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MIG Shielding Gas Control and Optimization

Also Available as a Short Movie: http://youtu.be/H5nabh9deLE

By: Jerry Uttrachi

Find Out:

- **Why Most MIG welders are wasting over 50% of the shielding gas used and getting inferior weld starts!**
- **How to save money by reducing the high *"Gas Blast"* surge at each weld start.** ***Slash total MIG shielding gas use, typically "in half."***
- ***How to Improve weld quality and reduce weld start spatter*** **by limiting peak gas flow surge at weld starts that pulls in air.**

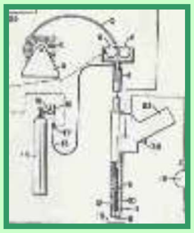
- ***Achieve these benefits easily and at low cost.*** **Our patented gas saving products eliminate past problems with gas surge control devices, like simple orifices and low-pressure devices.** ***Price of Gas Saver System starts at $80.00.***
- **Well over 15,000 of our patented Gas Saver Systems are in use.** ***Payback is often measured in months or one cylinder refill!***

This Technical Paper Provides:

- ***A "one page" summary:*** follows this Index Page
- History of MIG shielding gas flow control
- Maximum usable shielding gas flow rates documented
- Methods of setting shielding gas flow
- Maintaining consistent flow automatically when inevitable flow restrictions occur in production
- Why some extra gas is needed at each weld start to purge air in the weld zone and gun nozzle
- High pressure is needed to achieve "coked flow" but causes excess stored gas
- Excess stored gas in delivery hose blasts out at each weld start causeing significant gas waste
- Published reports show average MIG welder wastes up to 80% of shielding gas used
- Fabricator testimonial shows a 63% total gas savings with just a starting gas surge reduction
- Details of patented, inexpensive Gas Saver System provided that reduces starting surge
- Gas Saver System improves weld start quality – fabricator testimonials testify
- Low pressure, surge reducing, "Gas Guard" devices cause significant problems
- Orifices or other flow control at the wire feeder cause problems and frustrate welders
- Causes of gas flow restriction variations while welding, are outlined
- Calculations show average industrial MIG welder may waste 7 tons CO_2/year/welder
- Extensive References: support comments and findings
- Appendix A: Case examples of fabricators savings with Gas Saver System
- Appendix B: Fabricators report major problems with low pressure, surge reducing devices
- Appendix C: Q & A; other reasons for gas loss; -1) leaks and 2) excess flowmeter settings
- Appendix D: Why Gas Saver System purchases should be made at ***www.NetWelding.com***?
- Appendix E: Check flow at nozzle/cup and demonstrate gas waste:
- Appendix F: MIG/TIG Shielding Gasses. Argon ***has recently quadrupled in Price.*** See why.
- Appendix G: Controlling Peak Shielding Gas Flow at MIG Weld Start is Critical
- Appendix H: Author & Company background:

As a Past President of the American Welding Society (*a 1 year, volunteer position*) Jerry Uttrachi gave technical talks about MIG Shielding Gas Control Optimization at over 20 locations in the USA and conferences in Peru (*Picture left*,) Denmark, and South Korea. The talk was also presented at the International Institute of Welding (IIW) Annual Assembly in the Czech Republic. This report summarizes the details presented in those talks. Author/Company details are in Appendix H.

One Page Report Summary



Most MIG Welders are wasting over half the shielding gas being used due to starting gas surge. The high peak gas flow surge at weld starts also pulls in moisture laden air causing excess spatter and inferior weld start quality.

From the introduction of MIG welding in the 1950's the developers knew excess shielding gas flow rate created weld quality problems. Key claims as well as the teaching in the original MIG patent state gas shielding must be: ***"… none turbulent to exclude air from the arc."*** *Several references sited in this report show MIG shielding gas flow rates cannot exceed about 50 to 60 cubic feet per hour (CFH) to achieve this non turbulent flow.*

The engineers that designed the gas flow control systems understood spatter buildup in the MIG gun nozzle and gas diffuser, bending of the small gas passage in the gun cable, etc, would cause significant variations in gas flow restrictions. They used a "choked flow" design, requiring a minimum of 25 psi upstream of the flow control device to automatically keep shielding flow at the preset level. However, the use of this high pressure stores excess stored gas in the gas delivery hose when welding stops, up to 7 times the physical hose volume. Most of this stored gas "blasts out" of the MIG gun nozzle at every weld start! Most of this excess gas is wasted. About 87% of the excess gas volume is caused by the Gas Pressure/Gas Volume relationship while about 13% is due to hose expansion created by the high pressure. At each weld start, this excess stored gas in the hose from the gas supply to wire feeder (over that needed to purge air in the weld start area) exits the MIG gun nozzle at a peak flow rate often exceeding 200 CFH! This causes considerable shielding gas waste and very turbulent flow. The turbulent flow lasts for several seconds even after the preset level is reached, which mixes moisture-laden air into the gas stream. This creates inferior quality weld starts with excess spatter and possibly internal weld porosity.

Published data shows the average MIG welder uses over 3 times the amount of shielding gas they should! *After conducting extensive laboratory and field tests, we have determined a major cause of this waste is the gas surge at the weld start and not the often-blamed gas leaks. A patent by Stauffer is cited showing that some extra shielding gas is needed at each weld start to purge air from the gun nozzle and weld start area. However, this initial extra purge gas must not be at a high flow rate that creates excess turbulence - as occurs with most standard shielding gas flow control systems.*

A patented, inexpensive device (our ***Gas Gaver System****;* ***GSS™****) that reduces shielding gas waste is discussed.* ***A fabricator employing it was able to weld 632 parts with one cylinder of gas using the same steady state shielding gas flow rate where one cylinder and their existing system was only sufficient to weld 236 parts.*** *An appendix presents tests of other fabricators who saved 40% to 50% shielding gas use with this gas saving system. In addition to gas savings, the reduced peak gas surge, flow rate at the weld start reduces spatter and internal weld porosity. Welders appreciate the system weld start benefits.*

Past attempts at reducing gas surge and gas waste have frequently met with objections by welders. Some devices tried reducing starting gas surge by using either: (a) low pressure, (b) orifices mounted near the wire feeder and gas solenoid or (c) other flow controls mounted at the wire feeder like regulators or flowmeters. Some combine low pressure devices with mounting at the wire feeder. Welders often rightfully reject these solutions or counter their use by setting excess flow rates. They either eliminate: (a) automatic flow compensation by using low pressure causing flow variations or (b) the purge gas needed at the weld start by controlling flow at the feeder. Or, in the worst case, (such as employed for a "Gas Guard" foolish product) using a low-pressure device mounted at the feeder creating both problems! Examples are presented where fabricators removed this and other devices because of poor weld performance.

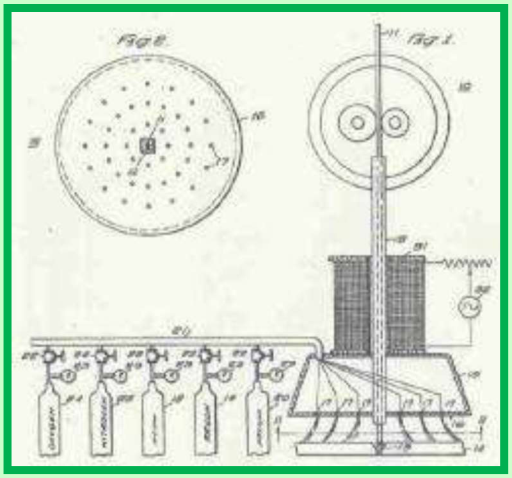
The patented ***GSS*** *does not alter pressures and allows the welding operator to set any reasonable, shielding gas flow rate. It eliminates the excess "gas blast" at each weld start and limits peak gas flow rate avoiding excess turbulence.* ***The GSS has no moving parts to maintain, set or adjust. Welders appreciate its starting benefits. Well over 15,000 are in use in industrial shops!*** *It is inexpensive, easy to install with payback measured in weeks. A patented flowmeter* ***"Flow Rate Limiter and Lock"*** *is discussed that can control the maximum allowed gas flow setting. Argon has tripled in price- See Why in Appendix F.*

No time to read report? Watch this short video summary*: http://youtu.be/H5nabh9deLE*

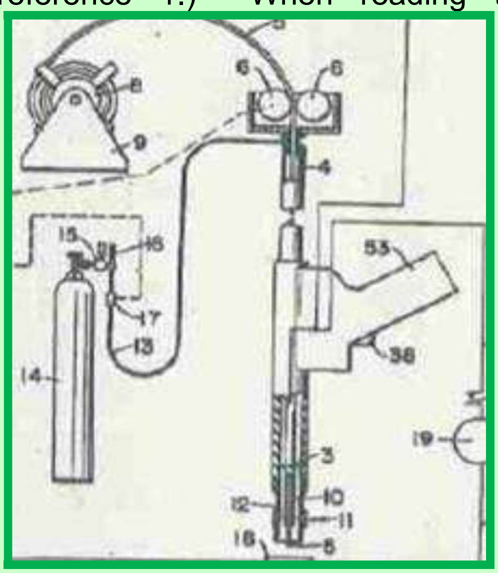
REPORT:

MIG SHIELDING GAS CONTROL AND OPTIMIZATION

History of MIG Welding Gas Flow



Several sources quote MIG welding as being invented in the 1930's; however, these systems did not work. An example is shown in the figure above from a 1936 General Electric patent (reference 1.) When reading the patent teaching it's obvious, some elements required to produce quality welds were missing. One of these missing elements was proper quality gas shielding and flow rate.



A 1950 patent by Airco (reference 2) was the first that many sources acknowledge as producing the first workable MIG process. One of the key elements was a MIG gun that provided quality shielding. In Claims 8, 9, 11 and 12 they state the shielding must be, ***"..nonturbulent to exclude air from the arc."***

Turbulent MIG Gas Flow Rate

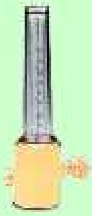
Only a few technical articles discuss the maximum shielding gas flow rate needed to produce a non-turbulent or minimum turbulence gas shielding. Two references that discuss the subject do quantify this maximum flow level. The first is by The Welding Institute (TWI) in Cambridge England (reference 3.) This research discusses tests made using a number of methods to measure air intrusion in the shielding gas stream. For a common 5/8-inch size ID industrial MIG gun nozzle the transition from ***desirable laminar to turbulent flow occurs at 48 CFH.***

In another published article (reference 4), Kevin Lyttle, then, Manager Welding R&D for Praxair (*now Linde AG*) states; *"In many instances production site surveys (of fabricators using MIG sold and cored wire) determine that shielding gas flow rates typically are set* ***in excess of 50 CFH. This can contribute to poor weld quality*** *as atmospheric gases are drawn into the arc zone because of excess gas turbulence. Optimized flow enhances quality and reduces shielding gas usage."* This supports The Welding Institute findings of 48 CFH being the maximum non turbulent flow rate.

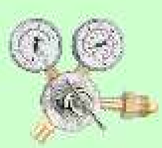
More information on flow rates is available in our FREE home study ***"Lean Manufacturing"*** Programs at: ***www.NetWelding.com/prod03.htm***

Setting Gas Flow

Several devices are used to set shielding gas flow rates. One type is



used on cylinder or pipeline gas supply, a flowmeter with flow control knob. The knob adjusts a needle valve where the small opening sets the gas flow velocity. Flow is dependent on gas pressure above the needle valve, that establishes the flow rate velocity. A float ball is visible and rises in the flow tube as flow rate increases. When used on cylinder gas supply a regulator precedes the needle valve and is set for a fixed delivery pressure, ranging from 25 psi to 80 psi depending on the specific model. For CO_2 service pressures range from 50 to 80 psi. Typical pipeline gas supply pressure is 50 psi.



The second type of flow control is used for cylinder gas supply and employs a very small outlet orifice The orifice is usually about 0.025-inch diameter. The pressure upstream of the orifice is varied to control flow using a regulator. These are called regulator/flowgauges. The output gauge, although actually measuring pressure, is calibrated to read flow based on the orifice size and gas type. Pressures for typical flow rates range from 40 psi to 80 psi.

In pipeline gas service, other devices such as fixed orifices or simply needle valves may also be employed.

Consistent Gas Flow

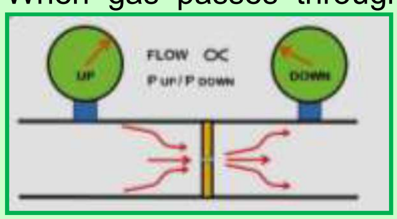
It is important that the flow rate set on the flowmeter or regulator/flowgauge remain constant while welding. However, restrictions occur in production that will alter flow such as spatter build-up in the MIG gun nozzle, bends occurring in the small gas passages in the MIG gun cable, and debris build-up in the gun conduit gas passage *(that often doubles as the wire liner retainer*.) When the MIG process was developed in the 1950's the engineers used a technique to assure constant flow rates regardless of these normal flow restrictions. This phenomenon is called "choked flow" or critical flow.

How Choked Flow Works

Understanding how "choked flow" works helps avoid pitfalls of products sold which do not maintain constant flow and cause flows to vary when the inevitable production restrictions occur.

The following is a short explanation of "critical flow or choked flow." A technical paper on the subject was published in The Welding Journal and has more details (reference 5.)

When gas passes through an orifice,



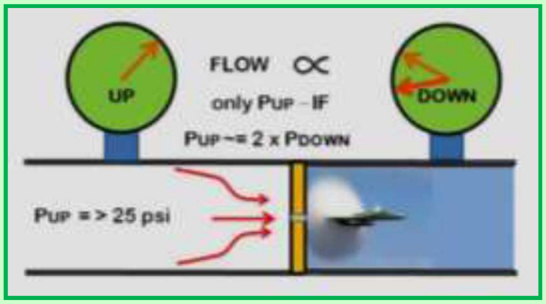
the flow rate depends on the pressure difference across the hole.

The Math is complex but the logic is understandable:

$$w = CA_2p_1\sqrt{\frac{2g}{RT_1}\frac{k}{k-1}\left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}}\left[\left(\frac{p_1}{p_2}\right)^{\frac{k-1}{k}}-1\right]}\Bigg/\sqrt{1-\left(\frac{A_2}{A_1}\right)^2\left(\frac{p_2}{p_1}\right)^{\frac{2}{k}}}$$

However, once the gas flow velocity reaches the speed of sound in the orifice it cannot increase further. When the pressure upstream of the orifice is greater than 2.1 times the downstream pressure the velocity will have reached the speed of sound in the orifice throat (for that gas at the upstream pressure.)

Note: all pressures are measured as

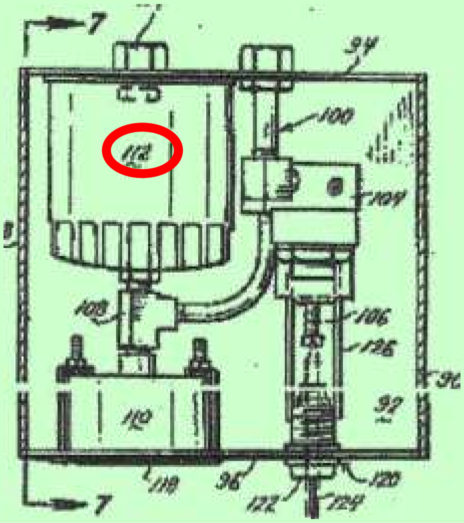


absolute, i.e. gauge pressure + 14.7 psi (*~15 psi for our purposes*.)

Using this fact, we can define the pressure needed above an orifice or needle valve to produce ***"choked flow"*** in a MIG (or TIG) system. The pressure needed at the wire feeder to achieve normal MIG shielding gas flow rates will vary from ~3 to ~7 psi. The exact value will be dependent on the MIG gun length, number, and tightness of bends in the gun cable, spatter build-up in the nozzle and gas diffuser etc. If we assume an average of 5 psi is required, then that would be 5 psi + 15 psi to get absolute pressure stated as 20 psia. To achieve constant flow regardless of normal downstream restrictions will require over ~2 times that pressure above the orifice or needle valve or ~40 psia. Stated as normal gauge pressure that is 40 psia – 15 psi = 25 psi. It is no coincidence that "quality" regulator/ flowmeters use a minimum of 25 psi regulators! The engineers that developed gas flow systems in the 1950's were also in the business of making MIG equipment. They knew MIG welding, were smart and understood what was needed! Information is presented later in this report showing the significant flow variations that occur if lower pressure devices are used.

Some Extra Gas is Needed at Each Weld Start

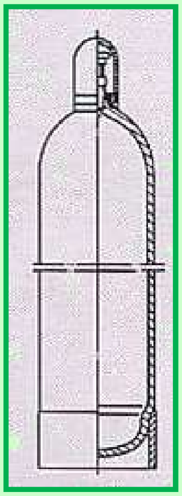
The preceding defined that it is important not to have an excessive gas flow rate to avoid turbulence in the shielding gas stream causing air to be pulled into and mixed with the shielding gas. However, it is necessary to purge the weld start area of air. In addition, air enters the MIG gun and MIG gun nozzle when welding stops. Stauffer in a patent (reference 6) defines the need stating: ***"... air leaks back into the MIG gun and lines when welding is stopped. The air must be quickly purged and replaced with inert gas to produce high quality welds. Also, it is critical to displace the air at the weld zone of the work piece upon initiating the weld."*** His patent defined a device that mounted near the wire feeder providing the extra gas needed at the weld start. He added a reservoir (item 112 in his patent figure below) to store some initial gas to be expelled at the weld start. Unfortunately, the device also uses relatively low pressure to avoid excess surge, requiring the large reservoir and reducing effectiveness of "Automatic Flow Compensation!"



High Pressure Causes Initial Gas Surge

We defined that a minimum of 25 psi was needed to have automatic flow compensation. This pressure is much higher than the 3 to 7 psi that is typically needed at the feeder inlet for the desired gas flow rate. When welding the pressure will reduce in the gas delivery hose to that needed to flow the gas volume flowing thru the needle valve or orifice into the MIG gun cable and nozzle. However, when welding stops, gas continues to flow through the needle valve or small orifice and very quickly fills the delivery hose until the regulator pressure (or if on pipeline supply, the pipeline pressure) is reached. Pressure in some regulators and pipeline gas supply is as high as 80 psi. These higher pressures cause an excess quantity of gas to be stored in the gas delivery hose from gas supply to wire feeder. The amount of excess is dependent on the absolute pressure difference and hose volume. If absolute pressure increases 5 times, then the gas volume increases 5-fold .

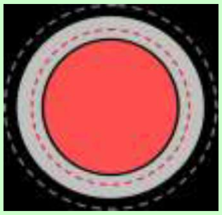
To help with understanding excess gas storage, consider a typical gas cylinder holding 310 Cubic Feet (CF) of gas. It has only 1.8 CF of physical volume. How does it hold all that gas? By raising the gas pressure to 2500 psi (= 2515 psia.) Therefore, the gas volume will be 2515/14.7 times 1.8 (physical) CF =310 CF of gas at 70 degrees and atmospheric pressure (*that is what you pay for*.)



The shielding gas delivery hose is subjected to the same pressure/ volume relationship. Therefore, for an 80-psi regulator/flowmeter and only 3 psi needed to achieve the desired flow rate:
(80 psi +15 psi)/(3 psi + 15 psi) = 5.3 times the physical hose volume of ***EXCESS*** gas is stored in the hose when welding stops.

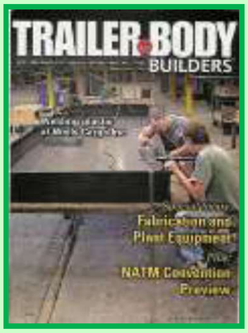
Hose Expansion Causes ~13% More Excess Stored Gas

In addition to the excess stored gas due to increased pressure, our tests show a standard 1/4-inch ID gas delivery hose expands when subjected to these pressure levels. The volume increased 13% with the internal pressure increase.



Therefore, the amount of excess gas is 5.3 (due to pressure) X 1.13 = 6 times the physical hose volume. Every time the MIG gun switch is pulled, this excess gas is rapidly expelled out the gun nozzle; ***most of it wasted!***

Excess Gas Expelled at the Weld Start Causes Significant Waste



Most welders understand that the excess shielding gas flow surge creates problems; they can hear it! However, only a few published documents quantify the typical amount of waste.

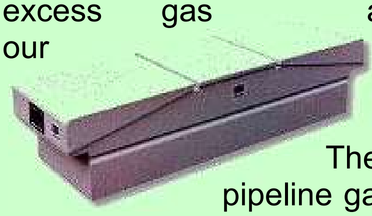
Looking first at documentation on waste. An article in Trailer Body Builders magazine (reference 7) quotes a representative from Praxair (now merged with Linde AG), a leading producer and marketer of shielding gases, indicating their fabricator survey findings show the average MIG welder consumes 5 to 6 times the amount of gas theoretically needed! Stated as a percentage, 80 to 83% of the shielding gas used is wasted!

Another article in The Fabricator Magazine (reference 8) concluded many times the needed shielding gas flow was being used in fabrication shops.

Just how much gas waste is caused by this surge at the weld start? The following is a case history of what one company found. We'll also introduce our patented ***Gas Saver System*** (***GSS***™) to help explain this fabricator's test results.

Truck Box Fabricator Tests *GSS*

A fabricator of truck boxes had 25 MIG welders. They knew they were using excess gas and tested our ***GSS*** as a possible solution.



They use pipeline gas supply but to test the ***GSS*** they purchased the same mixture in two gas cylinders. They purchased a flowmeter that utilized a 50-psi regulator similar to their pipeline pressure. A part was selected that they made by the thousands, truck box doors. *With their standard gas delivery hose* and normal welding conditions, gas flow etc they installed one of the full cylinders and proceeded to *welded 236 doors until the cylinder was empty.* Each weld was 2 ½ inches long. Only replacing their gas delivery hose with the small volume *patented **GSS,** they used the same welder, same welding conditions, and the same shielding gas flow setting. The new cylinder was able to make 632 doors before it was empty! That was 63% less gas used.* Or 2.7 cylinders would be needed to weld 632 doors with their old system! After about a year using the 25 ***GSS***'s purchased, they expanded their operation and added 10 more welding machines. They called and asked for 10 more of the "Magic Hose!"

Other fabricators test data are shown in Appendix A.

What is a *GSS*?

The ***GSS*** is a patented device (reference 9) that eliminates the excess "gas blast" at each weld start and can cut gas use in half or more. The ***GSS*** has no moving parts and does much more than just save gas! The picture below shows the cross section of this custom extruded very heavy wall, fiber reinforced, gas delivery hose.

In addition to reduced volume, the ***GSS*** avoids excess turbulence at the weld start. It accomplishes this by limiting gas surge flow rate using a built-in surge orifice in the feeder/welder hose end fitting. ***Note: the surge-limiting orifice does not limit setting any "reasonable, non-turbulent" steady state flow, with an existing flowmeter, regulator/flowgauge or at the gas source on pipeline gas supply a fixed orifice or flowmeter.***

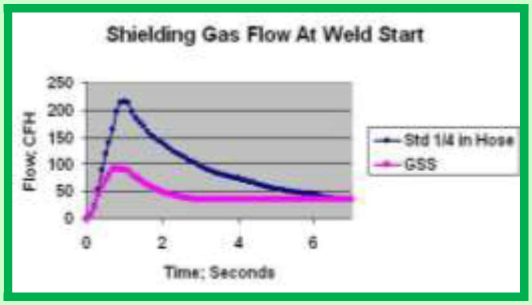
Will this smaller ID gas hose, flow the required amount of shielding gas? Yes, even 50 feet of hose will have only a moderate ~1 psi pressure drop at normal flow rates. On pipeline gas supplies using typically 50-psi, fabricates use 100 feet of ***GSS*** hose. If longer gas lines are used, email: ***TechSupport@NetWelding.com***
Also, see, Appendix C that discusses the reason normal gas delivery hose is wasteful 1/4-inch ID. It has nothing to do with MIG flow pressure drop!

More Than Saving Gas: The *GSS* Improves Weld Start Quality

The ***GSS*** not only saves gas (typically, 40 to 50+% is reported) it improves weld start quality. This is best described with another fabricators experience.

A manufacturer had several MIG welders using flux cored wire and CO_2 shielding gas to make weld repairs. Working with the welding engineer to check the amount of potential gas savings, a ***GSS*** was installed on the repair welder. All weld repair deposits required non-destructive testing before the repaired welds were accepted and the pipe could leave the welding station. When making the first weld repair with the ***GSS*** installed, the operator was excited; he could "see"

the improvement! Not in gas usage but in the reduced initial gas surge that he knew was causing internal weld porosity that made defective welds! He said he tried to weld with the wire cut back in the MIG gun and the gun held high to have the start gas slow surge rate! The accompanying graph shows flow rates measured in this application.



It clearly shows what he was up against and the ***GSS*** solution.

The blue line shows the starting gas flow with their standard gas delivery hose. Note, it peaks at 225 CFH! At this high gas flow rate, air is being pulled into the shielding gas stream. Note the flow rate remains above 100 CFH for about 3 seconds! Therefore, air was pulled into the gas stream for even longer since turbulent flow takes time to return to desired laminar flow!

With the ***GSS*** the peak flow was under 90 CFH and is only above 60 CFH for a very short time!

Of interest, although they measured over a 40% gas savings, the weld quality improvement saved even more money and avoided the previous production bottleneck. After 6 months of use, the operator was asked what he found in terms of repairs. He said he hardly had any need for rewelding, which was a common problem before the ***GSS*** was installed!

Nitrogen and Hydrogen Are Problems

What's wrong with air entering the shielding gas stream? Plenty! Air contains three items that create welding problems. Nitrogen is 78% of air and Oxygen 21%. Both are problems but the water vapor (humidity) can be a major problem as well. Elements can be incorporated in the welding wire to handle some amount of Oxygen. However, Nitrogen and the Hydrogen in water vapor can cause significant problems and there is no way to combine these ingredients without causing other problems. Only 2% Nitrogen in the shielding gas is enough to produce internal porosity (reference 10.) Ludwig, using a bubble chamber and mixtures of shielding gas with various amounts of nitrogen, found 1% was sufficient to cause problems (reference 11.) Assuming 2% Nitrogen will cause internal porosity and possibly brittle welds; since air is 78% Nitrogen only 2%/78% or 2.6% air needs to mix with the shielding gas to create problems. A turbulent shielding gas stream can mix far more than 2.6% air into the gas stream!

Therefore, the excessively high gas surge at the weld start caused by most standard shielding gas delivery systems allows often moist air to mix with the gas stream at the weld start and can cause internal weld porosity.

In addition, some extra gas is needed to purge the MIG gun nozzle, cable and weld start area of air. If you ever inadvertently started MIG welding before turning on your shielding gas cylinder (*haven't we all*) you have seen what a weld start looks like without shielding! A harsh arc, high spatter level, an oxidized weld and porosity was probably observed.

Attempting to control flow at the wire feeder provides insufficient extra gas is to purge the MIG gun nozzle and weld start area. The use of flow control orifices or flow control regulators mounted at the feeder cause lack of sufficient start purge gas. Excess starting spatter occurs with these systems. Also, welders will often set higher steady state flow rates in attempt to compensate for this lack of sufficient purge gas.

Maintaining system pressure and having a surge flow control orifice in the feeder end of the ***GSS*** hose provides optimized starting gas flow. The needed extra gas quickly purges the air in the weld start area and nozzle. The peak flow control orifice prevents excessive flow rate and turbulence.

Some research conducted by a major welding manufacturer employing one of our patented ***GSS'***s is of interest. They found the weld start current and voltage in a critical aluminum weld, monitored with an oscilloscope showed improvements in weld starts with shielding flow rate surge control.

Use of Low-Pressure Devices

Understanding the problems created by the start gas surge, some strictly gas apparatus manufactures had introduced low-pressure devices in attempt to solve the gas waste problem. However, they forgo automatic flow compensation built into gas delivery systems since the inception of MIG welding! In fact, one manufacturer who introduced a low-pressure system to their line of flow controls wrote a technical article published in Flow Control Magazine (reference 12) that states: ***"… there are applications in which a compensated unit (***referring to higher pressure flow compensating regulator/flowmeters***) may be required. When long lines from the flowmeter to the gun cause back-pressure or when wind causes the shielding gas to blow off, the compensated***

system may be the solution to these problems."

We have found these low-pressure devices create problems in all cases, not just where mentioned in the technical paper! A number of fabricators relayed the significant problems encountered with a low-pressure device that mounts at the wire feeder. It has both problems: 1) lack of automatic flow compensation causing variations in flow from preset levels and 2) since mounted at the wire feeder, insufficient extra gas at the start causing inferior weld starts. Tests were conducted with this device versus a normal 25 psi regulator/flowmeter (photo left).

The following table shows the test results with a conventional regulator/ flowmeter that operates at 25 psi and a low-pressure "Gas Guard" device (photo right) both subjected to varying MIG gun flow restrictions. Both were initially set to flow 31 CFH (shown in green in the following table.) Placing a test pressure gauge after the low-pressure device showed only 9 psi was required to flow 31 CFH.

As noted previously, 9 psi is well below the minimum 25 psi needed to provide automatic flow compensation. That means the shielding gas flow will not only be determined by the pressure upstream of the flow control device (in this instance an orifice) but also the downstream pressure that varies with flow restrictions. This foolish device does not operate using the historic "choked flow" design.

For these tests, the controls were left at the initial settings as if they were padlocked. MIG gun restrictions were then added and removed, and flow measured at the gun nozzle with a portable flowmeter.

Flow Control System	**< Typical Production Restriction Range; psi >**					
	3 psi	**4 psi**	**5 psi**	**6 psi**	**7 psi**	**8 psi**
Conven-tional = 25 psi	31 CFH	31 CFH	**31 CFH**	31 CFH	31 CFH	31 CFH
Low Pressure Harris "Gass Guard" = 9 psi	37 CFH	34 CFH	**31 CFH**	27 CFH	23 CFH	16 CFH

With the conventional 25 psi regulator/ flowmeter the gas flow did not change with the restriction variations. The pressure in the gas delivery hose automatically increased compensating for simulated spatter buildup in the gas diffuser, clogged gas passage in the MIG gun (which for many MIG guns is also the wire conduit,) spatter in the nozzle, twisted gun cables etc.

Note with the low-pressure "Gas Guard" device the flow reduced to a low of 16 CFH and rose to 37 CFH! 11 CFH difference. Outside of most allowed QA Control Range. The flow calibrated pressure gauge did not show any flow differences as pressure did not change. ***It gave a false indication flow was consistent!***

Four Fabricators documented the problems with this low-pressure device. Their experiences are outlined in Appendix B. Note, one discarded 50 and another 70 systems!

Tests of another low-pressure device showed it also produced flow variation! This device sets flow by setting pressure (yellow arrow, photo right). It reduces the surge but creates major flow variation problems more difficult to detect and analyze!

BE CAREFUL; SOME OF THESE "SURGE CONTROL DEVICES" DO NOT MENTION THEY USE LOW PRESSURE!

A surge control flowmeter (photo right) at least indicates in the literature, *"operates at pressures lower than usual."* Unfortunately, it does not mention the problems the lower pressure creates! Welders just open the needle valve when restrictions occur and leave the high setting when restrictions reduce!

Use of Restriction Orifices to Control Flow

Another method that has been used to reduce weld start gas surge is restriction orifices mounted at the feeder:

1. One approach uses an orifice to reduce surge flow but still control steady state flow back at the gas source. This reduces surge but when welding stops gas pressure/volume still builds in the gas delivery hose. At each start, excess gas is expelled but it takes somewhat longer!

2. Another approach is to use the orifice to control the steady state flow. A very expensive electronic "supposed" gas saving device (EWR) also does something similar! With these approaches or with any flow control placed at the feeder *there is insufficient extra gas to purge the MIG gun nozzle and weld start area.* The weld is *essentially starting in air with the accompanying problems. We have a report showing why the also foolish EWR device doesn't work!*

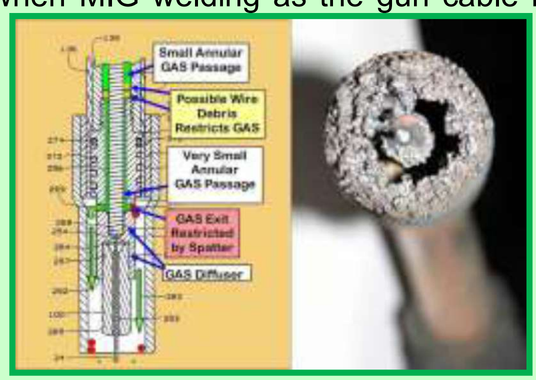
Use of an Orifice at Pipeline

In pipeline gas supply, an orifice is a satisfactory way to control shielding gas flow ***if placed at the pipeline outlet and used with our GSS***. The flow rate is controlled, and sufficient extra shielding gas is available to purge the weld start area and MIG gun nozzle of moisture-laden air. The surge orifice in the ***GSS*** also limits peak gas flow to a rate that minimizes turbulence.

An orifice also maintains automatic flow compensation if pipeline pressure is greater than 25 psi, which most are.

What Causes Flow Restrictions?

Flow restriction variations are inevitable when MIG welding as the gun cable is



bent, looped and as spatter builds in the nozzle and partially clogs some of the gas diffuser holes.

In addition, the gun cable gas passages often doubles as the passage holding the spring wire liner in most MIG gun designs. It may partially clog with wire debris, like copper flakes and lubricant.

Average MIG Welder Wastes ~ 7 Tons of CO_2 /Year!

If CO_2 shielding gas is being used, each welder is wasting about 7 tons per year!

Using the market survey results reported in reference 7 and validated by reference 8 (*and our findings*) the average MIG welder uses 30 CF of shielding gas per pound of welding wire when 5 to 6 CF/lb is needed. (Note: 0.045 solid wire welding at 200 amps deposits 6 lbs wire/hr. Assuming a flow rate of 30 CFH is set on the flowmeter then 30 CFH/ 6 lbs/hr = 5 CF/lb, validating the assumptions in reference 7.)

Therefore if 30 CF/lb is used and only 5 CF/lb is needed, 25 CF/lb is wasted or 25 CF wasted/5 CF needed = 5 times what should be used is wasted. Considering the average industrial MIG welder operates at about a 40% duty cycle (percentage of time the arc is on) then:

- A welder operating 8 hr day X 40% duty cycle = 3.2 hr of arc on time.
- 3.2 hrs X 30 CFH gas flow which should be used = 96 CF/day of CO_2 that should be used. But 5 times that amount is wasted, therefore 5 X 96 CF/day = 480 CF of CO_2 /day wasted.
- 480 CF/day X 5 days/week X 50 weeks/year = 120,000 CF of CO_2/year wasted.
- There are 8.7 CF/lb of CO_2 therefore 120,000/8.7 = 13,793 lbs wasted/year

Or about 7 tons of CO_2 wasted per year for each welder!

***Patented GSS* Has Significantly Lower Moisture Permeability**

A major industrial gas producer, Air Products, purchased more than 200

GSS's for their fabrication shops making cryogenic tanks and related components. They use an Argon Helium shielding gas mixture and needed to conserve Helium as well as control costs.

They historically had porosity problems in aluminum welds in the hot humid summer months. The welding engineer knew the porosity was caused by moisture entering the TIG and MIG system gas delivery hoses. This was most obvious when welding critical aluminum components. After testing, they found the custom extruded ***GSS*** hose has much lower moisture permeability. For two summers after installing the ***GSS***'s they had no porosity issues!

In fact, they and others use our GSS hose to replace their TIG Torch gas hose for the reduced moisture permeation benefits.

A report shows why ***GSS*** hose could have up to 8 times lower moisture permeability than a conventional 1/4-inch ID hose. If you would like a copy, email *Jerry_Uttrachi@NetWelding.com*

Benefits of *GSS*

The patented ***GSS***:

1. ***Saves about half the shielding gas used,*** is inexpensive and easy to install. The hose is made with a heavy wall thickness; is fiber reinforced for abrasion resistance and provides a very robust product.
2. ***Has no moving parts to set, wear, repair, or leak.*** Requires no knobs or pressures to adjust.
3. ***Controls the amount and flow rate of extra purge gas flow at the weld start.*** The preset flow rate is maintained while welding. A restricted maximum flow rate limits turbulence and quickly purges air in the weld start zone.
4. ***Retains automatic flow compensation*** for the inevitable pressure drops that occur in production. This occurs when the MIG gun cable is bent and twisted, and with spatter in gun nozzle.
5. ***Lowers moisture permeability.*** It eliminated weld porosity in humid summers at a major cryogenic tank fabrication shop and other fabricators of aluminum.
6. ***Pays for itself in gas waste reduction alone in a matter of a few months*** for most industrial applications. The improved weld starts are added benefits.
7. ***For new installations, payback may be instant – "Just Do It!"*** Cost about the same as heavy duty conventional gas delivery hose.
8. ***Is appreciated by welders for the starting improvement benefits.*** they can still set any "*reasonable*" steady state flow rate. Unlike other attempts at reducing surge that often frustrate welders, they appreciate the ***GSS!*** (Note: If desired, our patented ***FRLL*** product allows flow rate settings to be locked. It's covered in Appendix C.) For full details see: ***www.NetWelding.com/Flow_Rate_Limiter.htm)***

We receive questions about the ***GSS*** and gas delivery systems in general. Some of these are addressed in Appendix C.

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APPENDIX A

Case Examples of ***GSS*** Shielding Gas Savings

A number of fabricators have reported their ***GSS*** testing results in addition to the Truck Box Manufacturer whose 63% savings were mentioned on page 7. The following summarizes some of the savings' data they supplied:

Truck Body Builder

Double A Body Builders knew they were wasting shielding gas and wanted to reduce the high cost. Ken Ard, then President, set up a test using two of his 23 MIG welders that were both welding with the same 0.035 wire and the same welding conditions. He started the test with one welder using their standard 25-foot gas delivery hose and the other with an equal length ***GSS***. Both welders operated at the same current. He also started with new coils of wire on each machine. When both cylinders were empty, he weighed the coils of wire. The one with the ***GSS*** had used twice as much wire. Since both welders were doing the same job, the one with the ***GSS*** also welded about twice as long! Needless to say, Ken purchased systems for all 23 MIG welders. When he expanded his business 2 years later, he purchased 20 additional systems.

OEM Exhaust Manufacturer

Tenneco was conducting a Black Belt Lean Manufacturing study to reduce costs. They only had 6-foot gas delivery hose from their gas pipeline to their 126 MIG robotic welders. They purchased four 6-foot ***GSS***'s to test all of their various weldments. Since the robots repeated each joint with precision, their test data is very accurate. Although on pipeline gas supply, they used cylinders for the tests. Since their pipeline operates at 50 psi, they made sure, they used regulator/flowmeters that matched that pressure. Since they make many of the same parts, they could easily count the number of parts made with a full cylinder of gas and their standard hose and with the ***GSS***. After testing all their weldments, they found savings ranging from a low of 25% to in excess of 40%. They purchased systems for all 126 robots! Several other exhaust system fabricators have also installed ***GSS***'s.

Pipe Fabricator

Team Industries tested the ***GSS*** for gas savings. They again used cylinders to define a fixed amount of gas usage. In their case, they used flux-cored wire and on one job with their standard gas delivery hose, they welded 32 pounds of wire with one cylinder. Just substituting the ***GSS*** with no other changes in welding conditions or gas

flow; they used 53 pounds of flux-cored wire with a full cylinder. That equates to a 41% shielding gas savings. They initially purchased 114 systems and added another 80 when they installed more welding machines in their busy shops.

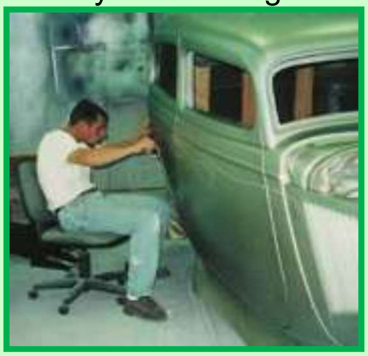
Chiller Manufacturer

Johnson Controls in Mexico conducted tests for their production of chillers. They purchased a 12-foot ***GSS*** and found savings ranged from 30% to a high of 42% easily justifying the investment. Since some of their applications use longer hoses than the 12-foot system tested, their savings will be even higher.

Remember it's the excess gas volume stored in the gas hose that causes waste and excess turbulence on each weld start. They initially purchased 60 ***GSS***'s, after a year in use expanded their operation, and purchased an additional 55 systems.

Street Rod Fabricator

A very interesting observation was



made by one of our first users of the ***GSS***. Kyle Bond, shown painting flames on our Street Rod. instantly understood the benefit of reducing weld start gas surge. He deals with it when painting cars! As he notes, "You never trigger the paint gun on a part, or you get excess paint." Too bad we don't have that option when MIG welding!

Kyle also appreciated having over twice as much welding time between cylinder changes since he had run out of gas on weekends!

Suggestions for Testing *GSS*

To test gas savings, use two cylinders. If using cylinder gas use whatever quality flow control is on your cylinders. If on pipeline supply. Be sure to use a flow control device where the regulator pressure is approximately the pipeline pressure.

Note: Miller sells an inexpensive one that operates at typical pipeline pressure of 50 psi. Many others operate at only 25 psi, which will not give accurate test results.

Use two cylinders of shielding gas and count part production with and without the ***GSS*** using the same gas flow settings and welding parameters. If counting parts is not possible measure wire usage with a full cylinder with and without the ***GSS***. Can start with new full wire reels or weight what is on the welder and any added after. That provides cubic feet of gas per pound of wire used for comparison.

APPENDIX B

Fabricators Reporting Problems with Low Pressure Devices and Orifices

As mentioned, low pressure devices eliminate what was designed into shielding gas delivery systems since the invention of MIG; "Automatic Flow Compensation." A number of fabricators found these devices create sufficient problems to have them removed and discarded. The following are four who reported the problems:

Automotive OEM Supplier

A welding engineer in a plant who purchased 32 systems stated:

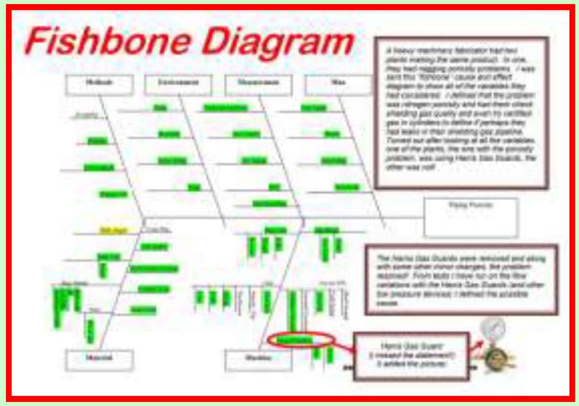
"After purchasing and using 32 low pressure "so called" gas saving devices (photo right) that mounted at the wire feeders we decided to discard all of them! There were two major problems:

1) *Lack of sufficient extra gas at the start made inferior welds and*

2) *Large flow variations from preset levels were evident when flow was checked at the MIG gun. In fact, he stated; "Even if the flow was blocked, the flow calibrated pressure gauge supplied with these devices had the same preset reading!"*

Heavy Equipment Manufacturer

A very interesting example of problems with the same low-pressure device mentioned above was discovered after extensive testing. This fabricator had two plants making the exact same part. Both used the same wire, gas, welding conditions etc. However, one was getting porosity and the other none. After looking at 30 variables using a Fishbone Diagram, the welding engineer (*and friend*)



discovered the plant having porosity was using low-pressure regulator flow control devices (*the same device we tested)* mounted at the feeders! They were removed and problem resolved!

Bar Joist Manufacturer

A Bar Joist manufacturer with 50 MIG welders also purchased low-pressure regulator flow controls. They found welders were continually setting excessive flow rates. All 50 were discarded in favor of orifices placed at the feeders. Although the orifices set flow at 45 to 50 CFH, which was more than sufficient, welders wanted more flow. The welding engineer called us and we found an interesting result. We moved the restriction orifice on one welder to the pipeline drop and installed our ***GSS***. This provided a controlled amount of extra gas to purge the weld start area at a rate that did not produce excess turbulence. The welder using the ***GSS*** instantly stated he saw a "better arc!"
In bar joist manufacture, welders are positioned next to each other.

With the fixed orifice at the feeder, there was little extra gas to purge the MIG gun nozzle and weld start area. It was obvious that the welder with the ***GSS*** had less spatter when starting and for much of the short weld. The welding engineer decided to lower the flow rate to 35 CFH on the welder with the ***GSS***. The arc remained very stable, and more important the welder was still very happy! The ***GSS*** was still quickly supplying a controlled amount of gas at the start. After several months of testing to assure it worked in all draft conditions (which it did,) all 50 welders were equipped with ***GSS*** systems and flow controls placed back at the pipeline drop.

About a year after installing the ***GSS***'s, their bulk gas supplier called and asked if their workload had reduced since there was a 30+% reduction in gas deliveries! It had not!

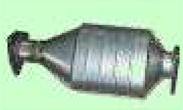
Reinforcing the problems associated with lack of purge gas at the weld start is a survey made of another bar joist fabrication shop where flowmeters had been placed at

the gas inlets on 100 MIG wire feeders to eliminate surge. When examining flow rates, about half were set at 50 to 55 CFH, with none less than 50. About 25% were set near the top of the flow tube at 65 to 70 CFH. The remaining 25% had the flow ball pinned to the top of the tube!

Welders were trying to compensate for the lack of sufficient starting gas purge by setting higher flow rates. That is only a partial help! Therefore, attempting to reduce gas waste by moving the flowmeters to the wire feeder actually caused gas waste and inferior weld starts!

Catalytic Converter Production

A manufacturer of catalytic converters had 70 new robotic MIG welding cells installed. The systems integrator



installed a model of low-pressure surge reducing flow control regulators at each pipeline drop. However, the welding engineer quickly observed flow variations were occurring when measured at the MIG nozzle for both the MIG welding robots and several manual MIG welders using the same flow device. The welding engineer saw one of our videos and had the low-pressure device manufacturer visit, but they were no help. We recommended these "Gas Guard" regulators be replaced with standard flowmeters. After replacing, flows remained at preset levels during production. That solved all shielding gas flow problems!

Tests in Drafts:

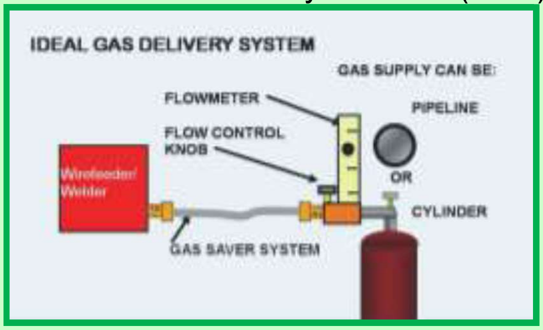
Some welders believe high gas flow rates can overcome draft problems. Tests were made to see what flow rates might assist in up to 5 mph drafts. Visual observations of weld quality and X-Ray's of the deposits were made to detect internal porosity showed interesting results. In a ~5 mph-controlled draft, welds made at 45 CFH with a 5/8 ID MIG gun nozzle had less internal porosity than welds made at 65 CFH gas flow rate! This again validates that with this size nozzle 50 CFH is about the maximum flow rate that should be used. If drafts are present, a small windbreak will often solve the problem ***BUT*** increasing gas flow beyond 50 to 55 CFH ***WILL NOT!***

APPENDIX C

Some Questions and Answers About The *GSS*

Question: ***What is the best way to deliver shielding gas to a MIG system?***

Answer: For systems with up to 50 feet from gas supply to wire feeder, the best system is shown in the picture below (for typical pipeline pressures the ***GSS*** can even be 100 feet long.) It consists of a rotameter flowmeter (one with a flow indicator ball) and our Gas Saver System (***GSS***).



This system will work for any gas supply. The benefits include being able to see the actual gas flow while the ***GSS*** eliminates the excess "gas blast" at each weld start and controls the gas surge peak velocity improving start weld quality.

Option: For pipeline shielding gas supply an orifice can be used **(only at the pipeline)** to set flow. See page 11 "Use of an Orifice at Pipeline."

Question: ***Why is MIG gas hose a wasteful ¼-inch ID?***

(Hint; it's not for the Nonexistent MIG Flow Pressure Drop!)

Answer: Why is most MIG gas delivery hose ¼ inch ID? This large size causes excess gas to be stored in the hose when welding stops and wasted every time welding starts. Fabricators find it causes from 30 to over 50% wasted gas!

Is this large hose size needed to handle pressure drop? No! The typical 35 CFH shielding gas flow rate creates very little pressure drop. A 100-foot, 1/4-inch ID hose, operating with pressures needed to flow 35 CFH, has a pressure drop of about 1 psi! The answer is MIG welding was developed in the 1950's by two of the dominant US industrial gas producers. Working at the Welding R&D Lab at one of these companies, Linde (renamed Praxair, now Linde AG) it was located with our equipment factory. The major equipment product line manufactured at the time MIG was introduced was Oxyfuel welding and cutting apparatus. The flow rate of oxygen required when cutting is quite high. It can use 250 CFH and higher flows. At a 50-psi regulator pressure setting 250 CFH will produce an 11-psi pressure drop in a 100-foot 1/4-inch ID hose versus the less than 1 psi at 35 CFH flow used for MIG welding. (N*ote the pressure drop at 35 CFH will be about 1 psi either at 50 psi or even lower hose pressure.)* The highest volume gas hose used for the largest sales volume sold (25 feet) was 1/4-inch ID that easily handled the pressure drop. Cutting and fitting this size hose was automated. In addition, the Compressed Gas Association (CGA) committee developed gas hose fittings designed for various size hoses. The inlet end of these fittings handles hoses up to 3/8-inch ID. Using CGA designs,1/4-inch inert gas fittings are relatively easy to make. Production starts with heavy wall tubing, making drilling the gas passage hole quick and economical. A minimum amount of material is required to be removed with this design approach. Functional hose clamps are also readily available for 1/4inch hose fitted to a hose barb.

Therefore, 1/4-inch hose, hose fittings, and hose clamps were readily available and lowest in cost! Production economics is the reason MIG gas delivery hose was ¼ inch ID!

The special fittings required for use with our very heavy wall small ID ***GSS*** hose are much more difficult and costly to manufacture. The hose does not expand over the fitting as do thinner wall hoses used for TIG, as an example. Even special hose clamps must be used. See the photo above left to view the ***GSS*** fitting on the gas supply side of the hose versus a 1/4-inch fitting.

As the saying goes, ***"Follow the Money!"***

Question: Is There More We Can Do in Addition to Purchasing *GSS*'s to Reduce Gas Waste?

Answer: Yes.

1. We have found many welders set flow rates too high. We patented a ***Flow Rate Limiter*** (***FRL***) that can be installed on most flowmeters. The maximum desired flow rate is set and the billet aluminum (***FRL***) is installed over the knob with a setscrew, which prevents the flow rate from being increased. A stainless blocking pin and brass lock prevent access to the setscrew. See details of this patented flow lock product at: **www.netWelding.com/Flow_Rate_Limiter.htm**

2. Another thing to consider is leaks. These can be very wasteful and allow moisture-laden air to enter the shielding gas lines.

In addition to fixing leaks on a one-time basis, there needs to be an ongoing vigilance to check the gas delivery systems in a systematic way. We offer several training programs that can be used to educate. One is called "Lean Welding Manufacturing" Learning Program Optimizing Shielding Gas Use and Eliminating Waste" (part # LWM-SG). This 71-page program can be used as a self-study leaning program. It includes a method of making a spreadsheet providing a way of quantifying and monitoring leak rates in pipeline gas supply; as shown below:

	A	B	C	D	E	F
1	Insert Data; Leave 0 if None		Answer	Insert Special Pipe Diameter - if Needed		
2						
3	Pipe Size ID inches	ID Volume ft^3 Per Foot of Pipe	Input Number of Feet of Pipe in System	Total Physical ft^3 in Piping System	Total ft^3 of Gas at STP At 50 psi	Total ft^3 of Gas at STP At 40 psi
4	1.0	0.09	150	13	58	49
5	1.5	0.20	0	0	0	0
6	2.0	0.35	400	140	615	520
7	2.5	0.53	0	0	0	0
8	3.0	0.79	0	0	0	0
9	4.0	1.40	20	28	123	104
10	0.0	0.00	0	0	0	0
11	Gas Deliver Hose Size inches	ID Volume ft^3 Per Foot of Hose	Total Piping =	181	795	672
12	0.375	0.0123	0	0	0	0
13	0.250	0.0055	300	2	7	6
14	0.125	0.0014	0	0	0	0
15		Total Pipe and Hose Volume, ft^3 =		182	802	678
16						
17			ft^3 Gas Reduced with 10 psi Pressure Drop =			124
18			Input Time to Reduce Pressure in Minutes =			5.5
19			Cubic Feet per Hour (CFH) Leak Rate =			1353

A shorter 60-page program with less theory is also available (part # UFG.) It defines shielding gas flow rates, minimums and maximums, and can be used to educate welders and welding supervisors. Because of the Pandemic and folks learning via the Net ***WE HAVE MADE LWM-SG & UFG FREE!*** See: www.NetWelding.com/prod03.htm

Appendix D:

Why Should Purchases of Patented Gas Saver Systems be Made at www.NetWelding.com?

Or: If MIG Shielding Gas Waste is so Common, Why Has My Shielding Gas Supplier Not Told Me How to Fix the Problem?

Background

Understanding and quantifying issues and reasons of shielding gas waste is rather complicated. While managing a >30-person Material Technology R&D Laboratory for a leading producer of industrial gases (*Linde renamed Praxair, now merged with Linde Germany!*) we developed MIG and TIG shielding gas mixtures as part of our development effort. At the time, the company was the leading supplier of Argon with over half the US production capacity. Neither myself nor our group of engineers, metallurgists, or skilled welding technicians could have defined the main reasons shielding gas waste existed! We knew it did, since when Argon was in short supply, as it often was, the company would help large customers with hundreds of MIG welders in shipyards and offshore drill rig production, reduce waste by setting the proper flow rates, finding and fixing leaks, etc! We were aware a minimum of 25 psi gas pressure was needed above the flow control orifice or needle valve to achieve "*automatic flow compensation*." That was necessary to keep preset gas flow constant with the inevitable flow restrictions that occur in the MIG gun cables, spatter in the gas diffuser and nozzle etc. We also knew the high gas pressure created an excessive gas surge at the weld start that had a negative effect on weld start quality. However, we did not conduct the field research to quantify the reasons for gas waste, The Company would often subjectively blame leaks since that was out of our control!

Of interest, the results of fabricator surveys were mentioned in a recently published article by a representative from that same industrial gas manufacturing company saying their shop surveys show the average fabricator uses three to five times the amount of gas they should! (See Reference 7, on page 13.)

Cause of Waste Defined

Since forming WA Technology ~20 years ago, we have made thousands of weld starts and gas waste tests in our lab and hundreds at fabricators. After our extensive testing and fabricator visits, we have found the gas surge at the weld start is often the most significant cause of shielding gas waste - NOT LEAKS! We have evaluated a number of devices to reduce waste before inventing and patenting our simple, low-cost ***Gas Saver System (GSS.)*** Our customers have quantified the gas savings achieved by properly controlling gas surge at the weld start (typically, total gas use can be cut about 40 to 50%.) We understand why other approaches some have tried frustrated welders and have been altered, misused or removed such as low-pressure devices, simple orifices, moving the flowmeter to the wire feeder etc. We have also seen welders appreciate our ***GSS*** reducing peak flow at the weld start while still quickly providing a controlled amount of extra gas to purge air in the weld start area without an excess flow rate that causes turbulence. In addition, our ***GSS*** does not interfere with the welder's ability to set reasonable flow rates. If limiting maximum flow settings is desired, we have another patented device that locks the flow control knob. See our ***Flow Rate Limiter*** on previous page.

Another obvious reason why welding gas suppliers do not take the time to understand the issues and help reduce gas waste is their financial disincentive to do so!

Our simple, low cost ***GSS*** is patented; it is unique. It will usually pay for itself in a very short time. Over 15,000 are in use - it works! Our customers purchase additional ***GSS***'s. They report significant gas saving and most important, "happy welders!"

Bottom Line

To maintain a focus on saving NOT selling shielding gas we sell our patented products directly to users. This also keeps our prices low, allowing very quick payback.

The next page presents a graphic comparison of our ***GSS*** with other devices tried over the years to eliminate excess gas surge, which just frustrated welders and management. We defined the reasons they were frustrated!

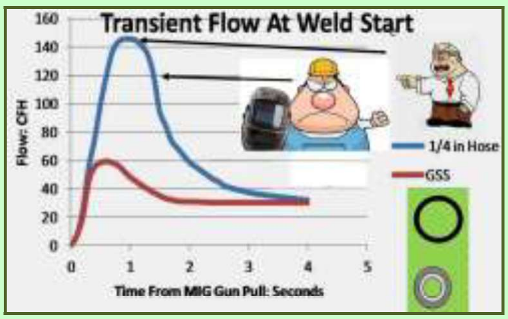
Graphic View Compares Patented *GSS* With Other Devices

The following graphs show how our patented ***GSS*** performance compares to other devices that have been tried over the years to eliminate excess starting gas surge. These devices often frustrate welders and they may try to defeat them and may be blamed for not accepting these "so called" gas saving devices. In fact, we have found why these devices rightfully frustrated welders and managers! We'll explain; (also see pictures.)

Note, welders appreciate our patented ***GSS;*** it does not have these past problems of:

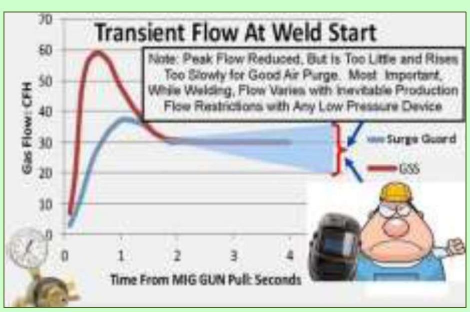
1. Eliminating "automatic flow compensation" by using low pressure or
2. Providing insufficient extra gas at the weld start that is needed to purge the area of air, and possibly moisture.

First: *GSS* (Red Line) Compared to Conventional ¼ inch ID Gas Delivery Hose.



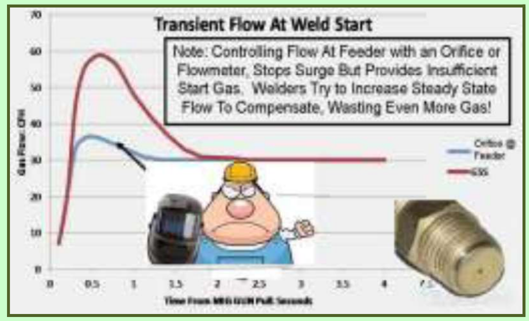
*The **GSS** quickly provides sufficient extra gas to purge the weld start area of moisture laden air at a flow rate that avoids excess turbulence. It quickly reaches the preset, desired gas flow rate. The ¼ inch ID standard hose has peak flows exceeding 150 CFH, which pulls air into the shielding gas stream creating inferior starts and wasting gas.*

Second: *GSS* (Red Line) Compared to "Gas Guard" (Blue Line, Low-Pressure Device)



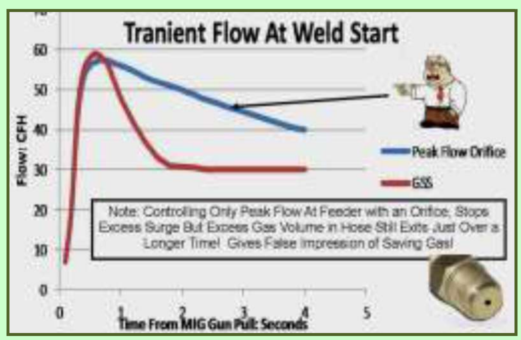
Low pressure devices like the "Gas Guard" tested, eliminate the key feature built into all quality MIG flow control devices since the 1950's, "automatic flow compensation," required to manage the inevitable flow restrictions that occur in production. If not present, when welding flows vary significantly, while the flow-calibrated pressure gauge gives a false impression, gas flow is constant! In addition, if these devices are mounted at the feeder, they also have the problem noted in the next comparison with a simple orifice, air purge is insufficient.

Third: GSS (Red Line) Compared to a Simple Orifice (or regulator or flowmeter. Blue Line) Placed at the Wire Feeder to Control the Welding Gas Flow Rate



Mounting a simple orifice at the feeder, sized to control welding gas flow (or regulator or flowmeter) reduces surge but does not provide sufficient extra gas at each weld start to purge air! It's like starting the weld in air. Welders rightfully see the problem and try to compensate by increasing flow rates! This only partially helps and wastes the gas trying to be saved! (See page 17)

Fourth: GSS (Red Line) Compared to Peak Flow Control Orifice at Feeder



*An orifice can be mounted at the feeder that just limits peak flow (similar to the **GSS**) while flow is controlled at the gas supply with a flowmeter, regulator/flowgauge or orifice. However, since the gas volume in the gas delivery hose still increases significantly when welding stops, about the same amount of gas is wasted as with any standard 1/4-inch hose - it just takes longer to be expelled! This gives a **false impression of gas savings**! Note, the **GSS** only holds ~15% of that amount of gas as a standard hose; **that creates the gas savings.***

Appendix E:

CHECK FLOW AND DEMONSTRATE GAS WASTE

Many fabricators using piped gas supply are employing flowmeters to set and measure flow. We have found many are using flowmeters calibrated at 25 psi (as are most low-cost flowmeters.) However, they are being used typically on 50 psi pipelines. If reading 35 CFH in this situation the flowmeter it is actually flowing 45 CFH. If the pipeline pressure is 75 psi the actual flow when the flowmeter reads 35 CFH is 53 actually CFH! A table can be used to define the actual flow since it is proportional to the gas density at the higher pressure. However, the flow tube cannot be recalibrated except with a marker noting the desired flow ball position.

Check Shielding Flow Using Portable Flowmeter

Portable flowmeters operate using basic physics of gas flow. They are accurate and very repeatability. When gas is flowing, a float ball rises in a tapered tube. The gas pressure forces acting on the ball balance gravity as the ball rises. The density of the gas must be factored into the calibration. For welding, measuring the shielding gas exiting a MIG nozzle or TIG cup is easy and accurate. Just place the nozzle/cup into the tapered bottom and open the gas solenoid. This device is calibrated at atmospheric pressure since the gas exits at that pressure.

We have a very rugged portable flowmeter, WAT-PFM. It measures Argon and Argon/CO_2 mixtures from 10 to 45 CFH. A table supplied with the instructions shows how to measure helium gas mixtures up to 125 CFH.

Portable Pressure Measurement Device

Pipeline shielding pressures may vary as welders are turned on and off during the day. The amount should be monitored to assure flow rates remain in an acceptable range. Our portable pressure measurement test device, WAT-PTD, (two are shown in the photo above) can provide valuable information and is easy to connect to a gas delivery hose for periodic spot checks. It has a standard inert gas 032 “B” female fitting on one end and a male CGA 032 “B” fitting on the other.

It is also an excellent device to quantify the pressure buildup in the gas delivery when welding stops and to demonstrate why gas waste exists at each weld start!

The WAT-PTD is supplied with full instructions showing how to perform gas restriction changes, checks of pipeline pressure at various welding stations and well as how to use it to demonstrate gas waste.

The WAT-PFM and WAT-PTD can be purchased at: ***http://netwelding.com/prod02.htm***

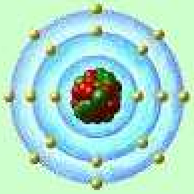
Details of measuring and quantifying shielding gas waste are provided in our 71-page, ***Lean Manufacturing Home Study Course.*** Now available ***FREE*** of charge at:

http://netwelding.com/Lean_Mfg._Tools.htm

Appendix F:

Gases Used for MIG/TIG Welding Argon Prices Have Quadrupled!

The US Industrial Gas Industry has undergone major ownership changes, effecting Argon prices.



Argon: is an inert gas, the third most abundant gas in air, after Nitrogen and Oxygen. Although Argon is less than 1%, (0.93%) that is 24 times the next most abundant gas, Carbon Dioxide at only 0.039%. Argon is produced by liquefying air and then distilling the Argon out in large columns. Several steps are required to achieve the required 99.997% purity. A first stage distillation column produces what is called "Crude Argon" that reacted with Hydrogen to eliminate the Oxygen. Another "Pure Argon" distillation tower removes the remaining Nitrogen and Hydrogen. This extra process equipment adds over 20% more capital investment to a gas plant making Oxygen and Nitrogen. Not all gas liquefaction plants built over the years included this extra capital cost.

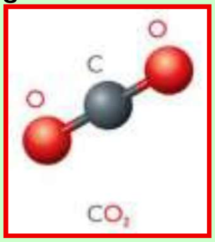
Argon Producers: Four major Industrial gas companies produce over 90% of the US Argon. These were all US companies a few years ago but two European Companies bought the largest US Industrial gas companies. Air Liquide from France bought Airgas, who owned about 30% of the Industrial Gas/Welding distributors. Linde AG from Germany had purchased what was AIRCO that had gone through several owners and recently merged with Praxair the former US Linde, the largest US industrial gas company.

Air Products, headquartered in PA is the only major US producer of Argon left (as well as Oxygen and Nitrogen.) These companies must be able to manufacturer, sell and distribute the 21% Oxygen and 78% Nitrogen from that liquefied air to make Argon profitable to produce. Argon is often in short supply. In years past some fabricators have been put on allocation based on prior annual usage. Argon demand is controlled is with price. Over the past few years Argon prices have increased over 200%. Air Products announced a 20% increase in 2017, 2018, 2019, and two increases in 2020 of 35% total. When US owned Industrial Gas Companies published upcoming price increases only 30 days prior for FTC collusion appearance reasons. No longer.

Helium: Unlike Argon, Oxygen and Nitrogen that come from the air, Helium is so light it escapes the earths atmosphere, it's only 0.0005%. The primary source is from natural gas production. In some natural gas deposits, it can be 0.5% and can be economically separated. But Helium also used for medical MRIs, for example, and is in very short supply.

If you're using Helium and Helium mixtures for welding try to substitute higher percentage Argon mixtures and employ our Gas Saver products that cut waste!

Carbon Dioxide: Unlike Atmospheric gases that are produced using very expensive, gas liquefaction, CO_2 is widely available as a waste product! Over half used for carbonating soda, welding etc. comes from Ethanol production as a waste product. Other waste streams come from ammonia and petrochemical production. Some occurs natural and is extracted from the ground. Although it's globular transfer and spatter in MIG welding are less desirable than Argon mixtures, it's cheap! It cannot be used for TIG welding as the Oxygen contaminates the tungsten in a short time.



WHAT IS THE BEST MIG GAS? We use one developed in the 1980s, a TriMix of 2% Oxygen, 8% CO_2 balance Argon.

Fun development story showing benefits. All MIG gas mixtures covered in this article:

http://netwelding.com/what_is_the_Best_gas.pdf

Appendix G

Controlling Peak Shielding Gas Flow at MIG Weld Start is Critical

High shielding gas flow surge at MIG weld starts was a known problem when I started working in Linde's Welding R&D Lab in the 1960's! Gas flow in excess of ~50 CFH with a 5/8-inch ID MIG gun nozzle pulls air into the shielding gas stream. But gas surge flow well over 150 CFH can occur at weld starts caused by excess shielding gas stored in the gas delivery hose whenever welding stops.

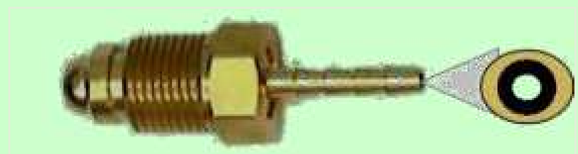
Prior to wide use of MIG Short Arc welding in the 1960s, low current Spray Transfer with 0.023 and 0.030 wires was used to weld sheet metal. Nozzle sizes were 3/8-inch & 1/2-inch ID, with maximum desired peak flow of 30 and 40 CFH respectively.

To reduce the start quality issues caused by the high initial gas surge, Linde sold a peak flow-limiting restrictor. It had a CGA Inert gas female inlet and CGA male outlet. It was screwed into the MIG wire feeder gas inlet. The restrictor size is designed for small gun nozzle, low flows. The old part number, 19X76, continues to be sold by ESAB who acquired Linde's welding business. Some fabricators use it for its intended purpose. O*ur tests found it*

***restricts weld start flow excessively for the typically larger wire sizes, higher currents and larger MIG nozzles used today.* Some fabricators buy this $92 MSRP 19X76 for the Peak Flow Restrictor Feature. Note it saves NO GAS just improves weld start quality! The *GSS* sells for less cost and stores ~85% less gas at weld stops due to its smaller ID. It reduces peak surge flow and saves gas.**

In addition, the BWR brass hose fitting at the wire feeder hose end contains the *Proper Size Weld Start Peak Flow Restrictor.* It quickly provides sufficient purge shielding gas needed to displace moisture laden air in the MIG Gun Nozzle and area surrounding the weld start. The size is selected for today's typical Industrial MIG welding nozzle sizes and wire diameters. NOTE: *IT DOES NOT* control the steady state flow. That is set by any "quality" gas flow control at the gas supply.

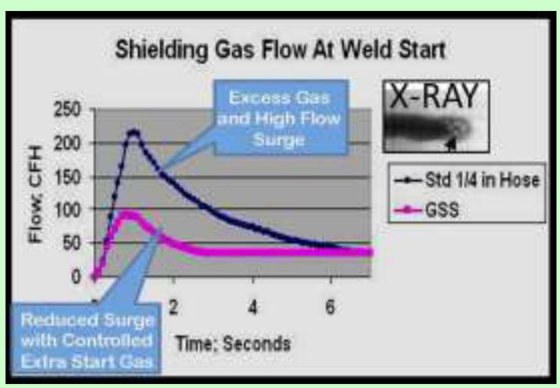
The BWR Peak Flow Restrictor (*black orifice in hose barb end shown in pictue*) is sized to provide the proper minimum turbulence shielding gas purge required



with MIG nozzle and weld wire sizes in use today. The gas supply *GSS* hose end fitting, BWOR, does not have a built-in orifice as it is not required.

Example of Weld Quality Improvement

The picture below summarizes results of a fabricator who tested our *GSS* and solved a weld start porosity problem caused by excessive weld start gas flow surge. Weld start porosity was eliminated with the *GSS* hose and BWR hose end fitting's Peak Flow Limiting Restrictor.



After welding with the *GSS* for ~6 months, the welder said that his prior frequent UT rejections were eliminated.

Appendix H:

Report Background

Jerry Uttrachi, President of WA Technology, was the 2007 President of the American Welding Society (*a 1 year, volunteer position*.) During his Presidential Year, Mr. Uttrachi presented technical talks about MIG Shielding Gas Control Optimization at over 20 AWS Sections in the USA and Conferences in Peru, Denmark and South Korea. A technical paper was also presented at the International Institute of Welding Assembly in the Czech Republic. The talks and technical discussions in China, Japan, and the UK reinforced that gas waste and inferior MIG weld start issues are common worldwide problems.

Unlike some Internet information, this Report is extensively referenced to validate and support the information provided. Technical journals, published articles, and US patents are quoted with patent numbers.

Mr. Uttrachi founded WA Technology, in 2000 dedicated to helping companies improve welding productivity and specializing in products and techniques to eliminate shielding gas waste.

Email Jerry_Uttrachi@NetWelding.com if there are questions about this Report.

About the Author

Mr. Uttrachi started his welding career over 50 years ago at the Linde Welding R&D labs. Linde (renamed Praxair, now Linde AG) was a leading company developing welding shielding gases, equipment, and filler metals. After managing the companies Material Technology Laboratory developing welding shielding gases and filler metals, he became Director of Welding Market Development. When the welding filler metals and equipment division became a separate company, he was named Vice President of Marketing for the newly formed company, L-TEC. He was responsible for business/product management, marketing, customer/technical service, special customer order production, training, and communications. When the business was acquired by ESAB in 1989, he remained in that position for the L-TEC brand and for ESAB's equipment business. In 1999, he left to form WA Technology.

Mr. Uttrachi is an active volunteer of the American Welding Society and served on numerous committees including being on the AWS Board as Director at Large, three years as Vice President and the 2007 President of the 75,000-member Society. He served for 15 years as Trustee on the Societies Education Foundation and was Chair of that Board for 6 years. He also Chairs his local Section of the American Society of Mechanical Engineers (ASME.)

Mr. Uttrachi has a Bachelors degree in Mechanical Engineering, a Masters degree in Mechanical Engineering (Emphasis Behavior of Metals) and a Masters degree in Management from the New Jersey Institute of Technology. He has 11 patents in the welding field, with 4 of 6 issued in the past 15 years related to reducing shielding gas waste and improving weld start quality. Two patents granted in 2012 define welding helmets that provide filtered and cooled air, employing a thermoelectric cooling module.

Many of Mr. Uttrachi's numerous welding related articles are published in technical journals and trade publications.

*In 2012, Mr. Uttrachi's book, entitled **"Advanced Automotive Welding"** was published by **CarTech** and includes information about the science of arc welding. **CarTech** published another book by Mr. Uttrachi in 2015, entitled **"Weld Like a Pro."***

The first book earned a bronze medal in 2013 and the second a silver medal in 2016 in a Media Competition conducted by the London based International Council for Press and Broadcasting. The books received excellent independent reviews by the editors of Hemming's Motor News, The Welding Journal and many published by readers at retailers such as Amazon.