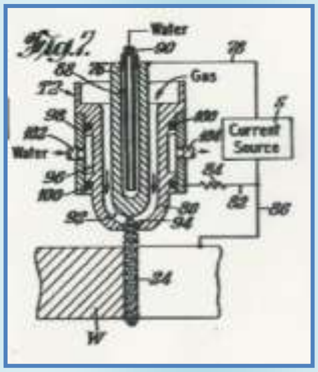
History, Applications, Advantages for Plasma Gouging
(It's Time Has Arrived- See Why!)

by Jerry Uttrachi

Plasma for both welding and cutting was invented by Bob Gage working for the Linde Labs, a pioneer in welding and cutting processes. Bob was a brilliant scientist and became the manager of all of welding and cutting R&D locations for Linde (now renamed Praxair.) I managed one of those welding Labs involved in developing welding gases and filler metals; Bob was a great boss. He could always make you think about ways to solve problems, often with a critical statement such as, "*You're solving a problem not known to exist, using a method known not to work!*" Bob's first Plasma patent was filed in July 26, 1955, # 2,806,124 entitled "Arc Torch and Process,"-patent figure right.



In 1985, a new, independent company was formed from Linde's welding filler metals, equipment and CNC cutting business in the US, Canada and Germany. That company, L-TEC, focused on increasing the development of plasma processes, which up to that time had been mainly used for cutting on CNC cutting machines utilizing nitrogen and oxygen gases. Having no ties to selling industrial gasses, L-TEC developed systems that used compressed air. We introduced one of the first inverter based, portable Plasma Cutters, weighing only 39 pounds and using air. It was a tremendous success in North America and Germany.

I recall an L-TEC employee working in the applications lab, Randy Stone (photo left), developing procedures for air Plasma cutting and Plasma Gouging that we were introducing to the metal working industry. The Plasma Gouging process was an instant success, displacing carbon arc gouging in many applications.

Visiting with our Canadian company, I saw a very successful implementation of Plasma Gouging at a large railroad repair shop. Numerous Plasma Gouging systems had replaced Air Carbon Arc Gouging removing most of the hundreds of welds in a locomotive overhaul.

Torch Problem Found When Plasma Gouging

It was found that Plasma torches often could not withstand the extreme environment when Plasma Gouging. Since plasma-cutting torches operate at relatively high voltages, they must be built using an insulating material on the outside of the torch body, to protect the operator. In normal cutting use, the torches stay cool, because the hot metal and gases are mostly ejected below the plate (except when starting.) In Plasma Gouging, however, the heat stays on the top of the plate, exposing the torch to intense heat and metal splash back. The result is unacceptably short torch body life.

A PLASMIT torch protector was developed during the 1980's, by Richard Hadley, who was at the time a region manager for L-TEC Welding and Cutting Systems. (That business was subsequently purchased by ESAB.) Shortly following large sales of Plasma Gouging equipment to the railroads (photo left); it became evident that plasma torches could not withstand the abuse from repair of railroad equipment. In this difficult application, Plasma Gouging can take place on painted and greasy surfaces. Quite often, the paint or grease ignites. The operator does not or cannot see that their torch is being damaged by the flames, until too late! Another example of a severe environment is when gouging into a corner. The molten metal splashes back onto the torch, melting the torch body. The Plasma torch is also subjected to being dragged across railroad rails, through locomotives and rail cars, physically breaking the torch head.

A solution had to be found if Plasma Gouging was going to be viable in heavy industry. There was no readymade product, so Hadley created PLASMIT (shown on right). Incorporated in 1988, he expected that the plasma torch builders might find a better solution to this problem, but so far, PLASMIT is the only proven torch protector on the market.

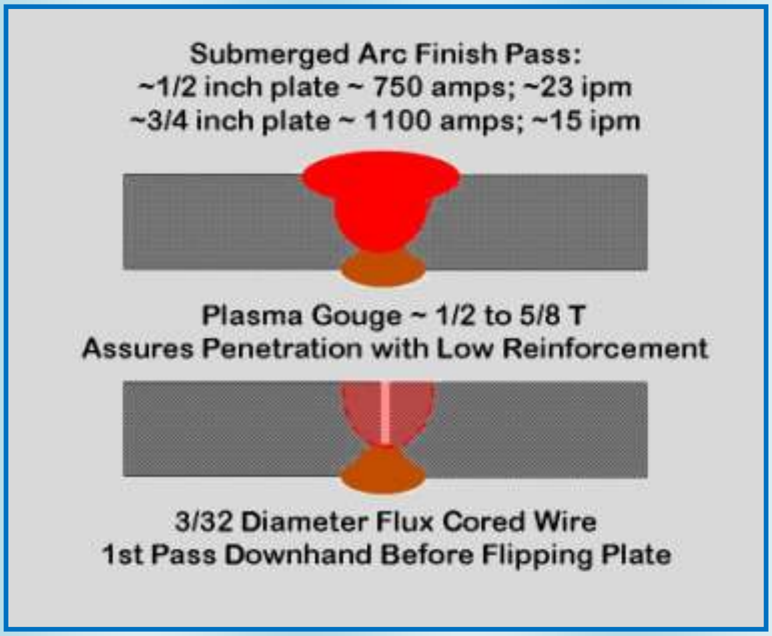
Plasma torches have improved over the years, but it is a simple fact that to build a torch to withstand the occasional heavy gouging abuse would make it heavy and likely not very user friendly. Note the torch on the right with a PLASMIT has seen severe use but is still functional. It would have been destroyed long before if it were not for this inexpensive and durable plasma torch protector. The PLASMIT also cushions the torch head so it can withstand some physical abuse.

Metal shields are an apparent solution, but there are serious drawbacks to using metal. Metal shields make it more difficult for the operator to maneuver the torch during gouging. In addition, plasma torches operate at high voltage and high amperage. Metal shields are electrically conductive. Should the arc power short circuit to the shield, and if the operator was touching the shield, there is a serious risk of electrical shock and injury. That is why there are no handheld plasma torches with metal near the operator handle. Although not a frequent occurrence, sometimes a torch will short circuit to the side of the nozzle or torch body, usually because a metal guide was used, and the torch was already damaged. There are very explosive fireworks when this occurs!

PLASMIT has allowed industry to benefit from the tremendous advantages of Plasma Cutting and Gouging in heavy industry applications, which is why PLASMIT celebrates 25 years in business!

Plasma Gouging in Japan

When Plasma Gouging was introduced, I went to Japan to visit an Engineering company that sold our Plasma products, Aichai Sangyo. They had purchased about one hundred 150-amp systems that could be combined in pairs, when needed, into a 300-amp system called a Duce Pack. They had detailed application information about the fabricators where the systems were being employed. Many were used for shipyard and bridge beam fabrication. Even for short web and flange splicing, the system was saving a great deal of time and money. Square butt joints were often used for both ship, web and flange plates, many starting with a relatively high current flux cored wire weld-backing pass. With flux-cored wire it was possible to weld over normal gaps in the square butt joint, allowing steel mill edges to be used. After making the backing weld, the plates were turned over and a Plasma Gouge made on the top side. There was no need to grind the finished, uniform gouge. A single pass submerged arc weld was made over the Plasma Gouge and penetrated into the first pass. It was not necessary to gouge fully into the first pass, as the Plasma Gouge is wide and the submerged arc weld has significant penetration. The accompanying schematic provides a summary of approximately what they were able to accomplish.



Air Carbon Arc Gouging versus Plasma Gouging

Carbon Arc Gouging is a noisy, messy process. The high airflow creates large amounts of smoke, making it very difficult and costly to effectively capture the smoke and fumes. In addition, Carbon Arc Gouging leaves carbon on the gouged surface. If the gouged surface is to be welded, it must be cleaned with a grinder, adding even more dust to the worker's environment. This post gouge grinding is also labor intensive.

Plasma Gouging offers a significant reduction of smoke and fume compared to Carbon Arc Gouging. Because the gas flow with plasma is much lower than Carbon Arc Gouging, the small amount of smoke that is generated is much easier to capture. Plasma Gouging offers productivity improvements as well. Plasma Gouging can be a continuous operation, (no carbon electrodes to replace), the travel speed can be high, and the gouged groove is clean and ready to weld. The noise level of Plasma Gouging is typically 5 to 10 dB lower than with Carbon Arc, which makes the workplace more comfortable for all workers. As a comparison, a motorcycle creates about 90 dB and a Jet taking off 100 dB.

The table below provides fume measurement data from a production case study comparing total fume levels from Plasma Gouging and Air Carbon Arc Gouging. For both processes, specific elements must be measured depending on what materials are being gouged. More on that critical step after reviewing the case study data.

Location of Fume Measurement	Ventilation	Process	Fume Measurement Total mg/m^3
Reported as Breathing Zone; Usually a Lapel Measurement	With Local Ventilation	Plasma Gouging	0.45 mg/m^3
		Carbon Arc Gouging	192 mg/m^3
	Without Ventilation	Plasma Gouging	< 0.1 mg/m^3
		Carbon Arc Gouging	136 mg/m^3
Reported as Inside Helmet	With Local Ventilation	Plasma Gouging	< 0.1 mg/m^3
		Carbon Arc Gouging	1.7 mg/m^3
	Without Ventilation	Plasma Gouging	0.42 mg/m^3
		Carbon Arc Gouging	1.9 mg/m^3
Reported as Measured 6 feet from the Arc	With Local Ventilation	Plasma Gouging	< 0.1 mg/m^3
		Carbon Arc Gouging	41 mg/m^3
	Without Ventilation	Plasma Gouging	2.9 mg/m^3
		Carbon Arc Gouging	124 mg/m^3

Summary of Fume Measurement:

As noted, Plasma Gouging has from 5 to several orders of magnitude less fumes! Note the fume levels 6 feet from the arc are not much lower with Carbon Arc Gouging than measurements made in the breathing zone, assuming it was the standard lapel measurement location. However, all elements in the fume must be measured to assure specific elements, as well as gases such as ozone, do not exceed allowable maximum levels.

Measurement of Critical Fume Constituents: In the past, it was sufficient to measure total fumes or even observe fume levels to estimate where the levels might be excessive. Recent reductions in allowable maximums for specific elements have changed that scenario. When gouging (or welding) stainless steel, for example, the latest maximum levels of allowable fumes cannot be detected or estimated visually. The TLV (Threshold Limit Value) defined by the ACGIH (the accepted body who defines such levels) are currently a very low level of 0.05 mg/m^3 for water-soluble Chrome VI and 0.01 mg/m^3 for insoluble Chrome VI. For Nickel, the other critical element in stainless steel, the TLV is 1.5 mg/m^3.

The Time Has Come for Plasma Gouging

Perhaps the greatest issue related to fume generation occurred in January 2013. The ACGIH lowered the TLV for a very common element in carbon steel, by far the largest material welded and gouged. Through 1979, the TLV for Manganese was 5 mg/m^3, which was the same level as total fumes. Therefore "total fumes," was the only measurement needed since other elements usually did not exceed their maximum permissible levels if total fumes were within allowable levels. However, in 1995 the TLV was lowered to 0.2 mg/m^3. Published information shows that welding fumes, measured behind the welder's helmet, are typically close to that value even with quality ventilation. In January 2013 the ACGIH, after saying for several years they would lower the permissible Manganese level, reduced it by a factor of 10! The TLV for Manganese is now a very low 0.02 mg/m^3. This will probably be a difficult level to achieve in production. However, using a process that produces an order of magnitude less fumes will generally provide lower operator exposure measurements as well as the area around the welding or gouging operation. If lower operating cost was not sufficient incentive to invest in Plasma Gouging equipment in the past, the lower fume generation rate may be now!

Cost Differences Between Plasma Gouging and Carbon Arc Gouging

The American Welding Society Handbook, 9th Edition Volume 2 in Table 15.9, presents cost data comparing Plasma Gouging and Air Carbon Arc Gouging. They show for a specific gouge size, the cost for Plasma Gouging is \$0.16 per foot of gouge while Air Carbon Arc Gouging cost \$0.42/foot.

That can be stated as a percent reduction in total cost of ($0.42-$0.16)/$0.42 or 62%. The payback for the capital cost can be calculated based on the amount of gouging performed.

Bottom Line:

Plasma Gouging has lower operating cost than Air Carbon Arc Gouging (shown operating in photo right.) There are no carbon electrodes to buy or stubs to discard. If using compressed air as the plasma gas, gas cost is minimal. Even if Nitrogen or Oxygen gas is employed for some applications, the cost is low.

Welding fumes, as noted above, may be over 10 times lower with Plasma Gouging. However when gouging carbon steel, fume measurements must still be made with Manganese being the element that will probably be the deciding factor to define adequate ventilation to protect the operator. For stainless steel, Chrome VI will usually be the element requiring measurement and control. Gases, such as Ozone, could also be an issue depending on venation conditions.

Plasma Gouging may be 10 dB lower in noise level, although the operator and those workers in the area will still require hearing protection.

To help protect the Plasma torch from metal spatter and the operator from increased risk of electrical shock, a PLASMIT (photo right) is an inexpensive addition to the system. You can purchase one to fit your Plasma torch at:

http://www.netwelding.com/Cable_Hose_Cover.htm

Attached is an informational ad that presents another cost saving item, our patented shielding Gas Saver System cuts gas waste by 80% and total shielding gas use by typically 40 to 50%. Many thousands are in use.

WA Technology

Overview of Patented Gas Saver System (GSS™)

The GSS is a Patented Gas Delivery Hose Incorporating a Start Flow Surge Limiter That Can Save 50% or More of MIG Shielding Gas Use and Improve Weld Start Quality.

The Problem – An orifice or a needle valve are used to set and control gas flow. With Regulator/ Flowmeters (photo right) outlet pressures range from 25 to 80 psi. Flowmeters used on pipelines allow pipeline pressure to exit the flow control valve when welding stops. A typical pipeline pressure is 50 psi.

Flowgauge/ Regulators (photo left) operate by setting a pressure above a critical orifice. For most MIG shielding gas flow rates, the pressure exiting the control orifice when welding stops will range from 40 to 70 psi.

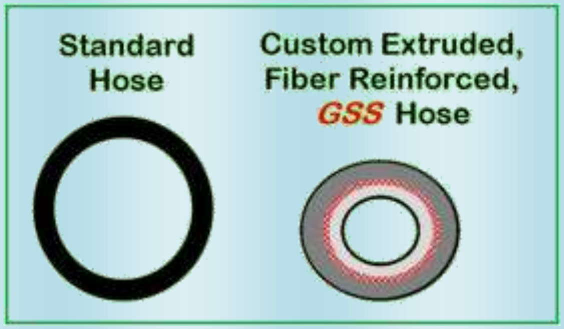
However, the pressure needed at the feeder can range 3 to 8 psi depending on MIG gun length and restrictions that occur when welding, such as spatter in the gas diffuser ports, clogged conduits that also serve as the gas passage in the gun cable. When welding stops, gas continues to flow though the orifice or needle valve and pressure in the gas delivery hose will rise to that of the regulator or pipeline. Therefore the pressure will be about 25/3 = ***8*** to 80/3 = ***26*** times the pressure needed to flow the desired amount of gas!

Excess Pressure Means Excess Shielding Gas is stored in the gas delivery hose due to this high pressure. Most of this excess gas is wasted every time the MIG gun switch is energized, even when just inching the wire. The excess can exceed the amount of gas used while welding! Inferior weld starts result from the high gas surge flow pulling air into the shielding gas stream.

How much excess gas can be stored in a 1/4 inch delivery hose? Up to *7 times* the physical hose volume depending on pressures!

The Solution - Our patented *Gas Saver System* (*GSS*) stores 80%+ less gas when welding stops.

The *GSS* solves this excess stored gas problem by utilizing a custom, very heavy wall, gas delivery hose with less volume than conventional hoses and the use of a surge flow-limiting orifice. Excess stored gas creates another problem as it exits the gun nozzle with a high surge flow at the weld start. Start gas flow rates far exceed the level that allows smooth laminar flow. It creates turbulent flow that pulls air into the shielding gas stream. The surge flow restrictor incorporated



in the ***GSS*** not only adds to waste reduction, it improves weld starts. The start surge flow restrictor is sized so it *does not* limit normal gas flow settings.

Superior Start Quality - Limiting start flow velocity to a rate that avoids excessive turbulence is achieved while quickly providing enough extra gas to purge the gun nozzle and weld start area. This controlled surge flow rate eliminates moisture-laden air from being mixed into the gas shield that results in excess spatter and possibly weld porosity.

The patented ***GSS*** design maintains system pressure to retain *Automatic Flow Compensation* built into standard gas delivery systems since the introduction of MIG and TIG processes! If the pressure is lower than 25 psi, this feature is lost! Retaining the high pressure also helps to quickly provide a controlled amount of extra gas at the weld start to purge air from the gun nozzle and weld start zone.

Proof of Savings - A Manufacturer making truck boxes reported the following test results. They used

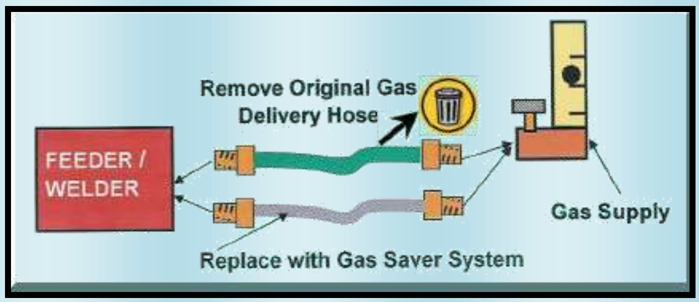
their standard gas delivery hose and welded 236 truck box doors with one cylinder of shielding gas. With the ***GSS*** installed; the same welding conditions and flow rate while welding, they welded 632 of these doors with one cylinder! That is a 63% savings in gas use.

Bottom Line - The patented ***GSS*** has no moving parts to wear, maintain or knobs to adjust. It *does not* control gas flow while welding. The welder sets that rate as usual. Welders appreciate the start benefits and are not irritated by restrictors that set flow or low-pressure devices that cause flow variations while welding! If you desire to control the range of allowable flow settings, see our patented ***Flow Rate Limiter*** device on our web site.

The ***GSS*** is inexpensive with ***Payback*** measured in weeks.

Saving Shielding Gas and Improving Weld Start Quality Is Easy and Inexpensive

Just Replace Your Gas Delivery Hose with Our GSS



US Patent Number 6,610,957
These other patents also cover some of our shielding gas saving products; 7,015,412; 7,019,245; 7,462,799 In Canada # 2,455,644
www.NetWelding.com