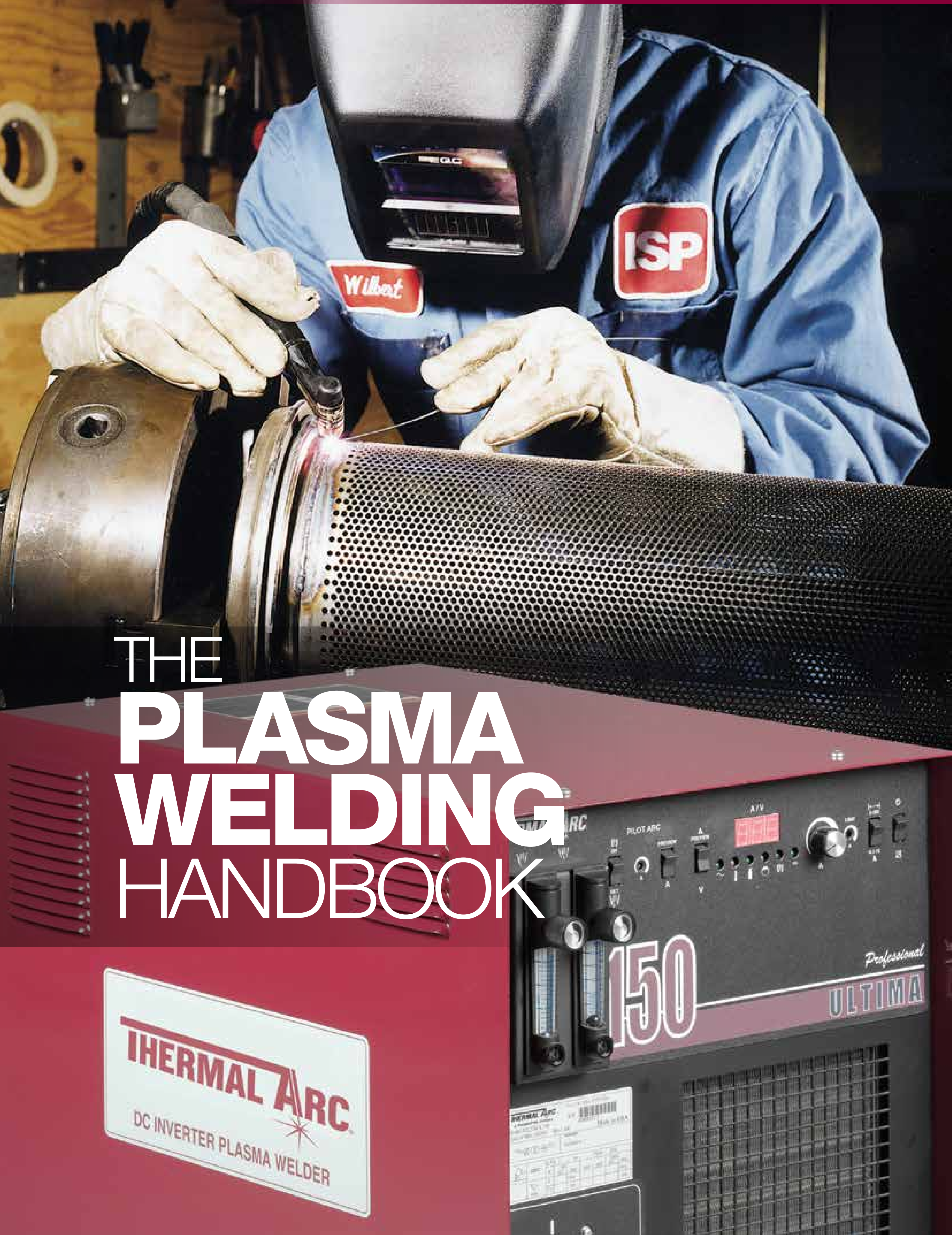
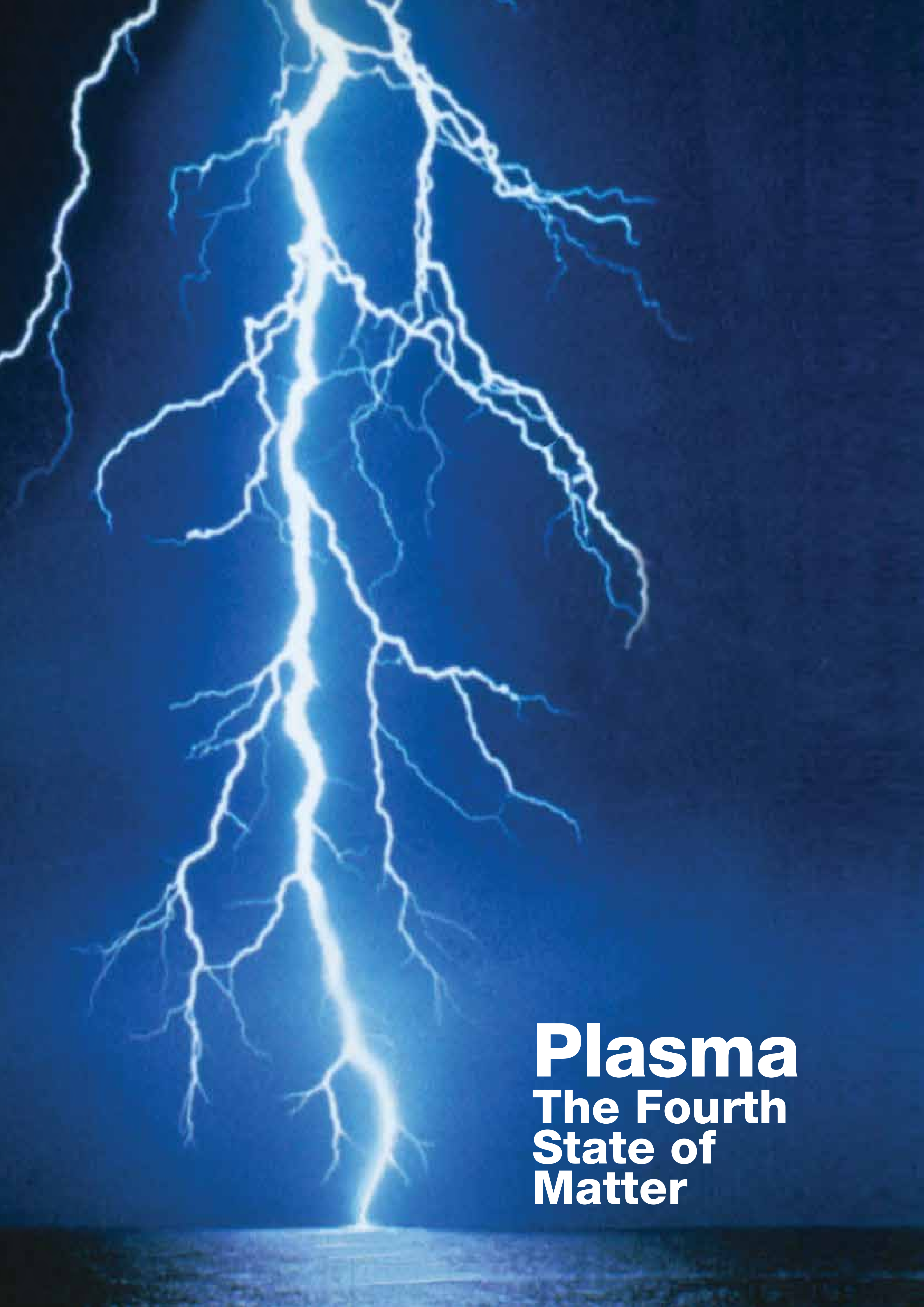
THE PLASMA WELDING HANDBOOK





Plasma

The Fourth State of Matter

Contents

Plasma

The term Plasma, refers to a gas that has been sufficiently ionized to conduct an electrical current. As we see matter in the world around us, we are usually conscious of its existence in three states ... solid, liquid and gas. We are all aware of the difference between solids, liquids, and gases, and the fact that increasing the temperature changes a material from one state to another. When enough energy is applied to a gas, this will cause an ionization of the gases atomic structure. This process is visible to us in the form of fluorescent lighting in our homes and offices, lightning in the night sky, or even our very sun. Most of the visible universe is a type of plasma.

When energy (heat) is added to a material in a gaseous state, the temperature of the gas keeps increasing. If enough energy is added, the temperature becomes high enough that the gas no longer exists as individual molecules. The molecules come apart and the material made up of individual atoms, if the temperature is further increased, the atoms will then lose electrons and become ions. This material then consists of a combination of ions (with a positive charge) and free electrons. Under these conditions, the matter now exists in a fourth state... the **PLASMA** state.

Plasma has many properties that are similar to those of a gas but also some special properties that make it unique. The most important property of the plasma, as far as welding is concerned, is that it contains free electrons which allows it to easily carry an electrical current. The plasma welding process does not have an exclusive on the use of plasma as it also exists in all other arc welding processes. Plasma welding utilizes the developed hot gases to provide unique benefits to the welding operation.

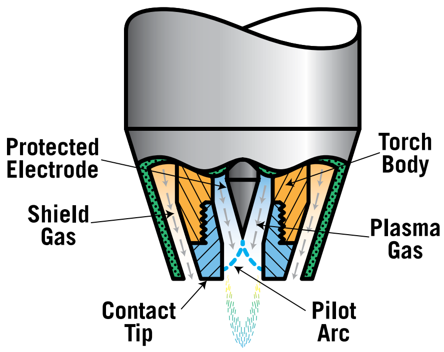
Plasma Arc Welding (PAW)

Plasma Arc Welding (PAW) is a welding process that heats an inert gas to an extremely high temperature so that the gas becomes ionized and electrically conductive. This plasma gas is constricted into a column by an orifice placed downstream of the electrode which is protected inside the nozzle of torch. The plasma is used to transfer an electric arc to the workpiece to obtain the melting and coalescence of most metals and to constrict the arc during the welding process.

Plasma welding is not a new process to the industry, but only in the past few years has it gained significant acceptance. Until recently, the process was considered exotic and difficult to understand. This was mainly due to the applications it was being adapted to.

Process Advantages

Plasma now has proven its value in the area of highly repetitive automated welds. The process provides increased reliability and repeatability to meet today's high standards of productivity. It is frequently used as an alternate to the gas tungsten arc welding process (GTAW).



All metals amenable to GTAW or TIG welding can be welded with the plasma arc process. Plasma arc welding shows its greatest advantages in the welding of high volume repetitive production operations. These applications normally demand repeatable welds on a near continuous basis using the melt-in fusion mode and include spot fusion welds, corner edge welds, lamination welds and circumferential / seam welds.

For most applications, the plasma arc process offers increased electrode life, reliable arc starting, improved arc stability, better penetration control and reduced current levels. In some cases plasma offers increased travel speeds, improved weld quality, and less sensitivity to operating variables.

Features & Benefits - The Protected Electrode

One of the most important features of the plasma arc welding process is the **Protected Electrode** which provides higher efficiency and reduces downtime in most applications.

The tungsten electrode, which is secured inside the plasma torch and behind the orifice, is protected from outside impurities that would normally attack its hot surface. With this protection, the electrode is shielded from materials that can constantly attack an "exposed" electrode. The protected electrode in the plasma welding torch normally requires a change only once every 8 hours for most operations. This reduction in electrode change allows for increased productivity.

The electrode is secured externally in the TIG welding process (GTAW). This exposes the electrode to the contaminants (stamping and forming oils, degreasers, oxides, etc.) present on the surface of the base material to be welded. These contaminants, under intense temperatures, will attack and erode the tungsten electrode requiring the frequent changing of the electrode on a repetitive basis.

It is not uncommon in many applications for the electrode in the GTAW torch to require replacement changes 1 to 2 times per hour depending on part cleanliness and production levels. The time required to change the electrode depends on the accessibility of the torches on the fixture apparatus. Five minutes or more may be spent on each electrode change in some cases, eating away costly production time.

Multiplying the number of electrode changes required in an 8 hour shift by the time required for each change, and dividing by the total amount of production time available, will yield the percentage of lost production time. Based on that number, it is now easy to figure parts lost due to frequent electrode changes. This reduction in electrode change allows for increased productivity.

(See chart below)

Typical Plasma/TIG Welding Productivity Benefit Analysis

COMPARISION		TIG			PLASMA		
Time	Total Parts @ 100% Capacity	TIG Electrode Changes	Minutes To Change Electrodes	Parts Lost With TIG	Plasma Electrode Changes	Parts Lost With Plasma	Net Gain Plasma Over TIG
Hour	208	1	5	17	0	0	**17**
Day	4,992	24	120	416	3	52	**364**
Week	24,960	120	600	2,080	15	260	**1,820**
Month	108,160	520	2,600	9,013	65	1,127	**7,887**
Year	1,297,920	6,240	31,200	108,160	780	13,520	**94,640**
Shift Hours per Week		24		**Value per Part**			**1**
Days Worked per Week		5		**Production Parts/Financial Gain with Plasma**			**94,640**

Application: Outside corner welds home appliance **NOTE:** *4 welds required on each part. For more information, contact Victor Technologies*

Plasma Arc Welding

Advantages and Disadvantages

Reliable, easy-to-operate Thermal Arc Plasma Welding Systems boost profits and productivity by helping you achieve consistently high quality repeatable welds – manually or automatically. Whatever your application needs, the broad, versatile line of Thermal Arc consoles, torches, power supplies, and accessories provide the right tools for the job.

Plasma arc welding is measurably the lower cost process with savings gained through increased productivity, reduced scrap, reduced downtime and fewer electrode changes.

Plasma arc welding offers many advantages over TIG Welding (GTAW - Gas Tungsten Arc Welding):

ADVANTAGES:

- Reliable Arc Starting
- Protected Electrode
- Less Sensitive to Stand-Off Changes
- Improved Arc Stability at Low Current
- Lower Current Levels Required
- Reduced Heat Input or Distortion
- Arc is More Directional (Less Arc Wander)
- Improved Weld Geometry and Penetration Control
- Less Filler Material Required
- Reduced Current Levels
- Single-Pass Welds
- Minimized Weld Preparation
- Narrower Weld Beads
- Visual Proof of 100% Weld Penetration
- Improved Weld Geometry

DISADVANTAGES:

- Limited to Flat, Horizontal, and Vertical-Up Positions
- More Sensitive to Variable Changes
- Limited to Automated Operations

What Is Plasma Arc Welding?

Simply stated, **Plasma Arc Welding** (PAW) is a superior variation to TIG welding (GTAW) that encloses the tungsten electrode in a protected environment (Figure 1) and delivers the arc through a cooled copper tip. Enclosing the electrode protects it from contamination, thus substantially extending its life.

The constant stable arc shape of plasma results in consistent welds for eight hours or more of operation as compared to automated TIG welding, where deterioration of the exposed TIG electrode (Figure 2) can result in weld arc variations (Figure 3) in one hour or less of operation. Plasma arc welding uses a pilot arc (Figure 4) to consistently transfer the arc to the work without the repeated use of high frequency current.

PROTECTED ELECTRODE

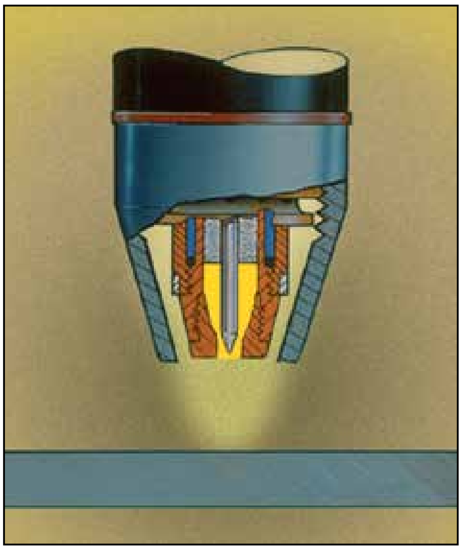


Figure 1

ELECTRODES

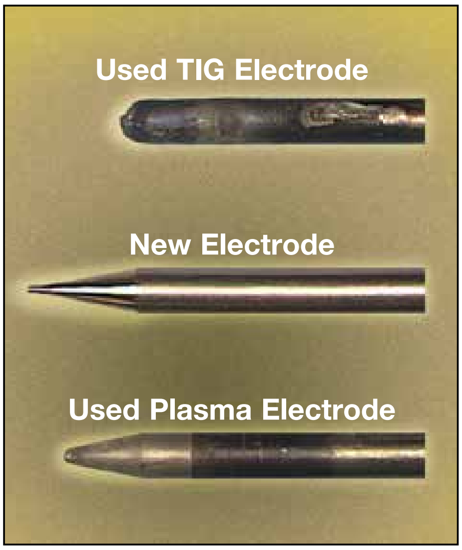


Figure 2

TIG WELD SAMPLE

Figure 3

PILOT ARC

Figure 4

Pilot Arc

Another outstanding feature of the Plasma arc welding process is the Pilot Arc which provides reliable arc starting and contributes to the repeatability and increased productivity of plasma welding.

The Pilot Arc is a low current DC arc that is sustained in the tip area of the torch to ionize a gas as it passes around the electrode and through the orifice. Arc initiation is provided by the pilot arc that transfers between the tungsten electrode and the tip. It is started by imposing high frequency (from a small high frequency generator or C.D. arc starter inside the control console) on a low DC current for a short duration of time to ionize the gas. Once the pilot arc has been established, the requirements for high frequency are no longer needed. The pilot arc now remains on to reliably assist the starting of the main transferred welding arc from a separate DC power source.

Without the need for high frequency used in TIG welding (GTAW), the erosion of the electrode by constantly etching its surface is diminished. This eliminates the phenomena of inconsistent arc starting, resulting in the loss of arc directability. The use of a pilot arc instead of conventional high frequency circuitry provides extremely reliable arc starting. This repeatable arc initiation nearly eliminates significant downtime and minimizes the number of rejects or reworks due to poor welds thus reducing scrap.

Constricted Arc

An orifice (also called a nozzle or a tip) which is inserted into the front end of the torch body provides for the laminar flow of the plasma gas and constriction of the arc. The magnitude of this constriction is normally controlled by three variables ... the orifice diameter, the plasma gas flow rate, and the electrode setback (the distance the electrode is recessed within the tip). The arc will be most constricted when the torch is operated at higher plasma gas flow rates and the electrode placed at maximum setback. This type arc is typically used when trying to achieve keyhole single pass welds requiring maximum penetration, narrower weld beads, minimized heat affected zone, and reduced base material distortion. Keyhole welding is generally used on material thickness ranging from .090" (2.3 mm) to .250" (6.4 mm).

By reducing the electrode setback and plasma gas flow rates, a softer, less constricted arc will occur. This type arc is typically used for the melt-in fusion (non-keyhole) mode and allows for faster travel speeds on reduced base material thickness .010" (.3 mm) to .187" (4.7 mm).

ULTIMA® 150 Plasma Welding Systems

SYSTEM INCLUDES: POWER SOURCE, TORCH, COOLANT & SPARE PARTS KIT

FOR PLASMA WELDING BELOW 150 AMPS

ULTIMA 150 PLASMA WELDING SYSTEMS

DC AMP RATING	SYSTEM DESCRIPTION	200-460VAC, 1/3PH, EMC	
		W/12.5 FT TORCH & LEADS	W/25 FT TORCH & LEADS
0.5-75 AMPS	PWH-2A, 70 DEG	1-1555-21	1-1556-21
	PWH-2A, 90 DEG	1-1555-22	1-1556-22
	PWH-2A, 180 DEG, OFFSET	1-1555-23	1-1556-23
10-100 AMPS	PWH-3A, 70 DEG	1-1555-31	1-1556-31
	PWH-3A, 90 DEG	1-1555-32	1-1556-32
	PWH-3A, 180 DEG, OFFSET	1-1555-33	1-1556-33
50-150 AMPS	PWH-4A, 70 DEG	1-1555-41	1-1556-41
	PWH-4A, 90 DEG	1-1555-42	1-1556-42
	PWH-4A, 180 DEG, OFFSET	1-1555-43	1-1556-43
	PWH-4A1, 180 DEG, INLINE	1-1555-53	1-1556-53

ULTIMA 150 OPTIONS	ULTIMA 150 POWER SOURCE ONLY	3-2772
	QUICK DISCONNECT KIT (ALLOWS EXISTING TORCHES TO BE CONVERTED FOR USE WITH ULTIMA 150)	5-2990

REPLACEMENT TORCHES

PART NO.	DESCRIPTION
PWH/M-2A TORCH (QUICK DISCONNECT)	
2-2100	70 deg. (H), 3.8m
2-2104	70 deg. (H), 7.6m
2-2101	90 deg. (H), 3.8m
2-2105	90 deg. (H), 7.6m
2-2102	180 deg. (H), offset 3.8m
2-2106	108 deg. (H) offset 7.6m
2-2103	180 deg. (M), offset 3.8m
2-2107	180 deg. (M), offset 7.6m

REPLACEMENT TORCHES

PART NO.	DESCRIPTION
PWH/M-3A TORCH (QUICK DISCONNECT)	
2-2110	70 deg. (H), 3.8m
2-2114	70 deg. (H), 7.6m
2-2111	90 deg. (H), 3.8m
2-2115	90 deg. (H), 7.6m
2-2112	180 deg. (H), offset 3.8m
2-2116	108 deg. (H) offset 7.6m
2-2113	180 deg. (M), offset 3.8m
2-2117	180 deg. (M), offset 7.6m

REPLACEMENT TORCHES

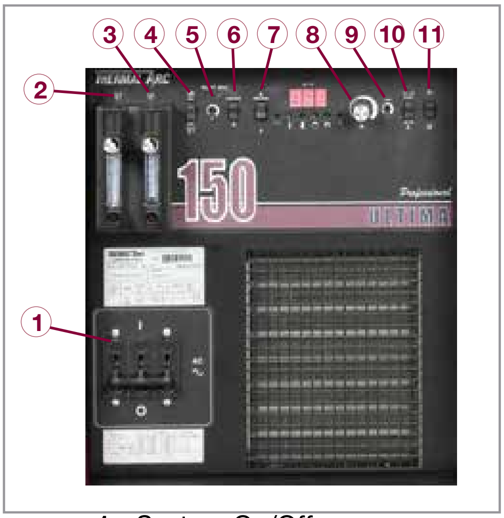
PART NO.	DESCRIPTION
PWH/M-4A1 TORCH (QUICK DISCONNECT)	
2-2120	70 deg. (H), 3.8m
2-2125	70 deg. (H), 7.6m
2-2119	90 deg. (H), 3.8m
2-2126	90 deg. (H), 7.6m
2-2121	180 deg. (H), offset 3.8m
2-2127	108 deg. (H) offset 7.6m
2-2122	180 deg. (M), offset 3.8m
2-2128	180 deg. (M), offset 7.6m
2-2123	180 deg. (H), inline 3.8m
2-2129	180 deg. (H), inline 7.6m
2-2124	180 deg. (M), inline 3.8m
2-2130	180 deg. (M), inline 7.6m

ULTIMA 150 - Features and Benefits

- **0.5-150 Amp current range** - providing quality performance on a wide variety of applications
- **Smooth DC arc** - repetitive, high quality welds
- **Pilot arc** - repeatable arc starting reducing defects and rework
- **Smart Logic** - circuit protects unit from damage if improper voltage is applied
- **Current Limiter** - limits power source output to torch capability to avoid torch damage
- **Preview Set Current** - eliminates costly test set-ups/ displays actual current/voltage
- **Protection devices:**
  - Coolant flow protection/interlock
  - Coolant temperature protection/interlock
  - Console temperature overload detection/interlock
- **Simple interface** - automated or manual control

MACHINE SPECIFICATIONS	
Processes	PAW Plasma Arc Welding
Rated Output	100A / 18V @ 100% 150A / 25V @ 50%
Open Circuit Voltage	60V DC
Rated Output:	150A @ 50%
Amperage Range	Low: 0.5 - 15 A High: 5 - 150 A
Warranty	2 Years
Dimensions (H x W x D)	457mm x 381mm x 724mm
Weight	59 kg
Shipping Weight	72 kg

PRIMARY POWER	
Primary Voltage	400 VAC
Supply Frequency	50/60 Hz
Number of Phases	3 ph



1 - System On/Off
2 - Shield Flow Control
3 - Plasma Flow Control
4 - Pilot Arc On/Set
5 - Pilot Current Adjust
6 - Pilot Current Preview
7 - Weld Current Preview / Actual
8 - Weld Current Adjust
9 - Current Limiter Adjust
10 - Weld Current Range
11 - Remote / Panel Control

The Ultima®150 Plasma Arc Welding System is self contained in a small package with a 150 amp power supply, coolant recirculator and control console with many advantages over traditional automated TIG welding. Its pilot arc circuit results in consistent arc starting every time, reducing scrap and improving process control for repeatable, high quality welds. The Ultima 150 virtually eliminates problems of high frequency interference (noise) with CNC controllers, phone systems and computers which are common with the TIG welding process. The perfect machine for Melt-In Fusion welding with power output needs under 150 amps when working on materials 3/16" (4.7 mm) thick or less.

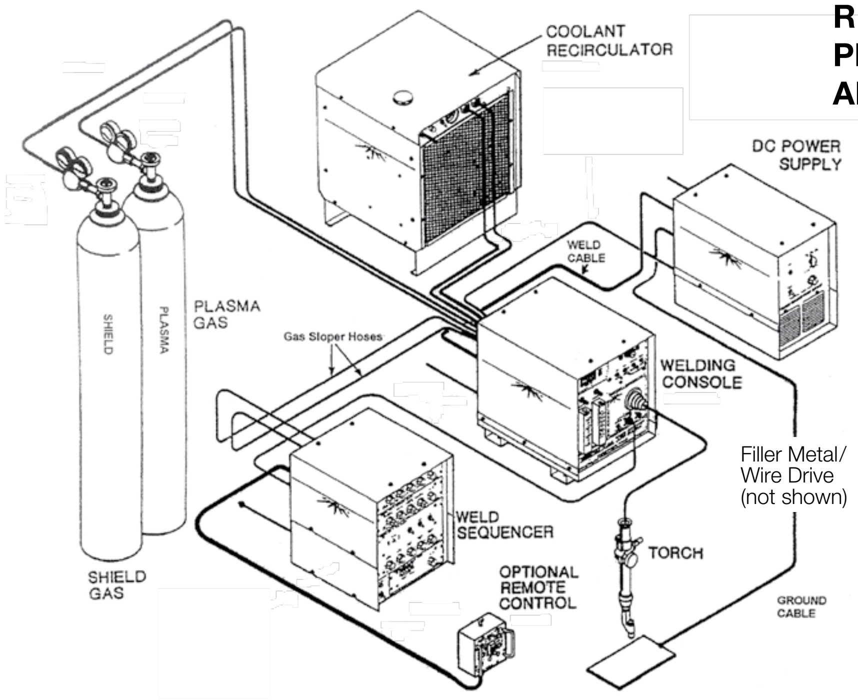
The Ultima 150 has a number of features for ionized coolant protection, coolant flow and console temperature monitors, as well as gas flow meters. Equipped with system status and error indicator lights to monitor input voltage, output current and pilot arc activity.

It can utilize any number of current Thermal Arc quick disconnect hand-held or automated torches and delivers high heat concentration and arc directability to work segment allowing for greater penetration and reduction in current levels in many applications.

OPTIONAL REMOTE CONTROLS	
PRODUCT	**PART NO.**
Foot Control, 25 ft. (Includes 7-3316 Adapter Cable)	7-3080
HP-100 Hand Held Remote Control, 25 ft. (Req. 7-3316 Adapter Cable)	10-2005
Adapter Cable	7-3316

Moldular Plasma Welding Systems

REQUIRED FOR PLASMA WELDING ABOVE 150 AMPS



Plasma Modular Equipment

Thermal arc offers everything to build the complete plasma arc welding system for your keyhole needs over 100 amps for welding metals greater than 3/16" thick.

A typical plasma welding system consists of:

- Welding Console
- DC Power Supply with a Suitable Welding Range
- Plasma Welding Torch (Manual or Mechanised)
- Closed Loop Coolant Recirculator
- Inert Gas Flowgauge Regulators

Plasma Welding Torch

(Manual or Mechanised)

A plasma welding torch suitable for the particular welding operation should be used. Torches are available with various head and size configurations. All are liquid cooled. The orifices of some torches are also liquid cooled to provide improved orifice life and higher current carrying capacity. Plasma torches use tungsten electrodes, which are normally 2% thoriated.

Welding Console

The pilot arc control console is the 'mixing box' into which the power, gases and coolant are controlled and monitored. It has a small DC power supply for the pilot arc. Some consoles provide additional controls and digital meters to assist in weld parameter control.

Closed Loop Coolant Recirculator

A coolant recirculator of a nonferrous design must be used. The use of deionized water to prevent electrolysis in the torch is required.

DC Power Supply

A typical DC power supply with constant-current characteristics, remote contactor/current control, and suitable welding range is recommended for most operations. A solid-state power supply with a non-mechanical contactor is recommended when performing high duty cycle short duration welds. Plasma arc welding is done almost exclusively with the use of straight polarity (DCEN). The use of an AC Square-Wave power supply is recommended for the welding of aluminum or aluminum alloys.

Optional Accessories

Options for the plasma welding system could include Weld Controllers with remote hand pendants and cables. A Weld Sequencer package would be needed to monitor and control pulse, weld timing, current and gas slopes. For applications using filler metals, a Wire Feeder Capstan with spool assembly and torch bracket would be required.

WC 100B Welding Console

Automatic/Manual Operation, Pilot Arc

Compatible with all Thermal Arc plasma welding torches, the WC 100B features reliable arc starting by means of a pilot arc. It offers advantages in low-current welding operations and in repetitive, high-duty-cycle, automatic applications. The pilot arc can be used in either interrupted or continuous mode. The latter provides greater arc stability along with instant arc starting at low currents or in high-duty-cycle, fast cycling welding. Other feature include: LED amperage/voltage display; large, easy-to-read plasma and shield gas flowmeters; internal torch leads connections for increased safety; Hi/Low pilot current switch to provide the best arc starting characteristics at various main arc current levels; plug-in enclosed relays; and auxiliary control receptacle for automatic or manual operation.

PowerMaster PLUS 400SP

400 Amp Welding Power Source

MACHINE SPECIFICATIONS	
Nominal Supply Voltage	400V±15%
Nominal Supply Frequency	50/60Hz
Phase	3 phase
Standard	IEC 60974-1
Power Factor at Maximum Output	0.99
Recommended Fuse Size	32 Amp
Input Current at Maximum Output	28.1 Amp
Torch Cooling	Fan Cooled / Liquid Cooled
Welding Current Range	5-400 Amp
Welding Voltage Range	15.2-34V
Nominal DC Open Circuit Voltage	81V
100% Rated Duty Cycle	350 Amp @ 31.5V
60% Rated Duty Cycle	400 Amp @ 34V
Dimensions (HxWxD)	855 x 445 x 1116 mm
Weight	112kg
Warranty Period	3 Years

The PowerMaster 400SOP Welding Power Source is designed to deliver the welding current power you need for those higher amperage plasma welding applications. The unit is perfectly fitted to connect to the Thermal Arc WC-100B Plasma Welding Console when used with the accessory remote control, cables and interface kit listed on page 12.

This workhorse will meet the productivity requirements you need on automated plasma welding applications.

Coolant Recirculators

For Modular Plasma Welding Systems

HE-100A Coolant Recirculator

High efficiency and completely non-ferrous internal construction (including a reusable metal filter) make the HE 100A a useful, dependable companion for any Thermal Arc plasma welding system to 300 Amps.

A positive displacement, rotary vane pump delivers a maximum of 2.3 gpm (8.7 lpm) at 100 psi (.9 lpm at 7 kg/cm2). The pressure is adjustable. Maximum rating is 20,000 BTU/hr (5040 K/Cal/hr) (based on 100°F [38.8°C] difference between ambient air and high coolant temperature, and 40°F [4°C] difference between high and low coolant temperature).

HE-150 Coolant Recirculator

The HE-150 is required for applications above 300 Amps, and is used with the PWM-6A Torch. The unit delivers a maximum of 4 gpm at 125 psi, and a maximum rating of 65,000 BTU/hr (based on 100°F [38.8°C] difference between ambient air and high coolant temperature, and 40°F [4°C] difference between high and low coolant temperature).

Moldular Systems Ordering Information

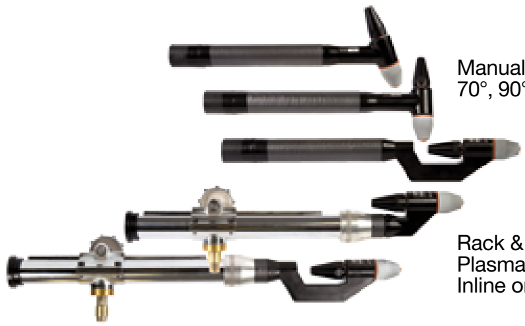
WELDING POWER SUPPLY			
PRODUCT	**AMP RATING / DUTY CYCLE**	**INPUT VOLTAGE**	**PART NO.**
PowerMaster PLUS 400SP	350A @ 100% 400A @ 60%	400V, 3Ph, 50/60Hz	W1000303PP

ACCESSORIES		
HR911 Remote Control	**REQUIRED** to use PowerMaster PLUS 400SP as part of a modular plasma welding installation	W4000100
CAN Cable		W7000450
14-Pin Interface Kit		W4012101

WELDING CONSOLE			
PRODUCT	**APPLICATION**	**INPUT VOLTAGE**	**PART NO.**
WC-100B Console	**KEYHOLE (USES FLOWMETER 0.2 - 3.6 SCFH)**	400V, 3Ph, 50Hz	3-2657-14
	KEYHOLE (USES FLOWMETER 0.8 - 7.0 SCFH)	400V, 3Ph, 50Hz	3-2657-24

COOLANT RECIRCULATORS				
PRODUCT	**NOTE**	**MAX RATING**	**INPUT VOLTAGE**	**PART NO.**
HE-100A Coolant Recirculator	For Systems Less Than 300A	**20,000 BTU/HR**	230V, 1Ph, 50Hz	7-3011-3
HE-150 Coolant Recirculator	**REQUIRED** for PWM-6A torch (Rating >300A DC and above)	**65,000 BTU/HR**	230V, 1Ph, 50Hz	7-2972-3

Plasma Torches



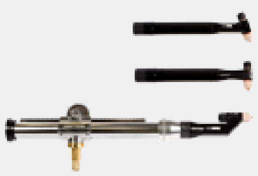
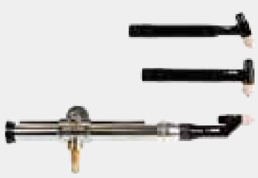
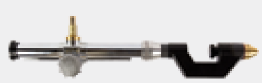
Manual Plasma Torches
70°, 90° and 180° (PWH)

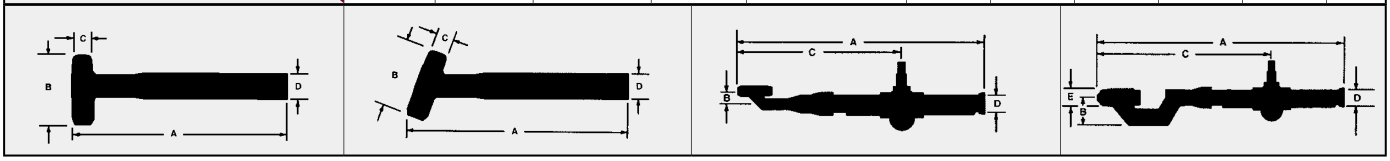
Rack & Pinion Automated
Plasma Torches 180°
Inline or Offset (PWM)

WELDING PROCESSES:
PLASMA (PAW)

Plasma Torches come complete with:

- Torch Spare Parts Kit
- Rack & Pinion Assembly
  (PWM designated models only)
- 12.5 ft (3.8 m) or 25 ft (7.6 m) Lead
- Operator's Manual *(not shown)*

Torch		Type	Part No.	Torch Lead Length	Current Rating	Coolant Requirements	Torch Dimensions					
							A	B	C		D	E
	2A	PWH-2A 70°	2-2443	12.5 ft (3.8 m)	75 Amps (DCSP)	2,000 BTU/hr (504 K/Cal/hr) 1/4 gpm coolant flow @ 50 PSI (0.9 lpm @ 3.7 kg/cm²)	7-15/16" (202 mm)	1-11/16" (43 mm)	5/8" (16 mm)		7/8" (22 mm)	
		PWH-2A 90°	2-2506	25 ft (7.6 m)			7-3/4" (196 mm)	1-11/16" (43 mm)	5/8" (16 mm)		7/8" (22 mm)	
		PWM-2A 180° Offset with rack & pinion	2-2480	12.5 ft (3.8 m)			18-1/4" (463 mm)	13/16" (21 mm)	Min. 9-1/4" (235 mm)	Max. 15" (381 mm)	1-3/8" (35 mm)	
	3A	PWH-3A 70°	2-2527	12.5 ft (3.8 m)	150 Amps (DCSP)	6,000 BTU/hr (1513 K/Cal/hr) 1/3 gpm coolant flow @ 50 PSI (1.25 lpm @ 3.7 kg/cm²)	8-3/4" (222 mm)	2-5/8" (67 mm)	7/8" (22 mm)		1-1/16" (27 mm)	
			2-2599	25 ft (7.6 m)								
		PWH-3A 90°	2-2529	12.5 ft (3.8 m)			8-1/2" (216 mm)	2-5/8" (67 mm)	7/8" (22 mm)		1-1/16" (27 mm)	
			2-2623	25 ft (7.6 m)								
		PWH-3A 180° Offset	2-2616	12.5 ft (3.8 m)			19-1/4" (489 mm)	1" (25 mm)	Min. 9-1/4" (235 mm)	Max. 16-3/4" (425 mm)	1-3/8" (35 mm)	
			2-2621	25 ft (7.6 m)								
		PWM-3A 180° Offset with rack & pinion	2-2531	12.5 ft (3.8 m)								
			2-2624	25 ft (7.6 m)								
	4A	PWH-4A 70°	2-2821	12.5 ft (3.8 m)	220 Amps (DCSP)	8,000 BTU/hr (2017 K/Cal/hr) 1/2 gpm coolant flow @ 50 PSI (1.9 lpm @ 3.7 kg/cm²)	12-1/2" (318 mm)	3-3/16" (81 mm)	1-1/4" (32 mm)		1-3/8" (35 mm)	
			2-2820	25 ft (7.6 m)								
		PWH-4A 90°	2-2819	12.5 ft (3.8 m)			12-1/4" (311 mm)	3-3/16" (81 mm)	1-1/4" (32 mm)		1-3/8" (35 mm)	
		PWM-4A 180° Offset with rack & pinion	2-2482	12.5 ft (3.8 m)			18" (457 mm)	1-3/4" (44 mm)	Min. 8-1/4" (209 mm)	Max. 16" (406 mm)	1-3/8" (35 mm)	1-1/4" (32 mm)
			2-2592	25 ft (7.6 m)								
		PWH-4A1 180° Inline	2-2850	12.5 ft (3.8 m)			21" (533 mm)	1-3/4" (44 mm)	Min. 11-1/4" (286 mm)	Max. 19" (483 mm)	1-3/8" (35 mm)	1-1/4" (32 mm)
			2-2851	25 ft (7.6 m)								
		PWM-4A1 180° Inline with rack & pinion	2-2804	25 ft (7.6 m)								
	300	PWM-300	2-2845	12.5 ft (3.8 m)	300 Amps (DCSP)	12,000 BTU/hr (3025 K/Cal/hr) 3/4 gpm coolant flow @ 100 PSI (1.9 lpm @ 3.7 kg/cm²)	22-3/16" (.56 m)	2-1/"2 (64 mm)	Min. 8-1/4" (209 mm)	Max. 8-1/4" (209 mm)	1-3/8" (35 mm)	1-5/8" (41 mm)
			2-2846	25 ft (7.6 m)								
	6A	PWM-6A	2-2731	12.5 ft (3.8 m)	500 Amps (DCSP)	20,000 BTU/hr (5042 K/Cal/hr) 2 gpm coolant flow @ 50 PSI (1.9 lpm @ 3.7 kg/cm²)	13-1/2" (343 mm)	1-1/8" (29 mm)	Min. 8-1/4" (209 mm)	Max. 8-1/4" (209 mm)	2-1/4" (57 mm)	
			2-2720	25 ft (7.6 m)								

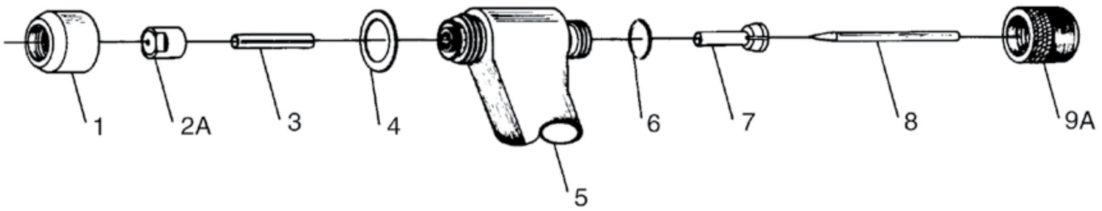


THERMAL ARC

Torch Parts & Consumables

PWH/M 2A Torch

75 Amp Plasma Welding Torch



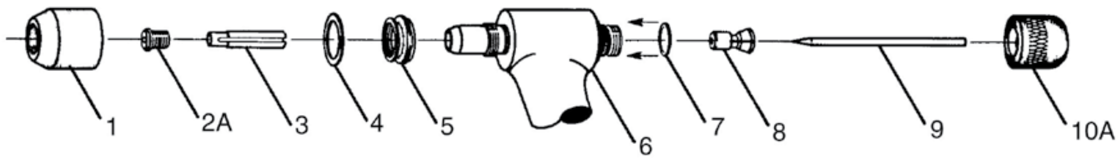
DESCRIPTION	REF.	PART NO.
Spare Parts Kit		5-2984
Torch Head - 70°	5	8-2027
Torch Head - 90°	5	8-2028
Torch Head - 180° (offset)	5	8-2097
Torch Leads set, 3.8m		4-2539
Torch Leads set, 7.6m		4-2585
PWH torch handle		8-2026
Quick Disconnect Adapter Kit		5-2990
Shield Cup - Standard Tip	1	8-2071
Shield Cup - Extended Tip	1	8-3236
Tip - 35A, (.045), Standard	2	8-2023
Tip - 55A, (.062), Standard	2	8-2024
Tip - 75A, (.081), Standard	2	8-2025
Tip - 15A, (.031), Extended	2	8-2079
Tip - 25A, (.045), Extended	2	8-2080
Tip - 35A, (.062), Extended	2	8-2082
Tip - 50A, (.081), Extended	2	8-2083

DESCRIPTION	REF.	PART NO.
Electrode (.093), Standard	8	8-2033
Electrode (.093), Extended	8	8-2006
Electrode (.040), Standard	8	8-2044
Electrode (.040), Extended	8	8-2046
Gas Distributor (.093)	3	8-2040
Gas Distributor (.040)	3	8-2042
Shield Cup Gasket	4	8-2036
O-Ring, Back Cap	6	8-2035
Collet for .093 Electrode	7	8-2039
Collet for .040 Electrode	7	8-2041
Back Cap - Standard	9	8-2032
Back Cap - Extended	9	8-2030
Electrode Gauge / Wrench		8-2021

Torch Parts & Consumables

PWH/M 3A Torch

150 Amp Plasma Welding Torch



DESCRIPTION	REF.	PART NO.
Spare Parts Kit		5-2985
Torch Head - 70°	6	8-3030
Torch Head - 90°	6	8-3031
Torch Head - 180° (offset)	6	8-3032
Torch Leads set, 3.8m		4-2615
Torch Leads set, 7.6m		4-2624
PWH torch handle		9-1757
Quick Disconnect Adapter Kit		5-2990
Shield Cup	1	8-3038
Shield Cup with gas lens	1	8-3040
Tip - 10A, (.014), Standard	2	8-3052
Tip - 15A, (.022), Standard	2	8-3053
Tip - 30A, (.031), Standard	2	9-1782
Tip - 50A, (.046), Standard	2	9-1783
Tip - 75A, (.062), Standard	2	9-1784
Tip - 100A, (.081), Standard	2	9-1785
Tip - 130A, (.093), Standard	2	9-1795

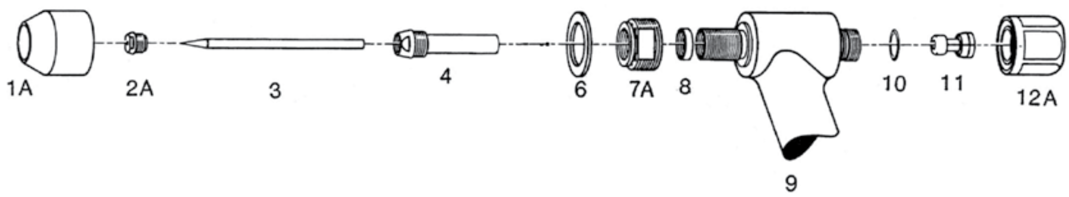
DESCRIPTION	REF.	PART NO.
Tip - 30A, (.031), Extended	2	9-1788
Tip - 50A, (.046), Extended	2	9-1789
Tip - 75A, (.062), Extended	2	9-1790
Tip - 100A, (.081), Extended	2	9-1791
Tip - 130A, (.093), Extended	2	9-1811
Electrode (.093), Standard	9	8-2007
Electrode (.093), Extended	9	9-1775
Gas Distributor	3	9-2240
Shield Cup Gasket	4	8-3057
Gas Diffuser	5	8-3059
O-Ring, Back Cap	7	8-0527
Collet	8	9-1780
Back Cap - Standard	10	9-1779
Back Cap - Extended	10	9-1803
Electrode Gauge / Wrench		9-1810

THERMAL ARC

Torch Parts & Consumables

PWH/M 4A Torch

220 Amp Plasma Welding Torch



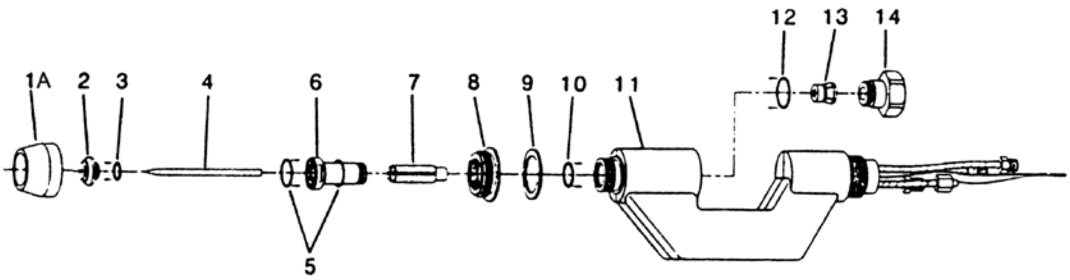
DESCRIPTION	REF.	PART NO.
Spare Parts Kit		5-2986
Torch Head - 70°	9	8-4014
Torch Head - 90°	9	8-4015
Torch Head - 180° (offset)	9	8-4016
Torch Head - 180° (inline)	9	8-4054
Torch Leads set, 3.8m		4-2525
Torch Leads set, 7.6m		4-2544
PWH torch handle		9-5914
Quick Disconnect Adapter Kit		5-2990
Shield Cup - Ext, Tip, (Threaded)	1	8-4064
Shield Cup - Std, Tip, (Slip-on)	1	8-4088
Tip - 100A, (.062), Standard	2	9-1847
Tip - 125A, (.093), Standard	2	9-1848
Tip - 150A, (.125), Standard	2	9-1849
Tip - 100A, (.062), Extended	2	9-1890
Tip - 125A, (.093), Extended	2	9-1891
Tip - 150A, (.125), Extended	2	9-1892

DESCRIPTION	REF.	PART NO.
Electrode (.187), Standard	3	9-1827
Electrode (.187), Extended	3	9-1834
Gas Distributor	4	9-2204
Liner		8-4011
Shield Cup Gasket	6	8-4069
O-Ring, Liner		8-0560
O-Ring, Torch		8-0528
Gas Diffuser (Threaded)	7	8-4040
Gas Diffuser (Slip-on)	7	8-4087
Collar	8	8-4024
O-Ring, Back Cap	10	8-0530
Collet	11	9-1876
Back Cap - Standard	12	8-4158
Back Cap - Extended	12	9-1877
Electrode Gauge / Wrench		9-1873

Torch Parts & Consumables

PWM 300 Torch

300 Amp Plasma Welding Torch

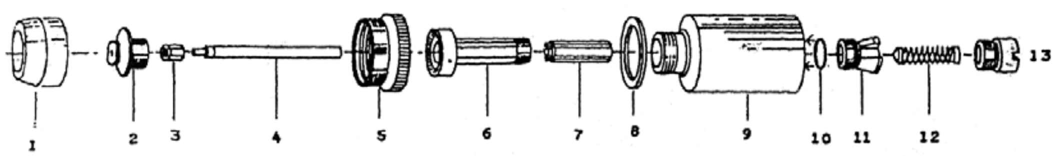


DESCRIPTION	REF.	PART NO.
Spare Parts Kit		5-2910
Torch Head - 180°	11	8-6649
Torch Leads set, 3.8m		4-2525
Torch Leads set, 7.6m		4-2544
Shield Cup - Brass	1	8-4373
Shield Cup - Ceramic	1	8-6542
Tip - 200A, (.093)	2	8-4370
Tip - 250A, (.113)	2	8-4371
Tip - 300A, (.125)	2	8-4372
Electrode (.178)	4	9-1827

DESCRIPTION	REF.	PART NO.
Gas Distributor	7	8-6651
Liner	6	8-6509
Shield Cup Gasket	9	8-6512
O-Ring, Liner	5	9-2956
O-Ring, Torch	10	8-0531
Gas Diffuser	8	8-6652
Shield Adaptor for 8-6542		8-6541
O-Ring, Back Cap	12	8-3487
Collet	13	8-6650
Back Cap	14	8-6654
Electrode Gauge / Wrench		8-6653

PWM 6A Torch

500 Amp Plasma Welding Torch



DESCRIPTION	REF.	PART NO.
Torch Head - 180°	9	8-6502
Shield Cup	1	8-6542
Tip - 100A (.067)	2	8-6526
Tip - 200A (.099)	2	8-6527
Tip - 300A, (.125)	2	8-6528
Tip - 400A, (.156)	2	8-6539
Tip - 500A, (.187)	2	8-6540
Electrode 100A - 300A	4	8-6545
Electrode 400A - 500A	4	8-6549

DESCRIPTION	REF.	PART NO.
Gas Distributor	3	8-6547
Liner	6	8-6509
Sleeve	7	8-6565
Shield Cup Gasket	8	8-6512
Shield Adaptor	5	8-6541
O-Ring, Back Cap	10	8-3487
Collet	11	8-6548
Spring	12	8-5031
Back Cap	13	8-6520
Tip Wrench		8-6517

Plasma Welding Controllers

WELD TIMERS, WELD PULSERS, CURRENT SLOPING, GAS SLOPING			
PRODUCT	CONNECTION	INPUT VOLTAGE	PART NO.
WC-1 Weld Process Controller		110/230V, 1PH, 50/60HZ	600279
Contol Cable, 10 ft.	WC-100B to WC-1		9-4129
Remote Hand Pendant, 25 ft.	WC-1		600280

WC-1 Weld Process Controller

SYSTEM FEATURES:

- Remote Hand Pendant
- Adapter Cables Included
- Full-Featured Current Pulser controls warpage, penetration and weld puddle
- 32 User-Selectable Weld Schedules

The Thermal Arc WC-1 Weld Process Controller adds a compact packaged micro-processor system to the plasma welding package providing accurate and repeatable parameter control over the entire welding system. The Sloper Function is designed to permit the development of a complete sequence of operation for a specific welding job. With two Programmable Outputs, the first is used to control the Plasma power source and the second controls a Cold Wire Feed Motor Drive Control. The perfect fit to control your Modular Plasma System.

WF-100 Wire Capstan Feeder

SYSTEM FEATURES:

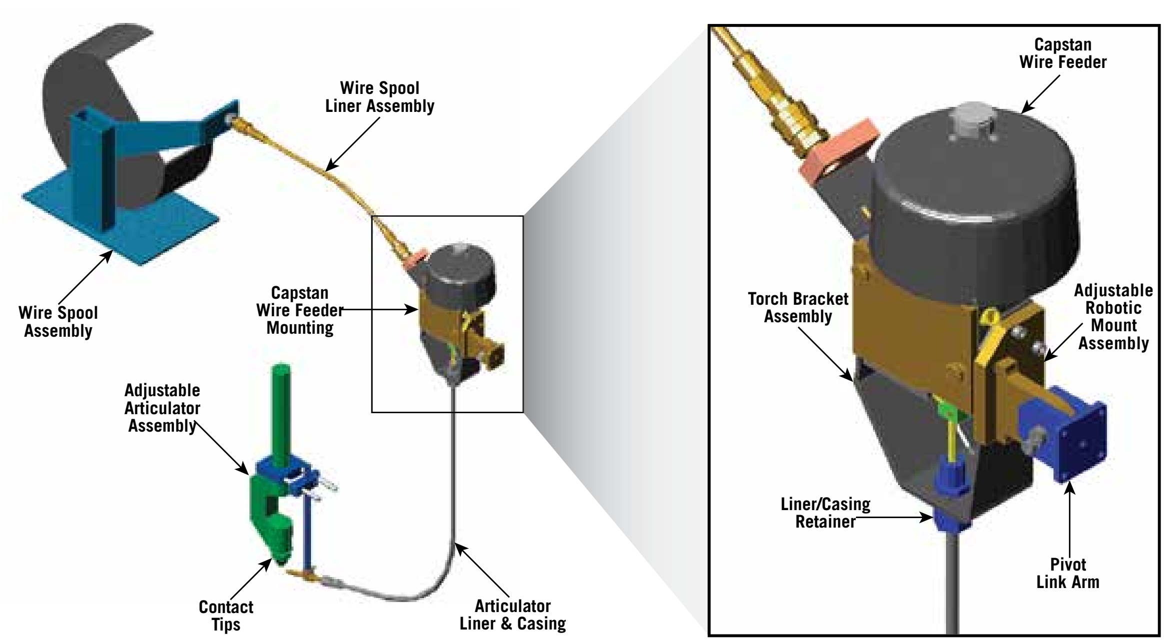
- Plastic Deforms the Filler Wire virtually eliminating wire cast
- Increased Drive Force eliminates wire slip, flattening and damage to wire surface

The Thermal Arc WF-100 Cold Wire Capstan Feeder is a compact, precision wire feeder for robotic or automation fixture applications. The Capstan's small size and light weight (less than 6 lbs.) allows it to be placed directly on the automated fixture or robot wrist and also provides an increase in wire drive contact area by wrapping the wire around the wire drive wheel. The Integral Wire Straightener on the discharge side of the feeder allows the wire drive to precisely locate the filler wire independent of wire cast.

Other Optional Equipment that might be required to complete your filler wire needs could include: Wire Size Configuration Kit, Torch Bracket, Adjustable Robotic Mounts, Pivot Link Arm, Casing/Liner Retainer, Wire Spool Assembly, Adjustable Articulator Assembly and Contact Tips.

Adding Filler Metal To The Weld Pool

WF-100 CAPSTAN WIRE DRIVE SYSTEM							
	PRODUCT	WIRE SIZE					PART NO.
		.030"	.035"	.040"	.045"/.047"	.052"	
	WF-100 Capstan Wire Drive	■	■	■	■	■	E2A5112
	Interface Control Circuit (Req. for WC-1 Weld Process Controller)	■	■	■	■	■	C3A5005
SELECT WIRE SIZE	Wire Size Configuration Kit, .030”, White	■					E2A5164
	Wire Size Configuration Kit, .035”, Red		■				E2A5165
	Wire Size Configuration Kit, .040”, Gold			■			E2A5166
	Wire Size Configuration Kit, .045”/.047”, Yellow				■		E2A5167
	Wire Size Configuration Kit, .052”, Blue					■	E2A5168
	Capstan Drive Torch Bracket Assembly	■	■	■	■	■	E2A5190
	Adjustable Robotic Mount Assembly, Right Side Mount	■	■	■	■	■	E2M5646
	Adjustable Robotic Mount Assembly, Left Side Mount	■	■	■	■	■	E2A5120
	Pivot Link Arm	■	■	■	■	■	E2M5816
	Casing/Liner Retainer	■	■	■	■	■	S2A5002
	Wire Spool Assembly	■	■	■	■	■	S2A5001
SELECT WIRE SIZE & LENGTH	Wire Spool Liner Assembly, .030”-.047", 10 ft (3 m)	■	■	■	■		E7A5001
	Wire Spool Liner Assembly, .030"-.047", 15 ft (4.6 m)	■	■	■	■		E7A5002
	Wire Spool Liner Assembly, .052"-.062", 10 ft (3 m)					■	E7A5003
	Wire Spool Liner Assembly, .052"-.062", 15 ft (4.6 m)					■	E7A5004
	Articulator Liner & Casing, .030"-.047", 3 ft (0.9 m)	■	■	■	■		E7A5011
	Articulator Liner & Casing, .052"-.062", 3 ft (0.9 m)					■	E7A5012
	Cold Wire Plasma Torch Articulator Assembly, 1-3/8", Adjustable	■	■	■	■	■	E2A5194
SELECT WIRE SIZE & TYPE	Contact Tips, .030", Solid/Flux Core Wire	■					X7T5005
	Contact Tips, .035", Solid/Flux Core Wire		■				X7T5003
	Contact Tips, .045"/.047", Solid/Flux Core Wire				■		X7T5004
	Contact Tips, .052", Solid/Flux Core Wire					■	X7T5033
	Contact Tips, .030”, Stainless Steel	■					X7T5034
	Contact Tips, .035", Stainless Steel		■				X7T5026

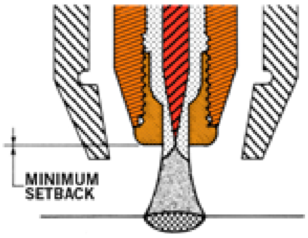


Modes Of Operation - Melt-In Fusion Welding

Plasma welding is commonly used in two modes of operation, Melt-In Fusion Welds and Keyhole Welds.

Melt-In Fusion Welding

This type weld mode is the most often used with the plasma arc welding process. It is accomplished with a softer, less constricted arc, using lower plasma gas flow rates, a reduced electrode setback, and current levels in the range of up to 200 amps. The minimum electrode setback distance is obtained with the electrode point set flush with the face of the tip. This technique of setting the electrode allows the plasma gas flow rate to be decreased while maintaining higher current ratings of the tip. This normally provides a slightly wider weld bead in most cases allows for increased travel speeds. This type weld mode is very similar to that of gas tungste arc welding with additional advantages in many applications.



Advantages:

1) Reliable arc starting
2) Reduced heat input or distortion
3) Protected electrode
4) Lower current levels required
5) Less sensitive to stand-off changes
6) Improved arc stability at low current
7) Arc is more directional (less arc wander)
8) Improved weld geometry and penetration control

Types of Welds/Joint Configurations:

1) Spot fusion welds
2) Corner/edge fusion welds
3) Flange fusion welds
4) Square butt fusion welds
5) Surface fusion welds
6) Lap fusion welds

Spot Welding

Plasma arc welding is well suited for spot fusion welding because of its reliable arc starting characteristics and high response time. It is typically used for tacking, joining, or sealing operations. All metals amenable to the gas tungsten arc process can be spot welded with plasma arc process.

Fusion Welding

Plasma arc welding can be used in all positions when using the melt-in mode. Typically circumferential and longitudinal seam welds are welded in the flat positions. Corner/edge and surface fusion (lamination welds) provide improved travel speeds and reduced heat input in the vertical down position.

Joint Design And Fixturing

In many cases the common practices in joint design and fixturing typically used with gas tungsten welding can also be incorporated with plasma arc welding. The use of copper or aluminum heat sinking in many applications can enhance the welding operation. When thin metals are welded, both joint edges must be in continuous contact and must melt simultaneously to fuse together into a single weld puddle. Separation between the joint edges before or during welding will allow the edges to melt separately and remain separate.

Much larger tolerances for joint fixturing can be obtained by flanging the edges. Turned-up edges act as pre-placed filler wire to fill the gap and ensure melt contact of the sides of the joint. They also stiffen the joint edges to minimize warpage from heat built up during welding. Flanging is recommended for all butt joints in foil thicknesses below 0.010" (0.25 mm).

Filler Metal Addition

Filler wire can be added to the leading edge of a plasma weld puddle, as in the gas tungsten arc process. Wire-height adjustments are not generally as critical with plasma arc welding because the wire can lift off the plate and melt into the plasma stream without contaminating the electrode. However, wire placement is still important because the wire can ball-up when lifted from the plate.

Suggested Parameters for Mechanised (Non- Keyhole) Circumferential, Seam, and Spot Fusion Welds

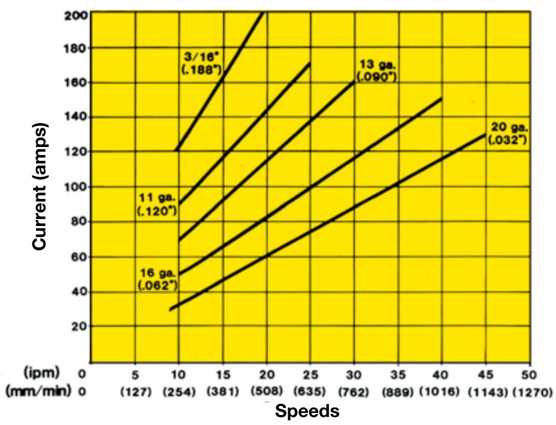


Figure 3-C. Current Levels

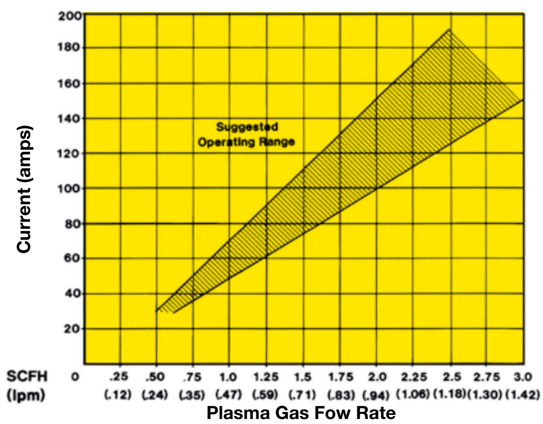


Figure 3-D. Plasma Gas Flow Rates

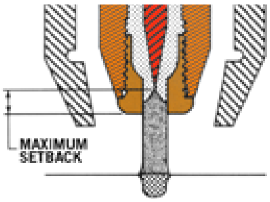
Materials	Joint Types	Electrode Setback	Plasma Gas	Shield Gas
Stainless Steel Carbon & Alloy Steels Nickels	Butts & Corners Edge & Flanged	Minimum Standoff set at 3/32" – 5/32" (2.4 – 4.0 mm)	Argon	Argon / Hydrogen Shield Gas at 10 – 20 SCFH (4.7 – 9.4 lpm)

Most steels require approximately 10 – 15% higher current at equal travel speeds. ** Faster travel speeds may be required for these welds.*
The maximum current rating of each tip is established using maximum electrode setback and maximum plasma gas flow rates.
Lower plasma gas flow rates can be used with the maximum current rating of the tip if the electrode setback is set at minimum.

Modes Of Operation - Keyhole Welding

Keyhole Welding

This type weld is generally obtained by using a stiff, constricted arc. Penetration is obtained by the combination of plasma and gas momentum with thermal conduction. With increased plasma gas flow rates and electrode setback, a hole known as the keyhole is pierced through the entire metal thickness at the leading edge of the weld puddle, where the forces of the plasma jet (column) displace the molten metal. As the torch travel progresses at a consistent speed, the molten metal, supported by surface tension, flows behind the keyhole to form the weld bead. Keyhole welding is almost exclusively performed in the automated mode. Typically this technique is used for square butt welds on material thickness from .093" (2.4 mm) to .250" (6.4 mm) requiring 100% penetration in a single pass. Manual keyhole welding is not recommended because of difficulties in maintaining consistent travel speeds, torch position or filler material addition.



Advantages:

1) Reduced current levels
2) Single-pass welds
3) Minimized weld preparation
4) Narrower weld beads
5) Improved weld geometry
6) Less filler material required
7) Visual proof of 100% weld penetration

Keyhole Starting

In material thicknesses under .090" (2.3 mm), circumferential and longitudinal seam keyhole welds can generally be started at full operating current, plasma gas flow rate and travel speed. In this thickness range, the keyhole is developed with little disturbance in the weld puddle, and the weld surface and under-bead are kept fairly smooth. However, in thicker materials, the operating parameters can produce a tunneling or gouging effect underneath the surface of the molten puddle just prior to piercing the weld joint and starting the keyhole. Because this tunneling or gouging action may cause gas porosity or surface irregularities, starting tabs for longitudinal welds and programmed taper (upslope) of plasma gas and current for circumferential weld is normally recommended.

Keyhole Ending

If the welding current is turned off abruptly at the end of a keyhole weld, the keyhole may not close. This is not usually objectionable when stopping on ending tabs that are typically used on longitudinal welds. Plasma gas and weld current taper (downslope) is recommended for the ending of the keyhole on circumferential welds. This allows for lowering of the arc force and heat input so that the molten metal can gradually flow into the keyhole and solidify.

Underbead Gas Backing

If a particular keyhole welding application requires an underbead backing, it is recommended that a rectangular shaped groove be used. This provides underbead shielding gas, and allows for the venting of the plasma column. Groove dimensions of approximately 1 to 1.5 T (metal thickness) wide and 2 to 2.5 T deep. Shallow grooved backing bars will cause the weld to become inverted toward the surface.

Filler Metal Addition

The exceptional penetration capabilities of a constricted arc reduce the amount of filler wire, the number of passes, and the total arc time needed to join metal thicknesses requiring multi-pass welds. Filler wire added to the leading edge of the puddle of a keyhole weld will flow around the keyhole to form a reinforced weld bead. This technique can be used on single-pass welds in materials up to about 1/4" (6.4 mm) thick, generally with a square-butt-joint preparation. Filler wire is not generally added on the root pass of a multi-pass weld because the plasma jet melts the maximum amount of base metal that can be supported by surface tension.

Multi-Pass Welding

In multi-pass welding, the root pass is usually a keyhole weld, followed by one or more non-keyhole weld passes with filler metal. In the fill and cover passes, the force of the plasma jet is adjusted for suitable penetration by regulating the type and flow rate of plasma gas. Helium in the argon shielding gas is favored for some fill and cover passes because it provides a broader heat pattern and produces a flatter cover pass.

Suggested Starting Parameters for Mechanized Circumferential and Seam Keyhole Welding

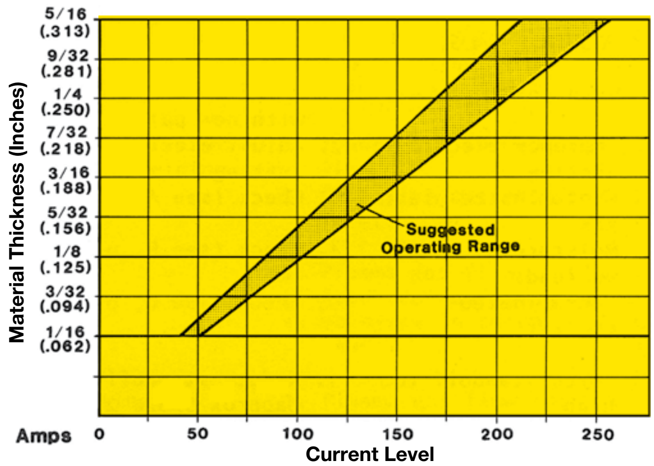


Figure 3-E. Current Levels

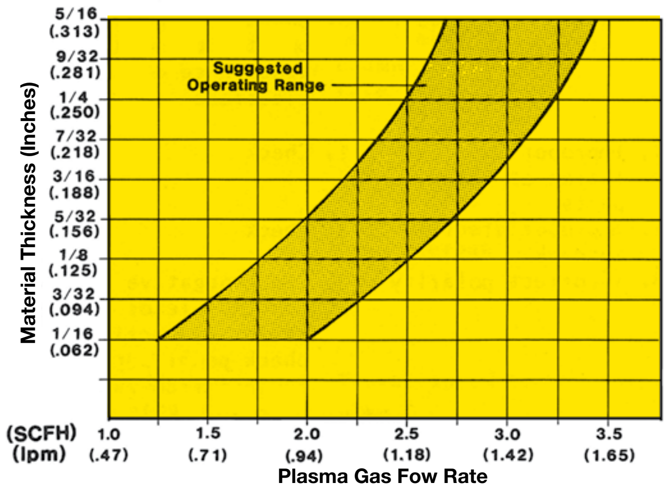


Figure 3-F. Plasma Gas Flow Rates

Materials	Joint Types	Electrode Setback	Plasma Gas	Shield Gas
Stainless Steel Carbon & Alloy Steels Nickels	Square Butts	Minimum Standoff set at 1/8" – 1/4" (3.2 – 6.4 mm)	Argon	Argon / Hydrogen Shield Gas at 10 – 20 SCFH (4.7 – 9.4 lpm) with travel speeds 10-12 ipm

Most steels require approximately 10 – 15% higher current at equal travel speeds. ** Faster travel speeds may be required for these welds.*
The maximum current rating of each tip is established using maximum electrode setback and maximum plasma gas flow rates.
Lower plasma gas flow rates can be used with the maximum current rating of the tip if the electrode setback is set at minimum.

NOTE: For material thicknesses greater than 5/16" the 6A Torch is required.

Plasma Arc Welding – Gas Selection

Plasma and shielding gases for melt-in fusion and keyhole weld modes are listed below.

PLASMA GASES

Argon

Argon is the preferred plasma gas and is used in over 90% of all applications. It is totally inert meaning it will not react with other materials at any temperature or pressure. Its low ionization potential assures reliable arc starting and a dependable pilot arc. Argon provides good arc stability and an excellent protective blanket for the tungsten electrode.
Flow rates range approximately
.25 SCFH (.18 lpm) - 5.0 SCFH (2.4 lpm)

Argon/Hydrogen (up to 3% Hydrogen)

Addition of small amounts of Hydrogen to Argon is sometimes recommended. This increases the heat input to the weld puddle. Argon/Hydrogen will provide a hotter arc assisting in both penetration and weld puddle fluidity. Torch parts life will be lower when using Argon/Hydrogen mixtures versus argon.

Tip Current Ratings are reduced by half when using Hydrogen gas mixture.
Flow rates range approximately
.25 SCFH (.18 lpm) - 5.0 SCFH (2.4 lpm)

N0TE: See section on Argon/Hydrogen in Shield Gases.

SHIELDING GASES

Argon

Argon may be used for all metals. It provides good arc stability and effective cleaning at the lower current levels (less than 20 amps). It is also recommended for use in the welding of aluminum, copper alloys, titanium and reactive metals.
In some cases, Argon may not perform satisfactorily due to the higher arc voltages that are used in plasma welding (18-32V). Where the weld puddle is not fluid, slight undercutting occurs, and/or surface oxidation of the weld is noticed. The use of argon/hydrogen, helium or argon/helium mixtures may be necessary.

Argon/Hydrogen (95/5%)

Argon/Hydrogen mixtures are used to provide increased heat input to the weld. The addition of Hydrogen to Argon reduces surface tension of the molten pool resulting in increased travel speeds. By reducing the surface tension of the molten metal, degassing of the weld pool is also facilitated so that the danger of gas inclusions in the form of porosity is lessened. At higher welding speeds, undercutting is also avoided and a smoother weld surface is achieved.

In addition to the increased arc heating efficiency, Hydrogen has a fluxing effect that reduces the amount of oxides formed when joining stainless steels, nickel and high nickel alloys. When welding nickel or nickel alloys, the presence of Hydrogen actually helps by preventing porosity. Nickel oxides formed by the entry of oxygen from the air are reduced by the hydrogen. The Hydrogen 'attacks' any stray oxygen before it can form nickel oxides.
The permissible percentage of Hydrogen varies up to 15%. It is indirectly related to the thickness of material being welded. With increased current welds and reduced travel speeds on thicker materials, the Hydrogen can become entrapped in the weld. This causes embrittlement of the weld. In general, the thinner the work-piece, the higher the permissible percentage of Hydrogen in a gas mixture that can be used. in automatic welding, a higher percentage of hydrogen can increase travel speeds on these thinner materials (.062", 1.6 mm or less).
Flow rates range approximately
10 SCF@I (4.7 lpm) - 20 SCFH (9-4 lpm).

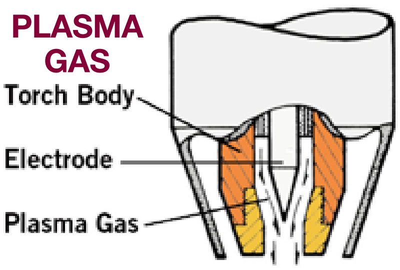
Helium

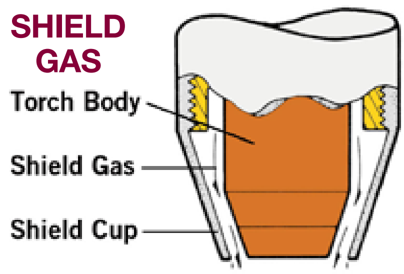
The use of helium as opposed to argon increases the weld heat by approximately 25%. This is due to the higher ionization potential of helium, which in turn increases the arc voltage. Helium is commonly used when welding aluminum alloys, copper alloys and thicker sections of titanium. These materials will dissipate heat more rapidly and need the assistance of the helium.
Flow rates range approximately
15 SCFH (7.1 lpm) 40 SCFH (18.8 lpm).

Helium/Argon (75/25%)

The addition of Helium to Argon produces a hotter arc for a given amount of welding current. A Mixture must contain at least 40% Helium before a significant change in heat can be detected. The argon has a tendency to stabilize the arc. Mixtures containing more than 75%, Helium will provide results very similar to pure Helium. A mixture of 75% Helium 25% Argon is used in applications like thicker segments of titanium or copper alloys.
Flow rates range approximately
15 SCFH (7.1 lpm) 40 SCFH (18.8 lpm).

NOTE: Arc starting may become more difficult with the use of helium or helium mixtures. Trailing shield addition may be required when welding titanium or reactive metals to minimize oxidation to the weld bead surface.





Trouble Shooting Guide

This guide provides information should a problem occur. The **PROBLEM** column is listed in the sequence of operation of the torch. The **POSSIBLE CAUSE** and **REMEDY** columns are listed beginning with the easiest to check and progressing to the more difficult to check.

Most problems related to the torch can be corrected within this section.

PROBLEM	POSSIBLE CAUSE	REMEDY
A. Erratic or Poor appearing Pilot Arc	1. Worn torch parts	1. Check and replace with new parts
	2. Improper electrode setting	2. Adjust electrode setting
	3. Contaminated plasma gas	3. Check plasma gas line (see A below in Service Test Procedures)
	4. Moisture in torch or leads	4. Check (see B below in Service Test Procedures)
	5. Contaminated coolant	5. Check coolant (see C below in Service Test Procedures)
B. Welding Arc will not transfer	1. Torch standoff too high	1. Reduce standoff (approximately 3/32", 2.4rrTn-3/161, 5 mm standoff for most applications)
	2. Power supply not properly connected	2. Check work lead, negative lead and contactor control cable
	3. Faulty electrode in torch	3. Check for sharp point and clean appearance of electrode
C. Welding Tip damaged	1. Improper installation of torch	1. Check on start up parts
	2. Improper electrode setback	2. Check electrode
	3. Incorrect polarity	3. Check negative and positive leads for proper connection; check power supply range switch (see D below in Service Test Procedures)
	4. Plasma gas flow rate too low	4. Increase flow rate
	5. Excessive current level	5. Reduce current or use larger orificed tip
	6. Inadequate coolant flow	6. Check (see E below in Service Test Procedures)
	7. Contaminated gas	7. Check torch and system (see A below in Service Test Procedures)
	8. Moisture in torch	8. Check torch o-rings for coolant leaks; check gas hoses
	9. Contaminated coolant	9. Check coolant (see C below in Service Test Procedures)
	10. Tip touching workpiece	10. Increase standoff
D. Tip damaged after a period of welding	1. Inadequate coolant flow	1. Check coolant (see E below in Service Test Procedures)
	2. Current too low	2. Increase current
	3. Electrode setback at minimum	3. Increase electrode setback
	4. Travel speed too high	4. Decrease travel speed
F. Porosity in welds	1. Contaminants on material	1. Clean material
	2. Plasma gas flow rate too high	2. Reduce (if plasma gas flow is too high but 100% penetration is not occurring, gas porosity may appear)
	3. Inadequate shield gas coverage	3. Increase flow rate or use additional 'trailer' shield to provide adequate gas shielding
G. Slight undercutting (in toe area of weld)	1. Travel speed too high	1. Reduce travel speed
	2. Plasma gas flow too high	2. Reduce flow rate
	3. Tip orifice size too small	3. Use larger orifice tip
	4. Electrode set at max setback	4. Reduce setback
	5. Current level too low	5. Increase current level

Service Test Procedures

The following tests correspond with the torch section of the troubleshooting guide.

A. Contaminated plasma gas normally causes a bluing tint toward the front of the electrode. Check the plasma gas line for leaks by plugging the tip and letting gas flow with the console in 'SET' position. Check the plasma gas line using a soap and water solution on each connection. Appearance of bubbles signifies a leak at the connection.

B. Moisture in the plasma gas may cause a black sooty material to appear on the electrode or in the tip. Use of rubber hoses may be a cause of moisture entrapment. Synflex tubing is always recommended.
To remove moisture from the torch, plug the tip and let gas pressure build before releasing. It may be necessary to repeat the procedure three or four times to remove contaminants.

C. Contaminated coolant gas can be caused by not using or maintaining proper coolant. Check the resistivity level of the coolant with a water tester. Replace coolant if indicated resistivity is below accepted levels. Purge the entire system.

D. Reverse polarity operation causes excessive electrode deterioration which may cause formation of a large ball on the electrode tip.

E. Inadequate coolant flow can cause excessive damage to the tip and liner. Check the 'return' flow rate against the GPM coolant requirement. If coolant flow is inadequate check the filter in the coolant recirculator. See instruction manual for that unit.

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