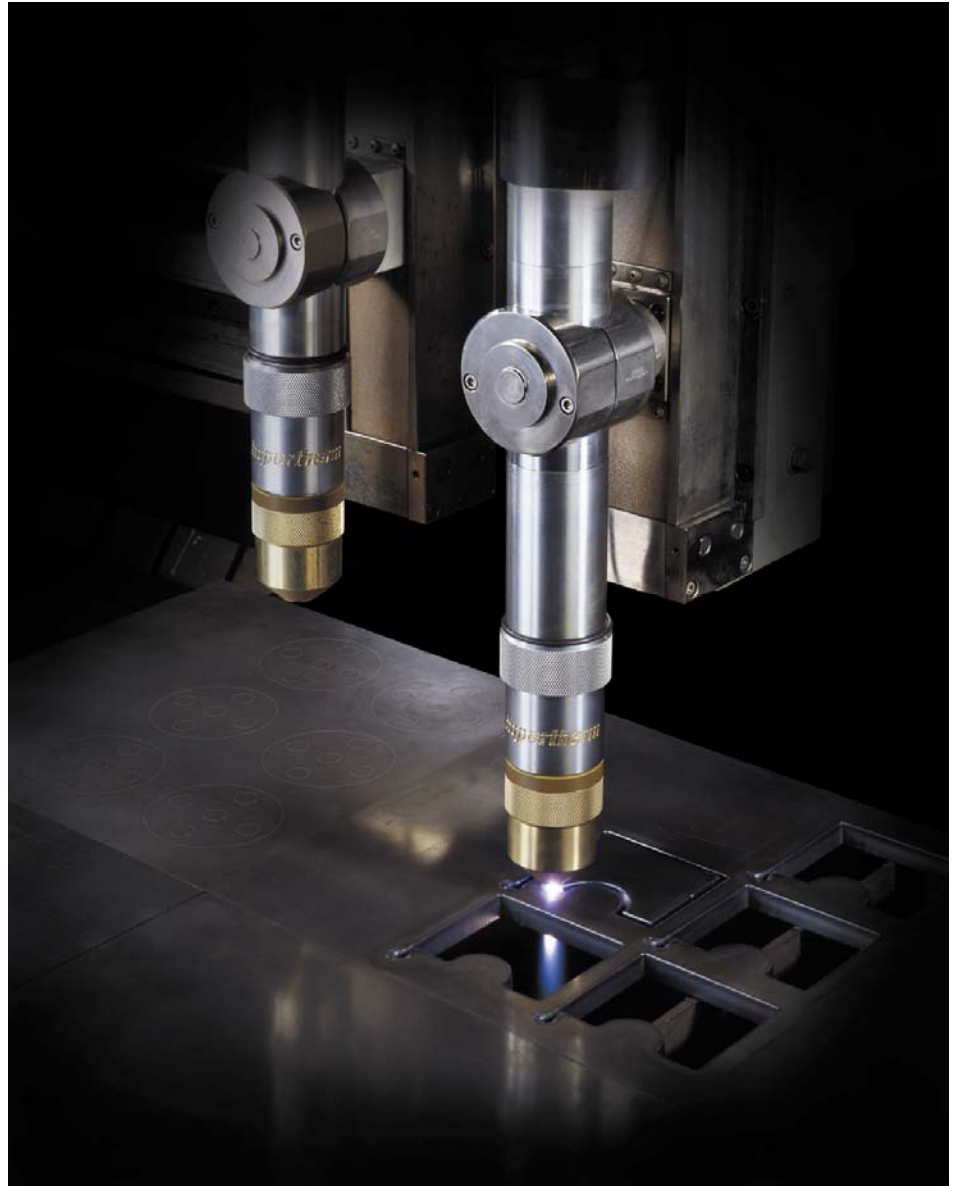


Basic Plasma Theory



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Basic Plasma Theory



To achieve optimum performance of your plasma cutting system it is necessary to first understand the plasma process.

Before we can do that, it is important to understand just what plasma is. Plasma is a state of matter. In fact, plasma is the most abundant form of matter in the universe.

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The “Perfect” Cut



All customers cutting metal are looking for essentially the same thing - **THE PERFECT CUT**. The perfect cut would have the following properties:

- ***Square angle***
- ***No metallurgical changes***
- ***No kerf***

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Metal Cutting Methods



Unfortunately, this is not a perfect world! All metal cutting methods have advantages and disadvantages. Fundamentally, all metal cutting processes on the market today fall into one of three categories:

- **Chemical** -Oxy-Fuel
- **Thermal** -Plasma (that does not use air or Oxygen)
- **Mechanical** -Sawing, punching, nibbling, abrasive water jet, shearing
- **Thermal-Chemical** -Air or Oxy-plasma

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Plasma: “The Fourth State of Matter”

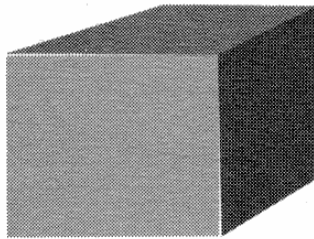
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The States of Matter



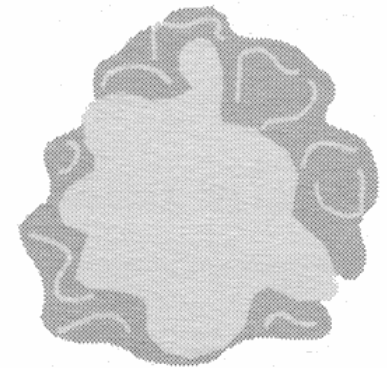
We understand the first three states of matter to be **solid**, **liquid**, and **gas**. For the most commonly known substance, H₂O (water), these states are ice, water, and steam.



solid



liquid



gas

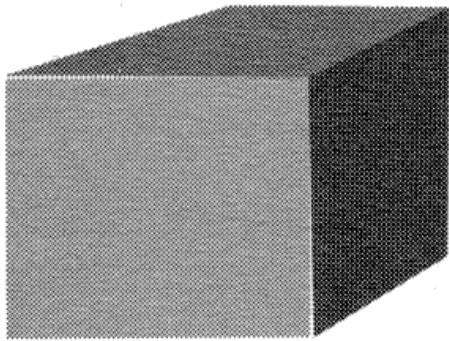
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The States of Matter



When energy, in the form of heat, is applied to ice, the ice melts becoming water. The H_2O transforms from the **solid** state, ice, to the **liquid** state, water.



solid



liquid

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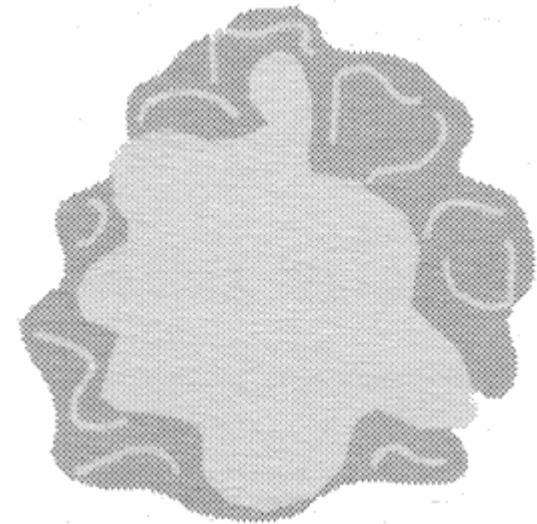
The States of Matter



When more heat is applied to the water, the water vaporizes becoming steam. The H_2O transforms from the **liquid** state, water, to the **gas** state, steam (H_2 & O_2).



liquid



gas

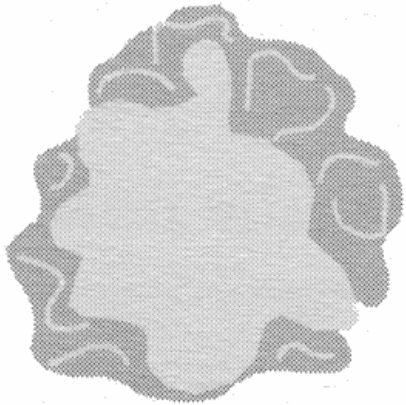
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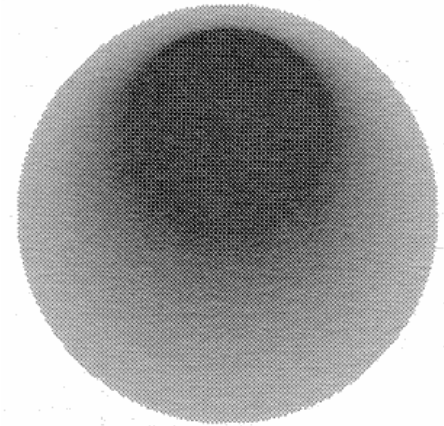
The States of Matter



Finally, when additional heat is applied to the individual gases, the gases ionize. The ionization of the gases is the final change in states. The gases are now in an electrically conductive state called a **plasma**.



gas



plasma

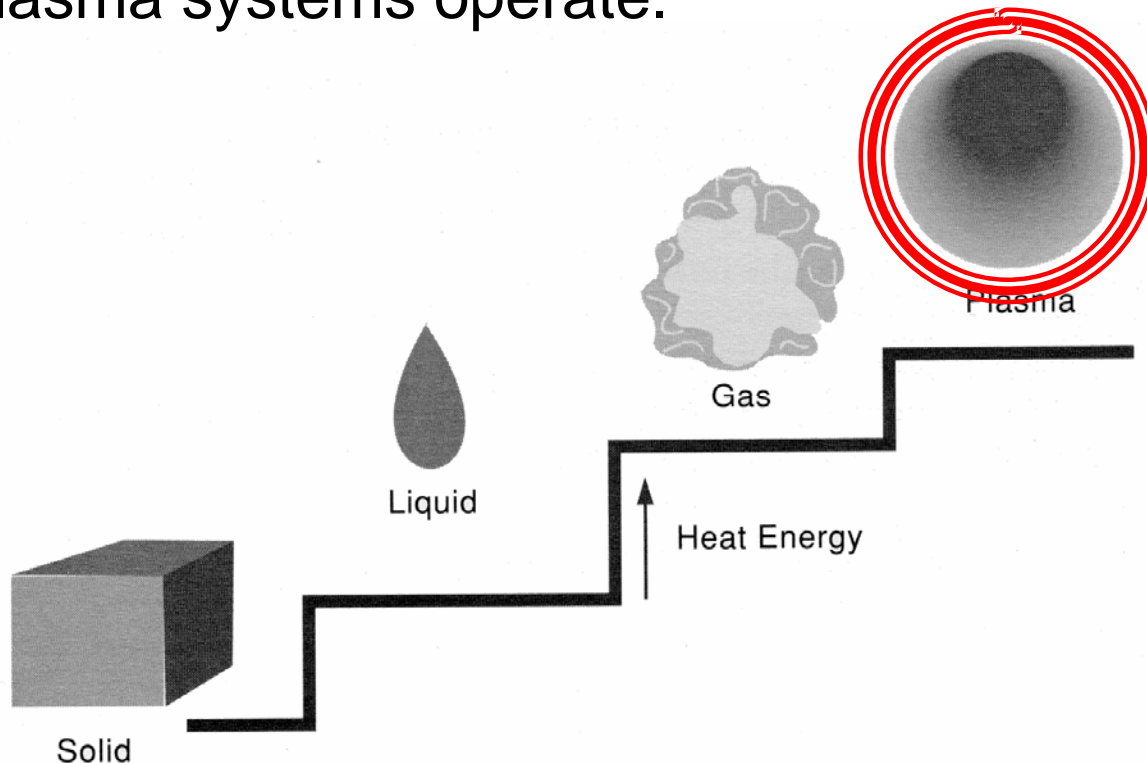
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The 4th State of Matter



This often overlooked “fourth state of matter” is called **PLASMA**. This ionized gas with its current carrying properties is the fundamental basis on which all plasma systems operate.



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Plasma in Nature



One example of **plasma**, as seen in nature, is lightning. Just like a plasma torch, the lightning moves electricity from one place to another. In lightning, gases in the air are the ionization gases.



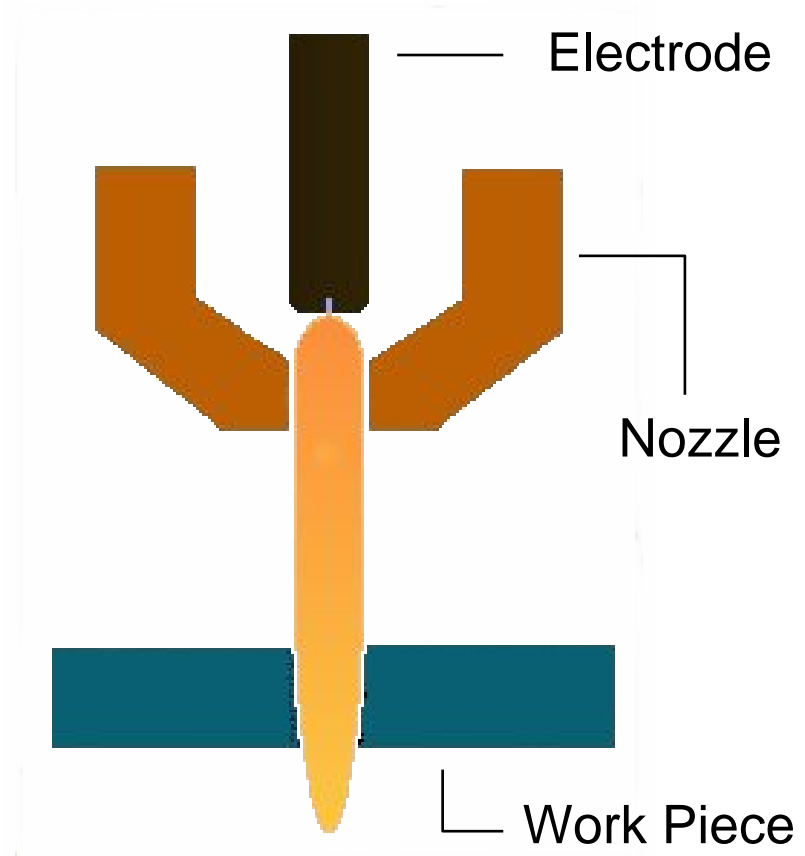
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Plasma Cutting



Plasma cutting is a process that utilizes an optimized nozzle orifice to constrict an electrically charged ionized gas.....so that it can be used to melt and sever sections of electrically conductive metals.



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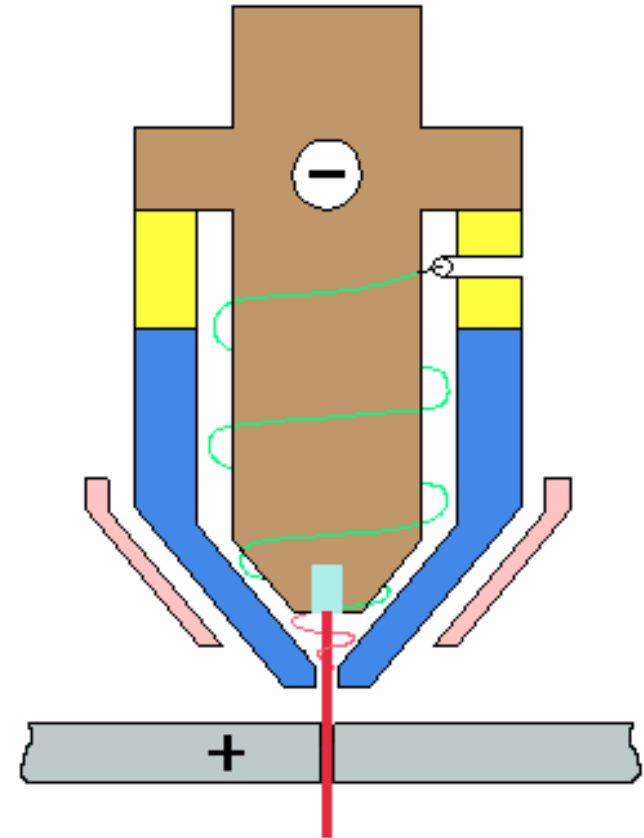
The Plasma Torch



An electrically conductive gas (plasma) is used to transfer negative energy supplied by an electrical power source from a plasma torch to the material being cut.

The torch serves as the holder for the consumable parts and provides cooling (either gas or water) to these parts.

The nozzle and electrode constrict and maintain the plasma jet.



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Sequence of Operation



In order to understand how the plasma arc is generated.....we need to understand the basic functions of the four major system components of every plasma cutting system:

- **Power Supply**
- **Start Circuit**
- **Gas Flow Control**
- **Torch**

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Component Analysis



Power Supply

- Produces constant current pure DC output.
- Houses the control circuitry for the proper sequencing of the entire system.
- Houses the cooling system for the torch.



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Component Analysis



RHF Console

Houses water and gas plumbing and related control devices as well as the high frequency starting circuit. The remote high frequency starting circuit permits more effective electrical noise shielding and allows the power supply to be installed up to 200 feet from the torch.



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Component Analysis

Gas Console

- Houses metering and solenoid valves for shield and plasma gases. The gas console interfaces with the plasma and shield gas supplies, the RHF Console, the Motor Valve Console and the Power Supply.
- Should be mounted in a convenient location for the operator



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Component Analysis



Torch

Houses the consumables.
The torch is where the arc is generated and therefore is the most important piece of the puzzle.



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Sequence of Operation



The four major components, power supply, starting circuit, gas flow control, and torch..... allow for the following sequence of events that initiate the plasma cutting process:

- start signal
- torch starting mechanism
 - gas flow
 - pilot arc
- arc transfer

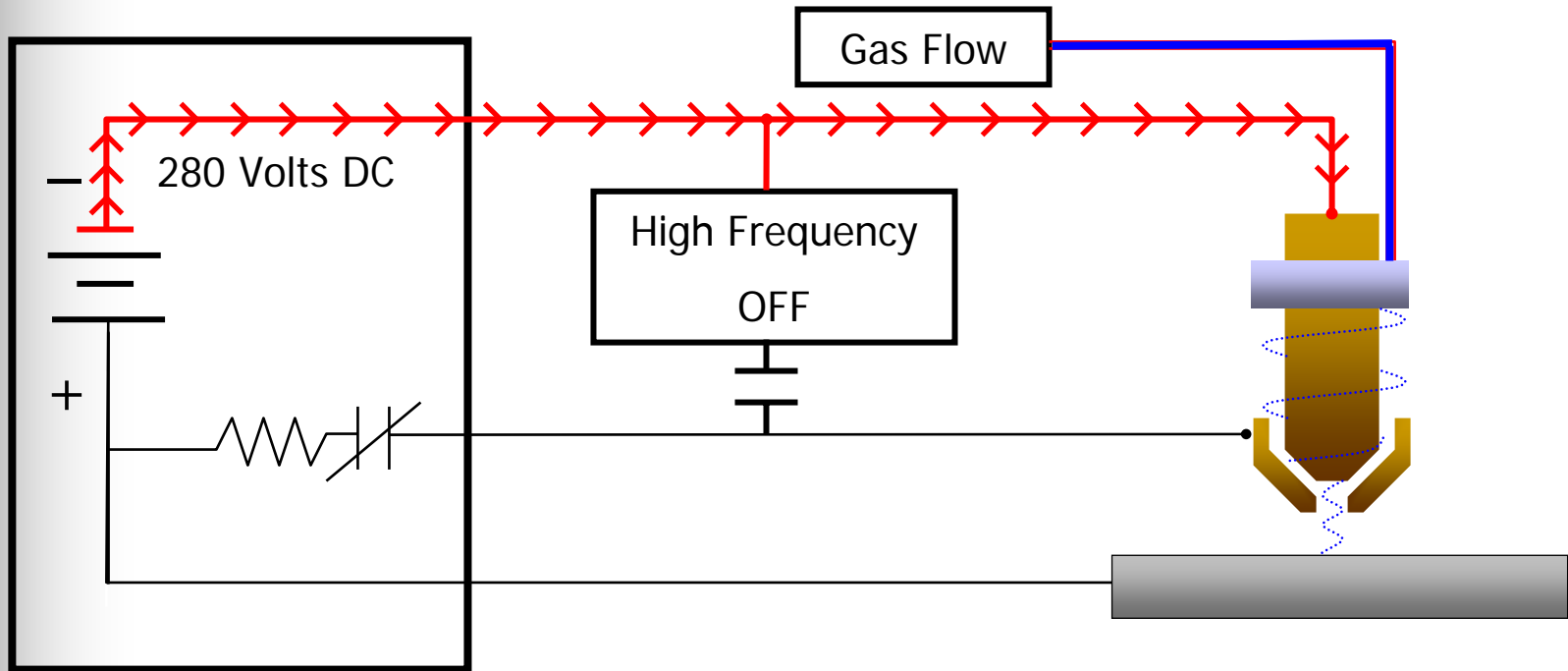
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Sequence of Operation



A start signal is sent to the DC power supply. This simultaneously activates the Open Circuit Voltage (OCV) and the gas flow to the torch.



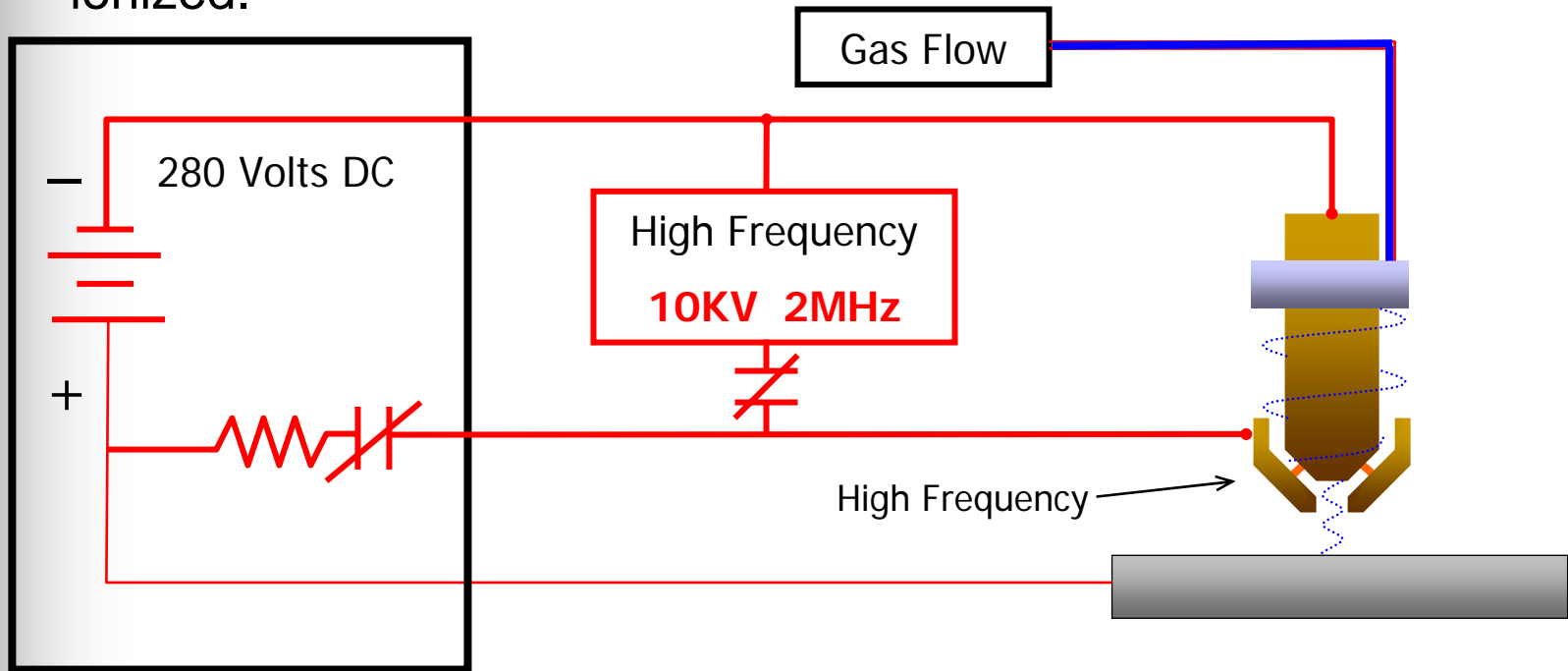
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Sequence of Operation



After the gas flow stabilizes, a High Frequency circuit is activated. The HF breaks down between the electrode and the nozzle inside the torch and the arc causes the gas passing through it to become ionized.



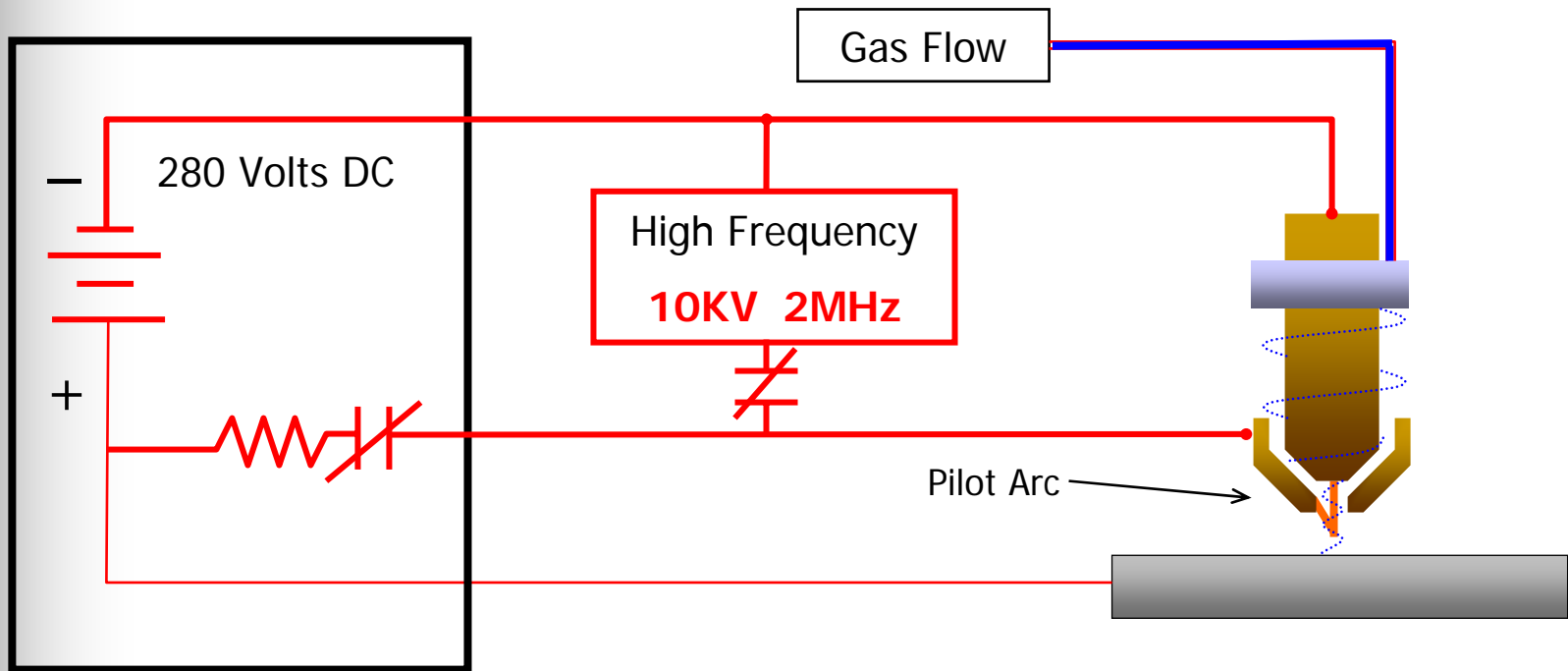
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Sequence of Operation



This electrically conductive gas creates a current path between the electrode and the nozzle and results in the formation of a pilot arc.



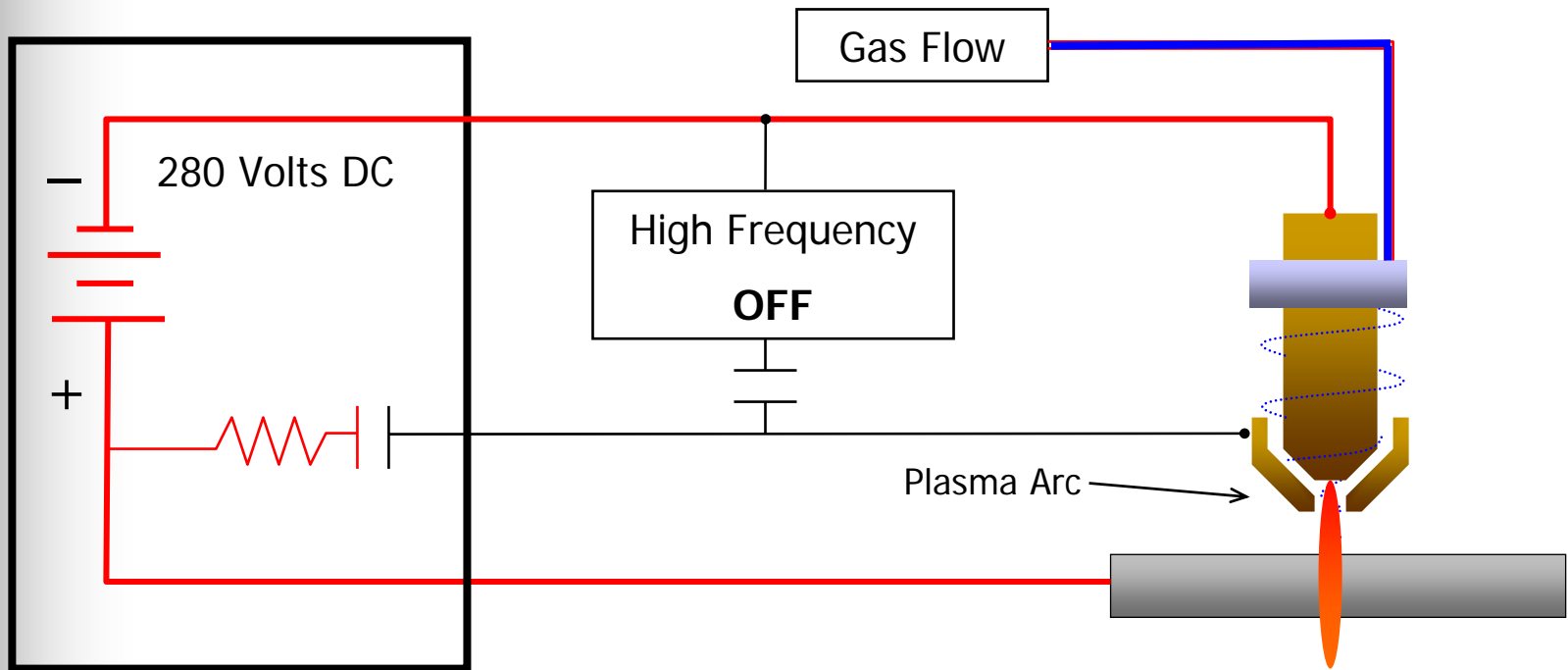
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Sequence of Operation



When the pilot arc is brought into contact with the workpiece, it will attach to the workpiece. The plasma arc melts the metal, and the high velocity gas removes the molten material.



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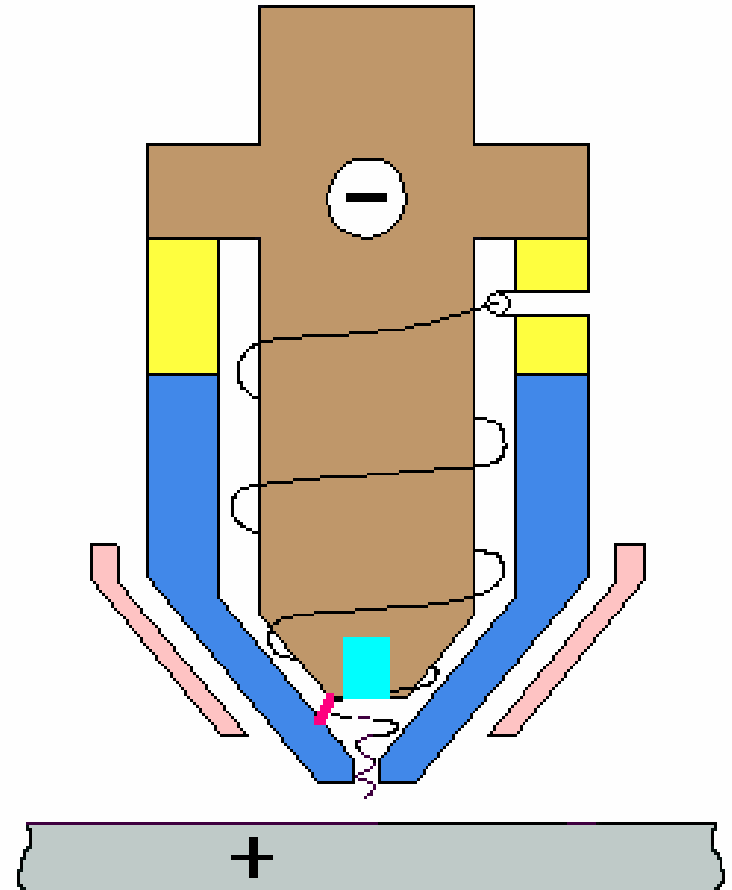
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Torch Starting Methods



High Frequency

- High voltage (5,000V - 10,000V), high frequency AC forms a spark between electrode and nozzle
- Gas is forced to flow through this spark, raising it to its ionization temperature
- This is an effective starting method, but generates electrical “noise” that may affect sensitive electronic equipment



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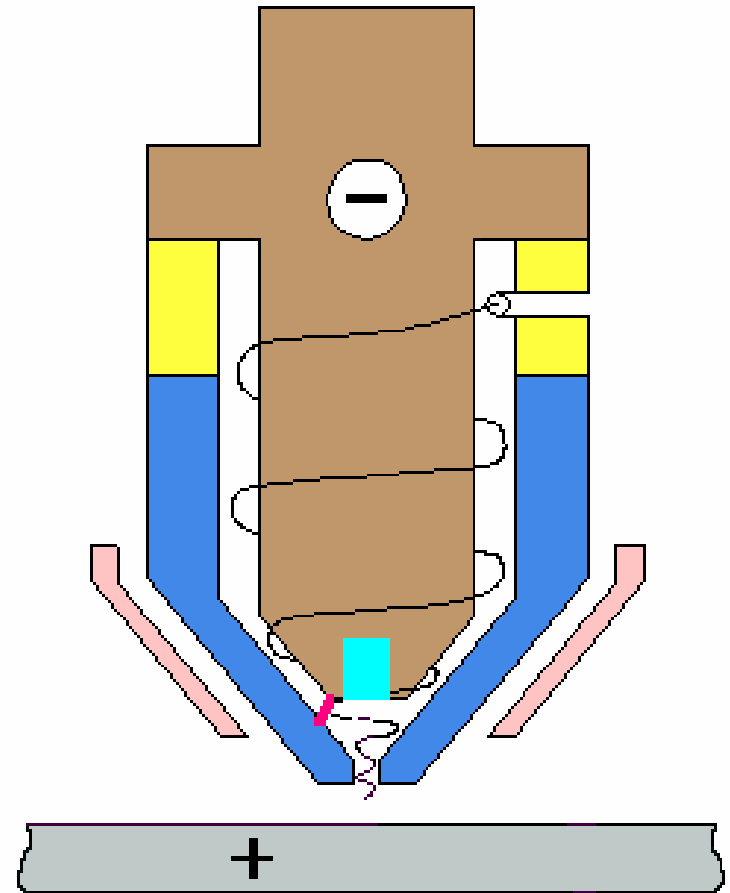
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Torch Starting Methods



Contact Starting

- Electrode and nozzle are in contact or “shorted” before the gas reaches the torch
- Gas flow causes the electrode and nozzle to move apart creating a short circuit spark
- The gas is forced to flow through this spark, raising the gas to its ionization temperature.
- This process works well at power levels under 100 Amps, and is well suited around sensitive electronic equipment



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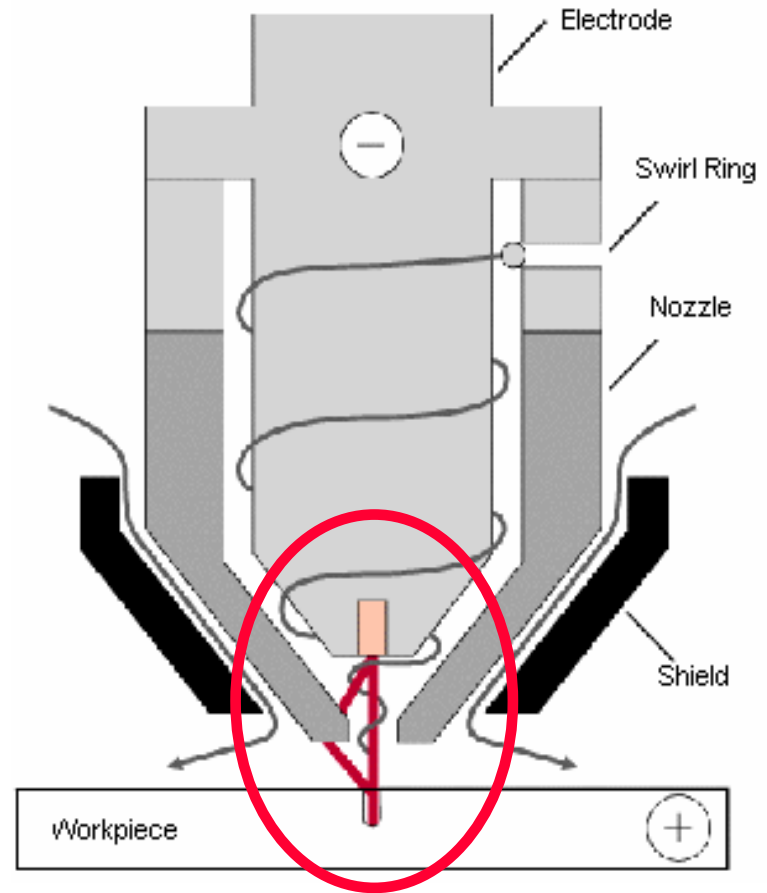
Torch Shielding Technology



Non-Shielded Parts Issues

Double Arcing

During the pierce, droplets of the molten metal can form a conductive path to the nozzle, causing the nozzle to be at positive potential. This can cause a “path of least resistance” from the electrode to the nozzle to the plate known as a “double arc”. This can also occur if the nozzle contacts the plate during a cut.



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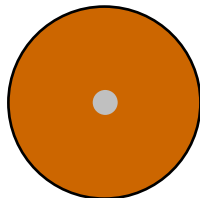
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Torch Shielding Technology

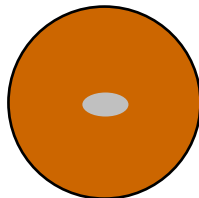


Non-Shielded Parts Issues Nozzle Damage

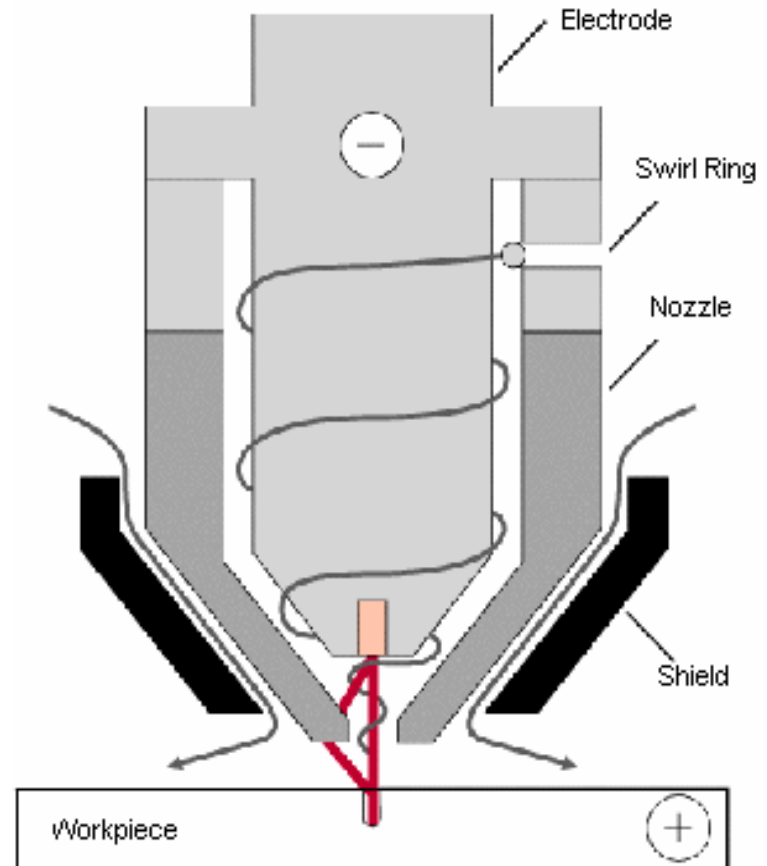
Contact to work piece
damage and blow-back
of spatter during cutting
damages the nozzle by
pitting and ovaling the
orifice.



normal



ovaling



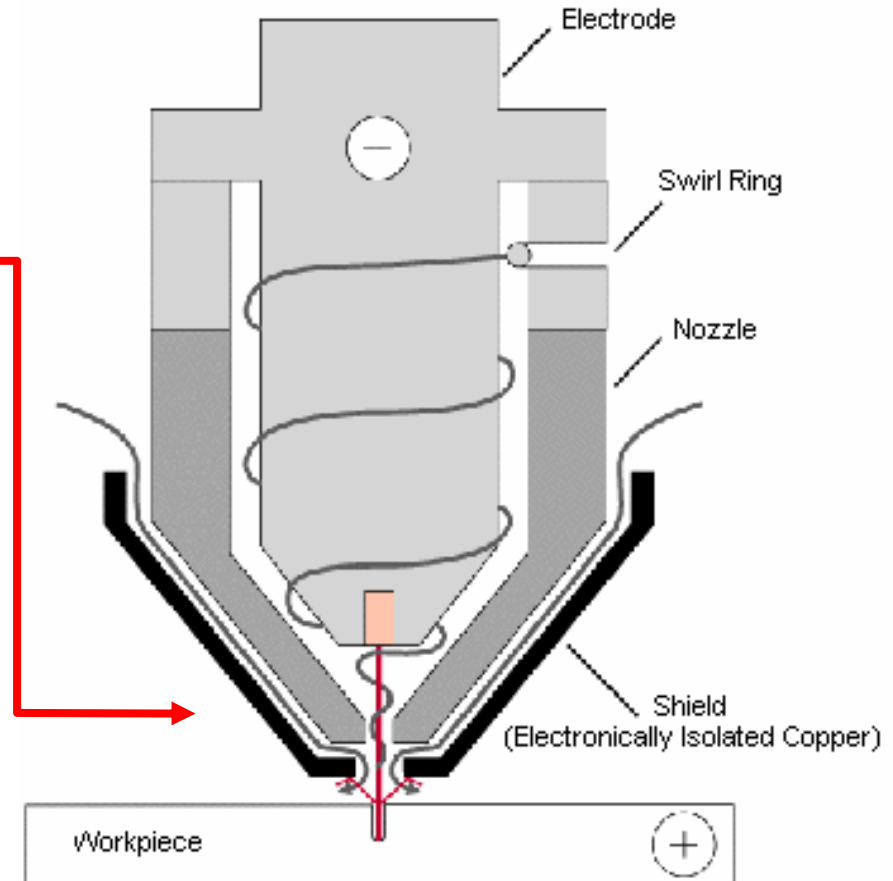
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Torch Shielding Technology

Shielded Front End

- Nozzle is protected by an electrically isolated shield
- Significantly reduces double arcing
- Prolongs parts life
- Facilitates drag cutting and template tracing
- Dramatic improvement in nozzle life



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Torch Shielding Technology

Shielded Front End Benefits

- During hand torch cutting:
 - *Ease of operation*
 - *Easy template tracing*
 - *Great nozzle life*
 - *Lower cost of operation*



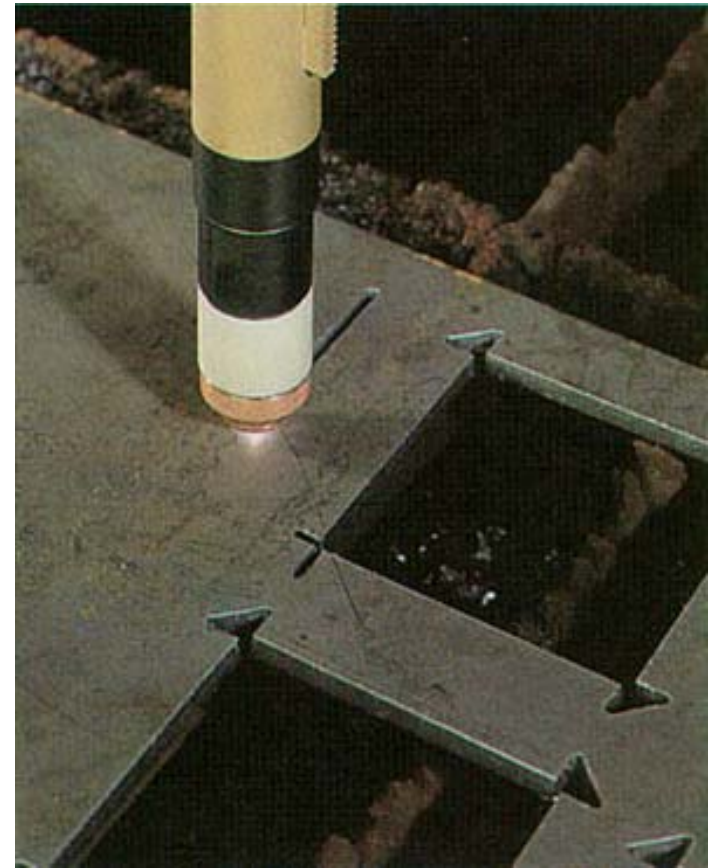
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Torch Shielding Technology . . .

Shielded Front End Benefits

- During mechanized torch cutting:
 - *Greater nozzle life*
 - *Lower cost of operation*
 - *Longer service life with consistent cut quality*
 - *Thicker Pierce Capacity*
 - *Protects the nozzle from occasional contact with plate.*



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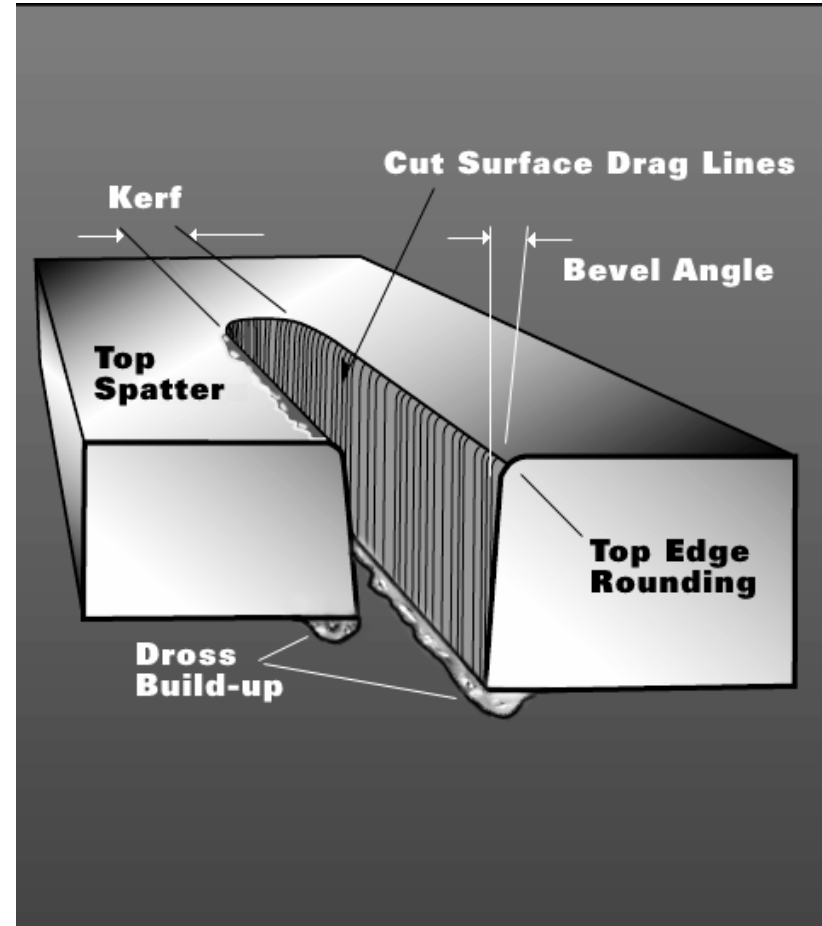
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Cutting Terms

Kerf:

Opening created by the metal removed by the plasma arc. The width of the kerf is determined by:

- *amperage*
- *gases*
- *nozzle orifice size*
- *consumable condition*
- *torch-to-work distance*



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Cutting Terms



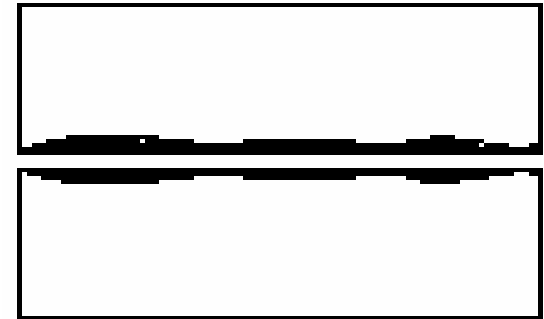
Dross:

The resolidified metal on the bottom or top of the cut.

Dross formation and its condition is determined by many factors:

- *travel speeds*
- *amperage*
- *gases used*
- *type and thickness of metal*
- *torch-to-work distance*
- *material surface coatings*

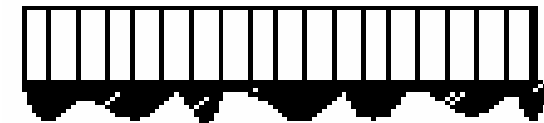
Top Dross



High Speed Dross



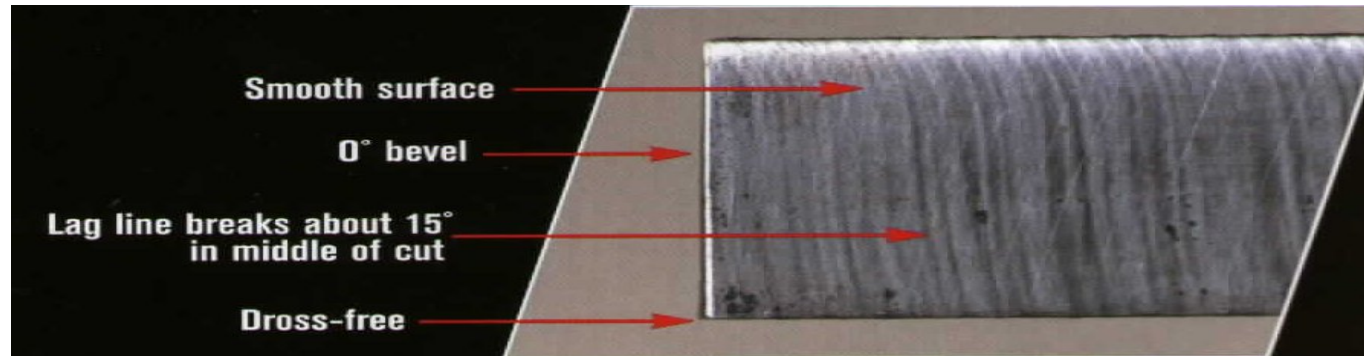
Low Speed Dross



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Cutting Terms



Lag Lines:

These are the ripples on the cut face or surface. The more consistent the power produced by power supply is, the smoother the cut. Depending on the process, normal lag lines are curved and slanted at about 15° with proper speeds.

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Using a Plasma Torch on an X-Y Table

- Mounted on an XY Table, a plasma torch can be controlled within all variations of the plane.
- In this manner, an operator can either control or set up a program to control the movement of the torch.



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Using a Plasma Torch on a Punch Press

- Combining punch presses with plasma creates a dual functioning machine.
- Often, the punch operation punches out precision holes while the plasma cutting operation is used to cut out the large holes, shapes, and perimeter of the parts.



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Using a Plasma Torch on a Robotic Arm

- Robots are multi-axis tool manipulators that can provide three dimensional movement.
- A plasma torch may be mounted on a robotic arm to help ease the cutting of irregularly shaped materials.



High Definition Technology

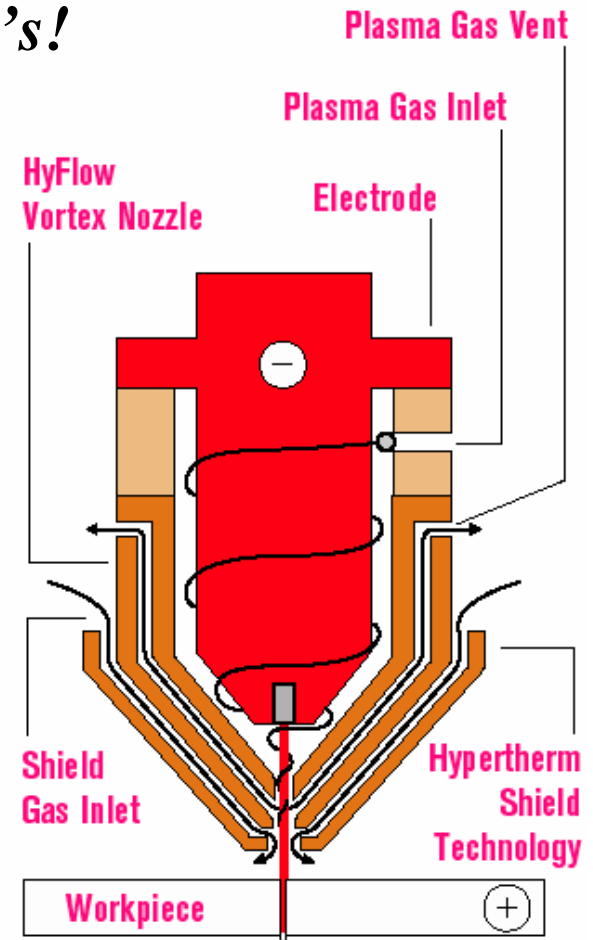


...Developed in the early 1990's!

Produces superior cut edge squareness, narrower kerf width, and less heat affected zone (HAZ)

This technology involves super-constricting the arc, dramatically increasing energy density of the arc.

Best thickness range is from 18 gauge to 3/4"



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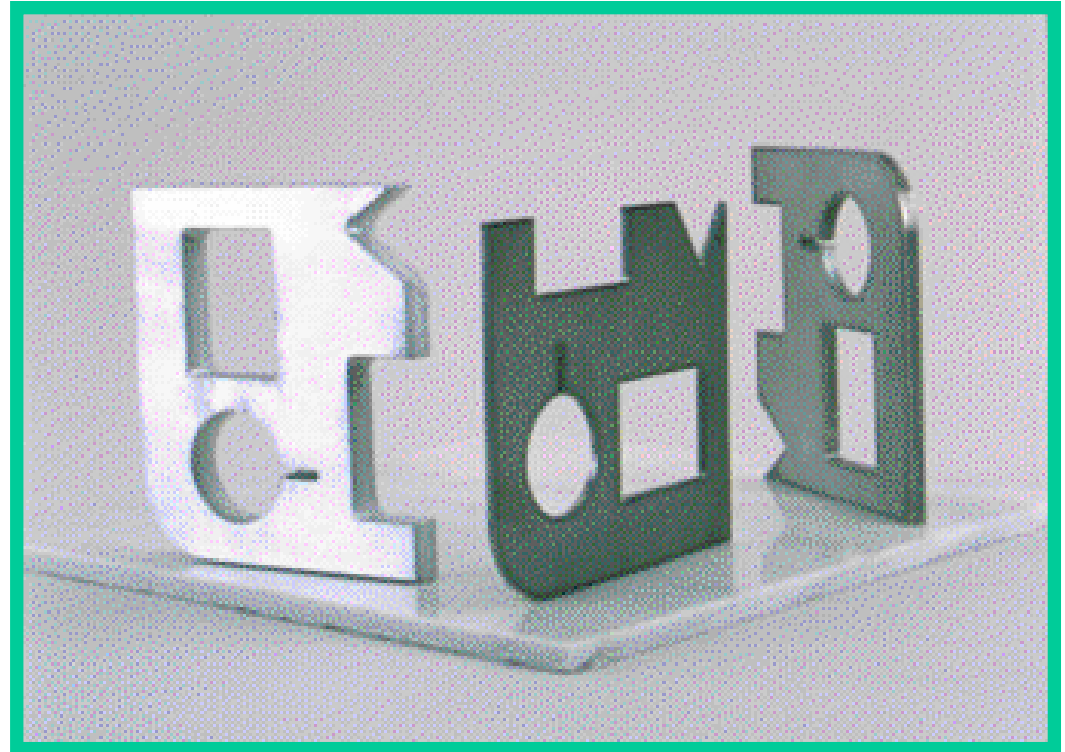
High Definition

New Levels of Automation and Performance



High Definition Plasma:

Q. What does it do
that conventional
plasma cutting
can't do?



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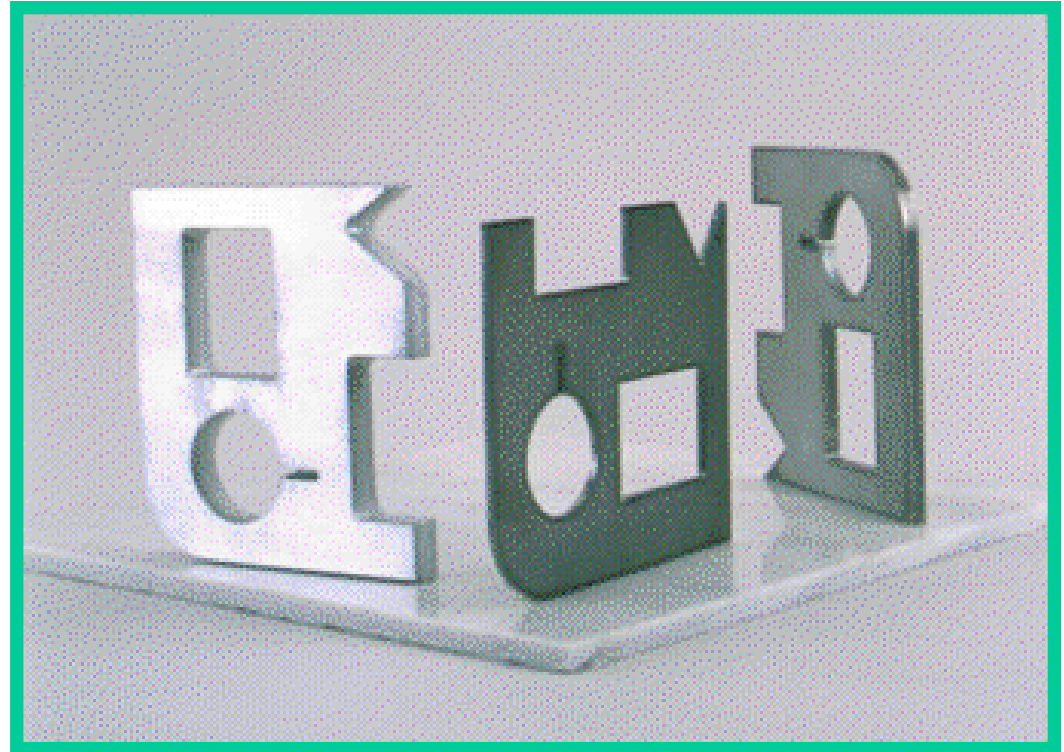
High Definition

New Levels of Automation and Performance



High Definition Plasma:

- A. Conventional plasma systems typically produce better cut edge angularity as the material thickness increases....High Definition plasma produces excellent cut edge angularity through it's entire cutting range.



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High Definition

New Levels of Automation and Performance



Superior Cut Quality & Tolerance

- Increased cut angle accuracy vs. conventional plasma....materials thinner than 3/8" are visibly sharper and more defined, while greater thicknesses (to 1") will be produced with much tighter tolerances as compared to conventional plasma cutting processes.
- Typical angularity....1/8" steel= 0 degree bevel

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High Definition

New Levels of Automation and Performance



Superior Cut Quality & Tolerance

- Narrow kerf width....typically 1/2 that of conventional plasma cutting.
- Very robust process.....cutting is rarely affected by surface of metal, or metalurgical composition as other cutting processes are.

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High Definition

New Levels of Automation and Performance



Superior Cut Quality & Tolerance

- Carbon steel is cut with Oxygen as the plasma gas producing a weldable, machineable, formable edge.
- HAZ is minimized.....typically less than .005”
- Virtually no dross on steel from gauge to 3/4”

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High Definition

New Levels of Automation and Performance



Wide thickness and material range

- Aluminum cuts very well.....Nitrogen is used as the cutting gas.....from gauge to 3/4"
- Thin stainless....gauge to 1/4"....is cut using Nitrogen with some edge oxidation
- Thicker stainless is cut using Nitrogen and Argon/Hydrogen with clean, weldable edges

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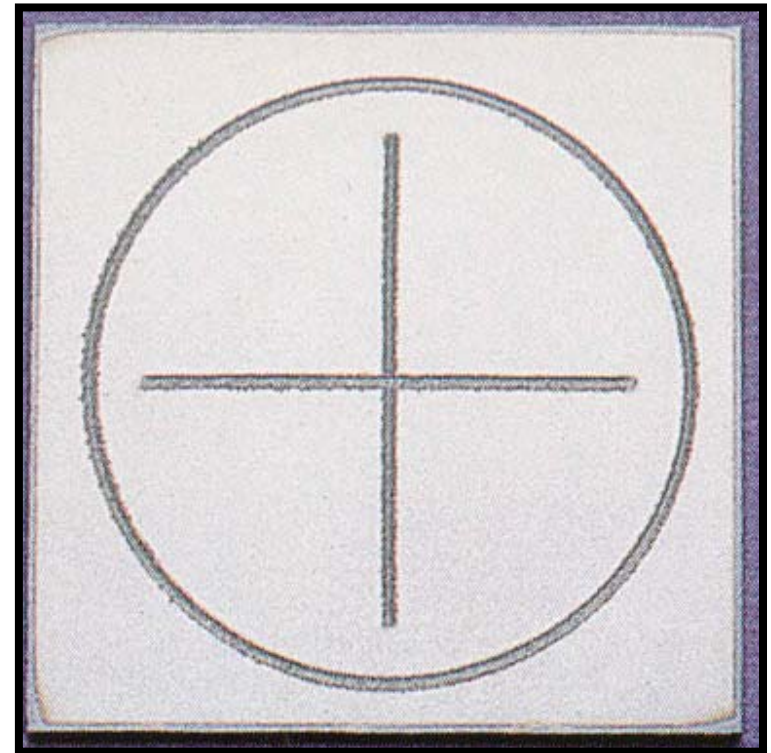
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Plasma Marking



Increased Process Flexibility

- Built-in **ArcWriter** plasma marking process for marking variety of metal surface. Same system can mark and cut further increasing productivity.
 - *light scoring & marking*
 - *heavy scoring & marking*
 - *punch marks or dimples*



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Conclusion



- Today's Plasma Cutting Systems are the high productivity cutting solution for many applications.
- High Definition Plasma effectively fills the gap between Laser and Conventional plasma and oxyfuel processes with excellent tolerances, high cut speeds and low operating cost.
- Take a look at today's plasma cutting capabilities!

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