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# An Approach to Best Welding Practice. Part – XXI. Section – III- BV-B(ii)

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**"AN APPROACH TO BEST WELDING PRACTICE. Part – XXI."** is the **Twenty First Detail Part** of **"AN APPROACH TO BEST WELDING PRACTICE"** which was written as a General and Overall approach to the subject matter. **AN APPROACH TO BEST WELDING PRACTICE. Part – XXI., Section III–BV - B(ii)** is particularly focused on the Generation and Computer based Storage of Welding Data on Plasma Arc Cutting and Welding Processes for Fabrication. This is a lengthy process to develop and as each and every step is connected with each other for cross references, none can be eliminated. In every Fabrication concern where Welding is the major manufacturing process preparation, recording and storage of welding processes must be done.

## PLASMA ARC CUTTING

Plasma Arc Cutting is a melting process in which a jet of ionised gas at temperatures above 20,000°C is used to melt and expel material to form the cut. During the process, an electric arc is struck between an electrode (cathode) and the workpiece (anode). The electrode is recessed in a water- or air-cooled gas nozzle which constricts the arc causing the narrow, high temperature, high velocity plasma jet to form.

When the plasma jet hits the workpiece, recombination takes place and the gas reverts to its normal state, emitting intense heat. This heat melts the metal and the gas flow ejects it from the cut. Plasma gases are usually argon, argon/hydrogen or nitrogen. These inert gases can be replaced by air but this requires a special electrode of hafnium or zirconium. Use of compressed air makes this variant of the plasma process highly competitive with the oxy-fuel process for cutting carbon-manganese and stainless steels up to 20mm thick plates. Inert gases are preferred for high quality cuts in reactive alloys.

Plasma arc can cut a very wide range of electrically conductive alloys including plain carbon and stainless steels, aluminium and its alloys, nickel alloys and titanium. Normally, the component or sheet to be cut remains stationary and the plasma torch is moved. Additionally, the cost of the plasma torch is low compared with the price of the manipulation.

## SEVEN MAIN FACTORS THAT AFFECT PLASMA ARC CUT QUALITY

To get the best quality plasma arc cutting results, it is necessary to be aware of the main factors that affect cut quality.

1. Consumables, correct rating/condition
2. Amperage (Current)
3. Plasma arc and Shield gases
4. Arc voltage
5. Torch height
6. Cut speed
7. Kerf width

PLASMAJET CUTTING PARAMETERS AN EXPERIMENTAL STUDY

| EXPERIMENT SL. No. | CUTTING CURRENT, I (A) | CUTTING SPEED (MM/MIN) |
|---|---|---|
| 1 | 60 | 425 |
| 2 | 60 | 535 |
| 3 | 60 | 635 |
| 4 | 80 | 490 |
| 5 | 80 | 610 |
| 6 | 80 | 730 |
| 7 | 80 | 870 |
| 8 | 80 | 1055 |
| 9 | 100 | 530 |
| 10 | 100 | 670 |
| 11 | 100 | 870 |
| 12 | 100 | 1055 |
| 13 | 120 | 730 |
| 14 | 120 | 870 |
| 15 | 120 | 1055 |
| 16 | 120 | 1320 |

**T45m unshielded consumables**

**Mild Steel**
**English**

| Air flowrate (scfh) | |
|---|---|
| Hot | 320 |
| Cold | 360 |

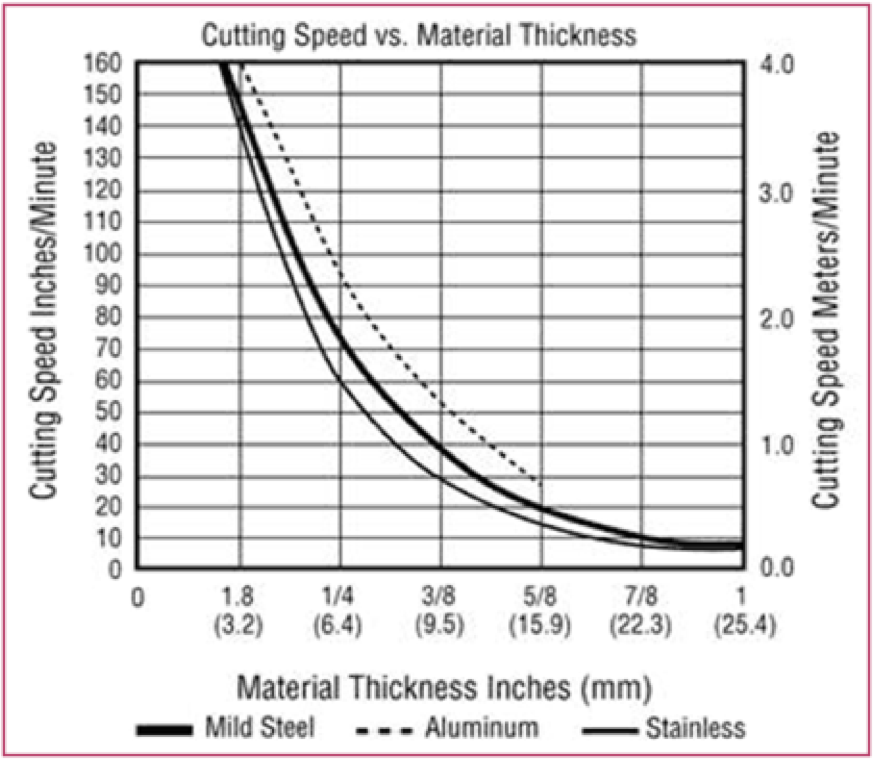
| | | | | | | Recommended | | Maximum | |
|---|---|---|---|---|---|---|---|---|---|
| Arc current (amps) | Material thickness | Torch-to-work distance (in) | Initial pierce height | | Pierce time delay (sec) | Cut Speed (ipm) | Voltage (V) | Cut Speed (ipm) | Voltage (V) |
| 30 | 0.018 in (26 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 360 | 118 | 400* | 114 |
| | 0.030 in (22 Ga) | | | | | 340 | 118 | 400* | 116 |
| | 0.036 in (20 Ga) | | | | | 320 | 117 | 400* | 120 |
| | 0.060 in (16 Ga) | | | | 0.2 | 225 | 113 | 285 | 119 |
| 45 | 0.036 in (20 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 380 | 118 | 400* | 110 |
| | 0.060 in (16 Ga) | | | | | 350 | 114 | 400* | 113 |
| | 0.075 in (14 Ga) | | | | | 240 | 114 | 300 | 114 |
| | 0.105 in (12 Ga) | | | | 0.3 | 175 | 116 | 220 | 114 |
| | 0.135 in (10 Ga) | | | | 0.4 | 135 | 118 | 170 | 116 |
| | 0.188 in (3/16 in) | | | | 0.4 | 85 | 118 | 110 | 116 |
| | 0.250 in (1/4 in) | | | | 0.5 | 60 | 118 | 75 | 118 |
| | 0.375 in (3/8 in) | | | | 0.7 | 32 | 120 | 40 | 118 |
| | 0.500 in (1/2 in) | | Edge start recommended | | | 20 | 130 | 25 | 124 |
| | 0.625 in (5/8 in) | | | | | 11 | 132 | 14 | 126 |
| | 0.750 in (3/4 in) | | | | | 8 | 138 | 10 | 132 |
| | 1.000 in (1 in) | | | | | 4 | 145 | 5 | 140 |

*Maximum cut speed is limited by the test table's maximum speed (400 ipm).

## PLASMA CUTTING STAINLESS STEEL

When it comes to cutting stainless steel, there are several methods available, but it's not always easy to understand which of these is the simplest, which is the most cost-effective, and crucially, which will give the best results.

Plasma cutting is a quick, affordable and easy way to cut stainless steel. Modern plasma systems allow you to select from an expanded range of gases and amperages, to produce optimal cut speeds and deliver the desired cut quality for a variety of needs.




**Metric**

The mid-range

| Select Gases | | Set Preflow | | Set Cutflow | | Material Thickness | Arc Voltage | Torch-to-Work Distance | Cutting Speed | Initial Pierce Height | | Pierce Delay Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plasma (1) | Shield (2) | Plasma (3) | Shield (4) | Plasma (5) | Shield (6) | mm | Volts | mm | mm/m | mm | factor % | seconds |
| | | | | | | 6 | 150 | | 6500 | | | 0.3 |
| | | | | 70 | 70 | 10 | 150 | 2.8 | 4440 | 8.5 | 300 | |
| | | | | | | 12 | 150 | | 3850 | | | 0.4 |
| | | | | | | 15 | 155 | | 3130 | | | 0.5 |
| | | | | 75 | | 20 | 159 | 3.6 | 2170 | 9.0 | 250 | 0.6 |
| | | | | | | 22 | 166 | | 1930 | | | 0.7 |
| $O_2$ | Air | 24 | 75 | | | 25 | 171 | | 1685 | | | 0.8 |
| | | | | | | 28 | 170 | | 1445 | | | 0.9 |
| | | | | | 75 | 32 | 172 | | 1135 | 9.5 | 200 | 1.0 |
| | | | | | | 38 | 174 | | 895 | | | 1.2 |
| | | | | 80 | | 44 | 185 | 4.8 | 580 | | | |
| | | | | | | 50 | 188 | | 405 | N/A | | |
| | | | | | | 58 | 193 | | 290 | | | |
| | | | | | | 64 | 202 | | 195 | | | |

**105 A Shielded cutting (Stainless Steel)**

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 6 | | | | | 4870 | 139 | 6000 | 141 |
| 8 | | | | 0.5 | 3460 | 141 | 4210 | 142 |
| 10 | | 6.4 | 200 | | 2240 | 144 | 2670 | 142 |
| 12 | | | | 0.6 | 1490 | 148 | 1860 | 144 |
| 16 | 3.2 | | | 0.75 | 950 | 149 | 1080 | 149 |
| 20 | | 8.0 | 250 | 1.25 | 660 | 154 | 810 | 152 |
| 25 | | Edge Start | | | 440 | 158 | 530 | 156 |
| 30 | | | | | 340 | 164 | 360 | 160 |
| 32 | | | | | 300 | 166 | 320 | 163 |

**Stainless steel – 170 A – $N_2$ Plasma / $N_2$ Shield – above water (Core, VWI, OptiMix)**

Metric

| Material thickness | Cut category | SYSTEM SETTINGS: XPR process ID | Shield pierce setting | Cutflow: Plasma gas | Cutflow: Shield gas | CNC SETTINGS: Cut speed | Arc voltage | Transfer height | Pierce height | Pierce delay | Cut height | Kerf compensation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | | | | | | mm/min | volts | mm | mm | seconds | mm | mm |
| 10 | 3 | 2057 | 54 | 90 | 54 | 1994 | 165 | 6.10 | 6.10 | 0.3 | 2.54 | 2.7 |
| 12 | 1 | | | | | 1834 | 165 | | | 0.4 | | 2.6 |
| 15 | | | | | | 1226 | 168 | | | 0.6 | | 2.8 |
| 20 | 2 | | | | | 705 | 177 | 7.62 | 7.62 | 2.5 | 3.43 | 3.2 |
| 25 | | | | | | 405 | 189 | | 15.24 | 4.0 | 3.81 | 3.6 |
| 30 | 4 | | | | | 289 | 194 | Edge start | | 0.5 | | 3.6 |

**Plasma Arc Welding (PAW)**

Leave a Comment / Types of Welding, Welding Processes / By Sandeep Anand

Plasma arc welding (PAW) is an arc welding process in which the heat required for welding is generated by a constricted arc between a non-consumable electrode and the workpiece.

Plasma Arc Welding is essentially an extension of Gas Tungsten Arc Welding (GTAW). Like GTAW, a non-consumable electrode is used in Plasma Arc Welding (PAW). However, a different technique is used to deliver the heat for welding in Plasma Arc Welding (PAW).

The welding torch used in Plasma Arc Welding (PAW) contains two nozzles an inner nozzle for orifice gas and an outer nozzle for shielding gas **(Fig. 1)**.

The inner nozzle contains orifice gas which surrounds the electrode. The orifice gas is a neutral gas that gets converted into a plasma state (the fourth state of matter) when an arc is ignited in the chamber. The arc heats the orifice gas to a temperature at which the electrons present in the atoms of orifice gas leave their orbit, due to which, the orifice gas becomes ionized. The ionized gases come out from the orifice of the nozzle as a "plasma jet stream". Plasma is a good conductor of electricity.

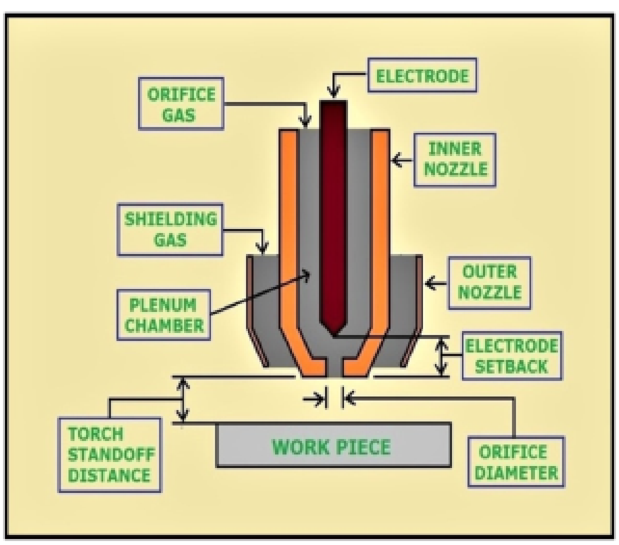



Figure 1

Plasma emanates from the nozzle of the orifice at a temperature of about 16,700°C (30,000°F), creating a narrow, constricted arc pattern that provides excellent directional control and produces a very favorable depth-to-width weld profile.

The outer nozzle contains shielding gas like Gas Tungsten Arc Welding (GTAW). The shielding gas covers the area of arc plasma impingement on the workpiece to avoid contamination of the weld. Shielding gas may be the same as the orifice gas or it may be different from orifice gas.

Some important terms used in Plasma Arc Welding:

**Electrode Setback:** The distance between the tip of the electrode and the face of the constricting nozzle is known as electrode setback (see **Figure 1**).

**Torch Standoff Distance:** The distance between the outer face of the constricting nozzle and the workpiece is known as the torch standoff distance (see **Figure 1**).

**Plenum or Plenum Chamber:** The space between the inside wall of the constricting nozzle and the electrode is known as the plenum or plenum chamber (see **Figur 1**).

## EQUIPMENT

Plasma arc welding can be performed in manual, mechanized, or robotic operations. However, for manual plasma arc welding following items are used:

1. A Power Source
2. A Welding Torch
3. A Plasma Control Console,

4. Gases (Orifice and Shielding gas)
5. Torch coolant
6. Other accessories such as remote control for current, gas flow timers and an on-off switch

**Power Source:** The power source used for plasma arc welding is similar to that used for TIG welding (GTAW). Both GTAW as well as PAW processes use constant-current power sources and a high-frequency source for arc starting.

**Welding Torch:** A Plasma Arc Welding (PAW) torch has the following features:

- It holds the electrode and allows current to pass through the electrode
- Inner nozzle for the supply of orifice gas or plasma gas
- Outer nozzle for the supply of shielding gas

**Plasma Control Console:** The crucial control systems of plasma arc welding are encompassed in a plasma console also known as plasma control console or console. The console is generally integrated with the primary power source, but it can also be available as a separate stand-alone unit. A typical plasma control console includes controls for the following;

- Plasma gas flow
- shielding gas flow
- the pilot arc current

**Gases (Orifice gas/Shielding gas):** Selection of gases for plasma arc welding depends on the following criteria;

- welding position
- joint configuration
- Base metal

Shielding gas is often the same as the orifice gas for many plasma arc welding applications. However, some advantages can be observed when a different gas is used for certain applications.

**Orifice Gas:** The orifice gas should be inert with respect to the electrode to avoid the rapid deterioration of the electrode. To enhance the electrode life 99.99% pure orifice gas must be used. Flow rates for orifice gases are generally between 0.1 liters per minute (L/min) to 5 L/min. The most commonly used orifice gases are;

- Argon
- Argon – Hydrogen Mixture

**Shielding Gas:** Generally inert gases are used as shielding gas. However, an active gas can also be used for shielding if it is not considered to adversely affect weld properties. Following gases are used for shielding the weld pool;

- Argon
- Argon – Hydrogen mixture
- Argon-helium mixture
- Carbon Dioxide

Flow rates for shielding gases are usually in the range of 5 L/min to 15 L/min for low-current applications. For high-current welding, flow rates of 15 L/min to 32 L/min are used.

**Coolant System:** Plasma Arc Welding requires a cooling system. A cooling system should consist of a coolant reservoir, radiator, pump, flow sensor, and control switches. Corrosion-resistant materials are used for the construction of the liquid-contacting surfaces.

**Electrodes:** Like GTAW, tungsten electrodes are used in Plasma Arc Welding (PAW). Tungsten electrodes with small additions of thorium, lanthanum, or cerium can be used for PAW with straight polarity (DCEN). Pure tungsten and zirconiated electrodes are seldom used in plasma arc welding because the electrode tip geometry cannot be maintained. To learn more about tungsten electrodes, Please click here.

**Filler Metal:** The filler metal is added externally (if required). In the case of manual welding, filler metal in form of rods is used. Whereas, filler metal in wire form is used for mechanized or robotic welding. Filler metal specification is the same as that used in gas Tungsten Arc Welding (GTAW). To learn more about tungsten electrodes.

## ARC MODES

Two types of arc modes are used in plasma arc welding, these are;

- Transferred Arc Mode
- Non-Transferred Arc Mode.

In transferred arc mode, the electrode is connected to one terminal of the power source (Generally with Negative polarity) and the workpiece is connected with the other terminal (Positive terminal). Hence the workpiece becomes a part of the electrical circuit (the nozzle remains intact), and heat is obtained from the anode spot on the workpiece and the plasma jet.

In the non-transferred arc mode, the electrode is connected to one terminal of the power source (generally with negative polarity) and the nozzle is connected with the other terminal (positive terminal). Hence, the arc is established and maintained between the electrode and the constricting orifice. The workpiece remains out of the electrical arc circuit. non-transferred arc mode is suitable for cutting and joining nonconductive materials.

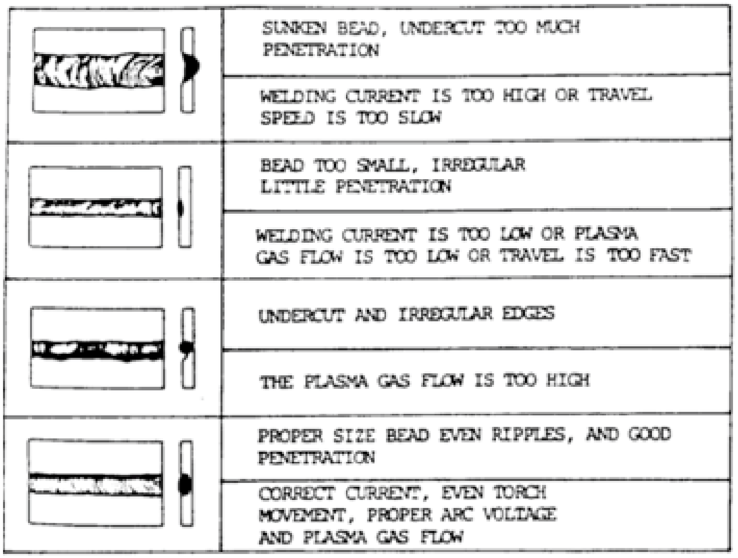
**Advantages of Plasma Arc Welding (PAW)**

1. The constricted opening yields high heat concentration in a smaller area
2. It gives deeper penetration and produces a sound weld
3. Less current input as compared to another welding process

4. The distance between torch and workpiece (standoff distance) does not affect the arc formation
5. Can achieve faster travel speeds
6. Less heat-affected zone (HAZ) if compared to GTAW (Gas tungsten arc welding)
7. It is more stable and does not gets deflected from the base metal

**Limitations of Plasma Arc Welding (PAW)**

1. PAW equipment are relatively costly, hence start-up costs are high
2. The safety concern is high due to harmful radiations
3. PAW is a very noisy process
4. A highly skilled operator is required




**Technical data (EN60974-7) :**

**ABIPLAS WELD 150 CT 20**

| | | |
|---|---|---|
| Type of cooling | : | liquid cooled |
| Welding current | : | 80 - 150 A |
| Duty Cycle | : | 100% |
| Welding speed | : | Vs upto 4.0 m/min. |
| Electrode diameter | : | 1.2 - 3.6 mm |

**ABIPLAS WELD 250 MT**
**ABIPLAS WELD 250 CT 20**

| | | |
|---|---|---|
| Type of cooling | : | liquid cooled |
| Welding current | : | max. 300 A |
| Duty cycle | : | 100% |
| Welding Speed | : | Vs upto 4.0 m/min. |
| Electrode diameter | : | 3.0 - 4.5 mm |

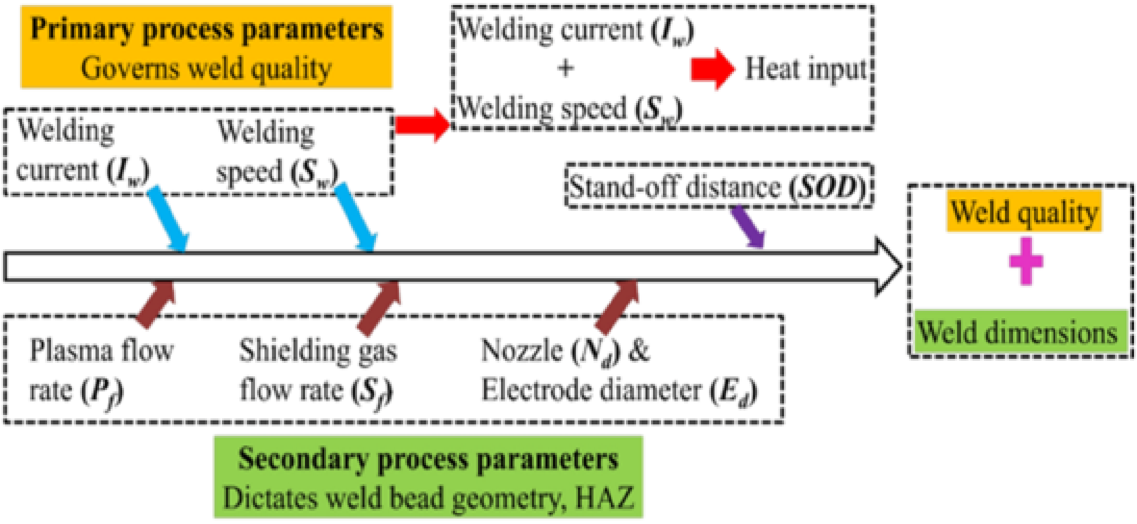
| No. | Parameter | Value |
|---|---|---|
| 1. | Diameter of wire | 1.2 mm |
| 2. | Standard current | 220 A |
| 3. | Voltage | 24 V |
| 4. | Shielding welding gases | 82% Ar/18% $CO_2$; 98% ar/2% $O_2$ |
| 5. | Kind of tested micro-jet cooling gas | 82% Ar/18% $CO_2$; 98% Ar/2% $O_2$; 78% Ar + 2% $Co_2$ + 20% He |
| 6. | Gas pressure | 0.4 MPa; 0.5 MPa |
| 7. | Number of micro-jets | 1 |
| 8. | Cooling steam diameter | 40 μm; 50 μm |

**PARAMETERS OF WELDING PROCESS**

| No. | Parameter | Value |
|---|---|---|
| 1. | Diameter of wire | 1.2 mm |
| 2. | Standard current | 220 A |
| 3. | Voltage | 24 V |
| 4. | Shielding MIG welding gas | Ar |
| 5. | Steam diameter of micro-jet gas | 50 μm |
| 6. | micro-jet cooling gas | argon |
| 7. | micro-jet gas pressure | from 0.3 MPa, upto 0.7 MPa |
| 8. | Distance between welding and micro-jet injector | 6 cm |

| Description | Parameter Value | Unit |
|---|---|---|
| Rated Supply Voltage | 220 / 230 | V |
| Supply Frequency | 50 / 60 | Hz |
| Rated Input Capacity | 6 | KVA |
| Rated Supply Current | 36.3 | A |
| No-Load Voltage | 86 | V |
| Welding Current Range | 20 - 180 | A |
| Welding Current Max | 220 | A |
| Rated Welding Voltage | 27.2 | V |
| Rated Duty Cycle | 60 | % |
| Usable Electrode | 1.6 - 5.0 | bar |
| Efficiency | 85 | % |
| Power Factor | 0.9 | CoS |
| Degrees of Protection | IP21S | IP |
| Class of Insulation | H | H |
| Net Weight | 4.5 | KG |
| Machine Size | L340*W150*H260 | MM |

**DIGITAL MICRO PLASMA MINISTICK MACHINE**




Development of microplasma welding for different thicknesses

## PLASMA CUTTING STAINLESS STEEL

When it comes to cutting stainless steel, there are several methods available, but it's not always easy to understand which of these is the simplest, which is the most cost-effective, and crucially, which will give the best results.

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**Metric**

| Select Gases | | Set Preflow | | Set Cutflow | | Material Thickness | Arc Voltage | Torch-to-Work Distance | Cutting Speed | Initial Pierce Height | | Pierce Delay Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plasma (1) | Shield (2) | Plasma (3) | Shield (4) | Plasma (5) | Shield (6) | mm | Volts | mm | mm/m | mm | factor % | seconds |
| | | | | | | 6 | 150 | | 6500 | | | 0.3 |
| | | | | 70 | 70 | 10 | 150 | 2.8 | 4440 | 8.5 | 300 | |
| | | | | | | 12 | 150 | | 3850 | | | 0.4 |
| | | | | | | 15 | 155 | | 3130 | | | 0.5 |
| | | | | 75 | | 20 | 159 | 3.6 | 2170 | 9.0 | 250 | 0.6 |
| | | | | | | 22 | 166 | | 1930 | | | 0.7 |
| $O_2$ | Air | 24 | 75 | | | 25 | 171 | | 1685 | | | 0.8 |
| | | | | | | 28 | 170 | | 1445 | | | 0.9 |
| | | | | | 75 | 32 | 172 | | 1135 | 9.5 | 200 | 1.0 |
| | | | | 80 | | 38 | 174 | | 895 | | | 1.2 |
| | | | | | | 44 | 185 | 4.8 | 580 | | | |
| | | | | | | 50 | 188 | | 405 | N/A | | |
| | | | | | | 58 | 193 | | 290 | | | |
| | | | | | | 64 | 202 | | 195 | | | |

**The mid-range**

**T45m unshielded consumables**

**Mild Steel**
**English**

| Air flowrate (scfh) | |
|---|---|
| Hot | 320 |
| Cold | 360 |

| | | | | | | Recommended | | Maximum | |
|---|---|---|---|---|---|---|---|---|---|
| Arc current (amps) | Material thickness | Torch-to-work distance (in) | Initial pierce height | | Pierce time delay (sec) | Cut Speed (ipm) | Voltage (V) | Cut Speed (ipm) | Voltage (V) |
| 30 | 0.018 in (26 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 360 | 118 | 400* | 114 |
| | 0.030 in (22 Ga) | | | | | 340 | 118 | 400* | 116 |
| | 0.036 in (20 Ga) | | | | | 320 | 117 | 400* | 120 |
| | 0.060 in (16 Ga) | | | | 0.2 | 225 | 113 | 285 | 119 |
| 45 | 0.036 in (20 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 380 | 118 | 400* | 110 |
| | 0.060 in (16 Ga) | | | | | 350 | 114 | 400* | 113 |
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| | 0.105 in (12 Ga) | | | | 0.3 | 175 | 116 | 220 | 114 |
| | 0.135 in (10 Ga) | | | | 0.4 | 135 | 118 | 170 | 116 |
| | 0.188 in (3/16 in) | | | | 0.4 | 85 | 118 | 110 | 116 |
| | 0.250 in (1/4 in) | | | | 0.5 | 60 | 118 | 75 | 118 |
| | 0.375 in (3/8 in) | | | | 0.7 | 32 | 120 | 40 | 118 |
| | 0.500 in (1/2 in) | | Edge start recommended | | | 20 | 130 | 25 | 124 |
| | 0.625 in (5/8 in) | | | | | 11 | 132 | 14 | 126 |
| | 0.750 in (3/4 in) | | | | | 8 | 138 | 10 | 132 |
| | 1.000 in (1 in) | | | | | 4 | 145 | 5 | 140 |

*Maximum cut speed is limited by the test table's maximum speed (400 ipm).

Plasma cutting (plasma arc cutting) is a melting process in which a jet of ionised gas at temperatures above 20,000°C is used to melt and expel material from the cut. During the process, an electric arc is struck between an electrode (cathode) and the workpiece (anode). The electrode is recessed in a water- or air-cooled gas nozzle which constricts the arc causing the narrow, high temperature, high velocity plasma jet to form.

When the plasma jet hits the workpiece, recombination takes place and the gas reverts to its normal state, emitting intense heat as it does so. This heat melts the metal and the gas flow ejects it from the cut. Plasma gases are usually argon, argon/hydrogen or nitrogen. These inert gases can be replaced by air but this requires a special electrode of hafnium or zirconium. Use of compressed air makes this variant of the plasma process highly competitive with the oxy-fuel process for cutting carbon-manganese and stainless steels up to 20mm thick. Inert gases are preferred for high quality cuts in reactive alloys.

Plasma arc can cut a very wide range of electrically conductive alloys including plain carbon and stainless steels, aluminium and its alloys, nickel alloys and titanium. The method was originally developed to cut materials which could not be satisfactorily cut by the oxy-fuel process. Normally, the component or sheet to be cut remains stationary and the plasma torch is moved. Additionally, because the cost of the plasma torch is low compared with the price of the manipulation equipment, it is common to fit several torches to a cutting table.

Plasma arc cutting can also be carried out under water using specialised equipment.

High tolerance plasma arc cutting (HTPAC) is an important development of plasma arc technology. The process gives better precision on material under 12mm thick and can be a low-cost alternative to laser cutting.

**PLASMAJET CUTTING PARAMETERS**

| No. of Experiment | Input parameters | |
|---|---|---|
| | Cutting current, I (A) | Cutting speed, v (mm/min) |
| 1 | 60 | 425 |
| 2 | 60 | 530 |
| 3 | 60 | 635 |
| 4 | 80 | 490 |
| 5 | 80 | 610 |
| 6 | 80 | 730 |
| 7 | 80 | 870 |
| 8 | 80 | 1055 |
| 9 | 100 | 530 |
| 10 | 100 | 695 |
| 11 | 100 | 870 |
| 12 | 100 | 1055 |
| 13 | 120 | 730 |
| 14 | 120 | 870 |
| 15 | 120 | 1055 |
| 16 | 120 | 1320 |
| 17 | 120 | 1585 |

**105 A Shielded cutting (Stainless Steel)**

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 6 | | | | | 4870 | 139 | 6000 | 141 |
| 8 | | | | 0.5 | 3460 | 141 | 4210 | 142 |
| 10 | | 6.4 | 200 | | 2240 | 144 | 2670 | 142 |
| 12 | | | | 0.6 | 1490 | 148 | 1860 | 144 |
| 16 | 3.2 | | | 0.75 | 950 | 149 | 1080 | 149 |
| 20 | | 8.0 | 250 | 1.25 | 660 | 154 | 810 | 152 |
| 25 | | | | | 440 | 158 | 530 | 156 |
| 30 | | Edge Start | | | 340 | 164 | 360 | 160 |
| 32 | | | | | 300 | 166 | 320 | 163 |

**Stainless steel – 170 A – $N_2$ Plasma / $N_2$ Shield – above water (Core, VWI, OptiMix)**

**Metric**

| Material thickness | Cut category | SYSTEM SETTINGS: XPR process ID | Shield pierce setting | Cutflow: Plasma gas | Cutflow: Shield gas | CNC SETTINGS: Cut speed | Arc voltage | Transfer height | Pierce height | Pierce delay | Cut height | Kerf compensation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | | | | | | mm/min | volts | mm | mm | seconds | mm | mm |
| 10 | 3 | 2057 | 54 | 90 | 54 | 1994 | 165 | 6.10 | 6.10 | 0.3 | 2.54 | 2.7 |
| 12 | 1 | | | | | 1834 | 165 | | | 0.4 | | 2.6 |
| 15 | | | | | | 1226 | 168 | | | 0.6 | | 2.8 |
| 20 | 2 | | | | | 705 | 177 | 7.62 | 7.62 | 2.5 | 3.43 | 3.2 |
| 25 | | | | | | 405 | 189 | | 15.24 | 4.0 | 3.81 | 3.6 |
| 30 | 4 | | | | | 289 | 194 | Edge start | | 0.5 | | 3.6 |

**Process fundamentals**

The plasma arc cutting process is illustrated in **Fig. 1**. The basic principle is that the arc formed between the electrode and the workpiece is constricted by a fine bore, copper nozzle. This increases the temperature and velocity of the plasma emanating from the nozzle. The temperature of the plasma is in excess of 20,000°C and the velocity can approach the speed of sound. When used for cutting, the plasma gas flow is increased so that the deeply penetrating plasma jet cuts through the material and molten material is removed in the efflux plasma.

The process differs from the oxy-fuel process in that the plasma process operates by using the arc to melt the metal whereas in the oxy-fuel process, the oxygen oxidises the metal and the heat from the exothermic reaction melts the metal. Thus, unlike the oxy-fuel process, the plasma process can be applied to cutting metals which form refractory oxides such as stainless steel, aluminium, cast iron and non-ferrous alloys.

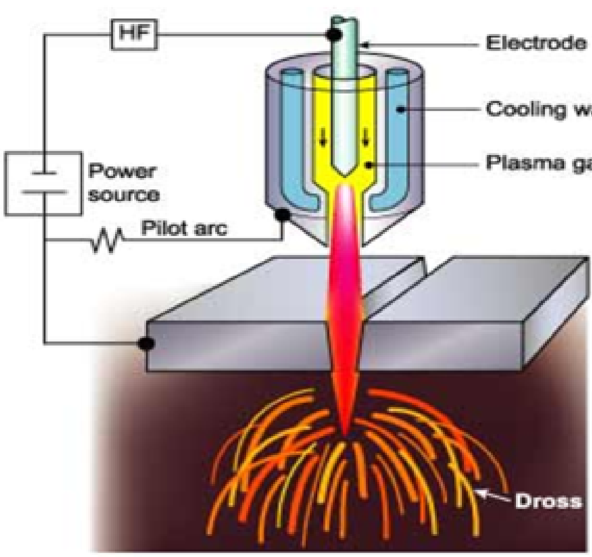



Fig.1 : The plasma arc cutting process

**Power source**

The power source required for the plasma arc process must have a drooping characteristic and a high voltage. Although the operating voltage to sustain the plasma is typically 50 to 60V, the open circuit voltage needed to initiate the arc can be up to 400V DC.

On initiation, the pilot arc is formed within the body of the torch between the electrode and the nozzle. For cutting, the arc must be transferred to the workpiece in the so-called 'transferred' arc mode. The electrode has a negative polarity and the workpiece a positive polarity so that the majority of the arc energy (approximately two thirds) is used for cutting.

**Gas composition**

In the conventional system using a tungsten electrode, the plasma is inert, formed using either argon, argon-H2 or nitrogen. However, as described in Process variants, oxidising gases, such as air or oxygen, can be used but the electrode must be copper with hafnium.

The plasma gas flow is critical and must be set according to the current level and the nozzle bore diameter. If the gas flow is too low for the current level, or the current level too high for the nozzle bore diameter, the arc will break down forming two arcs in series, electrode to nozzle and nozzle to workpiece. The effect of 'double arcing' is usually catastrophic with the nozzle melting.

**Cut quality**

The quality of the plasma cut edge is similar to that achieved with the oxy-fuel process. However, as the plasma process cuts by melting, a characteristic feature is the greater degree of melting towards the top of the metal resulting in top edge

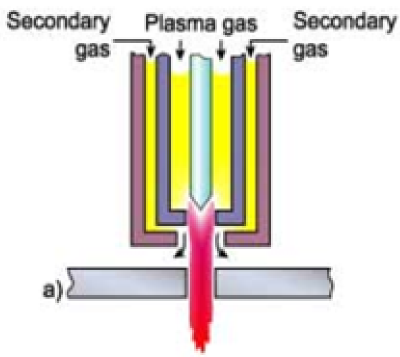



Fig.2a. : Dual Gas

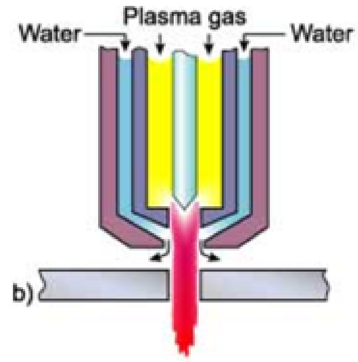



Fig.2b. : Water Injection

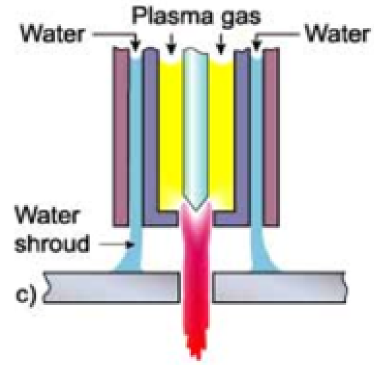



Fig.2c. : Water Shrouded

rounding, poor edge squareness or a bevel on the cut edge. As these limitations are associated with the degree of constriction of the arc, several torch designs are available to improve arc constriction to produce more uniform heating at the top and bottom of the cut.

**Process variants**

The process variants, **Figs. 2a** to **2e**, have principally been designed to improve cut quality and arc stability, reduce the noise and fume or to increase cutting speed.

**Dual gas**

The process operates basically in the same manner as the conventional system but a secondary gas shield is introduced around the nozzle, **Fig. 2a**. The beneficial effects of the secondary gas are increased arc constriction and more effective 'blowing away' of the dross. The plasma forming gas is normally argon, argon-$H_2$ or nitrogen and the secondary gas is selected according to the metal being cut.

**Steel:** air, oxygen, nitrogen

**Stainless steel:** nitrogen, argon-$H_2$, $CO_2$

**Aluminium:** argon-$H_2$, nitrogen / $CO_2$

The advantages compared with conventional plasma are:

- Reduced risk of 'double arcing'
- Higher cutting speeds
- Reduction in top edge rounding

**Water injection**

Nitrogen is normally used as the plasma gas. Water is injected radially into the plasma arc, **Fig. 2b**, to induce a greater degree of constriction. The temperature is also considerably increased, to as high as 30,000°C.

The advantages compared with conventional plasma are:

- Improvement in cut quality and squareness of cut
- Increased cutting speeds
- Less risk of 'double arcing'
- Reduction in nozzle erosion

**Water shroud**

The plasma can be operated either with a water shroud, **Fig. 2c**, or even with the workpiece submerged some 50 to 75mm below the surface of the water. Compared with conventional plasma, the water acts as a barrier to provide the following advantages:

- Fume reduction
- Reduction in noise levels
- Improved nozzle life

In a typical example of noise levels at high current levels of 115dB for conventional plasma, a water shroud was effective in reducing the noise level to about 96dB and cutting under water down to 52 to 85dB.

As the water shroud does not increase the degree of constriction, squareness of the cut edge and the cutting speed are not noticeably improved.

**Air plasma**

The inert or unreactive plasma forming gas (argon or nitrogen) can be replaced with air but this requires a special electrode of hafnium or zirconium mounted in a copper holder, **Fig. 2d**. The air can also replace water for cooling the torch. The advantage of an air plasma torch is that it uses air instead of expensive gases.

It should be noted that although the electrode and nozzle are the only consumables, hafnium tipped electrodes can be expensive compared with tungsten electrodes

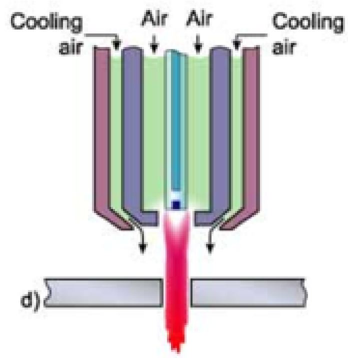



Fig.2d. : Air Plasma

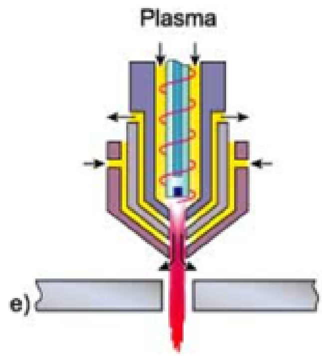
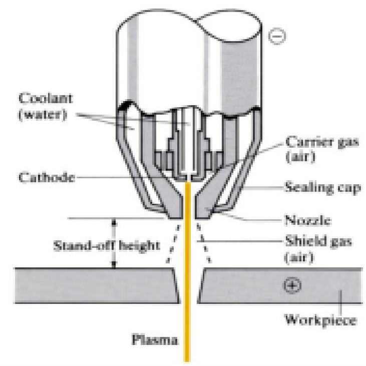



Fig.2e. : High Tolerance

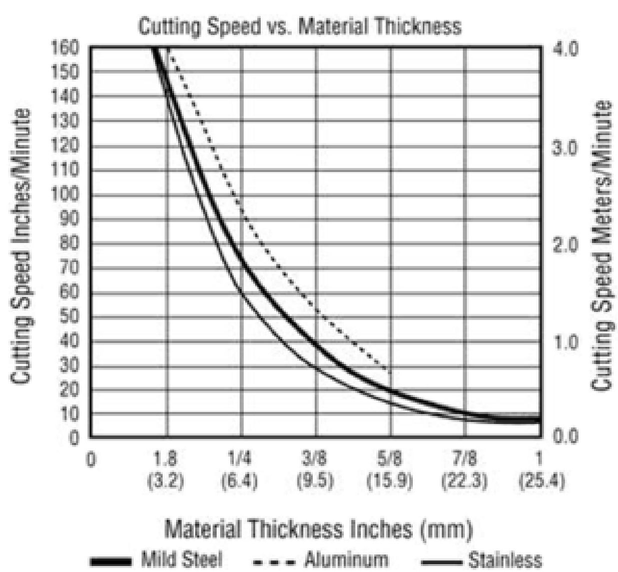


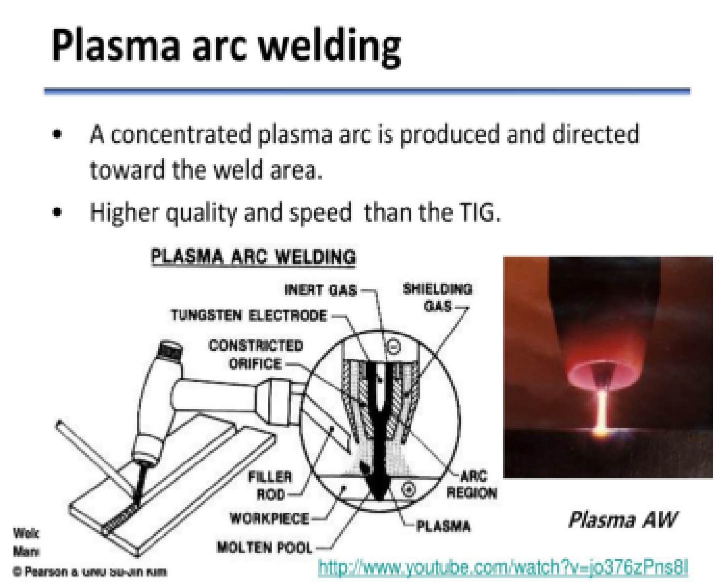

**High tolerance plasma**

In an attempt to improve cut quality and to compete with the superior cut quality of laser systems, High Tolerance Plasma Arc cutting (HTPAC) systems are available which operate with a highly constricted plasma. Focusing of the plasma is effected by forcing the oxygen generated plasma to swirl as it enters the plasma orifice and a secondary flow of gas is injected downstream of the plasma nozzle, **Fig. 2e**. Some systems have a separate magnetic field surrounding the arc. This stabilises the plasma jet by maintaining the rotation induced by the swirling gas. The advantages of HTPAC systems are:

- Cut quality lies between a conventional plasma arc cut and laser beam cut
- Narrow kerf width
- Less distortion due to smaller heat affected zone

HTPAC is a mechanised technique requiring precision, high-speed equipment. The main disadvantages are that the maximum thickness is limited to about 6mm and the cutting speed is generally lower than conventional plasma processes and approximately 60 to 80% the speed of laser cutting.



## HOW TO SELECT A HAND HOLD PLASMA CUTTER

**T45m unshielded consumables**

**Mild Steel**
**English**

| Air flowrate (scfh) | |
|---|---|
| Hot | 320 |
| Cold | 360 |

| Arc current (amps) | Material thickness | Torch-to-work distance (in) | Initial pierce height | | Pierce time delay (sec) | Recommended Cut Speed (ipm) | Recommended Voltage (V) | Maximum Cut Speed (ipm) | Maximum Voltage (V) |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 0.018 in (26 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 360 | 118 | 400* | 114 |
| | 0.030 in (22 Ga) | | | | | 340 | 118 | 400* | 116 |
| | 0.036 in (20 Ga) | | | | | 320 | 117 | 400* | 120 |
| | 0.060 in (16 Ga) | | | | 0.2 | 225 | 113 | 285 | 119 |
| 45 | 0.036 in (20 Ga) | 0.08 | 0.2 in | 250% | 0.0 | 380 | 118 | 400* | 110 |
| | 0.060 in (16 Ga) | | | | | 350 | 114 | 400* | 113 |
| | 0.075 in (14 Ga) | | | | | 240 | 114 | 300 | 114 |
| | 0.105 in (12 Ga) | | | | 0.3 | 175 | 116 | 220 | 114 |
| | 0.135 in (10 Ga) | | | | 0.4 | 135 | 118 | 170 | 116 |
| | 0.188 in (3/16 in) | | | | 0.4 | 85 | 118 | 110 | 116 |
| | 0.250 in (1/4 in) | | | | 0.5 | 60 | 118 | 75 | 118 |
| | 0.375 in (3/8 in) | | | | 0.7 | 32 | 120 | 40 | 118 |
| | 0.500 in (1/2 in) | | Edge start recommended | | | 20 | 130 | 25 | 124 |
| | 0.625 in (5/8 in) | | | | | 11 | 132 | 14 | 126 |
| | 0.750 in (3/4 in) | | | | | 8 | 138 | 10 | 132 |
| | 1.000 in (1 in) | | | | | 4 | 145 | 5 | 140 |

*Maximum cut speed is limited by the test table's maximum speed (400 ipm).

## SPEEDS AND FEEDS

**105. A Shielded cutting (Stainless Steel)**

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 6 | 3.2 | 6.4 | 200 | 0.5 | 4870 | 139 | 6000 | 141 |
| 8 | | | | | 3460 | 141 | 4210 | 142 |
| 10 | | | | | 2240 | 144 | 2670 | 142 |
| 12 | | | | 0.6 | 1490 | 148 | 1860 | 144 |
| 16 | | | | 0.75 | 950 | 149 | 1080 | 149 |
| 20 | | 8.0 | 250 | 1.25 | 660 | 154 | 810 | 152 |
| 25 | | Edge Start | | | 440 | 158 | 530 | 156 |
| 30 | | | | | 340 | 164 | 360 | 160 |
| 32 | | | | | 300 | 166 | 320 | 163 |

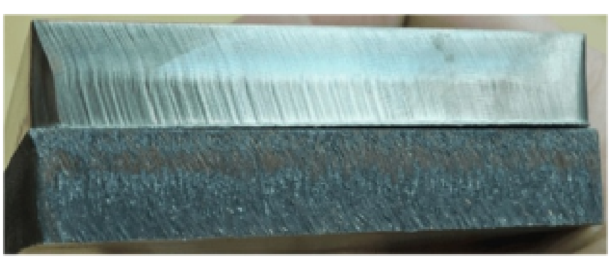
## PLASMA CUTTING STAINLESS STEEL

When it comes to cutting stainless steel, there are several methods available, but it's not always easy to understand which of these is the simplest, which is the most cost-effective, and crucially, which will give the best results.

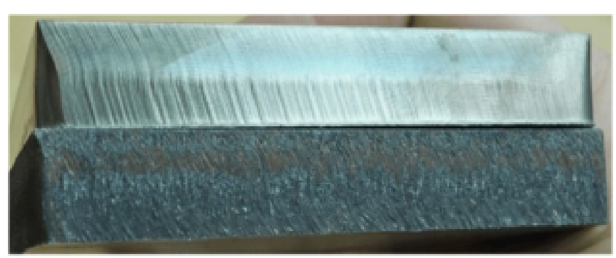
Plasma cutting is a quick, affordable and easy way to cut stainless steel. Modern plasma systems allow you to select from an expanded range of gases and amperages, to produce optimal cut speeds and deliver the desired cut quality for a variety of needs.

## CHARACTERISTICS OF A SHIELDING GAS WHEN CUTTING SS

| Shield Gas | Characteristics |
|---|---|
| Nitrogen | Leaves a well-flushed kerf and a shiny chrome-like edge. A high flow rate also cools the process, leading to less part distortion |
| Water* | Through vented water injection, an attractive edge finish can be produced. |
| Carbon dioxide | Leaves a slag-free and brown coloured edge |
| Air | Flushes the kerf well, and leaves a bronze coloured edge |



F5 Plasma cutting gas used vs compressed air to cut stainless steel



Difference between Air Plasma & Mechanised Plasma systems

**HOW CLEAN IS THE CUT ON STAINLESS STEEL?**

As per the above picture, there is a difference between CNC plasma cutters that use air vs a CNC plasma cutting machine using a mechanised plasma system. The cut is clean for both systems, although a stainless edge that is cut with air will be much rougher.

**105. A Shielded cutting (Stainless Steel)**

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 6 | | | | | 4870 | 139 | 6000 | 141 |
| 8 | | | | 0.5 | 3460 | 141 | 4210 | 142 |
| 10 | | 6.4 | 200 | | 2240 | 144 | 2670 | 142 |
| 12 | | | | 0.6 | 1490 | 148 | 1860 | 144 |
| 16 | 3.2 | | | 0.75 | 950 | 149 | 1080 | 149 |
| 20 | | 8.0 | 250 | 1.25 | 660 | 154 | 810 | 152 |
| 25 | | | | | 440 | 158 | 530 | 156 |
| 30 | | Edge Start | | | 340 | 164 | 360 | 160 |
| 32 | | | | | 300 | 166 | 320 | 163 |

**Stainless Steel cutting chart 105 A with Air Hypertherm Powermax105® plasma cutting system**

But remembering which gasses you need to buy and what the processes are to get the best cut results can be a bit overwhelming.

Therefore we created this article about plasma cutting stainless steel. We have tried to make it the most useful stop on your journey to a solution by answering the 10 most frequently asked questions on this topic!

- Question 1 : Can you cut stainless steel with a plasma cutter?
- Question 2 : Can you cut polyethylene-coated stainless steel with plasma?
- Question 3 : Can plasma cut painted stainless steel?
- Question 4 : How clean is the cut on stainless steel?
- Question 5 : Does True Hole exist with stainless steel?
- Question 6 : What is the right gas for plasma cutting stainless steel?
- Question 7 : What cutting speed & amperage can I expect?
- Question 8 : What are plasma cutting stainless steel hazards?
- Question 9 : Is using plasma the best way to cut stainless steel?
- Question 10 : How to choose the best plasma cutter for stainless steel?

## CAN YOU CUT STAINLESS STEEL WITH A PLASMA CUTTER?

Absolutely. Plasma is one of the most effective methods to cut stainless steel over a wide range of thicknesses. However, the type of stainless steel cutting table and plasma source you use makes a big difference.

**Does the cutting machine make a difference?**

The build quality of your cutting machine will make a significant difference in the cut quality in the long run.

Specifically, the edge quality (ripples vs no ripples) and angularity of the cut may be impacted by mechanical imperfections of the cutting table.

You need to assess the stiffness of the gantry (Y-axis that moves over the material to be cut) and whether the construction of the rails can be affected by the heat dissipated by the cut.

Whilst cut quality may look the same when machines are brand new, heat can bow the metal construction of your table over time, which may impact the straightness of the cutting machine.

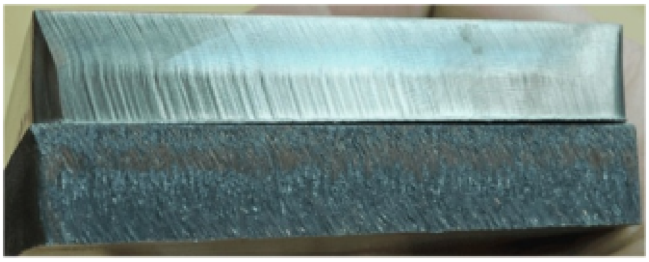
Next to this, various machine components, like the drives, rails, and gears impact motion. Poorly assembled or poor quality components could lead to motion irregularities.

This, in turn, causes vibrations, which transfer through the machine axis into the cut edge and can cause a rough-cut surface, nonlinear cut edges, and overall poor cut quality.

Therefore, we recommend checking the quality of the drives, rails, and gears before you purchase any plasma cutting machine.

**Does the plasma system make a difference?**

The main difference between a low-cost air plasma system vs an industrial type of plasma cutting systems relate to the types of gasses that are used to cut and the pressure at which the plasma gas will come out of the torch. Both of these significantly impact the end-result of the cut.



F5 plasma cutting gas used vs compressed air to cut stainless steel

The image below illustrates the quality difference one can expect between using a more expensive F5 blend gas as plasma cutting gas vs. a cheaper solution like compressed air.

Low-cost CNC air plasma systems will only use air to cut stainless. It can cut stainless steel through to around 25mm.

Due to the Nitrogen that is present in air (~78%), you will always get a black finish. In addition, as there is about 20% Oxygen in air, which has the tendency to burn, your edge finish may not be as good, especially on thicker material. Overall you're getting a decent cut quality at low running costs.

Industrial CNC plasma cutting systems use a variety of gas combinations to cut stainless steel. Especially the most modern mechanised systems are equipped to cut sharp edges with smooth surfaces and a shiny finish. Systems such as the HyPerformance® HPR800XD® or the Kjellberg HiFocus 600i Neo can cut stainless steel to up to 160mm.

In the range of industrial CNC plasma cutters, there are certainly other variables to take into consideration as well when cutting stainless steel; a range of processes (including output currents and gas combinations) will impact the cut edge results and cut speeds you can achieve.

For example, using nitrogen will give you a faster cut, but can also result in top edge rounding, and using an oxidizing plasma gas (such as air or O2) will produce surface oxides on the face of a cut that will need to be removed with a grinder before welding. These secondary operations take additional time, which you may want to avoid.

Using non-oxidizing plasma such as argon-hydrogen (H35) makes the cutting process slower but produces bright chrome-like edges that need little or no preparation before welding. Using gasses that contain some hydrogen (such as F5) will also result in sharper cut edges.

The most modern industrial plasma sources, such as Hypertherm's X-Definition™ XPR300™ plasma cutting system enable you to mix gasses. Like this, you will be able to produce a blend that has, for example, the cut-quality of argon-hydrogen, and the cut-speeds of air and nitrogen.

## CAN YOU CUT POLYETHYLENE-COATED STAINLESS STEEL WITH PLASMA?

Polyethylene-coated stainless steel sheet is used extensively in industries such as food services. A thin plastic film is applied to the metal after the polishing process and is used to protect the polished stainless steel finish.

In most circumstances you can still use plasma to cut polyethylene-coated stainless steel, but cutting this material without burning and melting the polyethylene film requires the use of low plasma cutting currents and a nitrogen shield gas.

Nitrogen is useful as a shield gas because as well as flushing the slag from the kerf, it also prevents oxygen from entering the cutting zone and causing the polyethylene to melt or burn.

The only condition under which plasma will not work on polyethylene-coated stainless steel is when the material is coated on both sides. This is because a plastic coating on the underside of the steel plate will prevent the positive part of the circuit from being completed.

## CAN PLASMA CUT PAINTED STAINLESS STEEL?

Unlike polyethylene, there are no restrictions when it comes to cutting painted or dirty stainless steel with plasma, as neither presents a barrier to the circuit being completed.

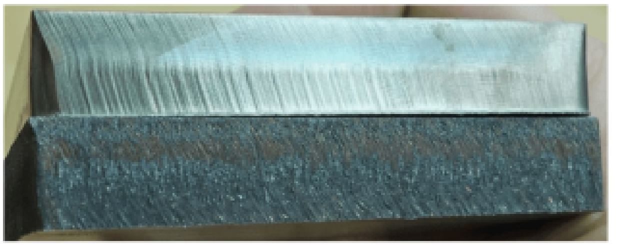
However, when cutting painted or very dirty stainless, you'll need to make sure you have a solid ground connection on a clean part of the work-piece as close to the cutting area as possible.

## HOW CLEAN IS THE CUT ON STAINLESS STEEL?

As per the above picture, there is a difference between CNC plasma cutters that use air vs a CNC plasma cutting machine using a mechanised plasma system. The cut is clean for both systems, although a stainless edge that is cut with air will be much rougher.

Both air plasma and industrial plasma systems will provide you with a chart indicating which cutting processes can cut a certain thickness with the cleanest possible cut. In the "best quality" range, sometimes a small amount of dross may be found around sharp corners, but removing this is fairly straightforward.

If you leave the "best quality" range, you will be able to cut faster (production cut), and this will be at the expense of more dross. Note that dross from stainless steel will be harder to remove than dross from mild steel. Unlike molten mild steel, molten stainless has a high level of viscosity, meaning that if lots of dross is deposited, it will be more difficult to remove than dross from mild steel.



Difference between Air Plasma & Mechanised Plasma systems

Stainless Steel dross is difficult to remove

**Stainless steel – 170 A – $N_2$ Plasma / $N_2$ Shield – above water (Core, VWI, OptiMix)**

**Metric**

| Material thickness | Cut category | SYSTEM SETTINGS | | | | CNC SETTINGS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | XPR process ID | Shield pierce setting | Cutflow | | Cut speed | Arc voltage | Transfer height | Pierce height | Pierce delay | Cut height | Kerf compensation |
| | | | | Plasma gas | Shield gas | | | | | | | |
| mm | | | | | | mm/min | volts | mm | mm | seconds | mm | mm |
| 10 | 3 | 2057 | 54 | 90 | 54 | 1994 | 165 | 6.10 | 6.10 | 0.3 | 2.54 | 2.7 |
| 12 | 1 | | | | | 1834 | 165 | | | 0.4 | | 2.6 |
| 15 | | | | | | 1226 | 168 | | | 0.6 | | 2.8 |
| 20 | 2 | | | | | 705 | 177 | 7.62 | 7.62 | 2.5 | 3.43 | 3.2 |
| 25 | | | | | | 405 | 189 | | 15.24 | 4.0 | 3.81 | 3.6 |
| 30 | 4 | | | | | 289 | 194 | Edge start | | 0.5 | | 3.6 |

Stainless Steel cutting chart 170 A with N2 on a Hypertherm XPR300™ plasma cutting system

**105 A Shielded cutting (Stainless Steel)**

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 6 | 3.2 | 6.4 | 200 | 0.5 | 4870 | 139 | 6000 | 141 |
| 8 | | | | | 3460 | 141 | 4210 | 142 |
| 10 | | | | | 2240 | 144 | 2670 | 142 |
| 12 | | | | 0.6 | 1490 | 148 | 1860 | 144 |
| 16 | | | | 0.75 | 950 | 149 | 1080 | 149 |
| 20 | | 8.0 | 250 | 1.25 | 660 | 154 | 810 | 152 |
| 25 | | Edge Start | | | 440 | 158 | 530 | 156 |
| 30 | | | | | 340 | 164 | 360 | 160 |
| 32 | | | | | 300 | 166 | 320 | 163 |

Stainless Steel cutting chart 105 A with Air Hypertherm Powermax105® plasma cutting system

That viscosity of the molten metal can also make piercing of stainless steel difficult. Dross can accumulate around the pierce hole, which can adversely affect the movement of the torch. In practical terms, if you want to cut a drain cover with very narrow slots, you may need to look at optimizing the slots for the plasma process, and making them thick enough to allow for the torch to avoid the pierce puddle.

Using the right equipment and the optimal settings of speed and voltage (for air plasma) and the right process related to thickness for mechanised plasma normally results in a very clean cut, making stainless steel easy to work with.

The right equipment though is key because lower-end machines and those with less precision in their settings can produce cuts with lots of dross.

This can be a very frustrating experience for fabricators, but it is solvable.

If you want clean and hassle-free cuts on stainless steel, you might want to consider purchasing an industry-leading machine, rather than an entry-level CNC plasma cutting machine.

We would recommend to always contact your machine manufacturer to ask for more advice on machine specs and set up, as this will help you assess the feasibility of cutting the parts represented in your drawings.

## DOES TRUE HOLE EXIST WITH STAINLESS STEEL?

True Hole® technology is Hypertherm's unique solution to producing true, un-tapered holes in mild steel. Unfortunately, it is a process that currently only exists with mild steel due to the physics of the plasma arc and the dross accumulation during the cutting process.

With stainless steel, the arc lags the torch by up to 15 degrees and is therefore not currently consistent enough for True Hole technology.

Plasma cut hole quality in stainless steel is still acceptable for many applications; it is just not currently at the same level of precision as with mild steel.

## WHAT IS THE RIGHT GAS FOR CUTTING STAINLESS STEEL?

When it comes to an air plasma system, the choice is easy – you will always cut with clean, dry air (which is, of course, still 78% nitrogen) as the plasma gas and produce very acceptable cutting results on a wide range of thicknesses. Air is the most cost-effective cutting gas. Cuts will usually have a bronze to dark grey finish and a rougher edge than systems that enable multi-gas processes.

Intermediate (e.g. MAXPRO200®) or industrial, high definition or X-Definition plasma systems (e.g. XPR300™) are a popular choice for many fabricators as they deliver better results on stainless. The best edge finish is often realised with the more exotic gas combinations.

These dual gas systems also more readily produce cuts that are weld-ready without further preparations to the metal needing to be made, because of cutting without oxygen.

Industrial systems (e.g. XPR300™) specifically are capable of producing a high-quality dross free cut of stainless over a broader range of thicknesses.

Here's a brief rundown of the characteristics of different plasma gasses when cutting stainless steel with a plasma cutter:

**CHARACTERISTICS OF A SHIELDING GAS WHEN CUTTING SS**

| Shield Gas | Characteristics |
|---|---|
| Nitrogen | Leaves a well-flushed kerf and a shiny chrome-like edge. A high flow rate also cools the process, leading to less part distortion |
| Water* | Through vented water injection, an attractive edge finish can be produced. |
| Carbon dioxide | Leaves a slag-free and brown coloured edge |
| . Air | Flushes the kerf well, and leaves a bronze coloured edge |

**CHARACTERISICS OF DIFFERENT PLASMA GASES WHEN CUTTING SS WITH PLASMA CUTTER**

| Plasma Cutting Gas | Characteristics |
|---|---|
| 1. Argon Hydrogen | Excellent quality cut, and particularly recommended for cutting thicker stainless steel. Argon-hydrogen gas is the hottest burning plasma gas and it is essential that your system is appropriately equipped for working with it. |
| 2. Nitrogen | Good cut quality, used across all thicknesses and also has less of an impact on consumables leading to longer parts' life |
| 3. Air | Good cut quality and speed. This is an economical solution that will produce good, though not excellent results, primarily because of the presence of more than 20% of oxygen |
| 4. Oxygen | Pure oxygen is not recommended as it leaves an oxidised surface on the face of the cut |
| 5. Nitrogen with hydrogen (F5) | A non-oxidising combination that leaves slightly blue hue to the finish, primarily used for processes to cut under 10mm |

## CONCLUSION

You only need to think about the plasma gasses when you have a dual gas or multiple-gas system.

A dual gas system will allow cutting stainless with Nitrogen, giving you a dark edge. Both systems will use Nitrogen as shield gas where it is extremely effective at flushing slag from the kerf, leaving cuts with a smooth edge surface, a neutral, shiny finish, and virtually no dross.

A multi-gas or mechanised system (e.g. XPR170™, XPR300™, HiFocus 360i neo) will cut on the thin end with F5 plasma gas and on the thicker end with a mixture of hydrogen and argon. This will produce a dross-free, excellent finish, with bright, smooth edges and good perpendicularity.

For thinner stainless steel (up to around 10 mm), processes using either nitrogen for the plasma and shield gas or a combination of an F5 plasma gas (5% hydrogen, 95% nitrogen) and nitrogen shield gas deliver excellent edge quality. As a shield gas, nitrogen is extremely effective at flushing slag from the kerf, leaving cuts with a smooth edge surface, a neutral, shiny finish, and virtually no dross.

For the best cut quality on thicker stainless steel pieces (10mm+), we recommend argon hydrogen for the plasma (or argon hydrogen nitrogen), with a nitrogen shield gas.

Discuss your requirements with your machine manufacturer in order to choose the right machine for your needs.

| Plasma Gas / Shield Gas | ✓ PRO | ✗ CON |
|---|---|---|
| Air/Air | Fast | Surface is black |
| | Low Cost | Rough and heavily oxidised |
| | Minimal dross | Secondary operations |
| N2/N2 | Cheaper | Edge is black |
| | Fastest cut speed | Top edge is rounded |
| | Closer to perpendicular | Has dross |
| N2/Air | Cheaper | Edge is black |
| | Fastest cut speed | Top edge is rounded |
| | | Significant angle |
| F5/N2 | Silver color | Thickness limitations (<10mm) |
| | Good cut angles | Slower cut speeds |
| | Smooth, shiny cut edge | F5 gas is more expensive than compressed air |
| | Minimal weld prep | Slightly degraded cut quality on bevel cuts |
| | Ability to use the same consumables | |
| H35/N2 | Gold to blue color | Gas availibility issues |
| | Grey Color (+75mm) | Dross results on thin plates |
| | Square cut edge | |
| | Minimal weld prep | |
| | Wide cutting range | |
| H35-N2/N2 | Blue to gray color | Gas availibility issues |
| | Faster cut than H35/N2 | Auto-gas systems only |
| | Minimal weld prep | |
| | Wide cutting range | |

## WHAT CUTTING RANGE, SPEED & AMPERAGE CAN I EXPECT?

Thanks to advancements in plasma cutting technology, top range systems such as the Hypertherm XPR300™ can deliver very fast cutting speeds even on stainless steel.

### Cutting range

When thinking about thickness, you have to consider a few elements: dross-free limit, pierce capacity and severance cut. Dross-free cutting is the limit until which you can cut without considerable secondary operations. Pierce capacity is the maximum thickness the plasma source can cut without needing an edge-start. Finally, severance cut is the absolute maximum a machine is capable of doing when it starts its cut on the side of the plate.

### Speed

A fabricator with a mechanized plasma has the luxury to choose between speed and quality. When cutting stainless steel as fast as possible, more dross will be created at the expense of speed. The best cut quality is obtained by a process which is often slightly slower, but results in a cut that is nearly dross-free:

Cutting speeds are generally proportional to cutting current (amps), example:10mm stainless on an XPR300. We highly recommend cutting this on 130amp, resulting in a cut quality of 1 (the best) unless 400mm/min additional speed would be critical for your operations. Yet that increase in speed will result in a lot more secondary operations.

| Amperage | Cut quality level | Speed (mm/min) | Result |
|---|---|---|---|
| 80 A (N2/N2, N2/H2O, MIX/N2 ) | 2 | ~1,000 | Dross and slow |
| 130 A (N2/N2, N2/H2O, MIX/N2 ) | 1 | ~1,600 | Black edge (N2/N2)<br>Shiny edge (Mix/N2) |
| 170 A (N2/N2, N2/H2O, MIX/N2 ) | 3 | ~2,000 | Lots of dross |

In general, cutting speeds for stainless steel are lower than they are for mild steel at a given thickness and cutting current. As an example, the Hypertherm XPR300 will cut 12mm mild steel at nearly 3 meters per minute (quality = 1), whereas it would cut stainless steel at 1.7m/min (quality 1).

In the table below you find the cutting range (in mm) for each gas combination at a given amperage:

| Plasma Gas / Shield Gas | 45A | 80A | 130A | 200A | 260A | 400A | 600A | 800A |
|---|---|---|---|---|---|---|---|---|
| N2/N2 | 0.8-4 | * | 6-20 | 10-20 | * | * | 40-80 | * |
| N2/Air | * | * | * | * | 6-50 | 12-45 | * | * |
| F5/N2 | 0.8-6 | 4-10 | * | * | * | * | * | * |
| H35/N2 | * | * | 10-25 | 10-20 | 8-50 | 20-60 | 40-100 | 50-160 |
| H35-N2/N2 | * | * | 6-20 | 10-20 | 6-50 | 12-80 | * | * |

## WHAT ARE PLASMA CUTTING STAINLESS STEEL HAZARDS?

Safe and effective plasma cutting requires the implementation of safety procedures and practices to regulate aspects such as the management of dangerous electrical currents, fire hazards and personal operator protection. But is there anything else we need to be aware of when plasma cutting stainless steel specifically?

The primary concern is how to control the potentially hazardous fumes. Stainless steel fumes will contain more chromium and nickel than mild steel, and both of these metals are toxic. The type of chromium released is called Hexavalent Chromium (or Hex Chrome), which is a highly carcinogenic gas with links to health conditions such as cancer and respiratory problems.

Many thousands of different substances are used in the workplace, but the UK's Health and Safety Executive has outlined exposure limits for 500 of them. Chromium and Nickel are both listed. Research into the damaging effects of breathing these fumes is on going, but the risk can be easily managed with an appropriate fume extraction system, cutting table and filtration system.

Fume extraction and filtration systems remove the damaging particles from the air and make it safe to breathe. When considering the filtration system that's right for you, it's helpful to consider your safety to end up with a filter that is strong enough. Whatever filter, always ensure that the cutting area is covered with at least 80% of the material.

This will ensure better air suction. The higher the amperage of the plasma (i.e. the thicker the material) and the wider the cutting bed, the more powerful your fume extraction system needs to be. It's possible to bring in specialists to measure your air quality and advise you on the type of ventilation that will be best for your work environment.

Last but not least, cutting with H35 or an H2-Ar-N2 mix underwater is not without risks. If a plate is left submerged on the table for an extended period of time, hydrogen bubbles can accumulate under the plate. Piercing such a plate with a plasma torch could ignite that bubble of hydrogen and a serious explosion can occur.


## IS USING PLASMA THE BEST WAY TO CUT STAINLESS STEEL?

The answer to which cutting system is best ultimately depends on the requirements of the job. But when it comes to stainless steel, the versatility of plasma makes it the all-rounder that fabricators tend to opt for.

This is especially true for thicker stainless steel plates, where plasma cutting is almost universally considered the best solution. Precision plasma can pierce and cut stainless steel up to around 40mm and high amperage plasma systems can pierce and cut stainless steel up to around 100mm. With an edge start, plasma can cut up to about 160mm.

Lasers can be used for thinner stainless materials where intricate detail is required, and they can also offer higher cutting speeds in the thinner ranges. If the product does require extreme hole accuracy, (PCD insert or 4-bolt pitch for a pump or motor to go on) you have to work with laser-cutting technology, whereas if you can live with some taper from top to bottom when you put a bolt through the hole, HD plasma cutting machines could also be used.

If you want to learn more about the possibilities of industrial fiber laser cutters and how much they cost, we can recommend you this article we wrote about cutting stainless steel with laser cutters.

This being said, laser-cutting technology that cut stainless steel of 15mm and above requires triple the investment of comparable plasma cutting technology, Vented nozzles, originally developed for use on mild steel, are now available for stainless as well. The increased the pressure on the plasma arc produced by the vented nozzle constricts it for a finer and cleaner cut.

This coupled with the fact that the reflective surface of the material can cause back-reflection problems for lasers means than plasma cutting is the preferred option in many cases, especially on thicker stainless where you'll get a very smooth edge.

Using waterjet to cut stainless steel produces high-quality results with smooth cut edges but is limited in application as a result of the very slow cutting speeds compared to other solutions. And although the waterjet cut is extremely smooth, the quality of cut delivered by plasma is considered sufficient for most applications and industries.

## HOW TO CHOOSE THE BEST PLASMA CUTTER FOR STAINLESS STEEL?

When selecting a machine for plasma cutting stainless steel, a useful first task is to prioritize your needs. For some applications, productivity may be the number one concern, while for edge quality may be the most important issue.

Budget is, of course, an important constraint that underpins the whole decision. Cost-effective air plasma solutions are available but will require you to compromise on the speed and cut that a higher quality machine with precision plasma will provide.

Cutting stainless steel with a plasma cutter is not only possible; it's probably the solution that will give you the quickest, most consistent and overall best results.

**65A Shielded**

**Mild Steel**

| Air flow rate - slpm/scfh | |
|---|---|
| Hot | 160 / 340 |
| Cold | 220 / 470 |

**Metric**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| mm | mm | mm | % | seconds | (mm/min) | Volts | (mm/min) | Volts |
| 3 | 1.5 | 3.8 | 250 | 0.2 | 5200 | 125 | 6100 | 123 |
| 4 | | | | 0.5 | 4250 | 125 | 5100 | 124 |
| 6 | | | | | 2550 | 127 | 3240 | 127 |
| 8 | | | | | 1700 | 129 | 2230 | 128 |
| 10 | | 4.5 | 300 | 0.7 | 1100 | 131 | 1500 | 129 |
| 12 | | | | 1.2 | 850 | 134 | 1140 | 131 |
| 16 | | 6.0 | 400 | 2.0 | 560 | 138 | 650 | 136 |
| 20 | | Edge Start | | | 350 | 142 | 450 | 142 |
| 25 | | | | | 210 | 145 | 270 | 145 |

**English**

| Material Thickness | Torch-to-Work Distance | Initial Pierce Height | | Pierce Delay Time | Best Quality Settings | | Production Settings | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cut Speed | Voltage | Cut Speed | Voltage |
| | in | in | % | seconds | ipm | Volts | ipm | Volts |
| 10GA | 0.06 | 0.15 | 250 | 0.1 | 190 | 125 | 224 | 123 |
| 3/16 in | | | | 0.2 | 140 | 126 | 168 | 125 |
| 1/4 in | | | | 0.5 | 90 | 127 | 116 | 127 |
| 3/8 in | | | | 0.7 | 45 | 130 | 62 | 129 |
| 1/2 in | | 0.18 | 300 | 1.2 | 30 | 135 | 40 | 132 |
| 5/8 in | | 0.24 | 400 | 2.0 | 23 | 138 | 26 | 136 |
| 3/4 in | | Edge Start | | | 15 | 141 | 19 | 141 |
| 7/8 in | | | | | 12 | 143 | 14 | 143 |
| 1 in | | | | | 8 | 145 | 10 | 145 |

**IMPROVED CUT QUALITY WITH CNC MACHINE**