PAC500®

Water Injection Plasma Cutting System

Instruction Manual
800370 – Revision 4

Hypertherm®
The world leader in plasma cutting technology

PAC500

Instruction Manual

(P/N 800370)

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EMC INTRODUCTION

Hypertherm's CE-marked equipment is built in compliance with standard EN50199. The equipment should be installed and used in accordance with the information below to achieve electromagnetic compatibility.

The limits required by EN50199 may not be adequate to completely eliminate interference when the affected equipment is in close proximity or has a high degree of sensitivity. In such cases it may be necessary to use other measures to further reduce interference.

This plasma equipment is designed for use only in an industrial environment.

INSTALLATION AND USE

The user is responsible for installing and using the plasma equipment according to the manufacturer's instructions. If electromagnetic disturbances are detected then it shall be the responsibility of the user to resolve the situation with the technical assistance of the manufacturer. In some cases this remedial action may be as simple as earthing the cutting circuit, see *Earthing of Workpiece*. In other cases it could involve constructing an electromagnetic screen enclosing the power source and the work complete with associated input filters. In all cases electromagnetic disturbances must be reduced to the point where they are no longer troublesome.

ASSESSMENT OF AREA

Before installing the equipment the user shall make an assessment of potential electromagnetic problems in the surrounding area. The following shall be taken into account:

a. Other supply cables, control cables, signalling and telephone cables; above, below and adjacent to the cutting equipment.

b. Radio and television transmitters and receivers.

c. Computer and other control equipment.

d. Safety critical equipment, for example guarding of industrial equipment.

e. Health of the people around, for example the use of pacemakers and hearing aids.

f. Equipment used for calibration or measurement.

g. Immunity of other equipment in the environment. User shall ensure that other equipment being used in the environment is compatible. This may require additional protection measures.

h. Time of day that cutting or other activities are to be carried out.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area may extend beyond the boundaries of the premises.

METHODS OF REDUCING EMISSIONS

Mains Supply

Cutting equipment must be connected to the mains supply according to the manufacturer's recommendations. If interference occurs, it may be necessary to take additional precautions such as filtering of the mains supply. Consideration should be given to shielding the supply cable of permanently installed cutting equipment, in metallic conduit or equivalent. Shielding should be electrically continuous throughout its length. The shielding should be connected to the cutting mains supply so that good electrical contact is maintained between the conduit and the cutting power source enclosure

Maintenance of Cutting Equipment

The cutting equipment must be routinely maintained according to the manufacturer's recommendations. All access and service doors and covers should be closed and properly fastened when the cutting equipment is in operation. The cutting equipment should not be modified in any way except for those changes and adjustments covered in the manufacturer's instructions. In particular, the spark gaps of arc striking and stabilizing devices should be adjusted and maintained according to the manufacturer's recommendations.

Cutting Cables

The cutting cables should be kept as short as possible and should be positioned close together, running at or close to the floor level.

Equipotential Bonding

Bonding of all metallic components in the cutting installation and adjacent to it should be considered. However, metallic components bonded to the workpiece will increase the risk that the operator could receive a shock by touching these metallic components and the electrode at the same time. The operator should be insulated from all such bonded metallic components.

Earthing of Workpiece

Where the workpiece is not bonded to earth for electrical safety, nor connected to earth because of its size and position, for example, ship's hull or building steelwork, a connection bonding the workpiece to earth may reduce emissions in some, but not all instances. Care should be taken to prevent the earthing of the workpiece increasing the risk of injury to users, or damage to other electrical equipment. Where necessary, the connection of the workpiece to earth should be made by a direct connection to the workpiece, but in some countries where direct connection is not permitted, the bonding should be achieved by suitable capacitances selected according to national regulations.

Note. The cutting circuit may or may not be earthed for safety reasons. Changing the earthing arrangements should only be authorized by a person who is competent to assess whether the changes will increase the risk of injury, for example, by allowing parallel cutting current return paths which may damage the earth circuits of other equipment. Further guidance is given in IEC TC26 (sec)94 and IEC TC26/108A/CD Arc Welding Equipment Installation and Use.

Screening and Shielding

Selective screening and shielding of other cables and equipment in the surrounding area may alleviate problems of interference. Screening of the entire plasma cutting installation may be considered for special applications

WARNING

Genuine Hypertherm parts are the factory-recommended replacement parts for your Hypertherm system. Any damage caused by the use of other than genuine Hypertherm parts may not be covered by the Hypertherm warranty.

WARNING

You are responsible for the safe use of the Product. Hypertherm does not and cannot make any guarantee or warranty regarding the safe use of the Product in your environment.

GENERAL

Hypertherm, Inc. warrants that its Products shall be free from defects in materials and workmanship, if Hypertherm is notified of a defect (i) with respect to the power supply within a period of two (2) years from the date of its delivery to you, with the exception of G3 Series power supplies, which shall be within a period of three (3) years from the date of delivery to you, and (ii) with respect to the torch and leads within a period of one (1) year from its date of delivery to you. This warranty shall not apply to any Product which has been incorrectly installed, modified, or otherwise damaged. Hypertherm, at its sole option, shall repair, replace, or adjust, free of charge, any defective Products covered by this warranty which shall be returned with Hypertherm's prior authorization (which shall not be unreasonably withheld), properly packed, to Hypertherm's place of business in Hanover, New Hampshire, or to an authorized Hypertherm repair facility, all costs, insurance and freight prepaid. Hypertherm shall not be liable for any repairs, replacement, or adjustments of Products covered by this warranty, except those made pursuant to this paragraph or with Hypertherm's prior written consent. **The warranty above is exclusive and is in lieu of all other warranties, express, implied, statutory, or otherwise with respect to the Products or as to the results which may be obtained therefrom, and all implied warranties or conditions of quality or of merchantability or fitness for a particular purpose or against infringement. The foregoing shall constitute the sole and exclusive remedy for any breach by Hypertherm of its warranty**. Distributors/OEMs may offer different or additional warranties, but Distributors/OEMs are not authorized to give any additional warranty protection to you or make any representation to you purporting to be binding upon Hypertherm.

PATENT INDEMNITY

Except only in cases of products not manufactured by Hypertherm or manufactured by a person other than Hypertherm not in strict conformity with Hypertherm's specifications and in cases of designs, processes, formulae, or combinations not developed or purported to be developed by Hypertherm, Hypertherm will defend or settle, at its own expense, any suit or proceeding brought against you alleging that the use of the Hypertherm product, alone and not in combination with any other product not supplied by Hypertherm, infringes any patent of any third party. You shall notify Hypertherm promptly upon learning of any action or threatened action in connection with any such alleged infringement, and Hypertherm's obligation to indemnify shall be conditioned upon Hypertherm's sole control of, and the indemnified party's cooperation and assistance in, the defense of the claim.

LIMITATION OF LIABILITY

In no event shall Hypertherm be liable to any person or entity for any incidental, consequential, indirect, or punitive damages (including but not limited to lost profits) regardless of whether such liability is based on breach of contract, tort, strict liability, breach of warranties, failure of essential purpose or otherwise and even if advised of the possibility of such damages.

LIABILITY CAP

In no event shall Hypertherm's liability, whether such liability is based on breach of contract, tort, strict liability, breach of warranties, failure of essential purpose or otherwise, for any claim action suit or proceeding arising out of or relating to the use of the Products exceed in the aggregate the amount paid for the Products that gave rise to such claim.

INSURANCE

At all times you will have and maintain insurance in such quantities and types, and with coverage sufficient and appropriate to defend and to hold Hypertherm harmless in the event of any cause of action arising from the use of the Products.

NATIONAL AND LOCAL CODES

National and Local codes governing plumbing and electrical installation shall take precedent over any instructions contained in this manual. **In no event** shall Hypertherm be liable for injury to persons or property damage by reason of any code violation or poor work practices.

TRANSFER OF RIGHTS

You may transfer any remaining rights you may have hereunder only in connection with the sale of all or substantially all of your assets or capital stock to a successor in interest who agrees to be bound by all of the terms and conditions of this Warranty.

Section 1

SAFETY

In this section:

RECOGNIZE SAFETY INFORMATION

The symbols shown in this section are used to identify potential hazards. When you see a safety symbol in this manual or on your machine, understand the potential for personal injury, and follow the related instructions to avoid the hazard.

FOLLOW SAFETY INSTRUCTIONS

Read carefully all safety messages in this manual and safety labels on your machine.

- Keep the safety labels on your machine in good condition. Replace missing or damaged labels immediately.
- Learn how to operate the machine and how to use the controls properly. Do not let anyone operate it without instruction.
- Keep your machine in proper working condition. Unauthorized modifications to the machine may affect safety and machine service life.

DANGER WARNING CAUTION

A signal word DANGER or WARNING is used with a safety symbol. DANGER identifies the most serious hazards.

- DANGER and WARNING safety labels are located on your machine near specific hazards.
- WARNING safety messages precede related instructions in this manual that may result in injury or death if not followed correctly.
- CAUTION safety messages precede related instructions in this manual that may result in damage to equipment if not followed correctly.

CUTTING CAN CAUSE FIRE OR EXPLOSION

Fire Prevention

- Be sure the area is safe before doing any cutting. Keep a fire extinguisher nearby.
- Remove all flammables within 35 feet (10 m) of the cutting area.
- Quench hot metal or allow it to cool before handling or before letting it touch combustible materials.
- Never cut containers with potentially flammable materials inside – they must be emptied and properly cleaned first.
- Ventilate potentially flammable atmospheres before cutting.
- When cutting with oxygen as the plasma gas, an exhaust ventilation system is required.

Explosion Prevention

- Do not use the plasma system if explosive dust or vapors may be present.
- Do not cut pressurized cylinders, pipes, or any closed container.
- Do not cut containers that have held combustible materials.

WARNING

Explosion Hazard
Argon-Hydrogen and Methane

Hydrogen and methane are flammable gases that present an explosion hazard. Keep flames away from cylinders and hoses that contain methane or hydrogen mixtures. Keep flames and sparks away from the torch when using methane or argon-hydrogen plasma.

WARNING

Hydrogen Detonation with Aluminum Cutting

- When cutting aluminum underwater, or with the water touching the underside of the aluminum, free hydrogen gas may collect under the workpiece and detonate during plasma cutting operations.
- Install an aeration manifold on the floor of the water table to eliminate the possibility of hydrogen detonation. Refer to the Appendix section of this manual for aeration manifold details.


ELECTRIC SHOCK CAN KILL

Touching live electrical parts can cause a fatal shock or severe burn.

- Operating the plasma system completes an electrical circuit between the torch and the workpiece. The workpiece and anything touching the workpiece are part of the electrical circuit.
- Never touch the torch body, workpiece or the water in a water table when the plasma system is operating.

Electric Shock Prevention

All Hypertherm plasma systems use high voltage in the cutting process (200 to 400 VDC are common). Take the following precautions when operating this system:

- Wear insulated gloves and boots, and keep your body and clothing dry.
- Do not stand, sit or lie on – or touch – any wet surface when using the plasma system.
- Insulate yourself from work and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground. If you must work in or near a damp area, use extreme caution.
- Provide a disconnect switch close to the power supply with properly sized fuses. This switch allows the operator to turn off the power supply quickly in an emergency situation.
- When using a water table, be sure that it is correctly connected to earth ground.
- Install and ground this equipment according to the instruction manual and in accordance with national and local codes.
- Inspect the input power cord frequently for damage or cracking of the cover. Replace a damaged power cord immediately. **Bare wiring can kill.**
- Inspect and replace any worn or damaged torch leads.
- Do not pick up the workpiece, including the waste cutoff, while you cut. Leave the workpiece in place or on the workbench with the work cable attached during the cutting process.
- Before checking, cleaning or changing torch parts, disconnect the main power or unplug the power supply.
- Never bypass or shortcut the safety interlocks.
- Before removing any power supply or system enclosure cover, disconnect electrical input power. Wait 5 minutes after disconnecting the main power to allow capacitors to discharge.
- Never operate the plasma system unless the power supply covers are in place. Exposed power supply connections present a severe electrical hazard.
- When making input connections, attach proper grounding conductor first.
- Each Hypertherm plasma system is designed to be used only with specific Hypertherm torches. Do not substitute other torches which could overheat and present a safety hazard.

CUTTING CAN PRODUCE TOXIC FUMES

Cutting can produce toxic fumes and gases that deplete oxygen and cause injury or death.

- Keep the cutting area well ventilated or use an approved air-supplied respirator.
- Do not cut in locations near degreasing, cleaning or spraying operations. The vapors from certain chlorinated solvents decompose to form phosgene gas when exposed to ultraviolet radiation.
- Do not cut metal coated or containing toxic materials, such as zinc (galvanized), lead, cadmium or beryllium, unless the area is well ventilated and the operator wears an air-supplied respirator. The coatings and any metals containing these elements can produce toxic fumes when cut.
- Never cut containers with potentially toxic materials inside – they must be emptied and properly cleaned first.
- This product, when used for welding or cutting, produces fumes or gases which contain chemicals known to the State of California to cause birth defects and, in some cases, cancer.

A PLASMA ARC CAN CAUSE INJURY AND BURNS

Instant-On Torches
Plasma arc comes on immediately when the torch switch is activated.

The plasma arc will cut quickly through gloves and skin.
- Keep away from the torch tip.
- Do not hold metal near the cutting path.
- Never point the torch toward yourself or others.

ARC RAYS CAN BURN EYES AND SKIN

Eye Protection Plasma arc rays produce intense visible and invisible (ultraviolet and infrared) rays that can burn eyes and skin.
- Use eye protection in accordance with applicable national or local codes.
- Wear eye protection (safety glasses or goggles with side shields, or a welding helmet) with appropriate lens shading to protect your eyes from the arc's ultraviolet and infrared rays.

Arc Current	Lens Shade AWS (USA)	Lens Shade ISO 4850
Up to 100 A	No. 8	No. 11
100-200 A	No. 10	No. 11-12
200-400 A	No. 12	No. 13
Over 400 A	No. 14	No. 14

Skin Protection Wear protective clothing to protect against burns caused by ultraviolet light, sparks and hot metal.
- Gauntlet gloves, safety shoes and hat.
- Flame-retardant clothing to cover all exposed areas.
- Cuffless trousers to prevent entry of sparks and slag.
- Remove any combustibles, such as a butane lighter or matches, from your pockets before cutting.

Cutting Area Prepare the cutting area to reduce reflection and transmission of ultraviolet light:
- Paint walls and other surfaces with dark colors to reduce reflection.
- Use protective screens or barriers to protect others from flash and glare.
- Warn others not to watch the arc. Use placards or signs.

GROUNDING SAFETY

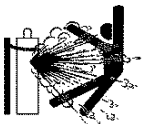
Work Cable Attach the work cable securely to the workpiece or the work table with good metal-to-metal contact. Do not connect it to the piece that will fall away when the cut is complete.

Work Table Connect the work table to an earth ground, in accordance with appropriate national or local electrical codes.

Input Power
- Be sure to connect the power cord ground wire to the ground in the disconnect box.
- If installation of the plasma system involves connecting the power cord to the power supply, be sure to connect the power cord ground wire properly.
- Place the power cord's ground wire on the stud first, then place any other ground wires on top of the power cord ground. Fasten the retaining nut tightly.
- Tighten all electrical connections to avoid excessive heating.

COMPRESSED GAS EQUIPMENT SAFETY

- Never lubricate cylinder valves or regulators with oil or grease.
- Use only correct gas cylinders, regulators, hoses and fittings designed for the specific application.
- Maintain all compressed gas equipment and associated parts in good condition.
- Label and color-code all gas hoses to identify the type of gas in each hose. Consult applicable national or local codes.



GAS CYLINDERS CAN EXPLODE IF DAMAGED

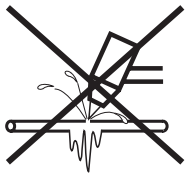
Gas cylinders contain gas under high pressure. If damaged, a cylinder can explode.

- Handle and use compressed gas cylinders in accordance with applicable national or local codes.
- Never use a cylinder that is not upright and secured in place.
- Keep the protective cap in place over valve except when the cylinder is in use or connected for use.
- Never allow electrical contact between the plasma arc and a cylinder.
- Never expose cylinders to excessive heat, sparks, slag or open flame.
- Never use a hammer, wrench or other tool to open a stuck cylinder valve.

NOISE CAN DAMAGE HEARING

Prolonged exposure to noise from cutting or gouging can damage hearing.

- Use approved ear protection when using plasma system.
- Warn others nearby about the noise hazard.



A PLASMA ARC CAN DAMAGE FROZEN PIPES

Frozen pipes may be damaged or can burst if you attempt to thaw them with a plasma torch.

PACEMAKER AND HEARING AID OPERATION

Pacemaker and hearing aid operation can be affected by magnetic fields from high currents.
Pacemaker and hearing aid wearers should consult a doctor before going near any plasma arc cutting and gouging operations.

To reduce magnetic field hazards:

- Keep both the work cable and the torch lead to one side, away from your body.
- Route the torch leads as close as possible to the work cable.
- Do not wrap or drape the torch lead or work cable around your body.
- Keep as far away from the power supply as possible.

ADDITIONAL SAFETY INFORMATION

1. ANSI Standard Z49.1, *Safety in Welding and Cutting,* American Welding Society, 550 LeJeune Road P.O. Box 351020, Miami, FL 33135
2. ANSI Standard Z49.2, *Fire Prevention in the Use of Cutting and Welding Processes,* American National Standards Institute 1430 Broadway, New York, NY 10018
3. ANSI Standard Z87.1, *Safe Practices for Occupation and Educational Eye and Face Protection,* American National Standards Institute, 1430 Broadway, New York, NY 10018
4. AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances,* American Welding Society 550 LeJeune Road, P.O. Box 351040, Miami, FL 33135
5. AWS F5.2, *Recommended Safe Practices for Plasma Arc Cutting,* American Welding Society 550 LeJeune Road, P.O. Box 351040, Miami, FL 33135
6. CGA Pamphlet P-1, *Safe Handling of Compressed Gases in Cylinders,* Compressed Gas Association 1235 Jefferson Davis Highway, Arlington, VA 22202
7. CSA Standard W117.2, *Code for Safety in Welding and Cutting,* Canadian Standards Association Standard Sales 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3, Canada
8. NFPA Standard 51B, *Cutting and Welding Processes,* National Fire Protection Association 470 Atlantic Avenue, Boston, MA 02210
9. NFPA Standard 70–1978, *National Electrical Code,* National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210
10. OSHA, *Safety and Health Standards,* 29FR 1910 U.S. Government Printing Office, Washington, D.C. 20402

WARNING LABEL

This warning label is affixed to some power supplies. It is important that the operator and maintenance technician understand the intent of these warning symbols as described. The numbered text corresponds to the numbered boxes on the label.

1. Cutting sparks can cause explosion or fire.

1.1 Keep flammables away from cutting.

1.2 Keep a fire extinguisher nearby, and have a watchperson ready to use it.

1.3 Do not cut on any closed containers.

2. The plasma arc can cause injury and burns.

2.1 Turn off power before disassembling torch.

2.2 Do not hold the material near cutting path.

2.3 Wear complete body protection.

3. Electric shock from torch or wiring can kill. Protect yourself from electric shock.

3.1 Wear insulating gloves. Do not wear wet or damaged gloves.

3.2 Insulate yourself from work and ground.

3.3 Disconnect input plug or power before working on machine.

4. Breathing cutting fumes can be hazardous to your health.

4.1 Keep your head out of the fumes.

4.2 Use forced ventilation or local exhaust to remove the fumes.

4.3 Use ventilating fan to remove the fumes.

5. Arc rays can burn eyes and injure skin.

5.1 Wear hat and safety glasses. Use ear protection and button shirt collar. Use welding helmet with correct shade of filter. Wear complete body protection.

6. Become trained and read the instructions before working on the machine or cutting.

7. Do not remove or paint over (cover) warning labels.

Hypertherm

Section 1a

SÉCURITÉ

Dans cette section :

IDENTIFIER LES CONSIGNES DE SÉCURITÉ

Les symboles indiqués dans cette section sont utilisés pour identifier les risques éventuels. Si vous trouvez un symbole de sécurité, que ce soit dans ce manuel ou sur l'équipement, soyez conscient des risques de blessures et suivez les instructions correspondantes afin d'éviter ces risques.

SUIVRE LES INSTRUCTIONS DE SÉCURITÉ

Lire attentivement toutes les consignes de sécurité dans le présent manuel et sur les étiquettes de sécurité se trouvant sur la machine.

- Les étiquettes de sécurité doivent rester lisibles. Remplacer immédiatement les étiquettes manquantes ou abîmées.
- Apprendre à faire fonctionner la machine et à utiliser correctement les commandes. Ne laisser personne utiliser la machine sans connaître son fonctionnement.
- Garder la machine en bon état. Des modifications non autorisées sur la machine peuvent engendrer des problèmes de sécurité et raccourcir la durée d'utilisation de l'équipement.

DANGER AVERTISSEMENT PRÉCAUTION

Les signaux DANGER ou AVERTISSEMENT sont utilisés avec un symbole de sécurité, DANGER correspondant aux risques les plus sérieux.

- Les étiquettes de sécurité DANGER et AVERTISSEMENT sont situées sur la machine pour signaler certains dangers spécifiques.
- Les messages d'AVERTISSEMENT précèdent les instructions d'utilisation expliquées dans ce manuel et signalent les risques de blessures ou de mort au cas où ces instructions ne seraient pas suivies correctement.
- Les messages de PRÉCAUTION précèdent les instructions d'utilisation contenues dans ce manuel et signalent que le matériel risque d'être endommagé si les instructions ne sont pas suivies correctement.

LE COUPAGE PEUT PROVOQUER UN INCENDIE OU UNE EXPLOSION

Prévention des incendies

- Avant de commencer, s'assurer que la zone de coupage ne présente aucun danger. Conserver un extincteur à proximité.
- Éloigner toute matière inflammable à une distance d'au moins 10 m du poste de coupage.
- Tremper le métal chaud ou le laisser refroidir avant de le manipuler ou avant de le mettre en contact avec des matériaux combustibles.
- Ne jamais couper des récipients pouvant contenir des matières inflammables avant de les avoir vidés et nettoyés correctement.
- Aérer toute atmosphère potentiellement inflammable avant d'utiliser un système plasma.
- Lors de l'utilisation d'oxygène comme gaz plasma, un système de ventilation par aspiration est nécessaire.

Prévention des explosions

- Ne pas couper en présence de poussière ou de vapeurs.
- Ne pas couper de bouteilles, de tuyaux ou autres récipients fermés et pressurisés.
- Ne pas couper de récipients contenant des matières combustibles.

AVERTISSEMENT

Risque d'explosion
argon-hydrogène et méthane

L'hydrogène et le méthane sont des gaz inflammables et potentiellement explosifs. Conserver à l'écart de toute flamme les bouteilles et tuyaux contenant des mélanges à base d'hydrogène ou de méthane. Maintenir toute flamme et étincelle à l'écart de la torche lors de l'utilisation d'un plasma d'argon-hydrogène ou de méthane.

AVERTISSEMENT

Détonation de l'hydrogène lors du coupage de l'aluminium

- Lors du coupage de l'aluminium sous l'eau, ou si l'eau touche la partie inférieure de la pièce d'aluminium, de l'hydrogène libre peut s'accumuler sous la pièce à couper et détonner lors du coupage plasma.
- Installer un collecteur d'aération au fond de la table à eau afin d'éliminer les risques de détonation de l'hydrogène. Se référer à l'annexe du manuel pour plus de renseignements sur les collecteurs d'aération.


LES CHOCS ÉLECTRIQUES PEUVENT ÊTRE FATALS

Toucher une pièce électrique sous tension peut provoquer un choc électrique fatal ou des brûlures graves.

- La mise en fonctionnement du système plasma ferme un circuit électrique entre la torche et la pièce à couper. La pièce à couper et tout autre élément en contact avec cette pièce font partie du circuit électrique.
- Ne jamais toucher le corps de la torche, la pièce à couper ou l'eau de la table à eau pendant le fonctionnement du système plasma.

Prévention des chocs électriques

Tous les systèmes plasma Hypertherm utilisent des hautes tensions pour le coupage (souvent de 200 à 400 V). On doit prendre les précautions suivantes quand on utilise le système plasma :

- Porter des bottes et des gants isolants et garder le corps et les vêtements au sec.
- Ne pas se tenir, s'asseoir ou se coucher sur une surface mouillée, ni la toucher quand on utilise le système plasma.
- S'isoler de la surface de travail et du sol en utilisant des tapis isolants secs ou des couvertures assez grandes pour éviter tout contact physique avec le travail ou le sol. S'il s'avère nécessaire de travailler dans ou près d'un endroit humide, procéder avec une extrême prudence.
- Installer un sectionneur avec fusibles appropriés, à proximité de la source de courant. Ce dispositif permet à l'opérateur d'arrêter rapidement la source de courant en cas d'urgence.
- En cas d'utilisation d'une table à eau, s'assurer que cette dernière est correctement mise à la terre.
- Installer et mettre à la terre l'équipement selon les instructions du présent manuel et conformément aux codes électriques locaux et nationaux.
- Inspecter fréquemment le cordon d'alimentation primaire pour s'assurer qu'il n'est ni endommagé, ni fendu. Remplacer immédiatement un cordon endommagé. **Un câble dénudé peut tuer**.
- Inspecter et remplacer les câbles de la torche qui sont usés ou endommagés.
- Ne pas saisir la pièce à couper ni les chutes lors du coupage. Laisser la pièce à couper en place ou sur la table de travail, le câble de retour connecté lors du coupage.
- Avant de vérifier, de nettoyer ou de remplacer les pièces de la torche, couper l'alimentation ou débrancher la prise de courant.
- Ne jamais contourner ou court-circuiter les verrouillages de sécurité.
- Avant d'enlever le capot du système ou de la source de courant, couper l'alimentation électrique. Attendre ensuite 5 minutes pour que les condensateurs se déchargent.
- Ne jamais faire fonctionner le système plasma sans que les capots de la source de courant ne soient en place. Les raccords exposés de la source de courant sont extrêmement dangereux.
- Lors de l'installation des connexions, attacher tout d'abord la prise de terre appropriée.
- Chaque système plasma Hypertherm est conçu pour être utilisé uniquement avec des torches Hypertherm spécifiques. Ne pas utiliser des torches inappropriées qui pourraient surchauffer et présenter des risques pour la sécurité.

LE COUPAGE PEUT PRODUIRE DES VAPEURS TOXIQUES

Le coupage peut produire des vapeurs et des gaz toxiques qui réduisent le niveau d'oxygène dans l'air et peuvent provoquer des blessures, voire la mort.

- Conserver le poste de coupage bien aéré ou utiliser un masque respiratoire homologué.
- Ne pas procéder au coupage près d'endroits où s'effectuent le dégraissage, le nettoyage ou la vaporisation. Certains solvants chlorés se décomposent sous l'effet des rayons ultraviolets et forment du phosgène.
- Ne pas couper des métaux peints ou contenant des matières toxiques comme le zinc (galvanisé), le plomb, le cadmium ou le béryllium, à moins que la zone de travail soit très bien ventilée et que l'opérateur porte un masque respiratoire. Les revêtements et métaux contenant ces matières peuvent produire des vapeurs toxiques lors du coupage.
- Ne jamais couper de récipients pouvant contenir des matières inflammables avant de les avoir vidés et nettoyés correctement.
- Quand on utilise ce produit pour le soudage ou le coupage, il dégage des fumées et des gaz qui contiennent des produits chimiques qui, selon l'État de Californie, provoquent des anomalies congénitales et, dans certains cas, le cancer.

L'ARC PLASMA PEUT PROVOQUER DES BLESSURES OU DES BRÛLURES

Torches à allumage instantané

L'arc plasma s'allume immédiatement après que la torche soit mise en marche.

L'arc plasma coupe facilement les gants et la peau.

- Rester éloigné de l'extrémité de la torche.
- Ne pas tenir de métal près de la trajectoire de coupe.
- Ne jamais pointer la torche vers soi ou d'autres personnes.

LES RAYONS DE L'ARC PEUVENT BRÛLER LES YEUX ET LA PEAU

Protection des yeux Les rayons de l'arc plasma produisent de puissants rayons visibles ou invisibles (ultraviolets et infrarouges) qui peuvent brûler les yeux et la peau.

- Utiliser des lunettes de sécurité conformément aux codes locaux ou nationaux en vigueur.
- Porter des lunettes de protection (lunettes ou masque muni d'écrans latéraux ou encore masque de soudure) avec des verres teintés appropriés pour protéger les yeux des rayons ultraviolets et infrarouges de l'arc.

Courant de l'arc	Puissance des verres teintés AWS (É.-U.)	ISO 4850
Jusqu'à 100 A	N° 8	N° 11
100-200 A	N° 10	N° 11-12
200-400 A	N° 12	N° 13
Plus de 400 A	N° 14	N° 14

Protection de la peau Porter des vêtements de sécurité pour se protéger contre les brûlures que peuvent causer les rayons ultraviolets, les étincelles et le métal brûlant :

- Gants à crispin, chaussures et casque de sécurité.
- Vêtements ignifuges couvrant toutes les parties exposées du corps.
- Pantalon sans revers pour éviter que des étincelles ou des scories puissent s'y loger.
- Avant le coupage, retirer de ses poches tout objet combustible comme les briquets au butane ou les allumettes.

Zone de coupage Préparer la zone de coupage afin de réduire la réverbération et la transmission de la lumière ultraviolette :

- Peindre les murs et autres surfaces de couleur sombre pour réduire la réflexion de la lumière.
- Utiliser des écrans et autres dispositifs de protection afin de protéger les autres personnes de la lumière et de la réverbération.
- Prévenir les autres personnes de ne pas regarder l'arc. Utiliser des affiches ou des panneaux.

MISE À LA MASSE ET À LA TERRE

Câble de retour Bien fixer le câble de retour (ou de masse) à la pièce à couper ou à la table de travail de façon à assurer un bon contact métal-métal. Ne pas fixer le câble de retour à la partie de la pièce qui doit se détacher.

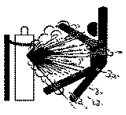
Table de travail Raccorder la table de travail à la terre, conformément aux codes de sécurité locaux ou nationaux appropriés.

Alimentation

- S'assurer que le fil de terre du cordon d'alimentation est connecté à la terre dans le coffret du sectionneur.
- S'il est nécessaire de brancher le cordon d'alimentation à la source de courant lors de l'installation du système, s'assurer que le fil de terre est correctement branché.
- Placer tout d'abord le fil de terre du cordon d'alimentation sur le plot de mise à la terre puis placer les autres fils de terre par-dessus. Bien serrer l'écrou de retenue.
- S'assurer que toutes les connexions sont bien serrées pour éviter la surchauffe.

SÉCURITÉ DES BOUTEILLES DE GAZ COMPRIMÉ

- Ne jamais lubrifier les robinets des bouteilles ou les régulateurs avec de l'huile ou de la graisse.
- Utiliser uniquement les bouteilles, régulateurs, tuyaux et accessoires appropriés et conçus pour chaque application spécifique.
- Entretenir l'équipement et les pièces d'équipement à gaz comprimé afin de les garder en bon état.
- Étiqueter et coder avec des couleurs tous les tuyaux de gaz afin d'identifier le type de gaz contenu dans chaque tuyau. Se référer aux codes locaux ou nationaux en vigueur.



LES BOUTEILLES DE GAZ COMPRIMÉ PEUVENT EXPLOSER EN CAS DE DOMMAGES

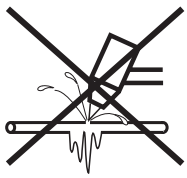
Les bouteilles de gaz contiennent du gaz à haute pression. Si une bouteille est endommagée, elle peut exploser.

- Manipuler et utiliser les bouteilles de gaz comprimé conformément aux codes locaux ou nationaux.
- Ne jamais utiliser une bouteille qui n'est pas placée à la verticale et bien assujettie.
- Le capuchon de protection doit être placé sur le robinet sauf si la bouteille est en cours d'utilisation ou connectée pour utilisation.
- Éviter à tout prix le contact électrique entre l'arc plasma et une bouteille.
- Ne jamais exposer des bouteilles à une chaleur excessive, aux étincelles, aux scories ou aux flammes nues.
- Ne jamais utiliser des marteaux, des clés ou d'autres outils pour débloquer le robinet des bouteilles.

LE BRUIT PEUT PROVOQUER DES PROBLÈMES AUDITIFS

Une exposition prolongée au bruit du coupage ou du gougeage peut provoquer des problèmes auditifs.

- Utiliser un casque de protection homologué lors de l'utilisation du système plasma.
- Prévenir les personnes aux alentours des risques encourus en cas d'exposition au bruit.



UN ARC PLASMA PEUT ENDOMMAGER LES TUYAUX GELÉS

Les tuyaux gelés peuvent être endommagés ou éclater si l'on essaie de les dégeler avec une torche plasma.

PACEMAKERS ET PROTHÈSES AUDITIVES

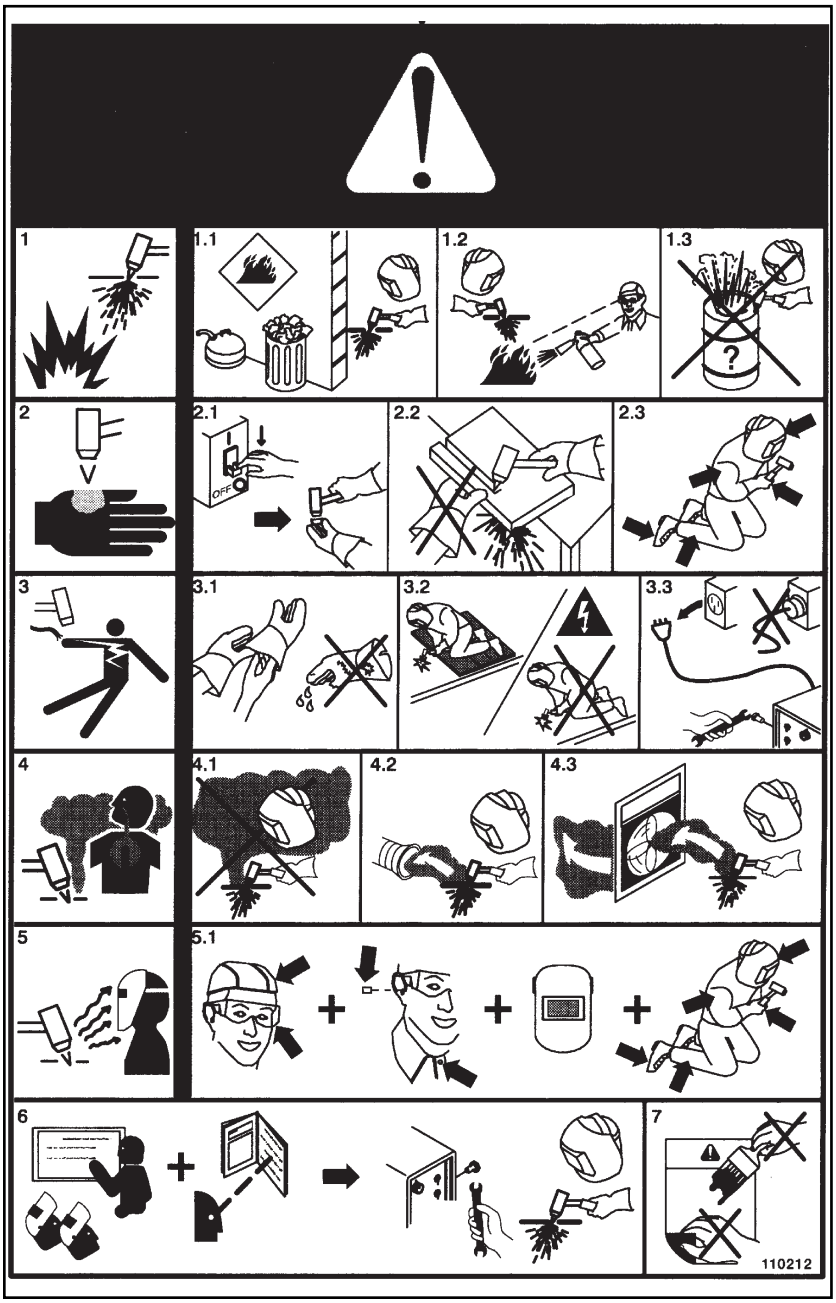
Les champs magnétiques produits par les courants à haute tension peuvent affecter le fonctionnement des prothèses auditives et des pacemakers. Les personnes portant ce type d'appareil doivent consulter un médecin avant de s'approcher d'un lieu où s'effectue le coupage ou le gougeage plasma.

Pour réduire les risques associés aux champs magnétiques :

- Garder loin de soi et du même côté du corps le câble de retour et le faisceau de la torche.
- Faire passer le faisceau de la torche le plus près possible du câble de retour.
- Ne pas s'enrouler le faisceau de la torche ou le câble de retour autour du corps.
- Se tenir le plus loin possible de la source de courant.

Étiquette de sécurité

Cette étiquette est affichée sur la source de courant. Il est important que l'utilisateur et le technicien de maintenance comprennent la signification des symboles de sécurité. Les numéros de la liste correspondent aux numéros des images.



1. Les étincelles produites par le coupage peuvent provoquer une explosion ou un incendie.

1.1 Pendant le coupage, éloigner toute matière inflammable.

1.2 Conserver un extincteur à proximité et s'assurer qu'une personne soit prête à l'utiliser.

1.3 Ne jamais couper de récipients fermés.

2. L'arc plasma peut provoquer des blessures et des brûlures.

2.1 Couper l'alimentation avant de démonter la torche.

2.2 Ne pas tenir la surface à couper près de la trajectoire de coupe.

2.3 Porter des vêtements de protection couvrant tout le corps.

3. Un choc électrique causé par la torche ou les câbles peut être fatal. Se protéger contre les risques de chocs électriques.

3.1 Porter des gants isolants. Ne pas porter de gants mouillés ou abîmés.

3.2 S'isoler de la surface de travail et du sol.

3.3 Débrancher la prise ou la source de courant avant de manipuler l'équipement.

4. L'inhalation des vapeurs produites par le coupage peut être dangereuse pour la santé.

4.1 Garder le visage à l'écart des vapeurs.

4.2 Utiliser un système de ventilation par aspiration ou d'échappement localisé pour dissiper les vapeurs.

4.3 Utiliser un ventilateur pour dissiper les vapeurs.

5. Les rayons de l'arc peuvent brûler les yeux et provoquer des lésions de la peau.

5.1 Porter un casque et des lunettes de sécurité. Se protéger les oreilles et porter une chemise dont le col peut être déboutonné. Porter un casque de soudure dont la protection filtrante est suffisante. Porter des vêtements protecteurs couvrant la totalité du corps.

6. Se former à la technique du coupage et lire les instructions avant de manipuler l'équipement ou de procéder au coupage.

7. Ne pas retirer ou peindre (recouvrir) les étiquettes de sécurité.

Hypertherm

Section 2

SPECIFICATIONS

In this section:

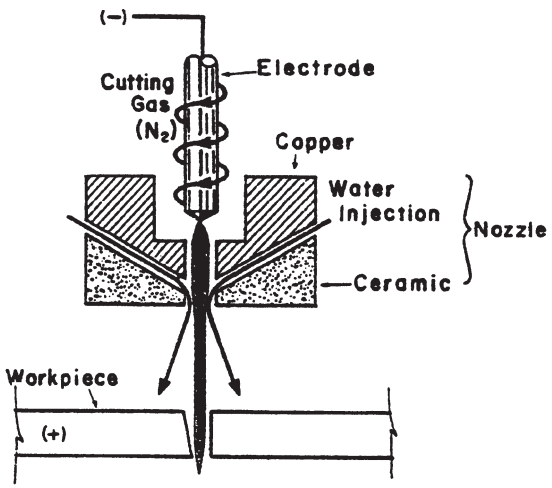
Introduction

This manual describes the installation, operation, and servicing of the Hypertherm PAC500 Water-injection Plasma Cutting System. If any problems arise beyond the scope of this manual, an authorized factory serviceman should be contacted.

Water-injection plasma cutting is a newly developed process for high speed-high quality cutting of virtually all metals from gauge sizes up to 3-in. thick. Unlike conventional plasma cutting which constricts the arc with a water cooled copper nozzle, the Water-injection technique provides arc constriction by radially injecting water uniformly around the arc as shown in the sketch below. The radial impingement of water around the arc provides a higher degree of arc constriction than can be achieved by conventional means. The net result is an extremely hot, high velocity plasma jet capable of producing excellent cut quality at high cutting speeds.

Nozzle life is longer with the Water-injection process because water cools the nozzle at the point of maximum arc constriction. The protection afforded by the water also allows the entire lower portion of the nozzle to be ceramic. Consequently, double arcing from the nozzle touching the workpiece is virtually eliminated.

The PAC500 can also be operated in the conventional mode for cutting plate in the 3-in. to 6-in. thickness range. In this mode of operation, the injection water is used for nozzle cooling only; arc constriction is achieved purely by the nozzle. A gas mixture of 65% argon-35% hydrogen is used instead of nitrogen because it develops a deep penetrating plasma jet ideal for cutting heavy plate.



Water Injection Plasma Cutting

Model 500 Torch

Cutting Thickness Range	.035 in. to 3 in. with nitrogen 3 in. to 6 in. with 65% argon-35% hydrogen
Maximum Current Capacity	750 amperes with nitrogen 1000 amperes with 65% argon-35% hydrogen
Cutting Gas Flow Range	165 to 260 cfh with nitrogen 270 to 300 cfh with 65% argon-35% hydrogen
Cutting Water Flow Range	.50 gpm
Electrode Cooling Water Flow	1.6 gpm
Dimensions	2 in. dia. x 17.5" long
Weight	3.5 lbs. without service lines 15 lbs. with 20 ft. service lines

Control Console

Electrical Input	120 VAC, 50/60 Hz, 5 amperes
Cutting Gas Supply	nitrogen: 260 cfh (max) at 150 psi 65% argon-35% hydrogen: 300 cfh (max) at 150 psi
Water Supply	2.5 gpm at 175 psi (includes both electrode and cut water flow)

Dimensions

Width	13 in.
Height	16 in.
Depth	15 in.
Weight	75 lbs.

Operator's Panel

Dimensions

Width	6.5 in. Add 6 in. in width for each additional torch
Height	14 in.
Depth	6 in.
Weight	12 lbs. (single torch)

Model H401 Power Supply

Refer to H401/H601 power supply instruction manual 800410.

Model H601 Power Supply

Refer to H401/H601 power supply instruction manual 800410.

Argon-Hydrogen Manifold

Electrical Input .....120 VAC, 50/60 Hz

Plasma Gas Supply .....65% Argon-35% Hydrogen:
260 cfh to 300 cfh @ 150 psi

Dimensions
Width.....5 in.
Height.....10 in.
Depth .....5 in.

Water Supply (single torch)

Input Voltage.....230/460 volts, 3 phase

Input Current.....6.0/3.0 amperes

Rated Pump Output .....2.5 gpm at 175 psi

Dimensions
Width.....10 in.
Height.....24 in.
Length.....26 in.
Weight.....90 lbs.

Water Supply (two torch)

Input Voltage.....230/460 volts, 3 phase

Input Current.....9.2/4.6 amperes

Rated Pump Output .....5.0 gpm at 175 psi

Dimensions
Width.....10 in.
Height.....24 in.
Length.....26 in.
Weight.....115 lbs.

Hypertherm

Section 3

INSTALLATION

In this section:

Pre-installation Requirements

The following requirements must be fulfilled before installing the PAC500 Plasma Cutting System.

Water Supply

The PAC500 system needs a clean water supply to cool the torch and constrict and accelerate the arc. The maximum water temperature recommended for the torch is 70° F (21° C). The total flow rate required is approximately 2.5 gallons/min. (9.5 liters/min.) per torch.

Install a disconnect switch near the pump fused at 6 amps for 460V, 3 phase, or 12 amps for 230V, 3 phase.

Water Quality

Water hardness must be less than 0.5 grains (8.5 ppm) to prevent build-up of calcium deposits in the water-injection slot of the torch nozzle. If impurities in the untreated water fall below the specifications in the following table, an ordinary water softener will adequately reduce water hardness to an acceptable level of 0.1 grains.

Hardness	300 ppm
Iron	0.3 ppm
Silica	15.0 ppm
Total Dissolved Solids	350 ppm
PH	6.5 to 8.5

A water softener is **not** adequate if impurities in the untreated water exceed the above levels; a reverse osmosis system or other de-ionizing equipment must be used.

Drain

The water pump system circulates 1.6 gallons/min. (6 liters/min.) to the cathode when the control console is on. An adequate drain must be provided to handle this flow. When the torch is on, water flows at approximately .4 gallons/min**.** (1.5 liters/min.) from the torch to the workpiece. Install a drain in the cutting area to handle this flow.

Gas Supply

The regulated nitrogen source must be 99.995% pure capable of delivering 165 to 260 cfh at 150 psi. The regulated argon-hydrogen (65% argon-35% hydrogen) source must be capable of delivering 300 cfh at 150 psi.

Note: Most regulators used for welding do not have adequate flow capacity. Be certain that the regulators meet both the flow rates and the delivery pressure.

Input Power

Refer to H401/H601 power supply instruction manual 800410.

Leads and Hoses Track

A means of supporting the leads and hoses from the power supply, water pump, and gas supply to the console must be provided. In a typical installation, with an X-Y cutting machine, the leads and hoses are carried on a track down the center or the side of the machine. Several types of these hanging systems are commercially available.

Equipment Supplied and Accessories

Table II (pages 5-10 and 5-11) breaks down what is included in the PAC500 single and two torch systems. A listing of the required and optional accessories is also included. Although standard lead and hose lengths are specified, other lengths are available to suit individual requirements. Refer to **Section 6** *Parts List* for additional information.

Installation Instructions

This section outlines, in sequence, the necessary steps to install the PAC500 Plasma Cutting System. Follow these instructions step by step. Do not skip ahead or do more than one step at a time. When a licensed workman is needed to do a particular job, such as wiring the power supply to the disconnect box, have the job inspected before proceeding.

An electrical and plumbing interconnection diagram for the PAC500 Plasma Cutting System is shown in figure 1 (page 5-12).

Control Console

1. Mount the control console on the cutting machine and secure with clamps or screws.

Power Supply

1. Unpack the power supply and insect for shipping damage.

2. Connect a ground strap from the grounding stub mounted inside the power supply to a high quality earth ground.

3. Connect the leads from the disconnect switch box to the input terminals. Refer to the power supply instruction manual for more details.

4. Connect a 4/0 welding cable from the positive (+) terminal on the power supply to the cutting table. The cable clamp must be tightly secured to a clean, oxide free area on the cutting table. A loose connection can cause operating difficulties. Use two 4/0 cables in parallel if the current exceeds 500 amperes.

5. Connect a 4/0 welding cable from the power supply negative (-) terminal to the 1/2-13X3/4 brass bolt on the cathode block in the plasma console (refer to figure 7, page 5-17). This cable should be passed through the 1-5/8 bushing (feedthru). Two parallel 4/0 cables should be used if the current exceeds 500 amperes.

6. Connect the control cable. Use 16/4 SJ cord (supplied with Power Supply Leads Package, Part No. 028009). This cable connects the power supply and the console through Amphenol receptacle 2 RECP. 2PL-A and 2PL-B provide control power, 120 VAC to the auxiliary relay which in turn actuates the contactor. 2PL-C is the (+) ground connection required for pilot arc starting and operation of the voltage sensing circuit. Refer to the power supply instruction manual for proper wiring instructions.

   Note: Do not connect 2PL-A and 2PL-B directly to the power supply contactor coil. Excessive inrush current can damage 1FLS and 2FLS in the console. An auxiliary control relay is required and provided in Hypertherm power supplies.

   Note: Do not omit the 2PL-C connection as improper grounding of the pilot arc circuit will result causing starting difficulties and possible damage to the control. In Hypertherm power supplies there is a specific terminal for this connection as noted in the power supply instruction manual. In other power supplies the connection should be made directly to the positive (+) terminal if no other appropriate terminal is available.

7. **Parallel Power Supply Connections.** If more than one power supply is to be used in parallel the following steps must be completed.

   1. Connect the positive (+) terminal of each power supply to earth ground.
   2. Connect each power supply to a suitably fused disconnect box.
   3. Connect the power supply outputs in parallel; positive (+) to positive (+) and negative (-) to negative (-).
   4. Connect the auxiliary contactor control relay coils in parallel. This may be done on H400 and H600 power supplies by means of the eight foot contactor paralleling cable, Part No. 023011. H401 and H601 power supplies do not use a stock cable. Connections must be made to terminal strips as specified in the power supply instruction manual.

Water Supply System

1. Connect the pump inlet to a water supply using a length of flexible hose. Use 1/2" I.D. hose.

2. **One Torch System:** connect a suitable length of 3/8" I.D. hose from the outlet of the pump to the control console fitting marked WATER IN PUMP (figure 2, page 5-13).

   Two Torch System: connect a suitable length of 1/2" I.D. hose from the outlet of the pump to the manifold. Two lengths of 3/8" I.D. hose are supplied to connect the manifold with each control console.

3. Connect the WATER OUT fitting to drain using the hose sizes specified in Step 2.

4. Connect a two-wire control cable for the pump to the contactor mounted on the pump motor. The control cable should be wired to the power supply control circuit, 120 VAC, so that the water pump is actuated when the power supply is turned on. Hard conduit or Sealtite is recommended for this interconnection.

5. Connect the contactor to a disconnect switch using suitable watertight flexible conduit. *Check motor rotation.*

Caution:	**Be sure the right voltage taps are used on the motor; the motor is connected for 460V, 3 phase.**

Torch

1. Mount the torch in a torch holder on the cutting machine. Torch must be held by the black insulator sleeve. **DO NOT hold torch by the stainless steel body.** Improper mounting may cause internal arcing and destroy torch body.

2. Feed the torch leads to a suitable support.

3. The water-cooled cables are marked with a red and a green tape.

   The green is water **in** to the electrode.

   The red is water **out** from the electrode.

4. Pass the water-cooled cables through the feedthru, figure 3, page 5-14, (shield adapter) and connect to the cathode block being careful to maintain the proper flow direction as indicated by color code on the cathode block fittings.

5. Attach the red hose to the WATER OUT fitting (figure 3, page 5-14). NOTE: *Left hand thread.*

6. Attach the green hose to the GAS fitting (figure 3, page 5-14).

7. The white pilot arc lead from the torch is passed through the shield adapter and the empty grommeted hole near the cathode block and is connected to point 33 of the air core transformer (figure 6, Tank Coil-right hand stud).

Gas System

Attach a 3/8" dia. gas hose from the cutting gas supply to the GAS fitting on the rear panel of the console (figure 2, page 5-13).

Operator's Panel

Interface connections are made to terminal strip 4TB located inside the operator's panel. Control power (120 VAC) is connected to 4TB-1 and 4TB-2. (L1, L2).

The START/STOP pushbutton station (supplied as an optional accessory item) is connected to the terminal strip 4TB. The START normally open contacts are connected to the 4TB-5 and 4TB-6 and the STOP normally closed contacts are connected to 4TB-6 and 4TB-7.

A provision for automatic start of the torch carriage ("Machine Start") is available through normally open contacts between terminals 4TB-20 and 4TB-21. The normally open contacts will close when the arc transfers to the workpiece. These contacts can be used to automatically start torch motion. (Consoles with serial numbers followed by the letter “H” have normally closed contacts between terminals 4TB-20 and 4TB-21).

The 20 pin Amphenol plug (1PL) is connected to the Receptacle (1 RECP) on the console. The gas and water hoses are connected to fittings provided on the console (see figure 2, page 5-13). These are color coded and care must be taken to connect them correctly. The water hoses are **black** and color coded with tape: a green band is water to the operator's panel; a red band is water from the operator's panel. The corresponding fitting is also color coded. The gas hoses are green and color coded with tape: a green band is gas to the operator's panel; a red band is gas from the operator's panel.

A ground connection is made to the mounting stud on the torch connection side of the console; number 10 wire should be used. Make sure a good clean connection is made. Run the ground cable to a high quality earth ground. If the PAC500 is installed on an N/C cutting machine, the ground leads from the console, cutting machine, power supply and cutting table should be connected to a common, high quality “star” ground. This will help reduce electrical noise.

Argon-Hydrogen Manifold

1. Position the manifold on top of the control console. Make sure the torch hose connection can be easily reached and that the flowmeter is conveniently located.

2. Drill four mounting holes and secure manifold with the four 8-32 x 3/8" screws provided.

3. Install a 1/2-in. cord grip to the rear panel of the control console. If possible, locate the cord grip on the left side of the rear panel. This will simplify solenoid cable routing since connections are made to the terminal strip 3TB located in the plumbing compartment (figure 7, page 5-17). If space is not available, install the cord grip on the right side of the rear panel and route the cable through the grommeted opening at the top of the center partition.

4. The pressure switch, 2PS, is electrically connected in parallel with the existing pressure switch, 1PS, to provide protection from loss of plasma gas. These leads are numbered and are connected to 3TB-10 and 3TB-25. The Argon-Hydrogen solenoid, 3 SOL, is paralleled with the water solenoid, 1 Sol. These leads are also numbered and are connected to 3TB-2 and 3TB-9.

5. Connect the gas supply hose to the fitting located at the rear of the manifold. Connect the green torch gas hose to the fitting located on the front of the manifold.

System Check-Out

1. Turn power supply disconnect switch OFF.

2. Verify proper consumables installed in torch. (Electrode, .032 Swirl Ring, .166 Nozzle)

3. Turn the nitrogen supply on; adjust the pressure to 150 psi.

4. Turn the operator's panel switches to OFF and TEST.

5. Open the water supply valve if a valve is used. Turn the disconnect switch for the water pump ON.

6. Turn the disconnect switch for the power supplies ON.

7. Adjust the power supply to an intermediate setting.

8. Check the pump output pressure; it should read 175 psig. This pressure can be adjusted by removing the large acorn nut cap on the relief valve and by turning the adjustment screw clockwise to increase pressure, counterclockwise to decrease pressure. Also check the water discharge from the torch cooling return line; 1.6 gal./min. is required.

9. Check to be sure the mode switch is in TEST. Push the START button.

10. Adjust the gas flow and water flow: for the .166 nozzle, set the gas flowmeter at 45% and the water flowmeter at 75%.

11. Depress the STOP button.

12. Check the pilot arc operation by positioning the torch over a clear space in the cutting table, a minimum of three inches from ground. Turn mode switch from TEST to RUN. When the START button is depressed, the pilot arc will start after 5 seconds of gas and water flow. It should emit a steady hissing sound and cone of light. The pilot arc will go out automatically after about 2 seconds.

13. Make a test cut with the .166 nozzle on 3/8" to 3/4" (10 to 20mm) thick scrap plate. Adjust the power supply to the required setting for the material being cut. Refer to *Cut Charts* for recommended operating parameters. Do not exceed the current limit of the nozzle in use. Press the start button to initiate the arc. When the arc is established, start the machine motion. Note the reading on the ammeter and adjust the power up or down to obtain the proper current as specified in the *Cut Charts.* Press the STOP button to terminate the cut.

14. The system is now operational.

Hypertherm

Section 4

OPERATION

In this section:

Operating Instructions

The control circuit is turned on by means of the ON/OFF switch on the operator's panel. A WHITE light indicates that the control is ON.

The TEST/RUN switch is turned to TEST. This allows the control circuit to be actuated without starting the arc. With the switch in the TEST position, depress the start button. Gas and water will start to flow immediately. Adjust the gas and water flowmeters to the settings recommended in *Cut Charts,* pages 4-6 through 4-10. The water spray pattern exiting from the nozzle should have a uniform conical shape. If there is a non-uniformity in the pattern, the nozzle should be inspected as discussed in **Section 5** *Routine Maintenance.* The STOP button is depressed to deactivate the gas and water flow.

The TEST/RUN switch is turned to RUN and the system is ready for cutting. The torch height is adjusted as specified in *Cut Charts.* Control sequence is initiated by depressing the START button. There is a five second preflow interval to allow the gas and water flows to be established. During this interval the GREEN light on the operator panel will come on indicating adequate gas and water flows and that the power supply contactor is energized. At the end of this preflow cycle, a high frequency, high voltage discharge establishes an ionized path between the electrode and nozzle. The power supply, because of its high open circuit voltage (400 volts), will conduct through this discharge and rapidly increase the current to form an arc between the electrode and nozzle. This pilot arc, transfers immediately to the workpiece, thereby establishing the cutting arc between the electrode and workpiece. Once the cutting arc is established, torch travel is initiated automatically by the control or manually by the operator. If heavy plate is cut, a torch travel delay will be necessary. One second torch travel delay per inch of plate thickness is a good rule of thumb.

The arc is switched off at the end of the cut by means of the STOP switch or by letting the torch run off the workpiece.

If the PAC500 is operated in the conventional mode rather than the Water-injection mode, a special premixed gas, 65% argon-35% hydrogen, must be used. **DO NOT** connect this gas mixture to the control console because this enclosure is not properly vented for hydrogen bearing gases (Refer to **Section 1** *Safety).* The Argon-Hydrogen Manifold, Part No. 028057, must always be used in conjunction with this gas mixture.

The operating procedure for the conventional mode is exactly the same as outlined above except that the gas flow is set at the Argon-Hydrogen Manifold. The Torch gas hose must be removed from the console fitting and re-connected to the fitting on the Argon-Hydrogen Manifold. The GAS flowmeter on the operator panel is shut off to prevent the flow of nitrogen.

Applications Data

Thickness Range: .035 in. to 3 in.

Water-Injection plasma cutting should be used in this thickness range. Optimum cut quality is obtained by careful control of the major cutting parameters: Nozzle size, Arc current, Cutting speed, Torch-to-work distance (arc voltage), Gas and Water flowrate. These parameters are specified in *Cut Charts.* For applications beyond the scope of this manual, contact your field representative.

Four nozzle sizes are available for Water-Injection cutting. Proper nozzle selection is extremely important to obtaining optimum cut quality. The thickness ranges of these nozzles are tabulated in Table I, page 4-3. Generally, when the operating range of two nozzles overlap, the larger nozzle will produce the best cut quality. This is especially true for mild steel cutting because the larger nozzle produces a wider dross-free speed range.

Table I
Nozzle Thickness Ranges and Limits

Nozzle Size	Nozzle Part No.	Swirl ring Size	Swirl ring Part No.	Thickness Range	Current Limit	Piercing Limit
**********		**********		(inches)	(amperes)	(inches)
.120	020050	.032	020039	.035 – 1/4	260	1/4
.166	020035	.032	020039	1/8 – 1	400	1
.187	020036	.032	020039	1/2 – 2	600	1-1/2
.220	020037	.052	020040	2 – 3	750	2
.250	020047	.062	020048	3 – 5	1000	Not Permitted

Note: The .250 Nozzle is for conventional cutting only. It must be used only with the Argon-Hydrogen Manifold.

Nozzles have current limits and piercing limits that should not be exceeded. The piercing limit is lower than the cutting thickness limit for the larger two nozzles. These limits are listed in the table above. Care should be taken that the proper swirl ring is inserted for the nozzle in use. Use of an incorrect swirl ring will significantly reduce the current handling capacity of a nozzle. Note that the three smallest nozzles (which are most commonly used) all use the same swirl ring.

Swirl rings are not marked with any identifying marks due to their small size. The plastic containers in which they are packaged are marked with the part number and the nozzle(s) with which they are to be used. Swirl rings may be identified if not in the container by knowing the following:

1. There are three sizes of swirl ring.
2. The largest size has EIGHT .062 holes and is used only with the .250 nozzle.
3. The two smaller sizes have FOUR holes.
4. Of the two smaller swirl rings, the one with .032 holes is for the .120, .166 and .187 nozzles. The one with the .052 holes is only used with the .220 nozzle.

Normally, the direction of gas swirl is clockwise. This clockwise swirling action causes the right hand side of the kerf to be square and the left hand side to be bevelled; hence, it is important that the direction of travel be selected so that the bevelled side is on scrap. For example, the outside diameter of a flange is cut with the torch traveling clockwise, while the inside diameter is cut counterclockwise. This results in the flange having a high quality edge on both cut surfaces as shown in figure 4, page 5-15. For applications which require the vertical side to be on the left hand side of the cut, a counterclockwise (.032) swirl ring, Part No. 020042, should be used.

Two nozzle retaining caps are available:

Cadmium plated, Flared Retaining Cap.....Part No. 020043

Brass, Tapered Retaining Cap.....Part No. 020034

The flared retaining cap is designed to provide optimum performance of the Water-Muffler. The flared front end produces a thicker, more stable water curtain thereby improving sound attenuation. This retaining cap also

incorporates a Delrin liner® which extends the life of the cap. This cap should not be used for piercing plate over 1 inch thick, or for cutting plate over 3 inches thick, as the liner can be melted by the metal ejected during piercing, or by the reflected heat of High Current Cutting.

The tapered brass retaining cap is suitable for cutting or piercing thicker materials within the limits of Table I on page 4-3. It must always be used for cutting in the conventional mode (High Current Mode).

The cutting conditions listed in the *Cut Charts* will generally produce excellent cuts without any modifications. Some materials, particularly mild steels tend to vary somewhat in composition and may require slight deviations from the conditions provided in the *Cut Charts.* The variables which will have the most significant effect on cut quality are in decreasing order of effect: Travel Speed, Torch-to Work Distance (arc voltage), and Current. The water and gas flows are optimized and should not be considered variables. Changing these flows from the recommended settings will adversely affect consumable life and likely will reduce cut quality.

Thickness Range: 3 in. to 6 in.

The PAC500 is operated in the conventional mode in this thickness range. The water spray from the .250 nozzle is used for cooling purposes only and does not constrict the arc. A mixture of 65% Argon-35% Hydrogen is used instead of nitrogen because it produces a deeper penetrating arc. This mixture is available in commercial high pressure cylinders. Some gas distributors may not routinely stock this mixture but since it is readily available they will usually stock it if requested to do so. It is possible to mix the gases on site with a gas proportioning device but this is not recommended due to the capital investment required and the maintenance needed to assure the proper mix.

Converting the PAC500 to the conventional mode requires the following steps:

1. Install .250 Nozzle–Part No. 020047 and .062 Swirl ring–Part No. 020048 in torch.
2. Install Tapered, Brass Retaining Cap Part No. 020034 on torch.
3. Remove Water-Muffler from torch.
4. Lower water level in Water-Table to four inches below workpiece. Shut off nitrogen flowmeter on operator panel. Disconnect Torch gas hose at console and reconnect to Argon-Hydrogen Manifold. Adjust cutting conditions as listed in Cut Chart – **Operating Data for High Current Cutting**, and in this section.
5. Shut off nitrogen flowmeter on operator panel.
6. Disconnect Torch gas hose at console and reconnect to Argon-Hydrogen Manifold.
7. Adjust cutting conditions as listed in Cut Chart – **Operating Data for High Current Cutting**, and in this section.

Operation in the conventional mode is identical to operation in the Water-Injection mode except that the gas flow is adjusted on the Argon-Hydrogen Manifold.

WARNING

Do not attempt to use Argon/Hydrogen mixtures through the console as it is not vented for flammable gases and could result in an explosion if a leak were to develop within the console.

General Comments:

Set the Torch-to-Work distance (arc voltage if equipped with automatic height control) according to the *Cut Charts.* Increase the distance (voltage) above the recommended setting if undercutting occurs.

Do not attempt to pierce heavy plate. (Refer to Table I, page 4-3, for limitations) Molten metal ejected during the piercing cycle may cause extensive damage to torch components.

The torch mounting assembly must hold the torch by the black insulator sleeve. Under no circumstances should the torch body be held by the stainless steel body. Improper mounting may cause severe arcing and destroy the torch. It may also cause rapid nozzle wear without any obvious arcing.

Do not operate the Water-Muffler when cutting in the conventional mode. Remove the Water-Muffler from the torch body to prevent damage from reflected heat from the arc. *Lower the water level* in the Water-Table to four or more inches below the bottom surface of the workpiece. These steps prevent the water from quenching the penetrating ability of the arc.

Be sure that the cutting area is well ventilated and that persons working in the immediate area have proper ear protection. (Refer to **Section 1** *Safety.*)

When cutting material over 2 inches in thickness, in the Water-Injection mode, it is sometimes beneficial to shut off the water muffler and lower the water level an inch or two to improve arc penetration.

Cut Charts

Operating Data for Mild Steel

Material Thickness Inches	mm	Nozzle and Swirl ring Size inches	Gas Type and Flowmeter Setting %		Injection Water Flow Setting %	Torch to Work Distance Inches	mm	Arc Voltage Setting Volts	Arc Current Setting Amperes	Travel Speed ipm	mm/min
.035	1					1/8	3	125	250	450	11430
.075	2	.120	N_2	30	85	1/8	3	130	250	300	7620
1/8	3					3/16	5	135	260	200	5080
1/4	6	Maximum current for this nozzle is 260 amp.				1/4	6	145	260	150	3810
1/8	3					1/4	6	140	300	200	5080
1/4	6	.166	N_2	45	75	1/4	6	145	350	150	3810
3/8	10					1/4	6	150	380	125	3175
1/2	13	Maximum current for this nozzle is 400 amp.				1/4	6	155	400	100	2540
1/2	13					3/8	10	160	500	115	2920
3/4	19	.187	N_2	45	75	3/8	10	165	500	75	1905
1	25					3/8	10	165	600	60	1525
1-1/4	32	Maximum current for this nozzle is 600 amp.				3/8	10	175	600	45	1145
1-1/4	32					1/2	13	185	700	50	1270
1-1/2	38	.220	N_2	70	100	1/2	13	195	700	40	1005
1-3/4	44					1/2	13	200	725	35	890
2	50	Maximum current for this nozzle is 750 amp.				1/2	13	205	725	30	760

Use the brass tapered retaining cap part no. 020034 above 400 amperes.

To obtain optimum cut quality, plasma arc cutting nozzles are usually operated at an arc current slightly below the level that results in double-arcing. Attempting to operate nozzles above the maximum limit will cause a deterioration in performance.

The conditions listed above are chosen for optimum cut quality (not speed) and will generally produce excellent results. If deviations from these conditions are necessary, they should be limited to changes in arc current, arc voltage, and travel speed. These parameters have a significant effect on cut quality. Do not deviate from specified gas and water flows.

Operating Data for Stainless Steel

Material Thickness Inches	mm	Nozzle and Swirl ring Size inches	Gas Type and Flowmeter Setting %		Injection Water Flow Setting %	Torch to Work Distance Inches	mm	Arc Voltage Setting Volts	Arc Current Setting Amperes	Travel Speed ipm	mm/min
.035	1					1/8	3	125	250	450	11430
.075	2	.120	N_2	30	85	1/8	3	130	250	300	7620
1/8	3					3/16	5	135	260	200	5080
1/4	6	Maximum current for this nozzle is 260 amp.				1/4	6	145	260	150	3810
1/8	3					1/4	6	140	300	200	5080
1/4	6	.166	N_2	45	75	1/4	6	145	350	150	3810
3/8	10					1/4	6	150	380	125	3175
1/2	13	Maximum current for this nozzle is 400 amp.				1/4	6	155	400	100	2540
3/4	19					5/16	8	160	400	50	1270
1	25					3/8	10	165	400	30	760
3/4	19					3/8	10	165	500	75	1905
2	25	.187	N_2	45	75	3/8	10	165	550	60	1525
1-1/2	38					3/8	10	170	580	30	760
2	50	Maximum current for this nozzle is 600 amp.				3/8	10	170	600	20	510
2	50					1/2	13	190	700	25	635
3	75	.220	N_2	70	100	5/8	16	200	750	12	305
		Maximum current for this nozzle is 750 amp.									

Use the brass tapered retaining cap part no. 020034 above 400 amperes.

When cutting materials greater than 1-1/2 inches (40mm) thick, lower the level of water in the water table to 3 inches (75 mm) below the lower surface of the workpiece. Also de-energize the Water Muffler pump to improve arc penetration.

For cutting thicker plate refer to the chart *Operating Data for High Current Cutting* on page 4-10.

Operating Data for Aluminum

Material Thickness Inches	mm	Nozzle and Swirl ring Size inches	Gas Type and Flowmeter Setting %		Injection Water Flow Setting %	Torch to Work Distance Inches	mm	Arc Voltage Setting Volts	Arc Current Setting Amperes	Travel Speed ipm	mm/min
.035	1					1/8	3	125	250	540	13715
.075	2	.120	N_2	30	85	1/8	3	130	250	360	9145
1/8	3					3/16	5	135	260	240	6095
1/4	6	Maximum current for this nozzle is 260 amp.				1/4	6	145	260	180	4570
1/8	3					1/4	6	140	300	240	6095
1/4	6					1/4	6	145	325	180	4570
3/8	10	.166	N_2	45	75	1/4	6	150	350	150	3810
1/2	13					1/4	6	155	375	120	3050
3/4	19	Maximum current for this nozzle is 400 amp.				5/16	8	160	400	60	1525
1	25					3/8	10	165	400	35	915
1	25					3/8	10	165	550	70	1830
1-1/2	38	.187	N_2	45	75	3/8	10	170	550	35	915
2	50	Maximum current for this nozzle is 600 amp.				3/8	10	170	600	25	610
2	50	.220	N_2	70	100	1/2	13	190	700	30	760
3	75	Maximum current for this nozzle is 750 amp.				5/8	16	200	750	15	355

Use the brass tapered retaining cap part no. 020034 above 400 amperes.

For cutting thicker plate refer to the chart *Operating Data for High Current Cutting* on page 4-10.

Sample Operating Data for Other Materials

Material Type	Material Thickness Inches	Material Thickness mm	Nozzle and Swirl ring Size inches	Gas Type and Flowmeter Setting %	Injection Water Flow Setting %	Torch to Work Distance Inches	Torch to Work Distance mm	Arc Voltage Setting Volts	Arc Current Setting Amperes	Travel Speed ipm	Travel Speed mm/min
Titanium	1/2	13								90	2285
Brass	1/2	13	.166	N_2 45	75	1/4	6	155	400	70	1780
Copper	1/2	13								60	1525
Cast Iron	5/8	16								80	2030
Titanium	1	25								50	1270
Copper/ Nickel-20%	1	25	.187	N_2 45	75	3/8	10	165	550	45	1145

Operating Data for High Current Cutting

Material Thickness Inches	mm	Nozzle and Swirl ring Size inches	Gas Type and Flowmeter Setting %		Injection Water Flow Setting %	Torch to Work Distance Inches	mm	Arc Voltage Setting Volts	Arc Current Setting Amperes	Travel Speed ipm	mm/min
					Stainless Steel						
3	75	.250	Premixed 65% Argon 35% Hydrogen	70	100	1	25	215	900	15	380
4	100	.250		70	100	1	25	225	1000	10	255
5	130	.250		80	100	1	25	235	1000	6	150
					Aluminum						
3	75	.250	Premixed 65% Argon 35% Hydrogen	70	100	1	25	210	900	18	460
4	100	.250		70	100	1	25	210	900	12	305
5	130	.250		70	100	1	25	210	1000	8	200
6	150	.250		70	100	1	25	210	1000	7	180

Use the brass tapered nozzle retaining cap – part no. 020034

High Current Cutting is conventional cutting. It does not use the Water-Injection principle. The water sprayed from the nozzle is for nozzle cooling purposes only. It does not constrict the arc.

Always remove the Water-Muffler and lower the water level in the Water-Table when operating in the High Current Mode.

Caution: Use of the Inductive IHS at high currents may damage the Inductive probes due to the high amount of reflected heat and ejected metal during the pierce process.

Warning: The plasma console is not vented for combustible gases. The optional ARGON/HYDROGEN MANIFOLD part number 028057 is required when using Argon/Hydrogen gas mixtures.

Caution: Never operate Water-Injection nozzles with Argon/Hydrogen gas mixtures.

Hypertherm

Section 5

MAINTENANCE

In this section:

Routine Maintenance

Protecting Copper Surfaces

To protect copper surfaces in the injection water/torch coolant open loop, do the following twice a year:

1. Mix a 16 ounce container of corrosion inhibitor benzotriazole (128020) in the water chiller's 45 gallon water reservoir.

2. Turn on the water chiller and run the pump for 2 hours. Do not start the power supply or attempt to cut with the torch while recirculating the solution.

3. Turn water chiller off and leave power supply off for 8 hours.

4. Resume normal operating procedures.


WARNING

Always disconnect the power supply from the main power source before inspecting or changing the torch parts.

Normal wear and tear on the nozzle, electrode and swirl ring limit the life of these parts, making replacement necessary. Replace the nozzle when the water spray cone becomes irregular and cleaning of its water flow passages does not correct the problem.

Nozzle

1. Place the 3Ø power ON/OFF switch on the cutting machine operator's panel to OFF.

2. Unscrew the retaining cap and remove the nozzle by hand.

3. Before replacing the nozzle, apply a *light* coat of silicone grease to the O-ring that is on the O.D. of the copper portion of the nozzle.

4. Insert the nozzle into the torch and push into place.

5. When replacing the retaining cap, tighten snugly by hand to insure good electrical contact between the nozzle and the torch. If the cap does not go on easily, clean threads and apply a small amount of silicone grease to the O-ring located just below the threads of the torch body.

Note: Failure to tighten the retaining cap snugly will result in pitting of the stainless steel nozzle seat (current ring) of the torch and subsequent gas and water leaks around the upper nozzle O-ring which will impair cut quality. However, **tighten the retaining cap by hand only**. Pitting will never occur if proper care is taken as outlined above. See *Torch* on next page.

Electrode

1. Remove the nozzle as outlined above.

2. Unscrew the electrode with the wrench supplied in the Spare Parts Kit. If the water tube in the torch appears loose or damaged, see *Water Tube* replacement.

3. Replace the electrode if crater in the center of the electrode insert exceeds .040 inch (1 mm).

4. Screw the electrode into the torch with the wrench. **Do not over tighten!**

Swirl Ring

1. Remove the nozzle and electrode as outlined previously.

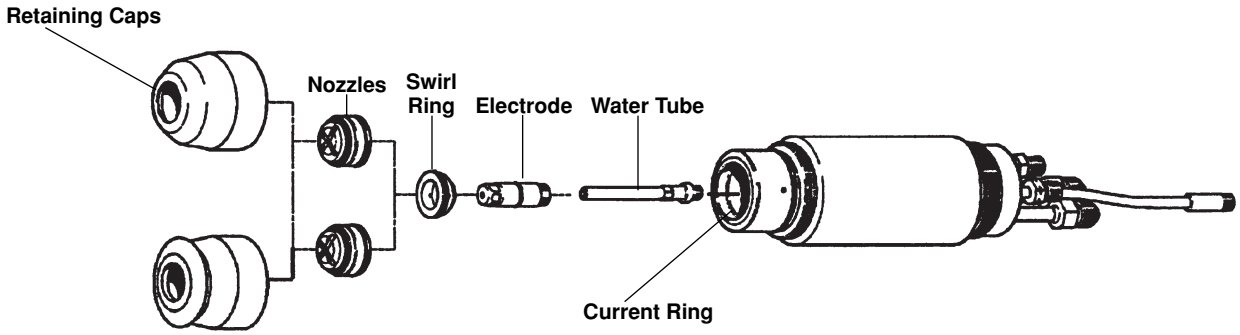
2. Remove the swirl ring from the electrode and inspect for plugged holes or other damage.

3. Before replacing the swirl ring, apply a *light* coat of silicone grease to both O-rings. Do not apply an excessive amount of grease because the grease can plug the swirl ring ports. As a general rule of thumb, you should be able to feel the grease but not see it.

4. Insert the swirl ring placing the smaller diameter end up toward the rear of the torch as in figure on page 5-4.

Torch

When changing or inspecting any consumable parts, clean the current ring of the torch with a clean paper towel or Q-tip to remove any dirt, grease, etc.



Water Tube

If the water tube is improperly installed, loose or bent, you may experience some difficulties such as: short electrode life, flow switch interlock shutting down the system, or humming or rattling sound coming from the torch. If you suspect a problem with the water tube, you may need to replace it.

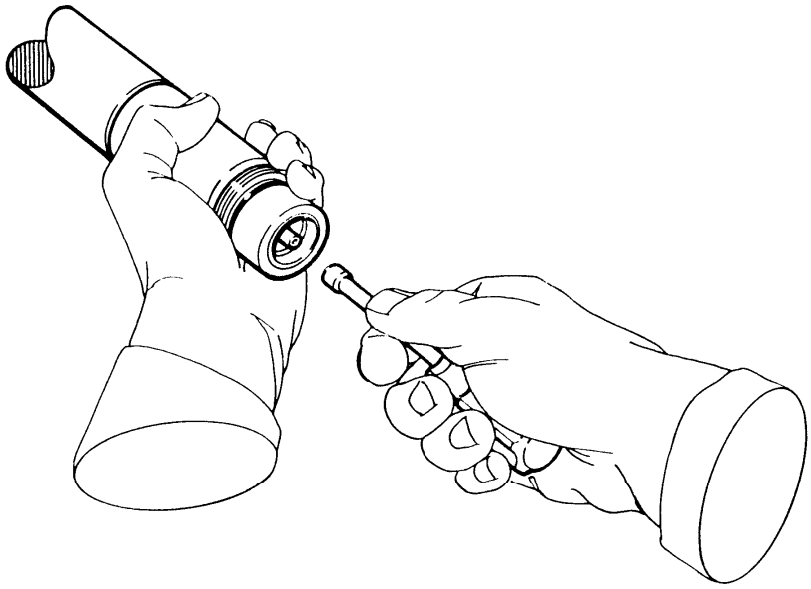
1. Remove all consumables from torch (see above).

2. Look for any damage or bends in the water tube. The water tube should be recessed from the face of the torch head by about 11/32" (8.5 mm). Check for tightness.

3. Remove and replace the water tube (120035) by using the water tube wrench (027347) supplied by Hypertherm. **When installing water tube, do not overtighten!** Snug down by hand only.

WARNING

Always disconnect the power supply from the main power source before inspecting or changing the torch parts.



Changing the Water Tube


WARNING

Before making this check, shut off the disconnect switches to both the control panel and power supply.

Spark Gap

The spark gap assembly located in the high frequency generator (figure 6, page 5-16), should be inspected every three months. The electrode spacing should be set at .020 in. If adjustment is necessary, loosen the 5/16 in. lock nut and 1/8 in. Allen set screw; push the electrode against the feeler gauge and tighten the set screw and lock nut. Repeat this procedure for the other electrode. The .020 in. setting delivers the maximum energy possible from the tank circuit. Do not use other settings.

Control Circuit Description

The control schematic for a single torch system is shown in figure 9, page 5-19. The location of the relays denoted in the control schematic, are shown in Figures 6 and 8. The locations of plumbing components such as solenoid valves, gas and water flow interlocks, and the water cooled pilot arc resistor are shown in Figure 7. The terminal strips are designated as follows: 1TB located on relay panel (figure 8), 2TB located on high frequency panel (figure 6), 3TB located in plumbing compartment (Figure 7), 4TB located in operator's panel.

When the ON/OFF switch (1SS) is turned ON the POWER ON light (WHITE) glows. The GREEN light indicating that the power supply contactor is energized will come on after the start command is given (manually with start button or automatically) if adequate gas and water flow is available.

Test Mode

The TEST mode allows the control to be cycled without the DC power coming on. When placed in the TEST position, the TEST/RUN switch, line 5, deactivates the TEST/RUN relay (1CR), line 5, so that NO contacts of 1CR opens both the circuit which controls the power supply contactor (CON), line 13, and the circuit which initiates machine start, line 26. The High Frequency Generator does not operate in the TEST mode because the contacts of 3CR line 28 are open. If testing of the high frequency circuit is required, a jumper wire may be placed across the 3CR contacts at 1TB-18 and 1TB-19. This will cause the high frequency circuit to operate in the TEST mode. Do not operate the High Frequency Generator without all of the consumables inserted in the torch as irrepairable torch damage will occur.

Arc Detection. The control sequence is much easier to follow if the operation of the arc detection circuit is understood. This circuit is simply a D.C. relay in series with two zener diodes connected across the power supply output (but physically located in the console). An R.F. Choke is used to protect the diodes from stray high frequency currents. The zener diodes drop the voltage down to an appropriate value for proper operation of the relay coil. When the power supply is energized the 400 volt output is more than sufficient to pull in the relay 3CR. When a main arc is established the power supply voltage drops to somewhere in the range of 125 to 220 volts which is insufficient for holding the relay in so it drops out. The relay therefore operates in reverse logic manner which may be confusing to those unfamiliar with the circuit. The *normally closed* contacts of the relay *are open when the arc is*

off (if the power supply is energized). These same normally closed contacts will be closed during actual cutting. The normally open contacts also operate in reverse of what a casual observer might expect.

When the START button is actuated, CRM is latched through the NC contacts on both the STOP pushbutton and the voltage sensing relay (3CR), lines 8 and 12. The control relay (CRM) initiates the water (1SOL) and gas (2SOL) flows, lines 15 and 16, and engerizes the gas preflow timer (1TR), line 18. After 5 seconds the NO contacts of 1TR close energizing both 2TR and the high frequency circuit, lines 22 and 28. Time delay relay 2TR times in after 1.7 seconds and opens NC contacts ending the high frequency starting cycle, line 28.

Note that water (1SOL) and gas (2SOL) are not automatically shut off at the end of the cycle in the TEST mode because the NC contacts of the voltage sensing relay (3CR) remain closed. The STOP button must be actuated to terminate gas and water flow.

Run Mode

After the proper gas and water flows have been set, the TEST/RUN switch is placed in the RUN Mode. The NO contacts, line 5, of the TEST/RUN switch close, energizing 1CR. This closes the 1CR NO contacts in the power supply contactor control circuit, line 13, and in the machine start circuit, line 26. When the START button is actuated, CRM is latched and CON is energized through 1CR, 1FLS, 2FLS flowswitch and 1PS pressure switch. A water flow of at least .25 gpm to the nozzle is required to close 2FLS; 1FLS requires a minimum of 1.5 gpm. Gas flow must be sufficient to create a backpressure greater than 30 psi to close 1PS.

The voltage sensing relay 3CR is energized by the open circuit voltage of the power supply (400 volts) which in turn energizes the pilot arc relay (4CR), line 19, thereby providing continuity between the nozzle and ground through the 3 ohm water cooled resistor, R2, line 32. Control relay CRM is held in by NC contacts on 2TR during the start cycle. Time delay relay 1TR closes NO contacts, line 22, after 5 seconds to energize 2TR, line 22, and the high frequency starting circuit, line 28. The high frequency initiates the pilot arc between the electrode and nozzle, line 33. the pilot arc current is limited by the water cooled pilot arc resistor (R2), line 32. The pilot arc immediately transfers to the workpiece, dropping the voltage to a value between 125 volts and 220 volts, thereby de-energizing 3CR. This closes 3CR NC contacts, line 12, holding in CRM and energizes the machine start relay (2CR), line 26. The high frequency starting cycle is ended by 3CR contacts, line 28, returning to the NO state. The pilot arc relay (4CR) is also de-energized by 3CR returning to the NO state, line 19.

At the conclusion of the cut, the STOP pushbutton is actuated which opens CRM and drops out the control circuit. If the torch is run off the workpiece, the main arc will go out and the voltage sensing relay will be energized by the open circuit voltage dropping out both CRM, line 11, and the machine start relay (2CR), line 26. If no main arc is established, 3CR will remain energized and CRM will drop out after 2TR times in, line 11, automatically ending the cycle.

Two Torch Operation

Two torch Operator's Panel is described in Figure 10. This circuit interfaces with two separate consoles. Independent control of each console is provided by a separate ON/OFF switch (1SS and 3SS). The mode of operation is controlled by a single TEST/RUN relay (1CR). For example, to operate both consoles on TEST, 2SS is placed in the TEST mode and both 1SS and 3SS are placed in the ON position. The TEST mode can be restricted to console #2 by switching 1SS to OFF.

The control relay (5CR) mounted in the Operator's Panel is energized on 1TR, line 22, figure 9. When both consoles are ON, the first preflow delay relay (1TR) to time in will energize 5CR, which actuates both high frequency starting circuits simultaneously. Three and four torch systems are a simple iteration of this circuit.

Equipment Trouble Shooting

If the equipment fails to operate correctly, several steps may be taken to try to locate the fault. If these are unsuccessful, an authorized factory serviceman should be contacted.

A. No power ON Light (WHITE) at Operator's Panel

1. No input power to control
2. Defective Switch (1SS, 3SS)

B. No Contactor Light (GREEN)

1. Water supply pump is not on.
2. Water supply solenoid not opening.
3. Water flowmeter valve closed.
4. Gas supply not on or pressure too low. (150 psig req'd.)
5. Console door interlock switches open.
6. Low water pressure
   a. Replace filter at water supply.
   b. Adjust water supply bypass valve to obtain 175 psig. (Refer to page 3-6 *System Check-Out* item no. 8)

C. Contacter Light (GREEN) ON, but arc does not strike.

1. No high frequency at torch.

   High Frequency Check

   a. Turn power supply disconnect switches OFF.
   b. Turn control power OFF.
   c. Place a jumper between terminals 1TB-18 and 1TB-19.
   d. Place TEST/RUN Switch in TEST.
   e. Turn control power ON.
   f. Turn water flowmeter OFF.
   g. Depress start button.
   h. Set gas flowmeter at 70%.
   i. Verify gas pressure input to console is 150 psig.

j. Depress the STOP button, then the START button to restart the test cycle.

k. After five seconds of preflow, a steady spark discharge should be observed inside the nozzle bore. **Do not touch the torch.** This discharge has a 1.7 second duration. It is terminated by 2TR. To observe the discharge again it is necessary to depress the STOP button and then the START button.

If there is no discharge or it is erratic, check the leads from the torch to the console for tightness. Check the spark gap setting for correct electrode spacing (.020 in.).

2. Power supply contactor not activating.

a. With the TEST/RUN Switch in RUN, the power supply should come on with the GREEN light. Contactor closure may be verified by reference to the Voltmeter on the power supply which should indicate open circuit voltage upon contactor closure.

3. Blown fuse(s) in the power supply disconnect box.

4. Burned out water cooled resistor, R2 (figure 7, page 5-17).

a. Resistance measured between terminals 31 and 32 should be approximately 3 ohms.

D. Pilot arc strikes, but will not transfer

1. Excessive torch-to-work distance (see **Section 4** *Applications Data).*

2. Poor ground connection to workpiece.

a. This problem may be caused by a buildup of heavily oxidized metal on the slats of the cutting table. Connect the ground lead directly to the workpiece. If this cures the problem, clean or replace the support slats.

3. Heavy layer of scale or primer on the workpiece.

E. Torch dives into workpiece during cutting, or torch height drifts.

1. **Defective Voltage Divider.** The Voltage Divider reduces the arc voltage by a ratio of 25:1. It may be checked by energizing the Plasma Power Supply and measuring the Divider output. At the power supply open circuit voltage of 400VDC, the Divider output should be approximately 16VDC. To take the Divider output measurement, perform the following:

a. Disable High Voltage Transformer (HVT) by disconnecting its primary wires. See figure 6 for location of HVT.

b. Place a voltmeter across the Signal and Ground terminals of the Voltage Divider.

c. Place the CONTROL switch to MAN position,the ARC switch to AUTO position, and the Plasma TEST/RUN switch to the RUN position.

d. Depress the START switch and note the Voltage Divider output.

e. Press the STOP switch to de-energize the main contactor after you have taken the Divider measurement.

Process Trouble-Shooting

The two major quality problems encountered in plasma cutting are excessive cut angle and dross. This section describes these conditions and recommends corrective action.

The cut angle should generally be square to within 2°. A small amount of rounding of the top edge is normal. The cut angle is said to be positive if the cut slants away from the high quality side, and negative if the cut slants in toward the high quality side (figure 5). Both of these conditions can be corrected by properly adjusting torch-to-work distance, cutting speed and arc current.

Dross is resolidified metal that adheres to the bottom edge of a cut. The tendency to form dross depends on metallurgical composition, plate surface condition, cutting speed, arc current and torch-to-work distance. Under normal conditions dross should be virtually nonexistent, or if it is present, easily removed.

Positive Cut Angle

1. Wrong direction of travel.

   High quality side is on the right with respect to the forward motion of the torch, except where CCW Swirl Ring, Part No. 020042 is used.
2. Excessive torch-to-work distance.
3. Excessive cutting speed.
4. Arc current set too low.
5. Damaged nozzle.

Negative Cut Angle

1. Torch-to-work distance is too low.
2. Cutting speed is too slow.
3. Excessive arc current.

Excessive Dross

1. Cutting speed is too slow.

   Increase cutting speed up to the point where the arc becomes unstable and excessive lag lines are evident. Reduce the speed just enough to obtain a stable condition. If dross still persists, follow the suggestion outlined in Step 3.
2. Arc current set too low.

   Increase arc current up to the maximum current rating of the nozzle and increase speed as outlined above.
3. Nozzle size too small.

   If steps 1 and 2 do not eliminate the dross, go to the next nozzle size and set the current 100 amperes below the maximum current rating of the nozzle; adjust the cutting speed accordingly.

Table II
Equipment Supplied and Accessories

PAC500 Single Torch System

Description	Part No.	Quantity
Items Included		
Model 500 Torch	028031	1
Torch Leads Pkg.	*	1 Set
Console	028121	1
Operator's Panel	028122	1
Operator's Panel Leads	*	1 Set
Amphenol Plug, 4 conductor	008005	1
Required Accessories		
Torch Mounting Assembly (5/8 shaft)	020046	1
Model H401 Power Supply	036035 (replaces 036010)	Specify
Model H601 Power Supply	036031 (replaces 036015)	Specify
Power Supply Leads Pkg.	028009	Specify
Water Supply System	028291	1
Cooling Water Leads Pkg. (1 torch)	028010	1
Spare Parts Kit	028041	1
Optional Accessories		
Remote Start/Stop Station	028005	1
Argon-Hydrogen Manifold	028057	1
Water Muffler System	034001	1
AVM-1 Arc Voltage Monitor	051001	1
THC-1 Torch Height Control	050001	1
THC-1/RVC Remote Voltage & Current Control	050006	1
THC-2 Torch Height Control	052001	1
Digital Current Control	054005	1

* Specify length and part number. See **Section 6** *Parts List* for a complete listing of torch leads and operator panel leads.

Table II (continued)
Equipment Supplied and Accessories

PAC500 Two Torch System

Description	Part No.	Quantity
Items Included		
Model 500 Torch	028031	2
Torch Leads Pkg.	*	2 Sets
Console	028121	2
Operator's Panel	028134	1
Operator's Panel Leads	*	2 Sets
Amphenol Plug, 4 conductor	008005	2
Required Accessories		
Torch Mounting Assembly (5/8 shaft)	020046	2
Model H401 Power Supply	036035 (replaces 036010)	Specify
Model H601 Power Supply	036031 (replaces 036015)	Specify
Power Supply Leads Pkg.	028009	Specify
Water Supply System	028320	1
Cooling Water Leads Pkg. (2 torch)	028013	2
Spare Parts Kit	028041	2
Optional Accessories		
Argon-Hydrogen Manifold	028057	2
Water Muffler System	034001	2
AVM-1 Arc Voltage Monitor	051001	2
THC-1 Torch Height Control	050001	2
THC-1/RVC Remote Voltage & Current Control	050006	2
THC-2 Torch Height Control	052001	2
Digital Current Control	054005	2

* Specify length and part number. See **Section 6** *Parts List* for a complete listing of torch leads and operator panel leads.

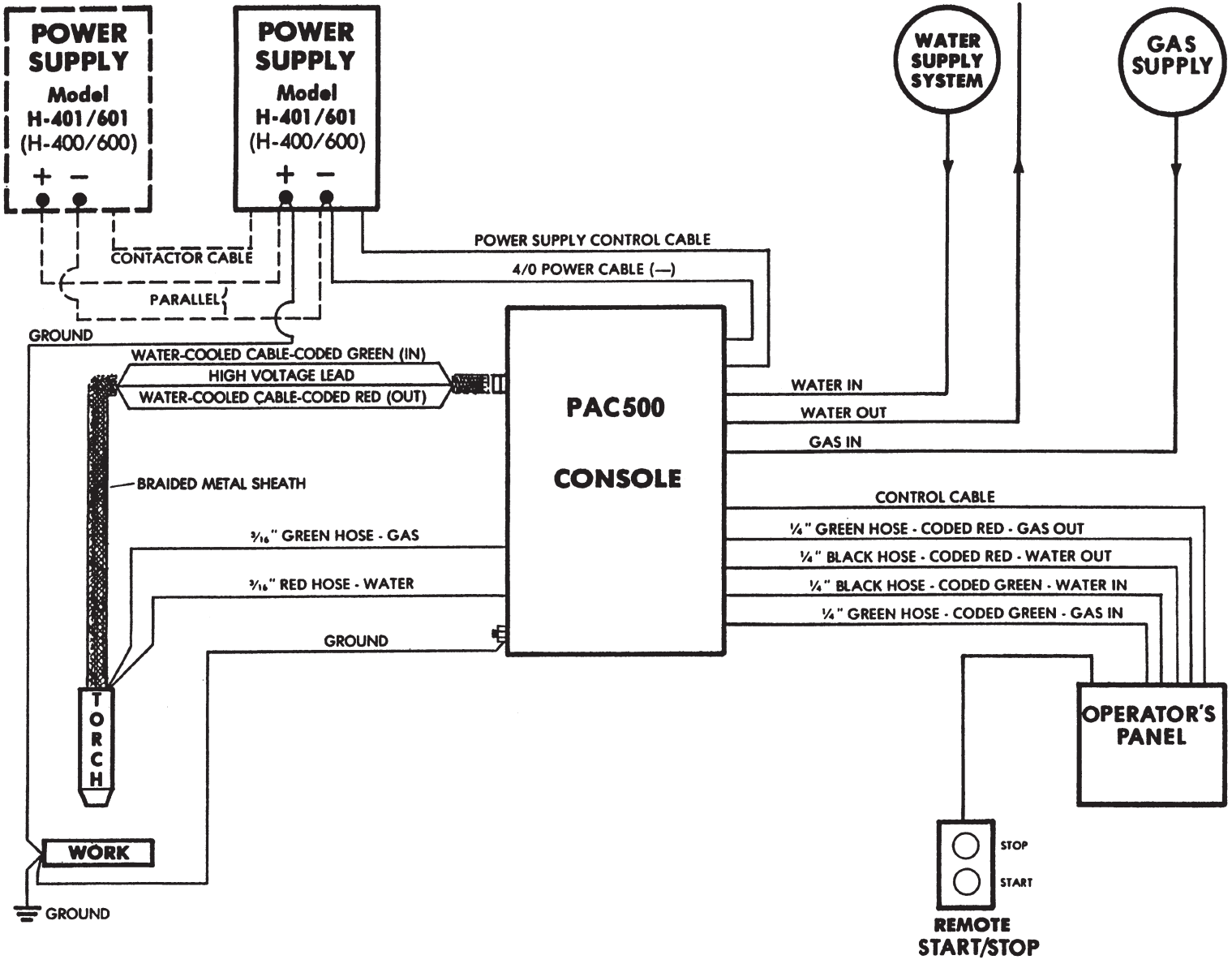


Figure 1 PAC500 Schematic Layout

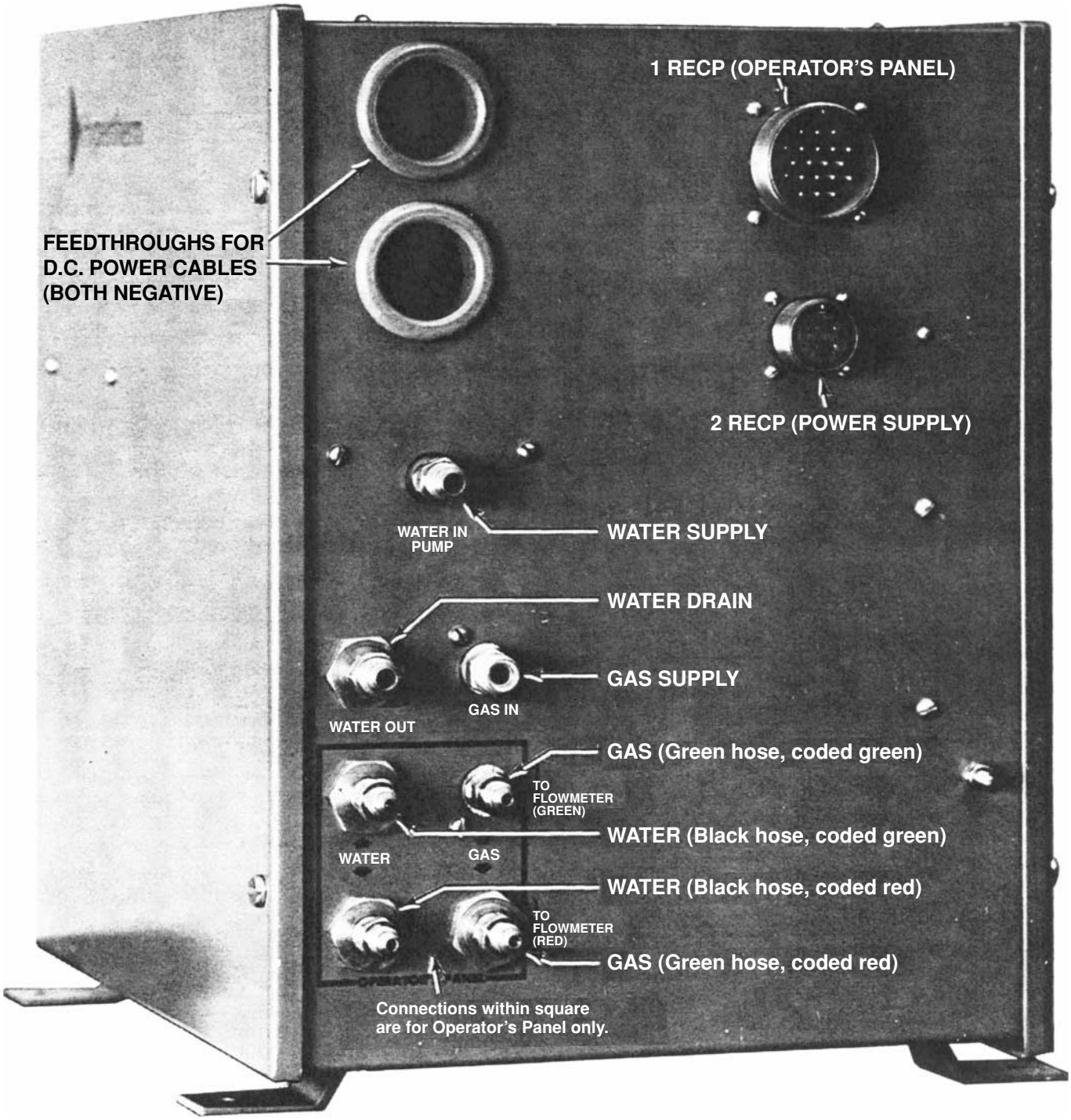


Figure 2 Service Connections

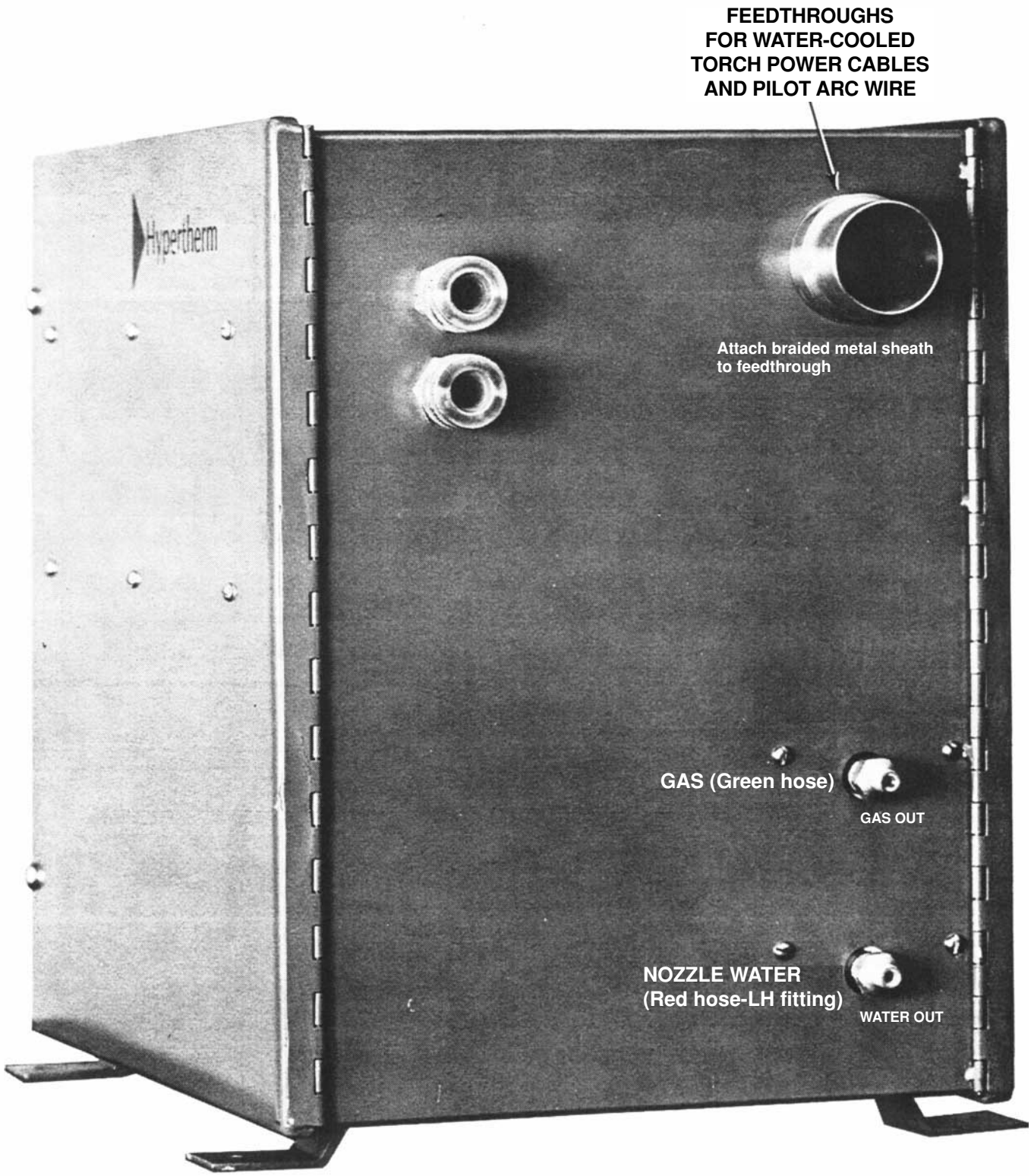


Figure 3 Torch Connections

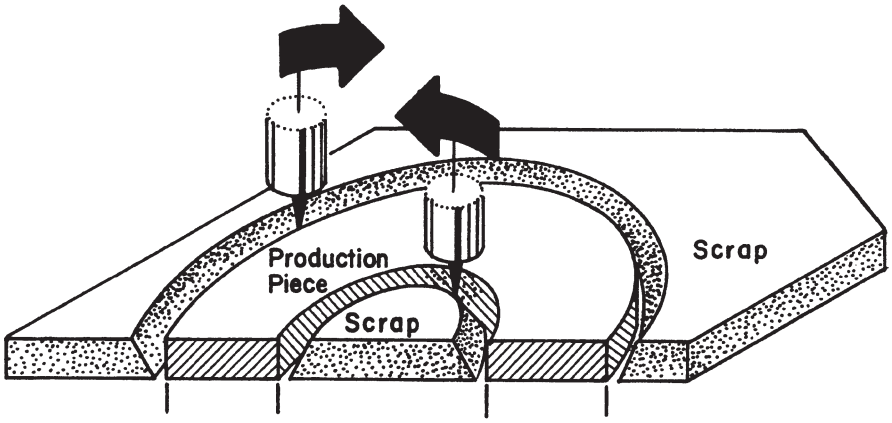


Figure 4 Direction of Cut

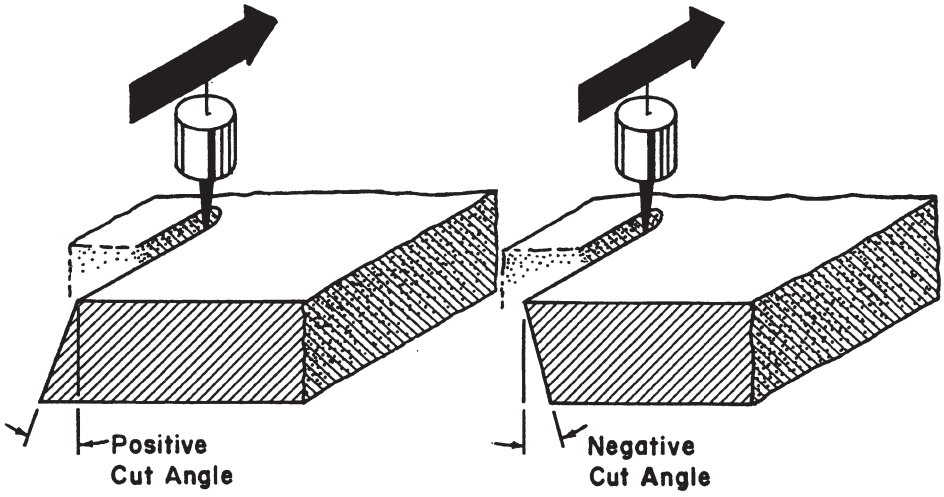


Figure 5 Cut Angle

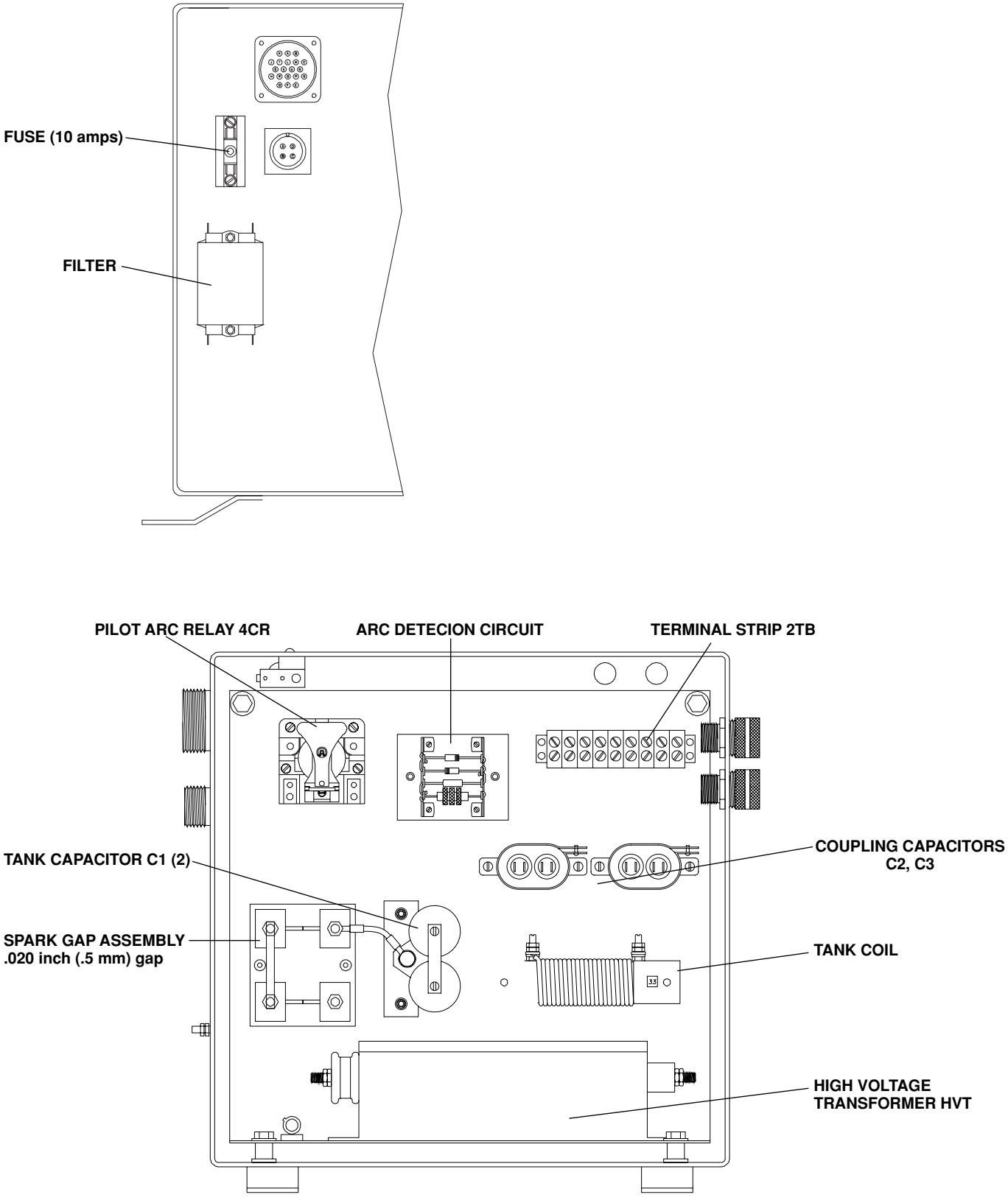


Figure 6 High Frequency Generator

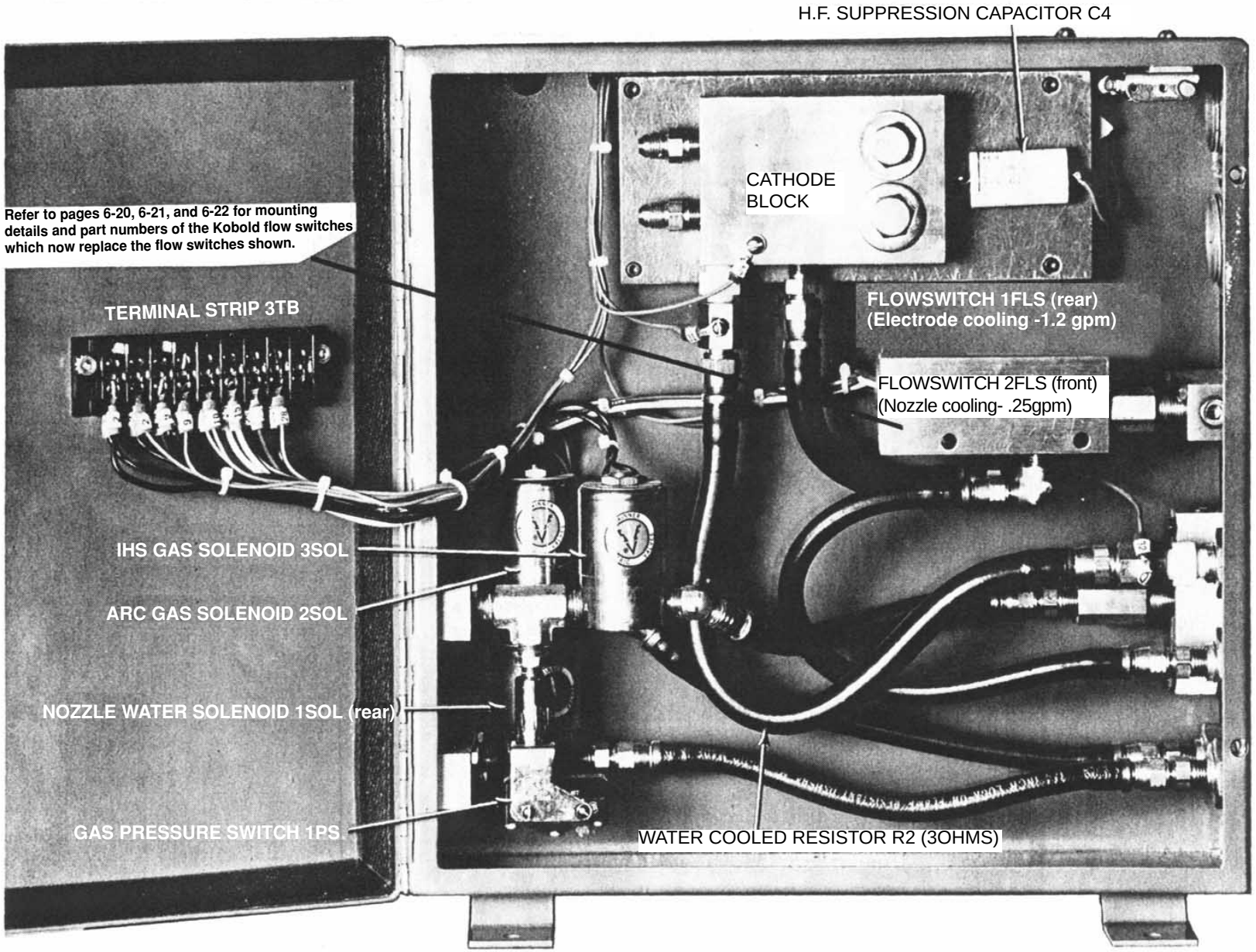


Figure 7 Plumbing Compartment

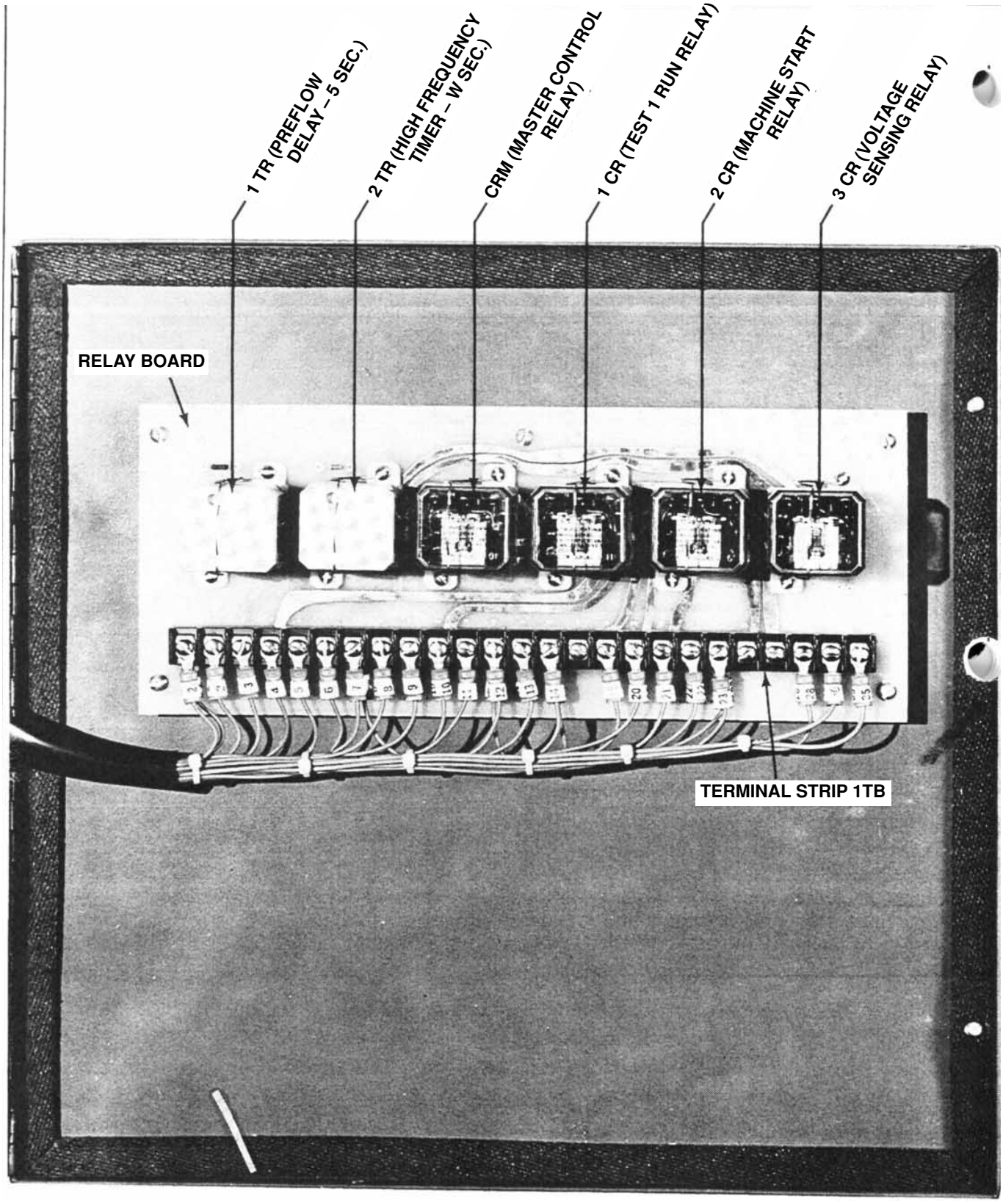


Figure 8 Relay Panel

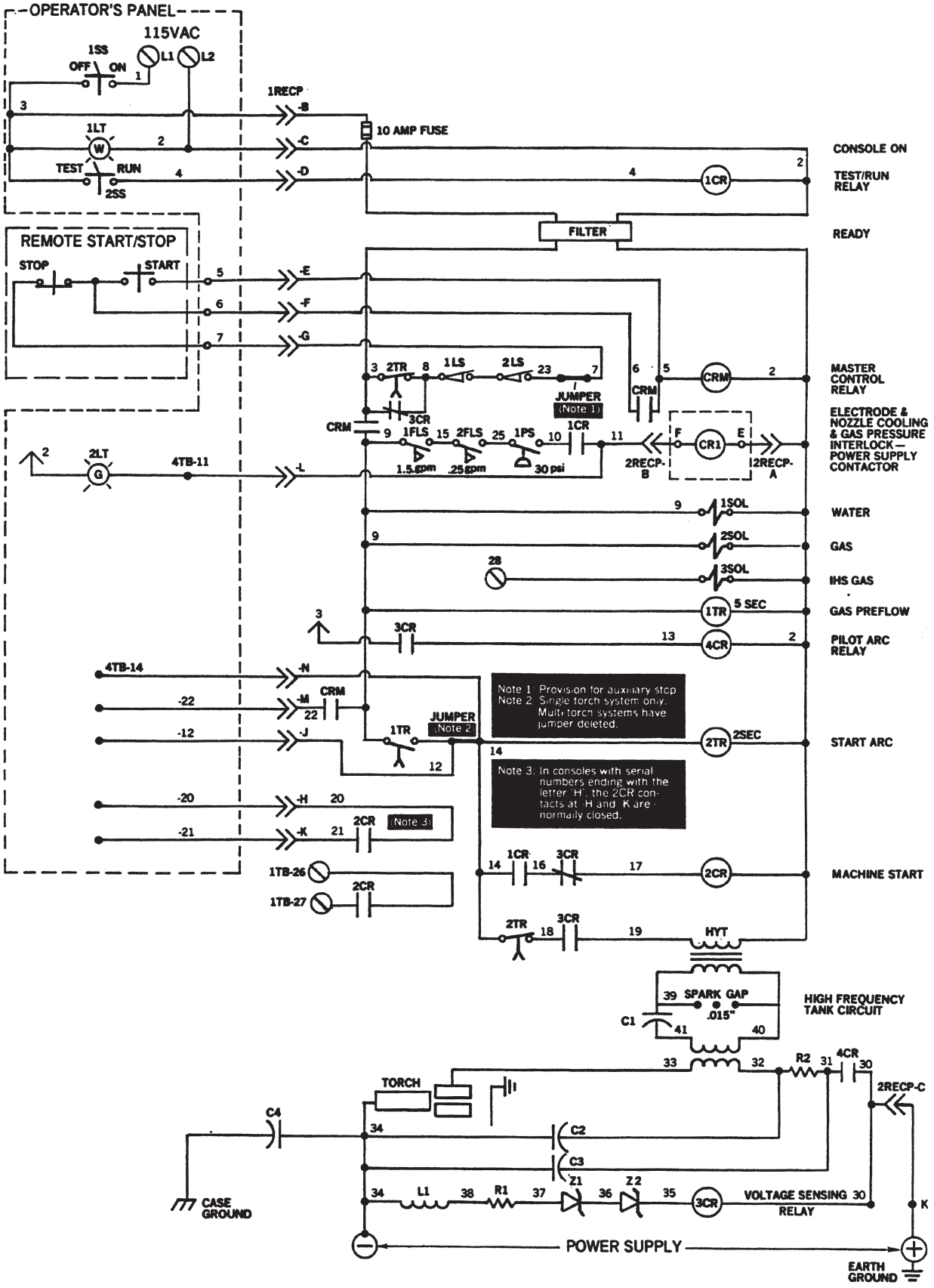


Figure 9 Plasma Console Electrical Schematic

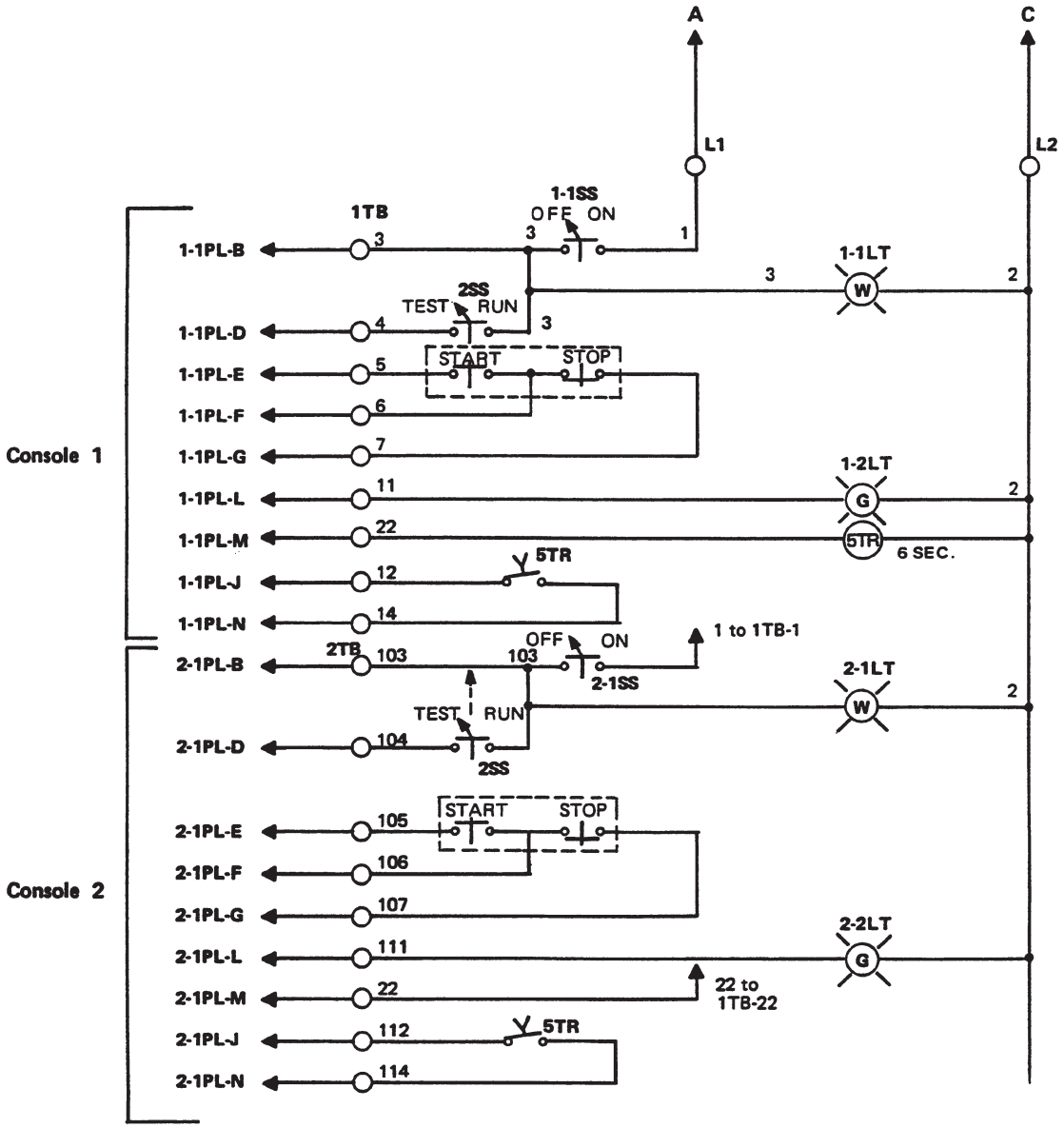


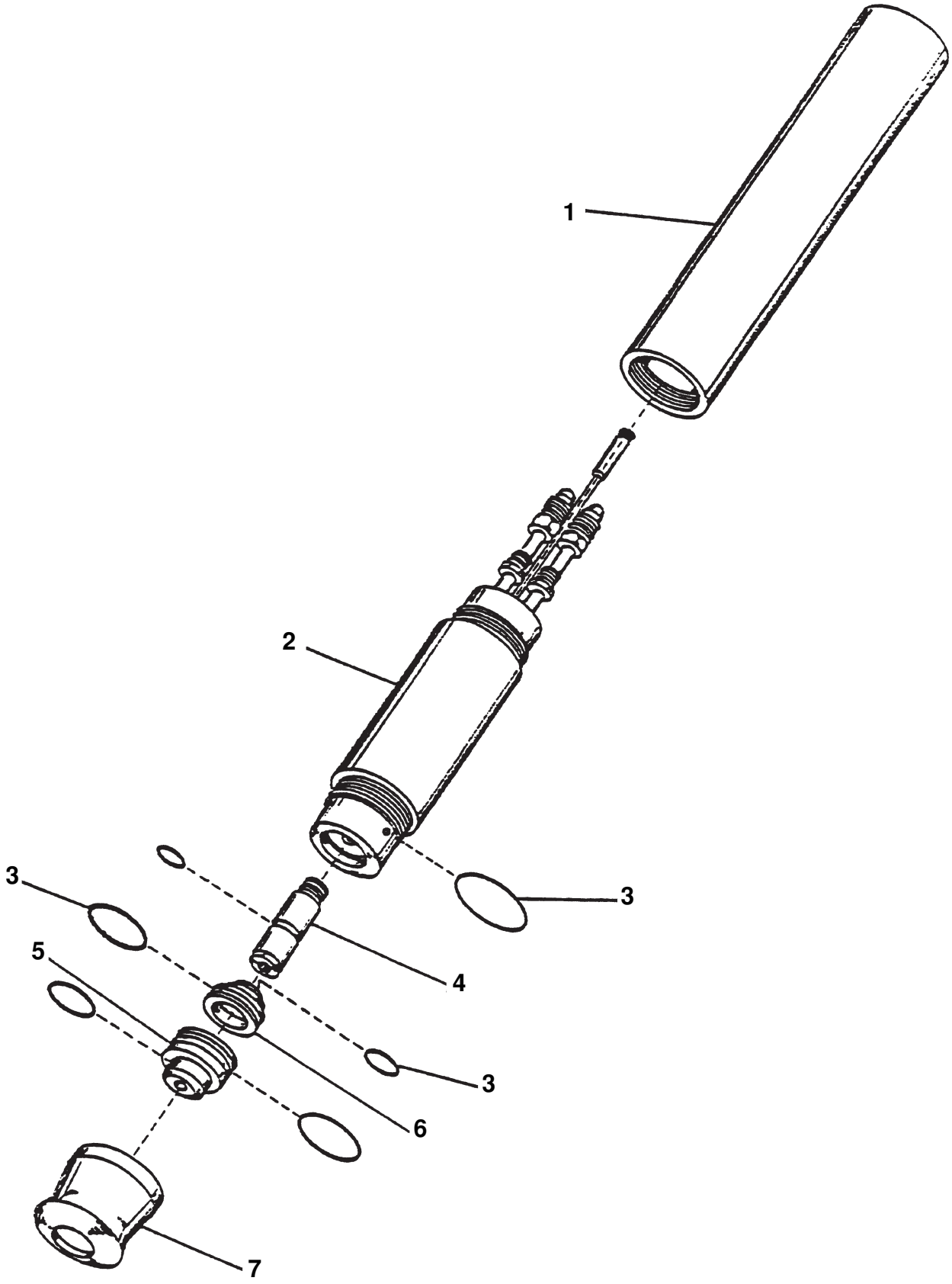
Figure 10 Operator's Panel Electrical Schematic (2 Torch)

Hypertherm

Section 6

PARTS LIST

In this section:



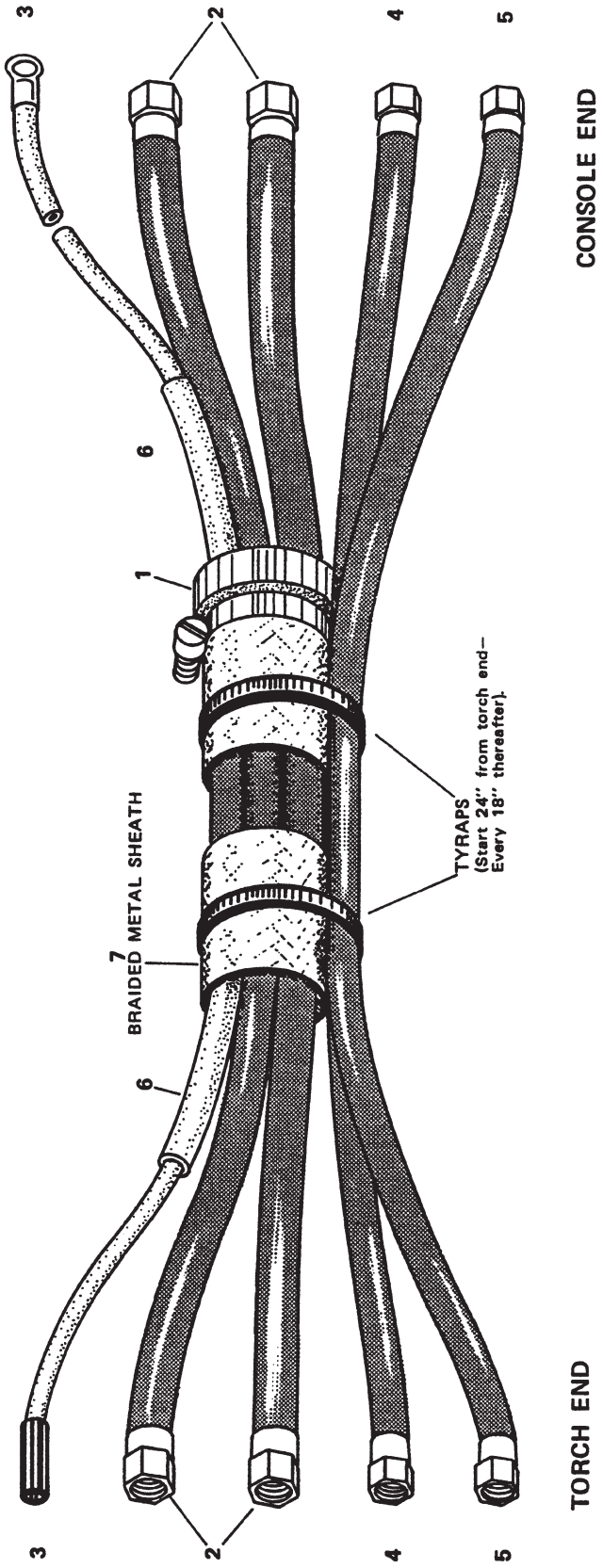
Model 500 Torch

Model 500 Torch Parts List – Part No. 028031

Item	Part No.	Description	Qty.
1	020041*	Insulating Sleeve	1
2	020030*	Torch Main Body	1
	120035*,**	Water Tube	1
3	025028	O-Ring Kit	
4	020038*	Electrode (O-rings included)	1
5	020035*	Nozzle, .166 (2 O-rings included)	1
	020036	Nozzle, .187 (2 O-rings included)	
	020037	Nozzle, .220 (2 O-rings included)	
	020047	Nozzle, .250 (2 O-rings included)	
6	020039*	Swirl Ring (.166 and .187 Nozzle)	1
	020040	Swirl Ring (.220 Nozzle)	
	020042	Swirl Ring (CCW, .166 and .187 Nozzle)	
	020048	Swirl Ring (.250 Nozzle)	
7	020043*	Nozzle Retaining Cap (Flared)	1
	020034**	Nozzle Retaining Cap (Tapered)	

* Components that come with 028031 torch

** See page 5-4 for illustration of water tube and tapered retaining cap


3
2
4
5
6
1
CONSOLE END
TYRAPS
(Start 24" from torch end—
Every 18" thereafter).
7
BRAIDED METAL SHEATH
6
TORCH END
3
2
4
5

Torch Leads

Torch Leads Package

Item	Part No.	Description	Qty.
Torch Leads, 10 ft. – Part No. 028137			
1	004080	Shield Collar & Ring	1
2	023032	Water Cooled Cable	2
3	023033	High Frequency Lead	1
4	024026	Gas Hose, Green, RH	1
5	024032	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	10 ft.
7	046114	RF Braided Shield	10 ft.
Torch Leads, 15 ft. – Part No. 028138			
1	004080	Shield Collar & Ring	1
2	023034	Water Cooled Cable	2
3	023035	High Frequency Lead	1
4	024027	Gas Hose, Green, RH	1
5	024033	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	15 ft.
7	046114	RF Braided Shield	15 ft.
Torch Leads, 20 ft. – Part No. 028139			
1	004080	Shield Collar & Ring	1
2	023012	Water Cooled Cable	2
3	023036	High Frequency Lead	1
4	024017	Gas Hose, Green, RH	1
5	024018	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	20 ft.
7	046114	RF Braided Shield	20 ft.
Torch Leads, 25 ft. – Part No. 028140			
1	040080	Shield Collar & Ring	1
2	023013	Water Cooled Cable	2
3	023037	High Frequency Lead	1
4	024028	Gas Hose, Green, RH	1
5	024034	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	25 ft.
7	046114	RF Braided Shield	25 ft.

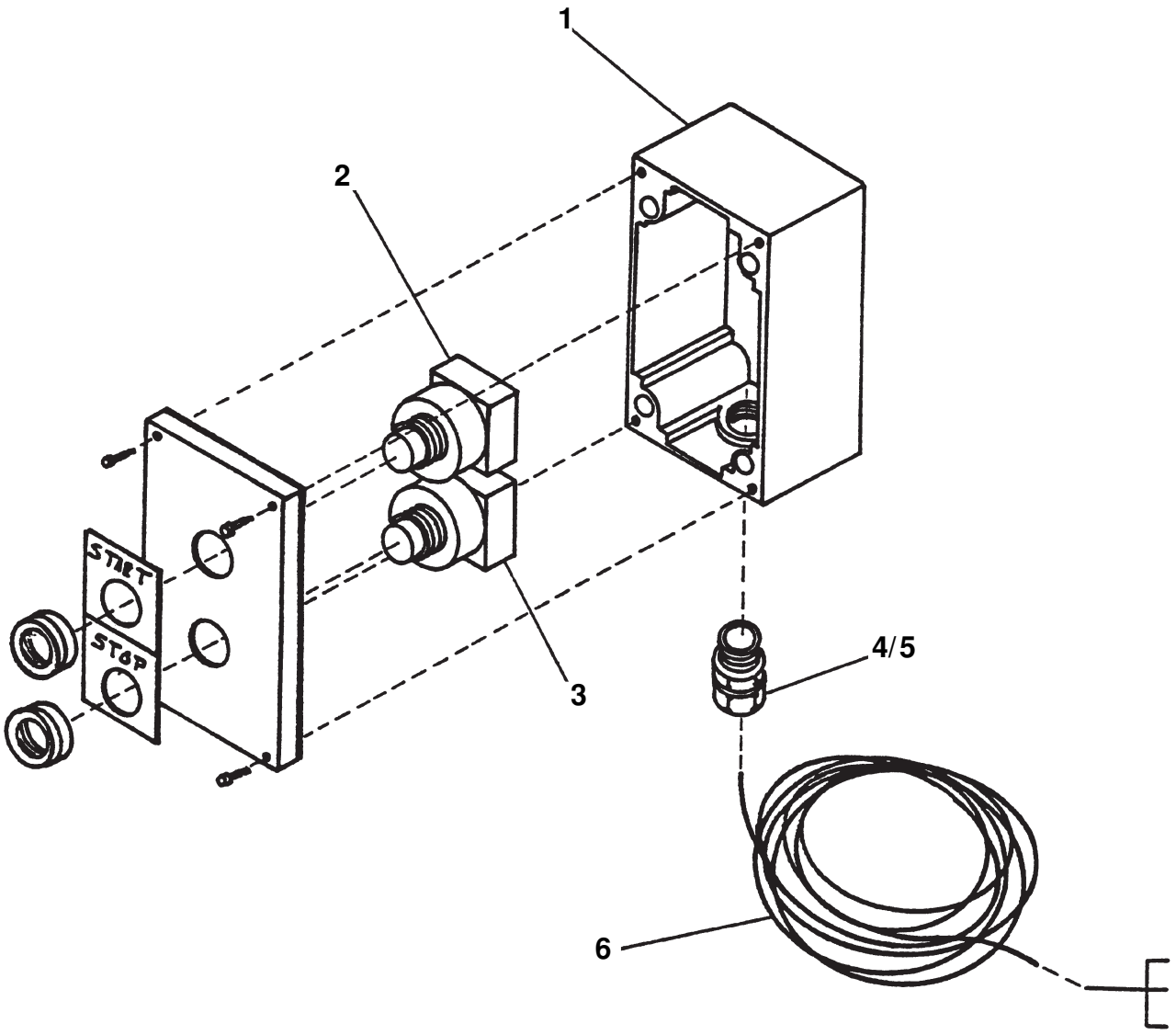
Torch Leads Package (continued)

Item	Part No.	Description	Qty.
Torch Leads, 30 ft. – Part No. 028141			
1	004080	Shield Collar & Ring	1
2	023014	Water Cooled Cable	2
3	023038	High Frequency Lead	1
4	024029	Gas Hose, Green, RH	1
5	024035	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	30 ft.
7	046114	RF Braided Shield	30 ft.
Torch Leads, 35 ft. – Part No. 028142			
1	004080	Shield Collar & Ring	1
2	023015	Water Cooled Cable	2
3	023039	High Frequency Lead	1
4	024030	Gas Hose, Green, RH	1
5	024036	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	35 ft.
7	046114	RF Braided Shield	35 ft.
Torch Leads, 40 ft. – Part No. 028143			
1	004080	Shield Collar & Ring	1
2	023016	Water Cooled Cable	2
3	023040	High Frequency Lead	1
4	024031	Gas Hose, Green, RH	1
5	024037	Water Hose, Red, LH	1
6	046033	HV Vinyl Hose Sheath	40 ft.
7	046114	RF Braided Shield	40 ft.

Operator Panel Leads Packages

Each package consists of four hoses and one multiconductor cable of specified length with fittings and plug attached.

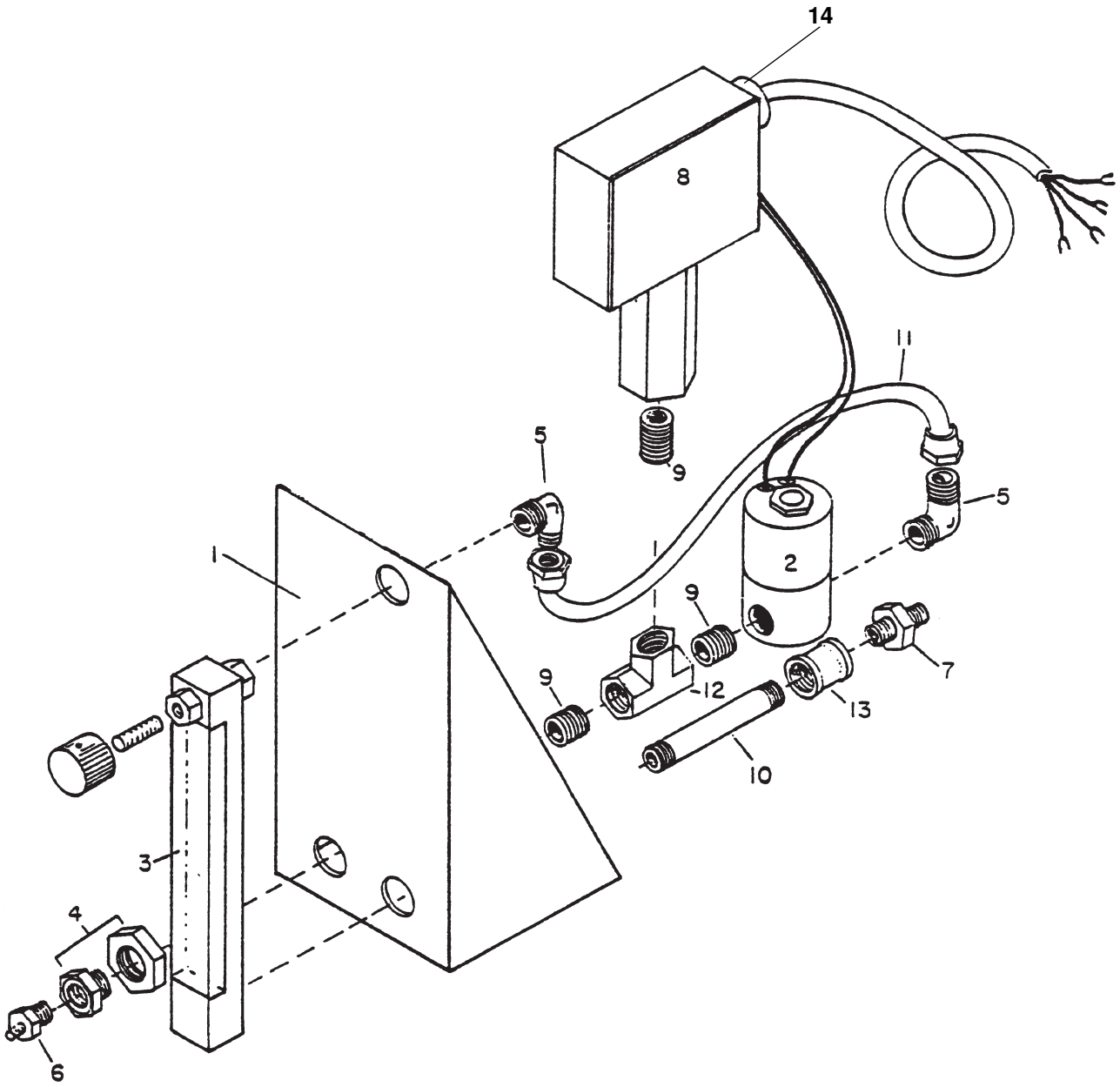
Length	Part No.
5 ft.	028144
10 ft.	028145
15 ft.	028146
20 ft.	028147
2S ft.	028148
30 ft.	028149



Remote Stop/Start

Remote Stop/Start – Part No. 028005

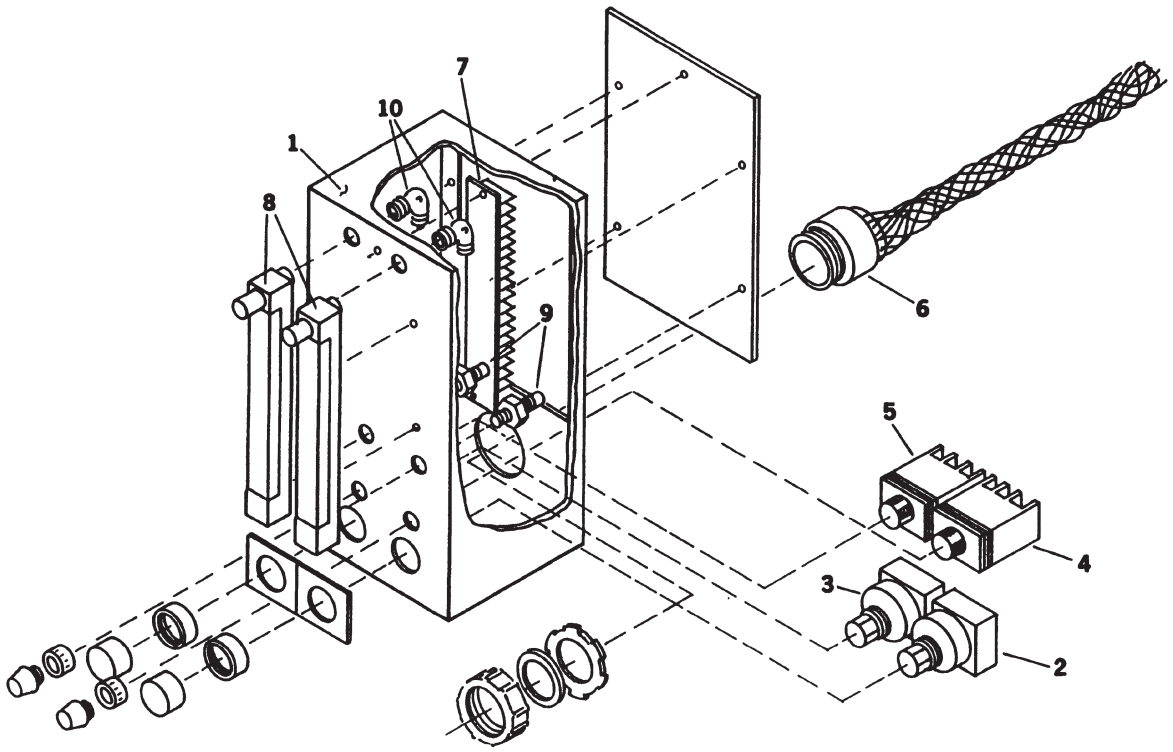
Item	Part No.	Description	Qty.
1	005021	Enclosure	1
2	005022	Pushbutton, Green “Start”	1
3	005023	Pushbutton, Red “Stop”	1
4	008043	3/4 NPT X 18/3 Strain Relief	1
5	008643	Lock washer: Used on 008043	1
6	047005	Cord: 6-4 SO UL / CSA	20 ft.



Argon-Hydrogen Manifold

Argon-Hydrogen Manifold – Part No. 028057

Item	Part No.	Description	Qty.
1	002050	Manifold Panel	1
2	006009	Solenoid	1
3	011005	Flowmeter	1
4	015001	Bulkhead Adapter	1
5	015014	Adapter 900, 1/2 NPT x #4	2
6	015048	Adapter, 1/4 NPT x Oxy “A”	1
7	015009	Adapter, 1/4 NPT x Oxy “B”	1
8	005046	Pressure Switch (Enclosed)	1
9	015510	1/4 NPT Close Nipple – Brass	3
10	015512	1/4 NPT x 3 1/2 Nipple – Brass	1
11	024041	#4 J1C Hose Assembly, 7"	1
12	015541	1/4 NPT Tee	1
13	015551	1/4 NPT Coupling	1
14	008047	Strain Relief	1

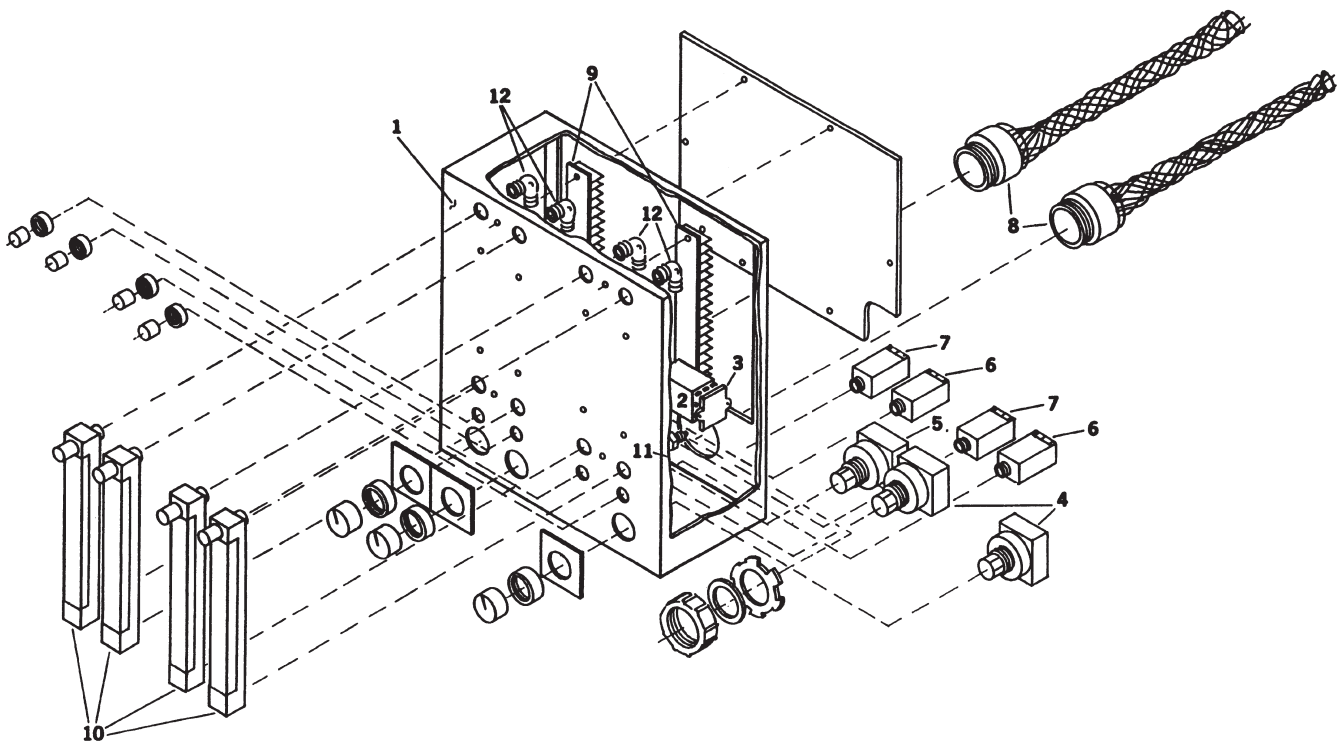


1-Torch Operator's Panel

Operator's Panel (1-Torch) – Part No. 028122

Item	Part No.	Description	Qty.
1	001087	Enclosure (1-Torch)	1
2	005017	Switch, ON/OFF	1
3	005018	Switch, TEST/RUN	1
4	014182	Xfmr:IDEC AP6 AC Adptr	2
	109009	Plt Lt:Wht 6VDC LED	1
5	014182	Xfmr:IDEC AP6 AC Adptr	1
	109008	Plt Lt:Grn 6VDC LED	
6	008052	Strain Relief, Basket Weave	1
7	008073	4TB Terminal Strip (16)	1
8	011005	Flowmeter	2
9	015005	Adapter, 1/4NPT X #4 JIC	2
10	015014	Adapter, 90 deg. 1/4NPT X #4 JIC	2
*	028212	Flowmeter Fittings Kit	1

* Parts not shown in drawing.

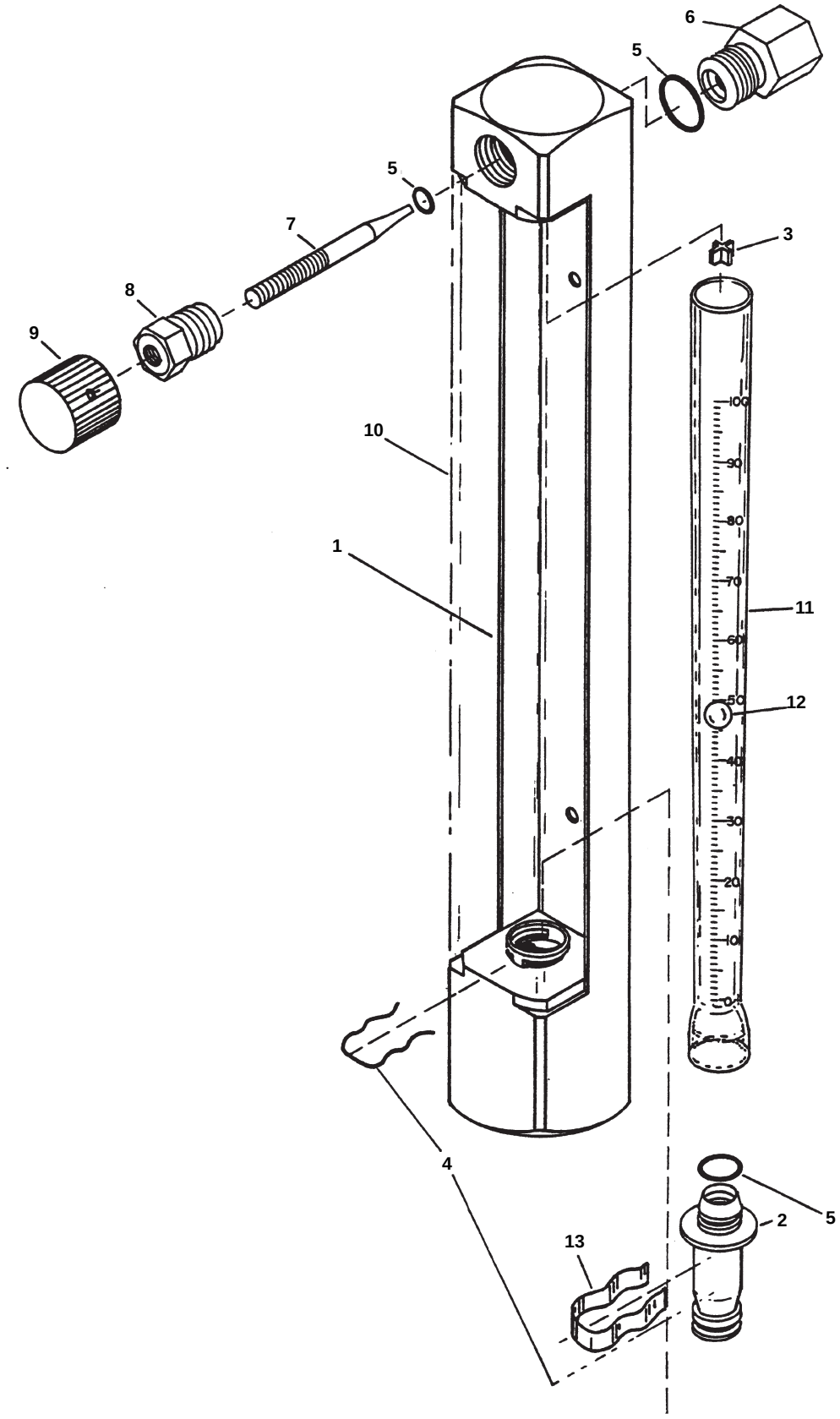


2-Torch Operator's Panel

Operator's Panel (2-Torch) – Part No. 028134

Item	Part No.	Description	Qty.
1	001092	Enclosure (2-Torch)	1
2	003040	Relay, Time Delay, DPDT (P&B #CLF-41-70010)	1
3	003026	Socket, Relay	1
4	005017	Switch, ON/OFF	2
5	005018	Switch, TEST/RUN	1
6	014182	Xfmr:IDEC AP6 AC Adptr	4
	109009	Plt Lt:Wht 6VDC LED	2
7	014182	Xfmr:IDEC AP6 AC Adptr	2
	109008	Plt Lt:Grn 6VDC LED	2
8	008052	Strain Relief, Basket Weave	2
9	008073	4TB Terminal Strip (16)	2
10	011005	Flowmeter	4
11	015005	Adapter, 1/4NPT X #4 JIC	4
12	015014	Adapter, 90 deg. 1/4NPT X #4 JIC	4
*	028212	Flowmeter Fittings Kit	1
—	009171	Resistor, 120K ohm	1

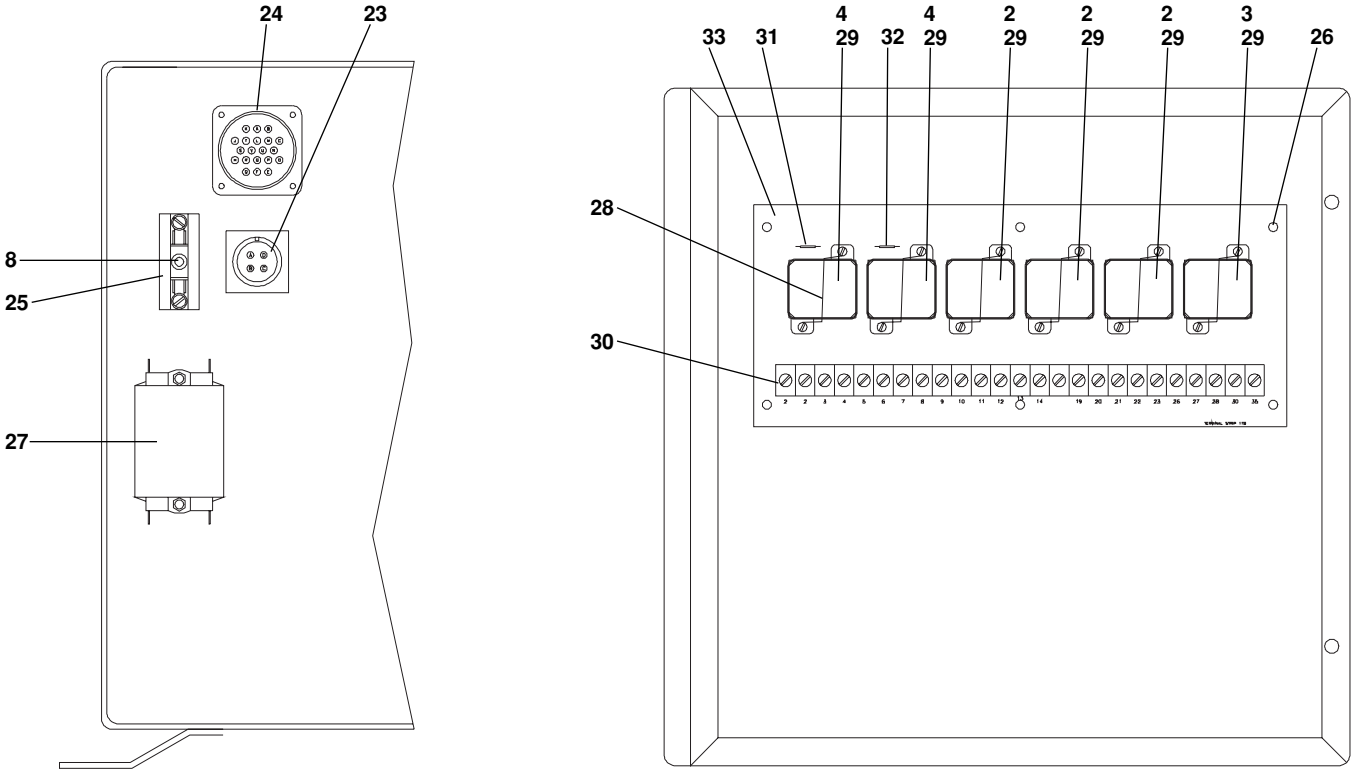
* Parts not shown in drawing.

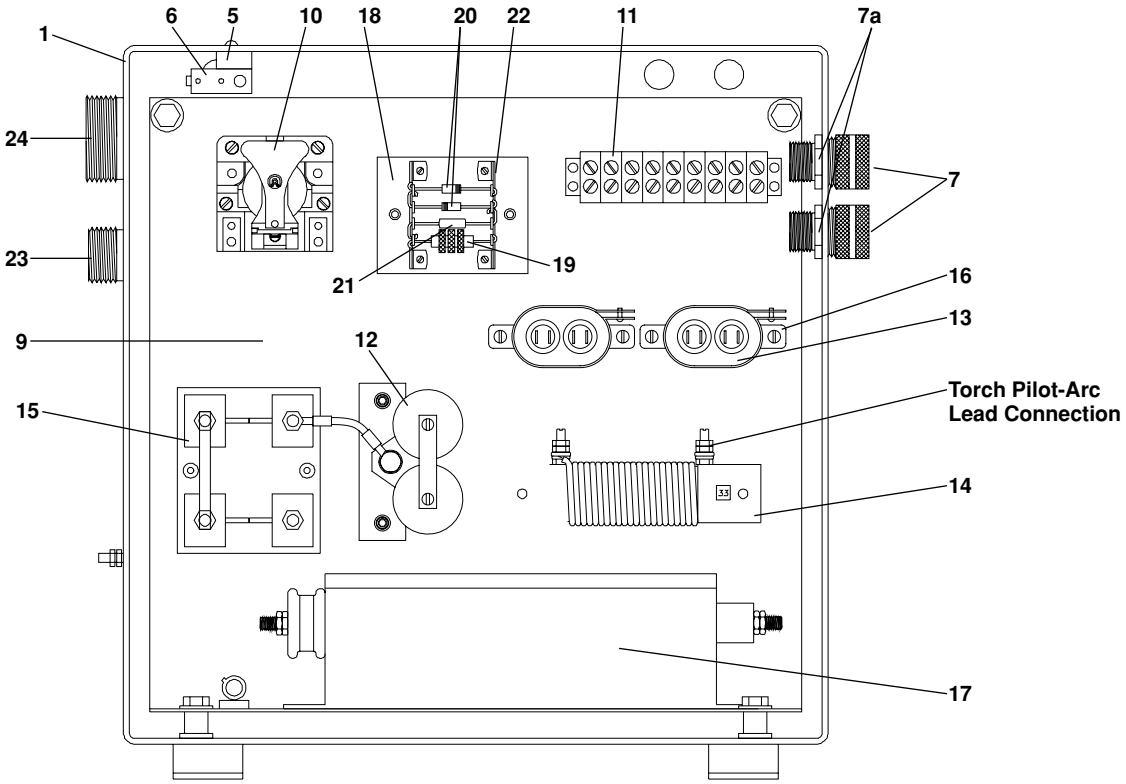


Gas and Water Flowmeter

Gas and Water Flowmeter – Complete Flowmeter Part No. 011005

Item	Part No.	Description
1	011029	Frame assembly
2	011019	Outlet adapter
3	011014	Float stop
4	011013	Adapter clip
5	025010	O-ring Kit Adapter O-ring Inlet adapter O-ring Spindle O-ring
6	011020	Inlet adapter
7	011018	Valve spindle
8	011021	Valve plug
9	011012	Control knob
10	011008	Shield
11	011006	Meter tube
12	011007	Float
13	011009	Wide spacer ss clip

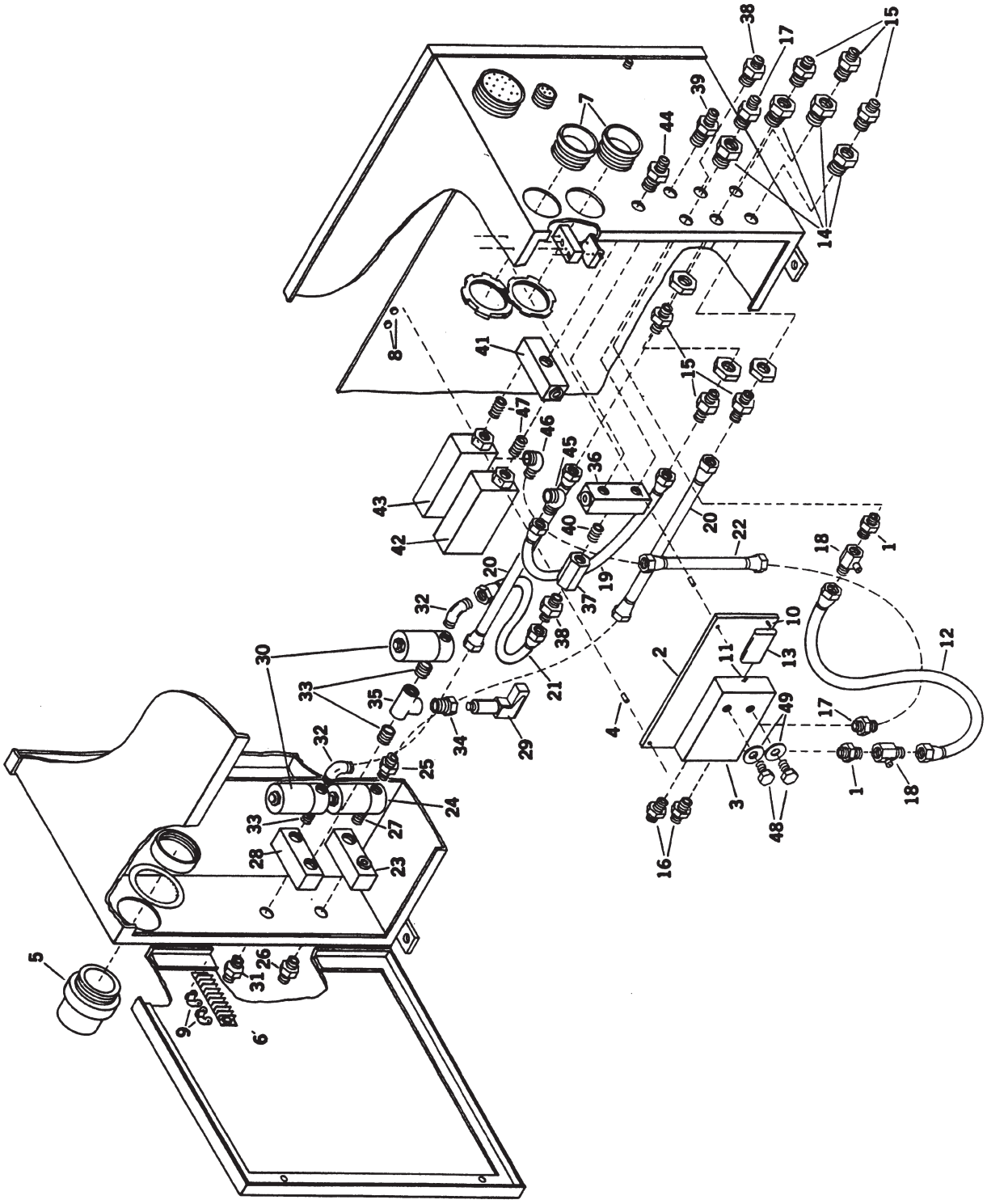




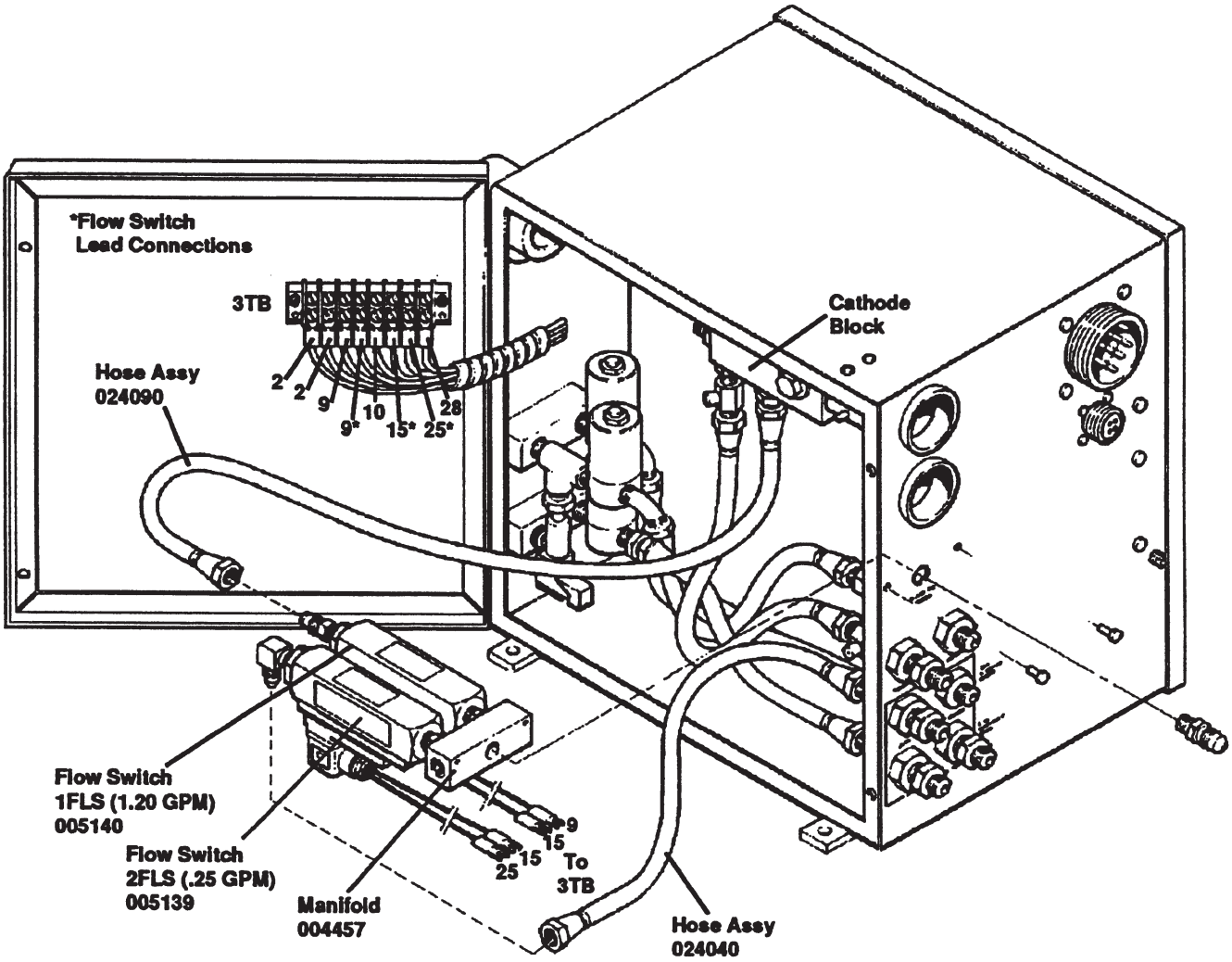
Electrical Compartment – PAC500 Console

Electrical Compartment – PAC500 Console

Item	Part No.	Description	Qty.
1	001086	Enclosure	1
2	003005	Relay, 3PDT, 120 VAC. (P&B#KUP14A15)	3
3	003015	Relay, 3PDT, 110 VDC. (P&B#KUP14D15)	1
4	003040	Relay, Time Delay (P&B#CLF-41-70010)	2
5	004076	Mtg. Block, Limit Switch	2
6	005100	Limit Switch	2
7	008071	Strain Relief	2
7a	008643	Loch Nut	2
8	008081	Fuse, 6 amp.	1
	029008	**High Frequency Subassembly**	**1**
9	002049	Mtg. Panel, High Frequency	1
10	003021	Relay, Pilot Arc (P&B#PRD3AJ0)	1
11	008058	2TB Terminal Strip (9)	1
12	029843	Spark Gap Capacitor SA	1
	009280	Capacitor:.002UF 15KV	2
	004144	Bar:Spark Gap Capacitor Mounting	1
13	009246	Capacitor, .5 UF	2
14	009043	High Frequency Coil (Tank Coil)	1
15	009044	Spark Gap Assembly	1
16	009247	Mtg. Bracket (for .5 Mfd. Caps.)	4
17	014004	Transformer, 5KV.	1
	029007	**Arc Detection Circuit**	**1**
18	004052	Base	1
19	009025	Choke, .5 mh.	1
20	009026	Diode, Zener	2
21	009027	Resistor, 10 K ohm	1
22	009061	Tie Point (4)	2
	029039	**Main Wiring Harness**	**1**
23	008015	Receptacle, 4 pin, female	1
24	008053	Receptacle, 20 pin, male	1
25	008080	Fuseholder	1
26	008104	Standoff, 8-32 X 5/8	6
27	009310	Filter (6W1)	1
	041034	**Relay Board Assembly**	**1**
28	003007	Clip, Hold-down	6
29	003047	Socket, Relay	6
30	008125	lTB Terminal Strip (25)	1
31	009046	Resistor, 90.9 K ohm	1
32	009123	Resistor, 31.6 K ohm	1
33	041031	P.C. Board (Board Only)	1



Plumbing Compartment – PAC500 Console



Plumbing Compartment with Kobold Flow Switches

Plumbing Compartment – PAC500 Console

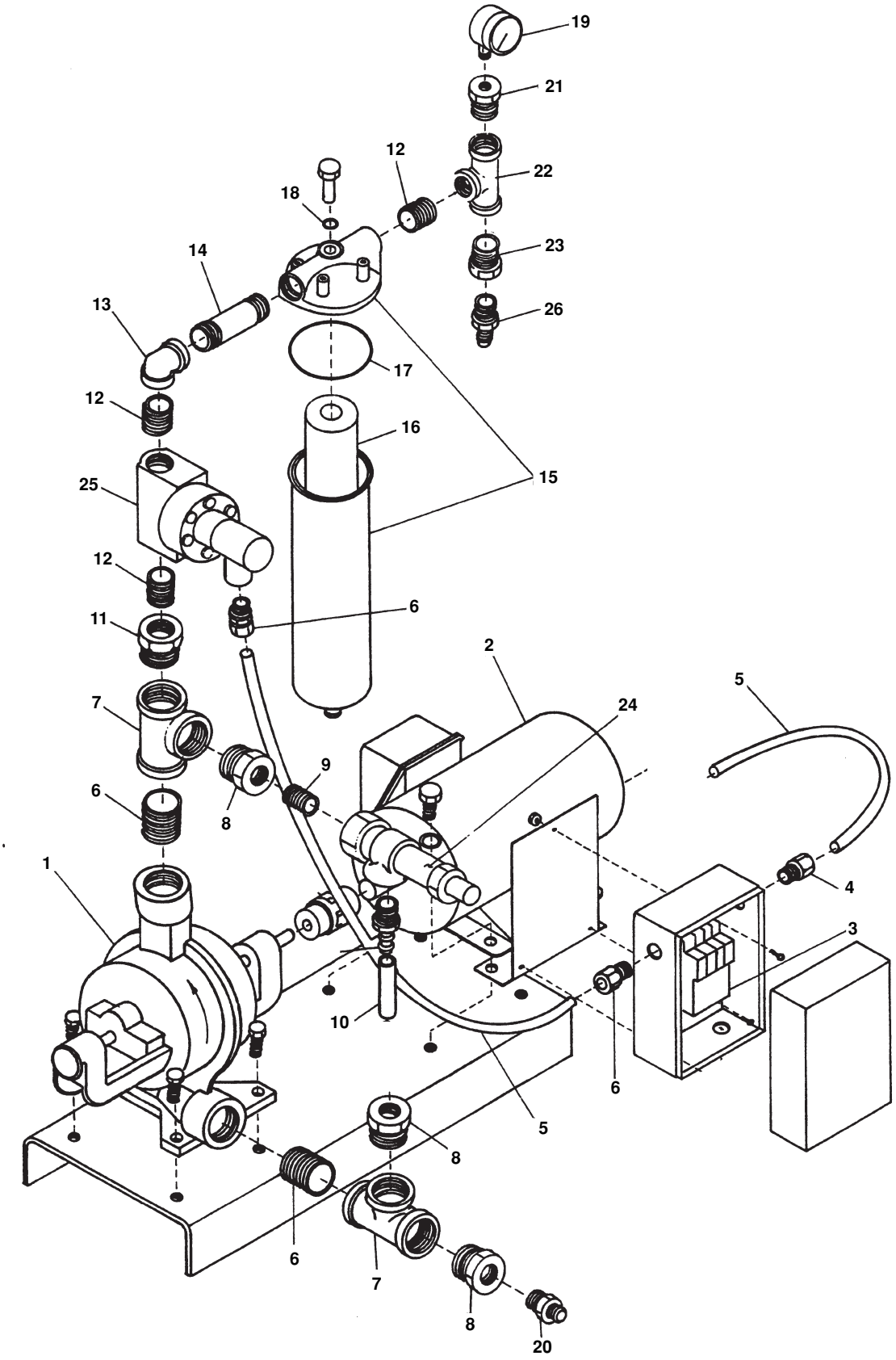
Item	Part No.	Description	Qty.
1	004040	Nipple, plastic	2
2	004073	Panel, insulating	1
3	004074	Cathode block	1
4	004075	Spacer	4
5	004078	Shield adapter w/027014 lockwasher	1
6	008058	3TB Terminal Strip (9)	1
7	008076	Bushing, 1-5/8 (Feedt-throughs)	2
8	008082	Bushing, 5/8	3
9	008095	Jumper	2
10	008123	Terminal	1
11	008124	Terminal	1
12	009017	Resistor, Water cooled, 3 ohm	1
13	009224	Capacitor, .22 Mfd.	1
14	015001	Adapter, bulkhead	4
15	015005	Adapter, 1/4 NPT x #4 JIC	6
16	015007	Adapter, 1/4 NPT x #5 JIC	2
17	015012	Adapter, 1/4 NPT x #6 JIC	2
18	015056	Adapter, W.C. resistor, 1/4 NPT-F x #6 JIC	2
19	024040	Hose assembly, #4 x 12"	1
20	024041	Hose assembly, #4 x 9-3/8"	2
21	024040	Hose assembly, #4 x 12"	1
22	024057	Hose assembly, #6 x 4-7/8"	1
*	024090	Hose assembly, #6 x 20"	1
	029005	**Water manifold subassembly**	**1**
23	004276	Manifold block	1
24	006009	Solenoid valve	1
25	015005	Adapter, 1/4 NPT x #4 JIC	1
26	015047	Adapter, 1/4 NPT x acc “A”	1
27	015510	Nipple, 1/4 NPT x close	1
	015561	Plug, 1/4 NPT	2
	029009	**Gas manifold, IHS, subassembly**	**1**
28	004276	Manifold block	1
29	005231	Pressure switch, 34 psi	1
30	006009	Solenoid valve	2
31	015048	Adapter, 1/4 NPT x oxy “A”	1
32	015057	Adapter, 45° 1/4 NPT x #4 JIC	2
33	015510	Nipple, 1/4 NPT x close	3
34	015570	Bushing, reducing, 1/4 NPT x 1/8 NPT	1
35	015541	Tee, 1/4 NPT	1
	015561	Plug, 1/4 NPT	1
	029013	**Inlet Gas Manifold, IHS Subassembly**	**1**
36	004276	Manifold Block	1
37	004048	Critical Orifice	1
38	015005	Adapter, 1/4NPT X #4 JIC	2
39	015009	Adapter, 1/4NPT X Oxy “B”	1
40	015510	Nipple, 1/4NPT X Close	1
	015561	Plug, 1/4 NPT	1

*Used with Kobold flow switches (see page 6-21)

Plumbing Compartment – PAC500 Console (continued)

Item	Part No.	Description	Qty.
	029545	**SA Kobold Flowswitch Manifold 500/500L**	**1**
41	004457	Manifold Block	1
42	005139	Flowswitch, .25 gpm	1
43	005140	Flowswitch, 1.2 gpm	1
44	015012	Adapter, 1/4NPT X #6 JIC	2
45	015014	Adapter, 90 deg., 1/4NPT X #4 JIC	1
46	015015	Adapter, 90 deg., 1/4NPT X #6 JIC	1
47	015510	Nipple, 1/4NPT X Close	2
	015561	Plug, 1/4NPT	1
48	—	Bolt, Brass, 1/2-13 X 3/4	2
49	—	Washer, Brass, 1/2	2

Note:
Older systems, without the manifold block, use flowswitch part numbers 005053 (.25 gpm) and 005054 (1.4 gpm)



Water Supply System

Water Supply System

One Torch – Part No. 028291
Two Torch – Part No. 028320

Item	Part No.	Description	Qty.
1	031008	Pump: 1 torch	1
1	031097	Pump/Motor assembly: 2 torch	1
2	031081	Motor: 1 torch	1
3	003057	Contactor	1
4	008250	1/2 NPT Conduit Fitting, Straight	3
5	046035	1/2 Flexible Conduit	2
6	*	1 1/4 NPT x Close Nipple-Brass	2
7	*	1 1/4 NPT x Tee-Brass	2
8	*	1 1/4 NPT x 1/2 NPT Reducer Bushing-Brass	3
9	*	1/2 NPT x 311 Nipple-Brass	1
10	*	1/211 Hose x 5 1/4 long	1
11	*	1 1/4 NPT x 1/4 NPT Reducer Bushing-Brass	1
12	*	3/4 NPT x Close Nipple – Brass	3
13	*	3/4 NPT 900 Elbow – Brass	1
14	*	3/4 NPT x 311 Nipple – Brass	1
15	027004	Filter Assembly	1
16	027005	Filter Element	1
17	027006	Filter Cover O-ring	1
18	027007	Filter Nut Gasket	1
19	022004	Pressure Gauge, 0-300 psi	1
20	015029	Adapter, 1/2NPT x #8 JIC	1
21	022007	1/4 NPT Adaptor	1
	015580	Bushing – Brass	1
22	015595	1/2 Tee – Brass	1
23	015574	3/4 NPT x 1/2 NPT Reducer Bushing - Brass	1
24	006029	Relief Valve, 175 psi	1
25	006073	Solenoid Valve 115/60	1
26	015030	Adapter, 1/2 NPT x #6 JIC	1
26	015029	Adapter,1/2 NPT x #8 JIC	1

* Obtain from local supply house.

Appendix A
PROPYLENE GLYCOL SAFETY DATA
BENZOTRIAZOLE SAFETY DATA

In this appendix:

Propylene Glycol Safety Data

Benzotriazole (COBRATEC) Safety Data

MATERIAL SAFETY DATA SHEET

SECTION 1 -- CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME	HYPERTHERM TORCH COOLANT

PRODUCT CODE	

ISSUE DATE	11-22-96

EMERGENCY TELEPHONE NUMBERS

MANUFACTURER	**HYPERTHERM**	**Transportation: (703) 527-3887 ***
STREET ADDRESS	**Etna Rd.**	*** For spill, leak, fire or transport accident emergencies.**
CITY, STATE, ZIP	**Hanover, NH 03755**	**Product Information: (603) 643-5638**

SECTION 2 -- COMPOSITION / INFORMATION ON INGREDIENTS

HAZARDOUS COMPONENT	CAS No.	% by wt.	EXPOSURE LIMITS OSHA PEL	ACGIH TLV	NIOSH REL
Propylene glycol	0057-55-6	< 50	None Established	None Established	None Established

SECTION 3 -- HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW	Can cause eye and skin irritation. Harmful if swallowed..

POTENTIAL HEALTH EFFECTS	
INGESTION	Can cause irritation, nausea, stomach distress, vomiting and diarrhea.
INHALATION	May cause mild irritation of nose, throat, and respiratory tract.
EYE CONTACT	Causes eye irritation.
SKIN CONTACT	Prolonged or repeated contact may cause skin irritation.

SECTION 4 -- FIRST AID MEASURES

INGESTION	DO NOT induce vomiting, but give one or two glasses of water to drink and get medical attention.
INHALATION	No specific treatment is necessary, since this material is not likely to be hazardous by inhalation.
EYE CONTACT	Immediately flush eye with cool running water for 15 minutes. If irritation persists, get medical attention.
SKIN CONTACT	Wash with soap and water. If irritation develops or persists, get medical attention.
NOTE TO PHYSICIAN	Treatment based on judgment of the physician in response to reactions of the patient.

SECTION 5 -- FIRE FIGHTING MEASURES

FLASH POINT / METHOD	None / N.A.	FLAMMABLE LIMITS	Not flammable or combustible
EXTINGUISHING MEDIA	If involved in a fire, use foam, carbon dioxide or dry chemical extinguisher. Water may cause frothing.		
SPECIAL FIRE FIGHTING PROCEDURES	None		
FIRE AND EXPLOSION HAZARDS	None		

SECTION 6 -- ACCIDENTAL RELEASE MEASURES

RESPONSE TO SPILLS	Small spills: Flush into a sanitary sewer. Mop up residue and rinse area thoroughly with water. Large spills: Dike or dam the spill. Pump into containers or soak up on inert absorbent.

SECTION 7 -- HANDLING AND STORAGE

HANDLING PRECAUTIONS	Keep container in upright position.
STORAGE PRECAUTIONS	Store in a cool dry place. Keep from freezing.

SECTION 8 -- EXPOSURE CONTROLS / PERSONAL PROTECTION

HYGIENIC PRACTICES	Normal procedures for good hygiene.
ENGINEERING CONTROLS	Good general ventilation should be sufficient to control airborne levels. Facilities using this product should be equipped with an eyewash station.

PERSONAL PROTECTIVE EQUIPMENT

X	**RESPIRATOR**	Recommended for prolonged use in confined areas with poor ventilation
X	**GOGGLES / FACE SHIELD**	Recommended; goggles should protect against chemical splash
	APRON	Not necessary
X	**GLOVES**	Recommended; PVC, Neoprene or Nitrile acceptable
	BOOTS	Not necessary

SECTION 9 -- PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE	Clear liquid	BOILING POINT	160 deg F
ODOR	Not Appreciable	FREEZING POINT	Not established
pH	4.6-5.0(100% concentrate)	VAPOR PRESSURE	Not applicable
SPECIFIC GRAVITY	1.0	VAPOR DENSITY	Not applicable
SOLUBILITY IN WATER	Complete	EVAPORATION RATE	Not determined

SECTION 10 -- STABILITY AND REACTIVITY

CHEMICAL STABILITY		**STABLE**	X		**UNSTABLE**	
CONDITIONS TO AVOID	No special precautions beyond standard safe industrial practices.					
INCOMPATIBILITY	Avoid contact with strong mineral acids and strong oxidizers, including chlorine bleach.					
HAZARDOUS PRODUCTS OF DECOMPOSITION	Carbon monoxide may be formed during combustion.					
POLYMERIZATION		**WILL NOT OCCUR**	X		**MAY OCCUR**	
CONDITIONS TO AVOID	Not applicable					

SECTION 11 -- TOXICOLOGICAL INFORMATION

CARCINOGENICITY

	THIS PRODUCT CONTAINS A KNOWN OR SUSPECTED CARCINOGEN
X	**THIS PRODUCT DOES NOT CONTAIN ANY KNOWN OR ANTICIPATED CARCINOGENS ACCORDING TO THE CRITERIA OF THE NTP ANNUAL REPORT ON CARCINOGENS AND OSHA 29 CFR 1910, Z**

OTHER EFFECTS

ACUTE	Not determined
CHRONIC	Not determined

SECTION 12 -- ECOLOGICAL INFORMATION

BIODEGRADABILITY		CONSIDERED BIODEGRADABLE	X		NOT BIODEGRADABLE	
BOD / COD VALUE	Not established					
ECOTOXICITY	No data available					

SECTION 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD	Product that cannot be used according to the label must be disposed of as a hazardous waste at an approved hazardous waste management facility. Empty containers may be triple rinsed, then offered for recycling or reconditioning; or puncture and dispose of in a sanitary landfill.								
RCRA CLASSIFICATION	NO								
RECYCLE CONTAINER		YES	X		CODE	2 - HDPE		NO	

SECTION 14 -- TRANSPORT INFORMATION

DOT CLASSIFICATION		HAZARDOUS			NOT HAZARDOUS	X
DESCRIPTION	Not applicable					

SECTION 15 -- REGULATORY INFORMATION

USA REGULATORY STATUS

	EPA REGISTERED (UNDER FIFRA)	
	FDA REGULATED	
	KOSHER	
	SARA TITLE III MATERIAL	
	USDA AUTHORIZED	

SECTION 16 -- OTHER INFORMATION

NFPA CLASSIFICATION

1	BLUE	HEALTH HAZARD
1	RED	FLAMMABILITY
0	YELLOW	REACTIVITY
--	WHITE	SPECIAL HAZARD

Information contained in this MSDS refers only to the specific material designated and does not relate to any process or use involving other materials. This information is based on data believed to be reliable, and the Product is intended to be used in a manner that is customary and reasonably foreseeable. Since actual use and handling are beyond our control, no warranty, express or implied, is made and no liability is assumed by Hypertherm in connection with the use of this information.

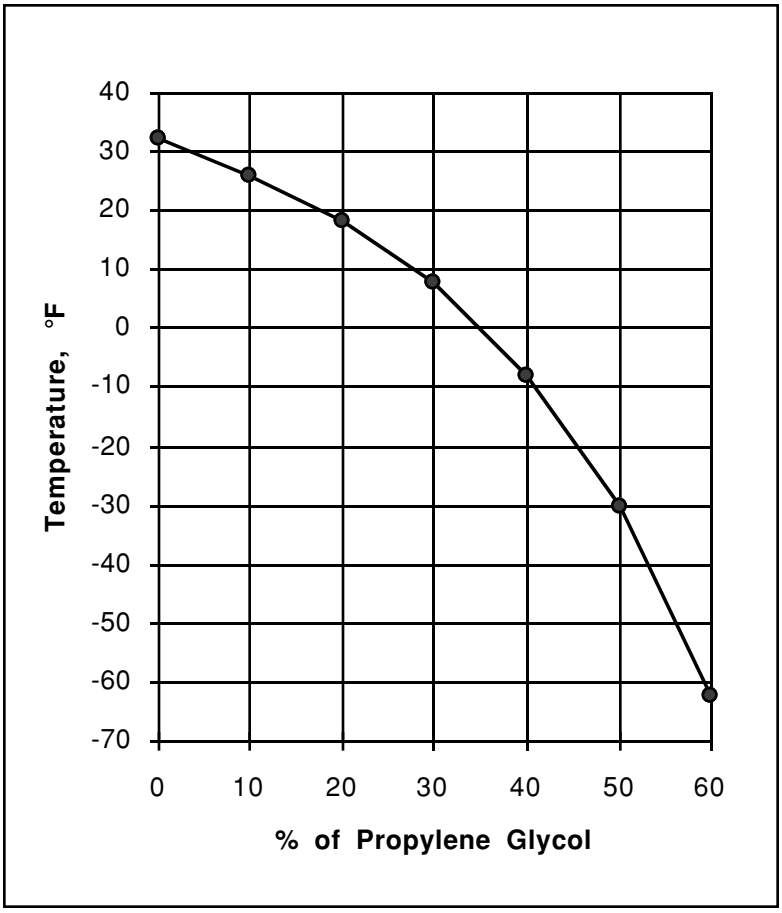


Figure a-1 Freezing Point of Propylene Glycol Solution

SECTION I

MANUFACTURER:	PMC SPECIALTIES GROUP, INC.
ADDRESS:	501 Murray Road Cincinnati, OH 45217
EMERGENCY TELEPHONE:	(513) 242-3300
FOR TRANSPORTATION EMERGENCY:	(800) 424-9300
CHEMICAL NAME AND SYNONYMS:	1-H Benzotriazole, Benzotriazole
TRADE NAMES AND SYNONYMS:	COBRATEC® 99 Powder
CHEMICAL FAMILY:	Triazole
FORMULA:	$C_6H_5N_3$
DOT SHIPPING DESCRIPTION:	Not Regulated (Benzotriazole)
PRODUCT NUMBER:	X18BT5585

NFPA BASED RATINGS: Health: 1, Flammability: 1, Reactivity: 0
HMIS RATINGS: Health: 2, Flammability: 0, Reactivity: 0, PPE: E
WHMIS CLASSIFICATION: D-2-(B)

SECTION II INGREDIENTS

Material	CAS No.	Wt. %	Exposure Limits
Benzotriazole	95-14-7	>99	None Established

SECTION III PHYSICAL DATA

BOILING POINT:	>350° C
FREEZING POINT:	94-99° C
SPECIFIC GRAVITY:	1.36 (solid)
VAPOR PRESSURE AT 20° C:	0.04 mm Hg
VAPOR DENSITY (air=1):	4.1 (calculated)
SOLUBILITY IN WATER % BY WT at 20° C:	2.0
% VOLATILES BY VOLUME:	None
EVAPORATION RATE (Butyl Acetate = 1):	Non-volatile
APPEARANCE AND ODOR:	Off white powder. Slight characteristic odor.

08/28/95

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	340° F. (CC)
AUTOIGNITION TEMPERATURE:	Not Available
FLAMMABLE LIMITS IN AIR:	LOWER: Dust MEC. 0.03 oz/(cu. ft.) UPPER: Not Available

EXTINGUISHING MEDIA: Carbon Dioxide, Dry Chemical, Foam

SPECIAL FIRE FIGHTING PROCEDURES: Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat. During emergency conditions, overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Get medical attention.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Airborne dust is rated a severe explosion hazard at a minimum concentration of 0.03 ounce per cubic feet (30 grams per cubic meter).

SECTION V HEALTH HAZARD DATA

OSHA AIR CONTAMINANTS: Due to its dusting nature during handling, exposure to dust must comply with OSHA's particulate not otherwise regulated limits for total and respirable dust.

EFFECTS OF OVEREXPOSURE: Contact with the eyes is likely to cause severe irritation. Detailed information about the effects of overexposure in the human being is unavailable. Experience thus far has not provided any example of obvious overexposure with resultant symptoms. Animal studies have indicated an effect on the central nervous system. An NCI bioassay showed no convincing evidence of carcinogenicity (NCI-CG-TR-88). Bacterial mutagenicity data exists. Experts consider the data inconclusive. (Environmental Mutagenesis, Vol. 7, Suppl. 5: 1-248 (1985) and references in RTECS #DM1225000).

EMERGENCY AND FIRST AID PROCEDURES: IF INHALED: If affected, remove from exposure. Restore breathing. Keep warm and quiet. IF ON SKIN: Wash affected area thoroughly with soap and water. IF IN EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention. IF SWALLOWED: Never give anything by mouth to an unconscious person. Give several glasses of water. If vomiting is not spontaneous, induce vomiting. Keep airway clear. Get medical attention.

TOXICITY DATA:

Oral LD_{50} (rat)	560 mg/Kg
Primary skin Irritation (rabbit)	Not a primary skin irritant
Dermal LD_{50}	>2000 mg/Kg
Eye irritation (rabbit)	caused severe eye irritation
Bluegill Sunfish (96 hr. Tlm)	28 mg/l
Minnow (96 hr. Tlm)	28 mg/l
Trout (96 hr. LC_{50})	39 mg/l
Algae (96 hr. EC_{50})	15.4 mg/l
Daphnia magna (48 hr. LC_{50})	141.6 mg/l

SECTION VI REACTIVITY DATA

STABILITY: Stable
INCOMPATIBILITY: Oxidizing Agents
HAZARDOUS DECOMPOSITION PRODUCTS: BY FIRE: Carbon Dioxide, Carbon Monoxide Nitrogen oxides, HCN in reducing atmospheres
HAZARDOUS POLYMERIZATION: Will Not occur

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE THE MATERIAL IS SPILLED OR RELEASED: If local high concentration of airborne dust occurs, dampen spill with water and ventilate to disperse dust laden air. Sweep up spill and reclaim or place in a covered waste disposal container.
WASTE DISPOSAL METHOD: Sanitary landfill or incinerate in approved facilities in accordance with local, state, and federal regulations. Do not heat or incinerate in closed containers.

SECTION VIII SPECIAL PROTECTIVE INFORMATION

RESPIRATORY PROTECTION: If personal exposure cannot be controlled below applicable exposure limits by ventilation, wear respiratory devices approved by NIOSH/MSHA for protection against organic vapors, dusts, and mists.

VENTILATION: Local exhaust recommended for dust control.
PROTECTIVE GLOVES: Recommended to avoid skin contact, Rubber, Vinyl
EYE PROTECTION: Use safety goggles where airborne dust is a problem.
OTHER PROTECTIVE EQUIPMENT: Safety shower, eye wash

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store in a cool, dry area. Keep containers tightly closed when not in use. Avoid creating airborne dust concentrations which could constitute a potential dust explosion hazard. Avoid contact with skin, eyes, and clothing. Avoid inhalation of dust and vapor. DO NOT TAKE INTERNALLY. Clean up spills immediately.

SECTION X REGULATORY STATUS

Benzotriazole (CAS No. 95-14-7) is contained on the following chemical lists:

1. TSCA Section 8(a)/40CFR 712 Preliminary Assessment Information Rule
2. TSCA Section 8(d) Health and Safety Data Rule
3. NTP Testing Program
4. Massachusetts Substance List
5. Canadian Domestic Substance List
6. WHMIS Ingredient Disclosure List
7. TSCA Inventory List

PREPARED: August 28, 1995
SUPERSEDES: May 25, 1994

The information contained herein is based on the data available to us and is believed to be correct as of the date prepared; however, PMC SPECIALTIES GROUP, INC. makes no warranty, expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof.