS-415

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INTRODUCTION

THANK YOU for purchasing a Hansvedt EDM Machine. This manual has been provided to make it easy for you to install, operate and maintain your machine.

If you have questions regarding the installation, operation or use of your machine, contact Hansvedt EDM for assistance. If necessary, we will send an EDM Service Representative to assist with your final installation and to train your people in the operation of the unit at an additional charge.

Hansvedt will also provide factory training to assist you in the areas of EDM applications, operation, and servicing for a nominal charge. In addition, Hansvedt's EDM application experts are available to assist you with your applications over the phone.

At the time of writing this manual was up-to-date. However, due to continual improvements in design it is possible that descriptions contained herein may vary from the machine delivered to you. If there are any such problems, you are encouraged to contact Hansvedt for clarification.

We strongly suggest that personnel responsible for the machine read this manual thoroughly and study the instructions carefully before attempting to operate or service the machine.

WE URGE YOU TO HEED THE SAFETY PRECAUTIONS IN THIS MANUAL

Warnings and cautions, such as the one below, are inserted throughout the manual. Please learn and understand them. We do not want you to incur accidents that result in damaged equipment or, especially, personal injury.

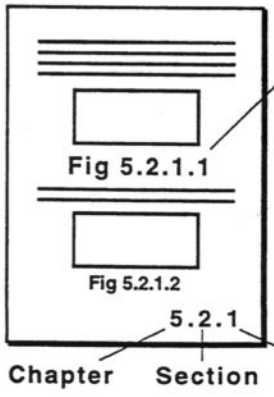
BASIC PRECAUTIONS

1. DO NOT OPERATE THE MACHINE UNATTENDED.
2. Always submerge the cutting gap with a 2 INCH MINIMUM OF DIELECTRIC FLUID.
3. Always set up the workpiece so that the START position of the program is 2 inches below the surface of the dielectric fluid in the worktank.
4. Always position the worktank float switch at the dielectric fluid level mark on the switch cover.
5. Never set the FAULT RETRACT so that the electrode could retract out of the dielectric fluid.
6. In the event of an oil fire actuate the EMERGENCY STOP switch and use carbon dioxide, halon or AFFF to extinguish. DO NOT USE WATER.
7. Be absolutely sure that there are no kinks or obstructions in fluid lines. Kinks or obstructions in the large fill/drain hoses or the flushing lines can cause damage and fluid loss.
8. Do not touch electrode or platen when gap power is on.

HOW TO USE THIS MANUAL

This manual is arranged to provide information with a minimum of searching. Tab dividers separate the main sections for quick access. A few minutes looking over the TABLE OF CONTENTS on the previous page will show the organization of the manual and make finding specific information much easier.

Pages are numbered in the lower outside corner, with chapter number, section number and page number within the section. Figures are numbered the same as pages on which they appear. Multiple figures on the same page are distinguished by suffix numbers.



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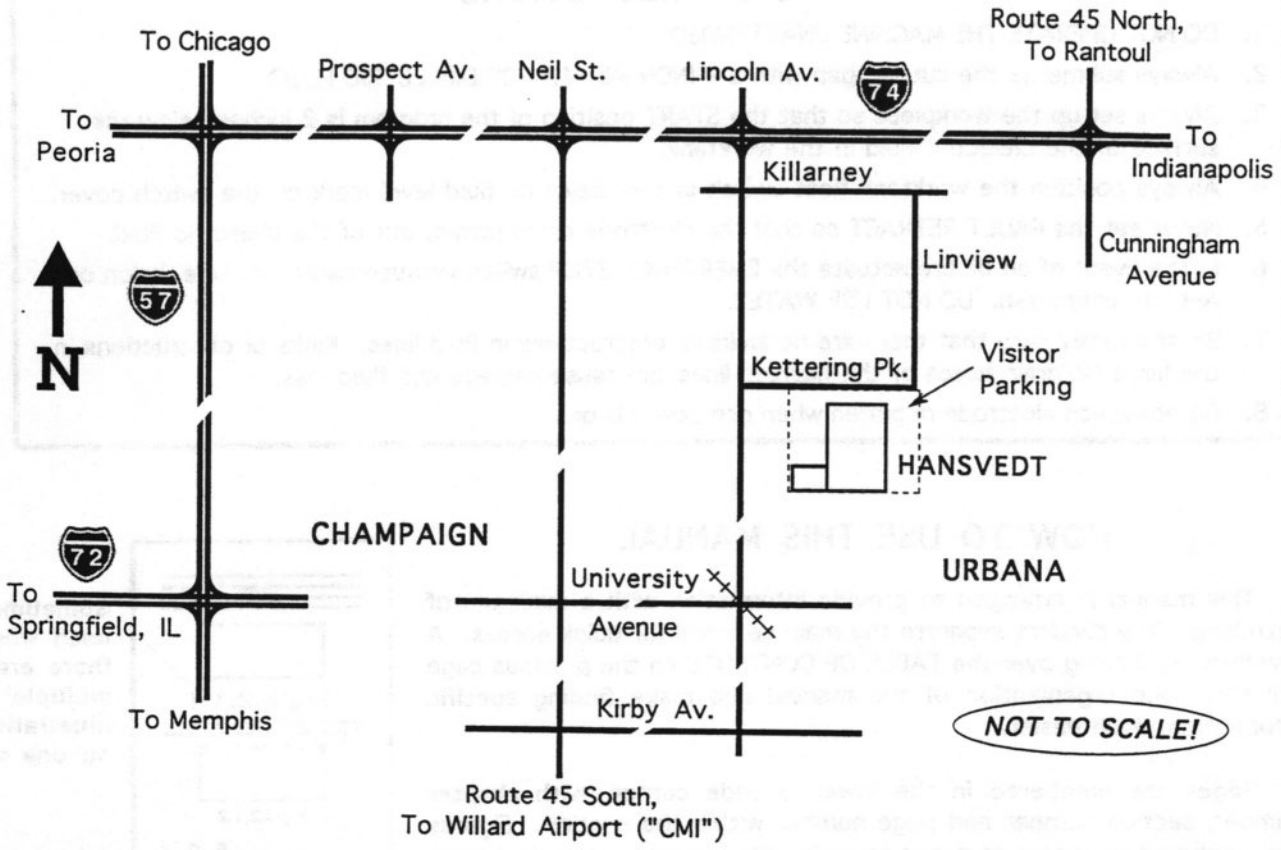

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GENERAL SAFETY

WARNING

Failure to follow instructions on this page may result in personal injury and/or damage to equipment.

IMPORTANT

These safety precautions have been prepared to assist the operator and maintenance personnel in practicing good shop safety procedures. Operators and maintenance personnel must read and understand these precautions COMPLETELY before operating, setting up, running or performing maintenance on the machine.

The precautions in this manual are to be used to supplement safety precautions and warnings from the following:

- Local, plant, and shop safety rules and codes.
- Federal and national safety laws and regulations. (See the latest edition of the OCCUPATIONAL SAFETY AND HEALTH STANDARDS, available from the DEPT. OF LABOR, WASHINGTON, D.C.)

NOTICE

Photographs and sketches shown throughout this manual are for illustrative purposes only and might not show all guarding necessary for safe operation.

PERSONAL SAFETY

Machine owners, operators, setup, maintenance and service personnel must be aware of the fact that constant day-to-day safety procedures are a vital part of their job. Accident prevention must be one of the principal objectives of the job regardless of what activity is involved.

A successful safety program is important from both a humanitarian and an economic standpoint. An accident will usually result in a loss of production. It may also cause costly damage to the machine. The worst accidents, of course, are those resulting in personal injury. These rules are intended to help prevent such accidents.

Know and respect your machinery. Read and practice the prescribed safety and checking procedures. Make sure that everyone who works for, with or near you fully understands and — more importantly — complies with the all safety precautions and procedures when operating this machine.

Sudden movements, loud noises, careless behavior, etc., must be avoided. These distractions may result in unsafe conditions for those working near the machinery.

Observe and follow safety instructions such as NO SMOKING, HIGH VOLTAGE, DANGER, etc. in your working area.

Accidents can occur that result in serious personal injury to yourself or others due to clothing and other articles becoming entangled in handwheels, levers, moving machine elements. The following

suggestions, if followed, will help you to avoid such accidents: Neckties, scarfs, gloves, loose hanging clothing, and jewelry such as watches, rings or necklaces must not be worn around moving machinery. Restrain long hair with a cap or net. Wear gloves only when handling rough, sharp or hot parts.

Use safety protective equipment. Wear clean, approved eye or face protection. Safety-toe shoes with slip-proof soles can help you avoid injury. Keep your protective equipment in good condition.

WARNING

Failure to follow instructions on these pages may result in personal injury and/or damage to equipment.

WORK AREA SAFETY

Always keep your work area clean. Dirty work areas with hazards such as oil, debris or water on the floor may cause someone to fall to the floor, into the machine or into other objects, resulting in serious personal injury.

Make sure your work area is free of hazardous obstructions and be aware of protruding machine members.

Return tools and similar equipment to their proper storage place immediately after use. Keep work benches neat, orderly and clean.

LIFTING AND CARRYING SAFETY

Contact supervision if you have any questions or are not sure about the proper procedures for lifting and carrying.

Before lifting or carrying an object, determine the weight and size by referring to such things as tags, shipping data, labels, marked information or manuals.

Use power hoists or other mechanical lifting and carrying equipment for heavy, bulky or hard-to-handle objects. Use hookup methods recommended by your safety department and know the signals for safely directing a crane operator.

Never place any part of your body under a suspended load or move a suspended load over any part of another person's body. Before lifting, be certain that you have a safe spot for depositing the load. Never work on a component while it is hanging from a crane or other lifting mechanism. If in doubt as to the size or type of lifting equipment, methods or procedures for lifting, contact HANSVEDT EDM DIVISION before proceeding to lift the machine or its components.

Always inspect slings, chains, hoists, and other lifting devices prior to use. Do not use lifting devices found to be defective or questionable.

Never exceed the safety rated capacity of cranes, hoists, slings, eyebolt and other lifting equipment. Follow standards and instructions applicable to any lifting equipment you use. (For example, ANSI Standard B18.15, available from the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018, contains information concerning safe lifting loads for different size eyebolts, for various angles of lift and application instructions for safe use of eyebolts.)

Before inserting an eyebolt, be certain that both the eyebolt and the hole have the same size and type threads. To attain safe working loads, at least 90% of the threaded portion of a standard forged eyebolt must be engaged.

INSTALLATION AND RELOCATION SAFETY

Before lifting the machine consult the INSTALLATION section of this manual or HANSVEDT EDM DIVISION for proper methods and procedures.

An electrician must read and understand the electrical schematics prior to connecting the machine to the power source. After connecting the machine, test all aspects of the electrical system for proper functioning. Always make sure the machine is grounded properly. Be certain that all exposed electrical systems are covered properly. Place all selector switches in their OFF or neutral (disengaged) position. The doors of the main electrical cabinet must be closed and the main disconnect switch must be in the OFF position after the power source connection is complete.

Always lock the main disconnect device in the OFF position if the machine is left unattended. Never bypass or wire around safety devices.

SET UP AND OPERATION SAFETY

Do not attempt to set up or operate this machine until you read and understand all the safety instructions.

Assign only qualified personnel instructed in safety and all machine functions to operate this machine.

Operators and maintenance personnel must carefully read, understand and fully comply with all machine mounted warning and instruction plates. Do not paint over, alter or deface these plates or remove them from the machine. Replace all plates that become illegible. Replacement plates can be obtained from HANSVEDT EDM DIVISION.

WARNING

Shut off power to the machine when you leave the operating area or at the end of your work period. NEVER leave a machine running unattended.

Do not operate the machine with safety guards, shields, barriers, covers and protective devices disconnected, removed or out of place.

Turn the master disconnect device to the OFF position before cleaning the machine at the end of the working day or when guards or covers are removed that expose hazardous areas.

MAINTENANCE SAFETY

Assign only qualifed service or maintenance personnel to perform maintenance and repair work on this machine. Carefully read the MAINTENANCE AND SERVICE section of this manual before attempting any service or repair work, and when in doubt, contact HANSVEDT EDM DIVISION. Use only HANSVEDT EDM DIVISION replacement parts; others may impair the safety of the machine. Before performing maintenance or service work, WARNING or DANGER signs must be placed conspicuously above the machine.

Before removing or opening any electrical enclosure, cover, plate or door, be sure that the main disconnect switch is in the OFF position. If any tool is required to remove a guard, cover, bracket or any basic part of this machine, place the main disconnect switch in the OFF position and lock it in the OFF position. If possible, post a sign at the disconnect switch indicating that maintenance is being performed.

Whenever maintenance is to be performed in an area away from the disconnect and the disconnect is not locked, tag all start button stations with a "DO NOT START" tag. Adequate precautions such as

locks on circuit breakers, warning notices or other equally effective means must be taken to prevent electrical equipment from being electrically activated when maintenance is being performed.

WARNING

Failure to follow instructions on these pages may result in personal injury and/or damage to equipment.

When removing electrical equipment, place numbered or labelled tags on those wires not marked. If wiring is replaced, be sure it is of the same color, type, length, size and has the same load carrying capacity.

Close and securely fasten all guards, shields, covers, plates or doors before power is reconnected.

An electrical technician must analyze the electrical system to determine the possible use of power retaining devices such as capacitors. Such power retaining devices must be disconnected, discharged or made safe before maintenance is performed.

Working space around electrical equipment must be clear of obstructions. Provide adequate illumination to allow for proper operation and maintenance.

Here are some of the warning labels that are applied to Hansvedt EDM equipment.

Please read them and heed them.

IMPORTANT SAFETY PRECAUTIONS

1. ELECTRICAL - DO NOT TOUCH ELECTRODE OR PLATEN WHILE GAP POWER IS ON.
2. FIRE - DO NOT ALLOW FLUID LEVEL TO DROP BELOW ARCING. ARCING ON THE SURFACE OR IN UNBURNED FUMES CAN CAUSE FIRES.
3. PERSONAL INJURY - KEEP HANDS CLEAR OF RAM DURING OPERATION.

WARNING

THIS POWER SUPPLY PRODUCES HIGH VOLTAGE.
BEFORE OPENING THE DOORS TO WORK ON ELECTRICAL CIRCUITS, TURN THE MAIN POWER SWITCH OFF. ALSO TURN OFF AND LOCK THE ELECTRICAL SUPPLY SOURCE TO THIS MACHINE.
FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS OR FATAL INJURY.

WARNING

THIS POWER SUPPLY PRODUCES HIGH VOLTAGE AND SHOULD BE USED ONLY WITH MACHINES HAVING GUARDS THAT WILL HELP PREVENT CONTACT BY PERSONNEL WITH THE TOOL ELECTRODE DURING MACHINING.
FAILURE TO FOLLOW THIS WARNING MAY RESULT IN SERIOUS SHOCK INJURY.

WARNING

BEFORE WORKING ON CIRCUITS CONNECTED WITH YELLOW WIRE, LOCATE THEIR SOURCE OF POWER, TURN IT "OFF" AND, IF POSSIBLE, LOCK IT. SINCE THEY MAY BE POWERED BY A SOURCE AWAY FROM THE MACHINE, TURNING THE MACHINE MAIN DISCONNECT "OFF" MAY NOT SHUT OFF POWER TO THEM.
FAILURE TO FOLLOW THIS WARNING MAY RESULT IN SERIOUS SHOCK INJURY.

WARNING

BEFORE WORKING ON ANY ELECTRICAL CIRCUITS, TURN THE MACHINE MAIN DISCONNECT DEVICE "OFF" AND, IF POSSIBLE, LOCK IT.

FAILURE TO FOLLOW THIS WARNING MAY RESULT IN SERIOUS SHOCK INJURY.

EDM SAFETY

Note: These safety precautions cover both the EDM machine tool and the EDM power supply used with it. The appropriate power supply and machine manuals should be consulted whenever specific information is desired concerning the location, function or other pertinent details of mentioned items or components.

NOTICE

Photographs and sketches shown throughout this manual are for illustrative purposes only and might not show all guarding necessary for safe operation.

1. Machine owners, operators, set-up and maintenance personnel should be aware that constant day-to-day safety procedures are a vital part of their job. Prevention of accidents must be one of the principle objectives, regardless of what job activity is involved. It has been proven that where safety is the primary concern operations are always more efficient.

2. A successful safety program is important from both a humanitarian and an economic standpoint. An accident will usually result in a loss of production. It may also cause costly damage to the machine. The worst accidents of course, are those resulting in personal injuries. These rules are intended to help prevent such accidents.

3. Operate the EDM equipment only as set forth in this manual.

4. Service or repair work should only be performed after carefully reading this manual.

5. Clamp all work and electrodes securely before starting machine. If manifolds are used, fill completely with oil before starting cut.

WARNING

NEVER ALLOW THE EDM MACHINE TO OPERATE UNATTENDED.

DIELECTRIC HAZARDS

1. HANSVEDT EDM DIVISION specifies the use of light dielectric EDM oil, listed as Rustlick EDM-250 for best finish and lowest overcut.

2. Maintenance of a certain oil level above the highest portion of the electrode-workpiece working gap is essential. The normal safe minimum level for EDM work on steel is 2" plus 1" per 25 amps of average current over 50 amps for flat geometry work. However, angled geometries, high velocity flow, low viscosity or low flashpoint dielectrics, as well as the more violent discharge action of some workpieces, will demand the maintenance of higher dielectric levels.

One or more of the above conditions can result in hot metal particles being expelled through the oil level into the discharge gases, causing them to ignite.

Once the safe oil level above the part has been determined the safety float switch should be adjusted to ensure the oil level is sensed. The gap power is automatically cut off from the working gap when the oil level drops below the float switch setting.

3. If discharge gases ignite, immediately press the MACHINE OFF or EMERGENCY STOP button. The electrical power will be turned off so that no additional gas and/or metal particles will be formed and the flame should extinguish.

4. It is imperative that a qualified person, trained in the operation of the machine, as well as in safety requirements, be present at all times during the EDM process.

5. EDM machining is a heat producing process. The dielectric oil removes the concentrated heat from the machining gap, and distributes it in the available oil. Operating parameters may vary, but we recommend that the oil be maintained at a temperature no higher than 130° F. If you experience dielectric temperatures that exceed 130° F, a chiller/refrigeration unit should be considered. Contact HANSVEDT EDM DIVISION for details on these systems.

WARNING

Failure to follow instructions on these pages may result in personal injury and/or damage to equipment.

WARNING

FAILURE TO PUT OUT A GAS FIRE IMMEDIATELY MAY CAUSE THE OIL TO CATCH FIRE. Smother an oil fire with a halon or carbon dioxide fire extinguisher only. It is necessary that a fire extinguisher be kept in the vicinity of the EDM machine. DO NOT use water on any electrical or oil fire.

WARNING

NEVER use Kerosene or other highly flammable oils in place of approved EDM dielectric oil. Failure to follow these instructions may cause a fire resulting in personal injury and/or damage to machine components.

EXPLOSION HAZARDS, TRAPPED DISCHARGE GASES

All discharge gases are flammable and should not be allowed to exist near a spark or flame. An EDM machine must be adequately ventilated. It is strongly recommended that all EDM installations be complete with a suitable exhaust system, such as one having the capability of exhausting a minimum of 50 cubic feet of air/minute per 100 amps of machining current.

Discharge gases must always be allowed to escape without being trapped in a closed area. Any setup which can result in trapped gases is extremely dangerous and must be avoided. Avoid starting or operating with air in chambers where it can combine with gases and form an explosive mixture.

WARNING

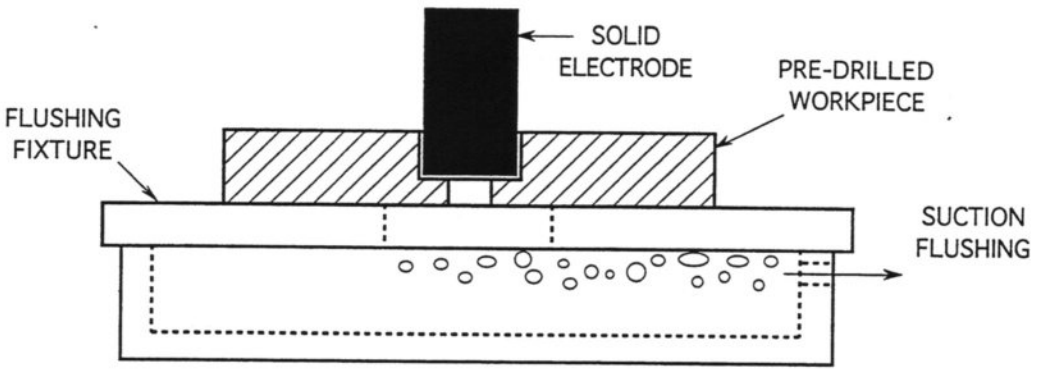
Avoid making the workpiece setup so that discharge gases can be trapped in work-supporting manifolds, in EDM electrodes or domed or hollow work structures which are susceptible to gas entrapment.

TYPICAL MACHINING HAZARDS AND THEIR SOLUTIONS

1. EDM MACHINING INTO MANIFOLDS —

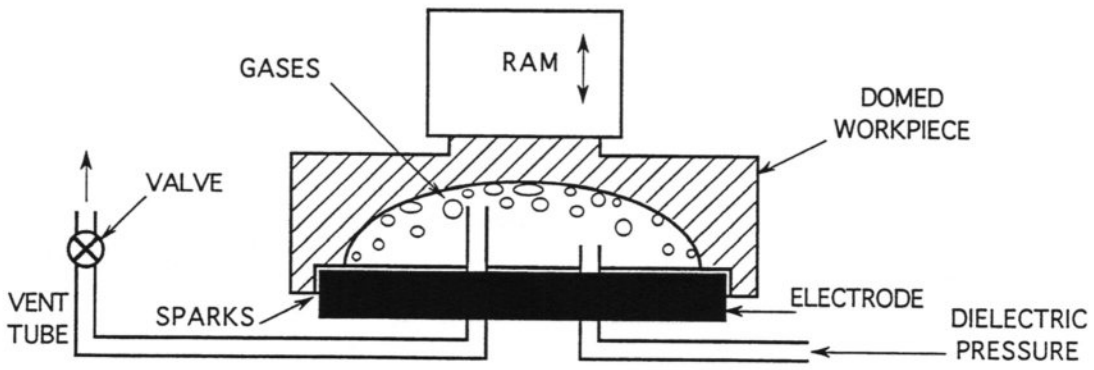
Includes "Reverse-Flush Dielectric Manifold," tanks, domes or any other structures capable of trapping discharge gases.

Completely fill all such structures with dielectric oil to eliminate all air space from the enclosed structure. Pressure dielectric flow will maintain a completely filled manifold. However, if vacuum dielectric flow is used, the vacuum outlet must be at the highest portion of the manifold to evacuate the discharge gases.



2. VERTICAL SERVOING A DOMED WORKPIECE —

Vent from the highest internal point to a controlled outlet having vent openings sized so that all gases, plus a small amount of dielectric oil, are expelled without starving the machining gap.

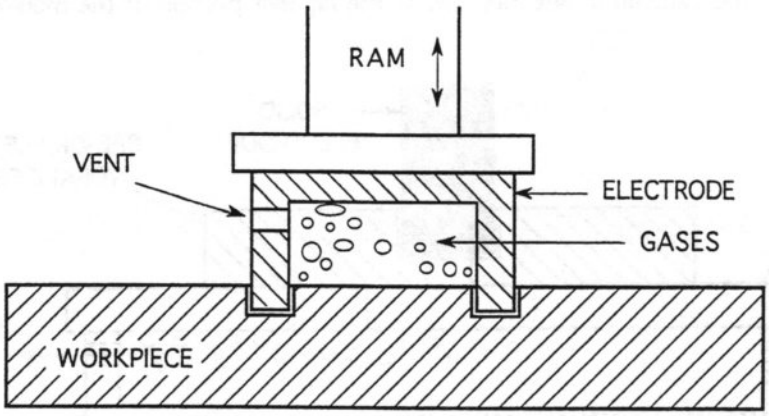


WARNING

Failure to follow instructions on these pages may result in personal injury and/or damage to equipment.

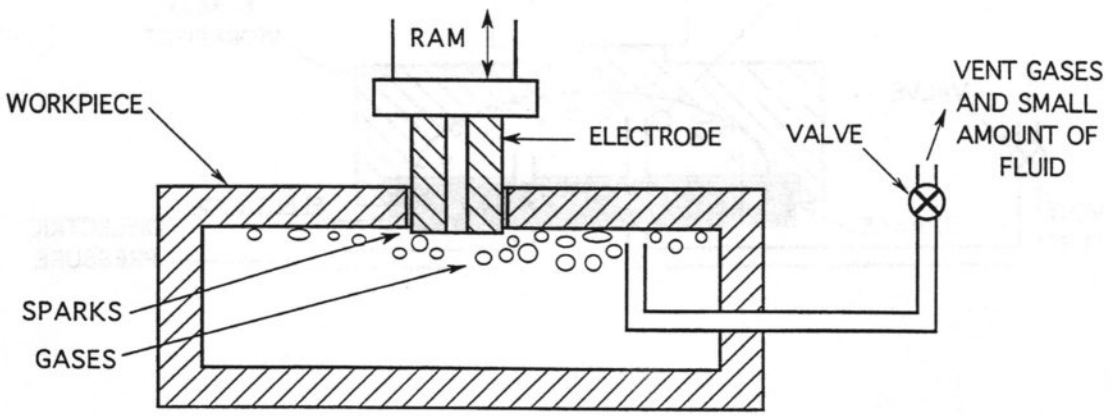
3. VERTICAL SERVOING A TREPANNING-TYPE ELECTRODE —

Vent the highest part of the internal cavity of the electrode to the worktank area to relieve discharge gases.



4. EDM MACHINING INTO A WORKPIECE WITH ENCLOSED CHAMBERS CAPABLE OF TRAPPING DISCHARGE GASES —

If possible, vent the highest part of the chamber to the outside air to relieve the discharge gas. If this is not possible, lead an internal tube, or tubes, from the highest part of the dome or chamber, to the worktank area. The tubes should be sized so that all gases, plus a small amount of dielectric oil, are expelled without starving the machining gap. Keep the dome or chamber under dielectric pressure so that the discharge gases are entrained in the outward flow of dielectric oil through the vent tube.



EXPLOSION HAZARDS, TRAPPED DISCHARGE GASES

Discharge gases will accumulate in the dielectric reservoir. These gases must be diluted to a safe level before servicing the reservoir.

WARNING

When the dielectric level in a storage tank is suddenly raised (by dumping a worktank, for example), a large volume of discharge gas will escape into the outside air. Ignition of such displaced gases may cause a fire which could backflash into the enclosed area causing an explosion.

LOCATION OF EDM POWER SUPPLY

The EDM power supply should be located in an adequately ventilated area. A minimum of 50 cubic feet of air/min. per 100 amps of machining current is strongly recommended. If the EDM unit is located near other machines, such as lathes, milling machines, or grinders, keep the EDM unit free of metal chips, grinding dust, and coolant. Excess accumulation of such material may cause damage to the EDM units.

CAUTION

EDM power supply must be in a ventilated area, or damage to components may occur from excessive heat, chips, dust, etc.

CAUTION

The exhaust of the fast dump exhaust valve must never be directed at the power supply air intake filter. Oil or oil mist exhausted into the power supply could cause damage to the power supply.

OPERATION OF EDM UNIT AT HIGH CURRENT

When operation of the EDM power supply is used at high current applications, the operator should allow the power supply unit to remain in the MACHINE ON mode and with GAP POWER turned OFF. It should be left on a period of five minutes or more prior to turning the power supply off. This will allow the exhaust fans to disperse excessive heat inside of the unit. If the operator should shut all power off right after machining, the excessive heat may cause damage to the components inside the EDM power supply.

ELECTRICAL HAZARDS, INTERLOCKS, SAFETY SWITCHES

Always turn the electrical disconnect switch(es) to the OFF position at the end of the working day.

WARNING

When in the machining mode the electrode or platen must NOT be touched, as electrical shock will result. Failure to follow this instruction may result in serious personal injury.

BASIC PRECAUTIONS

1. DO NOT OPERATE THE MACHINE UNATTENDED, unless it is equipped with an approved fire suppression system.
2. Always submerge the cutting gap with a 2 INCH MINIMUM OF DIELECTRIC FLUID.
3. Always set up the workpiece so that the START position of the program is 2 inches below the surface of the dielectric fluid in the worktank.
4. Always position the worktank float switch at the dielectric fluid level mark on the switch cover.
5. Never set the FAULT RETRACT so that the electrode could retract out of the dielectric fluid.
6. In the event of an oil fire actuate the EMERGENCY STOP switch and use carbon dioxide, halon or AFFF to extinguish. DO NOT USE WATER.
7. Be absolutely sure that there are no kinks or obstructions in fluid lines. Kinks or obstructions in the large fill/drain hoses or the flushing lines can cause damage and fluid loss.
8. Do not touch electrode or platen when gap power is on.

WARNING

Special Precautions Regarding Fire Suppression Systems

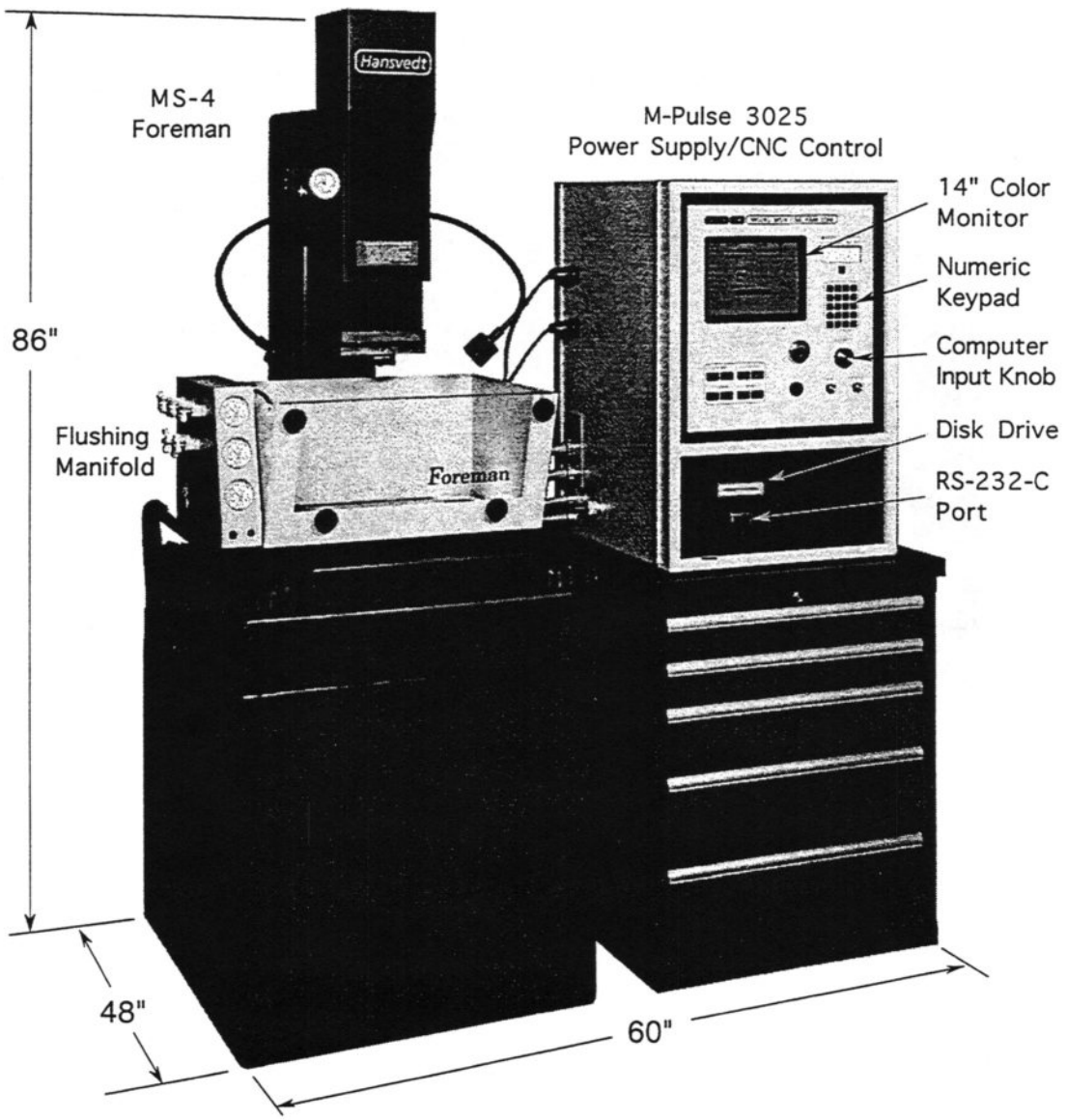
Hansvedt encourages the use of fire suppression systems. However, they should NOT be assumed to be 100% effective. Such systems installed on Hansvedt EDMs are not of Hansvedt's design or manufacture, and Hansvedt neither confirms nor denies claims that may be made by the manufacturers of such systems. Hansvedt makes no guarantees of their performance or success, and accepts no responsibility for their failure, whether installed by Hansvedt or others.

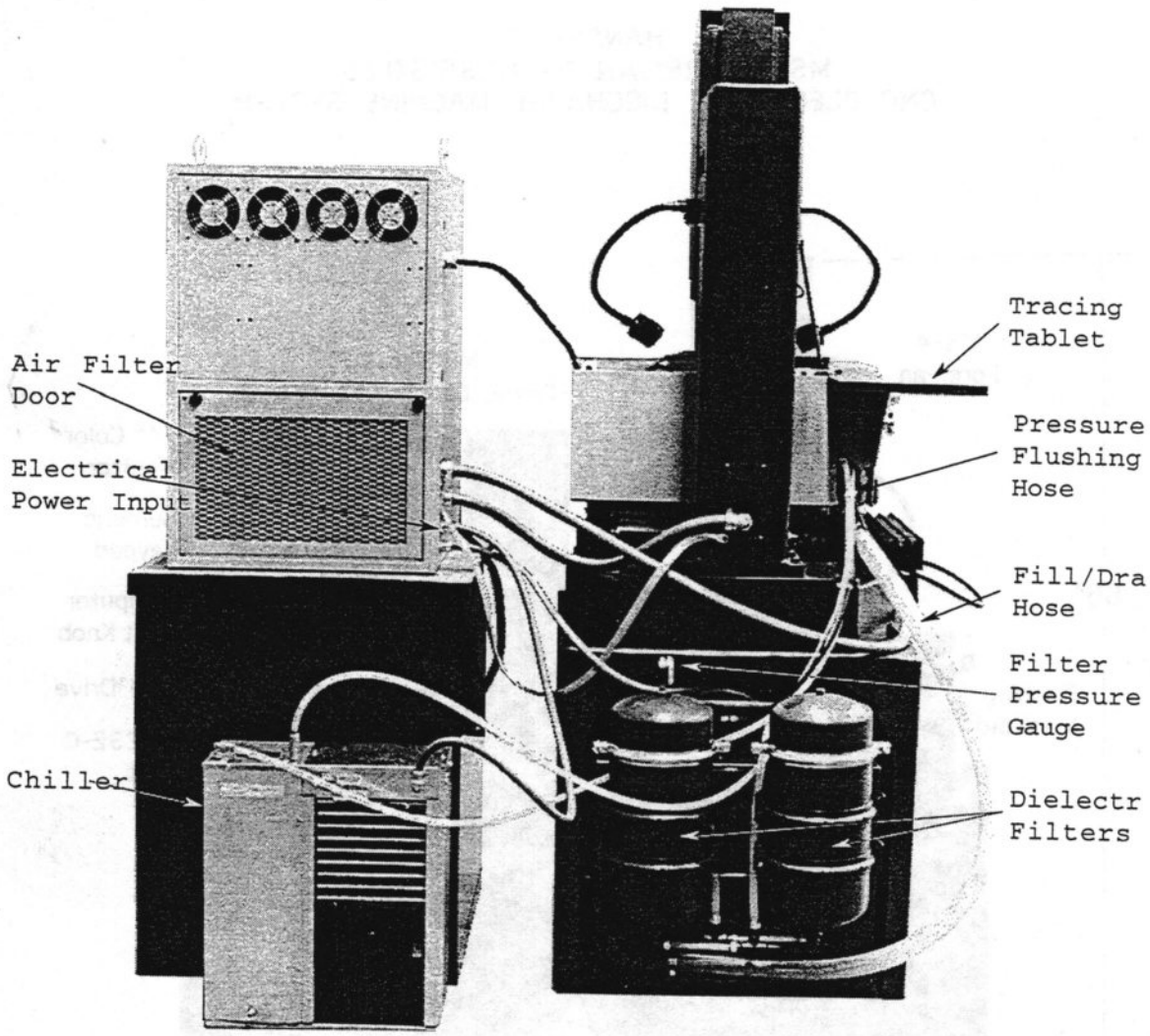
Hansvedt does NOT recommend that EDMs using oil-base dielectric and having fire suppression systems be operated completely unattended, such as overnight "lights-out" operation. Partially unattended operations, such as one operator overseeing more than one machine, should be done with due consideration for the possibility of failure of the suppression system in the event of fire. An overhead sprinkler system, because it uses water, may not instantly put out an EDM fire, though it is certainly a wise investment because it will probably limit the fire's extent.

CHAPTER 1
MACHINE DESCRIPTION

General Description and Specifications
Tooling and Optional Equipment

HANSVEDT
MS-4 FOREMAN/M-PULSE 3025
CNC ELECTRICAL DISCHARGE MACHINE SYSTEM




Tracing Tablet
Air Filter Door
Pressure Flushing Hose
Electrical Power Input
Fill/Dra Hose
Filter Pressure Gauge
Chiller
Dielectr Filters

SPECIFICATIONS

Machine Tool

Positioning table travel	7" x 12" *(177 x 304mm)*
Worktable size	9" x 15" *(229 x 381mm)*
Worktank size	16" x 24" x 11" *(406 x 609 x 279mm)*
Platen-to-table, maximum	16" *(406mm)*
Ram travel	8" *(203mm)*
Max. electrode weight	100 lbs. *(45 kg)*
Max. workpiece weight	300 lbs. *(136 kg)*
Table positioning accuracy	± .0001" *(± .0025mm*

Power Supply

Maximum average current	25 amps (50 amps optional)
Number of peak current selections	30
Arc duration range	.1 to 2,000 μseconds
%On-time	.1 to 90%
Best surface finish	8 μinch AA

CNC Control

Memory capacity	30MB
CRT display	14" VGA color *365mm*
Digital readout	.3" numbers, .0001" resolution, X, Y & Z
Input modes	Manual, RS-232, 3.5" disk drive
Output modes	RS-232, 3.5" disk drive
Servo controls, manual	Edge find, Hole center, Jog, Trace, Home, Tram, Zero set, Stop return, Line select, Start return.
Programmable parameters	Z cut depth, XY circular interpolation, XYZ linear interpolation, Orbit, Generator, Peak current, Arc duration, %On-time, Polarity, Gap spacing, Servo speed, Current cut-off, Fault retract, Ram cycle, Flushing, Auto shutoff
Programming codes	Start, Linear, Clockwise, Counterclockwise, Orbit, Vector, Trace Vector, Dwell, Pause, Jump, Rapid, Goto, Index, P(power), End
Edit	Program, Offset, Rotate, Rescale, Mirror

Dielectric System

Worktank capacity	18 gal *(68 lit.)*
Reservoir capacity	45 gal *(170 lit.)*
Pressure flushing, adj.	0-50 psi *(0-350 kPa)*
Vacuum flushing, adj.	0-15 in Hg *(0-52 kPa)*
Filtration	Two 5 micron elements
Temperature control	Chiller

General

Height/width/depth	89" x 76" x 50" *(2260 x 1930 x 1270mm)*
Net weight	2,200 lbs. *(1,000 kg)*
Color	Maroon and Putty
Power input, standard	220 VAC, 60 Hz, 3 phase

STANDARD EQUIPMENT

- Heavily ribbed cast iron machine base and ram with precision, anti-friction linear bearing worktable and ram ways, mounted on rigid steel stand.
- Large worktank with clear plastic removable door.
- Low inertia DC motor/ballscrew drives, rotary encoder feedback and leadscrew compensation.
- Dielectric fluid system including reservoir, 5-micron filters, chiller and manifold outlets for pressure, suction, pulse flush and worktank bypass.
- Worktank fluid level safety switch.
- Twin high intensity worklights.
- Tracing tablet.
- M-Pulse Model 3025, high efficiency 25-amp programmable power supply/control including:
  - Menu driven CNC control,
  - 14" color VGA CRT,
  - 3.5" disk drive,
  - RS-232-C port.
- Lista power supply stand, stationary, 5 lockable drawers, provides convenient storage for tooling and electrodes.
- Finish Comparator Scale.
- Two owner's manuals, floor plan and electrical diagrams.

OPTIONAL EQUIPMENT AND TOOLING

OPTIONAL EQUIPMENT

- Capacitor Mode, .2 to 12 MFD, programmable.
- Fire Suppression System.
- Trav-A-Dial Z-axis Indicator.
- Automatic Tool Changer, 6-position.
- Programmable Indexer Control.
- Transformer to Operate at 440V/60/3.
- Offline Programming System.
- M-Pulse Model 3050 50-amp Power Supply/Control.

TOOLING

- V-Block Electrode Holder, 1.5" capacity.
- 3R tooling is available upon request.

OTHER SELECTIONS

- Solid Crating for Export.
- Wired for other voltages and frequencies.
- Additional Owner's Manual.

CHAPTER 2
INSTALLATION

RECEIVING THE MACHINE

The MS-4 is shipped on two skids of the following approximate dimensions and weights:

Machine tool and power supply: 45" x 65" x 93" high, 1,600 lbs.
Reservoir and drawer unit: 50" x 75" x 60" high, 900 lbs.

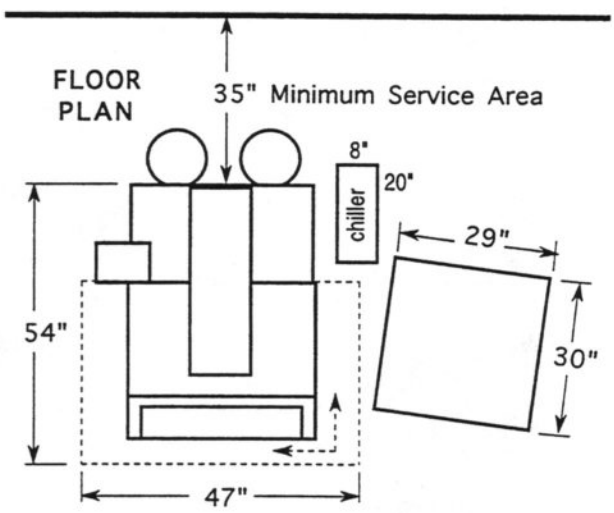
Important: Before signing the Waybill it is important to thoroughly inspect the machine for damage. If damage has occurred during shipping you have two options: (1) reject the shipment (if the damage is severe), or (2) note the damage on the Waybill and accept the machine. In either case notify Hansvedt's Service Department if the machine does not arrive in good condition.

MACHINE LOCATION

The machine must be located in a well ventilated area that is free from dust. Gases and dielectric evaporation produced by the EDM process could be harmful if they are allowed to accumulate in a confined area. A temperature controlled environment is necessary whenever high workpiece accuracies are required.

Airborne dust and dirt will affect power supply reliability! Graphite dust is particularly harmful if it penetrates the power supply filters and collects on the electronic components.

Allowance for about a 35 inch service area should be made behind the rear of the machine to access the dielectric filter and the rear power supply cabinet door.



UNPACKING, SPOTTING AND LEVELING

WARNING
Do not sling or lift the machine tool under the column or by the ram.
Move only by using a forklift through the base.

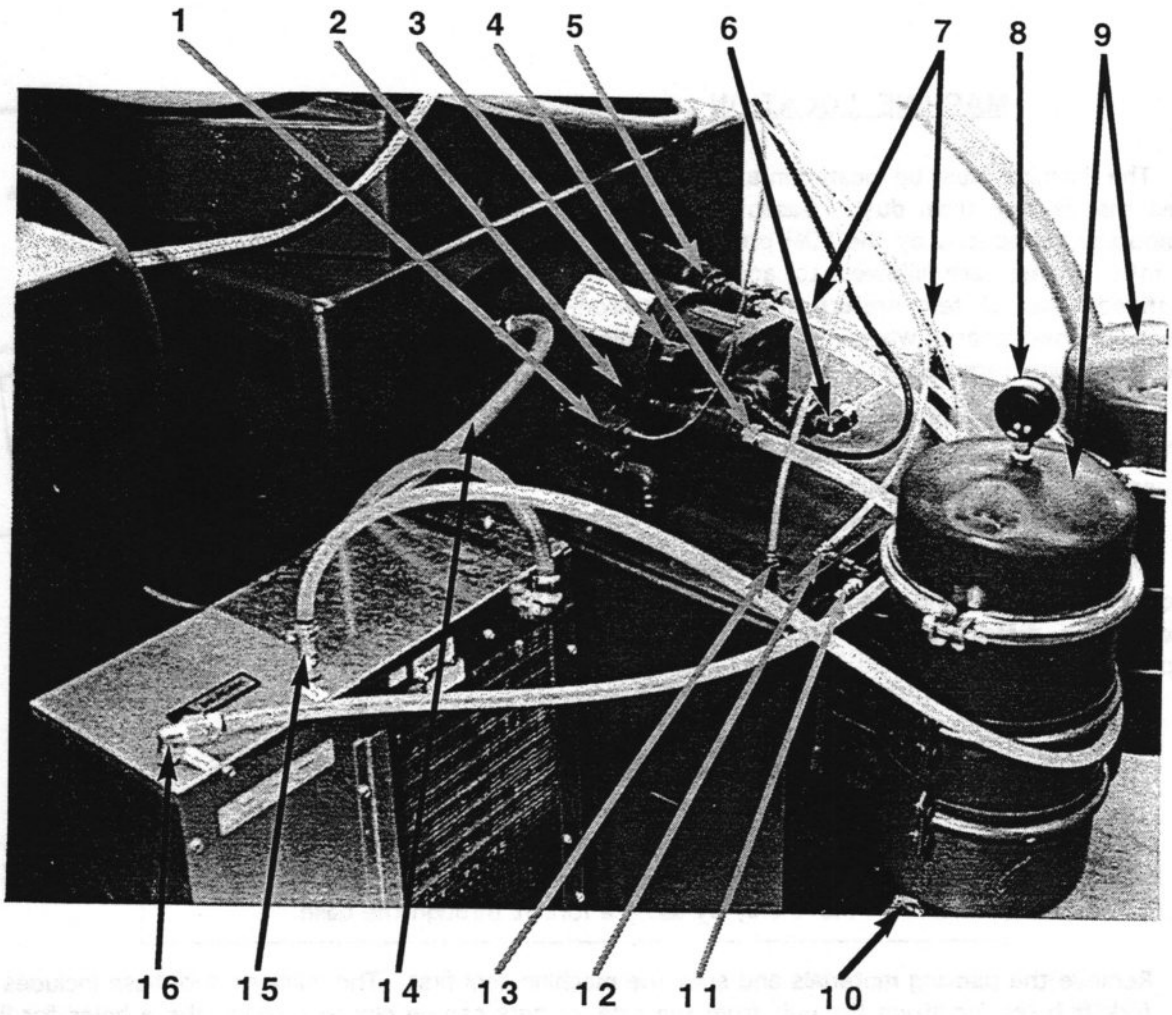
1. Remove the packing materials and spot the machine tool first. The machine tool base includes four forklift holes for lifting the unit from the side, or bars can be placed through these holes for lifting from the front. Install the four feet (3/4" bolts) in the bottom of the base and level as necessary.
2. Position the drawer unit on the right side of the machine tool.
3. Set the power supply/control unit on the drawer unit. Lifting eyes are provided on the top of the cabinet.
4. Position the dielectric reservoir under the base with the filter canister at the rear.
5. Position the dielectric chiller behind the drawer unit (or as shown in the floor plan above).

DIELECTRIC CONNECTIONS

1. The 1/2" Poly-Flo line from the rear of the machine tool manifold must be connected to the output of the dielectric chiller (#16 in photo). This is the coolant pressure line that provides clean dielectric to the worktank through the flushing manifold.

2. Connect the 1/2" Poly-Flo line from the pressure relief valve (#5 in photo) to the input of the chiller (#15 in photo).

3. Connect the 1.25" ID fill/drain hose (#10 in photo) between the push-on fittings on the dielectric reservoir and the pipe on the lower left side of the worktank. Hose clamps are provided to ensure a secure connection.



1. Exhaust Valve
2. Low Pressure Switch
3. Over-Pressure Switch
4. Pump (Pressure side)
5. Pressure Relief Valve
6. Pump (Suction side)
7. Dielectric Fluid Pressure Lines
8. Dielectric Pressure Gauge
9. Dielectric Filter Canisters
10. Fill/Drain Hose
11. Shop Air Input
12. Manifold Air Pressure (labeled "F")
13. Manifold Air Return (labeled "G")
14. Dielectric Pump Cable
15. Chiller Input
16. Chiller Output

AIR CONNECTIONS

1. Connect the 1/16" diameter flexible hose from the rear of the manifold to the fitting on the side of the exhaust valve. The exhaust valve (#1 in photo) is located at the top of the dielectric reservoir.
2. Exiting from the rear of the machine tool manifold are two small Poly-Flo lines, "F" & "G": "F" is an air pressure line and "G" is an air line that pressurizes the reservoir. Connect these lines to the fittings on the top rear of the dielectric reservoir (#12 and #13 in photo).
3. Connect a compressed air source (60-90 psi recommended for fast fill) to the dielectric reservoir at location #11 as indicated in the photo. It is recommended that a trap in the input air line be used to collect water and foreign debris.

FILLING WITH DIELECTRIC OIL

1. Place the HOLD/DRAIN switch in the DRAIN position. The exhaust valve will be opened and will allow the dielectric reservoir to vent air as the oil enters the reservoir. Check that the pet cock on the filter is closed. (Important: shop air must be connected before filling).
2. Fill the worktank with Hansvedt EDM-250 or an equivalent dielectric oil. Although the reservoir capacity is 45 gallons, it is recommended that only 42-44 gallons of dielectric oil be used. The fluid level can be observed in the 1.25" clear fill/drain hose. If the oil level in the reservoir is too high there will be an overspill through the air exhaust valve. If the oil level is too low, air will be forced into the worktank instead of oil when the worktank FILL valve is actuated. Clean dielectric oil may be added simply by pouring it directly into the worktank.

MACHINE LUBRICATION

Actuate the one-shot lubricator when the machine is installed. The table ways, ballscrews and certain bearings require periodic lubrication. Refer to Chapter 5 "Maintenance and Service" for lubrication instructions.

INSTALLING MISCELLANEOUS ITEMS

1. Position the worktank door on the worktank.
2. Install the tracing tablet on the left rear corner of the worktank (see photo). Holding the tablet in a vertical position, install one 10-32 screw through the edge of the tablet into the worktank. Rotate the tablet to a horizontal position so that it rests on the manifold support bracket. Magnetic strips, shipped in the accessory pack, are used to hold paper on the tablet.

POWER INPUT REQUIREMENTS

Standard electrical components are provided for operation between 195 and 250 Volts A. C., 60 hertz, 3 phase, 4.5 KVA, supplied with four #12 conductors. The primary electrical service for the MS-4 enters via the cord grip fitting at the left rear corner of the power supply/control cabinet. The main circuit breaker switch on the right side of the cabinet includes a lockable cover for machine maintenance.

The power supply/CNC control cabinet contains all of the electrical equipment, including the overload relays for the dielectric pump motors. For operator protection, when the doors of the enclosure are opened, a safety interlock trips a relay next to the circuit breaker inside the cabinet.

A HANSVEDT SERVICE REPRESENTATIVE WILL COMPLETE THE WIRING DURING THE START-UP PROCEDURE.

START-UP AND CHECK-OUT

HANSVEDT WILL PROVIDE A SERVICE REPRESENTATIVE TO START UP THE MACHINE, INCLUDING: (1) FINAL WIRING CONNECTIONS, (2) TRANSFORMER TAP CHECK-OUT, (3) PUMP MOTOR TAP/ROTATION CHECK-OUT, AND (4) POWER-UP TO ALL SYSTEMS.

BEFORE SCHEDULING A SERVICE REPRESENTATIVE, ELECTRICAL SERVICE SHOULD BE BROUGHT TO THE POWER SUPPLY AND THE RESERVOIR SHOULD BE FILLED WITH DIELECTRIC FLUID.

BASIC PRECAUTIONS

1. DO NOT OPERATE THE MACHINE UNATTENDED.
2. Always submerge the cutting gap with a 2 INCH MINIMUM OF DIELECTRIC FLUID.
3. Always set up the workpiece so that the START position of the program is 2 inches below the surface of the dielectric fluid in the worktank.
4. Always position the worktank float switch at the dielectric fluid level mark on the switch cover.
5. Never set the FAULT RETRACT so that the electrode could retract out of the dielectric fluid.
6. In the event of an oil fire actuate the EMERGENCY STOP switch and use carbon dioxide, halon or AFFF to extinguish. DO NOT USE WATER.
7. Be absolutely sure that there are no kinks or obstructions in fluid lines. Kinks or obstructions in the large fill/drain hoses or the flushing lines can cause damage and fluid loss.
8. Do not touch electrode or platen when gap power is on.

WARNING

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CHAPTER 3
EDM PRINCIPLES

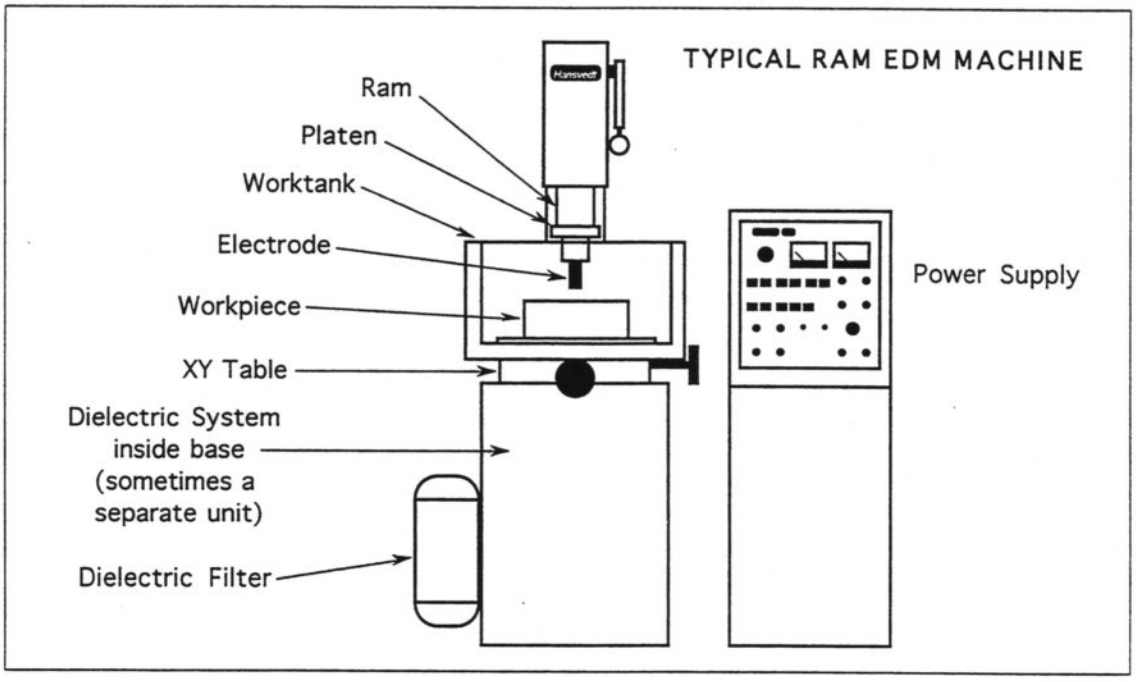
EDM Description 3.1.1
EDM Applications.....3.2.1
Glossary of EDM Terms 3.3.1

DESCRIPTION OF ELECTRICAL DISCHARGE MACHINING

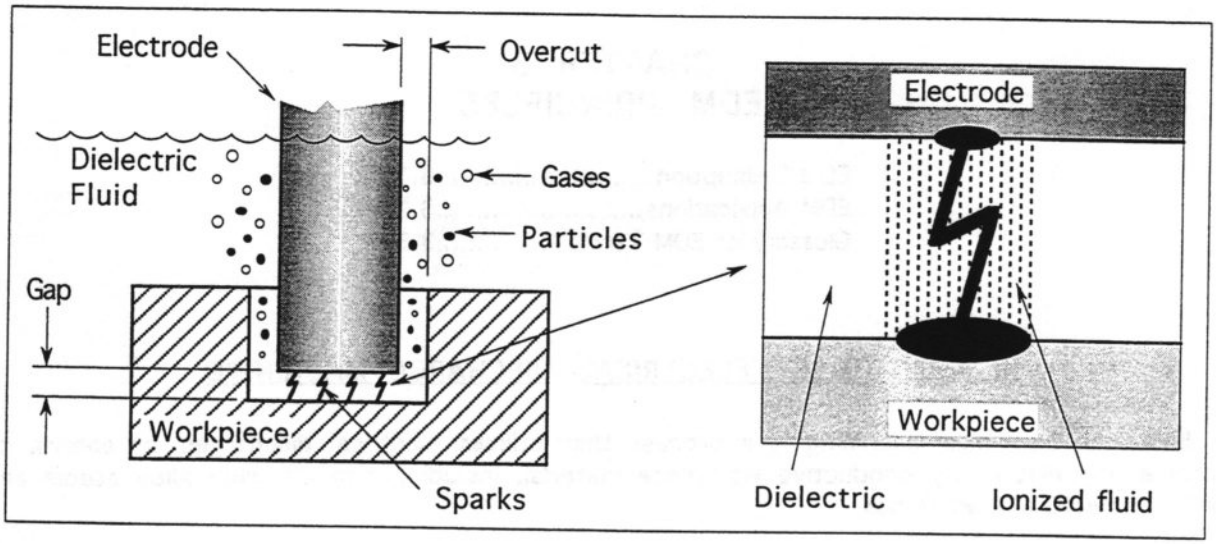
Electrical Discharge Machining is a process that utilizes electrical discharges, or sparks, to machine any electrically conductive workpiece material, including carbide, high alloy steels and hardened metals of many types.

Typically, the workpiece is clamped to a worktable and an electrode is fastened to a platen on the vertical ram above the workpiece. A dielectric fluid is needed to immerse the workpiece and electrode and surround the cutting action. The EDM machine tool is much like a milling machine except that it has a worktank and dielectric system to handle the flow of fluid.

A power supply is required to produce and control a DC voltage potential between the workpiece and electrode. The power supply also provides the means to automatically servo the downward motion of the ram as the erosion progresses.



The electrode is brought into close proximity to the workpiece and the accurately controlled electrical discharges take place between the electrode and the workpiece. As the electrode is moved toward the workpiece the fluid ionizes, allowing a discharge to occur when the gap is sufficiently small. This discharge, with the aid of the dielectric fluid, melts and removes metal from the workpiece at the point where the gap (the distance between the electrode and the workpiece) is the smallest.



As material is removed, the electrode is fed into the workpiece and held in the correct cutting relationship by electrohydraulic or electromechanical servo control of the ram. The servo control automatically maintains the desired gap between the electrode and workpiece.

The high energy spark, through vaporization, melting, and an explosive effect, dislodges a minute particle of metal from the workpiece, leaving a small crater. The dislodged particle, or chip, is then solidified and washed away by the dielectric oil. Although the chip and the crater produced by a spark is extremely small, energy pulses can be created by the power supply at rates in excess of 250,000 per second to make the total amount of metal removed significant.

Electrical discharge machining differs from conventional machining in two important respects: 1) with EDM only electrically conductive materials can be machined, and 2) the opening that is cut by EDM is always slightly larger than the electrode (cutting tool). This extra metal removal is referred to as the "overcut," and is a result of the gap maintained between the electrode and the workpiece and the fact that electrical discharges always occur at the nearest point.

EDM particles must be removed from the cutting area in EDM the same as chips must be removed in conventional machining. A flow of dielectric oil should be present at the cutting gap to insure good cutting ability. This flow, called flushing, is most effective when it exerts a positive force that moves the particles out of the cutting area.

Feeding the electrode into the workpiece and maintaining the gap as the stock is removed is controlled by electrical feedback from the cutting gap. The electrode never comes in contact with the workpiece. A reference voltage is established within the servo control to which the voltage at the gap is compared. As stock is removed the distance between the electrode and the workpiece is increased, which in turn increases the voltage across the gap. When the gap voltage differs from the reference voltage, a signal is sent to the servo which actuates the ram, moving the electrode closer to the workpiece and bringing the system back into balance.

CONTROLLING THE ENERGY DISCHARGE

The controllable factors in EDM are generally the same as in conventional machining: the rate at which metal is removed, the finish on the workpiece, accuracy, and the efficiency of the operation. In a conventional machining operation such as milling, these factors would be controlled by the motor horsepower, RPM, feed rate and type of cutting tool.

In EDM these factors are controlled by amperage, arc duration, % on-time, the electrode feed servo system and the electrode material. These are all interrelated, in that none of them have just one

simple outcome. In general, peak amperage (peak current) and percent on-time relate to metal removal rate and arc duration relates to surface finish and overcut. Average amperage is a result of all of these settings plus the servo settings and electrode and workpiece sizes, shapes and materials.

AVERAGE AMPERAGE

Amperage represents the total electrical energy, or cutting power, produced by the power supply and utilized in the cutting operation. This "average amperage" will determine the cutting rate. Average amperage can be adjusted within a given range to arrive at a machining rate best suited to the results desired. It is the result of three factors: 1) peak current level, 2) percent on-time, and 3) efficiency. The peak current limits the magnitude of the electrical pulses and the % on-time determines the repetition rate of the pulses. The gap adjust and flushing determine efficiency.

Average amperage, as referred to in this discussion, is the value registered on the ammeter of the power supply. This value is the actual current being utilized for the machining operation and may or may not be the maximum possible output from the power supply. The amperage is affected by a number of variables at the cutting gap, such as the level of dielectric contamination, the distance between the electrode and the workpiece, or the type and size of electrode material being used.

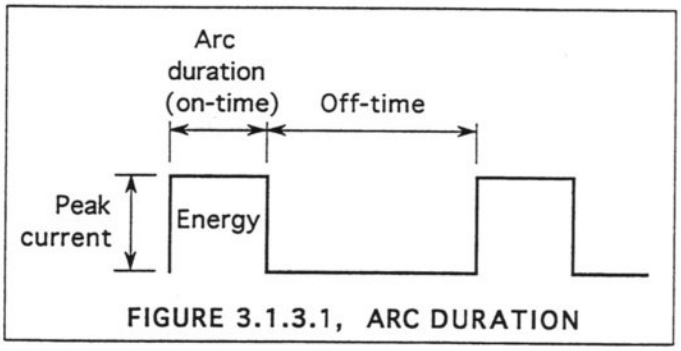


FIGURE 3.1.3.1, ARC DURATION

ARC DURATION

Arc duration is the length of the energy pulse. It, along with peak current, controls surface finish and overcut. Changing the arc duration will also affect electrode wear. If the peak current and % on-time are held constant, changing the arc duration will change the surface finish and the overcut. Short arc durations produce finer finishes; long arc durations produce coarser finishes. The total energy output will remain approximately the same.

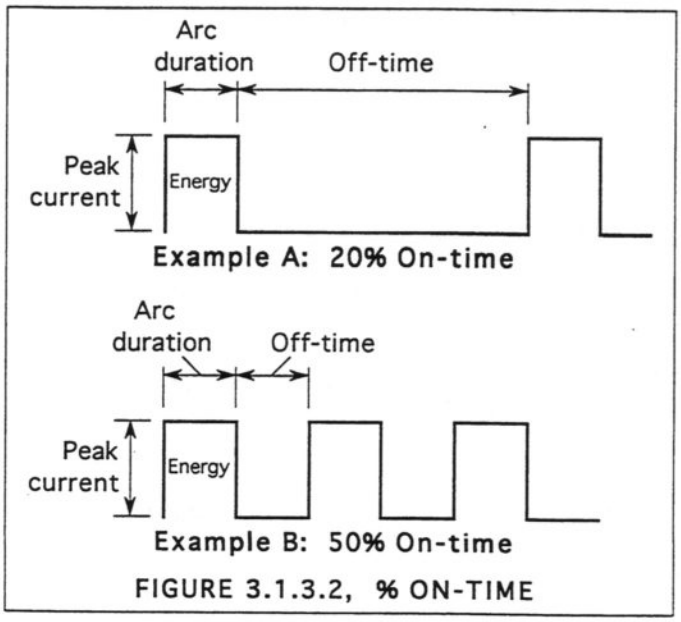


FIGURE 3.1.3.2, % ON-TIME

PERCENT ON-TIME

Percent on-time adjusts the off-time between energy pulses. Changing the % on-time will not affect surface finish or overcut. Its function is to achieve stability and set the machining rate. Generally speaking, a low % on-time will machine slower than a higher % on-time. Of the two settings illustrated, A and B will have the same finish, but B will cut faster.

The % on-time control also allows cutting of previously difficult or impossible cuts, due to its ability to control pulses over a wide range of from 1% to 80%.

CAPACITOR MODE

There are two different modes of producing a discharge. One is the "pulse mode," in which the peak current, arc duration, and % on-time settings determine the finish and speed of the cut.

The second is the "capacitor mode," where the pulses produced by the power supply are fed into capacitors. In this mode the energy is stored in capacitors until conditions at the gap are suitable. The capacitors then quickly dump this energy into the gap to produce a high intensity discharge.

In capacitor mode the value of the capacitor(s) determines the metal removal rate and the finish. The peak current, % on-time, and arc duration only determine the energy produced by the power supply for filling the capacitors. The higher the capacitor value selected, the greater will be the energy per discharge, resulting in a higher metal removal rate and a rougher finish.

The capacitor mode is useful when gap conditions are poor due to inadequate flushing, when machining exotic alloys, and for EDM'ing with metallic electrodes. The high intensity of the capacitor discharge serves to remove debris lodged in the cutting gap, making it possible to EDM with poorer flushing. Capacitors will also introduce a high electrode wear condition.

DIELECTRIC FLUID

The primary function of the dielectric fluid is to provide a constant dielectric property within the gap. To accurately control the EDM operation, the dielectric must act as an insulator and then break down when a specific voltage is reached. When this breakdown occurs, the dielectric has become ionized, permitting current to flow between the electrode and the workpiece.

For example, a common hydrocarbon oil might be rated at 1,000 volts per mil (.001"). This means that at 300 volts, an electrical discharge would be created at a gap of .0003". At 75 volts a discharge would be created at a gap of .000075".

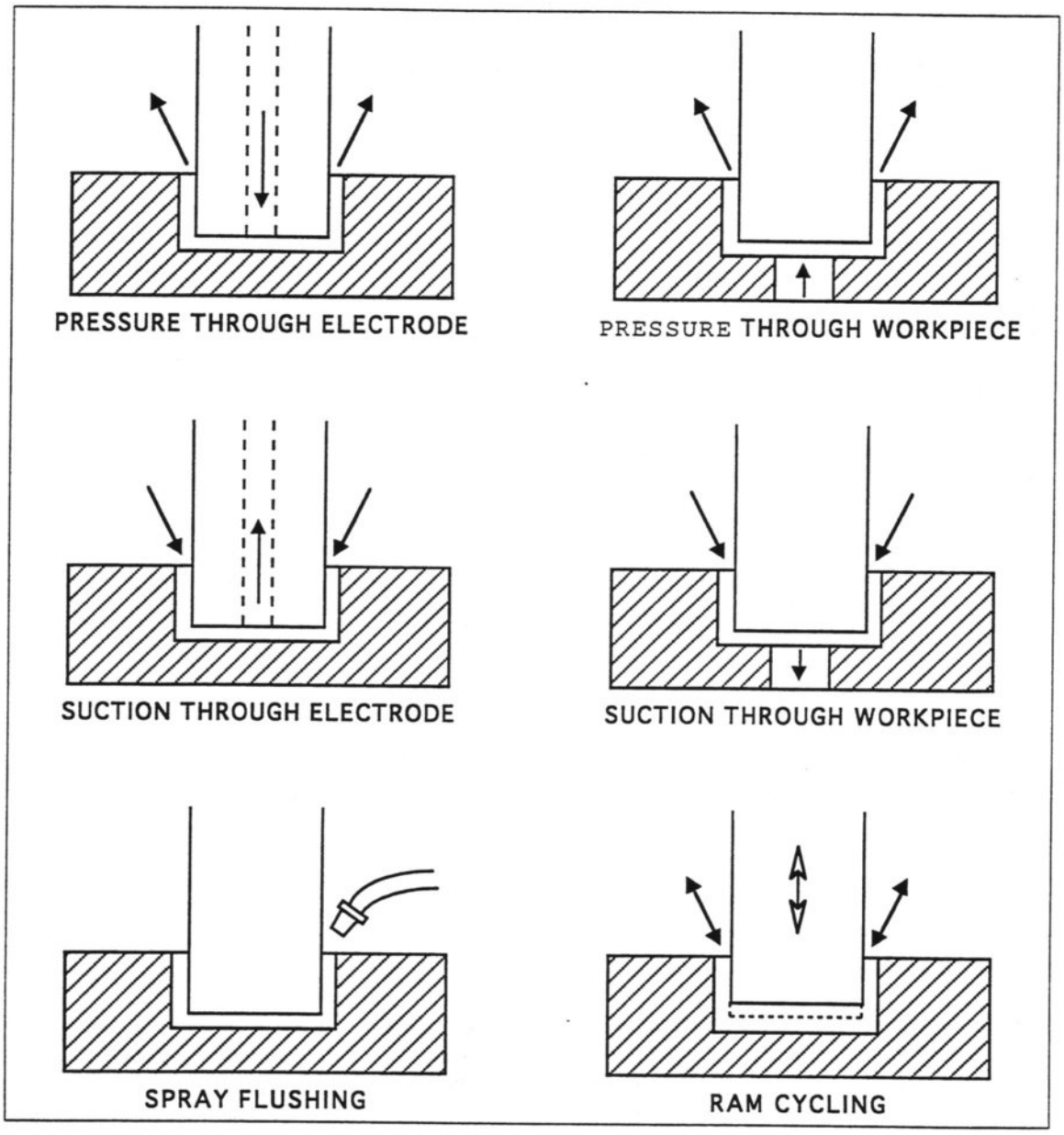
To be effective, the dielectric must break down quickly to insure a discharge with every energy pulse created by the power supply, and it must deionize quickly to prevent multiple discharges in the same area.

The fluid further serves the purpose of solidifying the molten particles and washing them away from the gap. It also helps to keep the electrode and workpiece cool, and/or to maintain the uniform gap temperature which is important in certain applications.

FLUSHING

It is extremely important that adequate flushing be introduced at the gap to clear the cutting area of residue. Poor flushing can easily destroy the effect of proper settings. When too much residue is left in the gap the electrical discharges may be transferred across the gap by the particles. This "stepping stone" effect reduces the efficiency of the discharge. Under this condition the gap will breakdown at a lower voltage and the magnitude of the discharges will be reduced. This lessening of discharge magnitude reduces the metal removal rate and permits the build-up of carbon on the workpiece. A carbon build-up reduces the efficiency of the servo sensing unit, which further reduces the cutting efficiency.

Without proper flushing, excess particles can also create a partial short circuit or resistive path between the electrode and the workpiece. This creates excessive energy at one localized area of the workpiece and results in a burning effect. This condition is referred to as a "DC arc" and can ruin a workpiece.

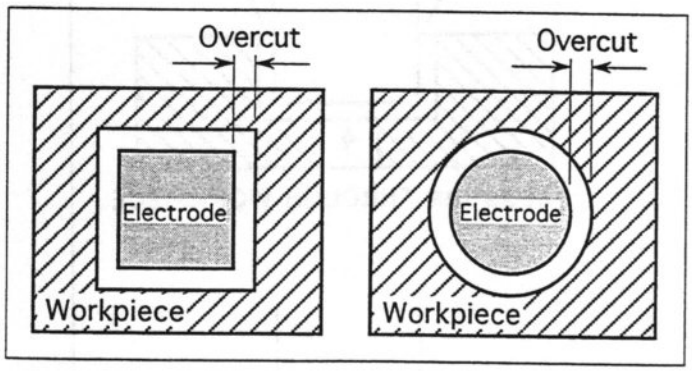


The flushing method and degree of flushing efficiency required must be established for the type of job being run. For example, when a high energy discharge is being used (higher peak current, high % on-time, long arc duration), the size of the particles is large. These "large" particles have a greater tendency to create "shorts" and must be removed more efficiently. Also, on metals that machine easily the amount of residue deposited in the gap is increased so a higher degree of flushing is required.

It has also been found that excessive flushing pressure can be detrimental. It can "blow" the arc around, producing uneven wear patterns, and it can deflect the electrode which will deform the opening being cut. Flushing then must be balanced for the particular job being run.

OVERCUT

Overcut is the clearance or excess stock removed around the electrode perimeter and is the result of discharges occurring at the closest point between the electrode and the workpiece. Consequently, the electrode cuts a hole slightly larger than itself.



Overcut is measured as the perpendicular distance between an unworn vertical surface of the electrode and a vertical surface of the hole. This dimension is measured on one side only. For example, if a 1" electrode cuts a 1.004" diameter hole, the measured overcut is .002".

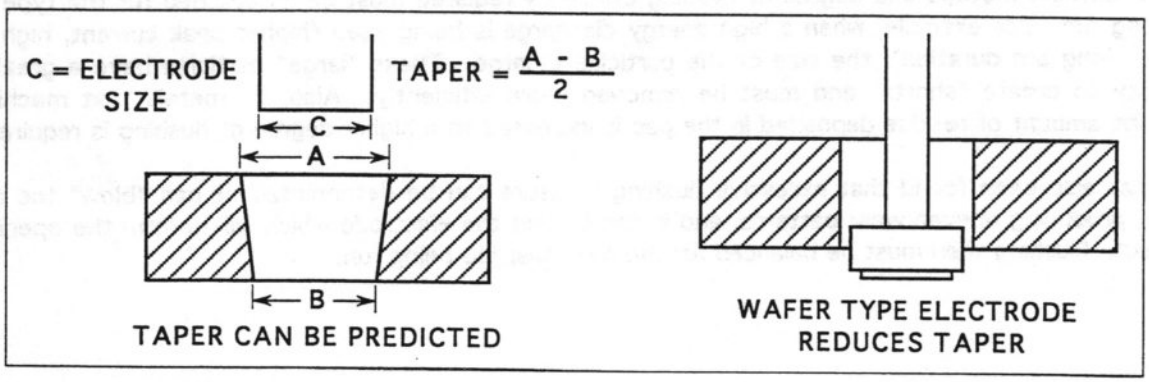
Determining overcut is very important as it will affect the size of the finished opening. Overcut will vary according to type of electrode, workpiece material and the cutting parameters selected. As a general rule the greater the energy contained in the discharges the greater will be the overcut. This will be discussed in more detail in the Operations Section, Chapter 4.

TAPER

A small amount of taper is inherent in the EDM operation, which in many cases is not severe enough to present a problem. Under normal conditions taper will amount to about .0001" per side per 1/8" of penetration.

Taper is caused by particles or residue being flushed out through the bottom of the hole and past previously machined surfaces. These particles continue to create discharges as they pass along surfaces causing more metal to be removed in these areas. A large amount of contamination in the dielectric will cause more taper.

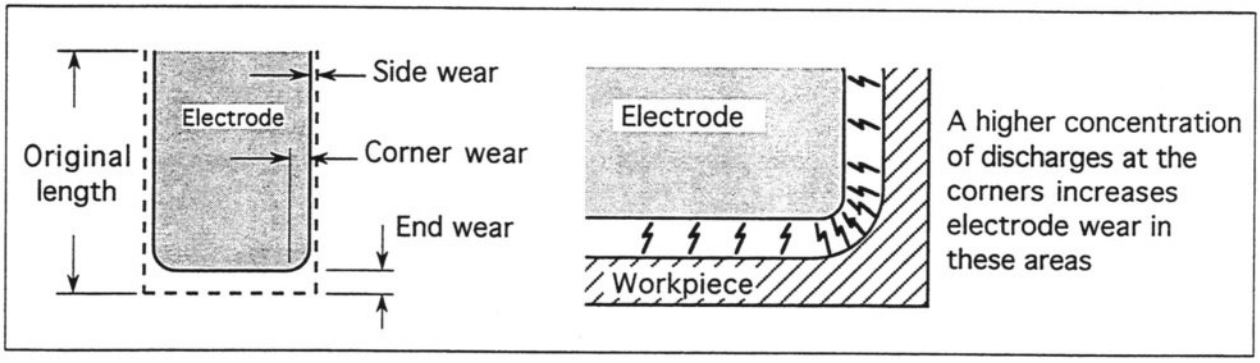
There are ways of minimizing taper or eliminating it completely. One method is to suction flush through the electrode or an opening in the workpiece. This then removes residue through the hole instead of allowing it to move up through the gap between the electrode and workpiece. Another method is to use "wafer" electrodes in which there is no electrode surface close to the wall of the workpiece at the top of the opening.



ELECTRODE WEAR

During each energy discharge stock is removed from the end and sides of the electrode as well as from the workpiece. Under normal operating conditions the stock removed from the workpiece exceeds that removed from the electrode, but the ratio of wear differs with different materials. By knowing the wear ratios, it is possible to manufacture electrodes to the exact size and quantity required for a particular job. The wear ratios of most known materials have been established. (See Graphs A, Electrode and Workpiece Combinations, in the Operations Section, Chapter 4.)

Electrode wear is commonly measured in three ways: corner wear, end wear and side wear. Some of these areas wear away faster than others.



The sharper the corner the greater the corner wear, because there is a higher concentration of discharges at the corners and a smaller volume of electrode involved. There is not enough surface area of electrode to absorb the heat as well as the flat surfaces can, which tends to deteriorate the corners more rapidly.

Corner wear is one reason why a perfectly square inside corner is not possible in EDM. The other reason is that in EDM there is always an overcut. No matter how small the overcut may be, the inside "square" corner of the workpiece will have a radius at least equal to the overcut. EDM is, however, capable of producing sharper corners than most other machining methods.

When machining a "through hole" the electrode should be long enough to pass the total eroded area of the electrode completely through the workpiece. The electrode length should be equal to the length of the erosion, plus the cutting depth, plus approximately 10% more of free length plus sufficient holding length.

LOW WEAR

It is possible to establish a cut in which the wear on the electrode is kept to a minimum. This is accomplished by setting the power supply to produce a pulse of sufficient length to permit slight plating of particles from the workpiece onto the electrode and by reducing the dielectric flow to a minimum to maintain uniform surface temperature at the arc gap. This is discussed in detail in the Operations Section, Chapter 4.

ELECTRODE MATERIALS

Following is a description of many of the electrode materials currently being used in EDM. It is important to note that the workpiece surface finish achieved in a cut can never be smoother than the finish on the electrode.

1. **Graphite.** Permits fast cutting rates, has a low wear ratio, is easy to machine and offers excellent stability. A number of different grades of graphite are available. One limitation with graphite is that surface finishes better than approximately 32 μinch Ra are not easy to achieve. (NOTE: some new grades of graphite promise to provide finishes as fine as 10 μinch Ra under certain circumstances.)

2. **Copper.** Offers good surface finishes and is excellent for no-wear EDM'ing. Copper electrodes can be made by wire EDMing or coining.

3. **Copper Graphite.** Better rigidity for fragile electrodes. Cutting rates and electrode wear not as good as graphite.

4. **Brass.** Has a high wear ratio, but can be economical for certain operations. Brass also cuts fast.

5. **Zinc-Tin Alloys.** Used where many identical electrodes are needed because they are easily cast in metal molds. Can be pressure-cast and coined to an existing cavity. Used in producing forging die cavities.

6. **Steel.** Slow stock removal rates. Applicable when doing parting line cuts.

7. **Copper Tungsten.** Good wear characteristics and rigidity. Used for close tolerances, fine detail, and low wear. Used when cutting carbide and for slotting operations. Metal removal rates are lower than graphite and the cost is higher. Complex molded shapes are available. Can be used for high speed, small hole drilling in hardened materials.

8. **Silver Tungsten.** Used to machine carbides. Provides less wear and faster removal rates than copper tungsten. Is more expensive and generally limited to intricate carbide dies.

9. **Tungsten Wire.** High rigidity makes it excellent for EDM'ing holes under .010" diameter. Keep the depth to diameter ratio < 10:1.

EDM APPLICATIONS

ADVANTAGES OF EDM

Although electrical discharge machining was introduced into machine shops as a specialized process, it has progressed to the production line and is doing many jobs faster and more economically than possible with conventional machining methods.

One of the most apparent advantages of EDM is its disregard for material hardness. If the workpiece is electrically conductive it can be machined. Exotic metals or fully hardened, heat-treated steels and super alloys can be cut as easily as soft metals. A whole new line of materials is available for tools and parts. Tools can be reconditioned without being softened first and parts can be machined after hardening, eliminating the distortion inherent in the hardening process. Expensive parts can be salvaged even after hardening.

There are essentially no mechanical forces in EDM since the electrode never contacts the workpiece. The most fragile materials can easily be machined without distortion.

EDM can produce burr-free parts with no additional polishing operations required.

The surface finish derived by EDM is superior to conventional methods. The non-directional pattern provides excellent lubricant retention.

Odd shapes do not present the problem in EDM that they do in conventional machining. Most shapes that can be machined into the electrode can be reproduced in the workpiece. Highly complex, 3-dimensional shapes, blind cavities and narrow slots can be easily cut using EDM.

Less sectionalizing is required when EDM is used to make dies. With conventional methods, highly complex shapes are produced by building dies in segments and mounting the segments together. EDM can produce dies in one piece, eliminating time-consuming fitting and resulting in a more accurate finished product.

The following is a list of various uses of EDM and their advantages over conventional machining methods.

Stamping Dies

1. Faster, less expensive die making.
2. Controlled accuracy.
3. Better design of parts.
4. Elimination of fit-ups.
5. Reduction of downtime of parts produced by EDM.
6. Reduction of tolerance limitations.
7. Improved quality and reduction of loss from heat treating.
8. Die component interchangeability.
9. Reduction of die try-outs.
10. Easier design or engineering changes to existing dies.
11. Longer wearing dies with greater production runs between sharpening.
12. Greater savings with more complex die openings.

Plastic Molding Dies

1. Produce deep slots and square pockets without sectionalizing.
2. Seat parting lines using one-half of the mold or insert to machine the opposite.
3. Capable of machining deep, difficult-to-reach areas.
4. Produce engraved areas difficult or impossible to engrave conventionally.
5. Faster production of raised designs or lettering.
6. Rework without annealing.
7. Permits use of higher alloy materials, thus improving life of mold.
8. Reduces design of cavities, using inserts only where necessary for maintenance.

Extrusion Dies

1. Finish machine-hardened blanks where advantageous.
2. Easier polishing without undercutting.
3. Absolute uniformity of openings in multiple-opening dies.
4. Simultaneous machining of mandrel and die components of bridge dies.
5. Some dies can be run as cut, thus eliminating polishing.

Die-Cast Dies

Has the same advantages given for plastic molding, above, plus:

1. The use of die-cast parts where practical.
2. Simplification of trim-die manufacture.

Production

1. Machines parts to extremely fine, minute cross-sectional configurations.
2. Many operations handled simultaneously.
3. Machines materials in designs considered impossible by conventional standards.
4. Accurate repeatability.
5. Machines dissimilar materials in one pass.
6. Machines flimsy or hard-to-reach areas.
7. Burr-free machining.
8. Reduces distortion.

Header Dies

1. Improves quality with better materials.
2. Washed out dies can be reworked without annealing.
3. Eliminates sectionalizing except where required for maintenance.
4. Reduces need for costly hobs.
5. Faster production of raised designs or lettering.

Forge Dies

1. Run most forge dies as-cut, thus reducing costly benching.
2. Resinking time reduced by improving through preventative maintenance.
3. More uniform parts reduce burden on trimming tools.
4. Resink hard-welded dies.
5. Improves quality with improved materials.
6. Absolute reproducibility.

Wire Draw Dies

1. Faster metal removal rates because of the extremely dense, hard materials used in wire drawing dies.

THE EDM DICTIONARY

by Hansvedt EDM

The words, terms and definitions in this dictionary were selected and defined only as they relate to EDM (Electrical Discharge Machines or Machining). They do not necessarily conform with strict trade or technical definitions. The terms and definitions are intended to be easy to understand and use by EDM operators.

ALPHANUMERIC. A combination of alphabetic and numeric (letters and numbers), often used to name computer programs.

ALTERED METAL ZONE. The mechanically and metallurgically altered zones created on a metal surface by the EDM process.

ALTERNATING CURRENT; AC. Alternating polarity current, which changes polarity from negative to positive and back again in cycles, as opposed to Direct Current (DC).

AMMETER. A meter, usually located on the power supply, that measures the average current in the machining gap.

AMPERAGE. In EDM, the amount of average current measured during the cut.

AMPERE; AMP. The unit of electric current. Equivalent to the steady current produced by 1 volt across 1 ohm.

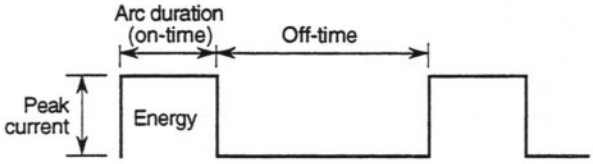
ANGSTROFINE. A class of EDM graphite characterized by a particle and pore size less than 1µ, very high strength, isotropy, and uniform structure. The most advanced graphite material available.

ANISOTROPIC. In a material such as graphite, exhibiting properties whose values change when measured along differing axes. Opposite of isotropic.

ANODE. The positive terminal of an electrolytic cell or battery. In EDM, incorrectly applied to the tool or electrode.

ARC. A luminous bridge across the gap that occurs during energy discharge and melts away a small amount of material from the workpiece and/or electrode. Sometimes incorrectly used to mean DC arc. *See also IONIZATION.*

ARC DURATION. The duration of a pulse during which energy is produced across the gap, usually measured in micro-seconds (µsec).



ARC SUPPRESSOR. A circuit in the EDM power supply that reduces the possibility of arcing.

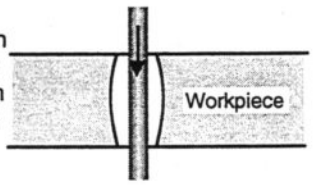
AUTOMATIC CYCLING. An attachment which provides automatic periodic retraction and reentry to improve flushing in difficult flushing conditions. *See RAM CYCLER.*

AUTOMATIC TOOL CHANGER (ATC). A device used with CNC EDM to provide automatic changing of electrodes for different operations.

AVERAGE CURRENT. The value of current indicated on the ammeter which is the current averaged over the complete pulse cycle (includes both on-time and off-time).

BACK UP. To copy one or more files on a diskette for safekeeping in case the original diskette gets damaged or lost.

BARREL EFFECT. In wire EDM, a condition where the center of the cut is larger than the entry and exit points, due to secondary discharges from particles being pushed to the center by flushing pressure from both the top and the bottom.



BAUD. A term used in describing data transmission rates: usually one bit per second.

BLIND HOLE. Any hole or cavity cut into a solid that does not connect with other holes.

BREAKTHROUGH. The exit end of a through-hole cavity at the moment of completion.

BUFFER. 1. An area in a computer's memory for temporary storage of data. It serves as a holding place for information that was last cut or copied, and the information can then be pasted to other locations or programs. Called a "clipboard" in Macintosh computers. **2.** An area in a computer's memory used to accumulate data from a slow device and transmit it speedily through a faster device.

BUG. An error in a computer program that keeps it from working properly.

BURN; BURNING. EDM and EDMing (informal).

BYPASS VALVE. A valve, usually on the flushing manifold, used to direct a portion of dielectric fluid not required for flushing directly to the filter and back to the reservoir, for maximum filtration and thermal stability.

BYTE. Originally defined as a subdivision of a long computer word, byte has come to mean a piece of information 8 bits long.

CAPACITOR. An electrical component that stores an electric charge. In some EDM power supplies, a bank of capacitors are connected across the machining gap. The current for the spark comes directly from the capacitors when they are discharged.

CARBON. An abundant, naturally occurring element, one form of which is graphite.

CARBIDE CONTACTOR. The part in wire guide assemblies on a wire EDM that conducts electricity to the wire. Needed because the diamond guides do not conduct electricity.

CATHODE. The negative terminal in an electrolytic cell or battery. In EDM, incorrectly applied to the workpiece.

CENTER FLUSHING. A method of flushing dielectric through a center hole in an electrode. For example, as when using a copper tube as an electrode. *See FLUSHING.*

CHILLER. A device that refrigerates dielectric fluid to keep its temperature from rising too high during high power cuts.

CHIP. An integrated circuit etched on a tiny piece of silicon or germanium.

CIRCUIT. A continuous path allowing and directing the flow of electric current.

CNC; COMPUTER NUMERIC CONTROL. A means of directing a machine to operate using an indirect manner of control, such as paper tape or a computer.

CNC CONTROL. That section of a power supply that oversees the CNC controlling functions of an EDM machine.

COLLOIDAL SUSPENSION. Particles suspended in a liquid that are too fine to settle out. In EDM, the tiny particles produced in the sparking action form a colloidal suspension in the dielectric fluid.

COMPOSITE. Made up of more than one material. In EDM, copper tungsten is an example of a metallic composite. The copper and tungsten do not alloy, but are simply combined together. Copper graphite is a metallic/carbon composite.

CONDENSER. Capacitor (obsolete).

CONDUCTOR. A material that will carry electric current.

CONTAMINATION. The accumulation of debris in dielectric fluid that may cause a decrease in its effectiveness.

COOLANT. Sometimes used to describe dielectric fluid.

COPPER GRAPHITE. A graphite EDM electrode material infiltrated with copper.

COPPER TUNGSTEN. A porous tungsten material infiltrated with copper.

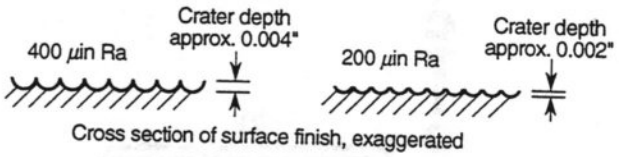
CORE. The slug that remains after EDMing with an electrode that has a flush hole in it.

CORNER WEAR. The relatively greater wear that occurs on sharp corners of an electrode. *See ELECTRODE WEAR.*

CRASH. A computer system is said to crash when it stops working completely for some reason and must be restarted by the operator.

CRATER. The small cavities left on the EDMed surface of the workpiece by the EDM sparks. Also known as pits.

CRATER DEPTH. The distance from the peaks to valleys on an EDMed surface. Also called pit depth. For finishes finer than 500 µin Ra, crater depth is roughly the surface finish number "pointed off" 5 decimal places to the left.



Cross section of surface finish, exaggerated

CRT. Cathode Ray Tube. The monitor on a video terminal; the picture tube in a TV set.

CUBIC INCHES PER HOUR (in^3/hr). The units of measure used in the U.S. to describe the rate of volumetric metal removal from the workpiece. *See METAL REMOVAL RATE.*

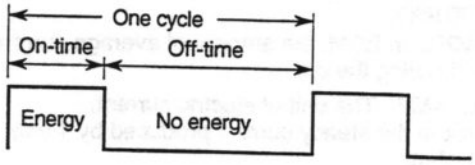
CURRENT CUT-OFF. An adjustable power supply feature that maximizes cutting stability by cutting off pulses when there is a problem in the gap.

CURRENT DENSITY. A measure of the amount of current applied to a given surface area, usually in amps/in^2.

CURSOR. A small movable symbol on a CRT monitor, interactive with the user, where the next character will appear when a new entry is made.

CUTTING RATE. The volume of workpiece removed in a given time. Usually expressed in cubic inches per hour (in^3/hr) in the U.S. *Also METAL REMOVAL RATE.*

CYCLE. 1. The beginning of one pulse to the beginning of the next; the total of on-time and off-time. The number of cycles per unit time is called frequency, as in 60 cycles per second (cps), or 60 Hertz (Hz). **2.** To ram cycle.



DC ARC. Multiple discharges at the same spot between the electrode and workpiece. (Normal discharges occur randomly on the cutting surface area.) Can occur if the power supply malfunctions or in an area of poor flushing in the cutting gap or from applying more power to the gap than the flushing is able to handle. Usually results in damage to the electrode and/or workpiece by developing a large carbon deposit which acts like the filament of a light bulb and produces an orange glow at the gap area.

DEIONIZATION. A return of the condition of the dielectric to a non-conductive state. Failure to accomplish deionization because of inadequate flushing during off-time is sometimes responsible for DC arcing.

DEIONIZED WATER; DI WATER. Water which has been processed through a resin bed to remove metallic ions in solution and is used as a dielectric fluid, usually in wire EDMs.

DEIONIZING RESIN. A special resinous material needed to deionize water for use on a wire EDM.

DEPTH-TO-DIAMETER RATIO. In small hole EDMing, the ratio of the depth of a blind hole to the diameter of the electrode used to make the hole.

DIELECTRIC FILTER. The filter used to remove particles that accumulate in the dielectric fluid during the EDM process. Dielectric filters commonly remove particles as small as 5-microns in size, some filters as small as 1-micron.

DIELECTRIC FLUID. The non-conductive fluid between the workpiece and the electrode. Its purpose is threefold: 1) to provide the dielectric strength between the electrode and the workpiece across which an arc can occur, 2) to act as a coolant to solidify particles melted by the arc and 3) to flush away the solidified particles.

DIELECTRIC STRENGTH. In EDM, the term is used to designate the electrical potential (voltage) needed to break down (ionize) the dielectric fluid in the gap between the electrode and workpiece. *See IONIZATION.*

DIE SINKER. A ram-type EDM machine (informal). *See also SINKER.*

DIGITAL POWER SUPPLY. A power supply that contains a computer controlled pulse generator to process information in digital form, as opposed to analog.

DIGITIZER. A device that converts analog measurements (such as a drawing) into digital form for input into a digital computer.

DIRECT CURRENT; DC. Constant polarity current, as opposed to Alternating Current (AC) which changes polarity from negative to positive and back again in cycles.

DISCHARGE. The spark that occurs between the electrode and the workpiece.

DISCHARGE CHANNEL. The conductive pathway formed by ionized dielectric and vapor between the electrode and workpiece. *See IONIZATION.*

DISCHARGE DRESSING. The process of dressing worn electrodes prior to making a finish cut. Sometimes done within the worktank by means of an automatic device that sequences the electrode to a dressing block then back to the cavity.

DISCHARGE GASES. Gases given off from vaporizing dielectric fluid during the sparking process. These gases are flammable and can be dangerous if they accumulate in hollow areas within fixtures or parts.

DISCHARGE VOLTAGE. The voltage established by the electrode-workpiece combination during the on-time of the machining pulse.

DISINTEGRATOR. A machine using technology similar to EDM, where the electric arcs are produced by physically vibrating the electrode against the workpiece. Used mostly for removing broken taps.

DISK DRIVE. A device that rotates a magnetic disk and accesses its data by means of a read/write head.

DISK; DISKETTE. A magnetic file storage and retrieval device for use in computers, newer ones being 3.5" in diameter. Also called floppy disk.

DITHER. A slight up and down vibratory motion of the machine tool ram and attached electrode used to improve cutting stability.

DNC. Direct Numerical Control using a computer to control a machine directly, i.e., a keyboard input.

DRESSING. The re-machining of the face of an electrode to sharpen its detail after it has been used to EDM a mold cavity.

DUAL POWER SUPPLY. Two EDM power supplies in a single cabinet which can be used to operate two machines simultaneously, or can be connected to apply the full power available to only one machine.

DUTY CYCLE. The percentage of a pulse cycle during which the current is turned on (on-time) relative to the total duration of the pulse cycle. *Same as PERCENT ON-TIME. See also ARC DURATION.*

EDGE FINDER. A feature on an EDM machine to establish accurate XY location of the electrode with respect to the workpiece. When the electrode is brought to within less than 0.0001" of the workpiece, a signal light or buzzer will be activated.

EDM. The common acronym for Electrical Discharge Machine or Electrical Discharge Machining. Now used as a noun: "an EDM," or an adjective: "an EDM machine," or a verb: "to EDM the cavity."

EDM OIL. Dielectric fluid (informal).

EFFICIENCY. A measure of EDM performance that relates actual cutting performance to ideally attainable performance.

EFFICIENCY METER. A meter, usually on the power supply, that provides operator assistance in making servo, flushing and power supply adjustments to achieve best cutting efficiency.

ELECTRICAL DISCHARGE GRINDING (EDG). An EDM process using a machine that resembles a surface grinder but has a wheel made of electrode material. The workpiece is EDMed instead of ground.

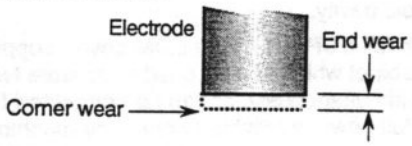
ELECTRICAL DISCHARGE MACHINING. Well, we all know what this is now, don't we?! We at Hansvedt EDM want to take this opportunity to thank you for your interest in EDM and in Hansvedt.

ELECTRICAL RESISTIVITY. The resistance of the flow of electricity through material. Measured in ohms.

ELECTRODE. The "cutting" tool used to remove workpiece material in the EDM process. Its form, or shape, is a mirror image of the form or shape desired in the workpiece, with its dimensions adjusted to take into account the amount of overcut that occurs. It must be made from an electrically conductive material. Common electrode materials used in ram EDM are graphite, copper, copper-graphite and copper-tungsten. In wire EDM, brass wire is most common, sometimes coated with other metals to enhance its performance.

ELECTRODE GROWTH. A plating action occurring at certain low-wear settings whereby workpiece material builds up on the electrode, causing it to increase in size.

ELECTRODE WEAR. The amount of electrode material consumed during the EDM process. This can be linearly or volumetrically measured end wear or corner wear, and can be expressed in absolute terms or as a percentage of workpiece material removed. Electrode wear is most commonly expressed as percent end-wear, measured linearly. *See also LOW-WEAR and NO-WEAR.*



ELECTROFORMING. An electroplating process used to make metal EDM electrodes.

END WEAR. The reduction in length of an EDM electrode occurring during EDMing. Can be given as a dimension or as a percentage of its original usable length. *See ELECTRODE WEAR.*

ENERGY. Measured in joules. Electrical equivalent to volt-coulombs or volt-ampere-seconds.

EPROM. An acronym for Erasable Programmable Read Only Memory. A programmable memory that, as opposed to RAM (random-access memory), can only be read and normally cannot be changed or written into.

ERODING. Another term for EDMing.

EXIT POINT. The point at which the electrode breaks through the other side of the workpiece in through hole EDM.

FARAD. The unit of electrical capacitance; the energy storing capacity of a capacitor.

FET. Field-Effect Transistor. A transistor whose internal operation is unipolar in nature. The metal-oxide semiconductor FET (MOSFET) is widely used in ICs because the devices are very small and can be manufactured with few steps.

FILTERING. Removing the debris from the dielectric fluid before pumping it back into the worktank or through flushing holes in the electrode or workpiece.

FINE-GRAIN. A class of EDM graphite characterized by a particle size range from 11µ to 20µ

FINISH. The relative roughness or smoothness of the surface texture produced by EDMing. Usually measured in microinches Ra (µin Ra, sometimes just Ra) in the U.S. *See also SURFACE FINISH.*

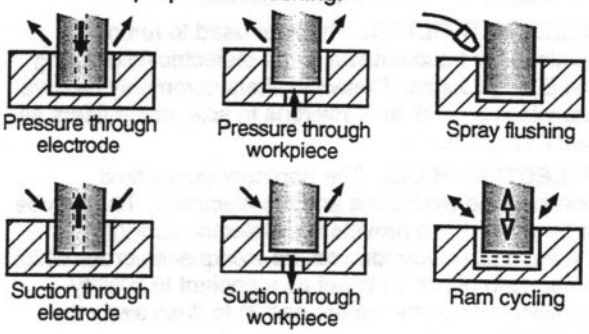
FINISH CUT. The last machining operation which usually involves the removal of a small amount of material at a comparatively low pulse energy to gain final size and surface finish desired.

FLASH POINT. The temperature at which a flammable material will burst into flame. A factor in selecting dielectric fluid for EDM.

FLOPPY DISK. A magnetic file storage and retrieval device for use in computers, newer ones being 3.5" in diameter. Also called disk or diskette.

FLUID LEVEL SWITCH. An adjustable switch that controls the depth of the dielectric fluid in the worktank.

FLUSHING. The flowing of dielectric through the gap to remove debris caused by EDMing. Flushing can be pressure or suction through the electrode or workpiece, or sprayed into the gap from the side. Ram cycling is done for the purpose of flushing.



FLUSHING FIXTURE. A multi-purpose precision box-like fixture which is clamped to the machine worktable. Primarily used for EDMing through-holes. The workpiece is clamped on top, usually over an opening that will permit an electrode to pass through the workpiece without hitting the tank's top plate. It is connected to the dielectric system and can be used for either suction or pressure flushing. *Also FLUSH TANK or FLUSH POT.*

FLUSHING HOLE. A hole through the workpiece or electrode used to introduce dielectric fluid to the gap for flushing purpose.

FLUSHING MANIFOLD. The central control part of a dielectric system, usually on or near the worktank, that embodies the valves and gauges necessary to direct and adjust the flow of fluid to the EDM gap and worktank.

FLUSHING PRESSURE. The pressure (usually in psi) of the dielectric fluid flowing through the electrode or workpiece and through the machining gap.

FREQUENCY. The number of cycles (on/off) completed per unit of time. Usually expressed in hertz.

GAP. The closest point between the electrode and the workpiece where an electrical discharge will occur. (Not the same as overcut.)

GAP CABLE. The wire(s) that conduct the electrical energy from the power supply to the machining gap.

GAP CURRENT. The average amperage flowing across the machining gap.

GAP FAULT. An undesirable gap condition that signals the operator to take corrective action.

GAP VOLTAGE. The voltage across the gap while current is flowing. The voltage across the electrode/workpiece before current flows is called open gap voltage.

GENERATOR. EDM power supply (informal). *See POWER SUPPLY.*

GRAIN. In manufactured carbon and graphite product technology, a region in a carbon or graphite body that is identifiable as being derived from a particle of filler.

GRAPHITE. One of the four forms of carbon. In EDM, a popular material used for electrodes which has high heat resistance and transfers electric current very efficiently.

HANSVEDT. (hanz ˈvet, hänz ˈvet) A company founded by Jack Haines and Bob Namtvedt in 1962, now a leading manufacturer of ram, CNC ram and wire EDM systems.

HARD DRIVE; HARD DISK. The usually internal memory disk in a computer that contains and manages all operating systems, programs, files and interconnections in the computer.

HARDWARE. The physical equipment that makes up a computer system.

HEAD. That part of the EDM machine tool in which the ram or quill travels.

HEAT-AFFECTED ZONE. The layer below the recast layer. This layer has been subjected to elevated temperatures that have altered the properties of the workmetal.

HERTZ. Unit of frequency equal to one cycle per second (Hz).

HOME. The starting position in a numerically controlled program which is the reference point from which subsequent movements are measured. As a convenient starting point, home position is usually set at zero.

HUNTING. Erratic movement of the ram of an EDM machine during a cut, apparently seeking but not finding the best position for proper cutting.

IC. Integrated Circuit. *See CHIP.*

INDUCTANCE. A property of a circuit tending to oppose changes in current flow through the circuit.

INFINITELY VARIABLE CONTROL. A control that permits unlimited settings within its range.

INITIATION VOLTAGE. *Same as OPEN GAP VOLTAGE.*

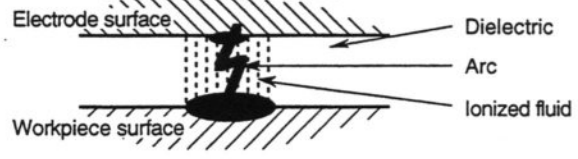
INJECTION FLUSHING. *Same as SPRAY FLUSHING.*

INSULATED DIE SET. A die set with upper and lower plates insulated from each other, used in some EDM jobs to maintain accurate alignment between the electrode and workpiece.

INSULATOR. Any material through which electric current will not flow.

ION. An atom or group of atoms that carries a positive or negative charge as a result of having lost or gained one or more electrons. It is ionization of the dielectric fluid that provides the conductive path for the EDM spark.

IONIZATION. The change in a dielectric fluid when it is subjected to a voltage potential whereby it becomes electrically conductive, allowing it to conduct the arc.



IONIZATION TIME. The length of time that the voltage is impressed across a gap before ionization of the dielectric fluid occurs.

IONIZATION VOLTAGE. The voltage level at which the spark discharge initiates.

IONIZED FLUID. That portion of the dielectric fluid that is made electrically conductive (ionized) by a voltage potential.

IONIZED PATH. The path of electrically conductive dielectric molecules between the points on the electrode and workpiece through which the spark current will flow.

ISOTROPIC. Exhibiting properties with the same values when measured along axes in all directions. Opposite of anisotropic.

JOGGING. Manual movement, either by hand or power operated, of the mechanical positioning components of machine tools to assist in set-up.

KEYBOARD; KEYPAD. An input device, on or near the power supply, having an array of keys with alpha, numeric and/or special characters for inputting commands to the computer.

keypad

KILOBYTE (KB). Roughly a thousand bytes (actually 1024 or two blocks).

LATERAL FLUSHING. *Same as SPRAY FLUSHING.*

LIBRARY. A collection of programs or routines that are used frequently by application programs or system programs.

LIMIT SWITCH. A switch provided on a machine to stop machine movements at predetermined points.

LOW-WEAR. An EDM process in which the volume of electrode wear is between 2% to 15% of the volume of workpiece wear. Normal negative polarity wear ratios are 15% to 40%; no-wear EDMing is generally under 2%.

MACHINE TOOL. The component of an EDM machine that performs the mechanical functions of holding and positioning the electrode and workpiece and includes a worktank for containing the dielectric fluid.

MACHINING PULSE. *See PULSE.*

MACHINING RATE. The volume of workpiece removed in a given time. Usually expressed in cubic inches per hour (in^3/hr) in the U.S. *Also METAL REMOVAL RATE.*

MEAN OVERCUT. Average of top, middle and bottom overcut dimensions. *See also OVERCUT and OVERCUT TAPER.*

MEDIUM-GRAIN. A class of EDM graphite materials characterized by a particle size from 2lμ to 100μ, anisotropy, non-uniform performance, and high porosity.

MEGABYTE (MB). Approximately a million bytes (actually 1024^2).

MEMORY. The memory of a computer is where it finds its instructions and the data it is to work with, also where it stores its results.

MENU. A list on a monitor screen of available operations or functions. The computer can be directed to do certain operations by using a keypad, mouse or input knob to move a cursor to make a selection from the menu.

METAL REMOVAL RATE. The volume of workpiece removed in a given time. Usually expressed in cubic inches per hour (in^3/hr) in the U.S. *Also CUTTING RATE and MACHINING RATE.*

METALLIC COMPOSITE. A non-alloyed combination of metals, such as copper tungsten.

MICRO-OHM (μΩ). One-millionth of an ohm (0.000001 ohm).

MICROFARAD (mfd or μfd). One-millionth of a farad. *See also FARAD.*

MICROINCH (μin). One-millionth of an inch (0.000001").

MICRON; MICRO-METER (μ). A unit of length equal to one-millionth of a meter.

MICROPROCESSOR. A computer-on-a-chip. Found in advanced EDM systems, microprocessors provide many control functions.

MICROSECOND (μs or μsec). One-millionth of a second (0.000001 sec.).

MIL. One thousandth of an inch (0.001").

MILLISECOND (ms). One thousandth of a second (0.001 sec.).

MISS. A pulse delivered to the gap that does not result in metal removal because the gap spacing is too wide to initiate a discharge. The pulse exhibits voltage but no current, hence no energy and no machining.

MODEM. An acronym for MOdulator DEModulator, a device that converts digital signals from a computer for transmission over standard telephone communication lines.

MODULAR CONSTRUCTION. 1. A power supply design where entire circuits are on replaceable boards or modules for easy servicing. **2.** A product configuration of standardized components for easy construction and flexible arrangement.

MONITOR. 1. A mechanical or electrical device used to indicate various operating conditions, such as ammeters, indicators, lights, pressure gauges. **2.** The CRT (cathode ray tube) on a computerized EDM power supply control unit that displays and enables manipulation of operating parameters.

MULTIPLE ELECTRODES. The simultaneous use of electrodes to produce multiple cavities in one or more workpieces.

MULTIPLE LEAD (MULTI-LEAD) POWER SUPPLY. A power supply designed so that the total power available can be divided into smaller, electrically isolated power units, each capable of being channeled through separate leads to multiple electrodes or workpieces.

MULTIVIBRATOR. A relaxation oscillator used in EDM power supplies to obtain various square wave voltage patterns or to generate pulses.

NANOSECOND. One billionth of a second (.000000001 sec.).

NC. Numerical Control.

NEGATIVE ELECTRODE. The electrode voltage potential is negative (-) with respect to the workpiece.

NO-LOAD VOLTAGE. *Same as OPEN GAP VOLTAGE.*

NO-WEAR. An EDM process in which electrode wear is virtually eliminated, where the wear ratio of the electrode to the work is usually less than 2% electrode wear by volume. *See also ELECTRODE WEAR.*

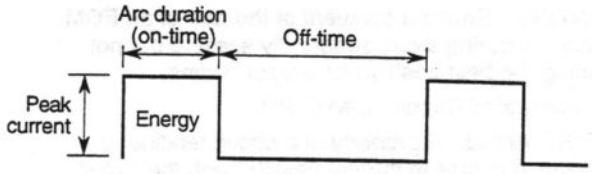
NOISE. Any variation in an electrical signal that is not supposed to be there.

NON-DIRECTIONAL FINISH. A surface finish having no specific direction to its surface pattern. An EDM finish is almost always non-directional.

NORMAL POLARITY. Negative polarity to the electrode.

OFFSET. 1. A small displacement to one side or the other of a programmed path to remove a small amount of material for final finishing or dimensioning. **2.** The measurement of material left on a part for a subsequent finish cut.

OFF-TIME. The amount of time in a pulse cycle while no energy is applied, usually measured in microseconds (μsec).



OHM. A unit of electrical resistance equal to that of a conductor in which a current of one ampere is produced by a potential of one volt.

OIL-THROUGH CHUCK. A sealed holder for tubular electrodes through which dielectric fluid can be pumped or sucked for center hole flushing.

ON-TIME. The duration of a pulse cycle during which energy is applied, usually measured in microseconds (μsec). *Also ARC DURATION. See illustration under OFF-TIME.*

OPEN CIRCUIT. An electrical circuit which is not complete.

OPEN GAP VOLTAGE. The voltage which can be read across the electrode/workpiece gap before the spark current begins to flow. *See GAP VOLTAGE.*

OPERATING CURRENT. *Same as AVERAGE CURRENT.*

ORBIT. A programmable motion between the electrode and workpiece, produced by a feature built into the machine or an accessory, which produces a cavity or hole larger than the electrode. The path can be planetary (circular), vectorial or polygonal (trace). Usually these can be combined in sequence and/or with Z-axis motion.

ORBITER An accessory attached to an EDM ram to enable orbiting. *See ORBIT.*

ORBIT LOCK. A feature that locks the ram in a preset position enabling an orbiting attachment to EDM without up or down movement.

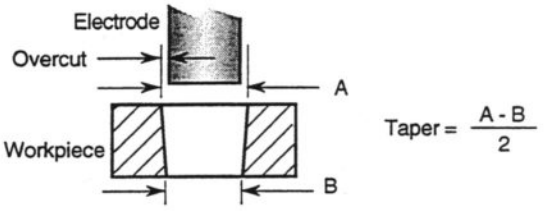
ORBIT STOP. A feature that stops the ram from feeding past a preset position during an orbit cut.

OSCILLOSCOPE. An electronic device used for visually checking the wave shape and electrical properties of pulses being generated by the EDM power supply.

OUTPUT. The voltage and current of an EDM power supply.

OVERBURN. Improper term for overcut.

OVERCUT. The distance between one side of an electrode and its adjacent wall of the workpiece cavity. *See also MEAN OVERCUT and OVERCUT TAPER.*



OVERCUT TAPER. The difference between the top (entrance) and bottom overcut dimensions. *See also MEAN OVERCUT and OVERCUT.*

PARTICLE BRIDGING. The occurrence of arcs jumping between the electrode and workpiece through EDMed particles in the fluid. The primary cause of overcut taper.

PARTICLE SIZE. 1. The size of the particles being produced by the EDM sparks and accumulating in the dielectric fluid. **2.** The average cross section of the solid graphite particles in a graphite system, determined by the material from which the graphite is produced and the method of manufacturing. Also referred to as grain size.

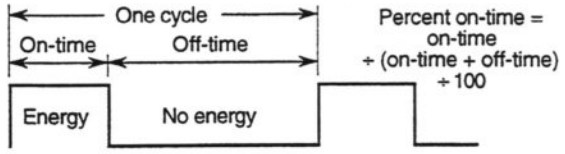
PAUSE. The absence of electrical energy for a preset time following a discharge of electrical energy (pulse).

PAUSE DURATION. *Same as OFF-TIME.*

PEAK CURRENT. The maximum value of current applied during a machining pulse.

PERCENT ELECTRODE WEAR. The volume of electrode worn away as compared to the volume of workpiece worn away. *See ELECTRODE WEAR.*

PERCENT ON-TIME. The percent of on-time with respect to the total cycle time of on-time plus off-time. *Also DUTY CYCLE.*



PIT DEPTH. The distance from the peaks to valleys on an EDMed surface. *See CRATER DEPTH.*

PLASMA. A superheated, highly ionized gas which forms in the discharge channel due to the applied voltage.

PLATEN. The mounting surface affixed to the end of the quill or ram of an EDM machine, on which electrodes or electrode holding devices can be mounted. It usually has tapped holes or machined T-slots for attaching electrodes or holders.

POLARITY. The designation of positive (+) or negative (-) electrical potential to the electrode.

PORT. An input/output connection for interfacing computers with peripheral units such as monitors, modems, printers, off-line programmers and the like.

POSITIVE ELECTRODE. The electrode voltage potential is positive (+) with respect to the workpiece.

POTENTIAL. The difference in voltage between two points of an electrical circuit.

POWER PACK. *Same as POWER SUPPLY.*

POWER PARAMETERS. A set of power supply, servo, electrode material, workpiece material and flushing settings that are selected to produce a desired metal removal rate and surface finish.

POWER SUPPLY. The part of the EDM system that supplies the voltage and current that causes the sparks or discharges between the electrode and workpiece. It is usually housed in a cabinet separate from the machine tool and connected to it by a cable. Modern power supplies produce pulsed direct current using transistor circuitry.

PREMIUM GRAPHITE. An electrode material with a particle size of 5 microns or less. *See GRAPHITE.*

PRESSURE FLOW. Positive pressure created by a pump to cause flow of dielectric fluid through an opening in the electrode or workpiece. Usually expressed in gallons per minute. *See also FLUSHING.*

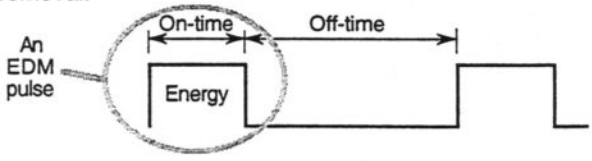
PRESSURE FLUSHING. The forcing of dielectric up through flush holes in the workpiece or down through flush holes in the electrode. Usually expressed in pounds per square inch (psi). *See also FLUSHING.*

PRESSURE GAUGE. A gauge in the dielectric system that measures the pressure of the fluid at the location of the gauge.

PROGRAM. A sequence of instructions used by a computer to perform specific operations.

PULSATOR. *See RAM CYCLER.*

PULSE. The electrical energy applied to the EDM gap, having a preset voltage, amperage and duration, that is intended to cause a discharge that results in metal removal.



PULSE DURATION. *Same as ARC DURATION.*

PULSE ENERGY. The energy in a machining pulse which is proportional to the value of the peak current and the arc duration. *See also ARC DURATION.*

PULSE LENGTH. *Same as ARC DURATION.* The reference is made to the length of time that the pulse lasts.

PULSE TIMER. This refers to the timing of spark pulses, not flushing. A control used to set the length of on-time and off-time of the spark. On some machines, on-time and off-time can be set individually in microseconds.

PULSE WIDTH. *Same as ARC DURATION.* The reference is made to the width of the pulse in a display of the wave form.

PULSED FLUSHING. Flushing synchronized with the ram cycler of the EDM machine. In this mode, flushing takes place only during the time that the electrode is retracted.

QUENCH. The rapid cooling of the EDMed surface by the dielectric fluid. Partially responsible for metallurgical changes in the recast layer and the heat-affected zone.

QUILL. The moving member of an EDM machine on which the electrode or electrode holder is mounted, more specifically a cylindrical ram working in bearings or bushings.

RAM. The moving member of an EDM machine on which the electrode or electrode holder is mounted.

RAM (RANDOM ACCESS MEMORY). The electronic circuitry a computer uses to process and temporarily hold information.

RAM CYCLER. A feature added to or built into an EDM machine which periodically causes the electrode to retract for a short period of time to aid in flushing a deep or blind cavity. Sometimes called a Pulsator.

RC (RELAXATION) CIRCUIT. An outmoded EDM power supply circuit which uses capacitors to store the charge that produces the spark at the gap. The capacitor is charged through a resistor and discharged across the gap when conditions are correct (gap distance, voltage, etc.). This is the original EDM circuit and is seldom used in advanced machines.

RECAST LAYER. A layer created by molten metal solidifying on the workmetal surface.

RECTIFIER. An electronic component that converts alternating current to direct current.

REFEED. Automatic electrode replenishment, usually used to refeed small diameter tubing for EDMing small holes in repetitive production applications.

RELAXATION CIRCUIT. *Same as RC CIRCUIT.*

REPETITION RATE. The frequency or the number of pulses per second. Measured in hertz.

RESERVOIR. That component of an EDM machine that contains the bulk of the dielectric fluid.

RESOLIDIFIED LAYER. *Same as RECAST LAYER.*

REVERSE BURNING. The technique of mounting the electrode on the machine table and the workpiece on the ram. Used in EDMing a blanking punch with female electrode.

REVERSE FLUSH. Flushing through the flushing fixture.

REVERSE POLARITY. A term used on some machines to indicate positive polarity of the electrode.

RMS (ROOT MEAN SQUARE). A term used in surface finish measurement. *See also SURFACE FINISH.*

ROM (READ-ONLY MEMORY). A memory circuit written during manufacture that cannot be altered by a user, program, or other means.

ROTATING SPINDLE. A device, either an accessory or built into the ram, used to rotate the electrode to improve flushing conditions and achieve more uniform wear and rounder holes. Another use for a rotating spindle is tramming the workpiece with an indicator for set-up purposes.

ROUGH CUT. An EDMing operation with high metal removal rates at rougher finishes.

SAFETY CUT. The method of undersizing roughing electrodes to leave enough material to be removed by the finishing electrodes.

SCROLLING. The movement of lines of text up or down on the monitor screen.

SECONDARY DISCHARGE. A discharge that occurs as conductive particles are carried out along the side of the electrode by the dielectric fluid.

SENSITIVITY. **1.** The response time of a servo mechanism. **2.** Detection and response to DC arcing.

SERVO DRIVE; SERVO MECHANISM. The device that drives and controls the movement of the quill or ram, either by motors or hydraulic pistons. *See also SERVO SYSTEM.*

SERVO REACTION TIME. The time between a signal to the servo and its physical response to the signal.

SERVO SPEED. The velocity of a servo mechanism.

SERVO SYSTEM. The automatic control of ram or table feed by the use of a reference signal. The servo voltage is compared to a reference voltage and amplified signals are used to operate the servo drive mechanism.

SHORT; SHORT CIRCUIT. What occurs when the electrode and workpiece are in direct contact. This stops all EDMing and causes the ram to retract.

SIDE WEAR. The wear along the side walls of an electrode.

SILICONE. A dielectric fluid for special situations consisting mostly of the chemical polymer silicone.

SILVER TUNGSTEN. A porous tungsten material which is infiltrated with silver.

SINKER. **1.** A ram-type EDM machine (informal). **2.** A small weight used with fishing lines, probably cast in dies made on EDM machines before being cast into the water.

SKIM CUT. The final cut to achieve high tolerance and improved surface finish in wire EDM.

SLUG. The unused interior piece of material cut out by wire EDM or a trepanning electrode.

SOFTWARE. The collection of programs and information associated with a computer.

SOLID STATE POWER SUPPLY. A power supply with transistorized circuitry. *See also TRANSISTOR.*

SPARK. An electrical discharge of very short duration between two conductors.

SPARK EROSION. Another name for EDM. Used primarily outside the U.S.

SPARK GAP. The distance between the electrode and the workpiece when discharges are occurring.

SPARK GENERATOR. *Same as POWER SUPPLY.*

SPARK INTENSITY. The amount of energy in the spark.

SPARK-IN. A method of "picking up" location of an electrode with respect to the workpiece. Using high frequency and low amperage settings so as not to do any cutting, the electrode is advanced toward the work until contact is indicated. This point is noted and used as a basis for job set-up.

SPARK-OUT. A technique used in orbiting which moves the electrode in the same path until sparking ceases.

SPINDLE. *See ROTATING SPINDLE.*

SPLIT ELECTRODE. Two or more electrodes on one machine insulated from each other. A separate gap and servo sensing cable is connected to each electrode and simultaneous discharges from each electrode are made possible with split, dual or multiple power supplies. *Also SPLIT-LEAD.*

SPLIT-LEAD POWER SUPPLY. *Same as MULTIPLE LEAD POWER SUPPLY.*

SPRAY FLUSHING. The use of nozzles or hoses to direct jets of dielectric fluid at the cutting area to flush away the debris. Usually employed while ram cycling the electrode. Also called INJECTION FLUSHING, LATERAL FLUSHING, SURFACE FLUSHING and WASH. *See also FLUSHING.*

SQUARE WAVE. A term for an electrical wave shape generated by a solid state power supply.

STABILITY. The steadiness of an EDM cut. The opposite of hunting.

STAGED ELECTRODE. A multiple electrode set designed to produce a single cavity in stages from rough to fine. Each electrode is sized to leave sufficient metal for the next electrode to produce the required finish and dimensions.

STEPPED ELECTRODE. An electrode constructed in such a manner as to allow the roughing and finishing of a through-hole cavity in a single set-up. The smaller front section roughs out the hole and the larger rear portion is used for finishing.

STROKE. The distance the ram travels under servo control.

SUCTION FLUSHING. Drawing dielectric fluid through the gap and through the electrode or workpiece by means of negative pressure. Expressed in inches of mercury (in. Hg.). Also called vacuum flushing. *See also FLUSHING.*

SUPERFINE. A class of EDM electrode materials with a particle size from 6µ to 10µ, characterized by moderately high strength, usually isotropic.

SURFACE AREA. The "frontal area" of an electrode doing the primary EDM cutting. Also the corresponding area of the workpiece. Usually expressed in square inches (in^2) in the US.

SURFACE FINISH. The relative roughness or smoothness of the surface texture produced by EDMing. Usually measured in microinches Ra (µin Ra, sometimes just Ra) in the U.S. *Same as FINISH.*

SURFACE FINISH EQUIVALENTS

µinches Ra	microns Ra	µinches RMS	microns RMS	VDI
16	0.40	17	0.44	12
22	0.56	24	0.62	15
44	1.12	49	1.24	21
88	2.24	98	2.49	27
177	4.50	197	5.00	33
354	9.00	394	10.00	39
709	18.0	787	20.00	45

SURFACE FLUSHING. *Same as SPRAY FLUSHING.*

SURFACE INTEGRITY. The physical and/or metallurgical quality of the machined surface and subsurface.

SURFACE ROUGHNESS. Surface irregularities on a machined surface. *See SURFACE FINISH.*

SWARF. Eroded particles or residue resulting from EDMing.

TAP BUSTER. *Same as DISINTEGRATOR.*

TAP. A control on some early power supplies that changes spark frequency and on-time.

TAPER. The dimensional difference between the entrance and exit opening of a through-hole, or between the entrance and bottom of a blind cavity. *See OVERCUT TAPER.*

TAPPING ATTACHMENT. An accessory that holds and rotates an electrode as it EDMs a threaded hole into a workpiece. It advances the electrode to produce the pitch of the thread desired.

TELLURIUM COPPER. An alloy of copper and tellurium.

TEMPERATURE CUT-OFF. A device for shutting off power when dielectric oil temperature reaches a certain temperature.

THERMOELECTRIC. Pertaining to the combination of heat and electricity. EDM, in spite of its name, is not simply an electrical process. It is a thermoelectric process, wherein electricity causes thermal effects that remove the metal.

THROUGH-HOLE FLUSHING. The use of a pre-drilled hole in the workpiece to inject dielectric fluid up through the gap by pressure flushing or down through the gap by suction flushing.

TILTING HEAD. An attachment allowing the electrode to be tilted in one or more directions.

TIMED RETRACTOR. *Same as PULSATOR.*

TOOL. *See ELECTRODE.*

TRACE VECTOR. *See ORBIT.*

TRACING TABLET. A device on a CNC EDM consisting of a stationary holder for paper and a holder for a pen that moves with the worktable so that a visual outline of a part program can be drawn to check it before making the actual part.

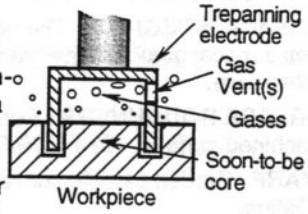
TRAMMING ATTACHMENT. A mechanical accessory used to check the accuracy of the set-up and to aid in the precise location of the workpiece in respect to the electrode.

TRANSDUCER. A device for changing electromagnetic force into mechanical force. In EDM, a transducer is used in ultrasonic machining of graphite.

TRANSISTOR. An electronic component used as a switch to open and close with extreme speed. Transistors have replaced the vacuum tube due to their reliability, long life, and much higher switching speed.

TRAVELING WIRE EDM, TW EDM. *See WIRE EDM.*

TREPANNING ELECTRODE. A hollowed out or tubular electrode used in through-hole EDMing to remove a large diameter without having to pre-machining by conventional means or EDM the large amount of material in the core. The word "trepanning" strictly refers to circular holes, but the principle applies well to other shapes.



TUBULAR ELECTRODE. A round electrode with a center hole.

TUNGSTEN. A high melting point (3380°C) metal used in pure or near pure state as an electrode material.

ULTRAFINE. A class of EDM graphite characterized by a particle size from 1μ to 5μ, isotropy, uniform structure, and high strength.

UNSTABLE. Erratic or intermittent EDMing. *See also HUNTING.*

UV AXIS. A mechanism or feature which enables movement of the upper head of a wire EDM to enable cutting tapers.

VACUUM FLUSHING. Drawing dielectric fluid through the gap and through the electrode or workpiece by means of negative pressure. Expressed in inches of mercury (in. Hg.). Also called suction flushing. *See also FLUSHING.*

VACUUM TUBE POWER SUPPLY. A mostly obsolete EDM power supply that uses vacuum tubes to switch the electrical pulses on and off.

VDI. Verein Deutscher Ingenieur. A surface finish measuring system used in EDM. *See SURFACE FINISH.*

VECTOR. *See ORBIT.*

VIBRATOR. An accessory used on an EDM machine to vibrate the workpiece or electrode rapidly, for improving flushing in blind cavities.

VISCOSITY. The tendency of a fluid to resist flow. High viscosity fluids are thicker.

VOLT. The unit of electrical potential; the difference of electrical potential between two points.

VOLTMETER. An instrument that measures voltage. On an EDM machine, it measures the voltage across the gap.

VOLUMETRIC WEAR. The total wear of the electrode expressed in cubic inches. *See ELECTRODE WEAR.*

WASH. Yet another term for SPRAY FLUSHING.

WAVE FORM. A geometric display of the output of a power supply as seen on an oscilloscope. *See also SQUARE WAVE.*

WEAR. The erosion of the electrode during the EDM process. *See ELECTRODE WEAR.*

WEAR RATIO. The percentage of volume of electrode material consumed with respect to the volume of workpiece material removed. *See ELECTRODE WEAR.*

WHITE LAYER. The surface layer of an EDM cut which is heat affected by the EDM process. Character of the surface depends on the material. It may be an extremely hard martensitic layer with apparent cracks or it may be an annealed layer.

WIRE EDM; WIRECUT. An EDM machine or process where the electrode is a continuously spooling conducting wire that moves in preset patterns around the workpiece.

WIRE GUIDE. A replaceable precision round diamond insert, sized for specific wire diameters, that guides the wire at the entrance and exit points of a wire cut.

WIRE SPEED. The rate at which the wire is fed through the workpiece (not the rate it cuts), adjusted fast enough to keep clean wire in the cut but slow enough to minimize waste.

WIRE TENSION. Drag in the wire-feed mechanism applied to the wire, adjusted to minimize wire deflection and promote cutting accuracy and speed without breaking the wire.

WORKPIECE. The part or material to be machined.

WORKTANK. The sealed tank, surrounding the worktable on an EDM, that holds the dielectric fluid.

X-AXIS. On a horizontal plane, the axis moving left and right.

Y-AXIS. On a horizontal plane, the axis moving front and back.

Z-AXIS. In a vertical line, the axis moving up and down. This usually represents the movement of the ram.

CHAPTER 4
OPERATION

Dielectric System.....4.1.2
Power Supply & CNC Controls.....4.2.1
Planning an EDM Cut; Low Wear Operation.....4.3.1
EDM Graphs.....4.4.1
EDM Worksheets.....4.5.1
EDM Quick Reference Charts.....4.6.1
Programming*.....4.7.1
Quick Cut.....4.8.1
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See page 4.7.1 for a detailed Table of Contents of the Programming Section.

INTRODUCTION

REMINDER: Please read and respect the safety information at the beginning of this manual.

Before attempting to operate your EDM familiarize yourself completely with the controls. A good understanding of the function of each of the operating parameters on the power supply/CNC control will permit the most efficient use of the equipment and eliminate many problems that might come up during the actual operation.

The operating parameters establish the cutting action of the electrical discharges. The proper performance of the power supply and degree of efficiency of the cutting action is totally dependent on the parameter selection for a particular job. Each parameter on the control establishes a particular cutting condition and, because of the interaction between all the parameters, each is equally important. It is therefore necessary that the correct combination of parameters be used to obtain maximum results.

It is possible to arrive at a satisfactory cutting action even though the correct combination is not being used. The cutting action may be stable but the metal removal rate may be minimal and/or the electrode wear excessive. Under these conditions the full potential of the power supply is not being utilized. When deciding on a cut, take all parameters into consideration so that maximum results will be realized for the cut being made.

Because there are several interrelated variables associated with EDM, it is important that an operator understands the general rules and basic theory. The information contained in this manual provides a foundation, or starting point, for most applications, but it may be necessary to vary the approach if conditions are out of the ordinary. It remains for the operator to decide, after considering all of the requirements for a job, which combination of settings best satisfy these requirements. Hansvedt encourages customers to contact its Applications Engineering Department with questions relating to the operation of Hansvedt EDM machines, at (217) 384-5900 (phone) or (217) 384-2225 (fax). We also invite EDM operators to attend classes conducted at Hansvedt's factory in Urbana, Illinois.

DIELECTRIC SYSTEM

The dielectric fluid system is a closed, air-fill system consisting of the reservoir, turbine pump, dielectric filter, pressure relief valve, fill/drain valve and worktank manifold.

Pump/Filter

Dielectric is pumped through a 5 micron filter to remove residue during operation. These filters are replaceable (see the MAINTENANCE AND SERVICE Section). The degree to which they remove residue will affect the cutting action. For example dielectric oil with a high degree of contamination may be suitable for roughing cuts but may be undesirable when a fine finish is required.

The turbine pump supplies pressure and vacuum flushing capability to the worktank by first routing the fluid through a 5 micron filter attached to the reservoir. Pump pressure can be bypassed through a pressure relief valve that opens at pressures above 50 psi. The fluid pressure output of the dielectric filter is then routed to the machine tool manifold. The manifold consists of a pressure valve for pressure flushing, a bypass valve to route excess fluid to the worktank as an aid to dielectric clarification, and a suction valve to provide vacuum flushing. When fluid from the reservoir is put into the tank either by pressure flushing or bypass, the resultant decrease in reservoir pressure allows a like amount of fluid from the worktank to return to the reservoir. Thus fluid level is maintained, once set.

Worktank Fill/Drain

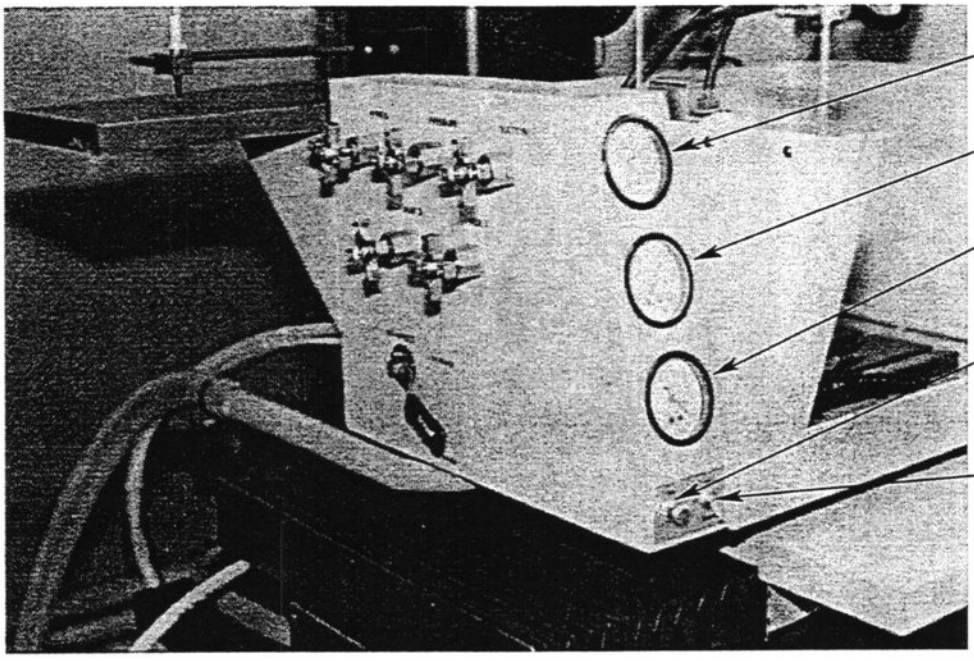
Facility air of 25-90 psi must be supplied to the fill valve which routes air to the reservoir to displace dielectric fluid to the worktank. When the HOLD/DRAIN switch is in the HOLD position air is trapped in the reservoir maintaining the worktank fluid level. When the HOLD/DRAIN switch is in the DRAIN position air pressure is routed through a control line to the dump valve on the reservoir to vent the air pressure and allow tank fluid to return to the reservoir through the fill/drain line. Actuation of the FILL valve push button simply controls the supply of air to the reservoir.

Flushing Manifold

Continuous Pressure - flow controlled by the PRESSURE valve provides fluid to one outlet whenever the coolant pump is on. The pressure gauge on the front of the manifold shows the actual pressure at the gap in pounds per square inch (psi). Continuous pressure is also available through the AUX 1 and AUX 2 valves when gap power is on and FLUSH is selected (enabled) on the OPERATING PARAMETER ADJUST screen.

Typical flushing pressure settings -

Sealed off cutting of cavities	Low, 1-5 PSI.
Spray from one side only, roughing	10-60 PSI.
Spray from one side only, finishing	5-10 PSI.
Spray from one side only, thin ribs	5-10 PSI. (adjust flow nozzle parallel to electrode.)
Small holes, tubing electrode, .010" - .070" dia.	60-100 PSI.
Small holes, tubing electrode, .070" - .250" dia.	20-60 PSI.
Small holes, solid electrode	Minimum spray flush, one side only. Use only enough to flush; excess might deflect the electrode.



Suction Flushing - is available whenever the coolant pump is on. The amount of suction is regulated by the SUCTION valve and the BYPASS valve. For maximum suction the BYPASS, PRESSURE and AUX valves should be completely closed. The lower gauge indicates suction in inches of mercury (in. Hg.). Use the lowest amount of suction that will provide proper flushing action, i.e. 5-15 in. Hg.

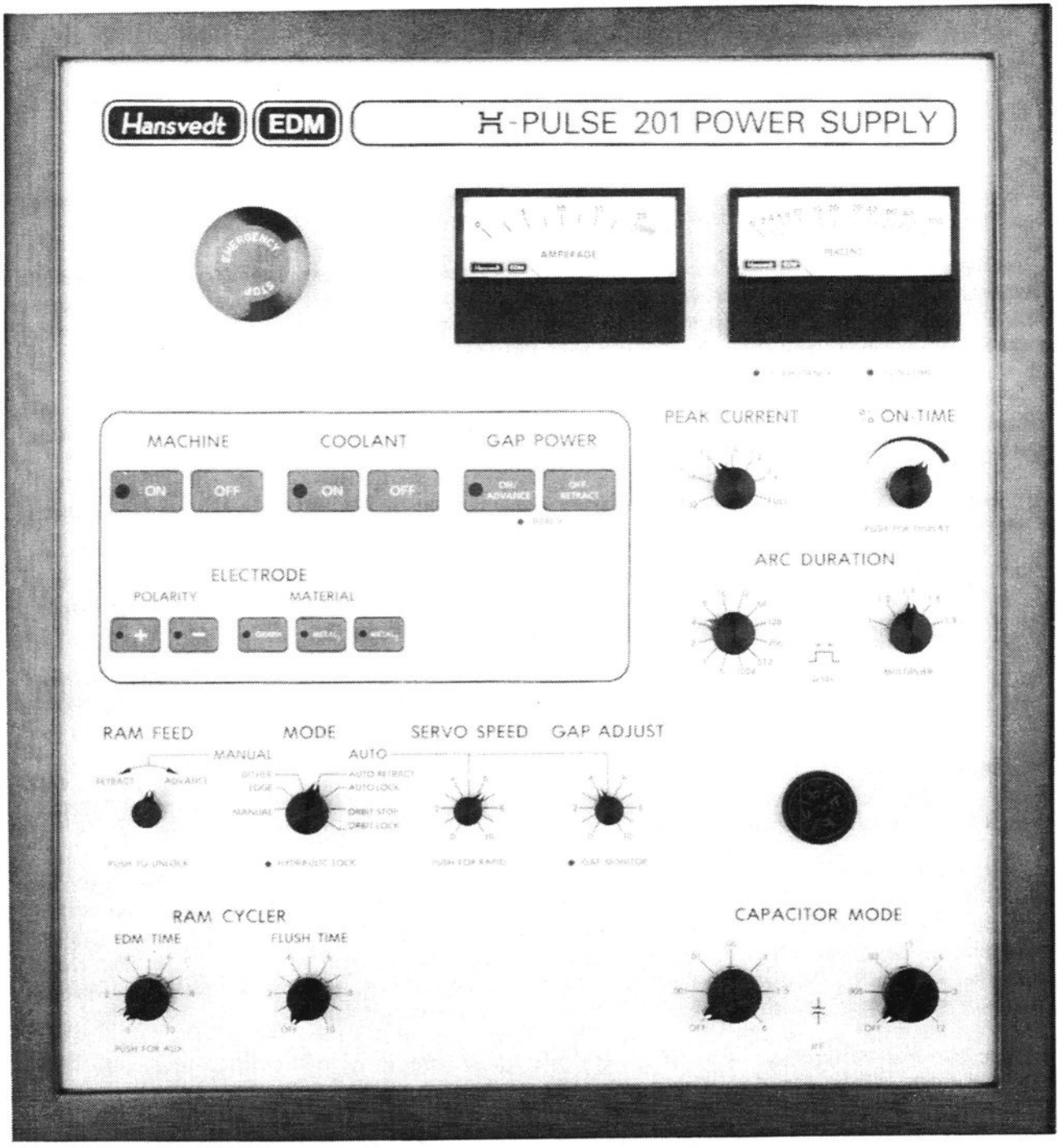
Worktank Bypass - enables maximum fluid exchange between the worktank and reservoir for efficient filtration and thermal stability. To optimize the dielectric flow any excess fluid not required for pressure or suction flushing should be circulated in the worktank with the BYPASS valve.

Pulsed Pressure Flow - is timed with the ram cycle retract so that the gap/arc is not disturbed by the fluid flow during the time cutting is taking place. To set for PULSE FLUSH, the RAM CYCLER must be enabled (CYCLE-EDM and CYCLE-RETRACT must be set) and the FLUSH should be set to CYCLE on the OPERATING PARAMETER ADJUST screen.

Flushing Hints

1. Adjust flushing by trying to achieve a clean, crisp sound at the gap and the highest efficiency reading.
2. When using small or thin electrodes that are subject to bending, very low or possibly no pressure should be directed from the side or through the electrode. Direct the flow from the nozzles so that it is parallel to the electrode.
3. In the no-wear mode excessive flow can cause unusual wear on copper or graphite electrodes.
4. To maintain clean fluid in the worktank while flushing with one or two lines it is advisable to discharge additional fluid into the tank with the BYPASS VALVE. If extremely high pressures are required at the gap this technique may not be possible.

POWER SUPPLY CONTROLS



Emergency Control — a red, mushroom shaped button, sometimes called the "E-Stop," that stops the cutting power, turns off the dielectric pump and stops the ram. Push to operate, wait two minutes, then pull to reset.

Machine On/Off — turns on the hydraulic pump, work light (option), electronic controls and generator. Also unlocks the ram if mode is in DITHER or AUTO RETRACT and the RAM LOCK switch on the ram is in AUTO.

Coolant On/Off — turns on the dielectric pump that provides coolant flow and pressure to a sensing switch that activates part of the ready circuit.

Ready Light — must be lit before gap power will come on. Requirements are:

1. MACHINE on.
2. COOLANT SWITCH on.

3.a AUTO RETRACT or AUTO LOCK mode **or**

3.b ORBIT STOP or ORBIT LOCK mode after contact is made with microswitch downstop.

4. Float switch properly submerged.
5. Door guard closed.
6. Pressure switch on dielectric manifold is closed. (This internal interlock will "open" when dielectric pressure falls below 4 PSI, indicating the need for a filter change.)

Gap Power On/Off — turns on cutting power, advances ram at servo speed/gap adjust settings unless button is held in. If button is held in, ram advances in rapid after a 1/2 second delay. Activates PULSE FLUSH (optional) if selected. OFF - turns off gap power, deactivates AUX or PULSE FLUSH, retracts ram as mode switch is set.

Electrode Polarity +/- — pushing "+" will light +LED and gap will be positive on ram and negative on table. Pushing "-" will light -LED and gap will be negative on ram and positive on table. (Note: changing polarity should be done with gap power off.)

Electrode Materials — Sets the sensing range for the automatic DC arc protection circuits. Three levels of protection are available:

1. **Graphite** — provides proper parameters inside power supply to prevent damage to the work when using graphite and tungsten electrodes. It also provides the highest level of protection when using other electrode materials (copper, carbide, tungsten).

2. **Metal 1** and **Metal 2** — provides proper parameters for work protection using metallic electrodes such as copper, copper tungsten, brass, tungsten carbide, steel, zinc, etc. Select Metal 1 first. If the cut is unstable or slow select Metal 2 to retain stability.

Peak Current — controls peak current of each pulse. Full, 3/4, 1/2, 1/4, 1/8, 1/16, 1/32 levels are used in conjunction with arc duraction and polarity to achieve different surface finishes, overcuts, and speeds. See Set-Up procedure for settings.

%On-Time — the %On-time range is from 1% to 80%. Set the %On-time on the meter by depressing the knob and turning clockwise to increase, counterclockwise to decrease. When the knob is released (out) the meter will switch to the efficiency mode. Use the set-up sheet (see Set-Up procedure) to determine maximum average amps and %On-time. Start a cut below the recommended %On-time then slowly increase the level to the desired setting. This will set cut stability and speed. When the gap monitor flickers the cut will have reached maximum efficiency.

Arc Duration/Multiplier — the arc duration range is from .5 to 1024 microseconds (μs). The multiplier range is from 1 to 1.8. These controls in combination set the arc duration, or on-time of the pulse energy. The MULTIPLIER allows more choices of arc durations for any EDM finish. The ARC DURATION control has 12 positions: .5, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024 μs. The MULTIPLIER has 5 positions: 1, 1.2, 1.4, 1.6 and 1.8.

Example 1: .5 μs X 1.4 = .7 μs arc duration
Example 2: 64 μs X 1.6 = 102.4 μs arc duration.

Ram Feed/Unlock — is used in manual positioning modes to bring ram up or down. When the HYDRAULIC LOCK LED is on, the ram is locked in position. To move the ram depress knob in and rotate clockwise or counterclockwise to raise or lower, then release knob and ram will stop. This allows table positioning while the electrode is in a fixed position.

Mode — there are seven mode positions possible (depending on options ordered):

1. **Manual**. Pushing RAM FEED control in and rotating clockwise or counterclockwise will manually move the ram. The 201 does not sense the electrode-to-workpiece contact and damage may occur to either if contact is made. This mode is useful to indicate electrode perpendicularity. The machine will not cut in this mode.

2. **Dither**. This position unlocks the ram and allows it to move up and down by the RAM FEED control. This mode will sense the electrode-to-workpiece contact and is used to set depth of cut. Again, EDM'ing is not possible in this mode.

3. **Edge**. Functions similar to manual with the exception that the electrode will dither on the workpiece and provide an audio signal from the Sonalert beeper on the front panel. This position is used to pick up an outside edge on a workpiece for XY positioning of the electrode. EDM'ing is also not possible in this mode.

4 **Auto Retract**. Gap power may be turned on in this position. Ram will retract at the servo speed setting when depth stop is activated.

5. **Auto Lock**. Gap power can also be turned on in this mode. The ram will lock in the down position when the depth stop is activated, until the operator changes mode switch or pushes the GAP POWER OFF/RETRACT switch to retract the ram. Upon release the ram will again lock.

6. **Orbit Stop** (optional). The servo electrically senses the electrode and also electrically senses the microswitch downstop. This is used to orbit down to a depth and "spark-out" without activating the depth microswitch. EDM'ing is possible in this mode.

7. **Orbit Lock** (optional). This position senses both the electrode and microswitch downstop until it first comes in contact with the microswitch. At this point it no longer senses the electrode and the ram remains locked in electrical contact between the thumbscrew (optional micrometer) and the microswitch downstop. All servo action is now the responsibility of the orbiting device. This position is used to EDM threads into a workpiece or to perform an undercut operation. Servo speed and gap adjust controls do not function in this mode.

Servo Speed — Sets the response speed of the servo while cutting. The numbers 0-10 are for reference only. A setting of 10 provides maximum servo response and a setting near 0 provides minimum servo response. A setting of 10 gives maximum speed while the electrode is approaching the work, but will cause too much vibration when doing fine cuts. The SERVO SPEED should be set as high as possible without causing oscillation of the dial indicator. This control, along with the GAP ADJUST, can be considered a fine-tuning control, and can be used to stabilize the cut after the following parameters are achieved: %On-time, peak current, flushing pressure, and arc duration.

Gap Adjust — controls the space maintained between the electrode and the workpiece. The calibrations 0-10 are for reference only. Clockwise rotation increases the gap and counterclockwise rotation decreases it. The GAP ADJUST control varies a reference voltage to which the voltage across the gap is compared. The gap is then automatically adjusted by the servo until the voltage across the gap is equal to this reference voltage.

The voltage at which the gap ionizes depends on the gap spacing. If the gap spacing is too wide, GAP ADJUST is set too high, no ionization will occur and no pulse current will flow. If the spacing is too close, GAP ADJUST is set too low, poor ionization will result, the gap will easily short, flushing is difficult and ionization may be extinguished, causing loss of finish control and high electrode wear.

Ram Cycler — this is used to stabilize cutting where good flushing is not possible. The controls are for two timers: one to control time in the cut, and the other to control time out of the cut, or in retract motion.

1. **EDM Time**. Used to operate PULSE FLUSH (optional) or AUX mode. Push this knob in, then when ram goes into its retract cycle a solenoid is opened which allows flushing to be synchronized with the retract motion.

2. **Flush Time**. Used to set retract time for flushing purposes. Also has an off position to defeat ram cycler action.

(Note: The numbers are relative: 1 being a short time and 10 being a long time. The controls work best if numbers are similar. For example if EDM TIME is set at 2.5 then FLUSH TIME should be set at 2 to 3. Also, if cycle rate increases past a certain point, the Aux spray solenoid will be turned on continuously, rather than pulsed.)

Capacitor Mode (optional) — capacitors are energy storage devices. When operating in a capacitor mode the electrical energy pulses generated by the power supply are fed to these capacitors and stored until conditions at the gap are suitable for a discharge. The capacitors then discharge the electrical energy into the gap.

Capacitors should be used in the following situations:

1. When gap conditions are poor due to inadequate flushing.
2. When machining high melting point metals, such as carbide.
3. For EDM'ing with most metal electrodes, such as copper tungsten and brass.

The high intensity of the capacitor discharge serves to remove debris lodged in the cutting gap making it possible to EDM with poor flushing. It should be remembered that for general cutting of steel workpieces with graphite electrodes and good flushing, the pure pulse mode will provide a higher metal removal rate.

Operating in Capacitor Mode

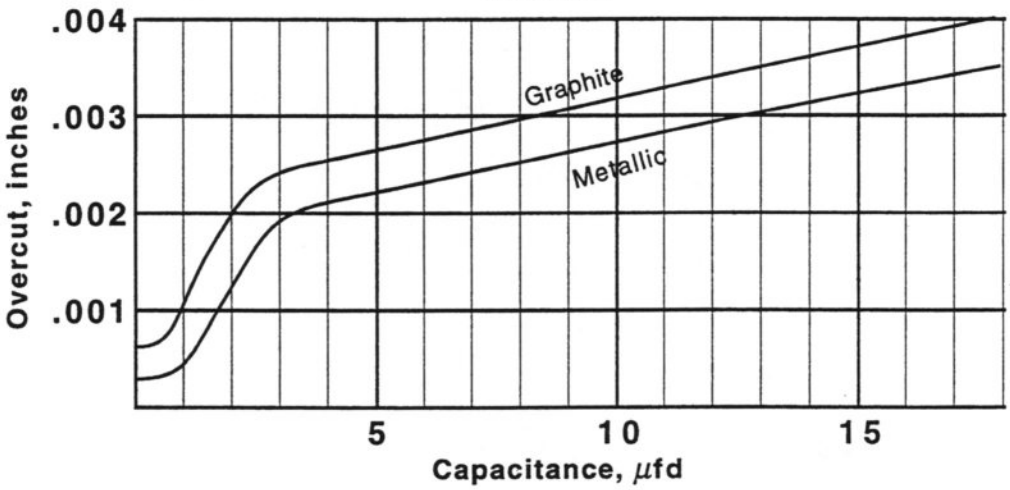
Capacitors are available in various energy storage capacities, ranging from .001 to 18 microfarads (μfd). When capacitors are switched in from both knobs, add the μfd values of each to obtain the total capacitance being used.

When operating in capacitor mode the μfd value determines the metal removal rate and the finish. The higher the μfd value selected, the greater the energy discharge and the greater the metal removal. This means that large capacitors should be used for roughing cuts and smaller capacitors for finishing cuts.

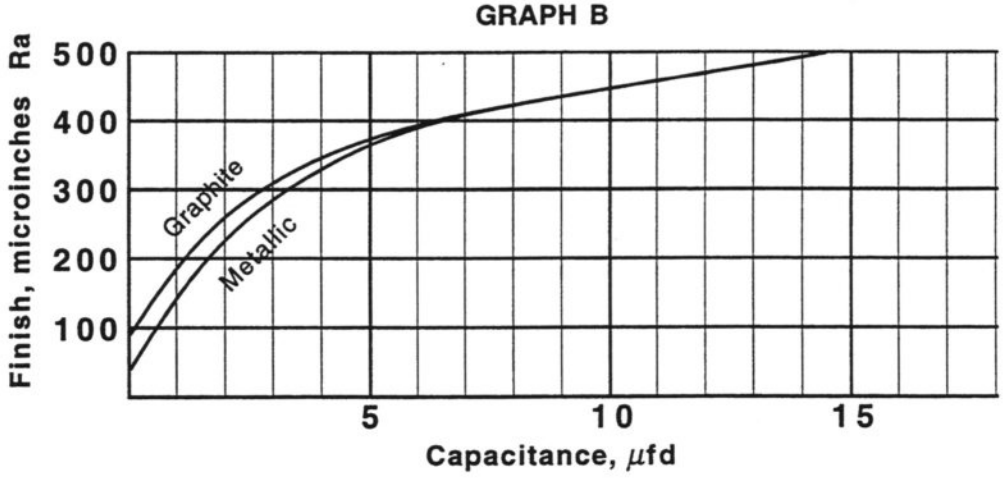
Capacitors require specific times to charge to their full potential. These charge times are dependent on capacitor value and ouput level. If the charge time is too short the capacitor will not fully charge. If the charge time is too long the excess will go to the cut as pulse mode operation and the overcut will be larger than predicted.

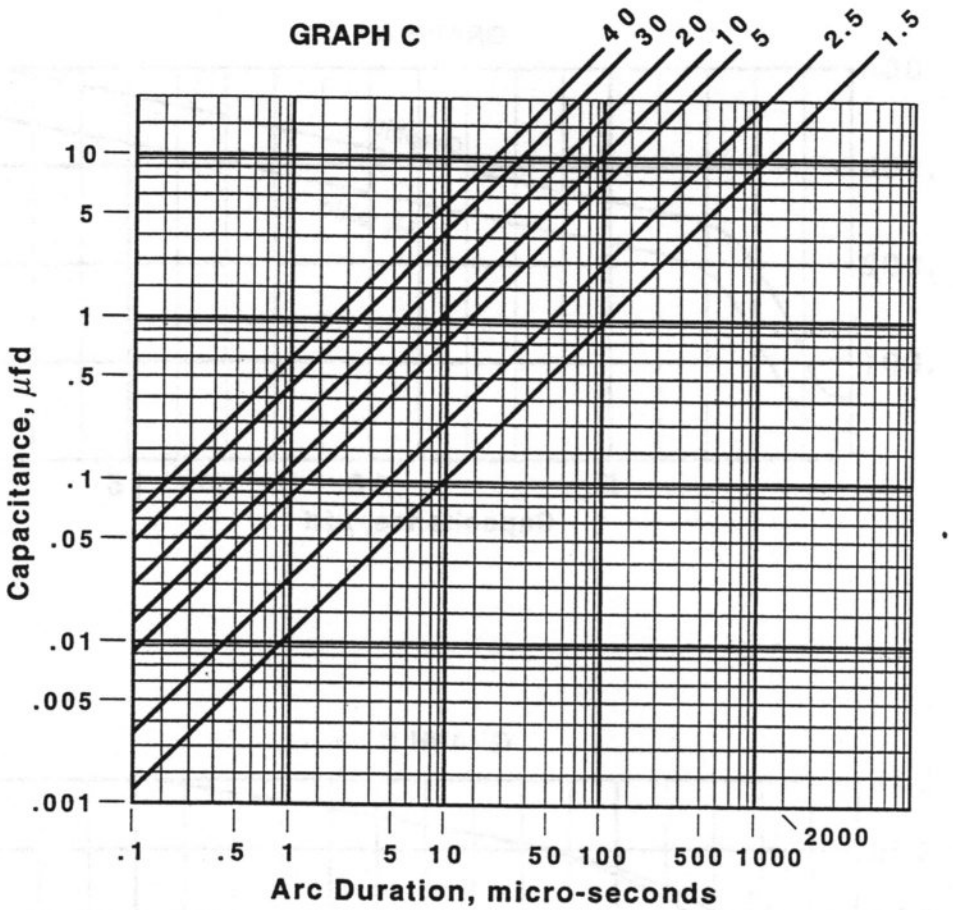
The following graphs should be used to select the proper size capacitor for the desired overcut or finish. Graph A gives the capacitor sizes with respect to overcut and Graph B gives the capacitor sizes with respect to surface finish. Graph C then gives the correct arc duration at different Peak Current levels with respect to capacitor size.

GRAPH A

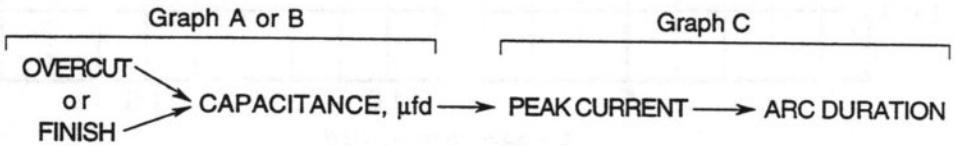


GRAPH B





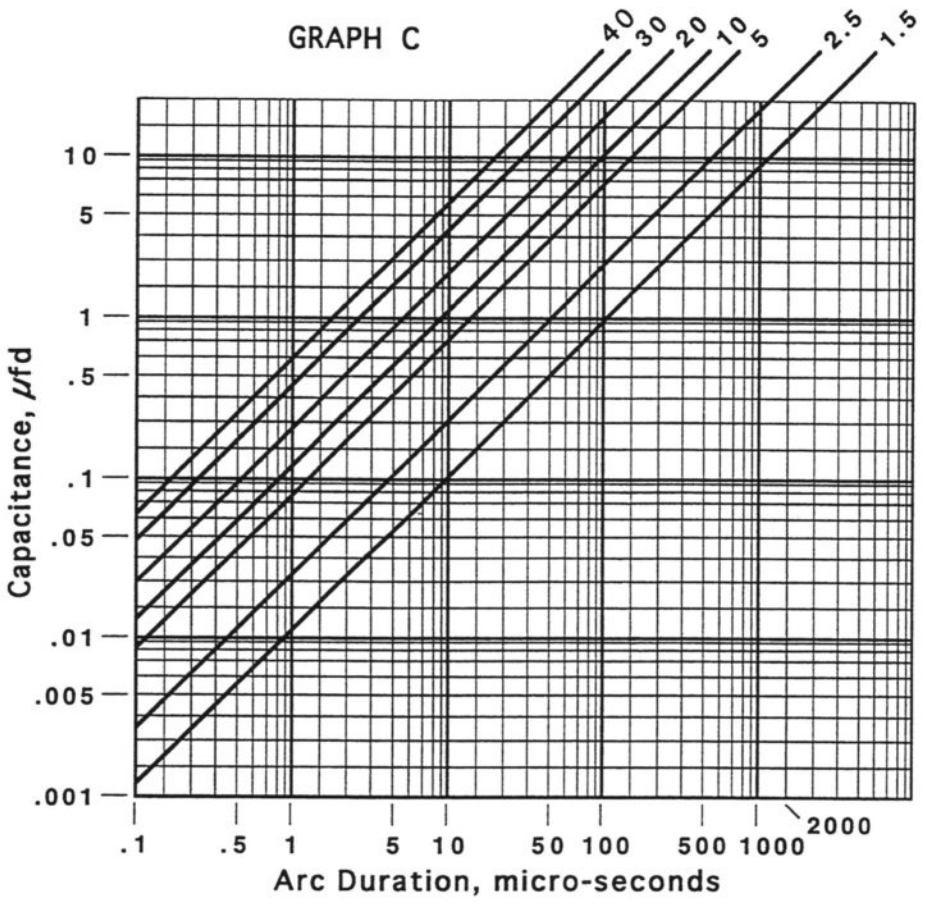
To review the basic cutting parameters when using capacitors:



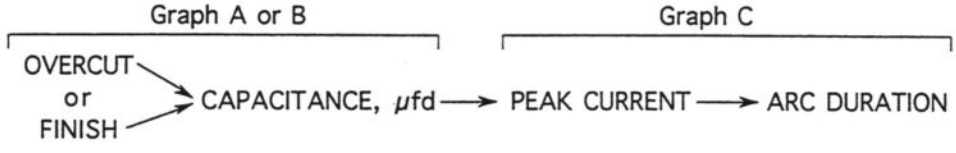
Either polarity may be used, however negative polarity might give less electrode wear and faster cutting, whereas positive polarity might provide more stable cutting conditions.

Capacitor mode cuts should always be run at a wide gap setting to insure adequate time for the capacitors to "fill up" with energy before discharging.

Capacitors will always cause electrode wear since the arc duration range of these discharges is .2 to 12 microseonds, depending on capacitor value. Always make sure that all capacitor switches are off when cutting in the low-wear mode.



To review the basic cutting parameters when using capacitors:



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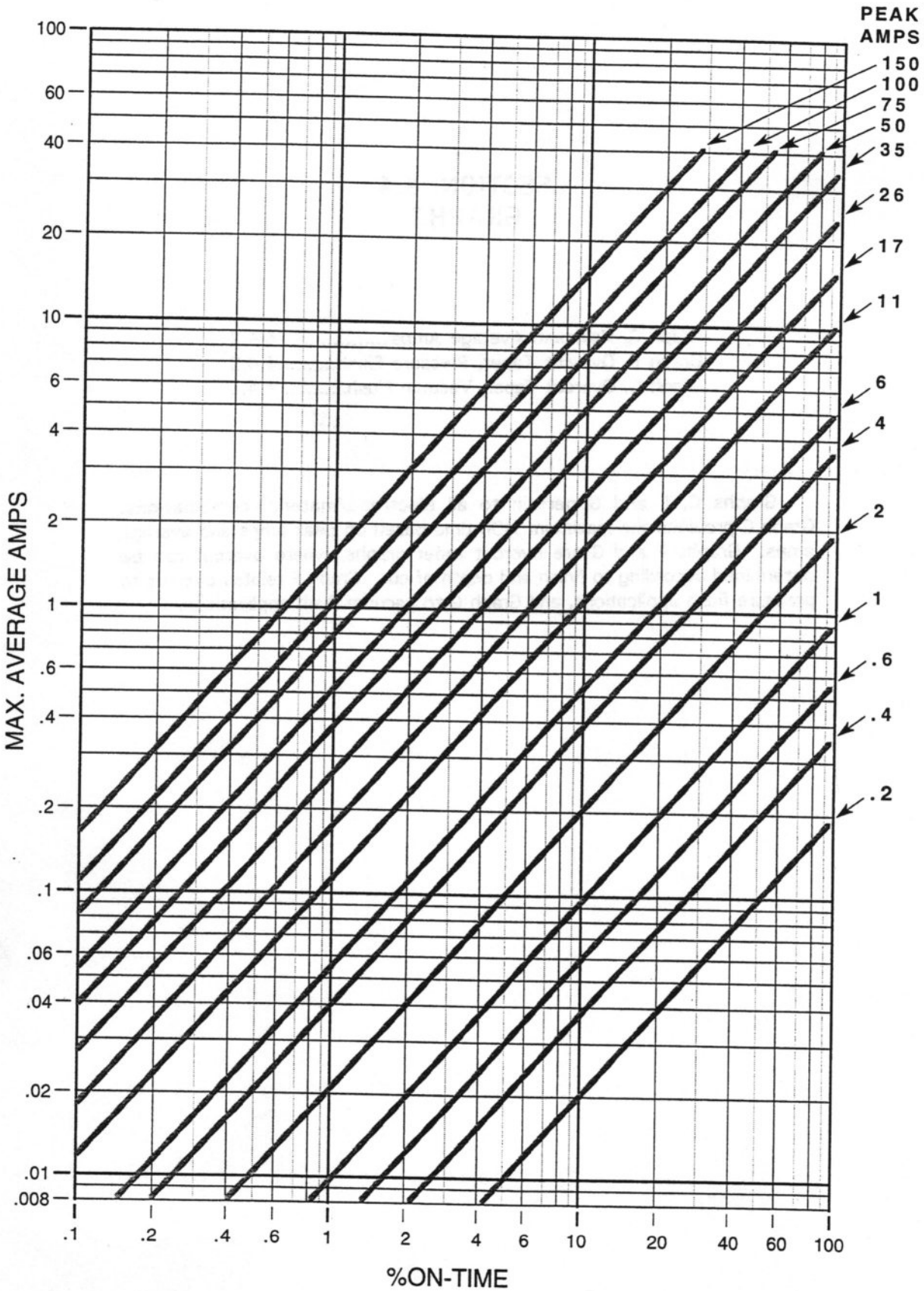
SECTION 4.4
GRAPHS

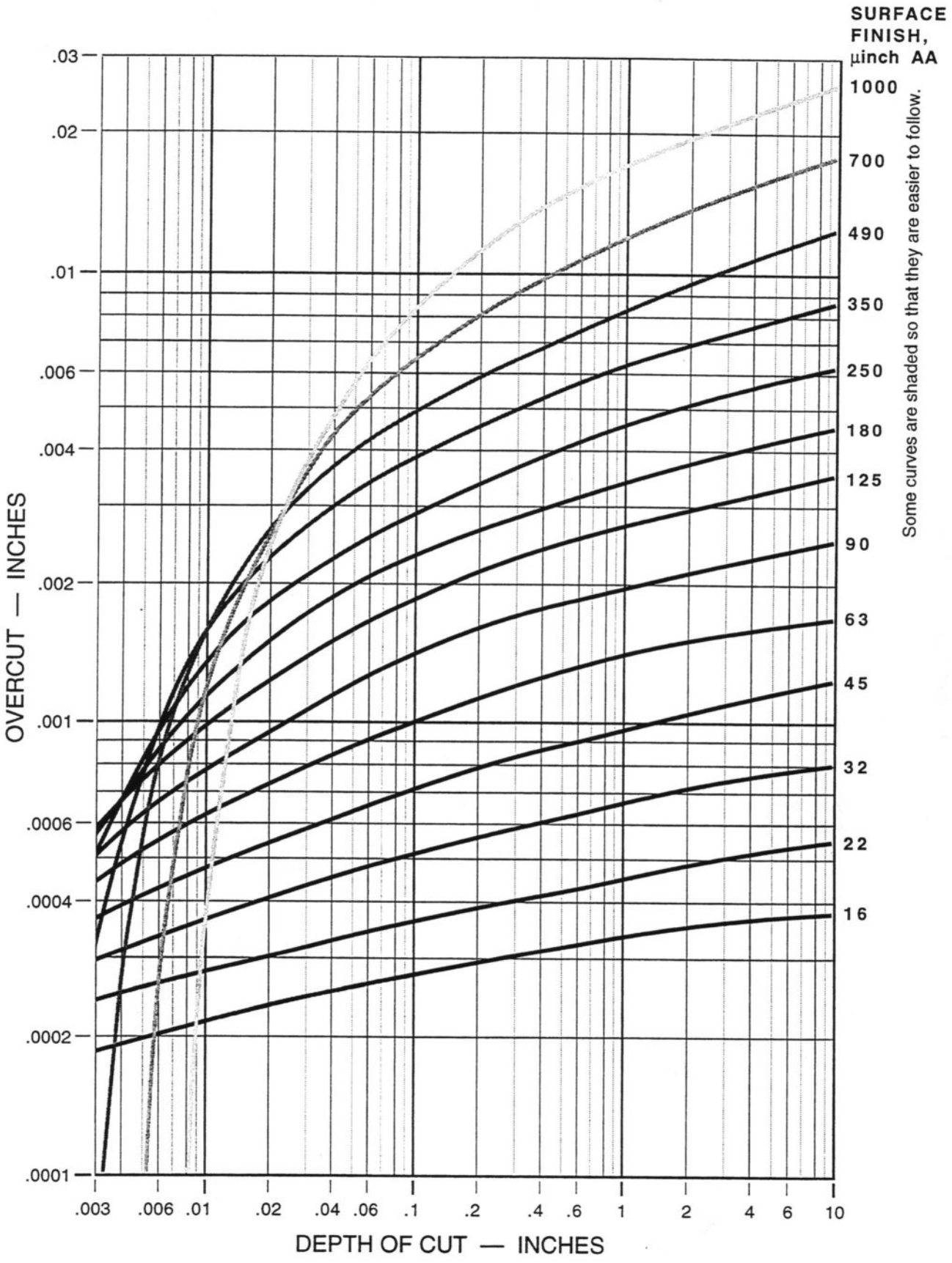
Graph C, Maximum Average Amps 4.4.2
Graph F, Overcut Taper, Pressure Flush.....4.4.3
Graph G, Overcut Taper, Vacuum Flush.....4.4.4

Graphs C, F and G pertain to all electrode/material combinations. Graph C provides the maximum %On-time based on peak amps and average amps. Graphs F and G are overcut taper graphs, where overcut can be determined according to finish and depth of cut. Graph F relates overcut to pressure flush applications, and Graph G to vacuum flush applications.

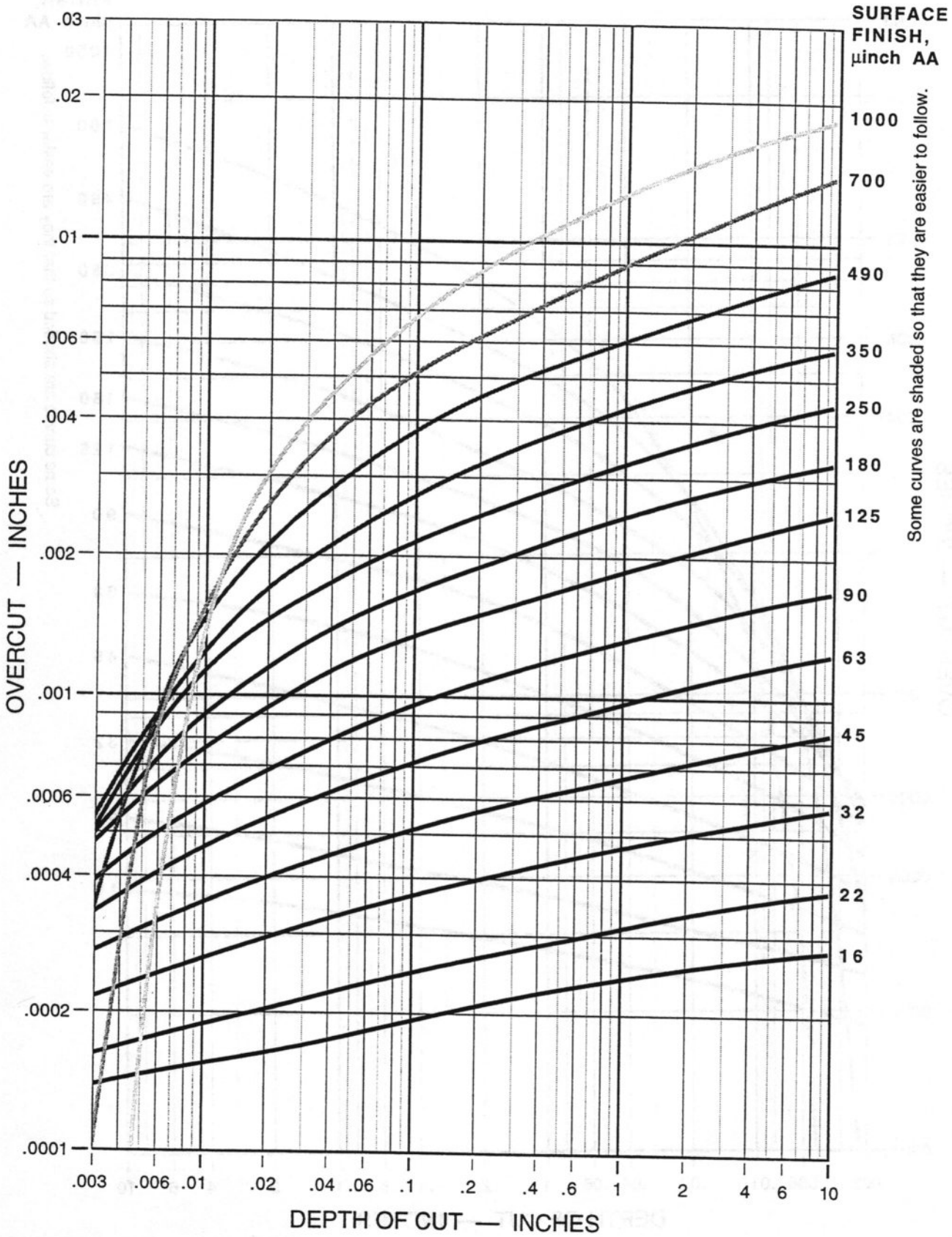
GRAPH C. MAXIMUM AVERAGE AMPS



GRAPH F. OVERCUT TAPER, PRESSURE FLUSH



GRAPH G. OVERCUT TAPER, VACUUM FLUSH



SECTION 4.6

QUICK REFERENCE TABLES
for
M-PULSE EDM POWER SUPPLY SETTINGS

Introduction . . . . . Page 4.6.2

Table of Chart & Page Numbers:

WORKPIECE MATERIAL		*ELECTRODE MATERIAL* Graphite	Copper Graphite	Copper	Copper Tungsten	Steel	Tungsten Carbide Tube	Copper Tube
STEEL	Low wear	**#3; 4.6.3A,B,C**	#6: 4.6.6	**#9; 4.6.9**	#11: 4.6.11			
	Fast	**#4; 4.6.4**	#7: 4.6.7		#12: 4.6.12			
	Fast & Fine	**#5; 4.6.5**	#8: 4.6.8		#13: 4.6.13			
	Fine			**#10; 4.6.10**				
						#14: 4.6.14	#15: 4.6.15	#16; 4.6.16
ALUMINUM	Low wear	**#19; 4.6.19**		#21: 4.6.21				
	Fast & Fine	**Use #19**						
	Fine			#22: 4.6.22				
								#23; 4.6.23
CARBIDE			**#27; 4.6.27**		**#28; 4.6.28**			#29: 4.6.29
300 S.S.	Low wear	#31; 4.6.31						
	Fast	#32; 4.6.32						
400 S.S.	Low wear	#33; 4.6.33						
	Fast	#34; 4.6.34						
INCONEL		#35; 4.6.35		#36: 4.6.36				
AMPCOLOY		#39; 4.6.39						
TITANIUM	Fast & Fine	#41; 4.6.41		#42: 4.6.42				

NOTE: Tables shown in Light Gray **are in process of being updated. They will be sent to you as soon as available. Please consult with the factory for the latest information and recommendations on these electrode/material combinations.**

INTRODUCTION

USING THE QUICK REFERENCE TABLES

The tables in this section are provided for your convenience as a quick reference of typical settings for common electrode and workpiece material combinations. In order to best apply the settings in the tables to your specific job, it is important that you understand the general information on this page as well as any specific notes that might appear with each table.

Maximum Average Amps and Peak Amps of M-Pulse Power Supplies

Model	Avg	Peak	Model	Avg	Peak
1025, 3025	25	75	1200, 3200	200	300
1050, 3050	50	150	1350, 3350	350	500
1100, 3100	100	150	1500, 3500	500	750

Relationships Between Parameters

- Cubic in = in^3 = cutting surface area x depth of cut.
- Cutting time = in^3 to be removed ÷ in^3/hr.
- Average amps — see separate Graph C in Section 4.4.
- Overcut — see separate Overcut Graphs F & G in Section 4.4.
- Electrode %wear = electrode end wear ÷ cut depth.

IMPORTANT GUIDELINES

The Quick Reference Tables are provided only as general guidelines. They were established under the conditions of electrode, workpiece and settings specified. Results can vary due to many factors. If specific surface finishes or estimates of cutting times are required, it is recommended that you make representative tests of your job. This should become less necessary as you gain experience.

Actual electrode size, grade of material and size and location of flushing holes can have considerable effect on cutting results. The electrode geometry and sizes used in these examples do not necessarily represent the optimum dimensions for maximum metal removal rates or best possible finish in every case. They were chosen as typical examples that can be used as good starting points for making further calculations and tests.

For fine-finish cuts (≤ 90 μinch Ra), the electrode surface is polished so that the workpiece finish is the result of the EDM parameters and not roughness of the electrode surface finish. Depth of cut is greater than the deepest crater for the indicated finish to assure true surface finish measurement. On all EDM cuts, the electrode surface finish is finer than the expected workpiece surface finish. Workpiece surfaces are finish-ground before EDMing to assure that the EDMed finish is the result of only the EDM process. Surface finish is measured using a Taylor-Hobson Surtronic 3+ diamond stylus profilometer.

Flushing pressure is at 2 psi through the electrode unless otherwise noted. Pressure is monitored and adjusted as needed to compensate for changes in geometry of the cutting area during the EDM cut. A stand-tube is recommended to regulate very low PSI flushing. Ram cycle flushing is less efficient than pressure flushing and lower metal removal rate is expected. Using a chiller to reduce the dielectric temperature will result in better metal removal rate and repeatability.

The arc duration used is a value determined for best metal removal rate and surface finish at a given peak amp setting. GAP and SERVO settings were adjusted for maximum efficiency. Arc durations other than those listed might produce better removal rates and/or finishes, depending on electrode geometry, gap spacing, servo speed, and other factors.

Electrode corner wear will be higher than end wear due to the additional material removed at the sharp edges of the electrode.

See also *The EDM Dictionary* by Hansvedt for definitions of terms.

QUICK REFERENCE TABLE #3A

GRAPHITE INTO STEEL - LOW WEAR
0.25 in ^{2} Surface Area

GENERAL

Electrode material:	Poco EDM-3	Generator:	M-Pulse
Max. amps/in^2	50	Polarity:	Positive
Electrode size:	.5" x .5"	Depth of cut, > 350 μinch:	.2"
Electrode wear:	≤ 1%	Depth of cut, 250–350 μinch:	.1"
Workpiece:	01 Steel	Depth of cut, < 250 μinch:	.05"
Flushing:	Pressure, 4psi		
Flush hole:	0.125" dia.		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
600	.005	.325	13.2	45	10	150	PLGST600
500	.0044	.3	8.75	45	15	100	PLGST500
350	.003	.175	5	45	20	32	PLGST350
250	.002	.025	1.6	51	20	11	PLGST250
180	.0015	.0063	.69	51	20	6	PLGST180
150	.0011	.0035	.5	51	17.5	5	PLGST150
125	.0008	.002	.31	51	12	4	PLGST125
63	.0006	Note 2	.1	51	6	3	PLGST063
45	.0004	Note 2	.06	51	6	2	PLGST045

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 125 Ra, low wear was achieved with less consideration for metal removal rate.

QUICK REFERENCE TABLE #3B

GRAPHITE INTO STEEL - LOW WEAR
1 in^2 Surface Area

GENERAL

Electrode material:	Poco EDM-3
Max. amps/in^2	50
Electrode size:	1" x 1"
Electrode wear:	≤ 1%
Workpiece:	01 Steel
Flushing:	Pressure, 4psi
Flush hole:	0.25" dia.

Generator:	M-Pulse
Polarity:	Positive
Depth of cut, > 350 μinch:	.2"
Depth of cut, 250–350 μinch:	.1"
Depth of cut, < 250 μinch:	.05"

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
600	.005	1.3	53	45	40	150	PLGST600
500	.0044	1.2	35	45	60	100	PLGST500
350	.003	.7	20	45	90	32	PLGST350
250	.002	.1	6.5	51	90	11	PLGST250
180	.0015	.025	2.75	51	90	6	PLGST180
150	.0011	.014	2	51	70	5	PLGST150
125	.0008	.008	1.25	51	50	4	PLGST125
63	.0006	Note 2	.4	51	25	3	PLGST063
45	.0004	Note 2	.25	51	25	2	PLGST045

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 125 Ra, low wear was achieved with less consideration for metal removal rate.

QUICK REFERENCE TABLE #3C

GRAPHITE INTO STEEL - LOW WEAR
4 in² Surface Area

GENERAL

Electrode material:	Poco EDM-3	Generator:	M-Pulse
Max. amps/in²	50	Polarity:	Positive
Electrode size:	2" x 2"	Depth of cut, > 350 μinch:	.2"
Electrode wear:	≤ 1%	Depth of cut, 250–350 μinch:	.1"
Workpiece:	01 Steel	Depth of cut, < 250 μinch:	.05"
Flushing:	Pressure, 4psi		
Flush hole:	0.25" dia.		

RESULTS				SETTINGS			
Surface Finish μinch Ra	**Crater Depth, inches**	**Cubic Inches per Hour**	**Average amps**	**Arc Duration** μsec	**Percent On-time** %	**Peak Amps**	**Power File Code**
800	.007	1.3	53	200	40	150	PLGST800
650	.006	1.2	35	125	60	100	PLGST650
350	.004	.7	20	75	90	32	PLGST350
250	.0018	.1	6.5	65	90	11	PLGST250
180	.0015	.025	2.75	51	90	6	PLGST180
150	.0011	.014	2	51	70	5	PLGST150
125	.0007	.008	1.25	45	50	4	PLGST125
63	.0005	Note 2	.4	38	25	3	PLGST063
45	.0004	Note 2	.25	38	25	2	PLGST045

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 125 Ra, low wear was achieved with less consideration for metal removal rate.

QUICK REFERENCE TABLE #4

GRAPHITE INTO STEEL - FAST

GENERAL

Electrode material:	Poco EDM-3	Flush hole:	0.25" dia.
Max. amps/in^2	25	Generator:	M-Pulse
Electrode size:	1" x 1"	Polarity:	Negative
Electrode wear:	15% to 25%	Depth of cut, > 250 μinch:	0.1"
Workpiece:	01 Steel	Depth of cut, ≤ 250 μinch:	.01" to .05"
Flushing:	Pressure, 2psi		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
1000	.0070	1.5	30	125	25	150	NNGST999
800	.0056	1.4	25	87	25	125	NNGST800
650	.0046	1.2	20	75	25	100	NNGST650
550	.0039	.86	15	38	25	75	NNGST550
350	.0025	.31	5.8	33	25	29	NNGST350
250	.0018	.17	4.1	25	25	17	NNGST250
180	.0013	.023	.7	22	25	3	NNGST180
150	.0011	.011	.4	22	25	2	NNGST150
125	.0009	.006	.3	19	25	1.5	NNGST125
90	.0006	.003	.2	10	25	1	NNGST090

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.

QUICK REFERENCE TABLE #5

GRAPHITE INTO STEEL - FAST & FINE

GENERAL

Electrode material:	Poco EDM-3	Flush hole:	0.25" dia.
Max. amps/in^2	25	Generator:	V-Pulse
Electrode size:	1" x 1" (Note 3)	Polarity:	Negative
Electrode wear:	20% to 45%	Depth of cut, > 90 μinch:	.010"
Workpiece:	01 Steel	Depth of cut, ≤ 90 μinch:	.002"
Flushing:	Pressure, 2 psi		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
125	.001	.3	10	6	70	17	NFGST125
90	.0007	.09	5	4	70	8	NFGST090
63	.0005	.007	.5	3.2	70	1	NFGST063
45	.0003	Note 2	.3	2	50	1	NFGST045
32	.00022	Note 2	.2	1	30	1	NFGST032
16	.00016	Note 2	.1	.3	20	1	NFGST016

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. Results were achieved with less consideration for metal removal rate.
3. For finishes under 90 Ra, electrode size was .375" diameter.
4. Ram cycling was used with pressure flushing for best metal removal rate.

QUICK REFERENCE TABLE #9

COPPER INTO STEEL - LOW WEAR

GENERAL

Electrode material:	Copper	Flushing:	Ram cycling
Max. amps/in^2:	50	Generator:	M-Pulse
Electrode size:	3/8" dia.	Polarity:	Positive
Electrode wear:	≤ 1%	Depth of cut:	Note 3
Workpiece:	01 Steel		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
500	.003	.030	1.5	300	25	17	PLCST500
350	.0023	.015	.8	175	25	8	PLCST350
250	.002	.011	.6	150	25	6	PLCST250
180	.0016	.005	.55	125	25	5	PLCST180
125	.0009	.0009	.4	100	25	4	PLCST125
90	.0008	Note 2	.27	75	25	3	PLCST090

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For 90 Ra finish, low wear was achieved with less consideration for metal removal rate.
3. Depth of cut ranged from .1" to .2" to determine cutting rate and end wear, and from .005" to .010" to determine surface finishes.
4. Spray flushing from one side with ram cycling was used.
5. Higher cubic inches per hour can be achieved with low pressure flushing through the electrode or workpiece.

QUICK REFERENCE TABLE #10

COPPER INTO STEEL — FINE

GENERAL

Electrode material:	Copper	Flush hole:	
Max. amps/in^2	50	Generator:	V-Pulse
Electrode size:	3/8" dia.	Polarity:	Negative
Electrode wear:	Note 3	Depth of cut, ≥ 45 μinch:	0.002"
Workpiece:	01 Steel	Depth of cut, < 45 μinch:	0.001"
Flushing:	Ram cycling		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
63	.0003	Note 2	.05	1.2	.5	14	NFCST063
45	.0003	Note 2	.035	.5	.3	14	NFCST045
32	.0002	Note 2	.01	.3	.2	14	NFCST032
16	.0001	Note 2		.1	.1	14	NFCST016

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. Results were achieved with less consideration for metal removal rate.
3. During fine-finishing, electrode wear can be high as a percentage of workpiece metal removed but small as an absolute measurement. For example, if electrode wear is 40% while fine-finishing to a depth of .001", dimensional wear is .0004".
4. Spray flushing from one side with ram cycling was used.
5. Higher cubic inches per hour can be achieved with low pressure flushing through the electrode or workpiece.

QUICK REFERENCE TABLE #19

GRAPHITE INTO ALUMINUM - LOW WEAR; GRAPHITE INTO ALUMINUM - FAST & FINE (Note 3)

GENERAL

Electrode material:	Poco EDM-3	Flush hole:	0.25" dia.
Max. amps/in^2	20	Generator:	M-Pulse
Electrode size:	1" x 1"	Polarity:	Positive
Electrode wear:	≤ 1%	Depth of cut, ≥ 180 µinch:	.100"
Workpiece:	Aluminum	Depth of cut, < 180 µinch:	.020"
Flushing:	Pressure, < 5 psi		

RESULTS				SETTINGS			
Surface Finish µinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration µsec	Percent On-time %	Peak Amps	Power File Code
1000	.0051	.97	15	125	50	50	PLGAL999
800	.0042	.83	10	100	50	32	PLGAL800
650	.0035	.77	9	87	50	29	PLGAL650
550	.003	.6	8	75	50	24	PLGAL550
350	.0022	.42	6.6	65	50	20	PLGAL350
250	.0017	.3	4.5	57	50	14	PLGAL250
180	.0013	.23	3.85	51	50	11	PLGAL180
125	.0008	.14	2.2	45	50	8	PLGAL125
90	.0006	.03	1	38	50	4	PLGAL090
63	.0005	Note 2	.75	33	50	3	PLGAL063
45	.0004	Note 2	.2	29	20	2	PLGAL045
32	.0003	Note 2	.07	29	10	1.5	PLGAL032

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 90 Ra, low wear was achieved with less consideration for metal removal rate.
3. Positive polarity achieves best metal removal rate, surface finish and lowest electrode wear. Negative polarity is not recommended for graphite into aluminum.

QUICK REFERENCE TABLE #27

COPPER GRAPHITE INTO CARBIDE

GENERAL

Electrode material:	Poco EDM-C3	Flush hole:	0.070" dia.
Max. amps/in^2:	40	Generator:	M-Pulse
Electrode size:	3/8" dia.	Polarity:	Negative
Electrode wear:	35-65%	Depth of cut, > 65 μinch:	.2"
Workpiece:	Carbide	Depth of cut, ≤ 65 μinch:	.1"
Flushing:	Pressure, 5-20psi		

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
250	.0014	.125	4	65	10	75	NNCGC250
180	.0012	.105	4	25	15	50	NNCGC180
150	.0011	.076	4	19	30	24	NNCGC150
125	.001	.062	4	14	25	24	NNCGC125
90	.0008	.051	4	12	45	14	NNCGC090
63	.0005	.02	1.6	12	45	5	NNCGC063
45	.0003	.006	.75	5	40	3	NNCGC045
32	.00025	Note 2	.45	5	40	2	NNCGC032
16	.0002	Note 2	.24	5	40	1	NNCGC016

NOTES

1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 45 Ra, results were achieved with less consideration for metal removal rate.

QUICK REFERENCE TABLE #28

COPPER TUNGSTEN INTO CARBIDE

GENERAL

Electrode material:	Copper tungsten	Flush hole:	.070" dia.
Max. amps/in^2:	80	Generator, > 5μs:	M-Pulse
Electrode size:	1/2" x 1/2"	Generator, ≤ 5μs:	V-Pulse
Electrode wear:	10–25%	Polarity:	Negative
Workpiece:	Carbide	Depth of cut, ≥ 90 μinch:	.100"
Flushing:	Pressure, 45 psi	Depth of cut, < 90 μinch:	.010"

RESULTS				SETTINGS			
Surface Finish μinch Ra	Crater Depth, inches	Cubic Inches per Hour	Average amps	Arc Duration μsec	Percent On-time %	Peak Amps	Power File Code
125	.001	.29	27	16	25	150	NNCWC125
90	.00065	.22	20	10	35	75	NNCWC090
63	.00051	.09	15	5	60	32	NNCWC063
45	.00045	.0005	1.5	2	30	8	NNCWC045
32	.0004	Note 2	.5	.5	20	8	NNCWC032

NOTES

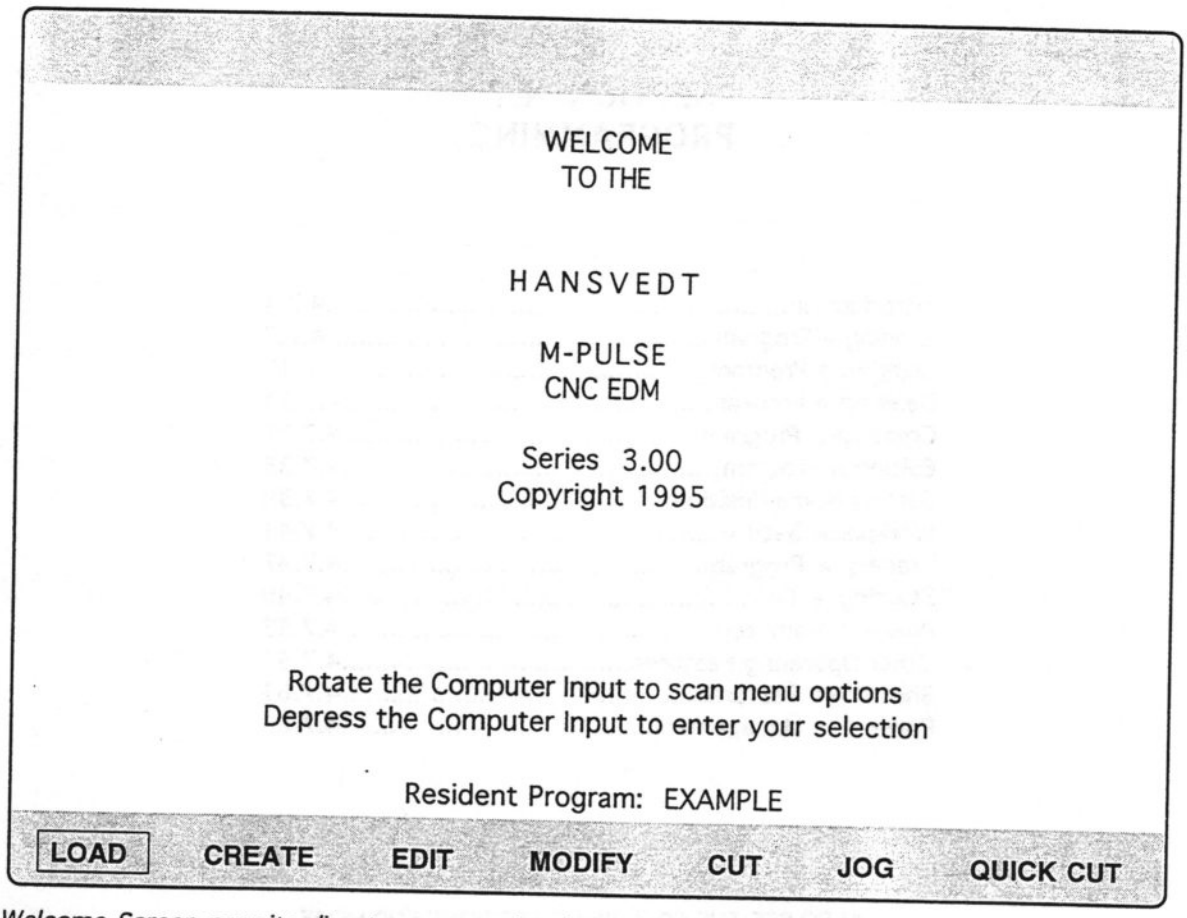
1. Refer to the IMPORTANT GUIDELINES on p. 4.6.2.
2. For finishes under 45 Ra, results were achieved with less consideration for metal removal rate.

SECTION 4.7
PROGRAMMING

Introduction.....4.7.1
Loading a Program.....4.7.7
Copying a Program.....4.7.13
Deleting a Program.....4.7.21
Creating a Program.....4.7.23
Editing a Program.....4.7.33
Setting Home Position.....4.7.39
Workpiece Set-Up.....4.7.41
Tracing a Program.....4.7.47
Starting a Cut.....4.7.49
Power Parameters.....4.7.53
Other Operating Features.....4.7.57
Shut Down Features.....4.7.61
Power File Management.....4.7.63

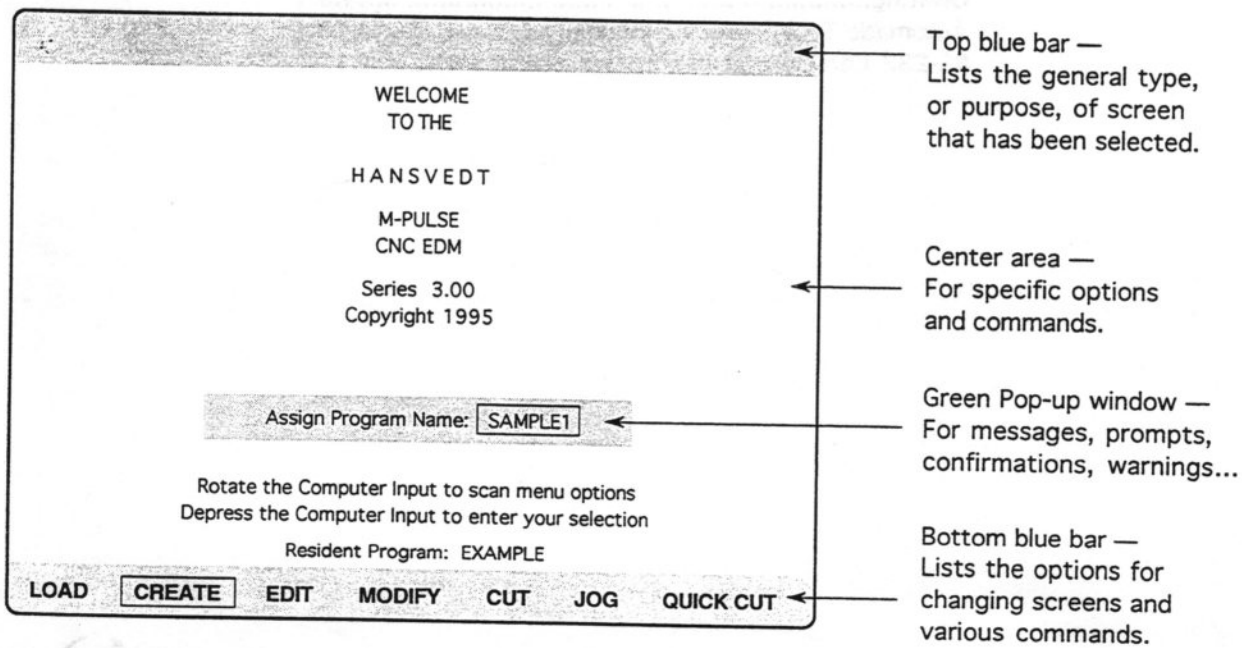
ALSO SEE THE FOLLOWING SECTIONS FOR MORE PROGRAMMING INSTRUCTIONS:

Quick Cut.....4.8.1
Orbiting.....4.9.1
Automatic Tool Changer (Optional).....4.10.1
RS-232 Communications Format Instructions.....4.11.1



The Welcome Screen permits direct access to Load, Create, Edit, Modify, Cut, Jog and Quick Cut Screens.

All screens consist of four basic areas:



Operation of the M-Pulse CNC control is extremely easy. Hansvedt's menu-based, internal software operating system uses a "Computer Input" (C.I.) knob and/or a numeric keypad to execute all of the CNC functions, eliminating the need to become familiar with computer codes.

The unique Hansvedt CNC software operating system allows the "mouse-like" C.I. knob to act as a cursor, a typewriter and a data input device at the appropriate times. In general, when a new screen is displayed, the knob controls a cursor, allowing the menu choices along the bottom of the screen to be selected. The cursor can be moved back and forth as desired, and the selection is made only when the knob is pressed and then released.

COMPUTER INPUT

The C.I. knob enables X, Y and Z part program entry, Z-motion control, power supply adjustments and servo adjustments. It has five movements:

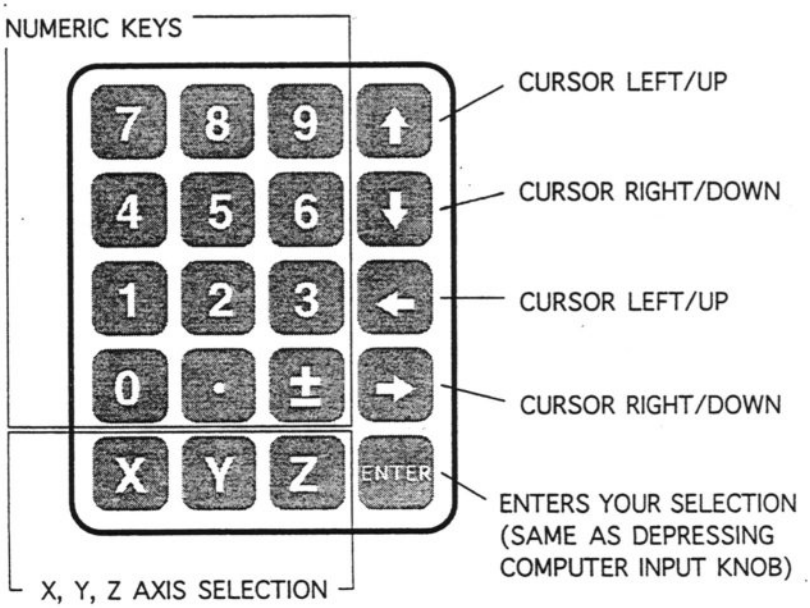
1. Rotate clockwise.
2. Rotate counterclockwise.
3. Press.
4. Press and rotate clockwise.
5. Press and rotate counterclockwise.

Several screens have the menu choice of EDIT SCREEN. When one of these choices is made, the C.I. knob now controls a cursor which moves up and down the screen, and pressing the knob will select that line for change.

When the line selected requires numeric input, rotation of the knob displays the appropriate choices. With the desired choice displayed, pressing the knob "locks in" that choice and automatically moves to the next digit. To correct a programming error, press the C.I. knob and rotate it to the position you wish to change. To advance through a digit without changing the entry, press the C.I. knob and rotate it clockwise to the position desired.

The computer will automatically present only those choices that are approved. When the line selected requires a name to be entered, all letters and numbers are made available by rotation of the knob. Other than the availability of letters, the knob operation is the same as for data input.

To cancel an entry without completing the entry, press and rotate the C.I. knob until the cursor returns to the lower menu. This digit selection process allows the knob to act as the data input device.

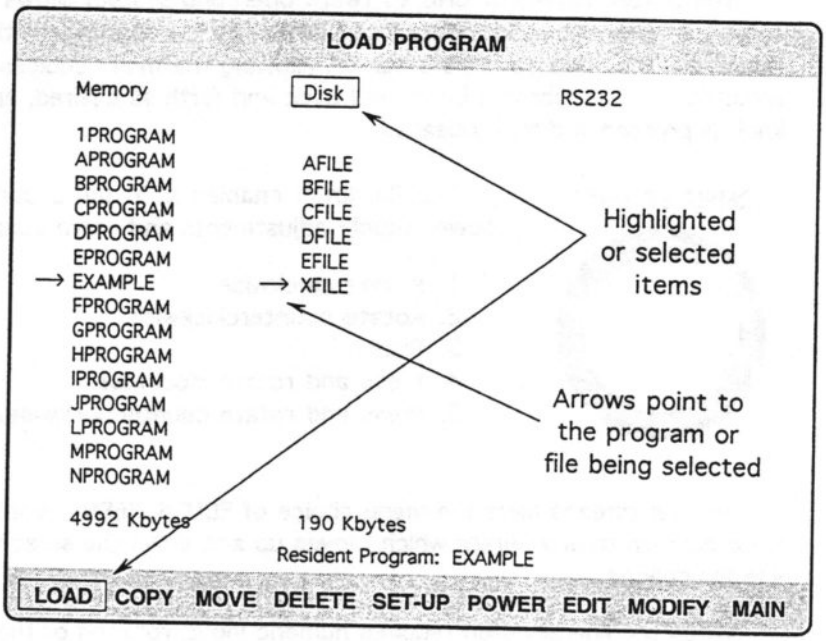


The numeric keypad provides another input system for part program entry, editing and jogging.

Note: Keypad and C.I. knob inputs can be used together.

Two types of screen illustrations are used with the text in the programming sections that follow — full screen and partial screen.

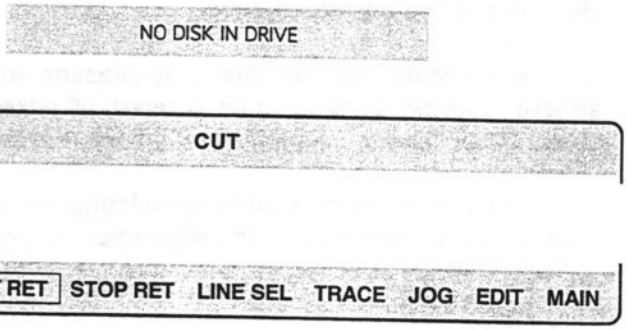
When only a few steps need to be shown and space permits, a full screen is illustrated.



In the actual screens on the M-Pulse monitor, items that have been selected are highlighted in different ways.

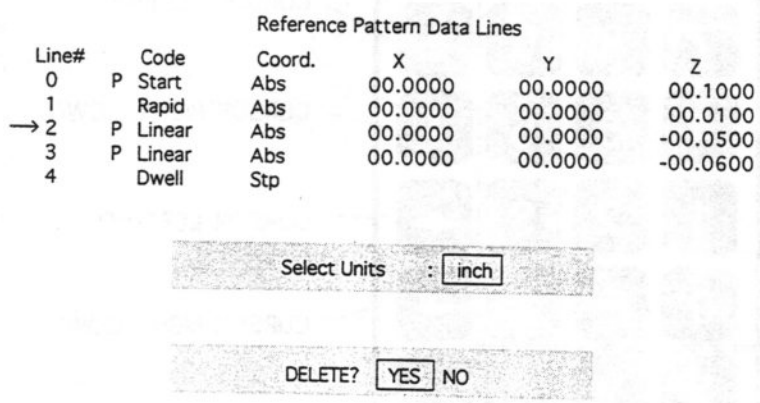
In the illustrations in this manual, selected or highlighted items will be pointed out by means of a rectangle around them.

When several steps need to be shown in sequence, only the parts of the screen having to do with those steps will be illustrated.



Many screens include a green pop-up message window which will appear when the control is fulfilling a command, such as "LOADING PROGRAM," or if an error occurs such as "NO DISK IN DRIVE."

OTHER MESSAGE window explanations are included in the sections of this manual in which they would apply.



Programming of the M-Pulse is possible at the machine, or the program can be developed on an off-line system and loaded into the M-Pulse through the RS-232-C port or the 3.5" disk drive. A program can be edited on the M-Pulse control whether or not the program was created at the machine or off-line. Programs can also be transferred between MS-4's via the RS-232-C port or the 3.5" disk drive.

Programming is not possible while the M-Pulse is cutting.

When you have finished using a program it will remain resident until another program is created or loaded. The resident program, programs in memory and other power parameters will not be lost if the machine is turned off or if a power interruption occurs.

The following is a typical operating sequence, from turning on the machine to EDM'ing:

1. Turn Main Power Switch on (up). Wait for short beep.
2. Press MACHINE ON.
3. Create or load a program.
4. Home the machine.
5. Trace the program with the electrode clear of the workpiece.
6. Mount and align the workpiece and electrode.
7. Establish the start point.
8. Record XYZ start point position.
9. Enter POWER PARAMETERS if they are not included in your program.
10. Fill the tank.
11. Press GAP POWER ON.
12. Set the flushing pressure.
13. Fine tune the %ON-TIME, SERVO SPEED, GAP ADJUST and FLUSHING settings.

Note: When the MACHINE ON button is pressed, if any of the machine tool axes have been moved during the time the machine was off (main power switch still on), the message "About to move X: nn.nnnn Y: nn.nnnn Z: nn.nnnn" will appear.

To return to original axis position(s), press the C.I. knob. Once movement has begun, the operator may allow the motion to continue until the position is reached or abort the move by pressing the C.I. knob a second time. In either case, the message will disappear and cursor control will be returned to the bottom menu.

LOADING A PROGRAM

Programs can be loaded from memory, a 3.5 inch disk drive or an outside device via the RS-232.

LOADING FROM MEMORY

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select LOAD from the bottom menu. The message SELECT WHERE TO LOAD FILE FROM appears.

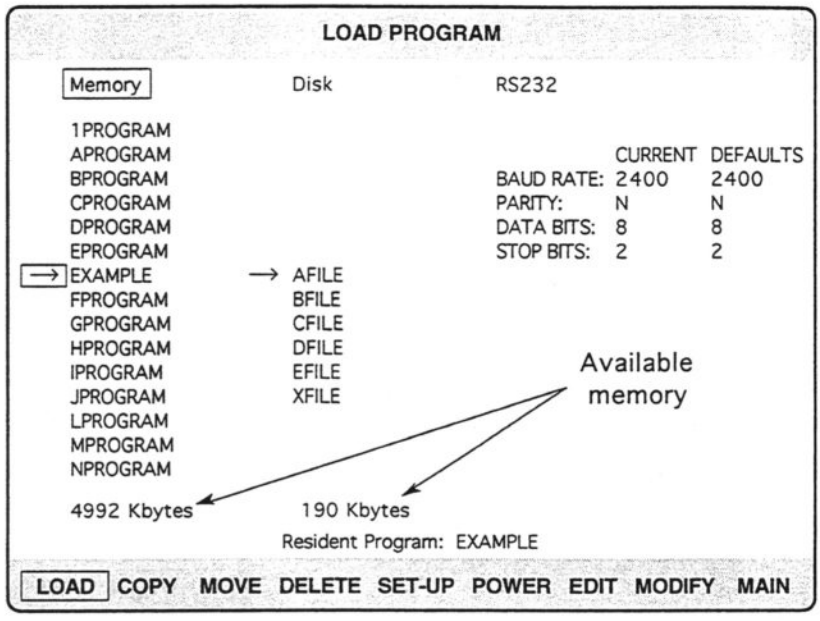
Note: Programs are stored and listed in numeric-alpha order: 1, 2, 3... followed by A, B, C....

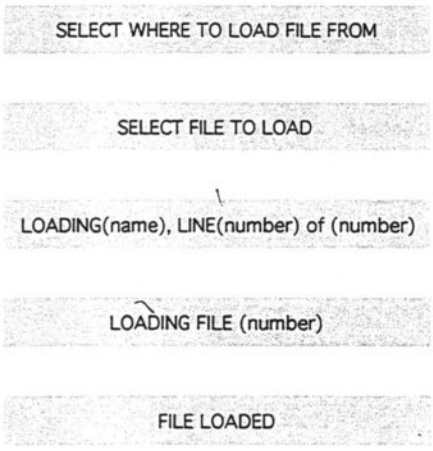
- Position the cursor on MEMORY and select it. The message SELECT FILE TO LOAD appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired program with the arrow.
- Press the C.I. knob to load the program. The messages

LOADING(name), LINE(number) of (number),
LOADING FILE (number)
and FILE LOADED

appear in sequence. The selected program then appears as the Resident Program.

NOTE: To abort during any step of LOAD, press GAP OFF.





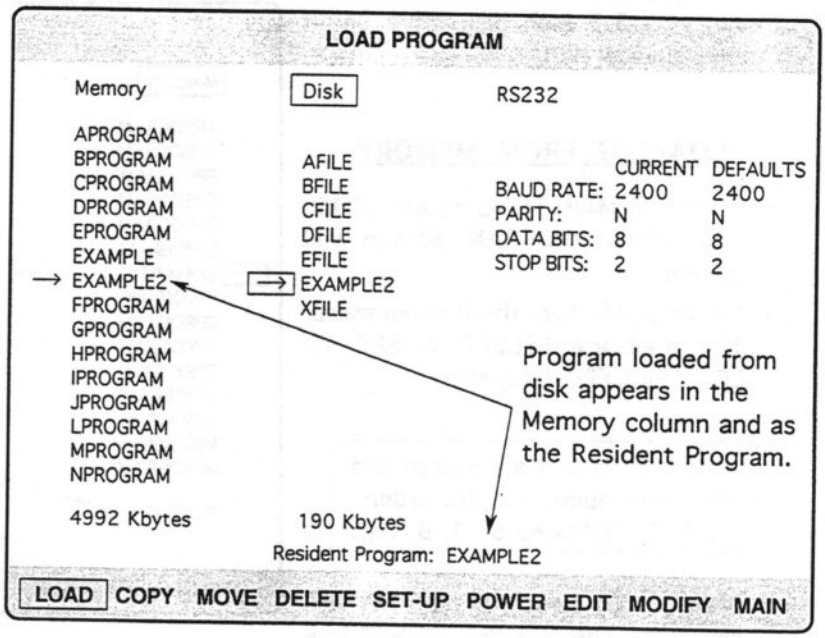
LOADING FROM DISK

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select LOAD from the bottom menu. The message SELECT WHERE TO LOAD FILE FROM appears.
- Position the cursor on DISK and select it. The message SELECT FILE TO LOAD appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired program with the arrow.
- Press the C.I. knob to load the program. The messages

LOADING(name), LINE(number) of (number),
LOADING FILE (number)
and FILE LOADED

appear in sequence. The selected program then appears in the Memory column and as the Resident Program.

NOTE: To abort during any step of LOAD, press GAP OFF.



SELECT WHERE TO LOAD FILE FROM

SELECT FILE TO LOAD

LOADING(name), LINE(number) of (number)

LOADING FILE (number)

FILE LOADED

If an attempt is made to load a program from disk with the same name as a program already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the program currently in memory with the program on disk, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

Then the messages

LOADING(name), LINE(number) of (number),
LOADING FILE (number)
and FILE LOADED

appear in sequence.

To rename the program you are trying to load, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILE NAME: _ _ _ _ _ _ _ _

will appear. Enter a new program name using the C.I. knob. Then the messages

LOADING(name), LINE(number) of (number),
LOADING FILE (number)
and FILE LOADED

appear in sequence.

SKIP is used only with multiple program COPY and MOVE functions. See "Copying a Program" Section.

OVERWRITE RENAME [SKIP] ABORT

To cancel the loading process select ABORT:

OVERWRITE RENAME SKIP [ABORT]

LOADING FROM RS-232

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select LOAD from the bottom menu. The message SELECT WHERE TO LOAD FILE FROM appears.
- Position the cursor on RS-232 and select it. The message

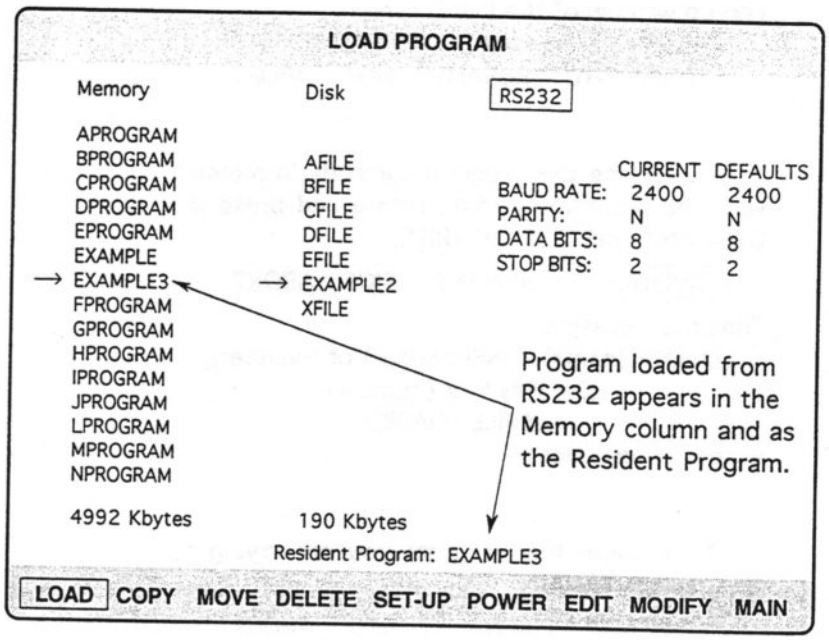
  ENTER FILENAME: _ _ _ _ _ _ _ _

  appears.
- Using the C.I. knob, enter the name you want to assign to the file you will be receiving from the host computer. Entering a space or the eighth digit will finalize the entry of the name. The message SERIAL PORT READY will appear.
- Begin transmitting from the host computer. The messages

  LOADING(name), LINE(number),
  LOADING FILE (number)
  and FILE LOADED

  appear in sequence. The message REMOTE TRANSFER COMPLETE will appear and the program will appear in the Memory column and as the Resident Program.

NOTE: To abort during any step of LOAD, press GAP OFF.



SELECT WHERE TO LOAD FILE FROM

ENTER FILE NAME: _ _ _ _ _ _ _ _

SERIAL PORT READY

LOADING(name), LINE(number)

LOADING FILE (number)

FILE LOADED

REMOTE TRANSFER COMPLETE

If an attempt is made to load a program from RS-232 with the same name as a program already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the program currently in memory with the program on RS-232, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

Then the messages

LOADING (name), LINE (number),
LOADING FILE (number)
and FILE LOADED

appear in sequence.

To rename the program you are trying to load, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new program name using the C.I. knob. Then the messages

LOADING(name), LINE(number),
LOADING FILE (number)
and FILE LOADED

appear in sequence.

SKIP is used only with multiple program COPY and MOVE functions. See "Copying a Program" Section.

OVERWRITE RENAME [SKIP] ABORT

To cancel the loading process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

OTHER MESSAGES

LOAD Screen

CHECKING DISK DRIVE.

ERROR: NO DISK IN DRIVE.

ERROR: UNEXPECTED DISK ERROR.

REMOTE TRANSFER TERMINATED.

REMOTE TRANSFER COMPLETE.

SERIAL PORT READY.

FORMATTING DISK.

FORMAT COMPLETE.

ERROR: FILE NAME ALREADY EXISTS.

ERROR: INSUFFICIENT MEMORY.

ERROR: DISK WAS REMOVED.

ERROR: FILE IS WRITE PROTECTED.

ERROR: DISK IS WRITE PROTECTED.

CAN'T COPY FROM RS-232 TO RS-232.

COPYING A PROGRAM

Programs can be copied between memory, a 3.5 inch disk or an outside device via the RS-232. This feature is useful to install disk or RS-232 programs into memory. It is also a convenient way to change a program name.

Power parameter files can also be copied between memory, disk or RS-232. See Power File Management Section. Copying programs and/or power files is especially useful for using existing files as "templates" for new programs, thus saving the work of creating a new program from scratch. When the existing file is copied with a new name, the original file remains untouched, and the new program can be edited to conform to a new job.

MOVING A PROGRAM

NOTE: Moving a program or power file is the same as copying, except that the original file is deleted from either memory or disk, whichever it came from. To move a file, select MOVE instead of COPY from the bottom menu. After the file is successfuly moved, the original file will automatically be deleted.

For specific copying instructions, see the following pages:

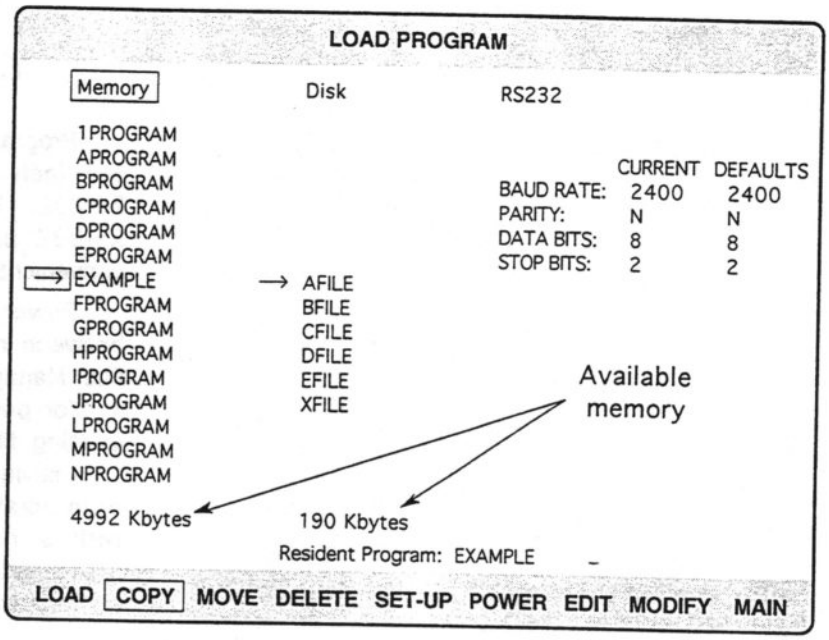
Copying From Memory 4.7.14
Copying From Disk 4.7.16
Copying From RS-232 ..... 4.7.18

COPYING FROM MEMORY

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.

> Note: Programs are stored and listed in numeric-alpha order: 1, 2, 3... followed by A, B, C...

- Position the cursor on MEMORY and select it. The message SELECT START OF GROUP OF FILES TO COPY appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired program (or the first or last program of a group) with the arrow.
- Press the C.I. knob to select the program. The message SELECT END OF GROUP OF FILES TO COPY appears.
- To copy one program, press the C.I. knob. The message SELECT WHERE TO COPY FILES TO appears.
- To select a group of programs, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message SELECT WHERE TO COPY FILES TO appears.



SELECT WHERE TO COPY FILES FROM

SELECT START OF GROUP OF FILES TO COPY

SELECT END OF GROUP OF FILES TO COPY

SELECT WHERE TO COPY FILES TO

> NOTE: To abort during any step of COPY or MOVE, press GAP OFF.

To copy to memory:

- Select MEMORY. (This is a way to rename a program that already exists and use it as a template for a new program.) The message
  ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _
  appears.
- Enter a new name using the C.I. knob. The messages
  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED
  appear in sequence. If a group of programs was selected, repeat the above sequence for each program. The newly named and copied program(s) will appear in the Memory column.

ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _

COPYING(name), LINE(number) of (number)

COPYING FILE (number)

FILES COPIED

To copy to disk:

- Select DISK. The messages

  COPYING(name), LINE(number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence.

If an attempt is made to copy a program with the same name as a program already in the disk, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the program currently in the disk with the program in memory, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To rename the program you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new program name using the C.I. knob. Then the messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To advance to the next file in a group without copying the file currently shown, select SKIP:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

To copy to RS-232:

- Select RS232. The message

  PRESS C.I. KNOB TO BEGIN TRANSFERRING _ _ (name) _ _

  will appear.
- Prepare the host computer to receive the program.
- Press the C.I. knob to begin the transfer. The messages

  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. If a group of programs was selected, repeat the above sequence for each program.

NOTE

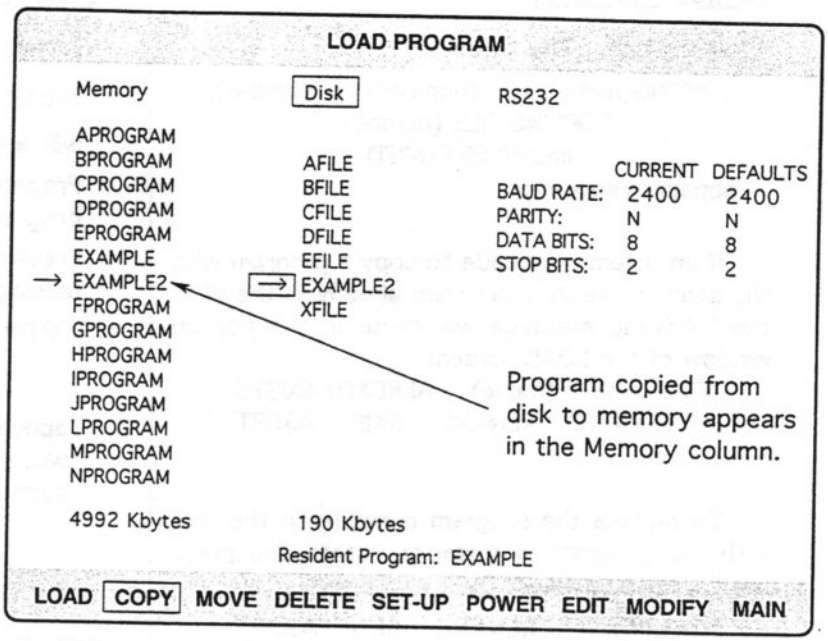
If you have selected MOVE in the bottom menu, the messages will read "MOVE" instead of "COPY." The program (or file) will be copied to the destination you have chosen, and the original program (or file) will automatically be deleted after successful completion of the move.

COPYING FROM DISK

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.

> Note: Programs are stored and listed in numeric-alpha order: 1, 2, 3... followed by A, B, C...

- Position the cursor on DISK and select it. The message SELECT START OF GROUP OF FILES TO COPY appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired program (or the first or last program of a group) with the arrow.
- Press the C.I. knob to select the program. The message SELECT END OF GROUP OF FILES TO COPY appears.
- To copy one program, press the C.I. knob. The message SELECT WHERE TO COPY FILES TO appears.
- To select a group of programs, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message SELECT WHERE TO COPY FILES TO appears.



SELECT WHERE TO COPY FILES FROM

SELECT START OF GROUP OF FILES TO COPY

SELECT END OF GROUP OF FILES TO COPY

SELECT WHERE TO COPY FILES TO

> NOTE: To abort during any step of COPY or MOVE, press GAP OFF.

To copy to disk:

- Select DISK. (This is a way to rename a program that already exists and use it as a template for a new program.) The message
  ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _
  appears.
- Enter a new name using the C.I. knob. The messages
  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED
  appear in sequence. If a group of programs was selected, repeat the above sequence for each program.

ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _

COPYING(name), LINE(number) of (number)

COPYING FILE (number)

FILES COPIED

To copy to memory:

- Select MEMORY. The messages

  COPYING(name), LINE(number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. The newly named and copied program will appear in the Memory column.

If an attempt is made to copy a program from disk with the same name as a program already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the program currently in memory with the program on disk, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To rename the program you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new program name using the C.I. knob. Then the messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To advance to the next file in a group without copying the file currently shown, select SKIP:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

To copy to RS-232:

- Select RS232.
- Press the C.I. knob to begin the transfer. The messages

  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. If a group of programs was selected, repeat the above sequence for each program.

NOTE

If you have selected MOVE in the bottom menu, the messages will read "MOVE" instead of "COPY." The program (or file) will be copied to the destination you have chosen, and the original program (or file) will automatically be deleted after successful completion of the move.

COPYING FROM RS-232

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.

> Note: Programs are stored and listed in numeric-alpha order: 1, 2, 3... followed by A, B, C...

- Position the cursor on RS232 and select it. The message

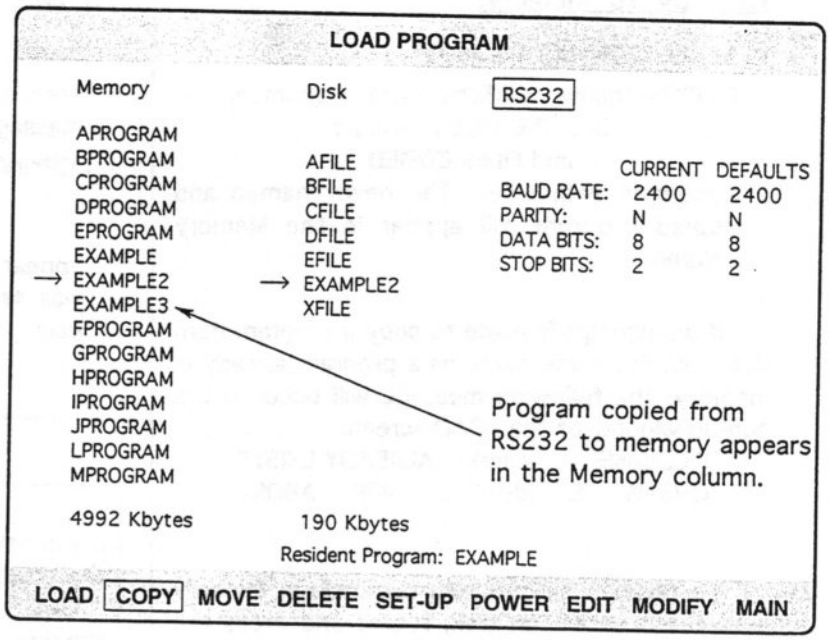
  ENTER FILENAME: _ _ _ _ _ _ _ _

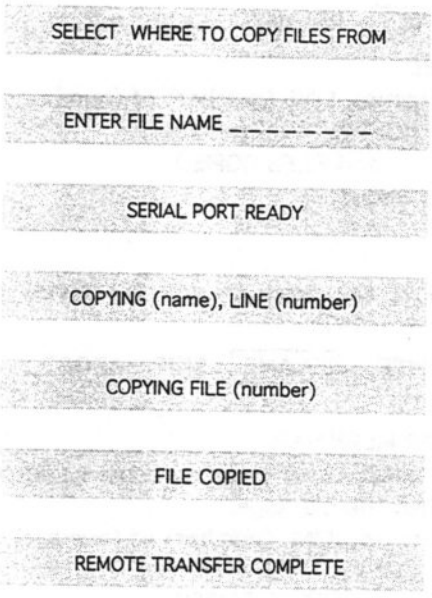
  appears.
- Using the C.I. knob, enter the name you want to assign to the file you will be receiving from the host computer. Entering a space or the eighth digit will finalize the entry of the name. The message SERIAL PORT READY will appear.
- Begin transmitting from the host computer. The messages

  COPYING (name), LINE (number),
  COPYING FILE (number)
  and FILE COPIED

  appear in sequence. The message REMOTE TRANSFER COMPLETE will appear and the program will appear in the Memory column.

> NOTE: To abort during any step of COPY or MOVE, press GAP OFF.





If an attempt is made to copy a program with the same name as a program already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the program currently in memory with the program to be transferred, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number),
COPYING FILE (number)
and FILE COPIED

will appear in sequence.

To rename the program you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new program name using the C.I. knob. Then the messages

COPYING (name), LINE (number),
COPYING FILE (number)
and FILE COPIED

will appear in sequence.

SKIP is used only with multiple program COPY and MOVE functions:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

OTHER MESSAGES

LOAD Screen

CHECKING DISK DRIVE.

ERROR: NO DISK IN DRIVE.

ERROR: UNEXPECTED DISK ERROR.

REMOTE TRANSFER IN PROGRESS.

REMOTE TRANSFER TERMINATED.

REMOTE TRANSFER COMPLETE.

SERIAL PORT READY.

FORMATTING DISK.

FORMAT COMPLETE.

ERROR: FILE NAME ALREADY EXISTS.

ERROR: INSUFFICIENT MEMORY.

ERROR: DISK WAS REMOVED.

ERROR: FILE IS WRITE PROTECTED.

ERROR: DISK IS WRITE PROTECTED.

CAN'T COPY FROM RS-232 TO RS-232.

DELETING A PROGRAM

Programs can be deleted from memory or a 3.5 inch disk. This feature is useful to remove unwanted programs.

Power parameter files can also be deleted from memory or disk. See Power File Management Section.

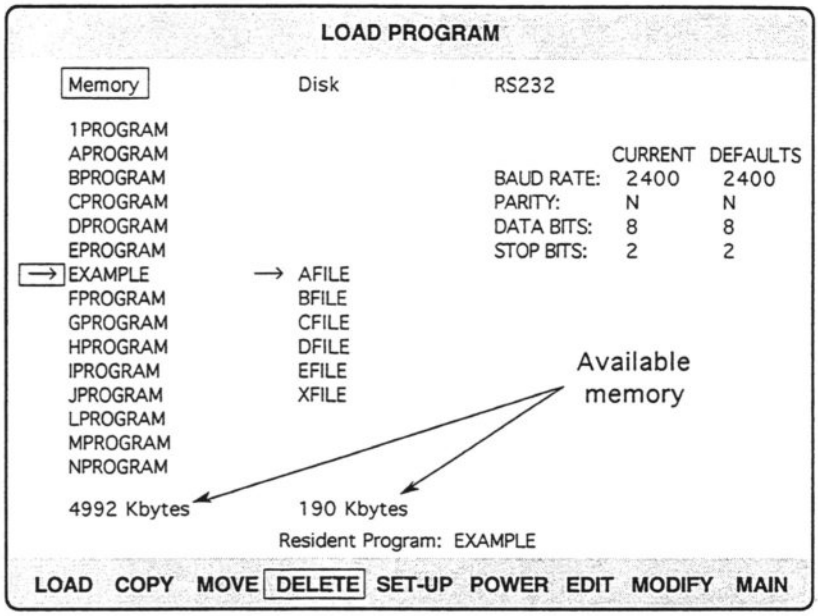
- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select DELETE from the bottom menu. The message SELECT WHERE TO DELETE FILES FROM appears.

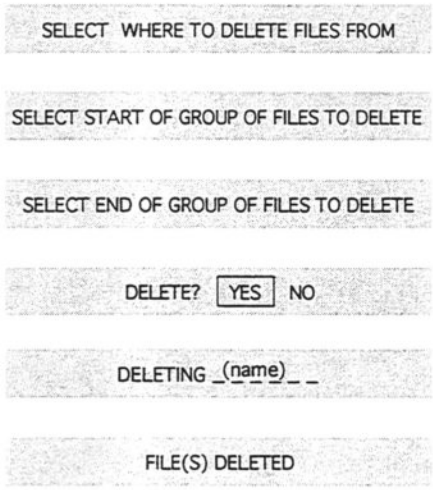
Note: Programs are stored and listed in numeric-alpha order: 1, 2, 3... followed by A, B, C...

- Position the cursor on MEMORY or DISK and select it. The message SELECT START OF GROUP OF FILES TO DELETE appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired program (or the first or last program of a group) with the arrow.
- Press the C.I. knob to select the program. The message SELECT END OF GROUP OF FILES TO DELETE appears.
- To delete one program, press the C.I. knob. The message DELETE? YES NO appears.
- To delete a group of programs, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message DELETE? YES NO appears.

NOTE
If you do not want to delete the program(s), select NO by rotating the C.I. knob and pressing it.

- To delete the program(s), select YES and press the C.I. knob. The messages DELETING(name) and FILE(S) DELETED appear.





NOTE
To abort during any step of DELETE, press GAP OFF.

NOTE
If you delete the program that is currently the Resident program, the Resident program name will change to "none."

CREATING A PROGRAM

Part programs, including power parameters, can be entered directly at the machine using the C.I. knob. They are automatically saved on a line-by-line basis. Although a graphic display of the pattern is not available on the monitor, movement can be verified by running the trace mode after the program has been completed.

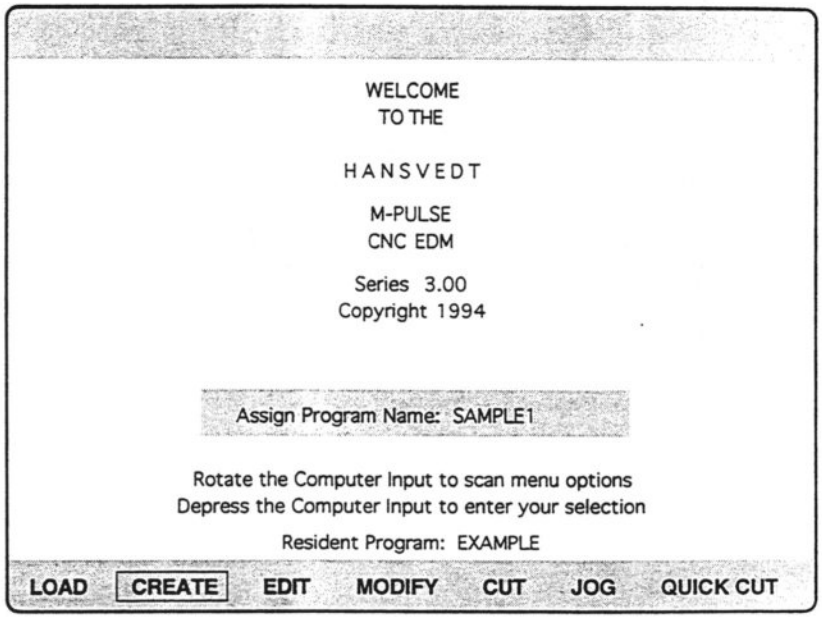
All editing features are available while creating a program. See EDITING A PROGRAM section for details.

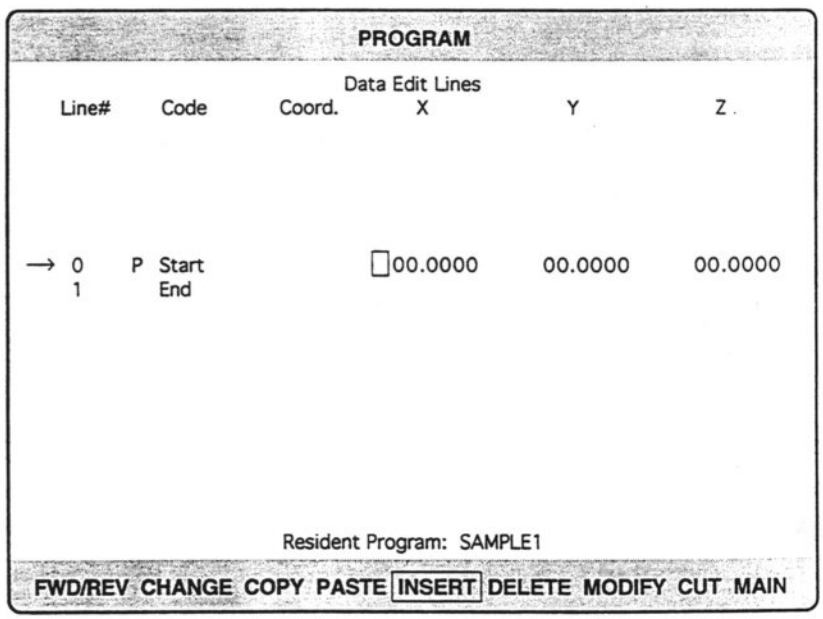
The M-Pulse program will accept P (power parameter), LINEAR, ZCYCLE, PAUSE, JUMP, RAPID, ORBIT, VECTOR, TRVECT, DWELL, GOTO, CW, CCW, and INDEX (optional) codes. START and END automatically appear at the beginning and end of every program.

- From the MAIN MENU select CREATE. ASSIGN PROGRAM NAME appears.
- Assign a program name by using the C.I. knob like a typewriter, entering one character at a time. Turning the knob will scroll the alphanumeric selections, and pressing the knob makes the entry. Names are limited to 8-characters. Spaces can only be used at the end of the name. "On-line" entry errors can be corrected by pressing the C.I. knob and rotating CCW to return to the character you wish to edit. Press the C.I. knob on a blank space or on the last character, and the program name will be assigned. Program names are saved in the directory in numerical alphabetical order.

> NOTE
> To exit this procedure press the C.I. knob and rotate it CCW; cursor will return to the lower menu.

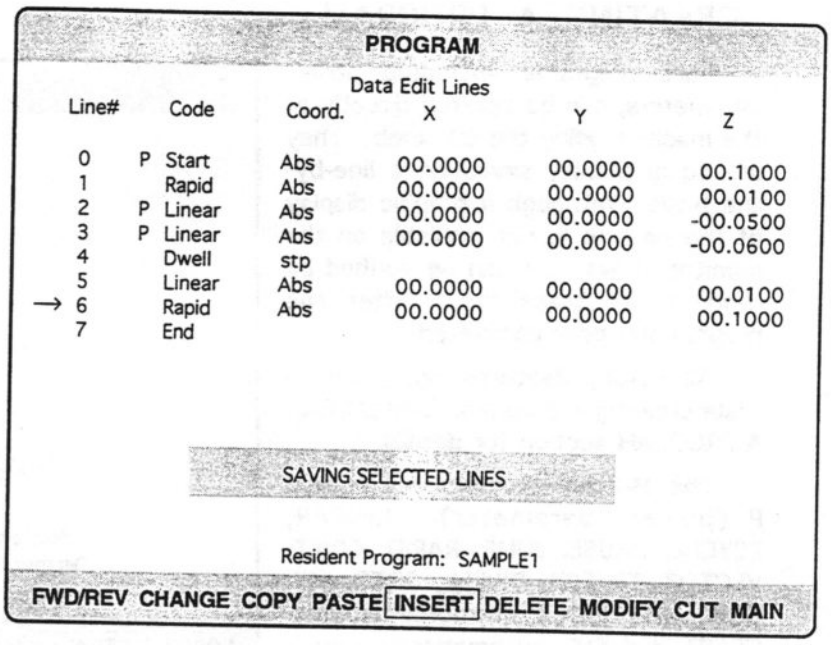
- Select INCH or METRIC. PROGRAM screen automatically appears with START and END line. The cursor appears at the X plus/minus position on the start line, and INSERT is highlighted on the lower menu.





> NOTE: It is not possible to enter programs while the machine is cutting.

- Begin PROGRAM entry by assigning a starting point.
- Rotate the C.I. knob to change the sign (+/-).
- Press the C.I. knob to select the sign. Cursor will move to the next position.
- Rotate the C.I. knob to desired value and press to select.
- Continue this entry method to the last digit in the Z column and check the line for accuracy before pressing the C.I. knob.



NOTE: To change any X, Y or Z value, +/- sign, code, or power parameter (P) on the line where the cursor is located, press the C.I. knob and rotate it CCW to the position you wish to change.

HINT: The starting point coordinates should not fall on the edge of the workpiece blank, because if the electrode is in contact with the workpiece it is not possible to actuate GAP POWER. It is always advisable to assign a program start point that is above the workpiece and below the dielectric fluid level.

- To advance to the next line, position the cursor on the far right character in the Z column and press the C.I. knob, or press the C.I. knob and rotate CW to exit the line.
- With INSERT highlighted on the lower menu, press the C.I. knob to insert the next line.
- Select a CODE (see next page) by rotating and pressing the C.I. knob.
- When you have entered the last line of the program, exit the PROGRAM screen by selecting CUT or MAIN with the C.I. knob or by pressing CUT, JOG or ON/ADVANCE on the front panel.

The capital letter P before the code column indicates that a set of power parameters is connected with that line. To edit the power parameters, move the line to be edited to the edit pointer using FWD/REV and select CHANGE. When the cursor appears on the code line, press the C.I. knob and rotate CCW. This will provide access to the POWER PARAMETERS screen. See ASSIGNING POWER PARAMETERS (P) TO A PROGRAM LINE and POWER FILE FORMAT on the following pages for details.

OTHER MESSAGES

SAVING SELECTED LINES
SELECTED LINES STORED
INSERTING LINES
MULTILINES MUST BE COMPLETELY SELECTED
ILLEGAL COORDINATE AT LINE #____
ORBIT END Z IS INCORRECT AT LINE #____

PROGRAM CODES

The M-Pulse program will accept P (power parameter), LINEAR, ZCYCLE, PAUSE, JUMP, RAPID, ORBIT, VECTOR, TRVECT, DWELL, GOTO, CW, CCW, and INDEX (optional) codes.

START: Automatically appears at the beginning of every program. It sets the program's start position coordinates with reference to the workpiece. It also sets the starting power parameters in the program.

END: Automatically appears at the end of all programs. It sets the termination point of the program. It will display the message CUT COMPLETED on the screen.

P: Indicates that a set of power parameters has been assigned to the program line.

> Note: Power parameters are inherited from program line to program line and will remain in effect until the program reaches a line that contains new power parameters.

LINEAR: A "cutting" command for a linear XYZ point-to-point move. The entered coordinates are the destination point of the cut and may be entered as absolute XYZ (Abs) or incremental XYZ (Inc). It can have power parameters defined in it, which will be in effect when LINEAR begins.

ZCYCLE: A "cutting" command used instead of LINEAR to enable longer ram cycling in the Z-axis. The entered coordinate is the destination position in the Z-axis and may be entered as absolute Z (Abs) or incremental Z (Inc).

The length of retract is determined by one of two limits — the CYCLE-RETRACT time limit or a Z-axis retract limit. The time limit is set with the CYCLE-RETRACT number. (The numbers 1 through 99 are for reference only.) When the time is up the ram will readvance.

The Z-axis retract distance is limited by one of three things: 1) the starting point of the program, 2) the Z-axis position of a prior CW/CCW/Pause/Index/Jump/Tool command or 3) the Z-axis position of a prior X or Y axis move. If ZCYCLE reaches any of these retract limits it readvances.

ZCYCLE can have power parameters assigned which will be in effect when it begins.

PAUSE: A "non-cutting" command that holds the current XYZ position and turns the gap power off without leaving the program. This allows for electrode changes, etc. It will prompt for gap power to be turned back on before it continues to the next program line. It does not take power parameters.

JUMP: A "moving" command that performs a protected linear XYZ point-to-point move with the gap power off and machine interlocks ignored. An automatic PAUSE will precede and follow the jump, permitting an electrode change.

The entered coordinates are the destination point of the move. They may be entered as absolute XYZ (Abs) or as incremental XYZ (Inc).

RAPID: A "moving" command that performs a high speed linear XYZ point-to-point move with gap power on. (Could be called a "cutting" command.) Useful between cuts to maximize speed in areas of the job where there is no cutting required.

The entered coordinates are the destination point of the move and may be entered as absolute XYZ (Abs) or incremental XYZ (Inc). RAPID can have power parameters defined in it.

RAPID should not be used if the electrode will contact the workpiece. If contact occurs during a RAPID move, gap power will automatically turn off. To resume the cut, perform a START RETURN, edit the RAPID move so the electrode will not contact the workpiece, reset HOME and press GAP POWER on.

ORBIT: A "cutting" command that provides a circular path about a center point. Further explanation and diagrams are given in Orbiting, Section 4.9.

ORBIT can have power parameters assigned to it.

VECTOR: A "cutting" command that cuts in a straight line out and back from a center point at a specified angle(s). Further explanation and diagrams are given in Orbiting, Section 4.9.

VECTOR can have power parameters assigned to it.

TRVECT: Trace vector. A "cutting" command that cuts out from a center point and follows a series of straight line segments. Further explanation and diagrams are given in Orbiting, Section 4.9.

TRVECT can have power parameters assigned to it.

DWELL: A "cutting" command that locks the XYZ position with gap power on for a specified amount of time. The timed setting prompts the user to enter a time of dwell, which can be set for 1-60 seconds, 1-60 minutes or continuous.

DWELL includes a stop (stp) setting and a lock (lck) setting. The stop setting holds the XYZ position but still has retract capabilities if/when the gap shorts.

The lock setting will NOT retract if the gap shorts and will remain in position until the user presses the ENTER button. This feature is useful when spark-out is desired using a rotating spindle.

It can have power parameters defined in it.

> CAUTION
>
> Do not program a DWELL/lck with CUT-OFF set at 0. If the gap becomes shorted, the servo and current cut-off circuit cannot respond to clear the short, and serious damage to the power supply may occur.

CW: Clockwise. A "cutting" command that performs a clockwise arc motion specified by an XY destination point and a radius center point. The first line of the command is the destination point, which can be entered as absolute XY (Abs) or incremental XY (Inc).

The second line of the command is the center point for the desired arc radius, which will automatically be entered absolute or incremental the same as what is entered on the first line. An incremental coordinate in the second line must be with respect to the end-point of the program line *prior* to the first line of the CW command.

See next page for detailed instructions and diagrams on programming CW or CCW arc cuts.

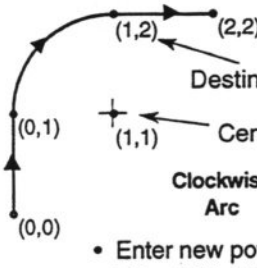
CCW: Counterclockwise. Exactly like CW except that it cuts counterclockwise.

GOTO: A "moving" command that performs an unprotected linear XYZ high-speed point-to-point move with gap power off. The entered coordinates are the destination of the move and may be entered as absolute XYZ (Abs) or incremental (Inc). Can be used for approaching or exiting cuts, positioning between multi-cavity cuts or with a PAUSE for electrode changes. This is the fastest moving command, but it does not have the safety feature of the RAPID command.

> CAUTION
>
> In GOTO, if the electrode encounters the workpiece or tooling the machine will not know to stop and damage may occur. Make sure that nothing is in the path of a GOTO command!

INDEX: (Optional.) A "non-cutting" command that holds the current XYZ position and signals a remote indexing device. It then waits for a signal from the remote indexing device to continue with the next program line. It does not take power parameters.

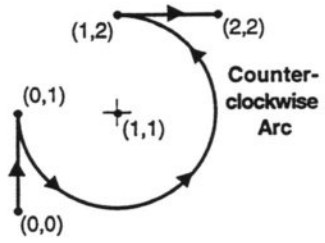
PROGRAMMING CLOCKWISE OR COUNTERCLOCKWISE ARC CUTS



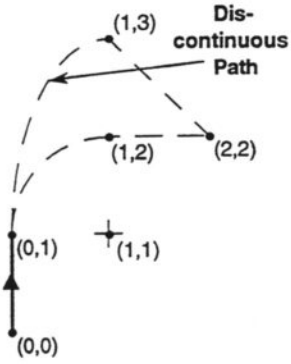
Line#		Code	Coord.	X	Y	Z
0	P	Start	Abs	00.0000	00.0000	00.0000
1		Linear	Abs	00.0000	00.0000	-00.0010
2		Linear	Abs	00.0000	01.0000	-00.0010
3		CW	Abs	01.0000	02.0000	
4		Ctr	Abs	01.0000	01.0000	
5		Linear	Abs	02.0000	02.0000	-00.0010
6		End				

- Enter new power parameters if desired.
- Enter CW or CCW.
- Enter absolute (Abs) or incremental (Inc) coordinates.
- Enter the destination of the arc.
- Enter the arc radius center.

CW and CCW will not need to know the length of the radius. They calculate the cut path based on the destination point of the move (1,2) and the center of the arc (1,1).



Using the same settings but in the CCW command, the cut would behave in this way.



If the center point is kept at (1,1) and the destination point is changed to (1,3), the message DISCONTINUOUS DATA appears, because the destination point does not fall in the path of a circle based on the starting point and center point of the arc. The distance between the destination point and the center point must equal the distance between the starting point and the center point.

ASSIGNING POWER PARAMETERS (P) TO A PROGRAM LINE

The M-Pulse programming format permits a unique set of power parameters (power supply, servo and flushing settings) to be assigned to each program line so that metal removal, electrode wear and surface finish can be automatically changed as the job progresses.

The letter P preceding the code column indicates that a set of power parameters is connected with that line. Power parameters are inherited from program line to program line and will remain in effect until the program reaches a line that contains new power parameters.

Power parameters can be entered when creating a program, editing a program or when a cut is in progress.

POWER PARAMETERS

	Pulse (μsec)	256.0	Cycle-EDM	10	
1	% On Time	0.10	Cycle-Retract	7	
	Peak Amps	8.0	Capacitor(μF)	6.0	
2	Gap Spacing	12	Generator Type	V Pulse	
	Servo Speed	3	Positive	Graphite	Steel
	Cut-off	4	Flush	OFF	
	Fault Retract	3			

NNGST312
NNGST325
NNGST350
NNGST400
→ NNGST450
PLGST032
PLGST041
PLGST053
PLGST058

Resident Program: SAMPLE1

EDIT SCREEN ACCEPT DELETE CANCEL FWD/REV SAVE

Power parameters are obtained from two sources, the Hansvedt Power File Library in system memory or custom sets that are created by the operator. Custom sets can be used one time in the program or they can be saved to the Power File Library if you intend to reuse them. To add, delete or transfer Power Files from memory or disk, see the Power File Management section.

To Add Operating Parameters When Creating A Program.

- Select the PROGRAM screen. Note that a "P" automatically appears in front of the Start code on line 0. You can change these power parameters or you can add or change power parameters on succeeding lines.
- Press and rotate the C.I. knob CCW and release. The POWER PARAMETERS screen appears. You can use power parameters from the Power File Library or create custom parameters.

1. Using power parameters from the Power File Library:

- To select a Power File move the cursor on the lower menu to FWD/REV.
- Press and rotate the C.I. knob to align the desired Power File with the arrow. The power parameters shown on the screen represent the currently selected power file.
- If you wish to modify any of the values, select EDIT SCREEN on the lower menu and execute the changes using the C.I. knob. ADJUST 1 and ADJUST 2 are also active on this screen.
- To apply the power parameters to the program line, select ACCEPT on the lower menu and press the C.I. knob. The PROGRAM screen reappears with the cursor on the code column preceded by a "P."

OR

- To exit the POWER PARAMETERS screen without changing the program line, select CANCEL and press the C.I. knob. The PROGRAM screen reappears with the cursor on the code column. The "P" status remains unchanged.

2. Creating a custom set of parameters:

- Select EDIT SCREEN on the lower menu and set parameters as desired.
- If you choose to save the custom parameters to the Power File Library, select SAVE on the lower menu. The message NEW POWER NAME: _ _ _ _ _ _ _ _ appears.
- Enter the new power file name.
- Press the C.I. knob to save. The message NEW POWER VALUE HAS BEEN SAVED appears.

If you entered a name that already exists in the Library File, the messages

POWER NAME ALREADY EXISTS
OVERWRITE RENAME ABORT

will appear. To install your new power values under the existing name, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME ABORT

The message NEW POWER VALUE HAS BEEN SAVED appears.

To save the new power values under a new name, select RENAME:

OVERWRITE [RENAME] ABORT

The message NEW POWER NAME: _ _ _ _ _ _ _ _ appears. Enter the new power name using the C.I. knob. The message NEW POWER VALUE HAS BEEN SAVED appears.

To exit this procedure, select ABORT:

OVERWRITE RENAME [ABORT]

- To apply the power parameters to the program line, select ACCEPT on the lower menu and press the C.I. knob. The PROGRAM screen reappears with the cursor on the code column preceded by a "P."

OR

- To exit the POWER PARAMETERS screen without changing the program line, select CANCEL and press the C.I. knob. The PROGRAM screen reappears with the cursor on the code column. The "P" status remains unchanged.

To Remove Existing Power Parameters from a Program Line (other than line 0).

- Select the PROGRAM screen. Using the FWD/REV feature, align the program line containing the P with the arrow.
- Select CHANGE on the lower menu. The cursor moves into the line on the code column.
- Press and rotate the C.I. knob CCW and release. The POWER PARAMETERS screen containing the Power File Library appears.
- Select DELETE and press the C.I. knob. The PROGRAM screen reappears with the cursor on the code column and the "P" will be removed.

NOTE: Refer to the Power File Format on the next page which shows the code for Polarity, Cutting Mode, Electrode, Workpiece and Finish, for assigning new Power File names.

POWER FILE FORMAT

The following POWER FILE FORMAT makes it easy to recognize and locate a Hansvedt file in the Power File Library. Each file's name consists of five parts and eight digits:

1	2	3	4	5	6	7	8
P	L	G	S	T	3	2	5

The eight digits correspond to the following five power parameters:

Digit	Parameter
1	**POLARITY** N assigned for — polarity, P assigned for + polarity. (See note below.)
2	**USER ASSIGNED** For wear, speed, class code, etc. For example: L for low wear, F for fast & fine, N for efficient, negative polarity cuts.
3	**ELECTRODE MATERIAL** For example: G = graphite, C = Copper.
4,5	**WORKPIECE MATERIAL** For example: ST = Steel, AL = aluminum.
6,7,8	**SURFACE FINISH** For example: 325 Ra.

Thus, in the example shown above,

PLGST325

is a power file for: Positive polarity; Low wear; Graphite electrode; Steel workpiece; 325 Ra surface finish.

NOTE: The use of N and P in the first digit should be reserved for existing and future Power Files supplied by Hansvedt.

Power files can be named using other formats as long as they contain no more than eight numeric or alpha characters. Files are stored in memory in numeric-alpha order: 1, 2, 3... followed by A, B, C.... Any time the list of Power Files is brought up on the screen, the top one on the list will be the first one in that order.

Instead of having the first digit represent polarity, you may wish to have it designate one of several groups, such as by type of job or most frequently used file, etc. — whatever you can easily relate to in your business. For example: A=coining dies, B=header dies, etc. Or, if you want the most used files to be at the top of the list: 0=most used, 1=next most used, etc. You might want to use the second digit for further designations that fit your own purposes.

EDITING A PROGRAM

Programs that are created at the M-Pulse, loaded from a disk or from a remote programming system via the RS-232, can be edited at the machine. Programmed power parameters can also be changed prior to a cut using the PROGRAM screen, or during a cut on the POWER PARAMETERS screen. Edited programs are automatically saved in place of the original program.

- Select EDIT. The PROGRAM screen appears. The arrow on the left side of the screen indicates the line to be edited.

CHANGING A LINE

- Select FWD/REF. Press and rotate the C.I. knob CW or CCW to scroll the program lines up or down. Rotating one detent scrolls the lines slowly, further rotation scrolls the lines faster. Position the line to be edited next to the arrow.
- Select CHANGE. The cursor moves into the line allowing CODE, COORD, X, Y AND Z to be edited. Rapid "on-line" cursor movement is available by pressing and rotating the C.I. knob CW or CCW. When the cursor exits the line, the changes are automatically saved.

IMPORTANT: If the Z position prior to an ORBIT, VECTOR or TRVECT is changed, the corresponding ORBEND, VECEND or TRVEND Z-axis coordinate must be updated.

If exiting the EDIT screen without updating the Z-axis, the message ORBIT END Z IS INCORRECT AT LINE #( ); RESTORE PROGRAM EDIT appears. Choose Restore to erase all changes and exit the screen. Choose Edit to stay in the EDIT screen.

- To add, delete or edit a power setting, press and rotate the C.I. knob CCW while on the CODE position. The POWER PARAMETERS screen appears, and settings can be adjusted. (Refer to ASSIGNING POWER PARAMETERS (P) TO A PROGRAM LINE in the Creating a Program section to change power parameters.)

PROGRAM

Data Edit Lines

	Line#		Code	Coord.	X	Y	Z
	0	P	Start	Abs	00.0000	00.0000	00.1000
→	1		Rapid	Abs	00.0000	00.0000	00.0100
	2	P	Linear	Abs	00.0000	00.0000	-00.0500
	3	P	Linear	Abs	00.0000	00.0000	-00.0600
	4		Dwell	stp			
	5		Linear	Abs	00.0000	00.0000	00.0100
	6		Rapid	Abs	00.0000	00.0000	00.1000
	7		End				

Resident Program: SAMPLE1

FWD/REV CHANGE COPY PASTE INSERT DELETE MODIFY CUT MAIN

FWD/REV CHANGE COPY PASTE INSERT DELETE MODIFY CUT MAIN

POWER PARAMETERS

	Pulse (μsec)	256.0	Cycle-EDM	10	
1	% On Time	0.10	Cycle-Retract	7	
	Peak Amps	8.0	Capacitor(μF)	6.0	
2	Gap Spacing	12	Generator Type	V Pulse	
	Servo Speed	3	Positive	Graphite	Steel
	Cut-off	4	Flush	OFF	
	Fault Retract	3			

NNGST312
NNGST325
NNGST350
NNGST400
→ NNGST450
PLGST032
PLGST041
PLGST053
PLGST058

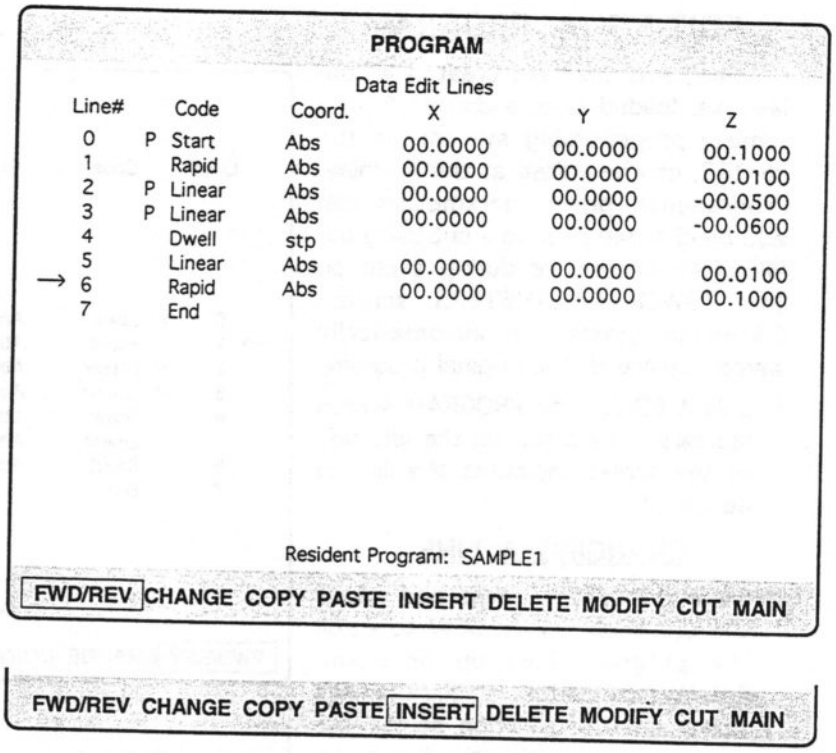
Resident Program: SAMPLE1

EDIT SCREEN ACCEPT DELETE CANCEL FWD/REV SAVE

NOTE: It is not possible to edit a program, other than power parameters, while the machine is cutting.

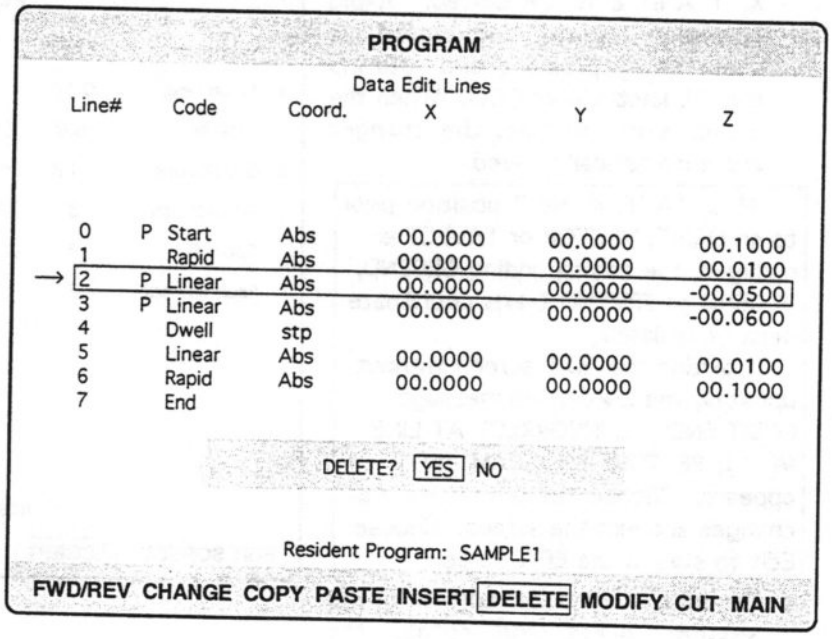
INSERTING A LINE

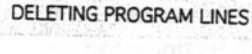
- Select FWD/REF. Press and rotate the C.I. knob CW or CCW to scroll the program lines up or down. Rotating one detent scrolls the lines slowly, further rotation scrolls the lines faster. Likewise, the 1Adjust knob will scroll one line per click and the 2Adjust knob will scroll ten lines per click.
- Position the line that is below the desired insertion point next to the arrow.
- Select INSERT. The cursor moves into the new line in the code column, and LINEAR is highlighted.
- Complete the line as desired.

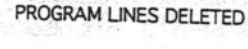


DELETING A LINE

- Select FWD/REF. Press and rotate the C.I. knob CW or CCW to scroll the program lines up or down. Rotating one detent scrolls the lines slowly, further rotation scrolls the lines faster.
- Position the line to be deleted next to the arrow. To delete a block of lines position the arrow on the first or last line of the block.
- Select DELETE; the program line opposite the arrow will highlight.
- If you wish to delete more than one line, turn the C.I. knob CW or CCW to highlight the additional lines.
- Press the C.I. knob to delete lines. DELETE? YES NO message appears.
- Answer YES. The messages DELETING PROGRAM LINES and PROGRAM LINES DELETED appear.







COPYING AND PASTING LINE(S)

This feature allows one or more lines of a program to be copied and pasted within the same program or into another program. The copied lines remain in the buffer until the COPY command is used again. The COPY command is most useful in the INCREMENTAL mode.

- Select FWD/REF. Press and rotate the C.I. knob CW or CCW to scroll the program lines up or down. Rotating one detent scrolls the lines slowly, further rotation scrolls the lines faster. Position the line to be copied next to the arrow.
- Select COPY. The line next to the arrow will highlight.
- Press the C.I. knob. SAVING SELECTED LINES and SELECTED LINES STORED messages appear.
- To copy a block of lines, rotate the C.I. knob CW or CCW to highlight them and press the C.I. knob to select the block. SAVING SELECTED LINES and SELECTED LINES STORED messages appear.
- To PASTE the lines, position the line below the insertion point next to the arrow.
- Select PASTE. The messages INSERTING LINES and LINES INSERTED will appear, and the line(s) will be inserted above the line next to the arrow.

NOTES

Copied lines will be saved in the buffer until a new set of line(s) are copied or until MACHINE OFF is pressed.

It is possible to paste the contents of the buffer 1) Within the existing program one or more times; 2) Into any program loaded from memory, disk or RS 232; or 3) Into a newly created program.

If any changes were made to the program and an Offset/Rotate/Rescale/Mirror is in effect, upon exiting the EDIT screen the software will enter the MODIFY screen and recalculate the O/R/R/M based on the new changes.

OTHER MESSAGES

ERROR: INSUFFICIENT MEMORY. Indicates that inactive memory is full. Delete existing program(s) to expand available memory.

UPDATING INTERNAL FILES. Indicates a momentary software routine.

ILLEGAL ANGLE INCREMENT OF ( ) AT LINE #( )

ORBIT END Z IS INCORRECT AT LINE #( )

CAN'T CHANGE 'END' LINE

CAN'T COPY 'START' OR 'END' LINE

CAN'T DELETE 'START' OR 'END' LINE

CAN'T PASTE BEFORE 'START' LINE

CAN'T INSERT BEFORE 'START' LINE

NO TEXT TO PASTE

MAKING SPACE IN PROGRAM

SAVING SELECTED LINES

SELECTED LINES STORED

EDITING MUST BE COMPLETE BEFORE EXITING

MULTILINES MUST BE COMPLETELY SELECTED

Z END COMPUTED

RADIUS END COMPUTED

MODIFYING A PROGRAM

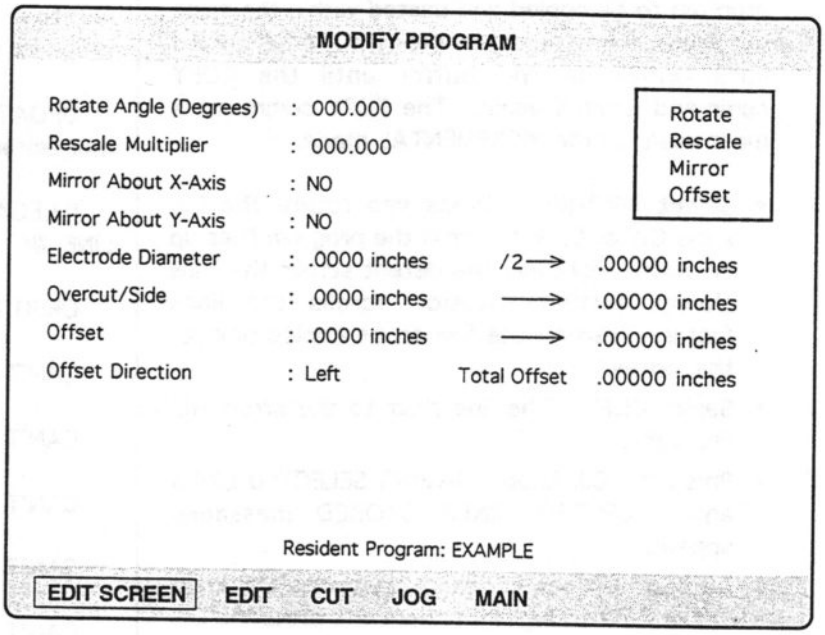
After a program has been created it is possible to edit the entire pattern by using the Rotate, Rescale, Mirror and Offset features on the MODIFY PROGRAM screen, in any combination. The box in the upper right hand corner of the MODIFY PROGRAM, CUT and screens will highlight the features that are active.

These features can be very useful for 2-axis contouring jobs that require fitting and sizing the tool path on a workpiece.

To engage one or more of the Modify features:

- Select MODIFY on the lower menu of the PROGRAM screen. MODIFY PROGRAM screen appears.
- Select EDIT SCREEN on the lower menu of the MODIFY PROGRAM screen and press the C.I. knob. Rotate Angle (Degrees) becomes bold.
- Rotate the C.I. knob CW to select the feature you wish to activate. Press the knob. The cursor moves to the next column where a value or instruction can be entered.
- Exit the entry column by completing your entry and pressing the C.I. knob, or press and rotate the C.I. knob CW.
- Exit the Modify choices by rotating the C.I. knob CW until the cursor moves back to the lower menu.

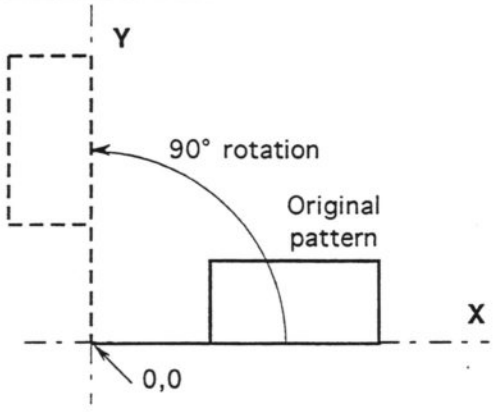
IMPORTANT
Execute a Trace after modifying a program to verify electrode, workpiece and tooling clearances.



NOTE: The Modify procedure replaces the entire original pattern with an entire new pattern of the different size and position selected. It is not possible to modify part of a program, such as rotating and repeating a gear tooth shape to create a complete gear pattern.

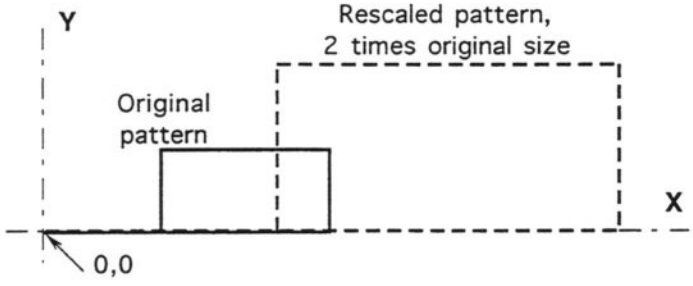
Rotate Angle (Degrees) : 090.000

The pattern will rotate CCW about the 0,0 coordinate point.



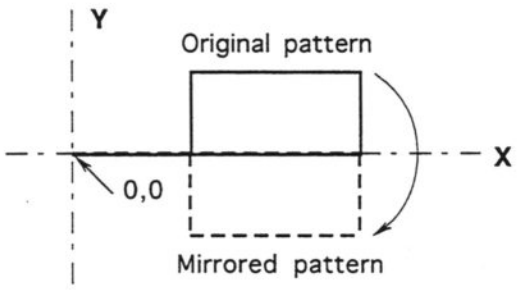
Rescale Multiplier : 002.000

The pattern size will increase or decrease from the 0,0 coordinate by the scale factor that is entered.



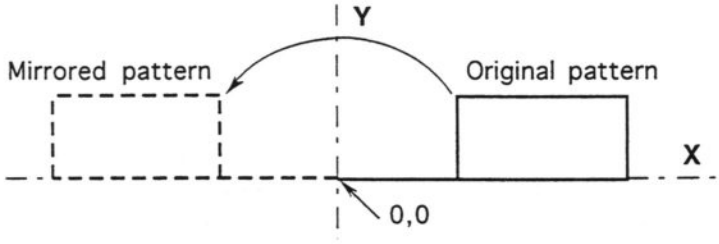
Mirror About X-Axis : YES

The pattern will mirror about the X-axis.



Mirror About Y-Axis : YES

The pattern will mirror about the Y-axis.



Offset Example

Electrode Diameter : .2000 inches /2 → .10000 inches

This entry will automatically divide by 2 to position the edge of a round electrode on the programmed path. This assumes that the center of the electrode was initially set up on the center of the path.

Overcut/Side : .0050 inches → .00500 inches

Refer to the graphs or charts for the overcut value. Note that when orbiting is used the overcut is zero.

Offset : .0050 inches → .00500 inches

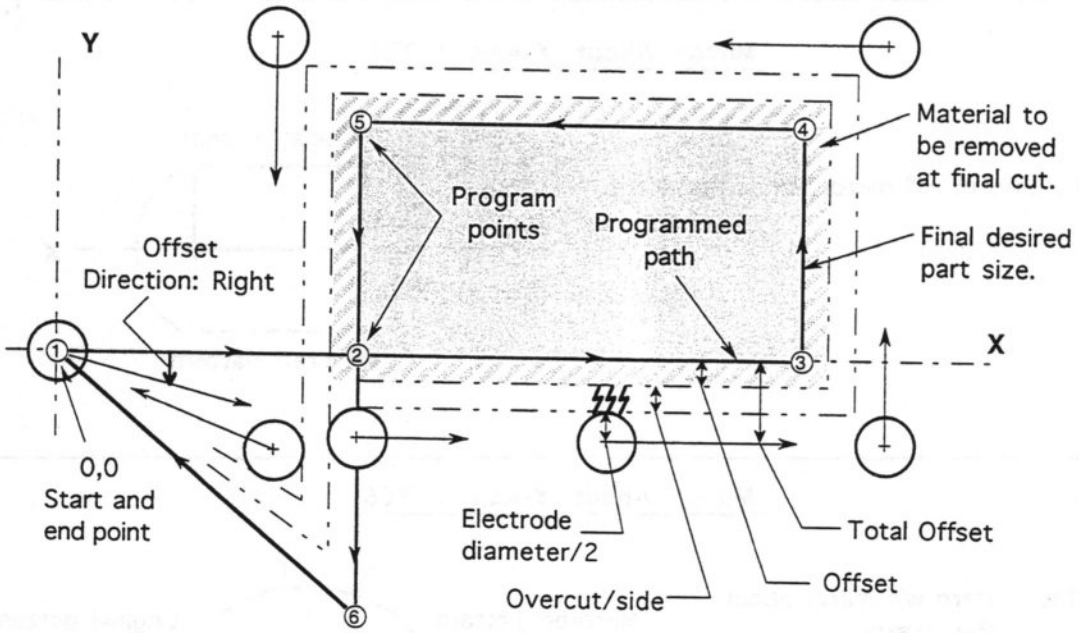
This is an additional amount that is left on the part for subsequent finish cuts.

Offset Direction : Right

The Offset Direction is with respect to the programmed path. Choices are Left, Right and Off.

Total Offset : .11000 inches

Total Offset is the sum of the Electrode Diameter/2 plus the Overcut/side plus the Offset. In the example below, program point 6 is past the 1st line segment, 1-to-2, a sufficient amount so that the electrode goes beyond point 2 in order to be sure that the final side is cleaned up.



NOTE: The Total Offset will occur in the first X,Y line segment of the program and disengage in the last X,Y line segment. Offsets will disregard Z,X or Z,Y or orbit moves.

SETTING HOME POSITION

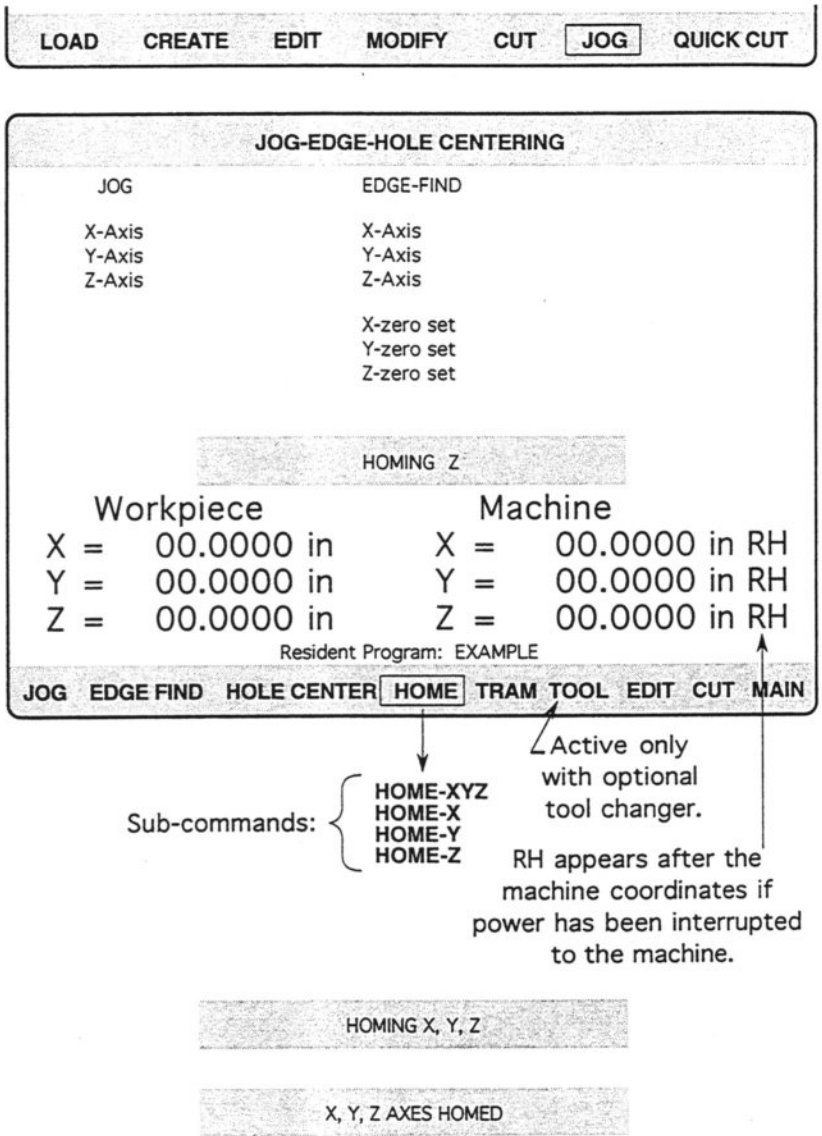
The home position establishes an XYZ axis machine reference. Home position is zero, with the ram retracted (up) and at the right rear corner of the table. Home position is retained when MACHINE OFF is pressed.

If the main power switch has been turned off or a power failure has occured, home position will be lost, and RH (re-home) will appear to the right of the Machine XYZ axis digital readouts. In this event, a homing procedure is required to ensure maximum positioning accuracy on the XYZ axes.

NOTE: Before initiating the homing procedure, check the work area for any obstructions that may interfere with the homing movement.

- Select JOG. The JOG-EDGE-HOLE CENTERING screen appears.
- Select HOME. The word HOME changes to HOME-XYZ. Rotating the C.I. knob changes the choices to the four sub-commands shown in the illustration at right.
- Select the axis (axes) to be homed, XYZ or X or Y or Z.
- Press the C.I. knob. The selected axis (axes) will move to the home position, and a HOMING... message appears while the machine is in motion. When the routine is complete, the message ...HOMED appears and the selected MACHINE and WORKPIECE digital readouts will be set to zero.

NOTE: To terminate a homing process before it is completed, press the C.I. knob. The message HOME TERMINATED appears.



OTHER MESSAGES

HOMING X-AXIS
HOMING Y-AXIS
HOMING Z-AXIS
X-AXIS HOMED
Y-AXIS HOMED
Z-AXIS HOMED

WORKPIECE SET-UP

The M-Pulse software system provides the capability to accurately set up a workpiece and electrode in preparation for cutting. All operations are controlled via the C.I. knob and the keypad.

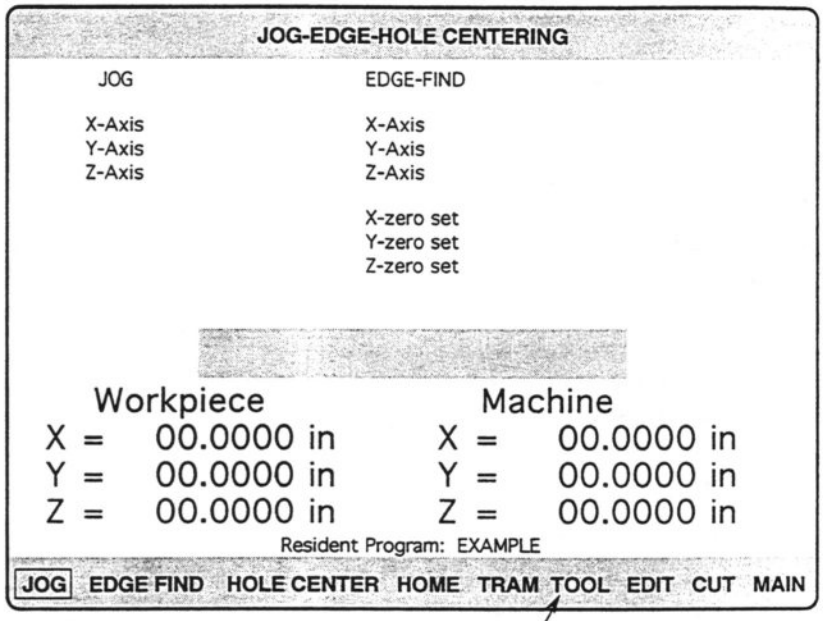
Positioning workpiece XYZ zero references can be made from outside workpiece surfaces or from burr-free holes in the workpiece using various routines. These routines are discussed on the pages that follow.

- JOG
- EDGE-FIND
- HOLE CENTERING
- TRAM

If, during any of the above procedures, the LIMIT TRIPPED message window appears, it indicates that the motion has actuated a limit switch. In this case:

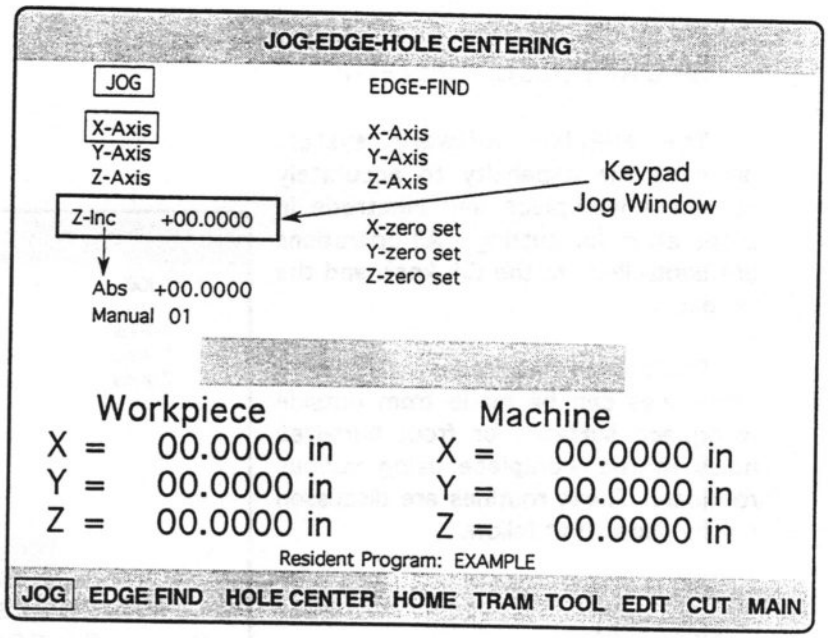
- Rotate the C.I. knob to clear the message window.
- It is not necessary to re-home the axis on which the limit was tripped.

Before you begin to set up a workpiece, you should trace your program to verify the position and orientation with respect to the proposed workpiece and electrode position. See the Tracing a Program section.



WARNING:
VERIFY THAT GAP CABLES AND SENSING LEADS ARE PROPERLY INSTALLED PRIOR TO WORKPIECE SET UP.

JOG



- Using the C.I. knob select JOG on the lower menu. JOG on the screen becomes highlighted and X-axis in the jog column becomes green, which indicates that this axis is active.
- The X-axis can be moved by pressing the C.I. knob and rotating CW or CCW. Releasing the C.I. knob will stop the motion. Y and Z axes, when selected, operate in the same manner.
- Jog speed is controlled by the amount of the C.I. knob's rotation, i.e. rotating one detent on the knob will increment the ram motion in .0001" steps. Faster jog speeds are available by rotating the knob further.

JOG DIRECTIONS:

X-axis	CCW	Tool left	-X
	CW	Tool right	+X
Y-axis	CCW	Tool out	-Y
	CW	Tool in	+Y
Z-axis	CCW	Tool down	-Z
	CW	Tool up	+Z

WARNING:
IN THE JOG MODE OF OPERATION, THE AUDIBLE TONE WILL SOUND WHEN THE ELECTRODE CONTACTS THE WORKPIECE. THE RAM OR TABLE WILL NOT STOP, AND DAMAGE COULD OCCUR .

- To use the numeric keypad, position the cursor on JOG on the lower menu.
- Press X, Y or Z on the keypad. Keypad jog window appears.

ABS — Moves to any absolute machine position (normally used when positioning with respect to home).

INC — Moves selected distance from current position (normally used to position tool away from work after performing an edge-find).

- To select INC or ABS mode of operation, press left arrow key. Cursor moves to the mode position.
- Change the mode using the up or down arrow keys.
- Press the right arrow key to accept the desired mode of operation.
- When ABS is selected, enter the desired machine position (absolute with respect to HOME position). The keypad and/or C.I. knob can be used.
- When INC is selected, enter the desired incremental move from the present location. The keypad and/or C.I. knob can be used.
- Press ENTER. Machine will move to the ABS (absolute) machine position or the INC (incremental) amount.

Note: The jog mode will always default to the prior mode that was used.

Example: If INC was previously selected and a -.1" Z move is desired, select JOG on lower menu and press "Z", "-", ".1", "ENTER".

EDGE-FIND, XYZ AXES

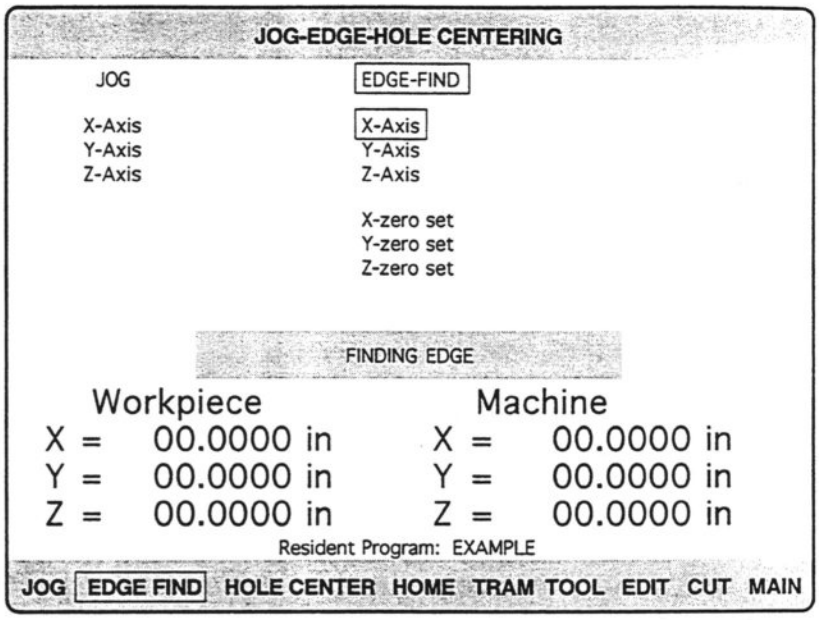
The EDGE-FIND routine automatically moves the tool in the direction that has been selected.

EDGE-FIND DIRECTIONS:

X-axis	CCW	Tool left	-X
	CW	Tool right	+X
Y-axis	CCW	Tool out	-Y
	CW	Tool in	+Y
Z-axis	CCW	Tool down	-Z
	CW	Tool up	+Z

Be careful to avoid obstructions in the work area that would interfere with the moving parts. Also, be sure that the workpiece edge is dry, burr-free and clean.

- Select EDGE-FIND on the lower menu. EDGE-FIND on the screen becomes highlighted and the X-axis becomes green, indicating that this axis is active.
- The EDGE-FIND routine is initiated by depressing C.I. knob and rotating CCW for tool left (-X) movement or CW for tool right (+X) movement. The tool will begin feeding automatically when the C.I. knob is released. FINDING EDGE message appears. The tool movement will dither when the tool reaches the workpiece.
- EDGE FOUND message appears and the routine continues to dither.
- Exit the EDGE-FIND routine by depressing the C.I. knob.
- The EDGE-FIND routine can be interrupted by depressing the C.I. knob. Y and Z axes, when selected, operate in the same manner.



Setting the Workpiece XYZ Zero Reference

It is important to set the electrode and workpiece XYZ zero references so that they correspond with the program.

- Zero the X-axis to establish the X-zero reference at the workpiece surface by rotating the C.I. knob to position the cursor on the X-ZERO SET.
- Press the C.I. knob. X-WORKPIECE DRO will zero. Y and Z axes, when selected, operate in the same manner.

NOTE: ZERO SET in the EDGE-FIND mode only sets the WORKPIECE digital readout.

HOLE CENTERING

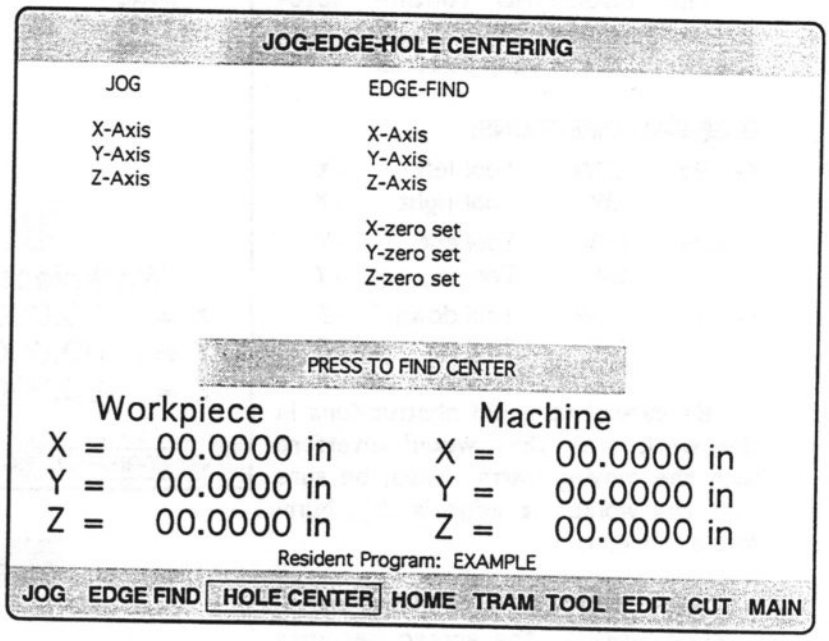
It is possible to automatically locate an electrode in the center of a hole using the following procedure.

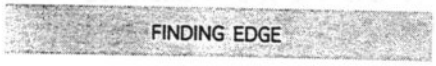
- Select JOG-EDGE-HOLE CENTERING screen.
- Be sure that the hole is burr-free, clean and dry.
- Using the JOG mode, position the workpiece and electrode so that the electrode is located in the hole and not touching any side.
- Select HOLE CENTER. The message PRESS TO FIND CENTER appears.
- Press the C.I. knob and release to initiate the hole centering routine. The message FINDING EDGE appears.

The machine automatically executes a sequence of X and Y axis moves to find the center. The HOLE CENTER routing can be interrupted by pressing the C.I. knob. To reinstate the routine, press the C.I. knob once again. The message HOLE CENTERED will appear when the routine is complete.

If you desire to use the center of the hole as the XY zero reference:

- Select EDGE FIND on lower menu.
- Select X-ZERO SET and Y-ZERO SET.



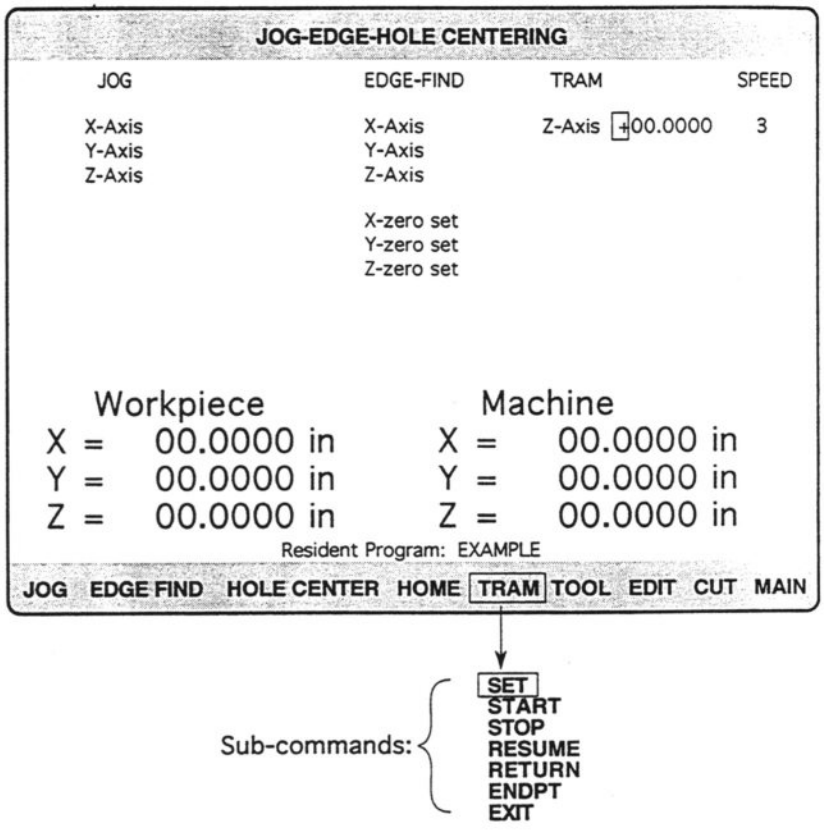


TRAM

The TRAM feature is useful for electrode and/or workpiece alignment. It automatically moves the workpiece or electrode back and forth a specified distance and speed for use with a dial indicator.

NOTE: The audible tone will not sound when the electrode touches the workpiece or the dial indicator.

WARNING:
In the tram mode, the ram or table will not stop if the electrode contacts the workpiece, and damage can occur.



XYZ-axis Automatic Tram

- To use the automatic tram, select TRAM on the lower menu and press the C.I. knob. SET appears in the lower menu, and X-axis +00.0000 and SPEED 3 appear in the upper right corner of the screen.
- Select the desired axis on the keypad.
- Input the direction (+,-) and distance and press ENTER.
- Input the SPEED 1 to 5 (the numbers 1 through 5 provide a range from approximately 6 seconds per inch to 5 minutes per inch) and press ENTER. START appears in the lower menu.
- Press the C.I. knob to start the tram. The machine will begin moving in the direction and speed selected. STOP appears in the lower menu.
- The tram motion can be stopped at any time by pressing the C.I. knob. RESUME appears in the lower menu. Press the C.I. knob again to RESUME. STOP will appear in the lower menu.

  Or rotate the C.I. knob to select the following:

  RETURN — moves back to the start point of the tram.

  ENDPT — moves to the end point of the tram.

  EXIT — takes you out of the auto-tram routine.

To change the tram distance and/or speed:

- Select EXIT
- Select TRAM.
- Select SET and follow the above procedures.

TRACING A PROGRAM

After a program is loaded or created on the M-Pulse, it is a good practice to verify its operation.

- Remove the electrode to avoid contact with the workpiece.
- Select CUT SCREEN.
- Select TRACE. START appears in the lower menu.
- Select START. TRACE IN PROGRESS message appears. When the trace is done, TRACE COMPLETE message appears.
- Rotate the C.I. knob to proceed.

NOTE: To save time, the TRACE mode does not execute XY orbit motions.

Selecting STOP and RESUME will allow you to interrupt and restart the tracing process. TRACE STOPPED message appears.

OTHER MESSAGES

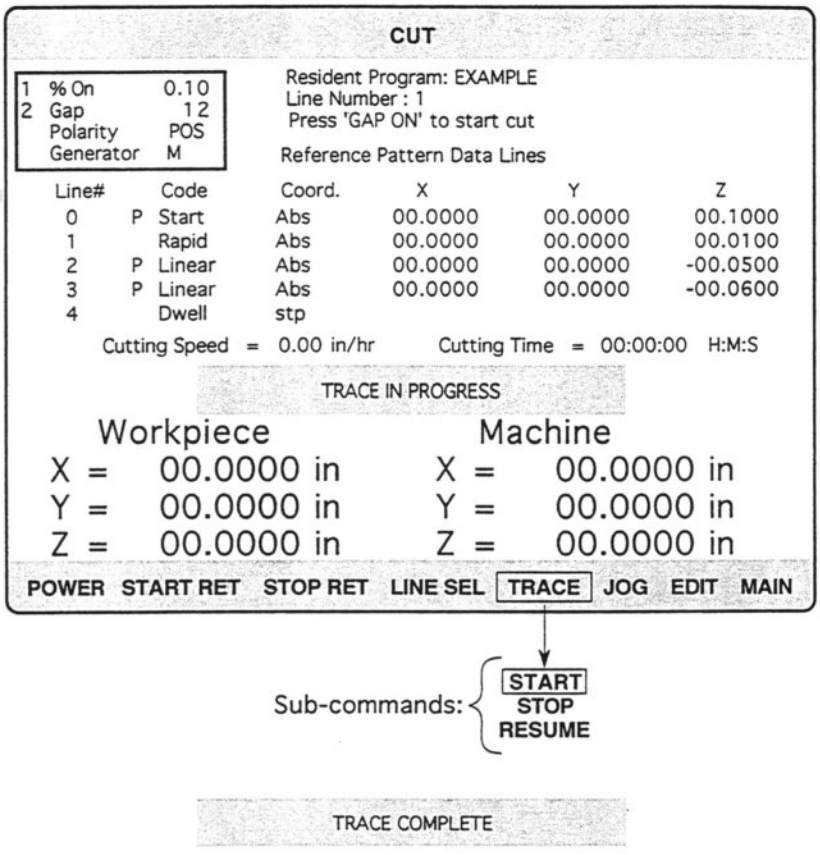
LIMIT TRIPPED. Indicates that the path falls outside the XYZ travel.

- Rotate the C.I. knob to exit the message window.

TRACE AT PAUSE. The trace motion stops when a pause is encountered in the program.

- Select RESUME with the C.I. knob to continue the trace routine.

GAP SHORTED. Indicates that the electrode is contacting the workpiece, tooling or workpiece support. Rotate the C.I. knob to exit the message window and carefully jog the ram or table to remove the shorted condition.



STARTING A CUT

After a program has been entered and the electrode is positioned at the start point, EDM cutting can begin. Verify that flushing lines are in place and that the worktank door is secure.

- Fill the worktank, submerge the cutting gap with a minimum of 2 inches of fluid and set the float switch.
- Select the CUT screen by pressing CUT under MODE or selecting via the C.I. knob.
- Press GAP POWER ON.

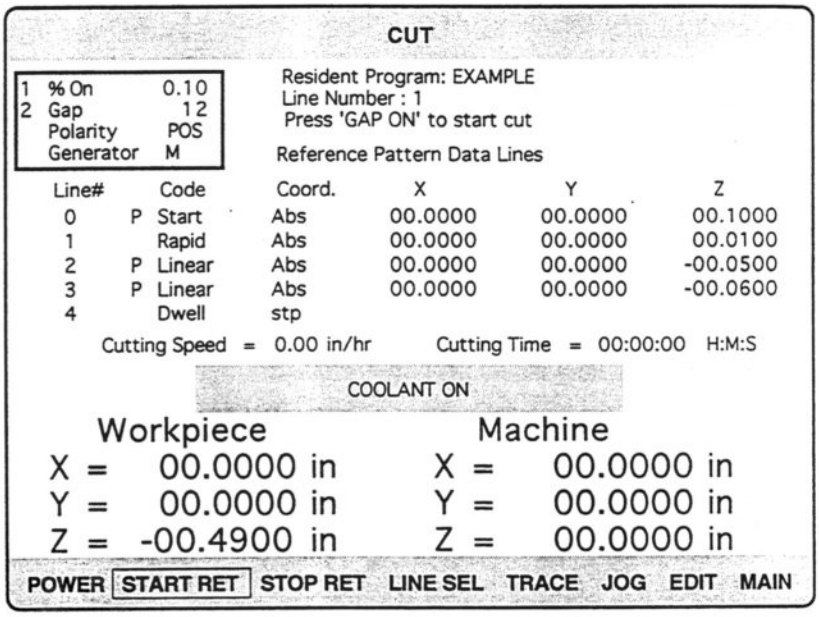
If START RETURN or PRESS GAP ON message appears, the ram and/or the XY table is not at the workpiece start point coordinates of the program as previously designated. Pressing GAP POWER on again will establish the present position as the start point.

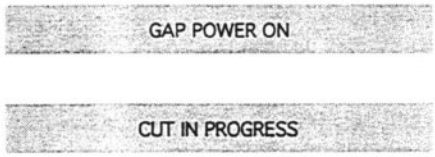
When the ram and/or XY table is in the proper position:

- COOLANT ON, GAP POWER ON and CUT IN PROGRESS messages appear in order.
- Adjust FLUSHING and, if necessary, GAP SPACING, SERVO SPEED, CYCLE EDM and CYCLE RETRACT for a stable cut with maximum cutting speed.

If a GAP FAULT message flashes on the screen, this indicates that flushing is not adequate for the power settings selected. Readjust %ON-TIME, FLUSHING, GAP SPACING, SERVO SPEED and CYCLE EDM/RETRACT to avoid this message.

If the electrode withdraws due to gap conditions, the gap power will turn off and (if selected in SHUTDOWN) the audible tone will sound when the programmed FAULT RETRACT distance is reached.





FORWARD PROGRESS INDICATOR

This feature, when activated, changes the WORKPIECE and MACHINE X, Y & Z digital readouts on the POWER PARAMETERS and CUT screens from a dynamic readout (showing actual axis position) to a forward progress readout. The Forward Progress mode is particularly useful in a cut with active servoing (positive and negative axis movement) or when the RAM CYCLER is activated or when orbiting.

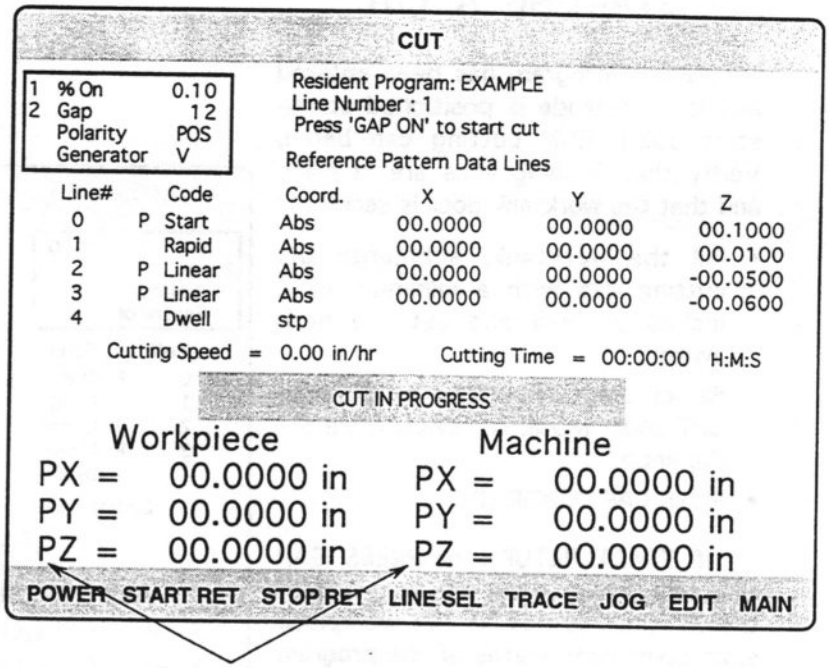
The Forward Progress mode is activated or deactivated on one or more axes by pressing the X, Y or Z keys on the keypad after GAP POWER ON has been initiated. The digital readout will display a "P" preceding the axis readout that was selected. For example, the Z-axis readout will show "PZ=" in the FORWARD PROGRESS mode and "Z=" when FORWARD PROGRESS is not selected.

The Forward Progress digital readouts will be reset to the retracted position when a retract movement results from any of the following:

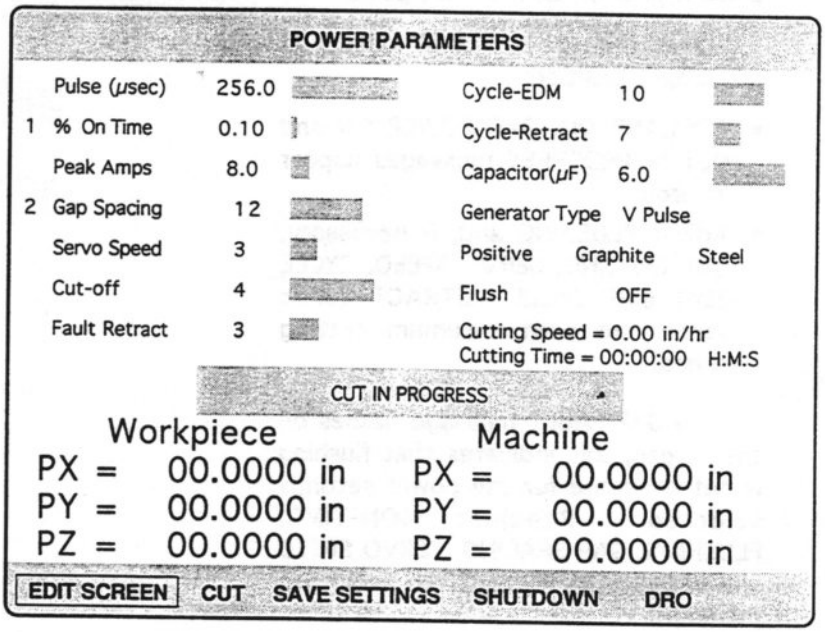
1. An auto fault retract;
2. GAP POWER OFF/RETRACT is pressed;
3. SERVO SPEED is changed.

The digital readouts will then track Forward Progress when it resumes.

When selected, the Forward Progress is automatically turned off when GAP POWER OFF is pressed and will restart when GAP POWER ON is pressed.



P indicates that Forward Progress is active.



STOPPING A CUT

If you wish to stop the cut to inspect the workpiece:

- Press GAP POWER OFF/RETRACT. CUT STOPPED message appears. If you press and hold the GAP POWER OFF/RETRACT button, the ram will retract rapidly in the cutting path.
- RAPID RETRACT ENABLED message appears. If the ram retracts to the start point, RETRACTED TO START message appears.

> NOTE: Always retract the tool clear of the workpiece (audible tone is off) so that the cut can be resumed.

RESUMING A CUT

If you have not exited the cut screen:

- Resume by pressing the GAP POWER ON/ADVANCE button; cut will resume.

If you exit the Cut screen and wish to resume the cut:

- Select CUT screen.
- Select STOP RETURN. The message PRESS GAP ON TO RETURN appears.
- Press GAP POWER ON. The messages RETURNING TO STOP POINT, RETURNED TO STOP POINT and CUT IN PROGRESS appear.

If STOP RETURN is unavailable:

- Perform a START RETURN or use the line select function.
- Press GAP POWER ON.

POWER PARAMETERS

Power parameters for the M-Pulse power supply and servo can be changed prior to starting a cut or while the machine is cutting. If no parameters are entered, a set of default parameters will appear on the start line of the program. This manual provides charts which will help you determine the most effective cutting parameters for each job.

To change a parameter, select EDIT SCREEN on the lower menu of the POWER PARAMETERS screen and rotate the C.I. knob to the desired parameter. Select the parameter by pressing the C.I. knob and change it by rotating the knob.

In addition to the C.I. knob, the "1 ADJUST and 2 ADJUST" knobs on the front panel can be used to change power parameters by pressing and turning to position the respective number in front of the parameter. Then release and turn the knob to adjust.

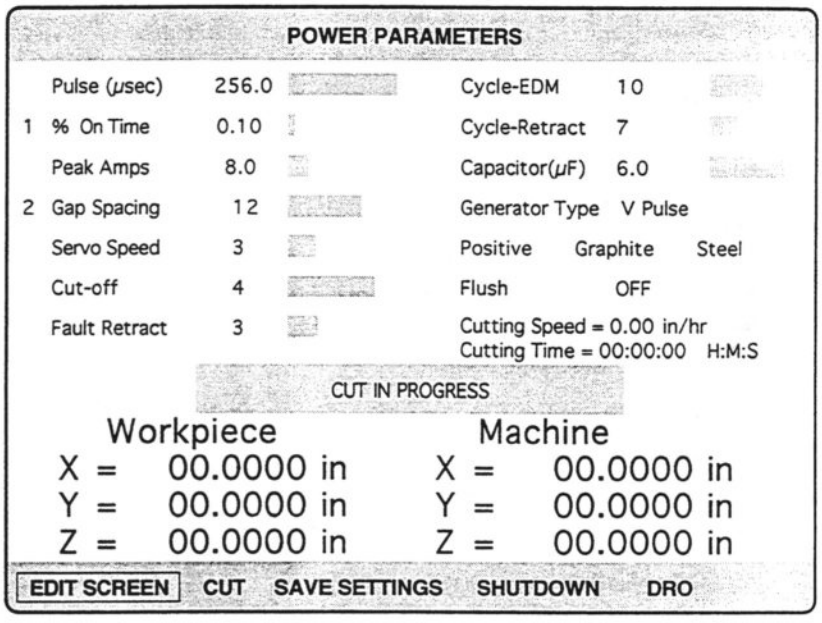
To replace or add new power parameters to the program line that is being executed, enter the desired settings on the POWER PARAMETERS screen and select SAVE SETTINGS on the lower menu. SETTINGS SAVED message appears.

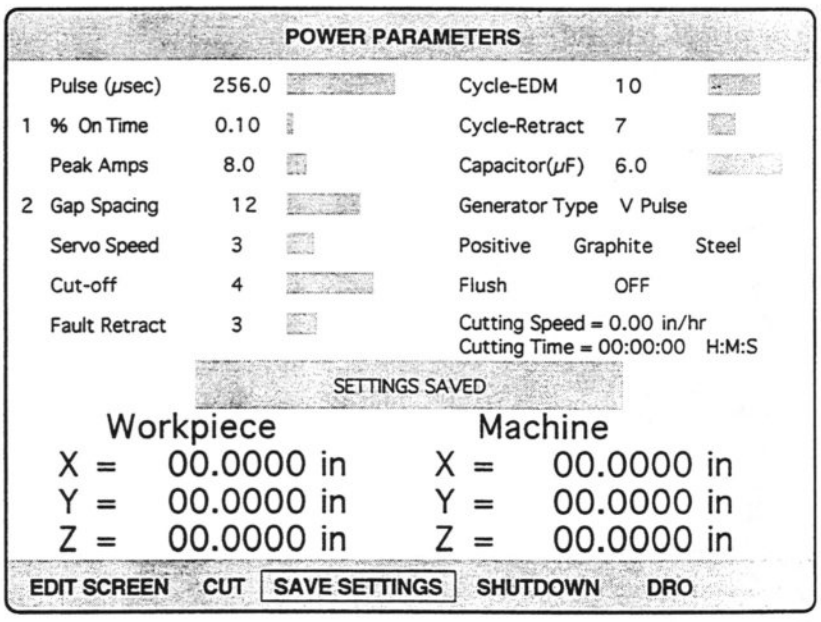
Surface Finish. PULSE, PEAK AMPS, POLARITY, ELECTRODE and WORKPIECE determine surface finish and overcut. They can also affect cutting speed.

Cutting Speed. %ON-TIME, SERVO SPEED, GAP SPACING and FLUSHING are considered fine tuning parameters that effect cutting speed.

Efficiency Meter. Provides important operator feedback showing the effect of %ON-TIME, SERVO SPEED, GAP SPACING and FLUSHING adjustments with respect to cutting performance.

Electrode Wear. The combination of polarity, PEAK AMPS and PULSE affect the electrode wear conditions. Usually, positive polarity provides lower electrode wear.





PARAMETER DESCRIPTIONS

Pulse (μsec). .1 through 1,800 μseconds. Controls the arc duration, or on-time, of the spark.

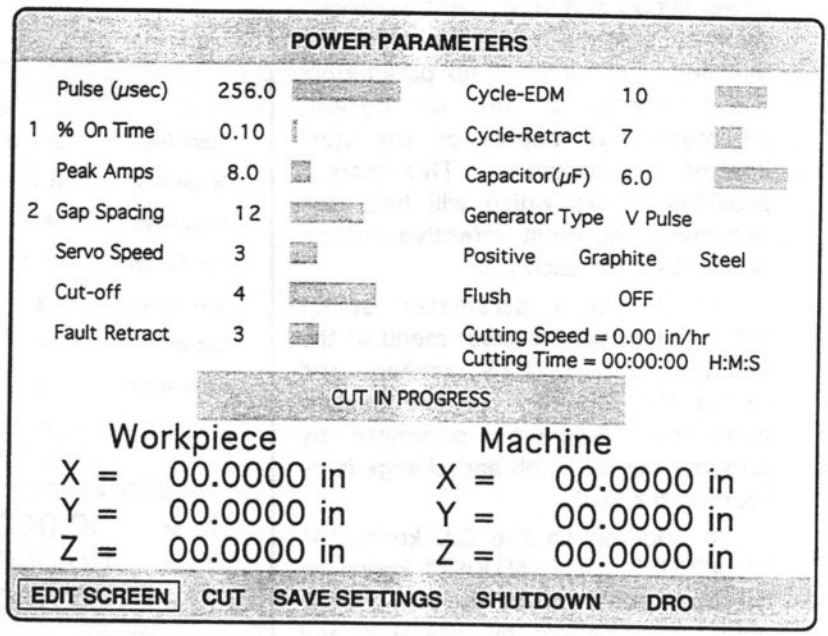
%On-Time. .1 through 95 percent. Controls the duty cycle of the cutting power by setting the spark repetition rate. Limitations on the %On-time range are based on the PULSE and PEAK selection. If flushing is good a higher %On-time can be used. If flushing is marginal a lower %On-time is necessary.

Peak Amps. .2 through 75 (M-Pulse Model 1025). Higher settings at the same pulse duration produce a coarser finish.

Gap Spacing. 1 through 20. Fine tunes the distance between the electrode and the workpiece. If flushing is marginal a wider gap (larger number) should be used. This control should be adjusted for maximum cutting speed, highest efficiently and minimum GAP FAULT messages.

Servo Speed. 1 through 7. Sets the maximum velocity of the servo. Be careful not to overdrive the servo because it is possible to damage a fragile electrode.

Cut-Off. 0 through 5. Sets the sensitivity to gap faults, with the highest number offering the most protection. Maximize EFFICIENCY METER and cutting stability by adjusting CUT-OFF and flushing. A setting of "0" provides no protection when using the V PULSE generator mode.



Fault Retract. 0 through 15. Controls the number of program lines that the machine will retract through if a gap fault condition occurs.

> WARNING!
> DO NOT SET UP THE MACHINE SO THAT A GAP FAULT RETRACT WILL CAUSE THE ELECTRODE TO RETRACT ABOVE THE DIELECTRIC LEVEL IN THE WORKTANK. THIS CONDITION INTRODUCES THE POTENTIAL FOR A FIRE TO OCCUR. TO AVOID RETRACTING THE ELECTRODE OUT OF THE DIELECTRIC ALWAYS SET UP THE WORKPIECE SO THAT THE START POSITION OF THE PROGRAM IS 2 INCHES BELOW THE SURFACE OF THE DIELECTRIC FLUID IN THE WORKTANK.

Some general FAULT RETRACT guidelines are as follows:

1. The cut will stop immediately with a "0" setting if a gap fault occurs.
2. Start with at least a setting of "1."
3. Do not use "0" for programs that include orbiting — "2" is usually best.
4. On programs that have several very short line segments use a higher number.
5. A setting of "15" will always result in a retract back to the START line of the program.

Cycle-EDM. 0 through 30. Determines the time that cutting is in process during a ram cycle operation. A higher number sets a longer cutting time. A value other than "0" must be entered in CYCLE EDM and CYCLE RETRACT for the machine to cycle.

Cycle-Retract. 0 through 15. Determines the time that the electrode is retracted out of the cutting gap during a cycle operation.

Capacitor(μF) (Optional). .2 to 12 microfarads. Promotes cutting conditions in exotic alloys and semi-conductive materials such as polycrystalline diamond material. Capacitors can be used only with V-PULSE and generally operate best in negative polarity.

Generator Type, M-PULSE (measured pulse). Produces sparks that are identical in duration. This mode produces the best electrode wear condition particularly at finish levels down to 90 μinches AA.

Generator Type, V-PULSE (variable pulse). Usually provides the best cutting rates but more electrode wear will occur. For cuts that require a pulse below 5 μseconds, the V-PULSE mode is required.

M-PULSE and V-PULSE are programmable and can both be used in the same program.

Polarity. POSITIVE or NEGATIVE. Determines the electrode wear condition. POSITIVE with M-PULSE produces the lowest electrode wear.

Electrode Material. GRAPHITE, Cu (copper), Cu-W (copper tungsten), Cu-GRAPHITE (copper graphite), BRASS, STEEL, and W-CARBIDE (tungsten carbide).

Workpiece Material. STEEL, AL (aluminum), INCONEL, Ti (titanium), CARBIDE, Cu (copper), and GRAPHITE.

Flush: Off/On/Cycle. The AUX 1 and AUX 2 connections on the flushing manifold can be programmed to be on, off, or to synchronize dielectric flow during CYCLE/RETRACT when the CYCLE mode is selected.

Cut Speed. 0.00 linear in/hr. (inches per hour) or mm/min. (millimeters per minute).

Cut Time. 00:00:00 (hours:minutes: seconds). Accumulates cutting time when GAP POWER is on. Will reset to zero if you execute a START RETURN.

OTHER OPERATING FEATURES

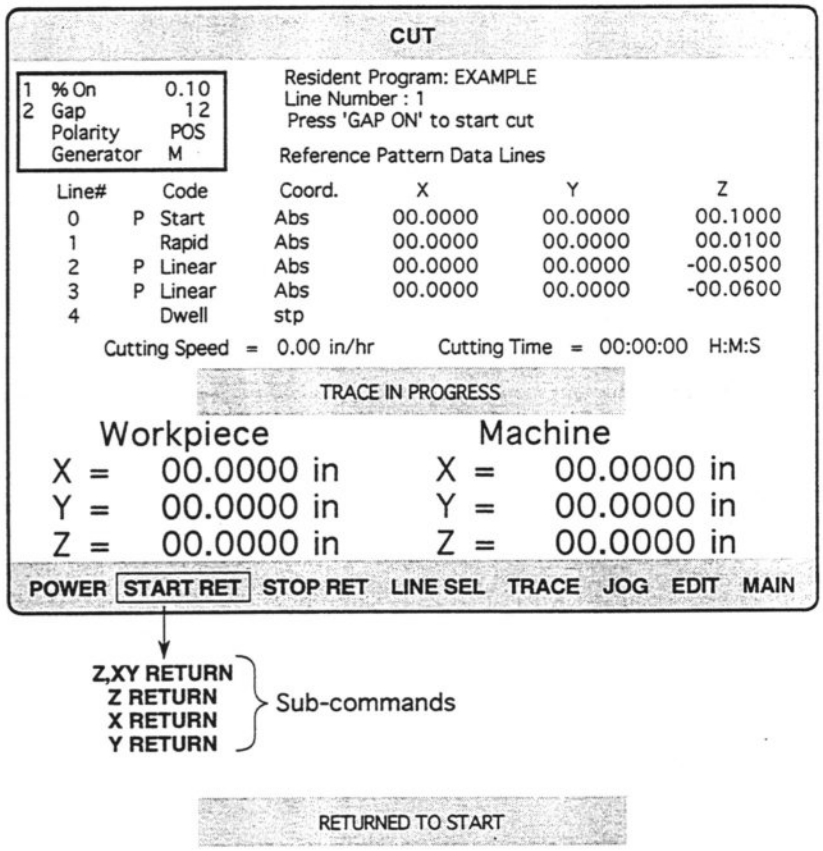
START RETURN

Located on the lower menu of the CUT screen, START RET automatically returns the electrode and workpiece position to the start point of the program. START RETURN is useful in the following situations:

1. After tracing a program.
2. After completing a cut.
3. If the machine has been manually jogged away from the start point.
4. Also refer to additional START RETURN features under LINE SELECT and QUICK CUT procedures.

To return to the start point:

- Select CUT screen.
- Select START RETURN.
- Rotate the C.I. knob and select either Z,XY RETURN, Z RETURN, X RETURN, or Y RETURN.
- Press the C.I. knob. The machine will move to the start point, as selected, via a direct path. RETURNING TO START POINT message appears while the machine is in motion. RETURNED TO START message appears when start point is reached.
- If you wish to interrupt a START RETURN routine press the C.I. knob.
- To resume a START RETURN routine, repeat the start return sequence above.



NOTE: START RETURN will abort if the gap is shorted when you begin the routine or if the gap becomes shorted during the routine.

STOP RETURN

Located on the lower menu of the CUT screen, STOP RET is used to automatically return and resume cutting after stopping a cut and moving the electrode out of the cutting path.

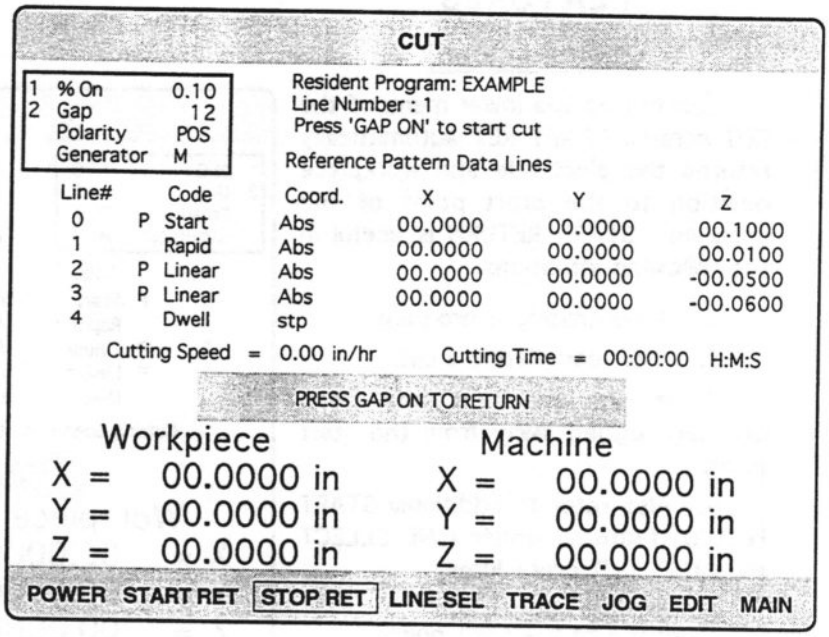
If GAP POWER OFF/RETRACT was activated and the JOG-EDGE-HOLE screen was selected, the STOP RETURN function will return the tool to the point in the program where the GAP POWER OFF/RETRACT button was released.

If a PAUSE interrupts the cut and the JOG-EDGE-HOLE screen was selected, the STOP RETURN function will return the tool to the PAUSE position.

- Press GAP POWER OFF/RETRACT and continue to hold the button until the electrode is clear from the workpiece or tooling.

> NOTE
> If the tool is retracted to the start point, STOP RETURN is disabled.

- Jog the electrode to another XYZ position.
- To return the electrode to the cutting position (stop point) select STOP RETURN. PRESS GAP ON TO RETURN message appears.
- Press GAP POWER ON. RETURNING TO STOP POINT message appears. The coolant pump and gap power will automatically turn on and the cut will resume when the stop point is reached. CUT IN PROGRESS message appears.



> NOTE: STOP RETURN is also functional if MACHINE OFF was pressed.

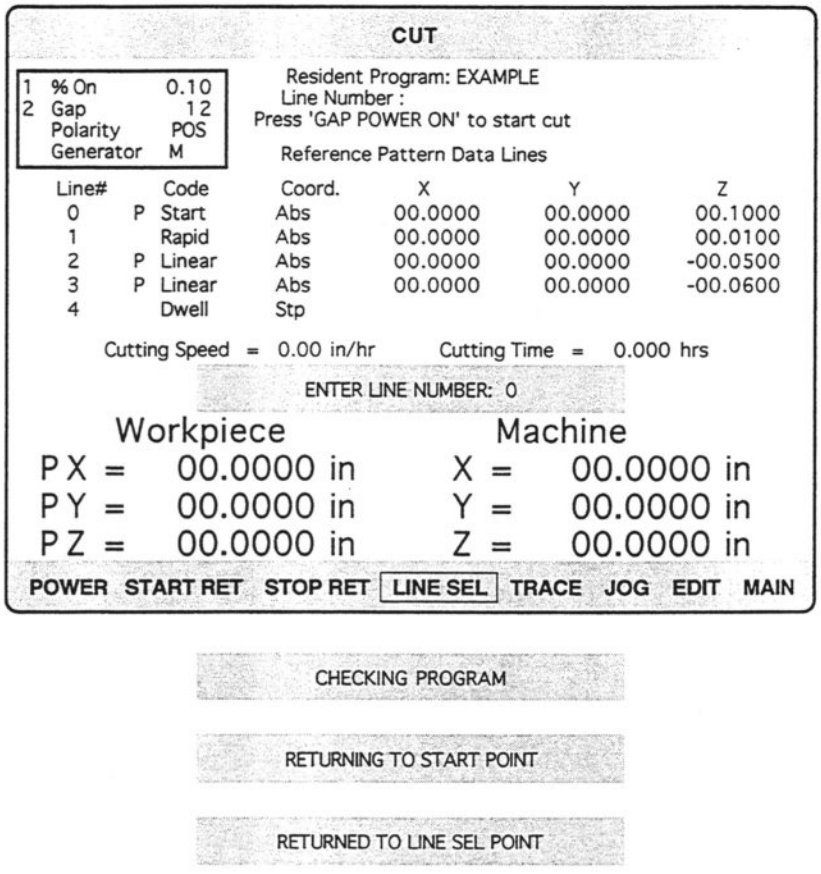
LINE SELECT

Located on the lower menu of the CUT screen, LINE SEL is used to begin a cut on a program line other than the beginning start line. It is possible to use this feature after entering a new program or it can also be used during a cut.

Before using LINE SELECT be sure that the START line of the program is established at the XYZ START position of the workpiece with respect to the electrode.

If the program includes four separate cavities and you wish to begin cutting on cavity #3, you can select the program line prior to cavity #3 to start the cut. This eliminates the need to spend unnecessary time cycling through cavities #1 and #2 in the cut mode.

Program lines with the following codes can be selected: START, LINEAR, RAPID, GOTO, PAUSE, CW, CCW, DWELL and the last line of an ORBIT command.



To select a line:

- Select the CUT screen.
- Select LINE SELECT on the lower menu. ENTER LINE NUMBER: _____ message appears.
- Using the C.I. knob enter the desired line number and press the knob. CHECKING PROGRAM message appears.
- Rotate the C.I. knob and select either Z RETURN, X RETURN, or Y RETURN by pressing the C.I. knob. If X or Y RETURN is selected, move table to X: 00.0000 or Y: 00.0000, PRESS ENTER message appears. The machine will automatically move the Z to the line selected. RETURNING TO START POINT and RETURNED TO LINE SEL PT messages appear.
- Press GAP POWER ON to start the cut.

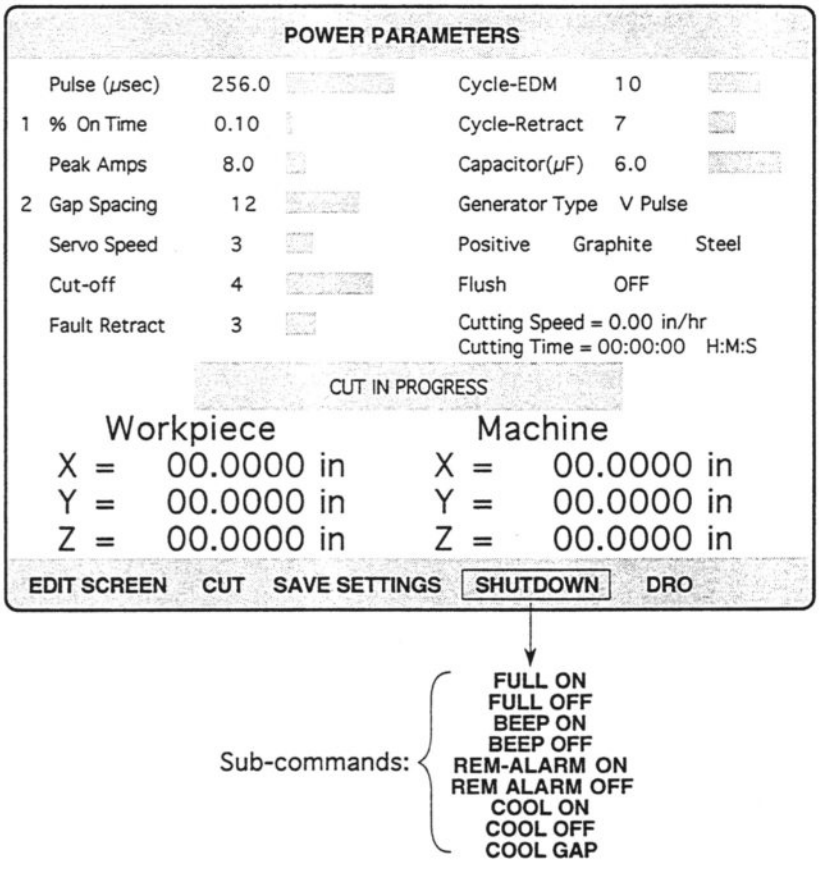
If the cut is completed or stopped by pressing GAP POWER OFF, the following START RETURN features are available:

- Select START RETURN. The machine will return to the previous LINE SELECT start point.
- If you desire to go back to the original start point, select START RETURN a second time. RETURN TO ORIGINAL START PT message appears.

SHUT DOWN OPTIONS

This feature allows the operator to choose certain events that will occur after the cut is complete and the gap power turns off. SHUTDOWN can be selected on the lower menu at any time.

- Select the OPERATING PARAMETERS screen.
- Select SHUTDOWN on the lower menu.
- Rotating the C.I. knob will display the selections, and depressing the C.I. knob will alternate each selection between ON and OFF. (The options are shown as sub-commands in the illustration to the right.)



Sub-commands:
- FULL ON
- FULL OFF
- BEEP ON
- BEEP OFF
- REM-ALARM ON
- REM ALARM OFF
- COOL ON
- COOL OFF
- COOL GAP

The options are explained as follows:

FULL ON — Full shutdown. The entire machine turns off, including the coolant pump listed below, whether or not it was selected to stay on or off.

FULL OFF — Full shutdown is not effected. The machine stays on and the coolant pump follows the instructions selected below.

BEEP ON — Activates the audible tone.

BEEP OFF — No audible tone.

REM-ALM ON — Activates optional remote alarm signal.

REM-ALM OFF — No remote alarm signal.

COOL ON — Coolant pump stays on.

COOL OFF — Coolant pump turns off.

COOL GAP — Coolant pump reverts to status prior to gap power on.

NOTE: Even when the machine is completely shut down, the computer stays on and maintains knowledge of the last position and any movement of the X, Y and Z axes.

POWER FILE MANAGEMENT

As you develop more and more EDM programs over time, the size of the Power File "Library" in the memory of the M-Pulse will increase. It is important, therefore, to know how to name and manipulate these files to keep a well-organized library in order to easily access the right file when you need it.

NAMING A POWER FILE

The following Power File Format (repeated here from the Creating a Program section) makes it easy to recognize and locate a Hansvedt file in the Library.

Each file's name consists of five parts and eight digits:

1	2	3	4	5	6	7	8
P	L	G	S	T	3	2	5

The eight digits correspond to the following five power parameters:

Digit	Parameter
1	**POLARITY** A to N assigned for — polarity, P to Z assigned for + polarity. (See note below.)
2	**USER ASSIGNED** For wear, speed, class code, etc. For example: L for low wear, F for fast & fine, N for efficient, negative polarity cuts.
3	**ELECTRODE MATERIAL** For example: G = graphite, C = Copper.
4,5	**WORKPIECE MATERIAL** For example: ST = Steel, AL = aluminum.
6,7,8	**SURFACE FINISH** For example: 325 Ra.

Thus, in the example shown above,

PLGST325

is a Power File for: Positive polarity, Low wear, Graphite electrode, Steel workpiece, 325 Ra surface finish.

NOTE: The use of N and P in the first digit should be reserved for existing and future Power Files supplied by Hansvedt.

Power files can be named using other formats as long as they contain no more than eight numeric or alpha characters. Files are stored in memory in numeric-alpha order: 1, 2, 3... followed by A, B, C.... Any time the list of Power Files is brought up on the screen, the top one on the list will be the first one in that order.

Instead of having the first digit represent polarity, you may wish to have it designate one of several groups, such as by type of job or most frequently used file, etc. — whatever you can easily relate to in your business. For example: A=coining dies, B=header dies, etc. Or, if you want the most used files to be at the top of the list: 0=most used, 1=next most used, etc. You might want to use the second digit for further designations that fit your own purposes.

COPYING, MOVING AND DELETING POWER FILES

Power Files can be copied or moved between memory, a 3.5" disk or an outside device via the RS-232. They can also be deleted from memory or disk. This feature is useful for keeping your most commonly used Power Files in the computer's memory, while storing less used files on a separate disk. It can also be used if you decide to rename files with a new name format.

	COPY FROM?	COPY TO?	MOVE FROM?	MOVE TO?	DELETE FROM?
MEMORY	√	√	√	√	√
DISK	√	√	√	√	√
RS-232	√	√		√	

In COPYING a file, the file is first selected at its source, then copied to the "buffer" (or "clipboard"), then pasted into a destination elsewhere. The original file remains in its source location, and it will remain in the buffer until the buffer is used for a subsequent copying or moving process or the machine is turned off.

MOVING a file is the same as copying, except that after the file is successfully moved, the original file is automatically deleted from either memory or disk, whichever it came from.

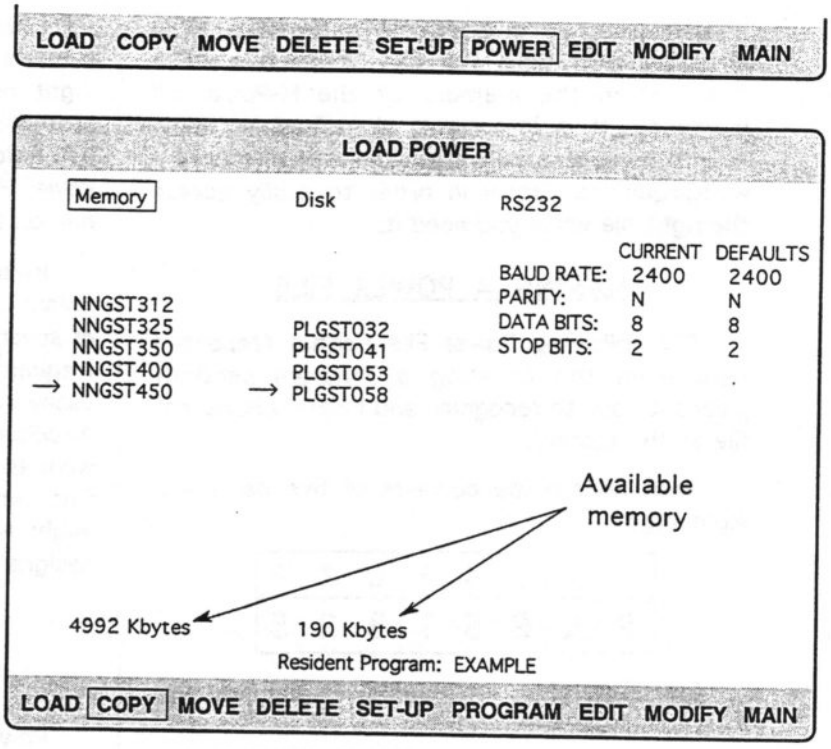
In DELETING a file, the file is removed from its source location without copying or moving it anywhere. Once deleted, it is gone.

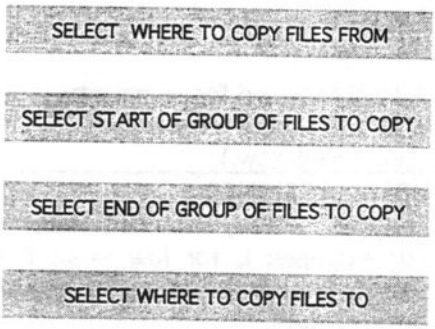
COPYING FROM MEMORY

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- From the bottom menu select POWER. The LOAD POWER screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.

NOTE: To MOVE a file, select MOVE instead of COPY from the bottom menu. The messages will read "MOVE" instead of "COPY."

- Position the cursor on MEMORY and select it. The message SELECT START OF GROUP OF FILES TO COPY appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired file (or the first or last file of a group) with the arrow.
- Press the C.I. knob to select the file. The message SELECT END OF GROUP OF FILES TO COPY appears.
- To copy one file, press the C.I. knob. The message SELECT WHERE TO COPY FILES TO appears.
- To select a group of files, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message SELECT WHERE TO COPY FILES TO appears.

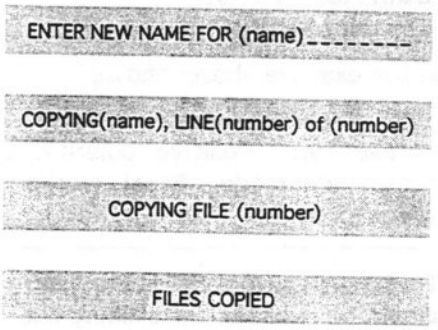




To copy to memory:

(This is a way to rename a file that already exists. After renaming the file, the old one can be deleted.)

- Select MEMORY. The message
  ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _
  appears.
- Enter a new name using the C.I. knob. The messages
  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED
  appear in sequence. If a group of files was selected, repeat the above sequence for each file. The newly named and copied file(s) will appear in the Memory column.



To copy to disk:

- Select DISK. The messages

  COPYING(name), LINE(number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence.

If an attempt is made to copy a file with the same name as a file already in the disk, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the file currently in the disk with the file in memory, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To rename the file you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new file name using the C.I. knob. Then the messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To advance to the next file in a group without copying the file currently shown, select SKIP:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

To copy to RS-232:

- Select RS232. The message

  PRESS C.I. KNOB TO BEGIN TRANSFERRING _ _ (name) _ _

  will appear.
- Prepare the host computer to receive the file.
- Press the C.I. knob to begin the transfer. The messages

  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. If a group of files was selected, repeat the above sequence for each file.

To return to the LOAD PROGRAM screen at any time, select PROGRAM from the bottom menu of the LOAD POWER screen.

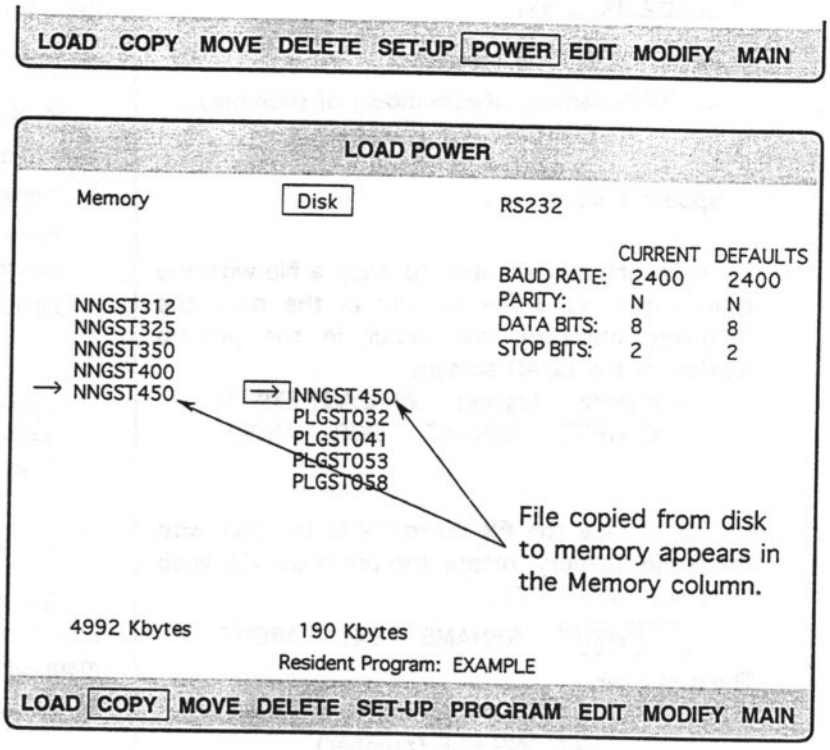
NOTE
If you selected MOVE in the bottom menu, the file will be copied to the destination you have chosen and the original file will automatically be deleted after successful completion of the move.

COPYING FROM DISK

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- From the bottom menu select POWER. The LOAD POWER screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.

Note: To MOVE a file, select MOVE instead of COPY from the bottom menu. The messages will read "MOVE" instead of "COPY."

- Position the cursor on DISK and select it. The message SELECT START OF GROUP OF FILES TO COPY appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired file (or the first or last file of a group) with the arrow.
- Press the C.I. knob to select the file. The message SELECT END OF GROUP OF FILES TO COPY appears.
- To copy one file, press the C.I. knob. The message SELECT WHERE TO COPY FILES TO appears.
- To select a group of files, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message SELECT WHERE TO COPY FILES TO appears.



SELECT WHERE TO COPY FILES FROM

SELECT START OF GROUP OF FILES TO COPY

SELECT END OF GROUP OF FILES TO COPY

SELECT WHERE TO COPY FILES TO

To copy to disk:

- Select DISK. The message
  ENTER NEW NAME FOR (name) _ _ _ _ _ _ _ _
  appears.
- Enter a new name using the C.I. knob. The messages
  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED
  appear in sequence. If a group of files was selected, repeat the above sequence for each file.

ENTER NEW NAME FOR (name)_ _ _ _ _ _ _

COPYING(name), LINE(number) of (number)

COPYING FILE (number)

FILES COPIED

To copy to memory:

- Select MEMORY. The messages

  COPYING(name), LINE(number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. The newly named and copied file will appear in the Memory column.

If an attempt is made to copy a file from disk with the same name as a file already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the file currently in memory with the file on disk, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To rename the file you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new file name using the C.I. knob. Then the messages

COPYING (name), LINE (number) of (number),
COPYING FILE (number)
and FILES COPIED

will appear in sequence.

To advance to the next file in a group without copying the file currently shown, select SKIP:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

To copy to RS-232:

- Select RS232. The message

  PRESS C.I. KNOB TO BEGIN TRANSFERRING _ _ (name) _ _

  will appear.
- Prepare the host computer to receive the file.
- Press the C.I. knob to begin the transfer. The messages

  COPYING (name), LINE (number) of (number),
  COPYING FILE (number)
  and FILES COPIED

  appear in sequence. If a group of files was selected, repeat the above sequence for each file.

To return to the LOAD PROGRAM screen at any time, select PROGRAM from the bottom menu of the LOAD POWER screen.

NOTE
If you selected MOVE in the bottom menu, the file will be copied to the destination you have chosen and the original file will automatically be deleted after successful completion of the move.

COPYING FROM RS-232

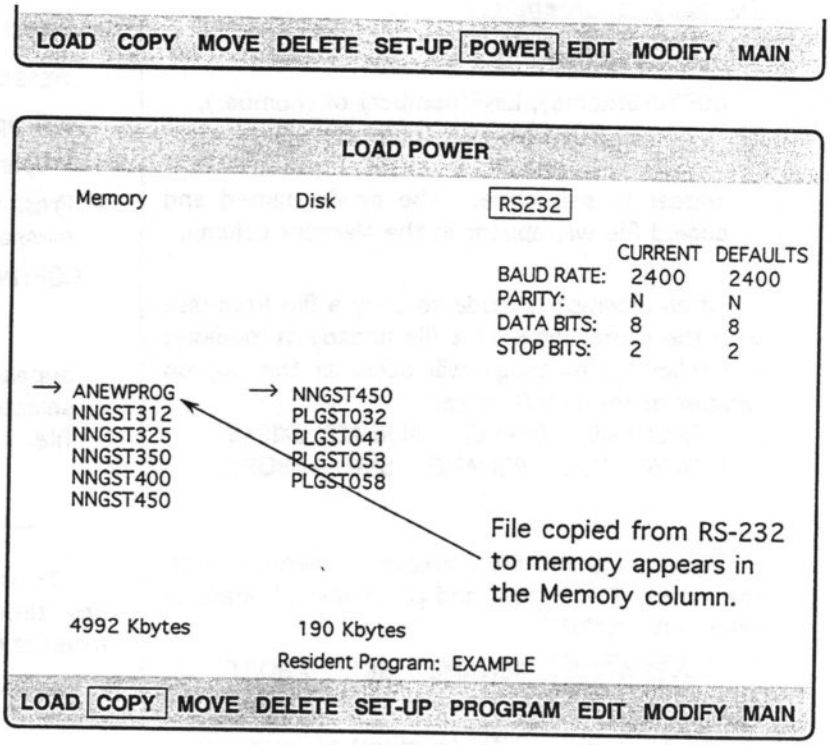
- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- From the bottom menu select POWER. The LOAD POWER screen will appear.
- Select COPY from the bottom menu. The message SELECT WHERE TO COPY FILES FROM appears.
- Position the cursor on RS232 and select it. The message

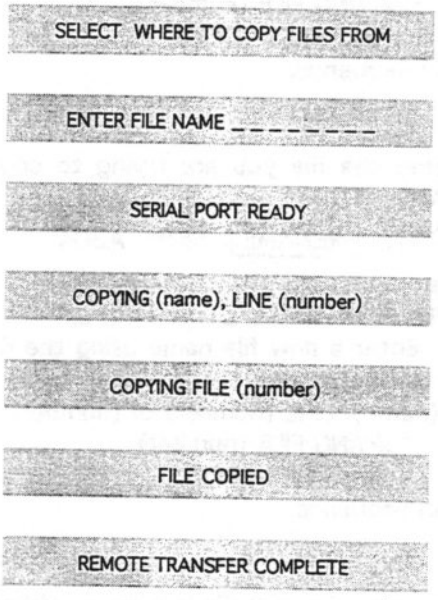
  ENTER FILENAME: _ _ _ _ _ _ _ _

  appears.
- Using the C.I. knob, enter the name you want to assign to the file you will be receiving from the host computer. Entering a space or the eighth digit will finalize the entry of the name. The message SERIAL PORT READY will appear.
- Begin transmitting from the host computer. The messages

  COPYING (name), LINE (number),
  COPYING FILE (number)
  and FILE COPIED

  appear in sequence. The message REMOTE TRANSFER COMPLETE will appear and the file will appear in the Memory column.





If an attempt is made to copy a file with the same name as a file already in memory, the following message will occur in the pop-up window of the LOAD screen:

FILENAME (name) ALREADY EXISTS
OVERWRITE RENAME SKIP ABORT

To replace the file currently in memory with the file to be transferred, rotate and press the C.I. knob to select OVERWRITE:

[OVERWRITE] RENAME SKIP ABORT

The messages

COPYING (name), LINE (number),
COPYING FILE (number)
and FILE COPIED

will appear in sequence.

To rename the file you are trying to copy, select RENAME:

OVERWRITE [RENAME] SKIP ABORT

The message

ENTER FILENAME: _ _ _ _ _ _ _ _

will appear. Enter a new file name using the C.I. knob. Then the messages

COPYING (name), LINE (number),
COPYING FILE (number)
and FILE COPIED

will appear in sequence.

SKIP is used only with multiple file COPY and MOVE functions:

OVERWRITE RENAME [SKIP] ABORT

To cancel the copying process, select ABORT:

OVERWRITE RENAME SKIP [ABORT]

To return to the LOAD PROGRAM screen at any time, select PROGRAM from the bottom menu of the LOAD POWER screen.

NOTE: To COPY from RS-232 to disk, copy first from RS-232 to memory then from memory to disk.

DELETING A FILE

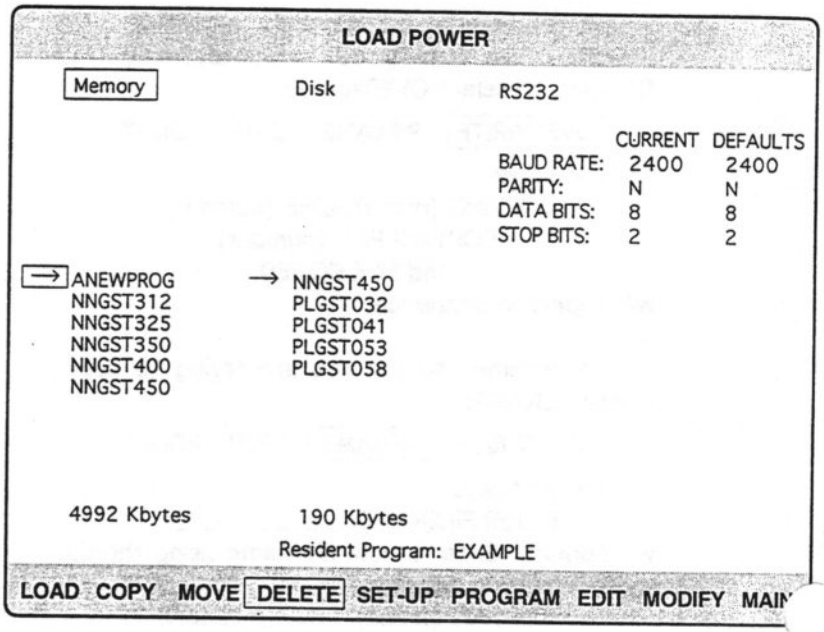
Files can be deleted from memory or disk.

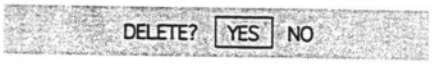
- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- From the bottom menu select POWER. The LOAD POWER screen will appear.
- Select DELETE from the bottom menu. The message SELECT WHERE TO DELETE FILES FROM appears.
- Position the cursor on MEMORY or DISK and select it. The message SELECT START OF GROUP OF FILES TO DELETE appears, and the arrow in that column becomes bold.
- Press and rotate the C.I. knob to align the desired file (or the first or last file of a group) with the arrow.
- Press the C.I. knob to select the file. The message SELECT END OF GROUP OF FILES TO DELETE appears.
- To delete one file, press the C.I. knob. The message DELETE? YES NO appears.
- To delete a group of files, press and rotate the C.I. knob to highlight the group. Press the C.I. knob again to select the group. The message DELETE? YES NO appears.

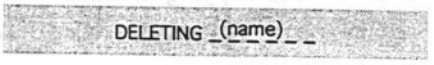
> NOTE
> If you do not want to delete the file(s), select NO by rotating the C.I. knob and pressing it.

- To delete the file(s), select YES and press the C.I. knob. The messages DELETING(name) and FILE(S) DELETED appear.

To return to the LOAD PROGRAM screen at any time, select PROGRAM from the bottom menu of the LOAD POWER screen.







OTHER MESSAGES

LOAD POWER Screen

CHECKING DISK DRIVE.

ERROR: NO DISK IN DRIVE.

ERROR: UNEXPECTED DISK ERROR.

REMOTE TRANSFER IN PROGRESS.

REMOTE TRANSFER TERMINATED.

REMOTE TRANSFER COMPLETE.

SERIAL PORT READY.

FORMATTING DISK.

FORMAT COMPLETE.

ERROR: FILE NAME ALREADY EXISTS.

ERROR: INSUFFICIENT MEMORY.

ERROR: DISK WAS REMOVED.

ERROR: FILE IS WRITE PROTECTED.

ERROR: DISK IS WRITE PROTECTED.

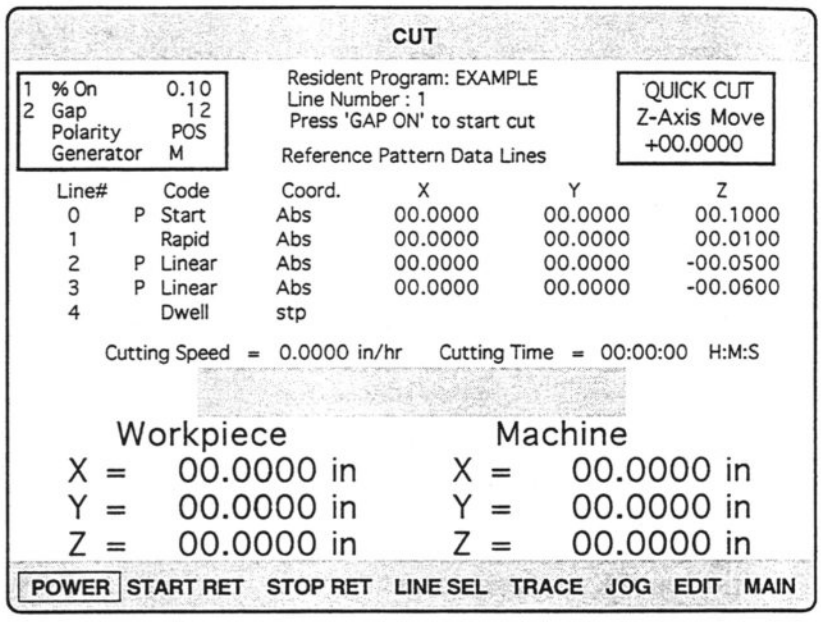
CAN'T COPY FROM RS-232 TO RS-232.

QUICK CUT

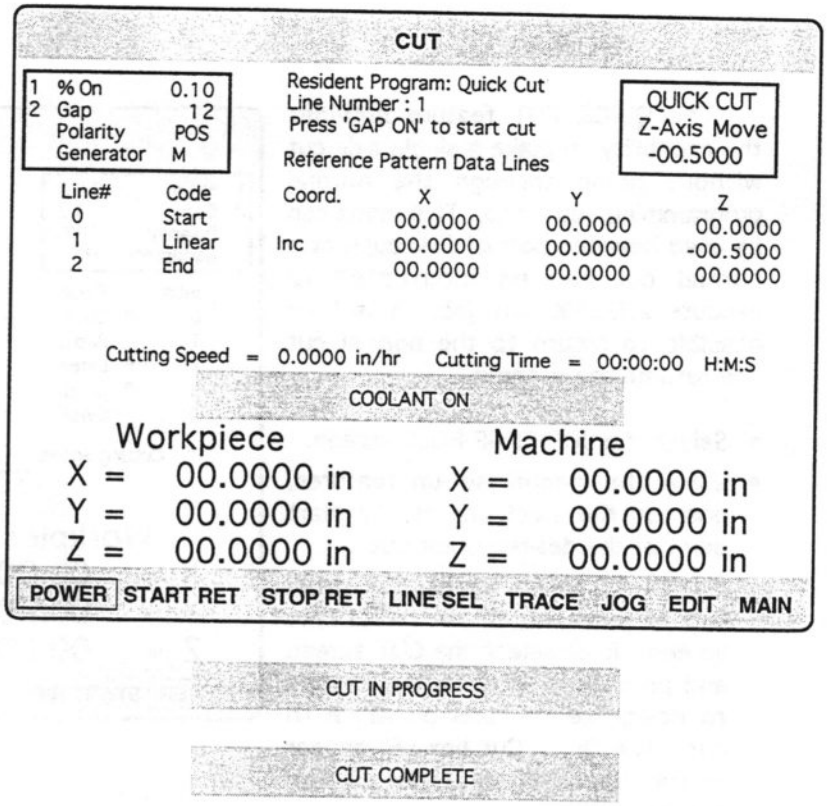
The QUICK CUT feature provides the capability to make a single axis cut without going through the normal programming sequence. This mode can be used between normal EDM cuts, or a normal cut can be interrupted to execute a QUICK CUT job. It is then possible to return to the normal cut and resume the program.

- Select the JOG-EDGE-HOLE screen.
- Using the manual set-up features, position the electrode at the start point of the desired Quick Cut.
- EITHER 1) Select QUICK CUT from the lower menu of the WELCOME screen OR 2) select the CUT screen and press X, Y, or Z on the keypad to designate the axis on which to cut. The Quick Cut box will appear in the upper right corner of the screen.
- Set the desired depth of cut.

(Cont'd next page ...)



- Press ENTER. The Resident Program name will be changed to Quick Cut and line 1 of the program will show the single axis move that was entered.
- Select OPERATING PARAMETERS screen and enter the desired cut parameters. (Quick Cut reference charts for graphite into steel are in section 4.6 of this manual.)
- Fill the worktank with dielectric fluid and set the float switch.
- Depress GAP POWER ON; the machine will perform the cut. COOLANT ON, CUT IN PROGRESS and CUT COMPLETE messages will appear.
- If you wish to inspect the part, depress GAP POWER OFF and either 1) manually jog out of the cut, 2) select START RETURN or 3) continue to depress GAP POWER OFF/RETRACT to move the electrode away from the workpiece.
- To resume the cut, select START RETURN and GAP POWER ON.
- Upon completing a Quick Cut, the CUT COMPLETE message will appear.
- Select START RETURN.
- If another Quick Cut is required, depress GAP POWER ON; the next cut will proceed.
- If you wish to return to the program that was interrupted, select START RETURN; the machine will return to the Quick Cut start position.
- Selecting START RETURN the second time reloads the prior program, and the Resident Program name changes from Quick Cut to the previous name.
- Selecting START RETURN for the third time positions the machine at the start point of the previous program.
- Depress GAP POWER ON to begin cutting.



ORBITING

The M-Pulse orbiting feature provides the ability to enlarge a cavity or through-hole by an equal amount on each side or on a segment. This is accomplished by using circular, vector or trace vector orbit(s).

Benefits of orbiting include:

- Fewer electrodes are required because electrode wear is more uniform
- Fine finish cutting times are faster on the side walls of the cavity.
- Electrode manufacturing costs are lower because the accuracy of some dimensions is not as critical, and separate roughing and finishing electrodes are not always necessary.

By properly combining the various orbiting features with the programmable power supply settings many EDM jobs can be completely automated with little or no operator intervention.

ORBIT SELECTION

Three types of orbit movements are available:

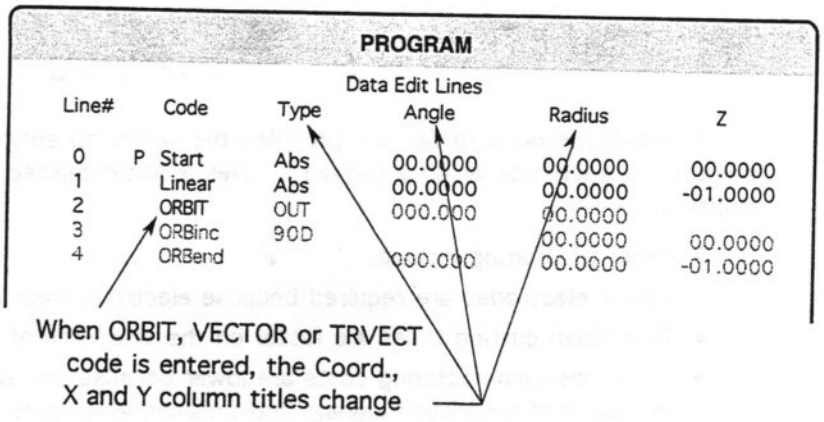
- CIRCULAR — Provides a circular path about a center point. Used where square corners are not required. Produces a very concentric round hole when used with a round rotating electrode. Also used in thread cutting and undercutting. The edit code for this mode is ORBIT.
- VECTOR — Recommended where inside square corners are necessary. The edit code for this mode is VECTOR.
- TRACE VECTOR — Used to enlarge an equilateral cavity, such as an octagon, using an electrode with the same shape but smaller in size. The edit code for this mode is TRVECT.

ORBITING CONSIDERATIONS

- Plan the job to minimize the amount of material to be removed by orbiting. To minimize cutting time, try not to orbit much beyond the crater depth of the preceding cut.
- Smaller orbit increments (.001" - .005") generally cut more effectively than large increments (over .010").
- Do not over-power an orbit cut. Be sure that the amperage per square inch is properly set for the actual electrode surface that is cutting. Electrode wear will increase if the cut is over-powered.
- Select the best orbit for each application (CIRCULAR, VECTOR or TRACE VECTOR).
- Orbiting eliminates overcut taper on the side walls that commonly occurs in the initial rough cut. Either redress or replace the electrode before orbiting if minimum taper is desirable.
- **Flush, flush and flush!** Like other EDM jobs, orbiting will cut better with good flushing conditions. Flushing volume is more important than pressure. Use low pressure in fine finish applications.
- Select the electrode material carefully, depending on the desired finish, rigidity and wear characteristics.

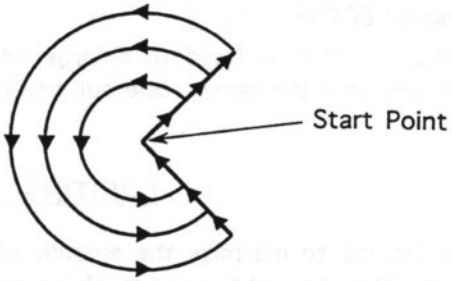
PROGRAMMING FOR ORBIT MODE

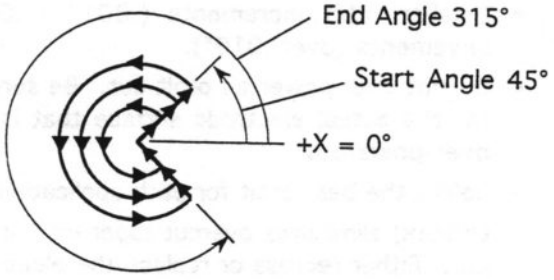
Orbit commands are included in the part program and they are entered on the PROGRAM screen. When an orbit code is selected, the COORD., X and Y column titles change to TYPE, ANGLE and RADIUS. The screen titles will automatically change back to the previous format upon completing an ORBend, VECend, or TRVend program line or exiting the orbit code lines.

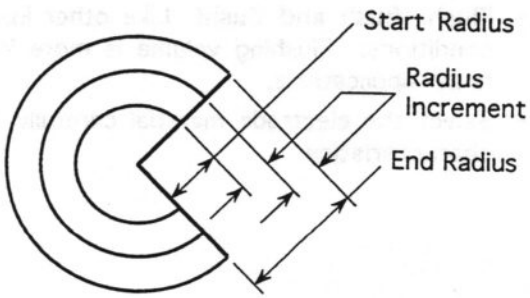


ORBIT MODE

- Enter ORBIT in the CODE column.
- Enter OUT, CON or enter the number of final orbit passes (1 to 16) in the TYPE column. OUT will cause the orbit to terminate when cutting is complete (spark out occurs). CON (continuous) can only be terminated by the operator actuating GAP POWER ON.
- Enter the ANGLE at which the move from the center point will begin. Values between 000.000 and 360.000 degrees can be used: 000.000 is the +X direction and 180.000 is the -X direction. The orbit will progress in a counterclockwise direction.
- Enter the RADIUS. This is the initial radius the machine will execute to begin the first orbit pass. This radius value should position the electrode as close to the workpiece as possible.
- Enter the retract TYPE 45D (45°) or 90D (90°). This determines the angle at which the electrode will withdraw from the orbit path when the gap becomes shorted.
- Enter the distance in the RADIUS column that each orbit will increment as it steps out to the final orbit radius. Note that after each incremental orbit the machine will momentarily go back to the orbit start point before executing the next orbit move.
- Enter the Z incremental value if a tapered cavity is required. The message Z END COMPUTED appears. Press the C.I. knob to continue. Use the value 00.0000 in the case of a straight sided cavity. Cursor advances to ORBend ANGLE.
- In the ANGLE column enter the angle at which the orbit will end.
- In the RADIUS column enter the radius at which the orbit will end.
- The ORBend Z position at the end of the orbit will automatically calculate if an ORBinc Z value was entered.
- Proceed with the next program line.





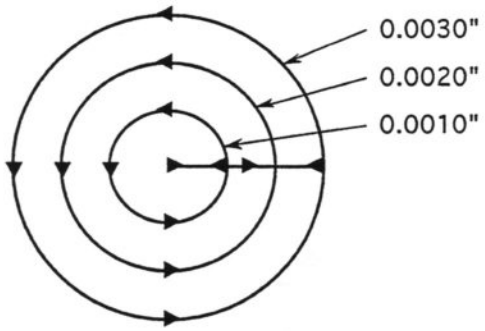


Orbit Mode Example 1

Start angle.....000.000
End angle.....000.000
Start radius.....00.0010
Radius increment (ORBinc).....00.0010
End radius (ORBend).....00.0030
Z-axis start.....-01.0000
Z-axis increment.....00.0000
Z-axis end.....-01.0000

Upon sparking out (designated by OUT), the program will advance to the next line.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-01.0000
2		ORBIT	OUT	000.000	00.0010	
3		ORBinc	90D		00.0010	00.0000
4		ORBend		000.000	00.0030	-01.0000

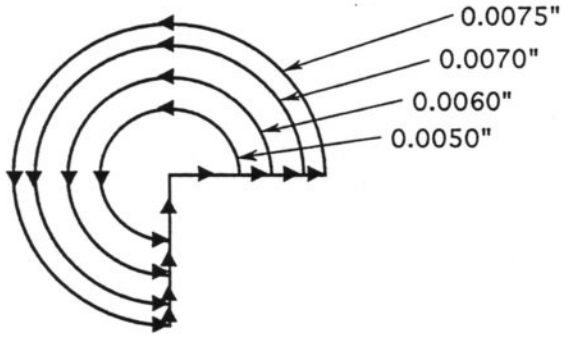


Orbit Mode Example 2

Start angle.....000.000
End angle.....270.000
Start radius.....00.0050
Radius increment (ORBinc).....00.0010
End radius (ORBend).....00.0075
Z-axis start.....-00.2500
Z-axis increment.....00.0000
Z-axis end.....-01.0000

Upon completing ORBIT CON, the machine will continue to cycle in the orbit path until the operator presses GAP POWER ON.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-00.2500
2		ORBIT	CON	000.000	00.0050	
3		ORBinc	90D		00.0010	00.0000
4		ORBend		270.000	00.0075	-00.2500

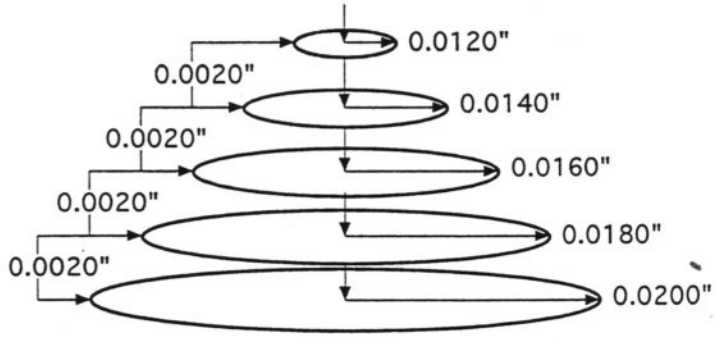


Orbit Mode Example 3

Start angle.....000.000
End angle.....000.000
Start radius.....00.0120
Radius increment (ORBinc).....00.0010
End radius (ORBend).....00.0200
Z-axis start.....-03.5000
Z-axis increment.....00.0020
Z-axis end.....-03.5080

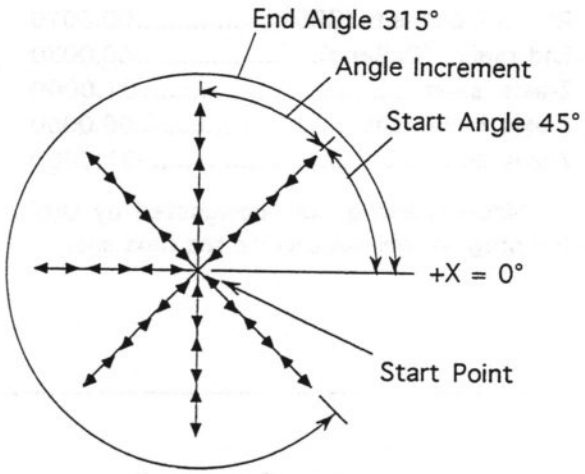
This orbit increments in the Z axis as it increments in the orbit to cut a 45° angle in .002" steps. Note that the ORBend/Z value is automatically calculated after all of the entries are made. If a specific ORBend/Z value is required, enter the desired value and the ORBend RADIUS will automatically be calculated.

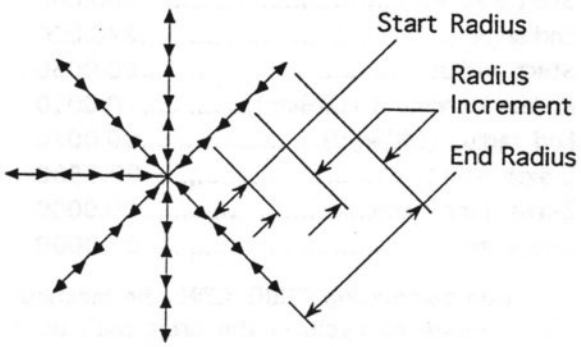
Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-03.5000
2		ORBIT	5	000.000	00.0120	
3		ORBinc	90D		00.0020	-00.0020
4		ORBend		000.000	00.0200	-03.5080



PROGRAMMING FOR VECTOR MODE

- Enter VECTOR in the CODE column.
- Enter OUT or CON or enter the number of final vector passes (1 to 16) in the TYPE column. OUT will cause the vector to terminate when cutting is complete (spark out occurs). CON (continuous) can only be terminated by the operator actuating GAP POWER ON.
- Enter the ANGLE at which the move from the center point will begin. Values between 000.000 and 360.000 degrees can be used: 000.000 is the +X direction and 180.000 is the -X direction. The vector will progress in a counterclockwise direction.
- Enter the RADIUS. This is the initial radius the machine will execute to begin the first vector pass. This radius value should position the electrode as close to the workpiece as possible.
- Enter the retract TYPE 45D (45°) or 90D (90°). This determines the angle at which the electrode will withdraw from the vector path when the gap becomes shorted.
- Enter the incremental angle in the ANGLE column.
- Enter the distance in the RADIUS column that each vector will increment as it steps out to the final vector radius. Note that after each incremental vector the machine will momentarily go back to the vector start point before executing the next vector move.
- Enter the Z incremental value if a tapered cavity is required. Use the value 00.0000 in the case of a straight sided cavity. Cursor will advance to VECend angle.
- In the ANGLE column enter the angle at which the last vector will end.
- In the RADIUS column enter the radius of the last vector.
- The VECend Z position at the end of the vector will automatically calculate if a VECinc Z value was entered.
- Proceed with the next program line.



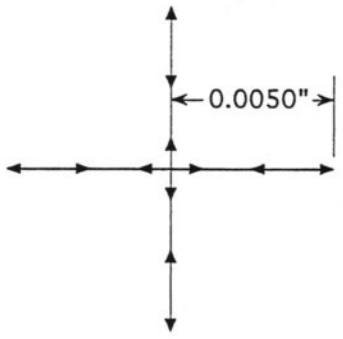


Vector Mode Example 1

Start angle.....000.000
Angle increment.....090.000
End angle.....000.000
Start radius.....00.0050
Radius increment (VECinc).....00.0000
End radius (VECend).....00.0050
Z axis start.....-01.0000
Z axis increment.....00.0000
Z axis end.....-01.0000

This program will move out to a distance of .0050" in four directions (one direction at a time until spark-out occurs). The Z-axis will remain stationary. Upon completing this vector the program will advance to the next line.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-01.0000
2		VECTOR	OUT	000.000	00.0050	
3		VECinc		090.000	00.0000	00.0000
4		VECend		000.000	00.0050	-01.0000

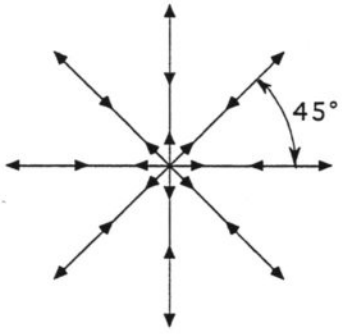


Vector Mode Example 2

Start angle.....000.000
Angle increment.....045.000
End angle.....000.000
Start radius.....00.0010
Radius increment (VECinc).....00.0000
End radius (VECend).....00.0010
Z axis start.....-01.0000
Z axis increment.....00.0000
Z axis end.....-01.0000

This vector pattern moves out every 45° to a distance of 0.0010". After completing each vector the machine will return to the center point prior to executing the next vector move. The TYPE "2" selection will cause two complete sets of vector moves to a .001" radius prior to advancing to the next program line.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-01.0000
2		VECTOR	2	000.000	00.0010	
3		VECinc		045.000	00.0000	00.0000
4		VECend		000.000	00.0010	-01.0000

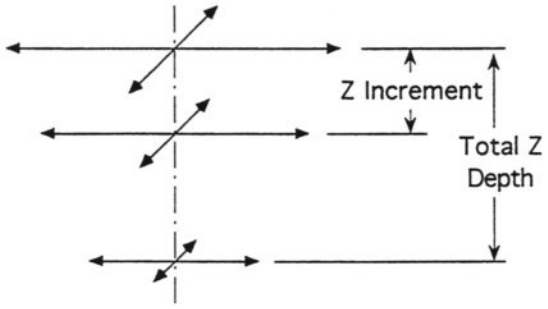


Vector Mode Example 3

Start angle.....090.000
Angle increment.....090.000
End angle.....090.000
Start radius.....00.0100
Radius increment (VECinc).....-00.0010
End radius (VECend).....00.0070
Z axis start.....00.0000
Z axis increment.....-00.0010
Z axis end.....-00.0030

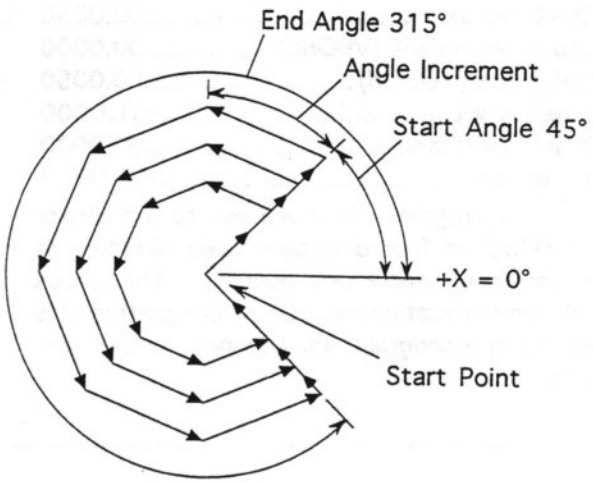
This vector increments the Z-axis and includes a decreasing vector radius that results in a tapered cavity. The CON selection will cause the last vector pattern to cycle until the GAP POWER ON is actuated.

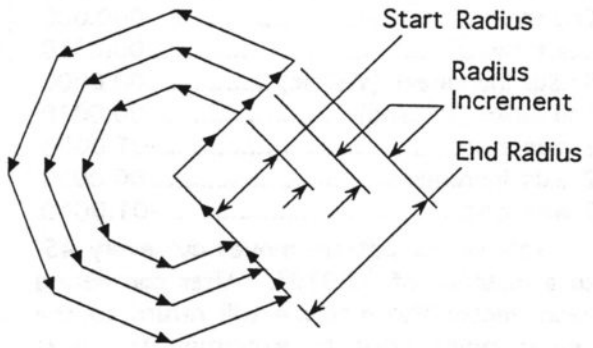
Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	00.0000
2		VECTOR	CON	090.000	00.0100	
3		VECinc		090.000	-00.0010	-00.0010
4		VECend		090.000	00.0070	-00.0030



PROGRAMMING FOR TRACE VECTOR MODE

- Enter TRVECT in the code column.
- Enter OUT or CON or enter the number of final trace vector passes (1 to 16) in the TYPE column. OUT will cause the trace vector to terminate when cutting is complete (spark out occurs). CON (continuous) can only be terminated by the operator actuating GAP POWER ON.
- Enter the ANGLE at which the move from the center point will begin. Values between 000.000 and 360.000 degrees can be used: 000.000 is the +X direction and 180.000 is the -X direction. The trace vector will progress in a counter-clockwise direction.
- Enter the RADIUS. This is the initial radius the machine will execute to begin the first trace vector pass. This radius value should position the electrode as close to the workpiece as possible.
- Enter the retract TYPE 45D (45°) or 90D (90°). This determines the angle at which the electrode will withdraw from the trace vector path when the gap becomes shorted.
- Enter the distance in the RADIUS column that each trace vector will increment as it steps out to the final trace vector radius. Note that after each incremental trace vector the machine will momentarily go back to the trace vector start point before executing the next trace vector move.
- Enter the Z incremental value if a tapered cavity is required. The message Z END COMPUTED appears. Use the value 00.0000 in the case of a straight sided cavity. Cursor advances to TRVend ANGLE.
- In the ANGLE column enter the angle at which the trace vector will end.
- In the RADIUS column enter the radius at which the trace vector will end.
- The TRVend Z position at the end of the trace vector will automatically calculate if a TRVinc Z value was entered.
- Proceed with the next program line.



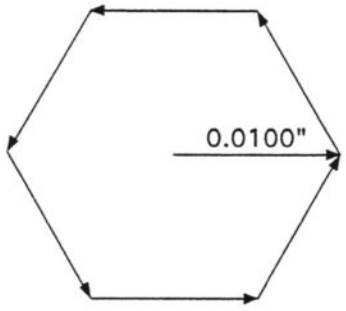


Trace Vector Mode Example 1

Start angle.....000.000
Angle increment.....060.000
End angle.....000.000
Start radius.....00.0100
Radius increment (TRVinc).....00.0000
End radius (TRVend).....00.0100
Z axis start.....-00.5000
Z axis increment.....00.0000
Z axis end.....-00.5000

The electrode will move out at 0.00° to 00.0100" and trace the pattern that is defined by the angle increment of 60°. Upon spark out (designated by OUT) the program will advance to the next line.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-00.5000
2		TRVECT	OUT	000.000	00.0100	
3		TRVinc		060.000	00.0000	00.0000
4		TRVend		000.000	00.0100	-00.5000

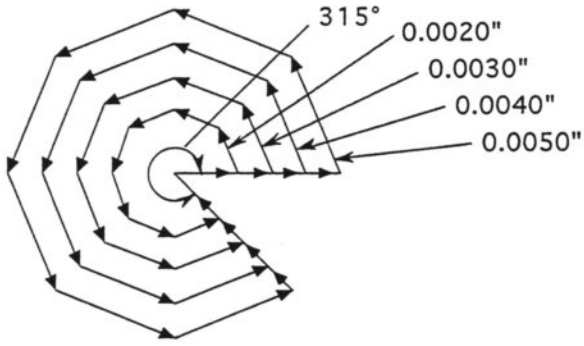


Trace Vector Mode Example 2

Start angle.....000.000
Angle increment.....045.000
End angle.....315.000
Start radius.....00.0020
Radius increment (TRVinc).....00.0010
End radius (TRVend).....00.0050
Z axis start.....-01.0000
Z axis increment.....00.0000
Z axis end.....-01.0000

This trace vector will move out to 00.0020" at an angle of 0.00° and trace on 45° angles. It will exit the trace at 315°. Incremental moves of 00.0010" will occur out to a final radius of 00.0050". The Z-axis will remain stationary. Using a TYPE "3" will cause the final trace vector to complete three passes before advancing to the next line of the program.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-01.0000
2		TRVECT	3	000.000	00.0020	
3		TRVinc		045.000	00.0010	00.0000
4		TRVend		315.000	00.0050	-01.0000

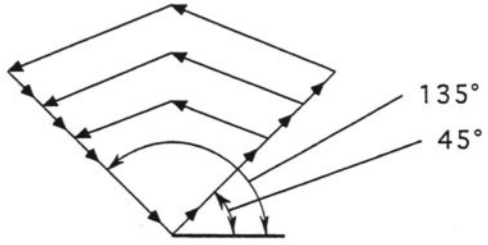


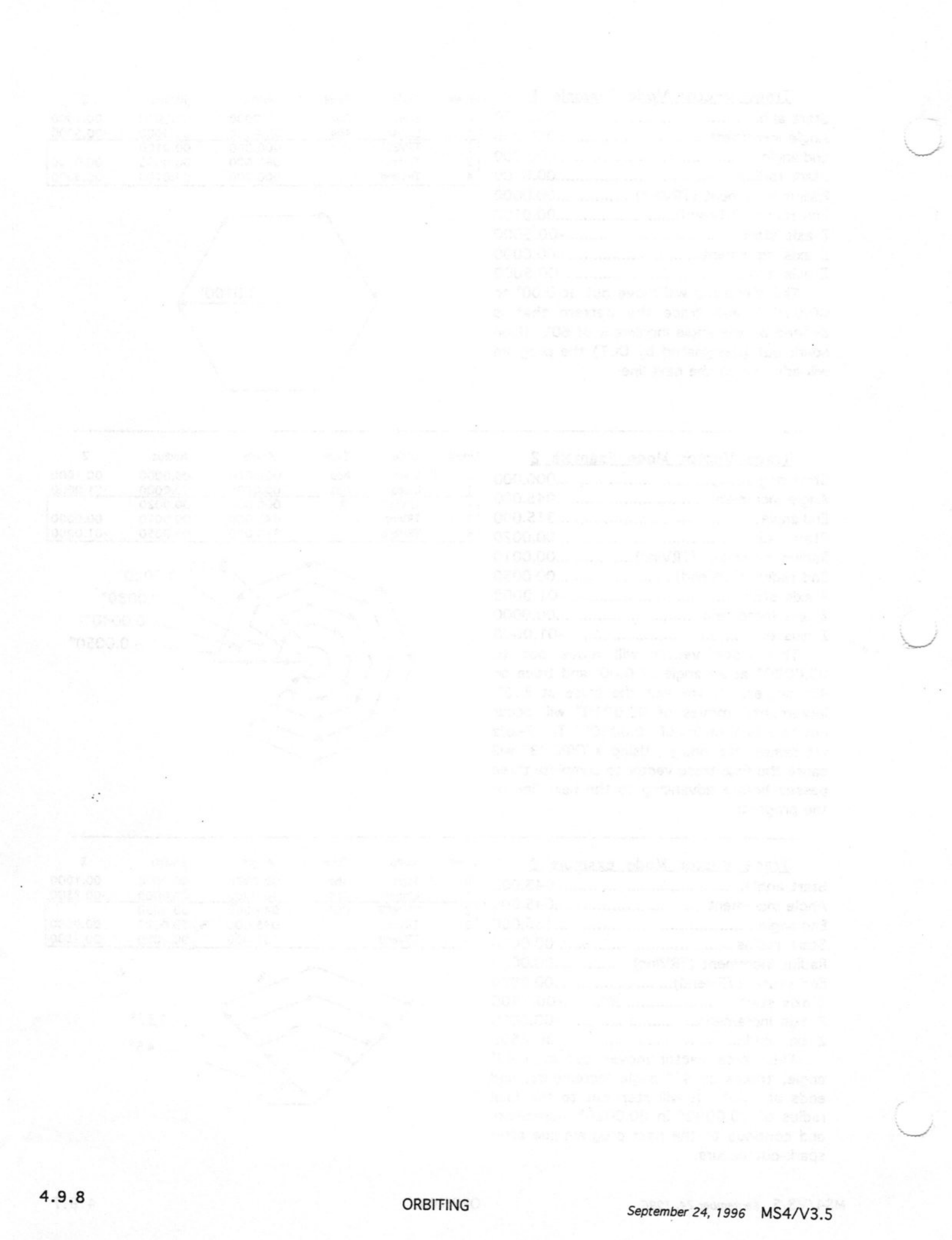
Trace Vector Mode Example 3

Start angle.....045.000
Angle increment.....045.000
End angle.....135.000
Start radius.....00.0050
Radius increment (TRVinc).....00.0020
End radius (TRVend).....00.0090
Z axis start.....-00.2500
Z axis increment.....00.0000
Z axis end.....-00.2500

This trace vector moves out at a 45° angle, traces at 45° angle increments, and ends at 135°. It will step out to the final radius of 00.0090" in 00.0020" increments and continue to the next program line after spark-out occurs.

Line#		Code	Type	Angle	Radius	Z
0	P	Start	Abs	00.0000	00.0000	00.1000
1		Linear	Abs	00.0000	00.0000	-00.2500
2		TRVECT	OUT	045.000	00.0050	
3		TRVinc		045.000	00.0020	00.0000
4		TRVend		135.000	00.0090	-00.2500





AUTOMATIC TOOL CHANGER
(Optional)

Safety.....4.10.2
Introduction.....4.10.3
Description; Specifications.....4.10.4
Creating and Editing a Program.....4.10.5
Setting Tool Changer Home Position.....4.10.6
Tool Changer Set-up.....4.10.8
Using the Pneumatic Chuck.....4.10.10
Other Operating Features.....4.10.11
Maintenance and Service.....4.10.12

SAFETY

WARNING

Failure to follow instructions on this page may result in personal injury and/or damage to equipment.

These safety precautions have been prepared to assist the operator and maintenance personnel in practicing good shop safety procedures. Operators and maintenance personnel must read and understand these precautions COMPLETELY before operating, setting up, running or performing maintenance on the machine.

The precautions in this manual are to be used to supplement safety precautions and warnings from the following:

- Local, plant, and shop safety rules and codes.
- Federal and national safety laws and regulations. (See the latest edition of the OCCUPATIONAL SAFETY AND HEALTH STANDARDS, available from the DEPT. OF LABOR, WASHINGTON, D.C.)

Also refer to the General Safety section of this manual for additional safety information.

NOTICE

Photographs and sketches shown throughout this manual are for illustrative purposes only and might not show all guarding necessary for safe operation.

TOOL CHANGER SAFETY

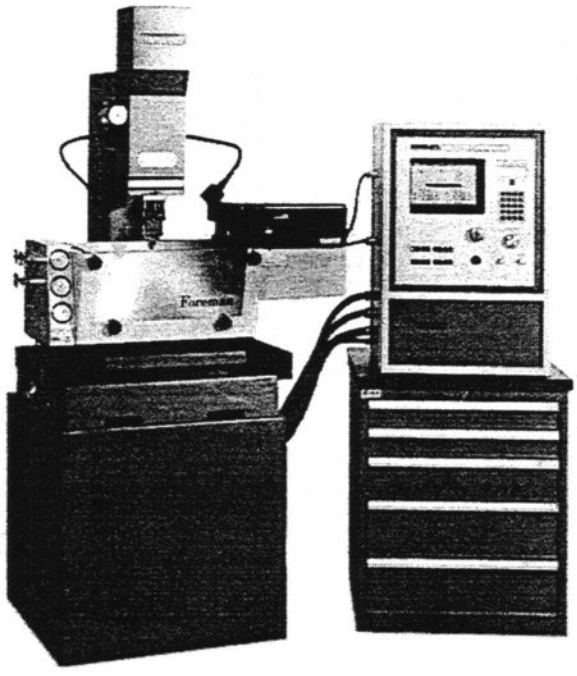
IMPORTANT SAFETY PRECAUTIONS

1. KEEP HANDS CLEAR OF AIR CHUCK.
2. DO NOT ATTEMPT TO LOAD OR ADJUST TOOLS WHEN THE TOOL CHANGER IS OPERATIONAL.
3. COVER MUST BE IN PLACE FOR TOOL CHANGER TO OPERATE.

The Automatic Tool Changer incorporates a motor driven mechanism and an air activated chuck that can cause personal injury. An interlock system will interrupt a cut in progress if the tool changer cover is opened. However, during normal operation the carousel rotates the electrode into the worktank area and the shuttle moves the mechanism into the "change" position. Keep hands clear of the worktank area when the Gap Power is on and the program includes tool changes.

When the air chuck is actuated (in either manual or automatic mode) a blast of air occurs to clean the reference surfaces, and normally-closed compression springs are compressed to unclamp the draw-bar. When manually inserting an electrode holder, it is important to avoid the pinch points where the air chuck and electrode holder clamp together.

INTRODUCTION

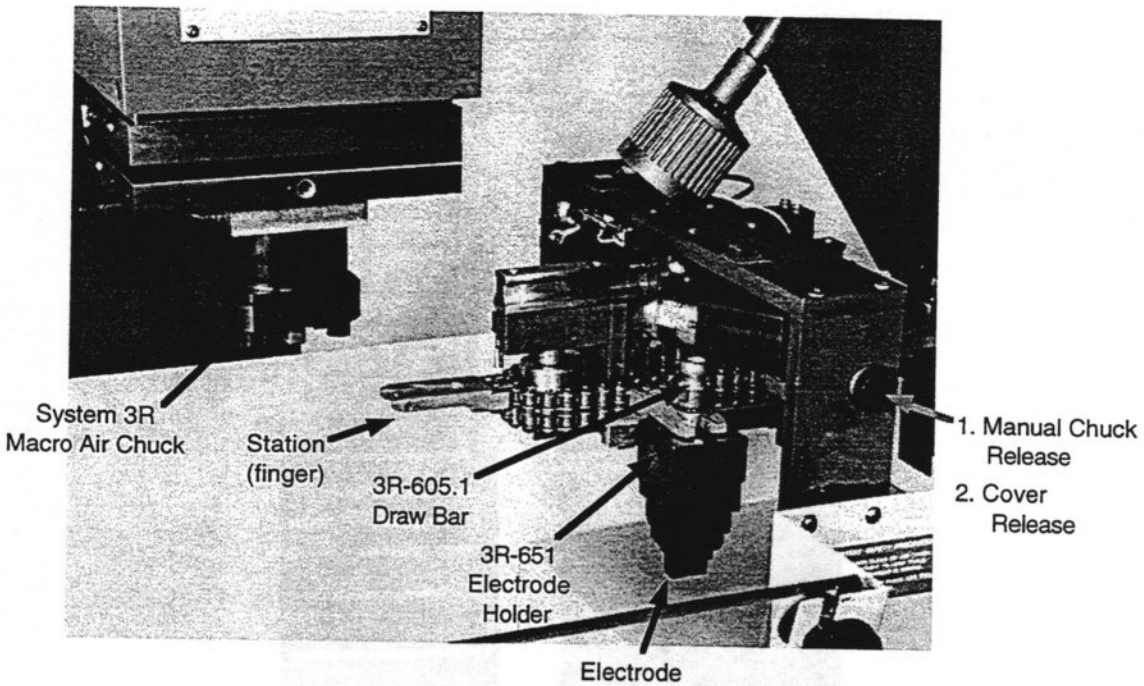


The Automatic Tool Changer, on the right side of the MS-4 worktank, can be programmed to change up to six electrodes without operator intervention. It includes six stations that hold different electrodes in System 3R Macro electrode holders. Electrodes are selected by means of a TOOL code in the part program.

Maximum electrode positioning accuracy and repeatability can be achieved by manufacturing electrodes after they have been mounted on their respective holders.

Applications for the use of a tool changer include single or multi-cavity cuts where multiple roughing and finishing electrodes are necessary. It is also possible to mount workpieces on the tool holders and fasten the electrode(s) to the machine table to facilitate certain production jobs.

DESCRIPTION: SPECIFICATIONS



Electrode stations are numbered from 1 to 6. When an electrode change is required, the program must include a separate line with a TOOL code, the tool station number and the absolute XYZ coordinate destination for the new electrode:

	Line#	Code	Coord.	X	Y	Z
→	6	Tool	1	00.0000	00.0000	00.0000

TOOL code — Station number — Coordinate destinations

Upon encountering a TOOL code in the program, the machine will automatically move from its existing position by fully retracting the Z axis and moving in the X and Y axes to the "change" position. The current electrode will be put away to its respective station and the specified new electrode will be inserted into the chuck. The machine will then fully retract the Z axis and move to the programmed XYZ destination, where it will execute the next line of the program.

Specifications

Number of stations	6
Tooling system	System 3R Macro
Air chuck	3R-600.86 modified for Hansvedt
Electrode holder	3R-651, 3R-651.2, 3R-651.4
Draw bar	3R-605.1
Max. Electrode size	3" L x 5" W x 6" H
Max. Electrode weight	10 lbs.
Shop air required	90 psi, 130 CFM
Water separator	Included

CREATING AND EDITING A PROGRAM

In addition to the standard programming codes, machines equipped with a tool changer also include the codes TOOL and TOLINC on the PROGRAM screen.

TOOL — Designates what tool is to be used. This is defined by the tool number entry in the COORD column; 1 through 6 select the numbered tool positions, "0" selects an empty chuck. The entered coordinates are the absolute XYZ destination after the tool has been changed. These are always given in absolute XYZ. After the new electrode is properly loaded in the chuck, TOOL then moves to the entered XYZ destination before continuing with the next program line.

All XYZ tool destinations are absolute (abs) with respect to the WORKPIECE (0,0,0). It is not possible to use an incremental (inc) move on a TOOL program line.

Always program the tool destinations above the workpiece surface. If an electrode encounters the workpiece or workpiece tooling during a tool change, the tool change and the cut will be aborted.

Always begin a tool change with the electrode clear from the workpiece. If the electrode is still in a cavity when a tool change occurs, the potential for a gap short is more likely and the result will be an aborted cut. Always retract from the cavity before a tool change by using a LINEAR or a GOTO.

TOLINC — Functions like a LINEAR code to produce an XYZ point-to-point cutting move. It is used to account for an electrode that is offset on its holder and/or to provide a convenient place in the program to compensate for a redressed electrode. The benefit of using TOLINC is that it is explicit to anyone viewing the program that the program line is a compensation for the tool, and not just another "cutting" leg of the program. It is required that the lines following TOLINC be incremental for it to properly function as an incremental offset.

Sample Program With Tool Changes

This program changes two electrodes. It begins and ends with an empty air chuck.

Data Edit Lines

Line#		Code	Coord.	X	Y	Z
0	P	Start	Abs	00.0000	00.0000	00.0000
1		Tool	1	-04.0000	-04.0000	-02.9500
2		Linear	inc	00.0000	00.0000	-00.1000
3		Goto	inc	00.0000	00.0000	00.2000
4		Tool	2	-04.0000	-04.0000	-02.9500
5		Tolinc	inc	-00.1000	-00.1000	00.0000
6		Linear	inc	-00.0000	-00.0000	-00.1000
7		Goto	inc	00.0000	00.0000	00.2000
8		Tool	0	00.0000	00.0000	00.0000
9		End				

The program starts at the machine home position. After it gets Tool 1 it moves to the Tool 1 destination (absolute position) on line 1, which positions the electrode .050" above the workpiece surface, assuming that the absolute surface position is -03.0000". The incremental Z axis linear move of -.1000" on line 2 results in cutting a .0500" deep cavity, and the GOTO on line 3 retracts the electrode .2000" to clear the workpiece. The minimum acceptable retract distance in this case is .0550" but it is possible to move further.

Line 4 executes the second tool change and goes to the same XYZ destination as the first electrode. However, the second electrode is offset on the tool holder by -.1000" in X and Y, so a TOLINC code is used on line 5 to compensate for this offset. If the length of the second electrode was different than the first electrode the TOLINC Z could also be changed. The program executes a linear move on line 6, cutting to the same depth as the first electrode. A GOTO on line 7 is used to retract the Z axis in preparation for putting the second electrode back in the tool changer using the TOOL 0 on line 8.

SETTING TOOL CHANGER HOME POSITION

NOTE: Use of the Tool Changer requires that it be homed.

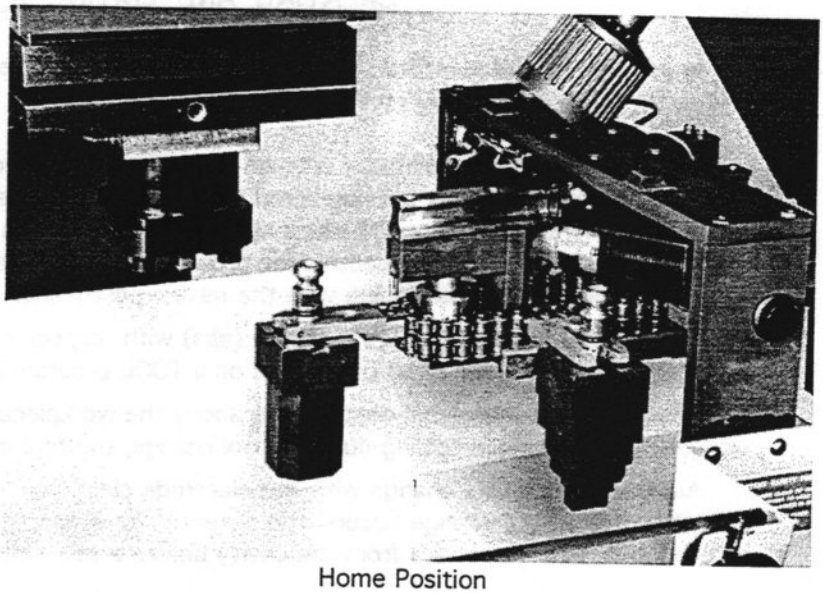
The home position establishes the Tool Changer's position with respect to the machine X, Y and Z axes. At the home position the tool changer finger #1 faces left as shown in the photo.

Home position is retained when MACHINE OFF is pressed. If the main power switch has been turned off or a power failure has occurred or a fault has occurred during a tool change, home position will be lost and MUST HOME will appear below the machine XYZ DRO display. In this event, a homing procedure is required.

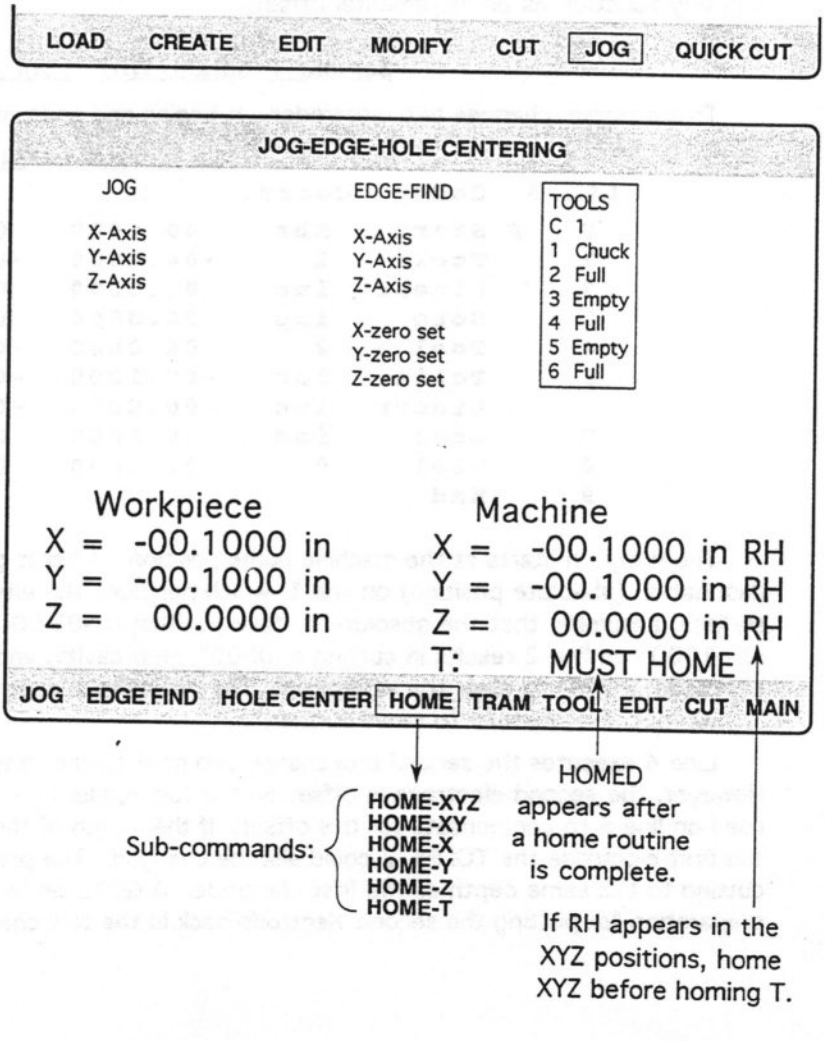
NOTE
The homing procedure will actuate the tool changer carousel. Before homing, check the work area for any obstructions that may interfere with the homing movement. Close the cover on the tool changer.

To home the tool changer:

- Select JOG. The JOG-EDGE-HOLE CENTERING screen appears.
- If necessary:
  1. Home X, Y and Z.
  2. Empty the air chuck.
  3. Drain the worktank (Automatic air blast will splash EDM fluid).
- Select HOME on the lower menu. HOME changes to HOME-XYZ. Rotating the C.I. knob cycles the choices of the six sub-commands shown in the illustration at right. Select HOME-T and press the C.I. knob. The T-axis will find finger #1 and move it to the home position. When the routine is complete the message ...TOOL CHANGER AT HOME POSITION SELECT MODE TO CONTINUE: SKIP appears. SKIP will automatically check status of tools and park the tool changer.

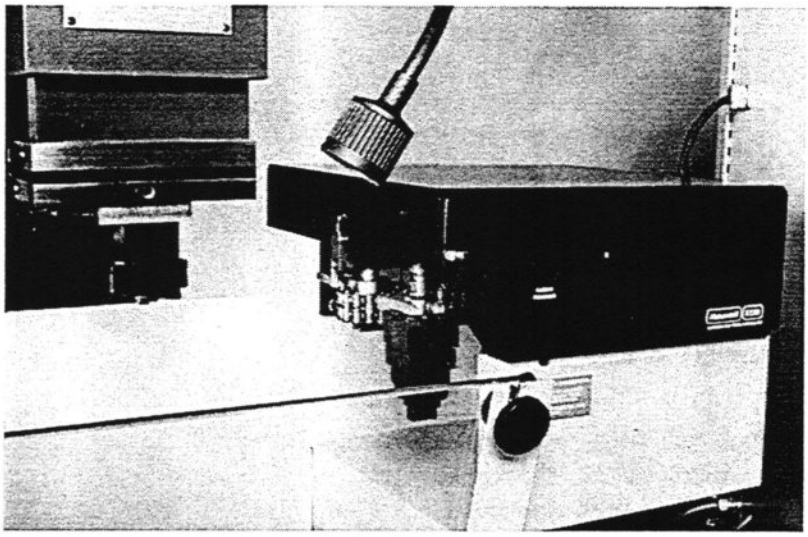


Home Position



Other choices available by rotating the C.I. knob include AUTOMATIC, MANUAL AND ALIGN FINGERS which are used if the normal homing procedure fails or if a tool change fails due to a gap short. See Maintenance Section for details on the use of AUTOMATIC, MANUAL and ALIGN FINGERS.

- Select SKIP and press C.I. knob. The message ...MOVING; ENTER OR C.I. TO EXIT appears. The tool changer moves to the park position.



Park Position

OTHER MESSAGE WINDOWS

HOMING X, Y
HOMING X
HOMING Y
HOMING Z
HOMING T
X, Y AXES HOMED
X AXES HOMED
Y AXES HOMED
Z AXES HOMED
T AXES HOMED

TOOL CHANGER SET-UP

NOTE: Use of the Tool Changer requires that it be homed.

LOAD - The LOAD command is used to load or unload tools in the tool changer fingers.

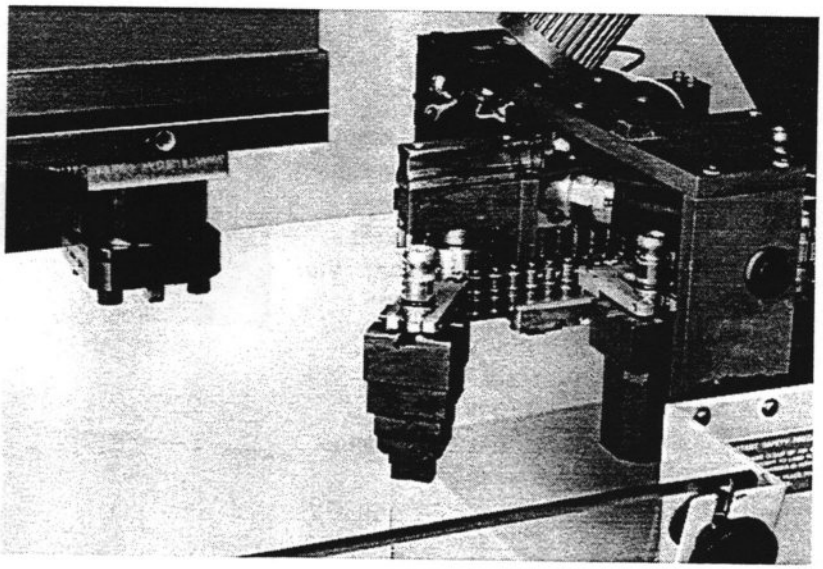
To use LOAD:

- Select TOOL on the menu bar; select LOAD. The message..SELECT TOOL NUMBER appears.
- Choose a number between 1-6, Choose 0 to abort. The Tool Changer will rotate to the finger that was chosen into the load position. The operator may now load, unload or swap the current tool. The message PRESS ENTER OR C.I. TO CONTINUE appears.
- Press Enter to park the current finger. The status of the finger will be automatically updated.

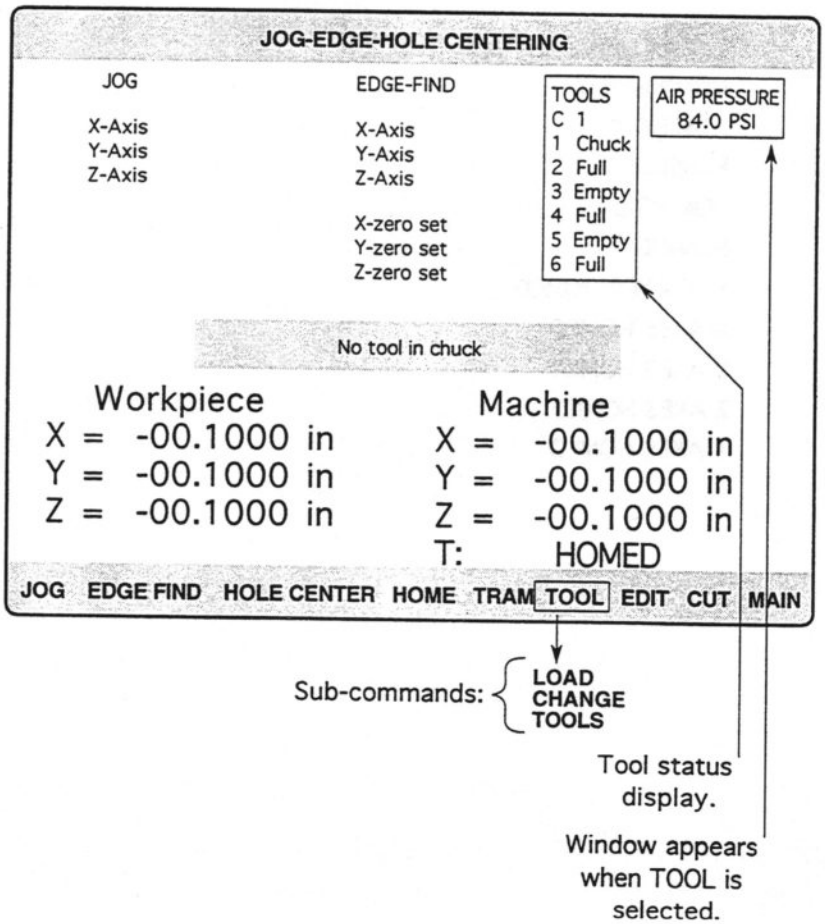
CHANGE - The CHANGE command is used to define the resident tool in the chuck.

To use CHANGE:

- Select TOOL on the menu bar; select CHANGE. The message SELECT NEW TOOL NUMBER appears.
- Choose the number of the tool to be loaded into the chuck. Choose 0 to empty the chuck. The machine will now unload the current tool from the chuck and then load the chosen tool into the chuck. The TOOLS display will be automatically updated.



Load Position



TOOLS - The TOOLS command is used to update the status of the tool positions

To use TOOLS:

- Select TOOL on the menu bar; select TOOLS.
- If there is no tool currently in the chuck, the Tool Changer will update the status of each tool position as well as the TOOLS display.
- If there is a tool in the chuck, the message PRESS 0 TO UPDATE THE CHUCK ONLY; PRESS 1 TO UPDATE ALL TOOL POSITIONS appears. If "0" is chosen, the message LABEL TOOL IN CHUCK; 1-6 OR 0 FOR NO LABEL appears. Choose a label and the machine will update the chuck status as well as the TOOLS display. If "1" is chosen, the Tool Changer will rotate and detect the status of each tool position. The message LABEL TOOL IN CHUCK; 1-6 OR 0 FOR NO LABEL appears.
- Choose a label and the machine will update the chuck status as well as the TOOLS display.

> NOTE
> The computer must know the status of all tool positions before it will run a program that uses the tool changer. If any position's status is unknown, question marks appear at that location in the TOOLS display.

USING THE PNEUMATIC CHUCK

Manual loading and unloading of the 3R Pneumatic Chuck is possible using the Chuck Release button on the work tank. This procedure is used when performing a cut that does not utilize the tool changer or when it becomes necessary to inspect, redress or exchange electrodes during a cut.

Manual air chuck operation is possible from either the CUT or the POWER PARAMETERS screens when gap power is off. When in the JOG-EDGE-HOLE CENTERING screen, manual operation of the chuck is possible while the cursor is on TOOL, LOAD, CHANGE or TOOLS on the lower menu.

CAUTION

When manually inserting tools that will be placed in the Tool Changer, make sure that the drawbar is oriented so that the Tool Changer fingers will be able to slide into the slot on the drawbar during the tool change. If the drawbar is inserted in the wrong orientation, the shear pin on the Tool Changer will break, the machine will stop and the pin will need to be replaced.

To manually load a tool into the chuck:

- Press and hold the Chuck Release button for 3 seconds. The chuck will open and a beep will sound.
- Insert the drawbar of the tool into the chuck while firmly holding the tool.
- Release the button and wait for the beep before letting go of the tool. One of three messages will appear:

TOOL IN CHUCK 'CLEAN';
ERROR: TOOL IN CHUCK MISCLAMPED OR DIRTY or
NO TOOL IN CHUCK.

- After a Clean load the message LABEL TOOL IN CHUCK 1-6 OR 0 FOR NO LABEL appears.
- Press the appropriate number for the newly loaded tool. The TOOLS display is automatically updated.

To manually remove a tool from the chuck:

- Firmly hold the tool to be removed.
- Press and hold the Chuck Release button, after 3 seconds the chuck will open and a beep will sound.
- Remove the tool from the chuck.
- Release the Chuck Release button. The message NO TOOL IN CHUCK appears.

OTHER OPERATING FEATURES

MACHINE POSITION RETURN

If the machine loses power during a cut , the recovery procedure is fairly simple.

- Drain the tank of EDM fluid.
- Recycle the 3-phase breaker.
- From the WELCOME screen, select JOG. Observe that "RH" follows each MACHINE coordinate and "MUST HOME" is in place of the T-axis DRO.
- Select HOME XYZ. After X,Y and Z are homed, the message X,Y,Z AXES HOMED appears. Observe that the WORKPIECE coordinates are not (0,0,0). The new WORKPIECE values are the machine position of the (0,0,0) coordinates for the cut that was interrupted.
- Rotate the cursor to TOOL on the lower menu.
- Manually remove the electrode from the chuck.
- Select HOME, then select HOME-T. The message TOOL CHANGER AT HOME POSITION; SELECT MODE TO CONTINUE: SKIP appears. Select SKIP.
- After the tool changer completes homing, manually insert the electrode that was removed from the chuck back into the chuck. Label it appropriately.
- Select CUT. The CUT screen will appear. Perform a START RETURN and observe that the WORKPIECE coordinates will return to the start line coordinates of the resident program.
- The machine is now set up to resume the interrupted cut by performing a line select or restarting from the start line.

> NOTE: The computer will assume that the resident tool is the tool needed for the selected program line of a LINE SELECT. When using LINE SELECT, make certain that the resident tool matches the expected tool in the selected program line.

MAINTENANCE and SERVICE

If the tool changer operation has become unstable, such as shorts during tool changes or it is unable to find the home position correctly, then some simple maintenance will be necessary.

If the tool changer is shorting during tool changes, one of two problems may exist. 1) The tool changer, or some of its fingers, has come out of alignment or 2) the draw bar home coordinates have been lost.

The first step in recovery is to re-find the draw bar home coordinates. This is achieved by performing an Automatic homing procedure. If this procedure does not come close to finding the draw bar, then the Manual homing procedure must be performed.

After performing the homing procedure, test whether or not the problem was solved by loading and unloading different tools from the tool changer. If the gap shorts still abort the tool changes, a realignment of the tool changer is necessary. If a total realignment fails to solve the problem, call Hansvedt.

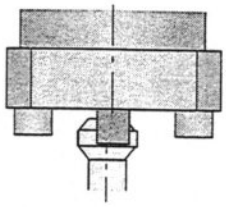
Procedure for Automatic Homing:

- Select HOME on lower menu; Select Home T.
- When Tool Changer finds the homed position, the message TOOL CHANGER AT HOME POSITION; SELECT MODE TO CONTINUE: SKIP appears.
- Select Automatic. The tool changer will check the status of all tool positions and automatically locate the draw bar home coordinates. The message SAVE NEW DRAW BAR HOME COORDINATES? ENTER AN ANSWER TO CONTINUE: YES appears.
- If the homing routine found the draw bar home coordinates properly, choose YES. The old coordinate values will be overwritten with the new coordinate values. If the homing routine incorrectly found the draw bar home coordinates, choose NO. The coordinates will be restored to their old values.

  The message TOOL CHANGER HOMED appears. The tool changer will then park finger #1 and the T-axis will read "HOMED".

Procedure for Manual Homing:

- Select HOME on lower menu; Select Home T. The Tool Changer will find the homed position. The message TOOL CHANGER AT HOME POSITION; SELECT MODE TO CONTINUE: SKIP appears.
- Select Manual. The tool changer will check the status of all tool positions and return to the homed position. The message LOCATE DRAW BAR X AND Y COORDINATES. ENTER OR C.I. TO CONTINUE appears.
- Press Enter. The message PRESS X,Y OR Z TO JOG IN THAT AXIS; ENTER OR C.I. TO CONTINUE appears.
- Using X,Y or Z keypad jog, position the draw bar in between the posts of the chuck, but not touching the face, as shown in the drawing at right.



- Press Enter. The machine tool will find the center of the chuck and the height of the drawbar. The message SAVE NEW DRAW BAR HOME COORDINATES? ENTER AN ANSWER TO CONTINUE: YES appears.
- If the homing routine found the draw bar home coordinates properly, choose YES. The old coordinate values will be overwritten with the new coordinate values. If the homing routine incorrectly found the draw bar home coordinates, choose NO. The coordinates will be restored to their old values.

  The message TOOL CHANGER HOMED appears. The tool changer will then park finger #1 and the T-axis will read "HOMED".

Procedure for the installation and alignment of fingers

- Make sure that the tool changer rail is level with respect to the tank.
- Select HOME on lower menu; Select Home T.

- When Tool Changer finds the homed position, the message TOOL CHANGER AT HOME POSITION. SELECT MODE TO CONTINUE: SKIP appears.
- Remove finger #1 and then re-install it making certain it is level with the ram.
- Select Align Fingers. Observe that the Ram succeeds in finding the surface of the finger with the corner post of the chuck. The message INSERT ALIGNMENT TOOL HOLDER INTO CHUCK FACING REAR; ENTER OR C.I TO CONTINUE appears.
- Manually insert the Alignment Tool holder facing the rear. The message TOOL IN CHUCK 'CLEAN' appears.
- Press Enter. Observe that after a series of edgefinds the machine succeeds in locating the fully extended position for Finger #1. The message SAVE NEW 1ST POSITION OFFSET VALUE? ENTER AN ANSWER TO CONTINUE: YES appears.
- Press Enter. The machine will double check on the finger location. The message ROTATE ALIGNMENT TOOL HOLDER TO FACE FRONT; ENTER OR C.I. TO CONTINUE appears.
- Manually rotate the alignment tool holder. The message TOOL IN CHUCK 'CLEAN'; ENTER OR C.I. TO CONTINUE appears.
- Press Enter. The message SELECT TOOL NUMBER; ENTER OR C.I. TO CONTINUE appears.
- Press the number of the finger to align. The chosen finger will rotate to the load position. The message REMOVE FINGER #; ENTER OR C.I. TO CONTINUE appears.
- Remove the finger and Press Enter. The message INSTALL FINGER #; ENTER OR C.I. TO CONTINUE appears.
- Re-install the finger so that it is seated flush on all three sides inside the alignment tool.
- Press Enter or C.I. knob, The message SELECT TOOL NUMBER; ENTER OR C.I. TO CONTINUE appears.
- Repeat these steps for all fingers that need realigning. When finished, press Enter. The message REMOVE TOOL HOLDER FROM CHUCK; ENTER OR C.I. TO CONTINUE appears.
- Manually remove the tool holder from the chuck and press Enter. The message NO TOOL IN CHUCK; ENTER OR C.I. TO CONTINUE appears.
- Press Enter. The message TOOL CHANGER POSITIONS HAVE BEEN ALIGNED appears.
- Re-home the Tool Changer. Continue with Automatic or Manual.

SHEAR PIN REPLACEMENT

If the tool changer will not run and the error message is "Shear Pin Broken" the tool changer shear pin needs replacing.

Procedure for replacing tool changer shear pin:

- Unplug the shear pin wire connection from the tool changer/power supply interface board.
- Unscrew the shear pin holder from its mount.
- Remove the shear pin holder.
- Loosen the set screw and remove the broken shear pin.
- Insert the replacement shear pin and tighten the set screw.
- Remount the shear pin holder, making sure the shear pin is seated correctly in the slot on the gear.
- Plug the shear pin wire connector into the tool changer/power supply interface board.

LUBRICATION

If it becomes necessary to lubricate either gear on the tool changer, it is recommended that Lubriplate brand AERO lubrication be used.

RS-232 COMMUNICATIONS FORMAT INSTRUCTIONS

IMPORTANT: The Hansvedt file structure IS CASE SENSITIVE with respect to alpha characters. It is extremely important to follow this format when creating a post processor for the M-Pulse.

The files are transferred as ASCII text files. The structure of each record is as follows:

The "-" stands for a blank space to fill the structure. All data is stored as strings.

Length	Type	
6 bytes	CODE	Start-, Linear, Pause-, Rapid-, Dwell-, Index-, Goto--
3 bytes	COORDINATE	abs, inc, lck, stp, ##m, ##s, 3R-, Bls. (## represents number of minutes or seconds of a dwell.)
8 bytes 8 bytes 8 bytes	XCOORDINATE YCOORDINATE ZCOORDINATE	+00.0000 or -.00.0000 "-" is a minus +00.0000 or -.00.0000 "-" is a minus +00.0000 or -.00.0000 "-" is a minus If the + is deleted in the above X, Y, or Z, it is assumed.
24 bytes	POWER SUPPLY PARAMETERS	
1 byte	CARRIAGE RETURN (ASCII 13)	

A sample file is presented next. Line breaks are not significant. Again, the "-" represents spaces in the file structure. The carriage return is represented by a "^" to maintain text character count.

```
Start-----00.0000-00.0000-00.0500434611190103080402AA0012^
Rapid-abs-00.0000-00.0000-00.0000----------------------^
Linearabs-00.0000-00.0000-00.1000----------------------^
Dwell-lck----------------------------------------------^
Dwell-stp----------------------------------------------^
Dwell-30m----------------------------------------------^
Dwell-10s----------------------------------------------^
Pause-^
Goto--abs-00.0000-00.0000-00.0500----------------------^
End^
```

Note: Metric programs should have the following format:

```
Start-----000.000-000.000-000.000----------------------^
Linearabs-000.000-000.000-000.000----------------------^
```

Etc.

The power supply parameters that fill the 24 spaces shown above are as follows:

Parameter	Range	Format	Spaces	Typical
Pulse (µsec)	00 - 63	00	2	43 (112 µsec)
%On Time	00 - 49	00	2	46 (80%)
Cutoff	0 - 5	0	1	1
Flush	0 - 2	0	1	1 (On)
Peak Amps	01 - 39	00	2	19 (32 amps)
Gap Spacing	01 - 20	00	2	01
Servo Speed	01 - 07	00	2	03
Cycle EDM	00 - 30	00	2	08
Cycle Retract	00 - 15	00	2	04
Fault Retract	00 - 15	00	2	02
Electrode	A - G	0	1	A (graphite)
Workpiece	A - G	0	1	A (steel)
Capacitors	00 - 12	00	2	00
Polarity	1, 2	0	1	1 (positive)
Generator Type	1, 2	0	1	1 (M-pulse)
			24	

Typical = **434611190103080402AA0012** = 24 characters. Note that "0" was inserted to fill the spaces.

Transmission Protocol

The M-Pulse DB25 is standard DC.

Baud rate	2400
Word length	8
Parity	None
Stop bits	2
End of block characater code	13
End of transmission code	4

Power Supply Parameter Definitions

Pulse (µsec)

00 = 0.1	10 = 1.2	20 = 4.5	30 = 19.0	40 = 75.0	50 = 300.0	60 = 1200
01 = 0.2	11 = 1.4	21 = 5.0	31 = 22.0	41 = 87.0	51 = 350.0	61 = 1400
02 = 0.3	12 = 1.6	22 = 6.0	32 = 25.0	42 = 100.0	52 = 400.0	62 = 1600
03 = 0.4	13 = 1.8	23 = 7.0	33 = 29.0	43 = 112.0	53 = 450.0	63 = 1800
04 = 0.5	14 = 2.0	24 = 8.0	34 = 33.0	44 = 125.0	54 = 500.0	
05 = 0.6	15 = 2.4	25 = 9.0	35 = 38.0	45 = 150.0	55 = 600.0	
06 = 0.7	16 = 2.8	26 = 10.0	36 = 45.0	46 = 175.0	56 = 700.0	
07 = 0.8	17 = 3.2	27 = 12.0	37 = 51.0	47 = 200.0	57 = 800.0	
08 = 0.9	18 = 3.6	28 = 14.0	38 = 57.0	48 = 230.0	58 = 900.0	
09 = 1.0	19 = 4.0	29 = 16.0	39 = 65.0	49 = 260.0	59 = 1000	

%On-Time

00 = .1	10 = .70	20 = 4.5	30 = 13	40 = 50
01 = .15	11 = .80	21 = 5.0	31 = 14	41 = 55
02 = .20	12 = .90	22 = 5.5	32 = 15	42 = 60
03 = .25	13 = 1.0	23 = 6.0	33 = 17.5	43 = 65
04 = .30	14 = 1.5	24 = 7.0	34 = 20	44 = 70
05 = .35	15 = 2.0	25 = 8.0	35 = 25	45 = 75
06 = .40	16 = 2.5	26 = 9.0	36 = 30	46 = 80
07 = .45	17 = 3.0	27 = 10	37 = 35	47 = 85
08 = .50	18 = 3.5	28 = 11	38 = 40	48 = 90
09 = .60	19 = 4.0	29 = 12	39 = 45	49 = 95

Peak Amps

01 = 0.2	11 = 6.0	21 = 38	31 = 250
02 = 0.4	12 = 8.0	22 = 44	32 = 300
03 = 0.6	13 = 11	23 = 50	33 = 350
04 = 0.8	14 = 14	24 = 60	34 = 400
05 = 1.0	15 = 17	25 = 75	35 = 450
06 = 1.5	16 = 20	26 = 100	36 = 500
07 = 2.0	17 = 24	27 = 125	37 = 600
08 = 3.0	18 = 29	28 = 150	38 = 700
09 = 4.0	19 = 32	29 = 175	39 = 750
10 = 5.0	20 = 35	30 = 200	

Flush
0 = Off
1 = On
2 = Cycle

Electrode
A = Graphite
B = Copper
C = Copper Tungsten
D = Copper Graphite
E = Brass
F = Steel
G = Tungsten Carbide

Workpiece
A = Steel
B = Aluminum
C = Inconel
D = Titanium
E = Carbide
F = Copper
G = Graphite

Capacitors
00 = 0.00
01 = 0.15
02 = 0.30
03 = 0.45
04 = 0.60
05 = 0.90
06 = 1.50
07 = 2.10
08 = 3.00
09 = 4.00
10 = 6.00
11 = 9.00
12 = 11.55

Polarity
1 = Positive
2 = Negative

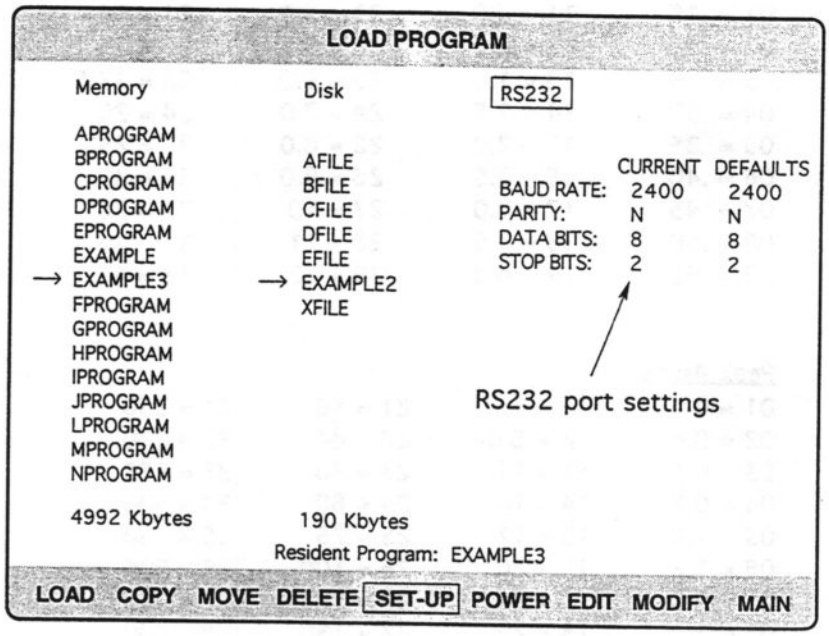
Generator Type
1 = V-Pulse
2 = M-Pulse

RS-232 Pin Out

Pin No.	Function
1	Protective GND
2	Transmit Data
3	Receive Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	GND (Computer)
8	Data Carrier Det.
9	NC
10	NC
11	NC
12	NC
13	NC
14	NC
15	NC
16	NC
17	NC
18	NC
19	NC
20	Data Term. Ready
21	NC
22	NC
23	NC
24	NC
25	NC

SETTING RS-232 PORT

- From the MAIN MENU select LOAD. The LOAD PROGRAM screen will appear.
- Select SET-UP from the bottom menu. BAUD RATE becomes green.
- Rotate and press C.I. knob to select BAUD RATE, PARITY, DATA BITS or STOP BITS. Each entry in the CURRENT column becomes highlighted.
- Rotate C.I. knob to change entry and press to select.



FIRE SUPPRESSION SYSTEM

Ansul Fire Suppression System (P/N 79534) Installed On Hansvedt MS-4 CNC EDM Machine Hansvedt Catalog Number MS-412

WARNING
The fire suppression system must be armed before initiating machining gap power.

GENERAL DESCRIPTION

The Ansul fire suppression system used on the MS-4 is a "Stored Pressure Wet Agent" system, activated either automatically by melting a 212° fusible link or by pulling the manual pull station ring. Activation of this system automatically turns the machine tool off, thus terminating the GAP POWER and all machining operations.

NOTE: No modification of the fire suppression system is allowed without written permission from Ansul Fire Protection Co., 1 Stanton St., Marinette, WI 54143, Phone 715-735-7411.

This includes redirecting the nozzles which must be maintained at an angle of 45° (±5°) with respect to the side of the worktank.

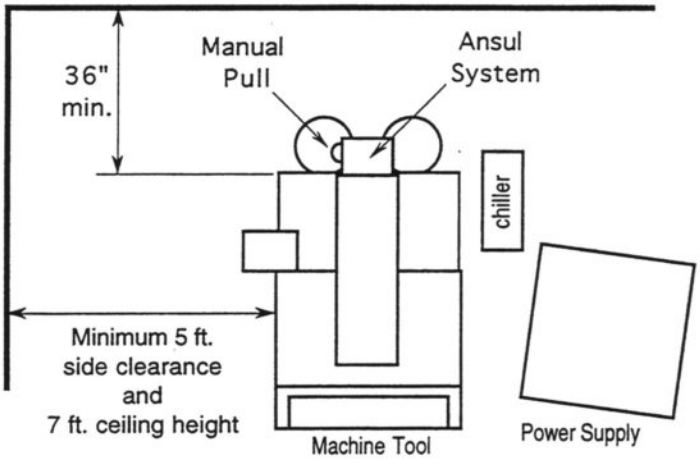


Figure 1. FLOOR PLAN

MACHINE INSTALLATION REQUIREMENTS

Machine tool clearance must be at least five feet between the left edge of the machine tool and any obstacle to the left, with a minimum ceiling height of seven feet to insure safe passage to manually actuate the fire suppression system.

WARNING
Special Precautions Regarding Fire Suppression Systems

Hansvedt encourages the use of fire suppression systems. However, they should NOT be assumed to be 100% effective. Such systems installed on Hansvedt EDMs are not of Hansvedt's design or manufacture and Hansvedt neither confirms nor denies claims that may be made by the manufacturers of such systems. Hansvedt makes no guarantees of their performance or success, and accepts no responsibility for their failure, whether installed by Hansvedt or others.

Hansvedt does NOT recommend that EDMs using oil-base dielectric and having fire suppression systems be operated completely unattended, such as overnight "lights-out" operation. Partially unattended operations, such as one operator overseeing more than one machine, should be done with due consideration for the possibility of failure of the suppression system in the event of fire. An overhead sprinkler system, because it uses water, may not instantly put out an EDM fire, though it is certainly a wise investment because it will probably limit a fire's extent.

OPERATION

Arming Procedure

> CAUTION
> Make certain fusible link is properly installed before removing shipping pin or system will discharge.

1. Locate the fire suppression tank assembly at the rear of the machine tool column. Pull down the cocking arm, shown in Figure 2.
2. Pull out the shipping pin.

THE FIRE SUPPRESSION SYSTEM IS NOW ARMED.

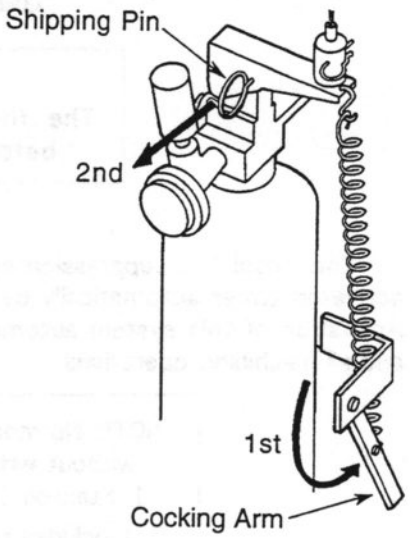


Figure 2

In Case of Fire

Go to the left rear of the machine tool and pull the manual pull station ring!

Clean Up Procedure

1. Drain the dielectric reservoir to remove the fire suppression agent and refill with clean EDM fluid.
2. Install recharged fire suppression tank assembly.
3. Replace fusible link.
4. Rearm the fire suppression system.

Disarming Procedure

1. Install the shipping pin in fire suppression tank.
2. Uncock cocking arm.

THE FIRE SUPPRESSION SYSTEM IS NOW DISARMED!

> NOTE
> Fire suppression system must be rearmed before starting any machining!

INSPECTION & MAINTENANCE

1. Check that the pointer on the tank pressure gauge is in the GREEN operating range. The upper and lower point of the operating range reflects the operating temperature range of the system.
2. Inspect the maintenance tag on the bottom of the shell for hydrotest date stamp. If shell requires hydrotest (every 12 years), hydrotest the shell to 600 PSI (4137 kPa), following the requirements stated in NFPA 17A and Ansul Manual Form No. F-7602 (Hydrostatic Test Instructions for Ansul Portable and Wheeled Fire Extinguishers). If the shell does not require testing, continue with Step 3.
3. Make certain no physical damage or condition exists that may prevent operation.
4. Insert shipping pin into valve handle (Figure 3). (Note: when inspecting pre-installed systems, the shipping pin will already be in place.)

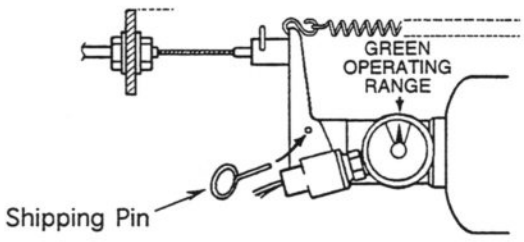


Figure 3

5. Release cocking arm and disconnect spring from valve handle (Figure 4).

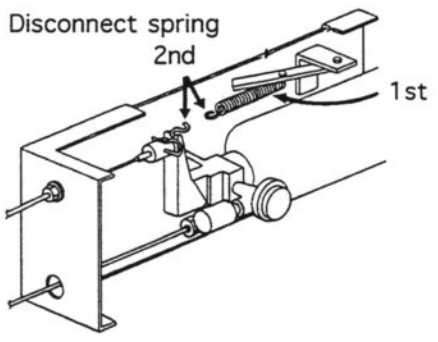


Figure 4

6. Disconnect cable coupling pin from cable coupling body by removing the cotter pin, P/N 79267 (Figure 5).
7. Disconnect wiring to shut-off relay.
8. Disconnect tubing from tank discharge adaptor, release tank bracket and remove tank.
9. Visually inspect the tank and valve assembly for corrosion, damage or unusual wear. Follow guidelines as stated in NFPA 17A.
10. Weigh the tank. The proper total charged weight is printed on the nameplate.
11. Place tank in bracket and fasten bracket clamp. Attach tubing to tank discharge adaptor.

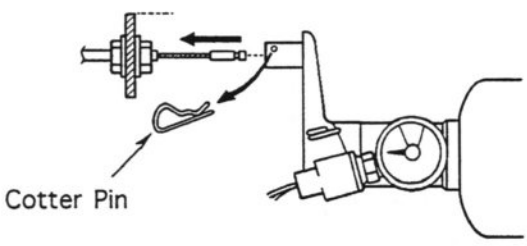


Figure 5

NOTE: Fusible links that have been installed in the system for over six months should be replaced with the properly rated Ansul approved link.

12. A fusible link covered with grease and other extraneous material can result in an excessive delay in actuation. Remove fusible link, clean with dry cloth, and return to detection point. This step will not be necessary for initial inspection of pre-installed system from the factory.
13. Connect cable coupling pin to cable coupling body with the cotter pin. Attach spring to valve handle with S-hook (Figure 6).
14. Remove blow-off caps from nozzles. Check both nozzles to ensure they are free of grease build-up and properly aligned (see Note on page 4.11.1), and then inspect each blow-off cap. Replace if deteriorated. If blow-off caps are in good condition, reinstall. This step will not be necessary on initial inspection of pre-installed factory systems.

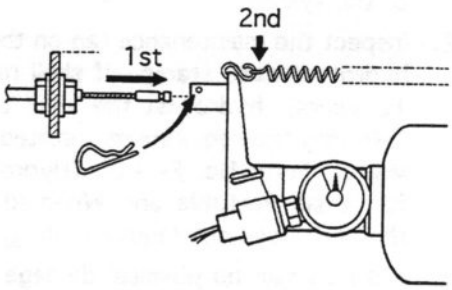


Figure 6

NOTE: Blow-off caps that have been installed in the system for one year must be replaced.

15. Inspect and tighten (if necessary) all piping connections.
16. Reconnect wiring to shut-off relay.

CAUTION
Before cocking system, make certain fusible link is properly installed or system will discharge.

17. Set cocking arm by pulling it down (Figure 7).
18. Remove shipping pin. If shipping pin does not slip out easily, lift valve handle slightly and remove pin.

CAUTION: The shipping pin is for installation and maintenance purposes only. Pin must be removed. If pin is not removed system will not operate.

19. Record date of inspection/maintenance on tag attached to unit and/or in permanent file.

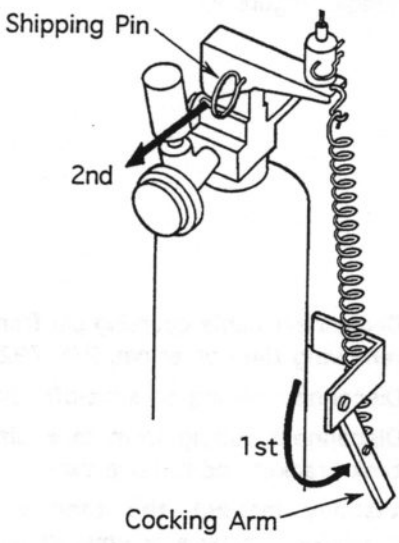


Figure 7

Data sheets on the Ansul Low pH extinguishing fluid and Ansul system are provided on the following pages.

ANSUL®

ANSUL FIRE PROTECTION
MARINETTE, WI 54143-2542

MATERIAL SAFETY DATA SHEET

ANSULEX Low pH
QUICK IDENTIFIER (In Plant Common Name)

Manufacturer's Name:	ANSUL INCORPORATED	Emergency Telephone No.:	CHEMTREC (800) 424-9300
Address:	One Stanton Street, Marinette, WI 54143-2542	Other Information Calls:	(715) 735-7411
Prepared By:	Safety and Health Department	Date Prepared:	March 15, 1995

SECTION 1 — IDENTITY

Common Name: (used on label) (Trade Name and Synonyms)	ANSULEX Low pH Liquid Fire Suppressant	CAS No.:	N/A
Chemical Name:	N/A This is a Mixture	Chemical Family:	Mixture
Formula:	N/A		

SECTION 2 — INGREDIENTS

PART A — HAZARDOUS INGREDIENTS

Principal Hazardous Component(s) (chemical and common name(s)):	Wt. %	CAS No.	ACGIH TLV	Acute Toxicity Data
None				

PART B — OTHER INGREDIENTS

Other Component(s) (chemical and common name(s)):	Wt. %	CAS No.	Acute Toxicity Data
Proprietary mixture of organic and inorganic salts and water			NDA
Phosphoric Acid	.2	7664-38-2	
Yellow-Green Fluorescent Dye	.011	518-47-8	Oral LD_{50}(rat) 6800 mg/kg

SECTION 3 — PHYSICAL AND CHEMICAL CHARACTERISTICS (Fire and Explosion Data)

Boiling Point:	113 °C			Specific Gravity (H_2O = 1):	1.33	Vapor Pressure (mm Hg):	Not Determined
Percent Volatile by Volume (%):	Approx. 50	Vapor Density (Air = 1):	1.03	Evaporation Rate (= 1):	0.13		
Solubility in Water:	100%			Reactivity in Water:	Mild exothermic reaction		
Appearance and Odor:	Fluorescent Yellow colored liquid, mild odor						
Flash Point:	None to boiling	Flammable Limits in Air % by Volume:	N/A	Extinguisher Media:	N/A	Auto-Ignition Temperature:	N/A
Special Fire Fighting Procedures:	NONE – THIS IS AN EXTINGUISHING AGENT						
Unusual Fire and Explosion Hazards:	None						

SECTION 4 – PHYSICAL HAZARDS

Stability:	Unstable ☐ Stable ☒	Conditions to Avoid:	N/A
Incompatibility (Materials to Avoid):	Reactive metals, ClF_3, electrically energized equipment, any material reactive with water.		
Hazardous Decomposition Products:	Not established, acrid fumes.		
Hazardous Polymerization:	May Occur ☐ Will Not Occur ☒	Conditions to Avoid:	N/A

4.12.5

SECTION 5 — HEALTH HAZARDS

Threshold Limit Value:	None Established
Routes of Entry: Eye Contact:	Irritant.
Skin Contact:	Irritant.
Inhalation:	Not an expected route of entry. Can be irritating to mucous membranes.
Ingestion:	Irritating to mucous membranes.
Signs and Symptoms: Acute Overexposure:	Material irritates skin, eyes, and mucous membranes.
Chronic Overexposure:	None known.
Medical Conditions Generally Aggravated by Exposure:	None known.
Chemical Listed as Carcinogen or Potential:	National Toxicology Program: Yes ☐ No ☒ I.A.R.C. Monographs: Yes ☐ No ☒ OSHA: Yes ☐ No ☒

SECTION 6 — EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	Flush and irrigate with water for 15 minutes while holding eyelids open. If irritation persists, seek Medical attention.
Skin Contact:	Wash thoroughly with soap and water; if irritation persists, seek Medical attention.
Inhalation:	Fresh air if symptoms occur. Seek Medical attention if irritation persists.
Ingestion:	Dilute by drinking large quantities of water.

SECTION 7 — SPECIAL PROTECTION INFORMATION

Respiratory Protection (Specify Type):	N/A		
Ventilation:	Local Exhaust: N/A	Mechanical (General):	N/A
Protective Gloves:	Rubber gloves for spill/leak.	Eye Protection:	Chemical goggles recommended during spill/leak procedures.
Other Protective Clothing or Equipment:	Eye wash and safety showers are good safety practice.		

SECTION 8 — SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

Precautions to be Taken in Handling and Storage:	Store in original container. Keep tightly closed. Keep separate from acid.
Other Precautions:	See incompatibility information in Section 4.
Steps to be Taken in Case Material is Released or Spilled:	Stop leaks. Contain Spill. Remove as much as possible. Place in closed container for proper disposal. Wash spill area with large amounts of water to remove traces and neutralize.
Waste Disposal Methods:	Dispose of in compliance with local, state, and federal regulations.

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM RATINGS

HAZARD INDEX:	
4 Severe Hazard 3 Serious Hazard 2 Moderate Hazard 1 Slight Hazard 0 Minimal Hazard	0 HEALTH 0 FLAMMABILITY 0 REACTIVITY

N/A = Not Applicable NDA = No Data Available

ANSUL®

EXTINGUISHING AGENT DATA SHEET

ANSULEX™ LOW pH LIQUID FIRE SUPPRESSANT

FEATURES

- Fast Flame Knock-Down and Securement of Grease-Related Fires
- Provides a Cooling Effect Which Further Enhances Its Ability to Prevent Reflash
- Designed for a Wide Variety of Restaurant Hazards
- Listed by Underwriters Laboratories, Inc. (UL) as Part of the R-102 Restaurant System
- Ease of Recharge and Post-Fire Cleanup
- Non-Corrosive

APPLICATION

ANSULEX Low pH Liquid Fire Suppressant is designed for use only in Ansul R-102 restaurant fire suppression systems. This "liquid" agent will combat grease-related fires as found in restaurant appliances and ventilating equipment. It should **not** be used for fires involving energized electrical hazards.

DESCRIPTION

ANSULEX Low pH Liquid Fire Suppressant is a specially-formulated, aqueous solution of organic salts. The agent is pre-mixed, eliminating the need for dilution before system charging. When used as an extinguishing agent, it will produce no toxic by-products.

AGENT PROPERTIES

Appearance	Color-Coded Fluorescent Yellow-Green
Storage Life	12 Years
Refractive Index	1.4040
Freeze Point	−40 °F (−40 °C)
Boiling Point	230 °F (110 °C)
Specific Gravity	1.32
Kinematic Viscosity	5.26 centistokes
pH	7.8 – 8.2

WARNING: Care should be taken when handling the agent. If contact is made with the eyes or skin, flush with water. If the agent is swallowed, dilute with water or milk and contact a physician.

PERFORMANCE

When used in the Ansul R-102 restaurant system, ANSULEX Low pH Liquid Fire Suppressant is extremely effective on fires in restaurant ventilating equipment – hoods and ductwork, as well as in a variety of cooking appliances – deep-fat fryers, griddles, range tops, and several types of broilers and char-broilers.

As the agent is sprayed in fine droplets (atomized) onto an appliance grease fire, it provides excellent flame knock-down, surface-cooling, and fire-securing capabilities. When the agent reacts with the hot grease, it forms a layer of foam on the surface of the fat. This soap-like blanket of foam acts as an insulator between the hot grease and the atmosphere, helping to prevent flammable vapors from escaping and reducing the chance for flame reignition.

Post-fire cleanup can be readily accomplished by flushing the area with water or steam.

Because of the composition of ANSULEX Low pH Liquid Fire Suppressant, it is compatible with metals commonly found in restaurant kitchen environments (i.e., stainless steel, aluminum, galvanized metal, mild steel, copper and brass).

APPROVALS AND LISTINGS

ANSULEX Low pH Liquid Fire Suppressant has been tested, and is listed with Underwriters Laboratories, Inc. (EX-3470) as part of the Ansul R-102 Restaurant Fire Suppression System.

ORDERING INFORMATION

ANSULEX Low pH Liquid Fire Suppressant is available in sealed containers.

Part No. 79694	1.5 gallon (5.7 L)
Part No. 79372	3.0 gallon (11.4 L)

Recharge services are available from Ansul-authorized distributors.

4.12 7.

ANSUL FIRE PROTECTION
MARINETTE, WI 54143-2542
715-735-7411

Form No. F-9140

4.12.8

HAND HELD REMOTE CONTROL
(Optional on Certain Models.)

For Hansvedt
M-Pulse Power Supply/Controls

Safety.....4.13.1
Description.....4.13.2
Operation.....4.13.3
Maintenance and Service.....4.13.5

SAFETY

WARNING

Failure to follow instructions in this Section may result in personal injury and/or damage to equipment.

Remote Control Safety

In addition to the general safety information in this owner's manual, certain precautions should be observed when using the remote control. Since the remote control allows the operator to be close to moving machinery it is important to understand the operation and functions of the machine to prevent accidents or machine damage.

- Be aware of the remote control cable at all times to prevent it from getting tangled with pedestrians.
- When not using the remote, place it on the power supply hanger and keep the cable out of the way of traffic and machinery.
- Keep remote control cable away from electrode cables.

- IMPORTANT: Certain operations using the remote control involve continuously moving machinery. Safety instructions for stopping the movement in an emergency are given with the specific Operation Instructions on the following pages.

DESCRIPTION

The M-Pulse Remote Control is a hand held controller for Hansvedt's CNC M-Pulse EDMs with software version 3.5 or higher. It allows the operator to be conveniently close to the work area for fast and accurate set-up adjustments, measurements and inspection.

A 10 foot cable plugs into a connector on the left side of the M-Pulse power supply/control unit.

When used on single axis machines (Z-axis models) or two axis machines (2-axis wire models), the non-functioning axes are automatically disabled.

> The term "electrode" or "tool" in this section refers to a solid electrode in the case of ram EDMs and a wire electrode in the case of wire EDMs.

Five set-up functions are available:

EDGE — finds the electrode or workpiece edge;

CENT — finds the center of a round hole;

TRAM — continuously moves between two points;

JOG — manually moves the XY (table) or Z (ram) axes;

ZERO — sets the DRO to 0.0000 for the X, Y or Z axes.

EDGE, CENT and TRAM, are automated movement operations and can be paused in the middle of a procedure. Selecting a new function always cancels the previous function and stops machine movement if the remote is on.

The axis keys select the desired axis (axes) of motion. The six motion keys are used to effect precise movement, incrementally or continuously, at different speeds, in the plus or minus direction. The ON/OFF key transfers control between the machine control panel and the remote control.

Keypad indicator lamps show at a glance which function and axis are selected. A blinking light indicates that the function is in effect but paused.

> Do not use extension cables with the remote. If a longer cable is required, contact the Hansvedt Service Department.

OPERATION

SAFETY PRECAUTIONS

Avoid obstructions in the work area that would interfere with moving parts, and be sure that the workpiece and electrode are dry, burr-free, and clean.

EDGE, CENT and TRAM are automated movements and will not automatically stop until their programmed path is completed.

JOG and TRAM will not automatically stop if the electrode contacts the workpiece, and damage can occur.

To stop and abort any movement when the remote is on:

- Press the ON/OFF key on the remote;
- Press any other function key on the remote;
- Press any axis key on the remote;

To stop and abort any movement whether the remote is on or not:

- Press the CI knob on the power supply;
- Press the red E-STOP button on the power supply.

It is a good practice to keep your thumb resting on an axis key during EDGE, CENT or TRAM movements as a quick abort key.

ON/OFF Transfers command to and from the remote and the main power supply panel. The remote control can be turned ON when the CI knob cursor is on the bottom blue menu bar, with GAP power off. It cannot be turned on when gap power is on or when editing or inputting data.

The display screen will go to the JOG EDGE HOLE CENTER screen when the remote is on, and the display monitor will highlight the operations while the remote is being used, just as if the CI knob on the power supply is used.

The remote can be turned off at the remote, or at the power supply panel by pressing the CI knob.

When the remote control is first turned ON:

- JOG function is automatically selected;
- The display goes to the JOG screen and JOG is highlighted on the lower screen menu;
- "Remote On" status is displayed on the JOG screen.

When the remote control is turned OFF:

- All remote control indicator lamps are off;
- Any remote control operation in progress is canceled;
- The JOG screen remains selected and "Remote Off" status is displayed.

MOTION KEYS

Left ⊖ keys move tool in negative direction.
Right ⊕ keys move tool in positive direction.

A momentary press increments the selected axis a specific distance:

◄ or ► = .0001"
◄◄ or ►► = .001"
◄◄◄ or ►►► = .010"

Press and hold for continuous movement:

◄ or ► = slow speed
◄◄ or ►► = medium speed
◄◄◄ or ►►► = fast speed

Release to stop movement.

In EDGE find mode the motion keys control direction only. Any ⊖ key will start edge find in the negative direction and any ⊕ key will start edge find in the positive direction.

X, Y & Z AXIS KEYS An axis key must be selected for each of the functions except CENT, which automatically selects the X and Y axes. An indicator lamp shows when the key is selected.

When a new function is selected, the previous function and axis is canceled. When a new axis is selected, the previous axis is canceled and any function in progress stops but remains selected.

EDGE Finds the contact point between the electrode and the workpiece. Any axis can be used with edge find on three-axis machines. Refer also to the EDGE-FIND instructions in Section 4.7 of this manual.

To start an edge-find operation:

- Press EDGE. Edge key lamp is on; EDGE FIND is selected on screen menu.
- Press X, Y or Z. Axis key lamp is on.
- Press any ⊖ motion key for -direction or ⊕ key for +direction. Movement begins and the message FINDING EDGE appears on screen. Axis will move until contact is made. When edge is found machine will dither (servo) on the workpiece edge, Sonalert will sound and the message EDGE FOUND appears on screen.

To pause an edge-find operation:

- Press EDGE. Edge-find operation will be temporarily paused and EDGE key lamp will blink. To resume the operation, press the blinking EDGE key.

To stop an edge-find operation:

- Press any other function key, any axis key or the ON/OFF key.

To set the DRO to zero after an edge find:

- Press the ZERO key then appropriate axis key.

CENT Finds the X-Y coordinates for the center of a round hole. The center of a rectangular or elliptical hole can also be found if the sides of the hole are parallel with the table XY axes. Refer also to the HOLE CENTERING instructions in Section 4.7 of this manual.

To find the center of a hole:

- Using the JOG function, move the electrode into the hole without touching any side.
- Press CENT. CENT key lamp blinks (paused); X and Y key lamps are on; HOLE CENTER is selected on screen menu.
- Press CENT again. CENT key lamp is on; movement begins, the message FINDING EDGE appears on screen. Axes will move until center is found. When center is found motion will stop, Sonalert will beep and the message HOLE CENTERED appears on screen.

To pause a hole centering operation:

- Press CENT. Center finding operation will be temporarily paused and CENT key lamp will blink. To resume the operation, press the blinking CENT key.

To stop a hole centering operation:

- Press any other function key, any axis key or the ON/OFF key.

To set the DRO to zero after finding center:

- Press the ZERO key then the X and/or Y axis keys.

TRAM An automated function that continuously cycles any axis between a start and end point. Tram is commonly used with a dial indicator to check workpiece or electrode flatness, parallelism, squareness, etc. Refer also to the TRAM instructions in Section 4.7 of this manual.

The Sonalert tone will not sound when the electrode touches the workpiece or dial indicator.

> Warning: In TRAM mode, movement will not stop if the electrode contacts the workpiece, and damage can occur.

To set up a TRAM operation:

- Using the JOG function, move the electrode or XY table to the position desired for the start of the tram cycle.
- Press TRAM. TRAM key lamp is on; TRAM is selected on screen menu.
- Press X, Y or Z. Axis key lamp is on; tram start position is set to zero; SET is selected on screen menu.
- Move to the desired end point of the tram using the motion key(s) for desired direction. The ►, ►► and ►►► keys correspond to speeds 1, 3 and 5, respectively, on the main control screen. Any combination of motion keys can be used when moving toward the tram end position, but the last motion key pressed is saved as the tram automatic cycle speed.
- When desired end position is reached, press TRAM. End position is set; RETURN is selected on screen menu. The axis returns to start position and pauses, and START is selected on screen menu.

To automatically repeat the TRAM cycle:

- Press TRAM. The axis will continuously cycle between start and end position. STOP will be selected on screen menu.

To pause a tramming operation:

- Press TRAM. Tramming will be temporarily paused and the TRAM key indicator lamp will blink. To resume the operation, press the blinking TRAM key.

To stop and abort the tramming operation:

- Press any other function key, any axis key or the ON/OFF key. This will prevent accidental damage that could occur if the table, workpiece or electrode was moved into the tram path during other operations. TRAM operations previously used with the power supply control panel are not affected by the remote control TRAM and will remain intact.

Tram Hint: It may have been necessary to use slow movement keys for setting the tram end point. If, after setting the end point, a faster speed is desired for repeat tram cycles, instead of pressing TRAM to return to the start position, press ►►► once to set the tram speed to fast and ◄◄◄ once to return to the end point. This will move the axis in 0.0100" increments, so be sure that the movement will not damage anything. Then press TRAM to return to the start position, and again to start.

JOG A manual motion control that can quickly and precisely move any axis. The JOG function is automatically selected when the remote control is turned on. Refer also to the JOG instructions in Section 4.7 of this manual.

> Warning: In JOG mode, the motion will not stop if the electrode contacts the workpiece, and damage can occur.

To JOG:

- Press JOG. JOG key lamp is on and JOG is selected on screen menu.
- Press X, Y or Z. Axis key lamp is on.
- Press motion key(s) to begin desired direction and speed.

Left ⊖ keys move tool in negative direction.
Right ⊕ keys move tool in positive direction.

Momentary pressing increments the selected axis a specific distance:

◄ or ► = .0001"
◄◄ or ►► = .001"
◄◄◄ or ►►► = .010"

Press and hold for continuous movement:

◄ or ► = slow speed
◄◄ or ►► = medium speed
◄◄◄ or ►►► = fast speed

Release motion key to stop movement.

ZERO Sets the workpiece DRO to zero for the selected axis. Refer also to the ZERO SET instructions in Section 4.7 of this manual.

To set the DRO to zero:

- Press ZERO. ZERO key lamp is on and JOG is selected on screen menu.
- Press X, Y or Z. Axis key lamp is on, the Sonalert beeps and the respective DRO coordinate is set to 0.0000.

To zero all three axes:

- Press ZERO, X, Y and Z. The Sonalert will beep when each axis key is pressed to confirm that the axis is set to zero.

> Be careful with ZERO, it cannot be un-zeroed!

MAINTENANCE

The M-Pulse Remote Control is rugged, splash-resistant and dust-proof, and all materials used are resistant to EDM dielectric oil. When not using the remote, place it on the power supply hanger to keep the cable out of the way of traffic and machinery.

The cable is designed to withstand normal EDM use for many years. If the cable is damaged or abused, do not use the remote as this may cause a safety hazard. Have it checked by the factory. If the cable has been abused but shows no visible damage, make sure all switches are operating properly before using it. Return it to the factory for testing if there is any doubt about its operation.

Clean the remote with a soft cloth and mild detergent to clean the case and switch panel. DO NOT immerse or soak the remote in any fluid.

There are no user serviceable parts or adjustments inside the remote control. The case is factory sealed. Do not remove case screws or attempt to disassemble as this will affect the seal. If the remote control has been damaged, return it to Hansvedt's Service Department for repair or replacement.

CHAPTER 5
MAINTENANCE & SERVICE

MAINTENANCE.....5.1.1

Schedule of Regular Maintenance.....5.1.1
Parts & Supplies.....5.1.3
Dielectric System.....5.1.3
Approved Lubricants & Suppliers.....5.1.6

HOW TO ORDER PARTS.....5.2.1
TROUBLE SHOOTING GUIDE.....5.3.1
SCHEMATICS.....5.4.1

MAINTENANCE SCHEDULE

DIELECTRIC FILTER ELEMENTS

The gauge on the filter housing should be checked once a day to determine the condition of the filter elements. The gauge will read about 60 PSI with a clean element when all manifold valves are closed. As the elements become dirty the pressure will rise. When the gauge reads 80 PSI with all manifold valves closed the elements need to be changed. Operation above 80 PSI is not recommended. The pump motor has a built-in overload which will shut off the motor at pressures above 85 PSI.

WARNING!
The built in overload is of the automatic resetting type and can cause the motor to restart automatically. For your general safety always disconnect the machine at the main breaker before working on or around the motor.

Changing Filter Elements

1. Turn off the machine. Place the toggle valve in the DRAIN position to drain the worktank. When the worktank is empty, place the valve in the HOLD position. It is important that the valve remains in the HOLD position until you are finished changing the filters.

2. Remove the gauge from the top of the filter housing. Place containers under the petcocks at the bottom of the filter housings. Open the petcocks and drain the housings — approximately 1 gallon of oil will drain out of each.

3. On each filter unit, loosen the strap clamping the lid to the housing and remove the lid. Remove the T-handle hold-down clamp. Lift out the filter element. Check that the metal insert, which is normally pressed in the bottom of the element, does not remain in the housing. Occasionally it becomes loose and does not come out with the element. If it remains in the housing, remove it before installing the new element, otherwise the element will not seat properly and unfiltered oil will leak past it.

4. Install new filter elements (RS-105) and clamp in place with the T-handle hold-down. Reassemble the housings, taking care to seat the gasket under the lid without pinching. Close the petcocks. Now open the bypass valve on the manifold and fill the worktank with at least one inch of dielectric fluid. Install the gauge a few turns and wrap a cloth around the stem. Bleed air from the filter housing by jogging the pump on and off until oil appears. Tighten the gauge with a wrench.

MACHINE TOOL

Semi-Annual MS-4 Ballscrew/Way-Bar Lubrication procedure

Tools: 1.) 14 oz. cartridge grease gun with rubber tip.
2.) 14 oz. Mobilux EP2 grease cartridge (Hansvedt P/N A3935).
3.) Nook Quicklube E-900 Linear Motion spray lubricant (Hansvedt P/N A5161).
4.) 1/8" allen wrench.
5.) Small common screwdriver.

Initial Setup:

Jog the table to the far left until it actuates the limit switch and then to the right 4 inches. Jog the table to the rear until it actuates the limit switch and then forward 3 inches. Turn the Machine OFF. Remove the Roller Way Cover Bar from the Table Top by removing the screws on each end of the bar. This will allow the Way Cover to roll up against the saddle. Remove the left end of the Left Bellows Way Cover by removing the 7 screws which fasten it to the bracket. Remove the Left Bellows Way Cover and then turn Machine ON. While being careful that the Left Bellows Way Cover does not catch on anything, jog the table until it actuates the right and rear limit switches.

Table Ballscrew Lubrication:

Remove the screw in the copper lubrication tubing on the rear of the table. Put the rubber tip of the grease gun against the copper tubing grease inlet and slowly squirt grease into the tubing as the table is being moved to the front. The total lube amount should be no more than 3 strokes of the grease gun pump (2 grams). Reinstall the screw in the end of the copper tubing.

Saddle Ballscrew Lubrication:

While being careful that the Left Bellows Way Cover does not catch on anything, jog the table to the left until it actuates the limit switch. Remove the screw in the copper lubrication tubing on the left side of the saddle. Put the rubber tip of the grease gun against the copper tubing grease inlet and slowly squirt grease into the tubing as the table is being moved to the right. The total lube amount should be no more than 3 strokes of the grease gun pump (2 grams). Reinstall the screw in the end of the copper tubing.

Way-Bar Lubrication:

With the Nook lubricant, spray as much of the Way-Bars as can be seen. Jog the Y-axis to about the middle of travel. Be sure to leave enough room to get the spray can into the opening on the front. Lubricate as much of the table Way-Bars as possible. Jog the table to the left until it actuates the limit switch. Remove the right end of the Right Bellows Way Cover by removing the 7 screws that fasten it to the bracket. Remove the Right Bellows Way Cover bracket. From the right of the machine, lubricate as much of the Way-Bars as possible.

Reassembly:

Shut the Machine OFF. Install the Way Covers. Install the Roller Way Cover with a pre-load of 2-3 turns. Jog the table to its full travel in the '+' and '-' directions at least twice to distribute the lubricant.

POWER SUPPLY CONTROL

Power Supply Air Filter

The air filter, located on the rear section of the cabinet, MUST be clean. It is possible to change this filter without turning off the machine. Unscrew the two black plastic knobs and swing the top of the door outward to access the filter. Do not place any items in front of the filter as this will restrict the air flow.

> NOTE: No other routine maintenance is required for the M-Pulse power supply/control units. And there are NO USER-SERVICEABLE COMPONENTS. Some minor problems can be diagnosed and corrected over the phone — please consult with Hansvedt's Service Department.

HEAVY-MEDIUM WAY OIL, P-47

This specification covers compounded heavy-medium oil for machine tool slide-ways. A noncorrosive additive is to be used to provide anti-stick-slip characteristics. A tacky additive is used to provide the required adhesive properties. These requirements meet or exceed I.S.O. standard G-68.

CHEMICAL AND PHYSICAL PROPERTIES		
A.P.I. Gravity (at 60°F)	(ASTM D 287)	18 to 27
Viscosity system	(ASTM D 2422-75)	ISO VG 68
(SUS at 100°F)	(ASTM D 2161)	317 to 389
(Centistokes at 40°C)	(ASTM D 445)	61.2-74.8
Flash (O.C.)	(ASTM D 92)	330°F Min.
Fire (O.C.)	(ASTM D 92)	360°F Min.
Neutralization No. (mg. KOH per gm. oil)	(ASTM D 664)	1.7 Max.
Fractional Test	(ASTM D 2877 Modified)	0.080 Max. Static Friction 0.100 Max. Kinetic Friction
Thermal Stability Test Results after Test:		
Neutralization No.	(ASTM D 664)	0.5 Max. Increase
Precipitate or Sludge		None
Condition of Steel Rod		No Deposit or Discoloration
Condition of Copper Rod	(CM Color Class)	2 Max.

FIELD TEST REQUIREMENTS: This lubricant must have all the general qualities and properties required to insure its satisfactory performance as a machine tool slideway lubricant. It is recommended to be changed at a quarter annual frequency and to be used under conditions consistent with good machine tool practice.

The following is a list of approved lubricants for use in a one-shot lubrication system that meet the minimum requirements of the above specifications. No inference should be made that all products are of the same quality.

APPROVED PRODUCTS LIST	
SUPPLIER	**PRODUCT NAME**
Amoco Oil Co.	Waytac Oil 68
Ashland Oil Co.	Waylube W-30
Atlantic Richfield Co.	Truslide S-315
BP Trading Ltd. and Affiliated Companies	BP Energol HP 20-C
Chevron U.S.A. Inc.	Chevron Vistac Oil 68 X
Continental Oil Co.	HD Way Lubricant 31
Exxon Co. U.S.A.	Febis K-68
Gulf Oil Corp. & Subsidiaries; Gulf Oil European	Gulfway 68
Gulf Canada Ltd.	Gulfway 56
Mobil Oil Corp.	Mobil Vactra Oil #2
Pennzoil Oil Corp. & Penreco Industrial Div.	Penreco Tableway Lubricant Medium
Shell Oil Co. & Shell Canada Ltd.	Tonna 68
Shell International	Tonna T-33
Standard Oil Co. (Ohio) & Boron Oil Co.	Factoway 50
BP Oil Inc.	BP Energol HP-68-C
Sun Petroleum Products	Sun Waylube 1180
Texaco Inc.	Way Lubricant 68

LITHIUM BASE, P-64
GENERAL PURPOSE GREASE

This specification covers a Premium Grade, general purpose, lithium base grease (N.L.G.I. No. 2) for cup service, gear boxes, ball and roller type bearings.

CHEMICAL AND PHYSICAL PROPERTIES		
Penetration worked, 60 strokes	(ASTM D 217)	265-295
Penetration (10,000 strokes) at 77°F	(ASTM D 217)	15% Max. Increase
Dropping Point	(ASTM D 566)	350°F Minimum
Viscosity		
(SUS at 100°F)	(ASTM D 2161)	500-750
(Centistokes at 40°C)	(ASTM D 445)	108.0-161.8
Lithium Soap (12 hydroxy stearate) %		8 Minimum
Water		Traces
Oxidation Stability Test (psi drop in 100 hrs.)	(ASTM D 942)	8 Maximum
Thermal Stability Test Results after Test:		
Condition of Steel Rod		No Deposit or Discoloration
Condition of Copper Rod	(ASTM D 130 Color Class)	1 Max.

FILLER: This grease shall not contain fillers such as resin, resinous oils, soapstone, powdered mica, asbestos, clay or other types of grit.

FIELD TEST REQUIREMENTS: This lubricant must have all the general qualities and properties required to insure its satisfactory performance as a lubricant when used under conditions consistent with good machine tool practice.

The following is a list of approved products for use on ram way bearings and the backslide work gear that meet the minimum requirements of this specification. No inference should be made that all products are of the same quality.

APPROVED PRODUCTS LIST	
SUPPLIER	PRODUCT NAME
AGIP U.S.A. Inc.	GR-MU-2
Amoco Oil Co. (Standard Oil Co. Division of American Oil Co.)	Amolith Grease No. 2
Atlantic Richfield Co.	Arco Multi-Purpose Grease
Chevron Oil Co.	Chevron Dura-Lith Grease 2
Exxon Co. U.S.A.; Esso Affiliates	Unirex N-2; Lidok EP-2; Unirex N-2; Beacon 2
Getty Oil Co.	Veedol Alitho 20
Gulf Oil Corp. & Subsidiaries	Gulfcrown Grease 2
Gulf Oil Canada Ltd.	Gulfcrown Grease Heavy
Lubriplate (Div. of Fiske Brothers Refining Co.)	Lubriplate 630 AAA
Mobil Oil Corp.	Mobilux EP2
Petrofina Group	Fina Grease Marson L-2
Shell Oil Co.	Alvania 2
Standard Oil Co. (Ohio); Boron Oil Co.; BP Oil Corp	Factran 2
Sun Oil Co.	Prestige 42
Texaco Inc.	Multifak 2
Union Oil Co.	Union Unoba EP-2

HOW TO ORDER PARTS

A staff of Product Service Specialists is available to help you with your orders and inquiries. Use this service to place orders, obtain delivery, check the status of an existing order and obtain shipping information such as routing and waybill numbers.

Hansvedt Industries, Inc.
Service Parts Department
Mail: P.O. Box 6099, Urbana, IL 61801
Phone: 217-384-5900
Fax: 217-384-0095

INFORMATION REQUIRED WHEN ORDERING PARTS

For improved service when ordering replacement parts, spare parts and supplies please have all of the following information, as applicable, clearly specified with your order:

1. Complete NAME OF COMPANY requesting a quotation or ordering parts. Include company division name if applicable.
2. Complete COMPANY ADDRESS - including postal zip code.
   a. Invoices - State if invoices are to be mailed to a different address.
   b. Shipping - Clearly state the address where the parts are to be shipped and to whose attention. Include gate, dock, or department number, as required.
3. Name of the INDIVIDUAL requesting the quotation or ordering the parts. Give telephone number and extension and fax number. This is helpful when additional information is later needed to fulfill the requirements.
4. PURCHASE ORDER or inquiry number.
5. PART NAME and PART NUMBER. If these are not available provide a part description, where the part is used, etc. A sketch or photograph of the part may be helpful. When ordering parts by number state the source of the number, such as:
   a. From parts catalog no., page no.
   b. From prior invoice (specify invoice no.).
   c. Part number stamped or etched on the old part.
   NOTE: Commercial parts might also be available from appropriate local distributors and suppliers.
6. QUANTITY of each individual piece required. If only certain parts of a unit are needed, do not use the word "complete" — it always raises a question as to how much of a unit to supply. In some cases, due to the nature of the part, it may be necessary and less costly to supply additional related pieces. This is especially true if the part needed is obsolete (not of current production).
7. The size, name and type of machine. A sketch or photograph of the machine may be helpful. Include model number if known (can usually be obtained from the original invoice).
8. The complete SERIAL NUMBER. These are usually stamped in the following locations:
   Machine tool: right side at base of machine column.
   Power Supply: on the nameplate on the rear of the cabinet.
9. Specify HOW TO SHIP if you have any preference. HOW URGENT is the order? Specify the agency desired, e.g., UPS (ground or air), Federal Express, air freight, air mail, truck, etc.
   If nothing is specified, we will select the cheapest, most practical method.
10. Any additional information deemed essential to facilitate supplying the part(s) required.

TROUBLESHOOTING

Problem	Cause	Solution
MACHINE ON switch will not function when main power switch is on.	E-STOP depressed.	Pull out E-Stop.
	Doors are open.	Secure doors.
	Motor, chiller or gap power overloads are tripped.	Reset overload.
Inaccurate edge finding and hole centering.	Paint, corrosion or burrs on workpiece.	Clean/deburr workpiece.
Crushes electrode.	Gap cables not connected.	Connect sensing cables.
	Paint, corrosion or burrs on workpiece.	Clean/deburr workpiece.
MAIN MENU will not appear when MACHINE ON is actuated.	Disk drive unit contains a disk.	Remove disk from disk drive.
Ready light will not turn on.	Float switch not set.	Set float switch.
	Improper screen.	Select either the CUT or OPERATING PARAMETER ADJUST screen.
PRESSURE SWITCH message appears.	Dielectric filter is full.	Change dielectric filters and actuate GAP POWER ON to continue cut.
	Dielectric pump has lost prime.	Prime pump.
GAP FAULT message appears when GAP POWER ON is actuated.	Electrode is touching the workpiece.	Reposition electrode away from workpiece.
	Gap cables are not connected.	Connect gap cables.
	Electrode or workpiece not secure.	Secure electrode or workpiece.
	Improper RETRACT distance set.	Select a higher RETRACT number.
Machine turns off at the end of a cut.	FULL OFF is enabled on the OPERATING PARAMETER ADJUST screen.	The FULL ON selection will cause the machine to remain on at the end of a cut.

Cont'd next page...

TROUBLESHOOTING, Cont'd

Problem	Cause	Solution
Inaccurate cutting results.	Internal stress in workpiece.	Begin with hardened material.
	Program error.	Check program data.
	Incorrect OFFSET or SCALE.	Check OFFSET or SCALE.
Screen disappears from CRT.	"Screen Saver" feature.	Turn or depress C.I. Knob and screen will reappear.
Auto Power Recovery does not work.	Disk drive unit contains a disk.	Remove disk from drive.
	Machine table was moved when power was off.	Have machine restart program.
Table position error detected. Automatic table shutdown occurred. To reset: cycle 3 phase, press MACHINE ON.	Control has detected a malfunction in the system.	Switch circuit breaker off and on, then home the table. Notify Hansvedt when this occurs.

No Lead Remote Chiller
Air Cooled
Model ER-10

ELKAY®

SPECIFICATIONS

GENERAL

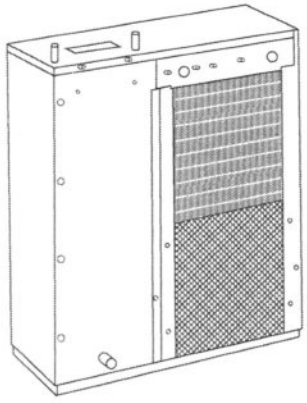
Remote type, electric refrigerated, water chiller unit. Chilling capacity of 9.6 gallons per hour of 50°F drinking water, based upon 80°F inlet water and 90°F ambient.

Compact, highly efficient water chiller units are designed for use with any drinking fountain. Also connects to a bubbler, glass filler or cold water dispenser. Converts a fountain into a water cooler. Installs directly under fountain or other application, or may be located in a service area to serve up to two remote outlets (within 15 feet of chiller recommended). Also recommended for photo-processing, medical or experimental laboratories and a pre-cooler for beverage dispensing.

NO LEAD DESIGN

THIS WATER CHILLER COMPLIES WITH THE LEAD-FREE DEFINITION IN THE SAFE DRINKING WATER ACT OF 1986 AND LEAD CONTAMINATION CONTROL ACT OF 1988.

Elkay Water Chillers are manufactured with a waterway system utilizing copper components and completely lead-free materials. These waterways have no lead because all lead-containing materials, such as leaded brass, have been removed. All joints are brazed using silver solder only. No lead solder is permitted.



ER-10 Remote Chiller

CAPACITIES CHART

Model Number	Inlet Water Temp. (°F)	*GPH of 50°F Drinking Water				No. People Served 50°F Drinking Water			Ship. Wt. Lbs.
		Room Temp. °F							
		70°	80°	90°	100°	School & Office	Light Mfg.	Heavy Mfg.	
ER-10	70°	15.0	13.8	12.7	11.5	115	67.2	48	73
	80°	11.1	10.4	9.6	8.8				
	90°	8.4	7.7	7.3	6.5				

*Based on 80° Inlet Water Temperature.

Rated watts shown are based on operational (run) time, in accordance with ARI Standard 1010 conditions. Specific applications will determine the actual watts consumed per hour. Watts consumed will be based on number of people served per hour (usage), ambient temperatures, and inlet water temperature.

Multiple-outlet capacities. Up to 2 stations.

COOLING SYSTEM

Motor Compressor: Hermetically sealed, reciprocating type, 1/4 HP, 115VAC, 60Hz single phase. Sealed in lifetime oil supply.

Power: Rated 5.8 amps; 490 Watts.

Condenser: Fan cooled, copper tube with aluminum fins. Fan motor is permanently lubricated.

Cooling Unit: Combination tube-tank type. Tube portion is continuous coil of copper tubing. Tank is copper.

Refrigerant Control: Refrigerant HFC134a is controlled by accurately calibrated capillary tube for positively trouble-free operation.

Temperature Control: Enclosed adjustable thermostat is factory preset. Requires no adjustment other than for altitude requirements.

CONSTRUCTION

Cabinet: Rust-resistant, galvanized steel. Expanded, cold rolled steel grill is painted black.

Drain Plug: This chiller is provided with a plastic drain plug which incorporates an o-ring seal. This fitting is designed for potable water applications and should be replaced with a suitable fitting if chiller is used with more aggressive liquids.

5 YEAR LIMITED WARRANTY on the refrigeration system of the unit. Electrical components and water system are warranted for 12 months from date of installation. Warranty pertains to drinking water applications only. Non-drinking water applications are not covered under warranty. Sample Certificate available on request.

Note: In keeping with our policy of continuing product improvement, Elkay reserves the right to change materials, design and specifications without notice.

Elkay Electric Air Cooled Water Chillers are listed by Underwriters Laboratories, approved by C.S.A., rated in accordance with A.R.I. Standard 1010 and meet all known federal and state plumbing codes.

STANDARDS

c UL us — Elkay Electric Air Cooled Water Coolers are listed by Underwriters Laboratories Inc. and comply with both Canadian and U.S. requirements.

Rated in accordance with A.R.I. Standard 1010 and meets all known federal and state plumbing codes.

This cooler is certified by WQA to lead-free compliance including NSF/ANSI 61 and 372.

This specification describes an Elkay product with design, quality and functional benefits to the user. When making a comparison of other producers' offerings, be certain these features are not overlooked.

Elkay Manufacturing Company
www.elkay.com

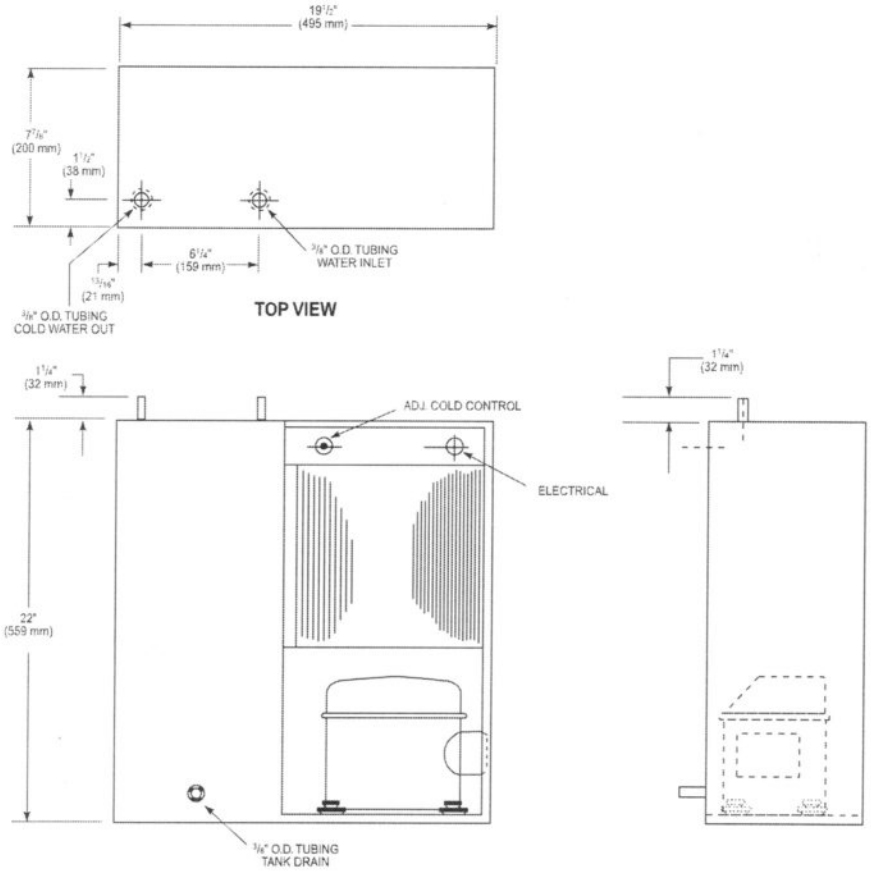
2222 Camden Court
Oak Brook, IL 60523

(Rev. 7/12) 13-5D

No Lead Remote Chiller
Air Cooled
Model ER-10

ELKAY®

ROUGH-IN DIMENSIONS



Drain Plug: This chiller is provided with a plastic drain plug which incorporates an o-ring seal. This fitting is designed for potable water applications and should be replaced with a suitable fitting if chiller is used with more aggressive liquids.

NOTE: It is important to insure proper ventilation. Allow a minimum clearance of 6 inches (152 mm) in front and 3 inches (76 mm) in the rear of the unit. If unit is to be installed in an enclosure, allow the following clearances around unit: 1 inch (25 mm) each side, 3 inches (76 mm) in the rear, 3 inches (76 mm) above. Wall grill, EG-1 or EG-2 may be used with this unit.

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Printed in U.S.A.

13-5D (Rev. 7/12)