Lean Welding Manufacturing

Learning Program

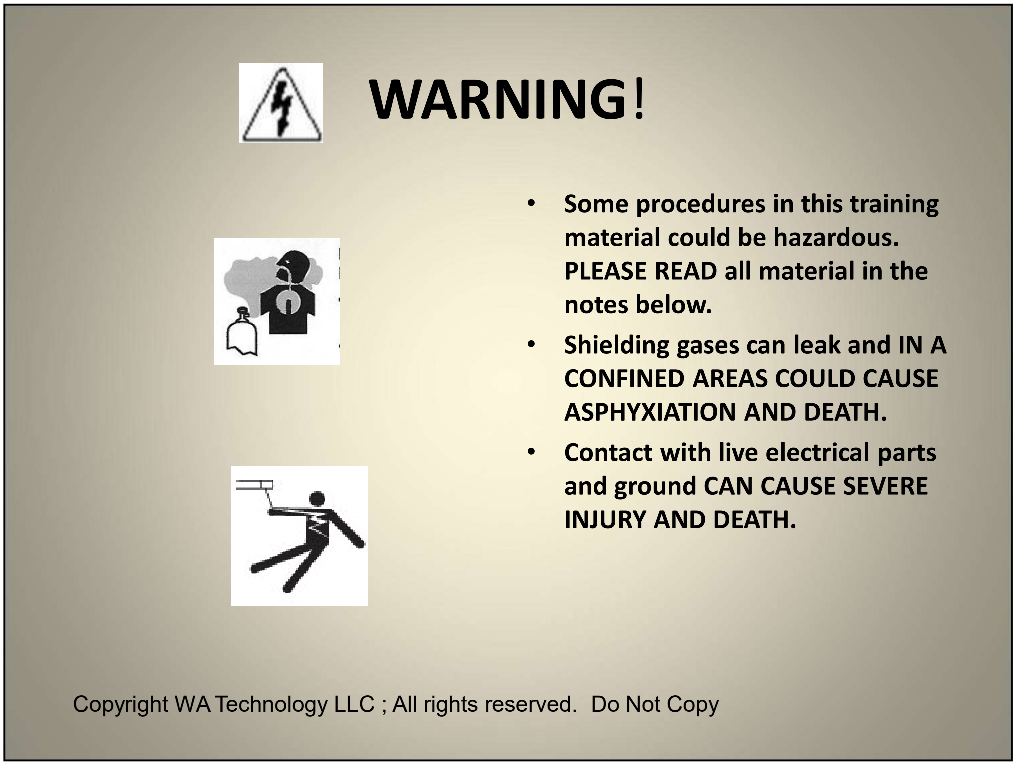
for Lead Welders & Welding Engineers

Optimizing Shielding Gas Use and Eliminating Waste

www.NetWelding.com

Our *Lean Welding Manufacturing Tools "Self Study" Leaning Program is designed for Lead Welders, Welding Engineers or Anyone Responsible for Welding Operations.* It presents the important facts to show why controlling shielding gas flow is not only important to reduce gas waste and cost but also to improve weld quality.

It can be used as a "Self Study" program and requires only a few hours of effort.



SOME PROCEDURES IN THIS TRAINING MATERIAL COULD BE HAZARDOUS. READ AND UNDERSTAND ALL MATERIAL IN THESE NOTES:

Special precautions must be considered when installing gas delivery hose, parts, fittings and devices that use them. Weld shielding gases. Although these gases are not generally considered harmful under normal circumstances they are usually heavier than air. Thus they will sink to the floor level **AND IN A CONFINED AREA COULD CAUSE ASPHYXIATION AND DEATH**. If the oxygen content reduces from the normal 21% to 18% unconsciousness without warning signs. All connections should be checked for leaks with an approved leak detection solution. Shut off shielding gas supply when not in use. **Check hose and connections periodically for leaks. Replace all suspect or worn hose**.

Some procedures such as checking flows at the MIG gun nozzle may involve having the welding power energized. If this must be performed because a PURGE SWITCH is not available on a particular piece of equipment, be very careful since the contact tip and the welding wire will be electrically energized if you use the gun trigger to activate the gas solenoid. Keep hands away from tip and wire or you could be shocked. The welding wire must be prevented from feeding, however do not fully remove it from the gun and feeder since that may increase backflow of gas. Just disconnect the pressure rolls and test to be sure the wire does not feed. **CONTACT WITH LIVE ELECTRICAL PARTS AND GROUND CAN CAUSE SEVERE INJURY AND DEATH.**

These statements are **NOT MEANT TO BE COMPREHENSIVE** in regard to the use of the welding products employed. Please carefully read and follow the manufactures instructions. Also refer to publications on safe practices for welding and cutting available from the American Welding Society, 8669 Doral Blvd., Doral, Fla 33166 including “Safety in Welding and Cutting” – ANSI/AWS Z49.1.

Module 1
Overview and Summary Outline

Lean Welding Manufacturing
Learning Program

Module 1 presents an outline of what is included in Module 2 though 7 as well as suggestions on how to use this Learning Program

Outline of What's Covered:

- Module 1--How to Use the Learning Program
- Module 2--Reasons for Gas Waste
- Module 3--Reasons for Gas Surge At Weld Start
- Module 4-- Solution To Excess Start Gas Surge
- Module 5--Setting Proper Gas Flow Rates
- Module 6--Gas Leaks and Solutions
- Module 7--Additional Info on Leaks etc

Module 1

The notes on the bottom of each slide are important. Please review them.

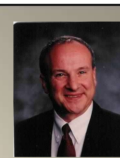
Printing Each Page

- One paper copy of the Learning Program may be printed. (note the copyright)
- The PDF file is of the Notes Page and the full page will print with the notes.
- If it is desired to print for others just email for a modest cost.

 Module 1

Printing the program is possible but is dependent on the program used to view the material as to what print options are available. If copies are desired for multiple persons, please contact Jerry_Uttrachi@NetWelding.com for the modest cost. We can personalize a copy with your company name and provide permission for reprinting for others in the organization.

About the Author



- Mr. Uttrachi has a Bachelors and Masters Degree in Mechanical Engineering and a Masters of Science Degree in Engineering Management from the Industrial Engineering Department at New Jersey Institute of Technology.
- Attended a number of related courses while in industry including:
  - Reliability and Maintainability (by Dorian Shannen @ AMA)
  - MRP/Costing by Ollie White (by Ollie White & Associates)
  - MRP II (by R.D. Garwood, Inc)
  - Achieving Process Improvements with Activity Based Analysis
  - Team Training Techniques (Attended 5 Programs)
- Participated with DeWolff Boberg and Associates Management Consultants in implementing Lean Manufacturing.
- While Materials and Process Laboratory Manager, group solved significant manufacturing problems using statistical procedures.
- Participated in change to Cellular Manufacturing.

 Module 1

Mr. Uttrachi, holds a:

1. **Bachelors Degree Mechanical Engineering**
2. **Masters Degree in Mechanical Engineering (Emphasis; Behavior of Metals)**
3. **Masters of Science Degree in Engineering Management from the Industrial Engineering Department**

All from New Jersey Institute of Technology.

In his graduate degree programs he focused in Statistical Techniques and Manufacturing Engineering; courses included:

a) **Advanced Management Engineering;**
b) **Managerial Economics;**
c) **Industrial Costing and Managerial Control;**
d) **Engineering Reliability;**
e) **Vector and Tensor Analysis;**
f) **Advanced Analytical Engineering Statistics**
g) **Statistical Inference.**

He attended a number of related business courses while in industry including:

1. **Reliability and Maintainability (by Dorian Shannen @ AMA);**
2. **MRP/Costing by Ollie White (Ollie White & Associates) [After working within this manufacturing system for a number of years I now understand that this approach was based on a very poor assumption!];**
3. **MRP II (R.D. Garwood, Inc);**
4. **Louis Allen Management System (Planning, Organizing, Leading Controlling) Union Carbide Corporation**
5. **Achieving Process Improvements Through Activity Based Analysis (National Association of Accountants);**
6. **TEAM TRAINING techniques were reinforced in the following courses:**
   a) **Team Training Skills (Cornelius);**
   b) **Team Training Management Update (Don Lyttle);**
   c) **Team Skills (American Welding Society);**
   d) **Conflict Management (American Welding Society);**
   e) **Quality Quest Leadership (Florence Darlington Technical College)**

Mr. Uttrachi has been involved in the welding industry for over 45 years. He managed a welding R&D facility developing welding shielding gases and filler metals for what has been renamed Praxair prior to them divesting of their welding businesses. He became VP of the company formed, L-TEC. That business was sold to ESAB where he remained as VP for 10 years before starting WA Technology. He has 6 welding related patents since forming this new company. He is an active volunteer for the 75,000 member American Welding Society (AWS) and was the 2007 President of the Society (a volunteer position.)
He is also the Chair of his local section of the American Society of Mechanical Engineers (ASME.)

Module 2

Reasons for Shielding Gas Waste

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Learning Program

Module 2

This Module covers the key reasons for shielding gas loss.

What’s Coved in Module 2

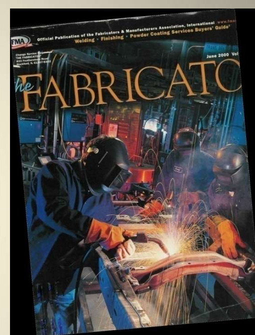
- Average users of MIG welding use 3 to 6 times as much shielding gas as necessary.
- References document these losses.
- Reasons for losses:
  - Excess gas surge at weld start creates waste and excess weld spatter
  - Excess flow settings
  - Leaks

 Module 2

The key reasons for excess gas waste are quantified.

Gas Waste Quantified

- **Fabricator Magazine, June 2000 issue quoted knowledgeable source indicating 3 to 5 times the amount of shielding gas is used as is needed! Defined the starting "gas blast" as the major cuse**
- **Trailer Body Builders Magazine in the January 2003 issue quoted a Praxair representative saying they find MIG users consume 3 to 6 times the amount of gas needed.**
- **We find 2 ½ to 4 times extra is typical.**
- **Other gas producer field representatives find usage is even more than 6 times when leaks are present!**



Module 2

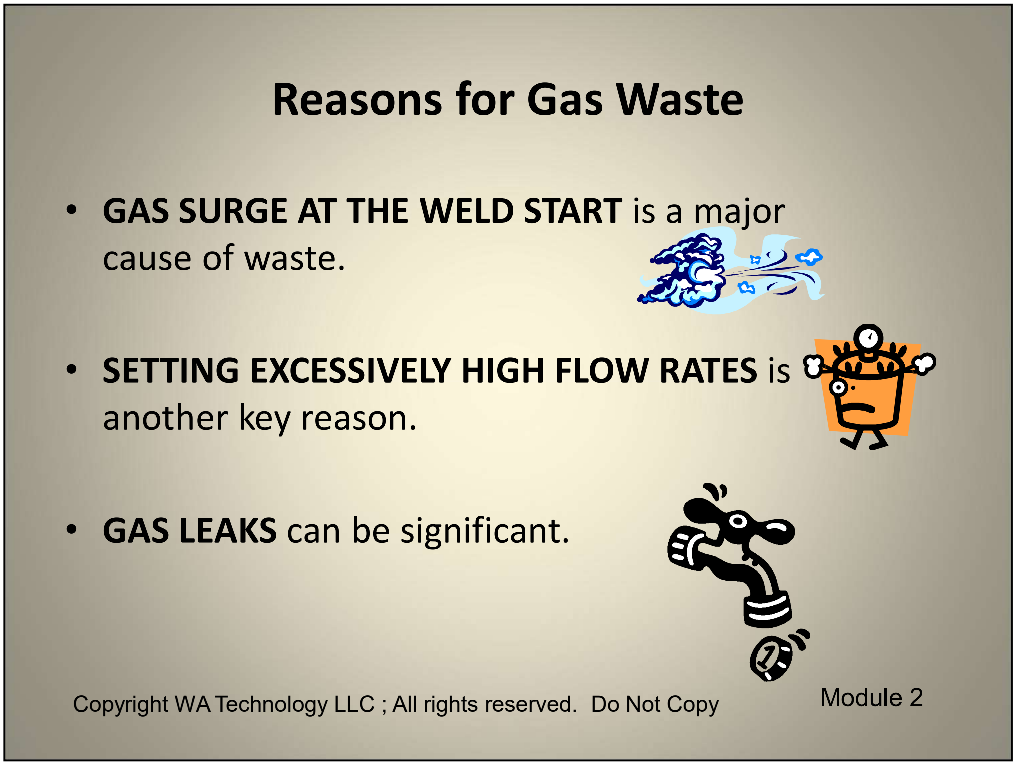
Little information has been published regarding shielding gas waste. The two articles referenced are significant since they quote knowledgeable sources who were willing to go on record about the significance of the problem. These two independent sources mention similar and very high loss values (see reference details below.) These have been independently verified by other suppliers of shielding gas who have the data available, as well as our direct observations.

Most published calculations of the cost of shielding gas versus overall welding cost ignore the problem of waste, although it is well known to exist. In fact gas cost is far in excess of the theoretical calculation values often published.

References:

Weber, R., How to Save 20% on Welding Costs. Trailer/Body Builders, Volume 44, Number 3, January 2003.

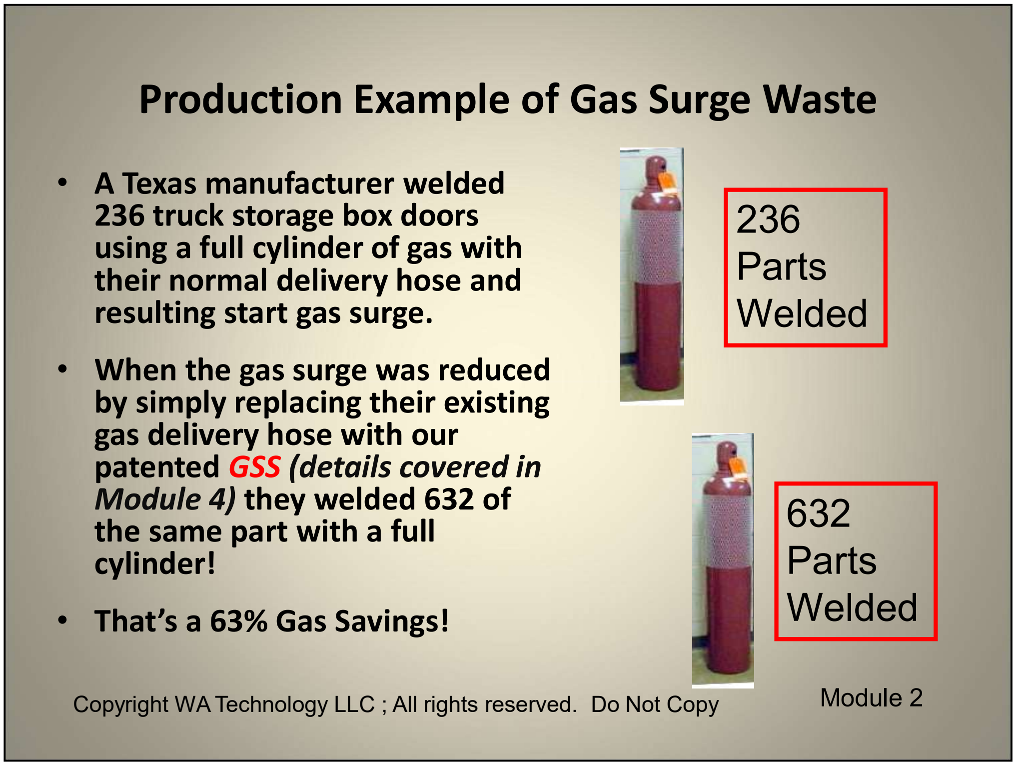
Standifer, L. R., Shielding Gas Consumption Efficiency. The Fabricator, Volume 30, Number 6, June 2000.



The Fabricator Magazine article quantified one of the major reasons for gas waste-GAS SURGE AT THE WELD START. That loss occurs every time the gun switch is pulled even if just to cut off the wire end for better starts. Gas surge at the weld start is often heard and is obvious but unfortunately often not considered significant. Some welders will tell you that the high gas flow blows out the arc at the start! That is not what is happening but the result, inferior starts, is similar. We'll discuss and quantify the start quality problem in a subsequent module.

Many folks realize that excessively high flow rates are a waste problem. What they often do not understand is the problem with shielding it creates. We'll discuss this problem later.

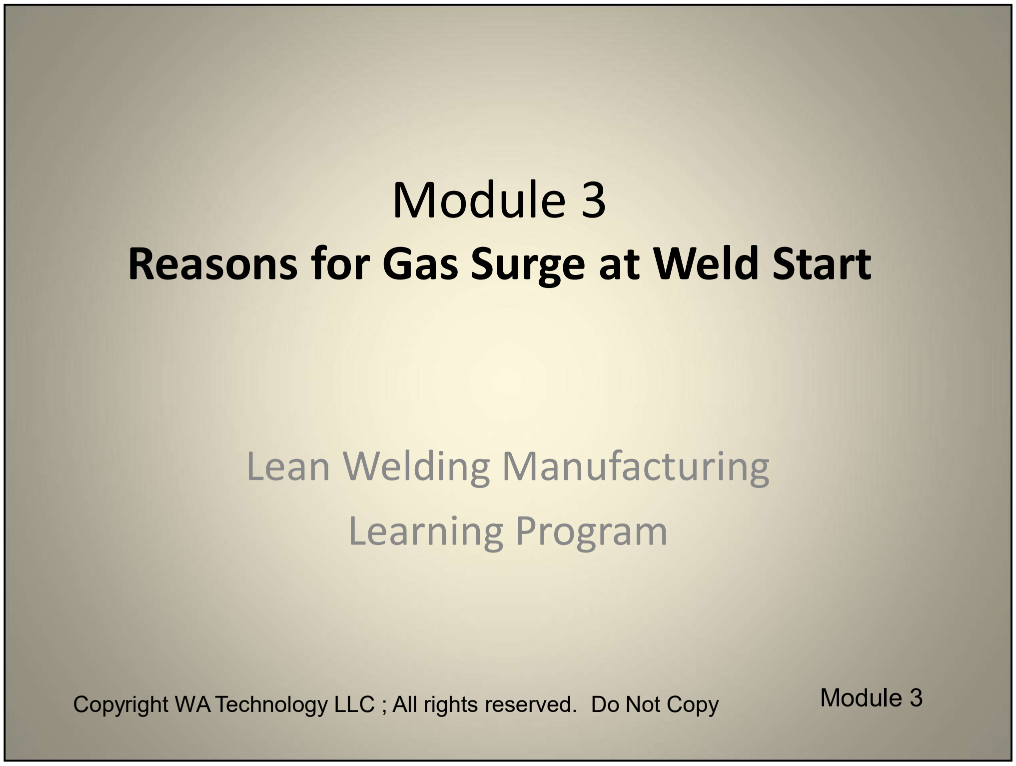
One more subtle loss problem is small leaks in the shielding gas control valve. This is particularly common in spool guns which have a mechanical valve in the gun. These valves often do have small leaks.



A Texas based manufacturer of various types of truck storage boxes purchased a 25 foot Gas Saver System (*GSS*) covered in Module 4, to check for shielding gas savings caused by the gas surge at the weld start. They picked a repetitive job, welding doors, and started with a full cylinder of gas. Welding with 0.035 solid wire MIG, using their standard ¼ inch ID gas delivery hose, <u>236 doors</u> were completed with that cylinder. Putting on a new cylinder and the *GSS*, <u>632 doors</u> were welded before the cylinder was empty! That is 2.7 times more parts due to the reduced gas surge at the weld start!.

And the *GSS* still provides the proper amount of extra gas at the weld start and maintains the pressure in the hose to automatically compensate for restrictions. The extra flow purges the weld area and gun nozzle of moist air but at a flow rate that does not cause excess turbulence in the shielding stream.

The gas savings can be started as equal to *63%*. After these results *GSS* 's were purchased for the whole shop.



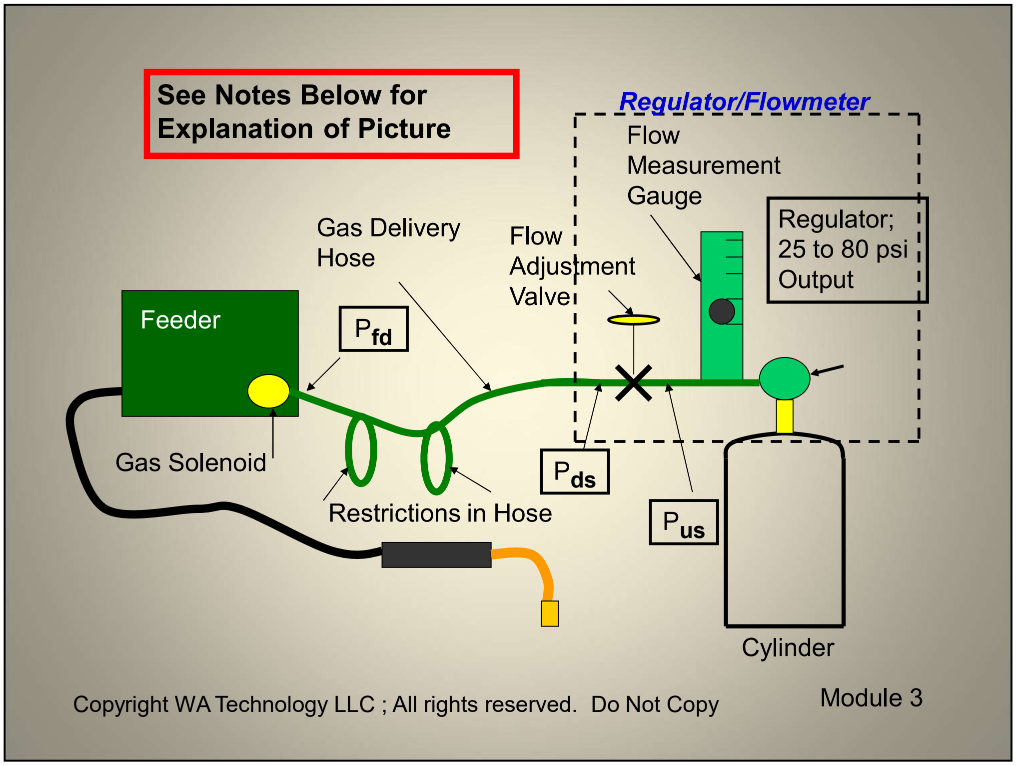
The gas surge at the weld start have been observed by welders for many years. Some will mention that it tends to blow the arc out! This Module outlines and quantifies the reasons for that gas surge.

What’s Coved in Module 3

- How High Pressure in gas delivery hose creates excess gas surge velocity and an excess amount of gas volume at each weld start.
- Reasons for high gas pressures
- Quantified levels of excess gas

 Module 3

The reasons for the high gas surge are defined.

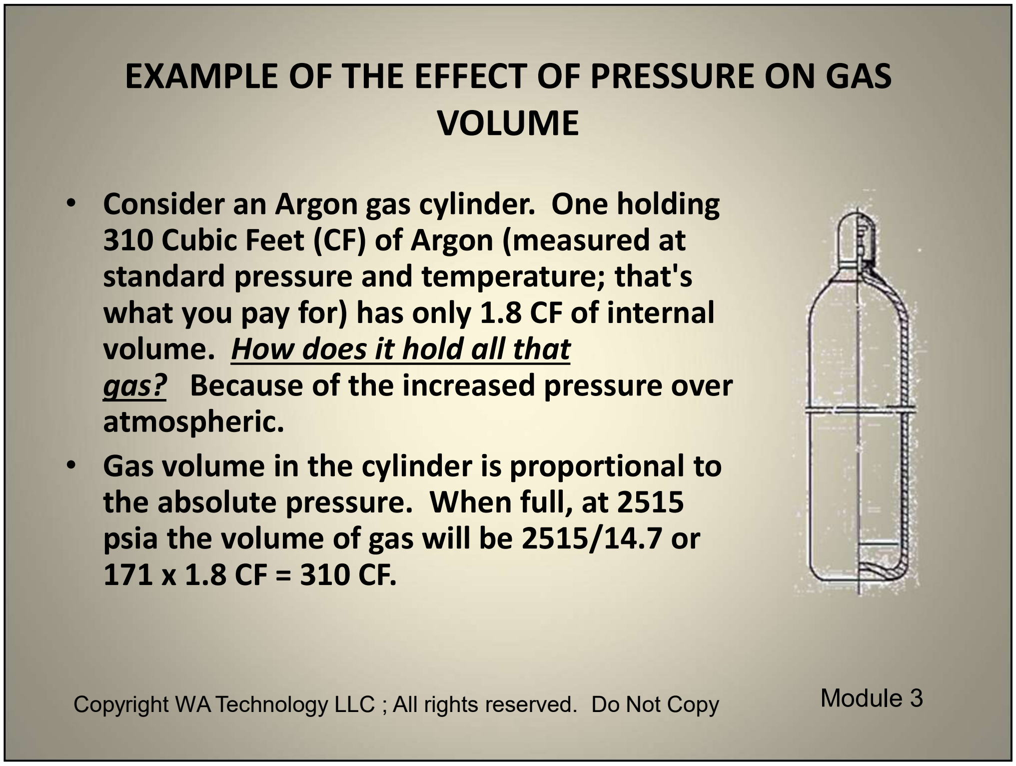


This schematic of a typical MIG system shows a regulator/flowmeter on a cylinder. These regulators typically operate from 25 to 80 psi (note 80 psi systems are often used when welding with carbon dioxide to reduce the formation of dry ice crystals forming in the flow control needle valve.) A regulator/flowgauge (one having a pressure gauge calibrated in CFH flow) usually operates with a critical orifice and the regulator varies pressure from 35 to over 75 psi. If using a pipeline, the pressure is frequently about 50 psi.

When welding is stops, gas continues to flow though the needle valve or orifice flow control until the pressure in the gas delivery hose, if using a cylinder supply, will be the regulator pressure, i.e. from 25 to 80 psi. If a pipeline supply, gas will quickly flow through the needle valve or orifice flow control and fill the gas delivery hose with pipeline pressure. That will take only a few seconds. Pds (pressure downstream) will equal Pus (pressure upstream) when welding is stopped.

The pressure needed to flow 30 to 40 CFH of shielding gas measured at the feeder will usually be 3 to 8 psi (Pfd = pressure at the feeder = pressure needed to flow gas through feeder and gun.)

Therefore excess gas will be stored in the gas delivery hose at a pressure much higher than needed. The amount of gas stored is proportional to the absolute pressure differential. When the gas solenoid is opened most of the excess gas will be quickly expelled until the gas pressure in the hose reaches the amount needed to flow the preset gas flow. That usually occurs in a few seconds. Most of this excess gas is wasted and even worse creates a gas flow that causes turbulence and pulls air into the shielding gas steam. This causes excess spatter at the weld start.



EXAMPLE, THE EFFECT OF PRESSURE ON GAS VOLUME

Consider an Argon gas cylinder. One holding 310 Cubic Feet (CF) of Argon (measured at standard pressure and temperature; that's what you pay for) has only 1.8 CF of internal volume. How does it hold all that gas? Because of the increased pressure over atmospheric.

The volume of gas in the cylinder is directly proportional to the absolute pressure. At 2500 psi = 2515 psia (psia = absolute pressure = the gauge reading +14.7 psi at sea level) the volume will be 2515/14.7 or 171 x 1.8 CF= 310 CF. At those pressures the Argon is still a gas but it's actually pretty heavy! (310 CF weights about 31 pounds.) It's about 30% the weight (density) of water!

Therefore when the shielding gas delivery hose is pressurized it holds more than the actual volume of the hose. How much more depends on the pressure.

Examples of the Amount Gas in Delivery Hose When Welding Stops

- **For a 25 psi regulator/flowmeter.**

  Gas = Hose Volume x (25 + 14.7)/14.7 =

  2.7 x Hose Volume

- **For a 50 psi pipeline.**
  - **Excess Gas = Hose Volume x (50 + 14.7)/14.7 =**

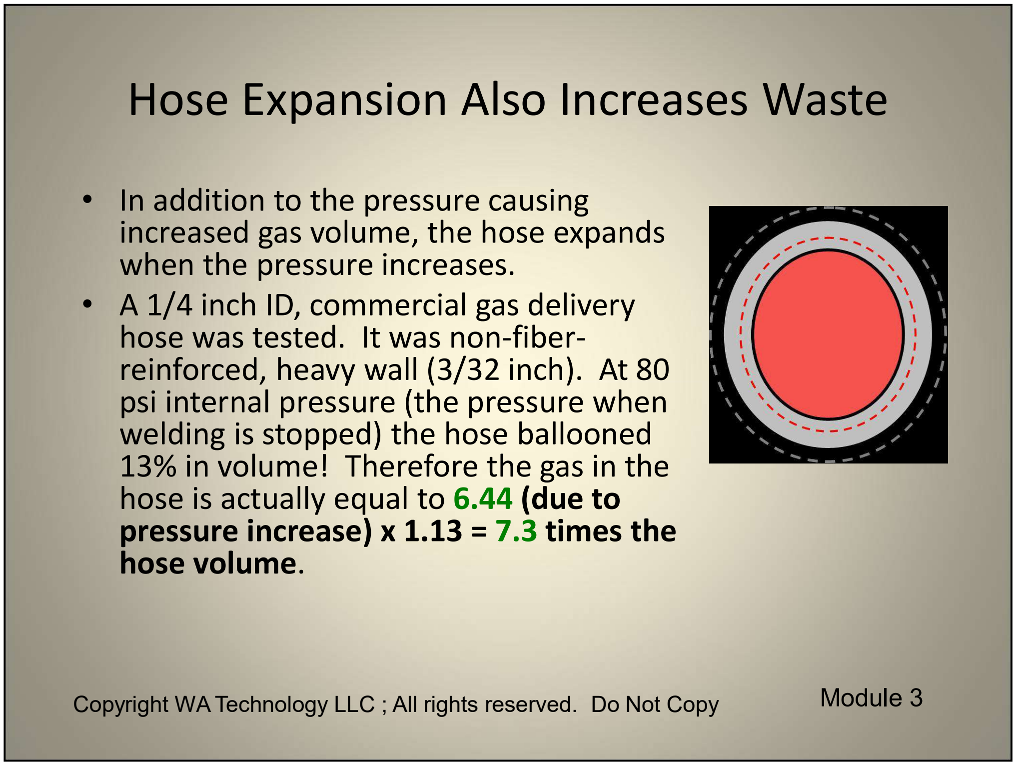
    4.4 x Hose Volume

- **For a 80 psi regulator/flowmeter.**
  - **Excess Gas = Hose Volume x (80 + 14.7)/14.7 =**

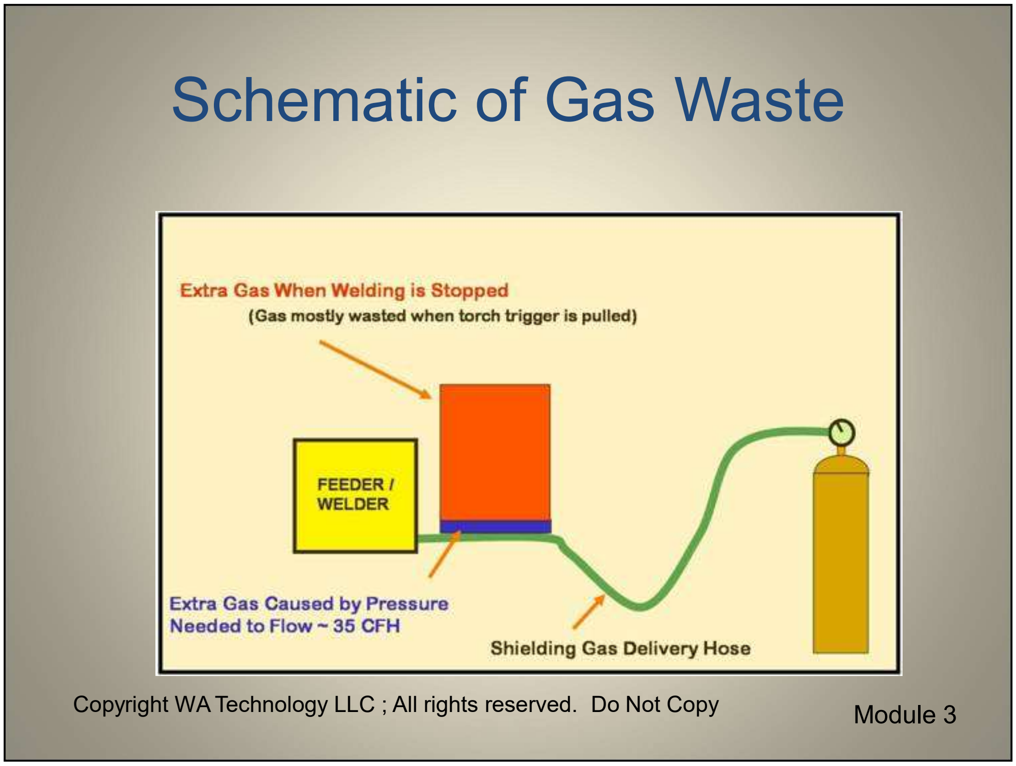
    6.44 x Hose Volume

Module 3

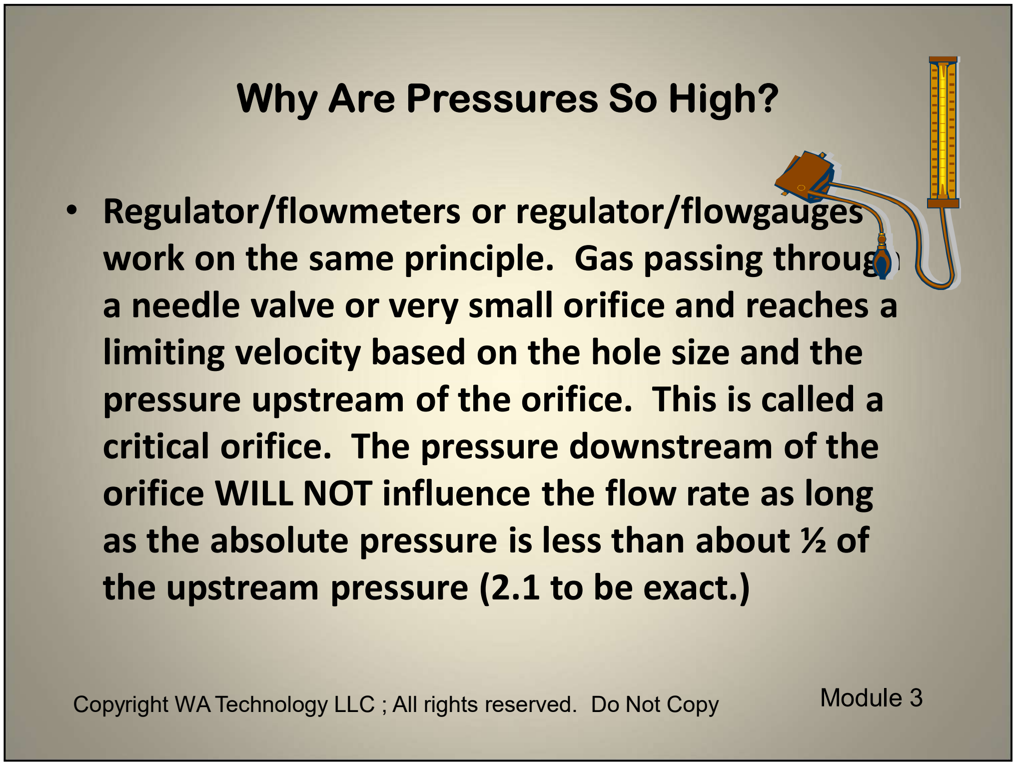
Calculating the amount of gas in the delivery hose when welding stops is simple and straight forward. It is proportional to the absolute pressure differential. Most of this excess is expelled within seconds of the gun switch being pulled.



HOSE EXPANSION: In addition to the pressure causing increased gas volume, the hose expands when the pressure increases. This volume increase is not considered in our gas savings calculations since it is dependent on the specific hose being used. A commercial, non fiber reinforced, 1/4 inch ID, heavy wall (3/32 inch) gas delivery hose was tested. At 80 psi internal pressure (the pressure when welding is stopped) the hose ballooned 13% in volume! Thinner wall hose would create a greater amount of extra volume. Therefore the stored gas in the delivery hose is actually equal to 7.3 times the hose volume.

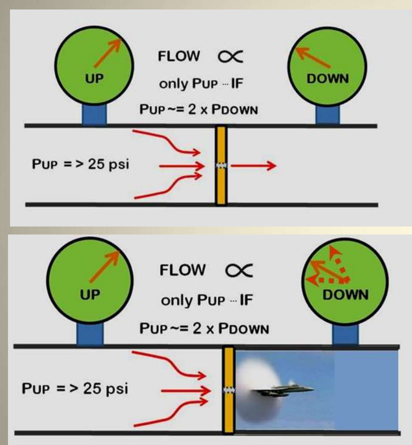


This schematic presents the volume of extra gas in the gas delivery hose. The Area in Blue represents the extra volume due to the ~ 5 psi needed to flow the required amount of gas when welding. The flow control (needle valve or orifice) creates the lower pressure when welding. The Area in Red shows the amount that can be excess due to the pressure in the gas delivery hose over the ~ 5 psi when welding stops. This higher pressure is set by the regulator/flowmeter; regulator/flowgauge or pipeline pressure. The Blue and Red areas are sized relative to the hose area shown in Green to provide proper perspective.



Regulator/flowmeters or regulator/flowgauges work on essentially the same principle. Gas passing through a needle valve or very small orifice (in the case of a regulator/flowgauge) will reach a limiting velocity (Note the velocity can not exceed the speed of sound at the upstream pressure) based on the orifice size and the pressure upstream of the orifice. This is called a critical orifice. The pressure downstream of the orifice will not influence the flow rate as long as it is less than about ½ of the upstream pressure (all measurements in absolute pressure).

Choked Flow Requires Min. 25 psi

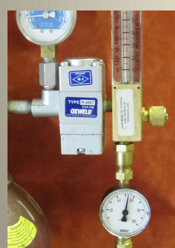


- Flow Set By Max Speed = of Speed of Sound
- Need ~2 X Upstream Absolute Pressure for Chocked Flow
- ~ 5 psi Needed at Feeder = 20 psia
- 2 x 20 psia = 40 psia = 25 psi Above Flow Orifice or Needle Valve

An interesting phenomena causes the need for high pressure. To automatically adjust for the inevitable flow restrictions that occur in production, “chocked” flow control is used. It relies on the fact that if the speed of sound is reached in an orifice or needle valve the speed can not increase further. That speed is reached when the absolute pressure above the needle valve or orifice flow control = 2.1 time the downstream pressure. (Note absolute pressure = gauge pressure plus atmospheric pressure. For our calculations we can assume twice the pressure is needed and atmospheric pressure = 15 psi.

Typically 4 to 7 psi is needed at the feeder to flow 30 to 45 CFH. Then to have the shielding gas flow remain at the preset level regardless of normal restrictions the pressure above the needle valve or orifice flow control must be twice 5 psi + 15 psi or twice 20 psia = 40 psia. To convert back to gauge pressure subtract 15 psi = 25 psi. It is no coincidence that all quality regulator/flowmeters or pipeline pressure range from a minimum or 25 psi to 80 psi.

Device Helps Demonstrate Gas Waste

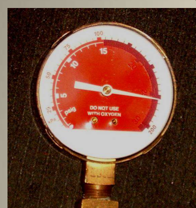


- We developed and sell a device to demonstrate gas waste; our PTD
- It also is a good way to measure pipeline pressure
- It is a pressure gauge with a male CGA "B" fitting on one end and female on the other.
- It can be placed at the flowmeter or welder/wire feeder
- This video shows how to use the PTD: https://www.youtube.com/watch?v=D-XuL3kubtI

We developed and sell a simple device to help demonstrate gas waste to welders and management. A key premise of "Lean Manufacturing" is most waste is invisible. Sure fits shielding gas! By showing how the pressure increases in the gas delivery hose every time welding stops and how it quickly drops when welding starts helps some understand that the gas stored in the hose is MUCH more than the physical hose volume. We typically use a car tire analogy to discuss how a pressure increase means more gas is in the system. Sometimes discussing now ~300 CF of shielding gas fits in a ~2 CF gas cylinder is also a way for some folks to relate to extra pressure means more gas is stored.

Another thing our PTD (Pressure Test Device) can do is check the pipeline pressure. When welding stops it measures the pipeline pressure at that drop with whatever welders are operating at the time. Pressure variations can be measured which changes flow and a flowgauge reading. The flowgauge is designed to be accurate at only the calibration pressure. It can not be changed! Unfortunately many welding flowgauges are calibrated at 25 psi and placed on a 50 psi pipeline! Then the 40 CFH flowgauge reading is actually flowing 50 CFH!

Summary: Why Pressures Are High



- If pressure at the wire feeder needed to flow 35 CFH is 5 psi then the absolute pressure is 5 psi + 15 psi (rounding 14.7) = 20 psia To have “choked flow” need 2 X 20 psia = 40 psi.
- To get back to gauge pressure subtract 15 psi = 40 psia-15 psi = 25 psi gauge pressure.
- Therefore the regulator or pipeline pressures above the flow control must be above 25 psi to provide this “flow compensating” feature.
- All quality regulators use from 25 to 80 psi, Pipelines are typically set at 50 psi.

Module 3

The reason that a critical orifice operates this way is the velocity though the small hole will reach a maximum speed (the speed of sound). Once that velocity is reached it can not increase any further. Crunching the math shows when the downstream pressure is ½ (actually 0.47) the upstream pressure that speed is reached. Further reduction will not increase the gas speed. The engineers who designed these systems when MIG Welding was developed in the 1950’s/’60’s understood the need to compensate for potential flow variations and designed systems accordingly. Too bad some have forgotten!

Module 4
Solutions for Excess Start Gas Surge

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Learning Program

 Module 4

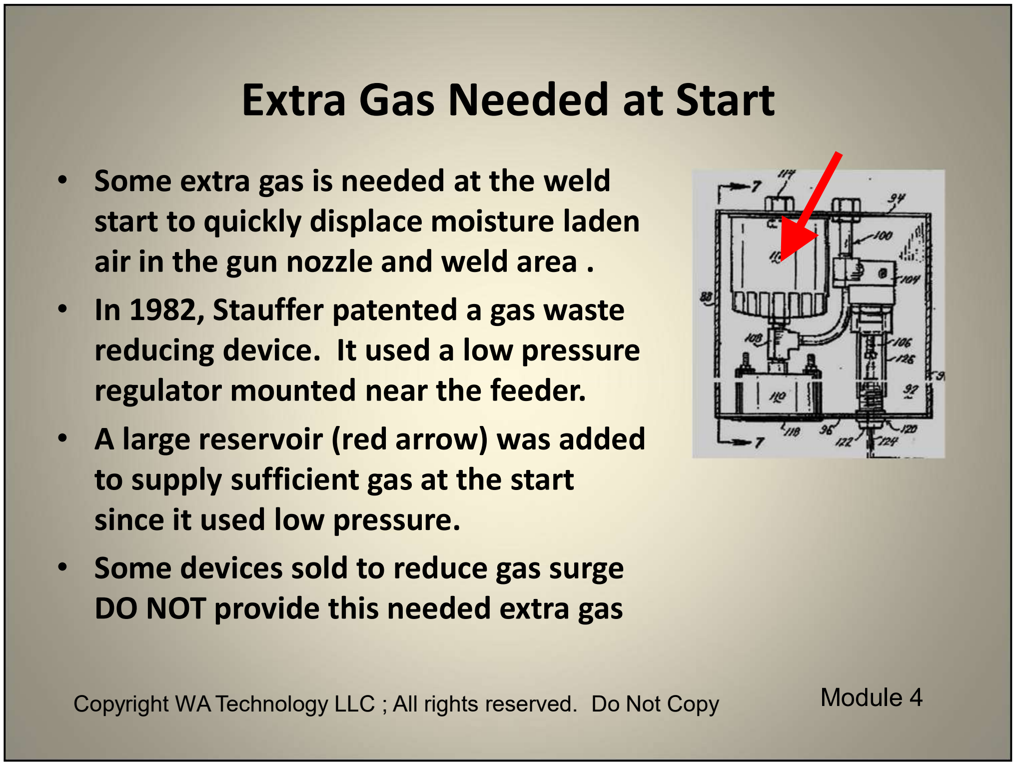
A number of solutions have been tried over the years to reduce or eliminate the gas surge at the weld start. This Module explains a simple and effective way to accomplish that objective while maintaining the benefits of retaining higher system pressures and providing some extra gas at the weld start.

What's Covered in Module 4

- Need for extra gas at start
- Use of a critical orifice
- Past solutions create other problems
  - High pressure needed for automatic flow compensation
  - Restriction orifice controlling flow at feeder creates two problem sand if just sized to stop surge saves little gas
- *GSS* solves gas flow related problems with no moving parts

Module 4

Some extra gas is needed at the weld start. In addition high pressure is needed to retain the automatic flow compensation to counter restrictions. That's why conventional systems were designed the way they are!



Stauffer in a patent published in 1982 discusses this issue. He clearly understood the problem and designed around it; he states in the patent teaching, *"... air leaks back into the 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. "*

Unfortunately some have tried devices that reduce the gas surge but either do not provide the needed extra gas or eliminate the automatic flow compensation the engineers who designed these gas flow systems knew was a needed feature. Some use low pressure and mount the device at the feeder creating both lack of sufficient start gas and no flow compensation for the inevitable flow restrictions that occur in production. These devices frustrate welders even if they do not understand why! They complain of "lack of gas."

What Occurs When Insufficient Extra Gas is Not Supplied at Weld Start

- Proper machine dynamic characteristics and settings are needed for a good weld start.
- However even with optimum machine and settings air must be excluded from the weld start zone.
- When Oxygen and particularly Nitrogen are introduced into the arc poor arc characteristics exist. This results in excess weld spatter
- Even a small amount of nitrogen will lead to weld porosity.

Module 4

Starting a MIG arc requires the proper machine dynamic characteristics and settings. However even with the optimum machine and settings, shielding gas must exclude air from the weld start zone. As a test, just shut off the shielding gas supply and try to make a weld start. You'll see excessive spatter and a poor quality arc! When Oxygen and particularly Nitrogen are introduced into the arc these poor arc characteristics exist. Even a small amount of nitrogen will lead to weld porosity, even if it is only below the surface.

Problems with Past Solutions to Gas Surge Problems

- Use of Critical Orifice to Reduce Gas Surge. These have been used two ways:
  - One way is to use it in conjunction with a standard regulator/flowmeter. The orifice size is selected to reduce surge flow but not steady state flow. However this gives a false impression that gas is saved when it is mostly just delayed. See graph on next page.

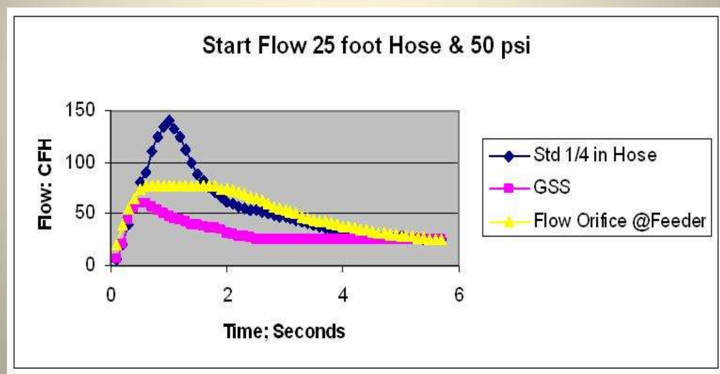
Module 4

The simplest device used to reduce gas surge at the feeder is a critical orifice. These are used two ways:

First way: If the critical orifice is used in conjunction with a flowmeter and flow control at the gas source the orifice size is selected so it limits surge flow but not the steady state flow. This limits the gas surge and will improve weld starts. However if a pressure gauge is placed in the gas delivery hose it will be noted that when welding is stopped pressure rises to that of the regulator or pipeline. After welding has started the gas pressure drops to that needed to produce the desired flow. Therefore the excess gas in the delivery hose is wasted; it just takes longer to be expelled, perhaps several seconds! This approach does maintain the automatic flow compensation feature and will properly manage variations in restrictions. Unfortunately since the surge flow is reduced, waste is less obvious and leaves the impression shielding gas is saved. But instead it just lengthens the time over which the waste occurs!

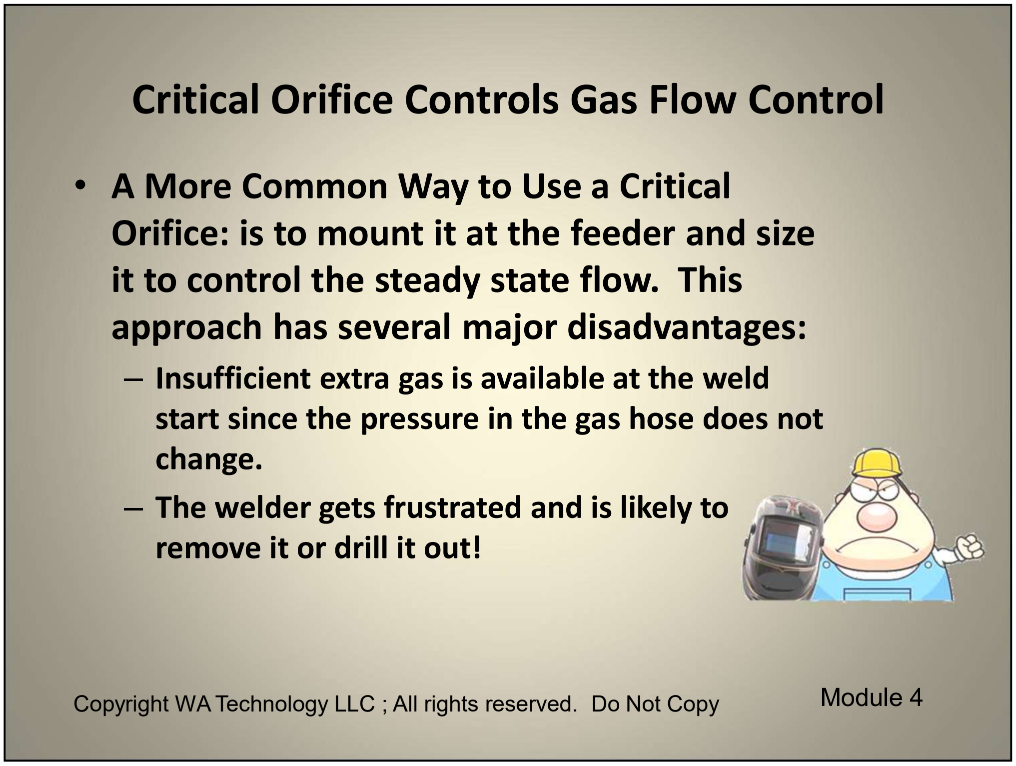
Critical Orifice Controls Only Surge Flow

- **Note the peak flow rate with a standard hose and the same peak flow limiting orifice size used with the *GSS* still creates waste. Some gas waste is reduced, 10 to 15% but not the 80% achieved with the *GSS*.**



Module 4

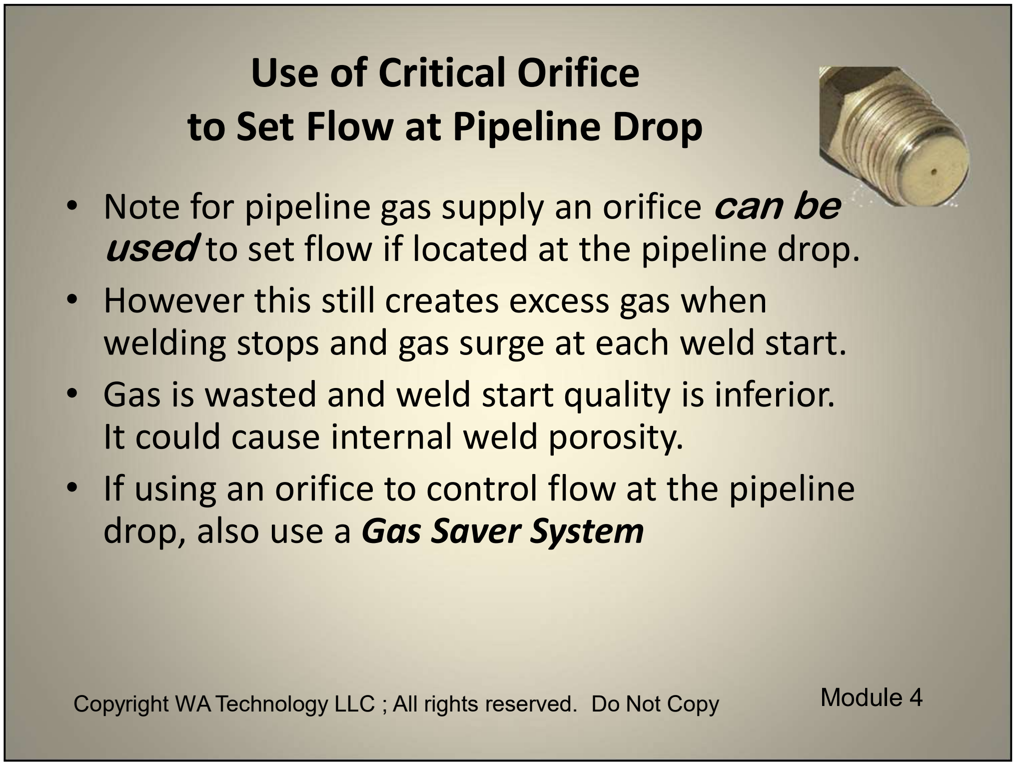
The use of just a critical orifice to control surge does work to reduce excess gas surge but the hose pressure still builds when welding is stopped and the volume of gas increases. Since the flow velocity is reduced it gives a false impression that gas waste is reduced-which it may be, but only a small amount! Most of the excess gas stored when welding stops still exits the hose, it just takes somewhat longer!



A 2nd way a critical orifice is employed if as the flow controlling device to establish the steady state gas flow. In this mode it has several disadvantages.

1. **This approach will eliminate surge but provides insufficient extra gas to displace the diffused air in the MIG gun nozzle, cable and to quickly provide some extra gas to the weld start area. This can lead to poorer starts and starting porosity.**
2. **Also, welders can not alter the flow setting. This can be a problem if the type of joints change (fillet welds require less gas flow than butt welds) or drafts are present. This usually means the flow rates are fixed at the highest needed level. Welders may drill out the orifice if they feel more gas is needed. To control flow at desired levels the orifice size may need to be as small as 0.025 inches depending on the desired flow and regulator or pipeline pressure. The smallest drill size readily available is often 1/16 inches. Sounds like a reasonably small size; however a 1/16 inch orifice will flow 170 CFH on a 50 psi pipeline! In general, welders find ways to make the adjustments they believe are needed which may not be in the interest of shielding gas conservation.**

This type system will however maintain the automatic flow compensation feature.



A critical orifice can be used at the pipeline drop to set flow. Gas pressure will drop across the orifice when welding to that flow needed to achieve the desired flow rate. However when welding stops the gas pressure will increase to the pipeline pressure storing excess gas in the line from pipeline to feeder. When welding starts the excess gas stored in the gas delivery hose blasts out at a flow rate that creates turbulence. This turbulence pulls air into the gas stream creating inferior deposits and excess spatter.

Use of Low Pressure Devices

- Low Pressure Devices have been tried to reduce gas surge at the weld start.
- These devices can be mounted at the gas supply, with the regulator or at the feeder.
- In either instance the automatic “flow compensation” feature is lost and flow will vary as welding progresses and the gun cable becomes twisted, the gas passages (also the wire passage) clog with debris, when spatter partially clogs the gun gas ports etc.

In tests conducted with a low pressure regulator devices, flow variations of up to 30 % were found to exist with added restrictions. In addition if these devices are mounted at the feeder they may not supply sufficient extra gas to purge the weld area or the gun nozzle of air. When welding is stopped air will diffuse all the way up the gun gas lines until it reaches the solenoid. This air which its contained moisture must be purged to assure sound quality deposits. There are good reasons regulator/flowmeter systems are designed to operate at a minimum of 25 psi or 50 psi. Also for CO_2 cylinder operation pressures up to 80 psi are used to avoid internal ice crystal formation and flow blockage.

Use of Low Pressure Devices (cont.)

- If the low pressure device is mounted at the feeder it reduces the start surge but provides little extra gas at the weld start.
- It is also not self compensating for flow and will cause variations in flow as welding progresses
- It also doesn't supply sufficient extra gas at the start.

 Module 4

The need for extra gas at the weld start was reinforced when *GSS*'s were installed at a bar joist manufacturer. They were using critical orifices at the feeder, controlling flow to 45 CFH. However the welders wanted more flow to counter drafts from time to time. We installed a *GSS* and limited steady state flow to 35 CFH. The lead welder, selected for the test, was still very pleased since we were providing a flow rate of about 70 to 80 CFH for a very short time at the start. This eliminated starting with excess air in the weld area and gave better starts with visibly less spatter. They have reported gas savings of 30+% with happy welders!

Sensitivity of Low Pressure Regulators to Variations in Downstream Pressure

Tests were conducted with a conventional 25 psi Regulator/Flowmeter and a "Low Pressure Surge Redacting Device" sold to reduce the initial gas surge. This model mounts at the feeder:

	Pressure @ Feeder					
System	**3 psi**	**4 psi**	**5 psi**	**6 psi**	**7 psi**	**8 psi**
Conventional (reg. 25 psi)	31 CFH	31 CFH	**31 CFH**	31 CFH	31 CFH	31 CFH
Low Pressure (reg. 9 psi)	37 CFH	34 CFH	**31 CFH**	27 CFH	23 CFH	16 CFH

Module 4

Tests made with a commercial Low Pressure Regulator shows the wide rage of flow created with modest flow restrictions. Note: the flow calibrated gauge incorrectly shows flow since the preset pressure does not change only flow!

An engineer at a major automotive supplier related his findings with a low pressure regulator that mounted at the feeder. It included a flow calibrated pressure gauge. He installed over 30 systems. After using them for some time he found he was measuring significant flow variations when the flow calibrated pressure gauge was reading the same flow he had set. He also found he had no extra gas at the start which caused inferior starts. He personally removed tem all!

The above calculated data uses the complex equation which defines flow through an orifice when it is not a critical orifice. This regulator requires only 9 psi to flow 31 CFH. That was set b adjusting the regulator to read 31 CF on the flow calibrated pressure gauge. Note that if the restriction is increased just 1 psi the flow reduces to 27 CFH. Note if the flow resistance increased to 8 psi the flow would reduce to 16 CFH a (31-16)/31 or a 49% flow reduction!

Flow restrictions occur due to spatter build-up in the gun nozzle, spatter clogging the small as holes in the gas diffuser and gun cable bends and twists that occur as the gun is moved. In addition clogging of the gas hose in the gun cable since most MIG guns use the wire conduit in the gun cable to also carry shielding gas to the diffuser near the gun tip. Therefore as wire debris, wire drawing lubricate etc accumulate in the gun liner.

Manufacturer of Low Pressure Regulators Designed to Reduce Gas Waste Cautions Use:

An article in **May 2003 issue of *Flow Control* magazine** quotes a representative from a company who manufactures low pressure flow-control regulators;

"… there are applications in which a compensated unit (authors description for higher pressure systems) may be required. When long lines cause back-pressure or when wind causes the shielding gas to blow off, the compensated system may be the solution to these problems."

- Article discusses design and use of high pressure regulators to maintain consistent, preset flow to handle restrictions.
- However it fails to mention the extra gas needed at the weld start which some low pressure systems do not provide.

 Module 4

Reinforcing the problems with low pressure devices is an article published in an industrial magazine, FLOW CONTROL. In the May 2003 issue, the Manager of Technical Services for a company that sells conventional gas flow regulators as well as low pressure devices published an article on selecting gas flow regulators. He describes the need for high pressure to achieve automatic flow compensation and its benefits. He also cautions on the use of low pressure devices. He gives reasons as noted above.

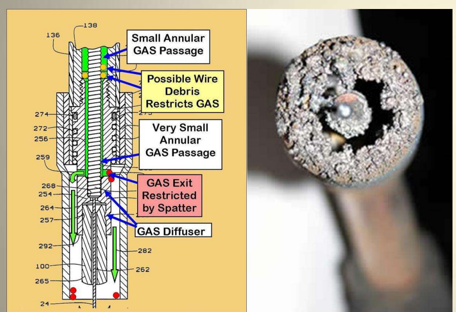
We could not understand the statement above about *"wind causing the shielding gas to blow off,"* until 1) we found welders using this term to describe what they thought was happening at the weld start when high gas flow surges exist and 2) from the flow data with low pressure systems presented on the previous page.

Actually the arc does not blow-off---this is not a propane gun! What happens is sufficient Nitrogen and Oxygen are pulled into the gas stream which makes the arc very unstable at the weld start. Just try welding in air and watch the spatter! Looking at the previous page, if the flow rate reduces to 15 CFH with even the slightest breeze will allow air to be pulled into the shielding gas stream. That is probably why the statement about wind. We found some folks using these low pressure devices set high flow rebates to compensate for these flow reductions!

Reference:

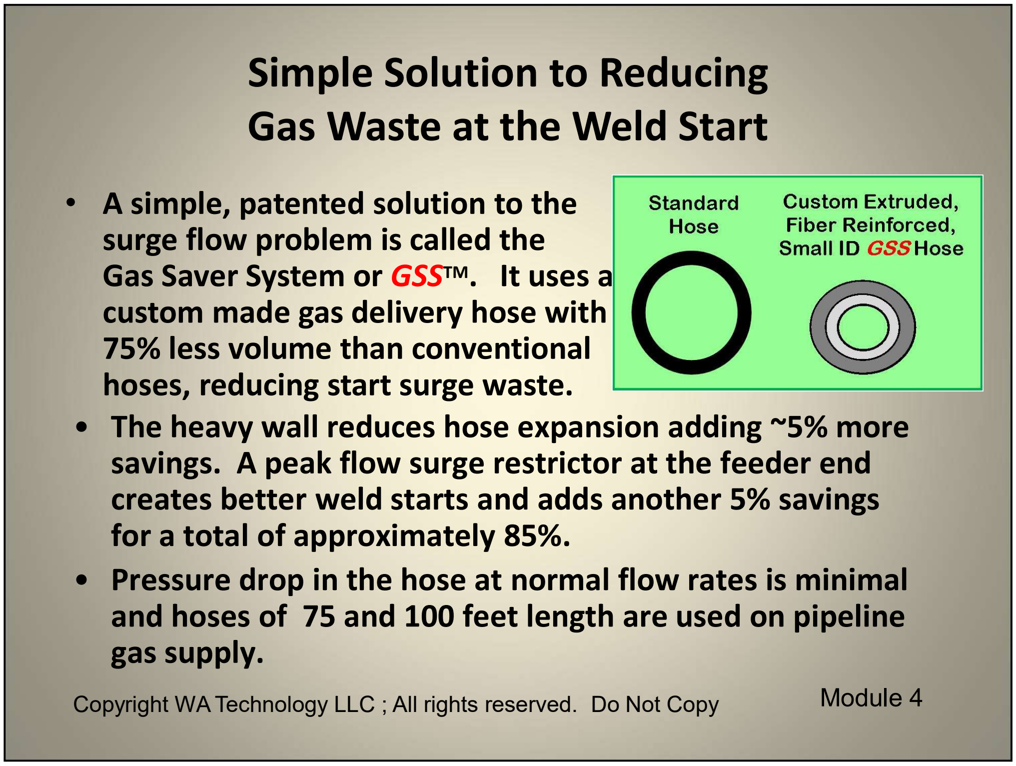
Uccellini, J., Gas-Saver Flowmeter Regulator. Flow Control, Volume 9, Number 5, May 2003.

Why Do Restrictons Occur?



- Spatter in Nozzle Most Obvious
- Spatter in Gas Diffuser Worse
- Debris from Wire (Copper & Drawing Lub) in Small Gas Passages in Gun Cable and Bends Also Contribute

Where do gas restrictions occur when welding. They can come from a number of sources. The most obvious is the spatter build-up in the gun nozzle. However probably more important is spatter clogging one or more of the small holes in the gas diffuser that allows shielding gas to enter the gun nozzle. A more subtle but important cause is debris accumulation in the gas passage in the gun cable. This often doubles as the hose containing the spring wire liner. Debris from the wire, such as copper flakes from the coating on steel wire and the heavy lubricants used when the wire is drawn though dies. These can be seen when the wire liner is removed and cleaned.



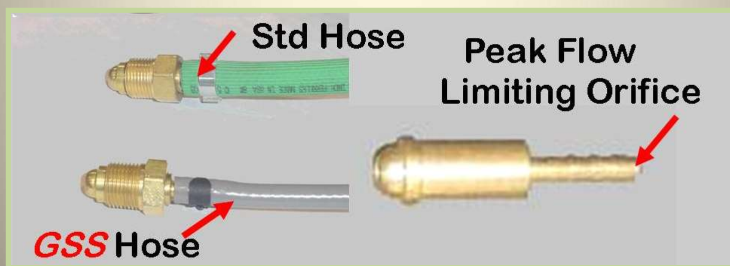
One question asked is the pressure drop in the small diameter hose. The flow rates in welding are very low, by flow standards. For example even a small air compressor will usually supply 4 to 5 CFM of air. That is 240 to 300 CFH! In welding we are usually using about ½ CFM or 30 CFH! An adult walking at a slow pace will consume more air (about 50 CFH) than a normal MIG welding uses shielding gas!

The pressure drop in a 100 foot *GSS* system at normal shielding gas flow rates of 35 CFH will be under 10 psi.

Therefore a 50 foot *GSS* will operate even with lower pressure regulator/flowmeters (25 psi) and still give satisfactory performance. If pipelines with 50 psi are employed, systems exceeding 100 feet will not produce sufficient pressure drop to restrict flow to unacceptable levels. One ATV Manufacturer is using *GSS* installations with 110 feet from pipeline to feeders with excellent results.

GSS Maintains System Pressure

- **The *GSS* does not alter system pressure so it maintains the automatic "flow compensation" built into normal regulator/flowmeters.**
- **The small volume reduces gas waste.**
- **Restriction orifice size selected to allow normal flows, ONLY restricts start surge gas flow.**



Module 4

Even though the volume of excess gas in the delivery hose is reduced by 80+% all the excess would be expelled to quickly . To assure it does not create turbulence in the shielding gas stream and to achieve better start quality a restrictor is placed in the hose outlet gas fitting. The size is selected so as NOT TO INTERFERE WITH THE STEADY STATE FLOW SETTING. Only the start surge flow rate is restricted and to a sufficiently high level to provided extra gas to displace air in the weld zone and gun cable and body. The flow reading on any pipeline flowmeter or cylinder regulator/flowmeter (one with a floating ball) or a regulator/flowgauge (one with two gauges , one calibrated in CFH) still read the same as when larger ID hoses are employed and accurately when the GSS is installed.

GSS Provides Needed Extra Gas

- As Stauffer quotes in his patent; *"... air leaks back into the 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. "*
- **The GSS achieves a controlled amount of extra gas at the weld start by maintaining the system pressure. This higher pressure provides the needed extra gas very quickly to displace air in the weld zone etc.**

Module 4

The *GSS* supplies sufficient extra gas to the weld zone and to displace air and accompanying moisture in the weld zone. By maintaining the higher system pressure this extra gas is supplied very quickly. Maintaining the higher pressure, as noted previously, also provides the "flow compensation" feature automatically. In fact that is the key reason regulator flowmeters were designed to operate at higher pressure.

Production Examples

- The following are a few production applications using the *GSS* and their gas savings

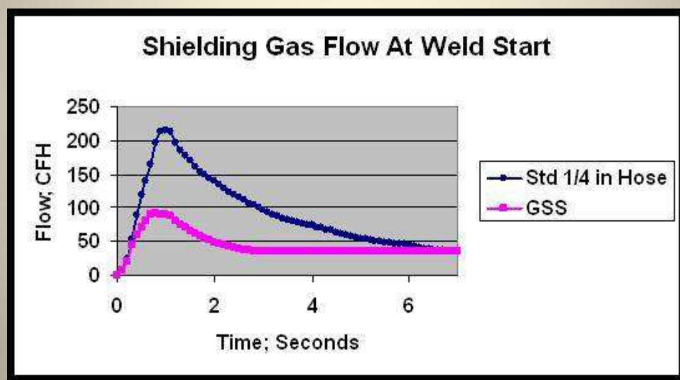
Truck Body Builder	50% gas savings
Pipe Shop	43% gas savings
Truck Tool Boxes	63% gas savings
ATV Producer	30 + % gas savings
Structural Aluminum	40% gas savings
Pipe Repair	33+ % gas savings and significant weld start quality improvement

 Module 4

These are just a few of the shops that have provide documented test evidence of the savings achieved. A number have purchased more systems when they have added welders.

Weld Start Quality Improved Significantly

- Graph shows start flow with and without *GSS*. At > 200 CFH peak flow with their standard system internal weld start porosity was encountered. See details in notes.



Module 4

A production application demonstrates a significant improvement in weld start quality as well as gas savings.

Details of Quality Improvement: While testing the *GSS* in a shop doing repair of welds in pipe, the quality benefits were clearly demonstrated. This shop is often required to ultrasonically test all welds. Repair of the sub arc welds are made with MIG in pipe which ranges up to one inch in thickness. These repairs must also pass ultrasonic tests. For a repair weld, starts are a significant part of the deposit. With the standard gas delivery system, flow surge at the start exceeded 220 CFH. With the *GSS* it was lowered to less than 80/90 CFH. The welder who was testing the system knew this excessive surge flow caused starting problems and stated that he; "*often cuts the wire and starts with it above the work to allow the initial surge flow to reduce in rate before the arc strikes!*" The pipe does not leave his work area until all welds are checked and pass. *After over a year in production the welder using the system reports he has found far less weld start porosity than previously.*

For Long Gas Delivery Hoses

- The *GSS* works for shielding gas lines up to 50 feet with even the lower range of gas regulators such as the common 25 psi regulator/flowmeters.
- The low flow rates used for MIG shielding gas flow of 30 CFH (0.5 CFM) create very little pressure drop.
- For pipelines operating at the typical pressure of 50 psi even longer lines of 100 feet can be used.
- For longer lines such as in shipyards we have also patented more elaborate systems; email *Jerry_Uttrachi@NetWelding.com* for information.

Module 4

The simple GSS system with its small diameter hose works for shielding gas lines up to 50 feet even the lower range of gas regulators such as the common 25 psi regulator/flowmeters. For pipeline pressures and higher regulator pressures of 50 psi even longer lines of 100 feet can be used.

For even longer lines such as used in construction or in shipyards we have patented other more elaborate systems; email Jerry_Uttrachi@NetWelding.com for a description of these systems.

Module 5

Setting Proper Gas Flow Rates

Lean Welding Manufacturing

Learning Program

Module 5

Defines why using philosophy of: “If some is good more is better” is a bad for making quality welds!

What's Covered in Module 5

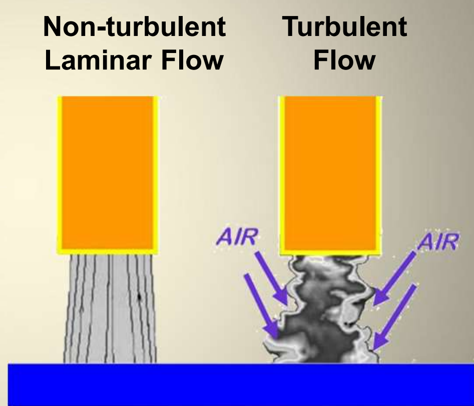
- Setting Proper Gas Flow Rates
  - Flow that creates turbulence –TWI
  - Tests evaluating flow rates needed to handle drafts
  - Minimum flow rates
  - Using recently patented Flow Rate Limiter and Lock to control flowmeter (cylinder or pipeline) maximum flow rates

Module 5

This Module discuses the maximum gas flow that should be used. Many publications define the approximate range and perhaps the minim flow but very few mention the maximum gas flow other than to say in a trouble shooting chart, for example-FLOW RATE MAY BE TOO HIGH!

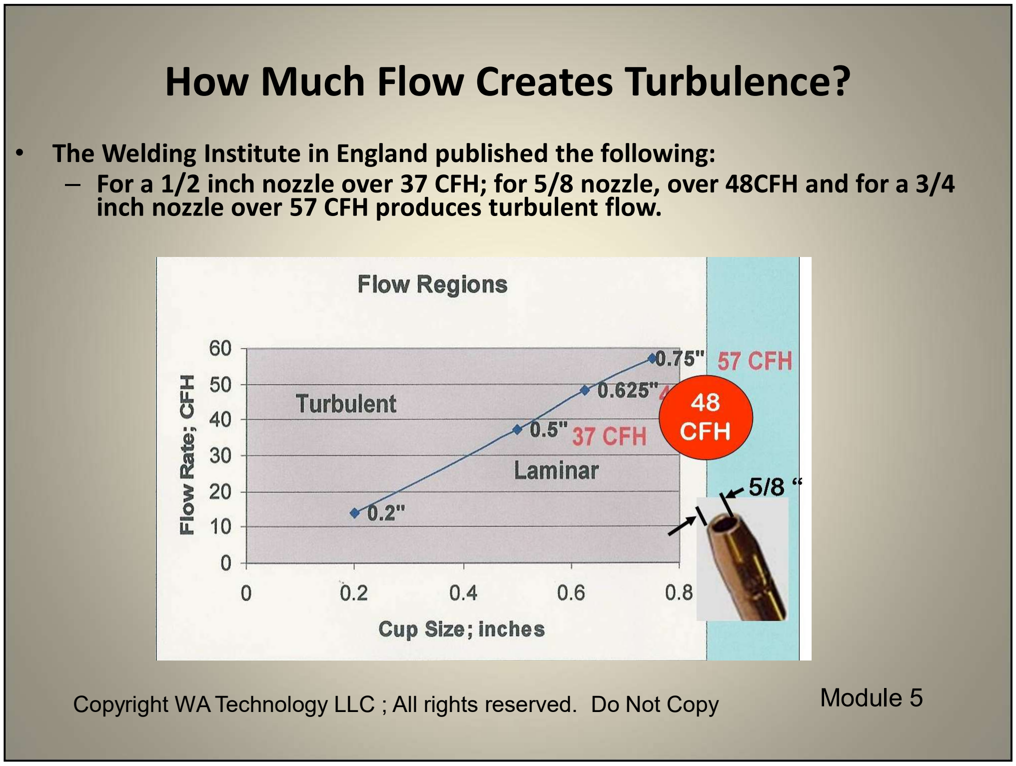
Excess Flow Rate Causes Turbulence

- The shielding gas stream should exit the gun nozzle with smooth, non - turbulent flow.
- If the velocity is high enough, it will become turbulent and pull air into the gas stream.



Module 5

Excess flow causes air to be pulled into the shielding gas stream. As we'll see in the next few pages, the maximum flow before this occurs is not much higher than the general recommended flow rates!



High gas flow surge at the weld start causes turbulence in the shielding gas stream. This turbulence causes air to be mixed into the shielding gas stream until the flow rate stabilizes to the preset level. The entrained air causes excess weld spatter and can cause internal weld porosity. This may be more noticeably with processes such as pulsed GMAW.

There is little published information on the maximum desirable flow rates for GMAW. One useful technical article was published by The Welding Institute (TWI) in England [Wilkinson, M. E., Direct Gas Shield Analysis to Determine Shielding Efficiency. Report of The Welding Institute, Cambridge, England, December 1974. [Note: The data is applicable for Argon, CO2 or mixtures of these gases. For shielding gas mixtures which include Helium these flow rates do not apply. Consult the gas supplier for the specific recommendations for these shielding gases.] In another article published in January 2005 Practical Welding Today magazine , the Manager of Welding R&D for Praxair, Kevin Lyttle, stated: *"In many instances, production site surveys 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 excessive gas turbulence."* **This validates the TWI information.**

INDEPENDENT STUDY CHECKING EFFECT OF WIND: An independent study investigating the level of gas flow rates needed to improve shielding in specific wind environments supports the TWI DATA. It was found that when welding in a 5 MPH cross wind with a 5/8 inch diameter gun nozzle, 45 CFH gas flow rate produced SOMEWHAT less internal weld porosity than when 65 CFH was used. When wind is over 4 to 5 MPH use a wind break.

Minimum Flow Rate

- Minimum acceptable flow rates depend on a number of variables (see notes).
- In general for Argon and CO_2 or mixtures of these gases :
  - for a ½ inch nozzle; flow rates of 18 to 21 CFH will be sufficient for most applications.
  - For a 5/8 inch nozzle; 22 to 25 CFH is sufficient.
  - For a ¾ inch nozzle, welding with cored wire at 400 to 500 amps; 30 to 33 CFH may be needed.
- In a draft of 3 to 4 MPH add up to 15 to 25 CFH. Beyond that, use a wind break- - a small one will work!

Module 5

Many variables effect the minimum allowable flow rates such as the gun design, cup to work distance, welding current, gas mixture, type of wire, joint type (fillets require less than butts, etc). In a closed shop environment with good general ventilation lower flows will be satisfactory. In fact some published data indicates flows as low as 15 CFH will be satisfactory. However these tests were probably done in an environment with no drafts.

When small drafts or local ventilation create an air flow past the work, a higher flow rate should be used. When drafts above 4 MPH are encountered a small wind break may be all that is needed. The welder can also block the draft by standing between the direction of the draft and the work piece.

Note for shielding gas mixtures which include Helium these flow rates do not apply. Consult the gas supplier for the specific recommendations for these shielding gases.

Maximum Flow Rates

- In general, for Argon and CO_2 or mixtures of these gases setting flow rates higher than about: :
  - **37 to 43 CFH on a 1/2 inch gun nozzle**
  - **50 to 60 CFH on a 5/8 inch gun nozzle**
  - **60 to 70 CFH on a 3/4 inch gun nozzle**

  is counter productive, and pulls excess moisture laden air into the gas stream.
- Air in the gas stream causes excess spatter, porosity and inferior properties

Module 5

With solid MIG wires, some Oxygen can be tolerated. The silicon and manganese contained in the wire can combine with the Oxygen to form a silicon oxide or a manganese oxide and avoid the carbon in the weld puddle forming a CO bubble. However published information indicates Nitrogen at levels less than 2% in the shielding gas can cause porosity in single pass welds. It has also been reported that 6% Nitrogen in the shielding gas causes visible surface porosity. Unlike Oxygen, chemically combining Nitrogen into harmless compounds is not viable with solid wire. Elements like titanium can be employed but only at low levels since significant amounts cause embitterment.

Eliminating Oxygen and Nitrogen at the weld start to reduce the possibility of weld porosity and excess weld spatter requires good shielding. In addition to Oxygen and Nitrogen the surrounding air contains Moisture or Water Vapor. The Water Vapor can also be drawn into the arc where it will disassociate into Oxygen and Hydrogen. Hydrogen can cause more than porosity problems. It can cause cracking.

Note for shielding gas mixtures which include Helium these flow rates do not apply. Consult the gas supplier for the specific recommendations for these shielding gases.

Summary: MIG Gas Flow Rates

Considering Typical Parameters, the Following are Reasonable Gas Flow Rates for Argon/CO^2 Gas Mixtures and Straight CO^2 Shielding.

Nozzle Size	Minimum	Typical	Maximum
1/2 inch	18 CFH	22-27 CFH	~ 40 CFH
5/8 inch	22 CFH	30-35 CFH	~ 55 CFH
3/4 inch	30 CFH	35-40 CFH	~ 65 CFH

Many believe; *"If some is good more must be better when it comes to gas setting gas flow rates."* They Are Wrong!

 Module 5

Suggested MIG Gas Flow Rates are summarized in this table.

Note, we have found if sufficient extra shielding gas is supplied at the weld start to purge the *Gun Nozzle* and *Weld Start Area* at a *Flow Rate* that *DOES NOT* cause excess turbulence (*NOT the Normal Blast of Gas Found in Most MIG Welding Systems*) the steady state flow setting can be reduced to the low levels shown in the table. Our WA Technology patented *Gas Saver System* provides this condition. This system is described in subsequent slides.

Recently Patented "Flow Rate Limiter" Mounted on Flowmeter

"Flow Rate Limiter & Lock" (FRLL) Mounted on a Victor FM372KM

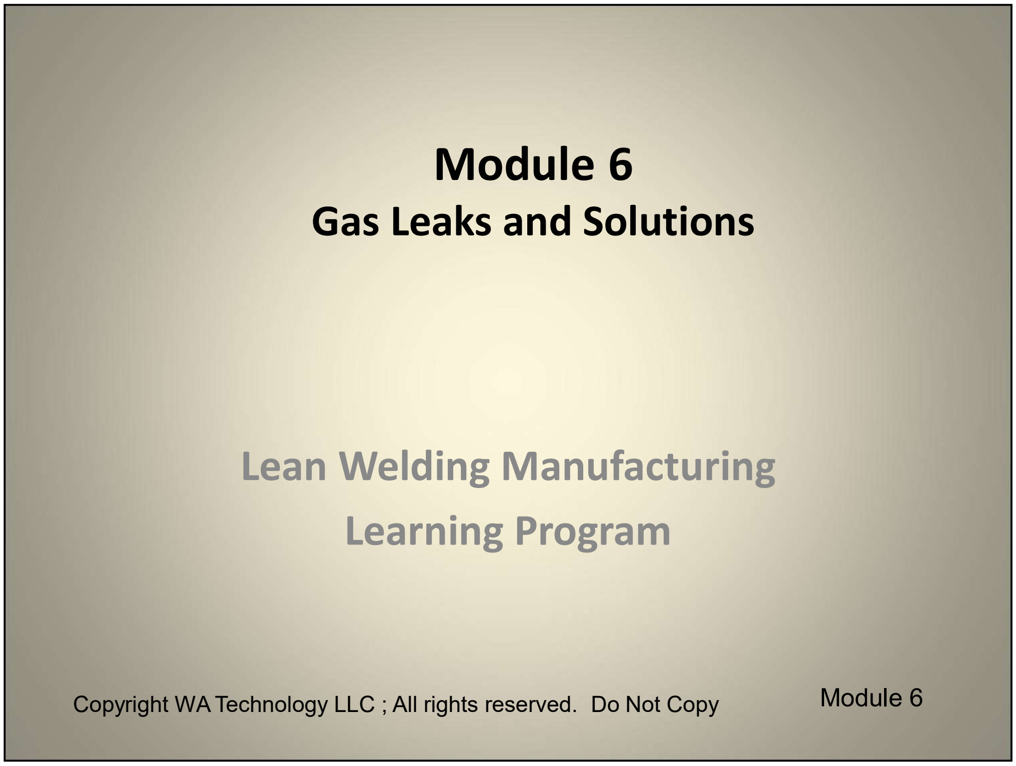
FRLL Fits Most Brands of Flowmeters

Module 5

If flow is set too high a flow there is a simple device to set the maximum flow rate or with some regulator/flowmeters or pipeline flowmeters lock the flow setting you select. This patent pending product is available on our web site, www.NetWelding.com.

Pictures show how the simple device mounts on most brands of regulator/flowmeter or on pipeline flowmeters. It attaches to the needle valve flow control knob with a set screw. A stainless steel pin connected to the billet aluminum body restricts the turning on the knob when it comes in contact with the regulator body. A blocking pin is inserted which prevents access to the set screw after the desired maximum flow or flow range is set. A pad lock is placed in a hole in the custom stainless steel blocking pin. Simple and unique, the device is patented, US Patent number 7,462,799.

Note Victor is a registered trademark of Thermadyne Corporation and ESAB is a registered trademark of ESAB Welding and Cutting Products.



Leaks not only cause waste but can also be a safety hazard.

What's Covered in Module 6

- Leaks in fittings
- Leaks in solenoid
- Leaks in internal feeder fittings
- Leaks in gun gas connections
- Leak in cylinder valve
- Calculating pipeline leak rate
- Plot moving average of gas and wire purchases
- Leaks are a safety issue (see notes on this page)

 Module 6

Leaks are an important source of gas loss. Checking for leaks is also a safety issue. Although these gases are not considered harmful under normal circumstances they are usually heavier than air. Thus they will sink to the floor level **AND IN A CONFINED AREA COULD CAUSE ASPHYXIATION AND DEATH**. All connections should be checked for leaks with an approved leak detection solution. Shut off shielding gas supply when not in use.

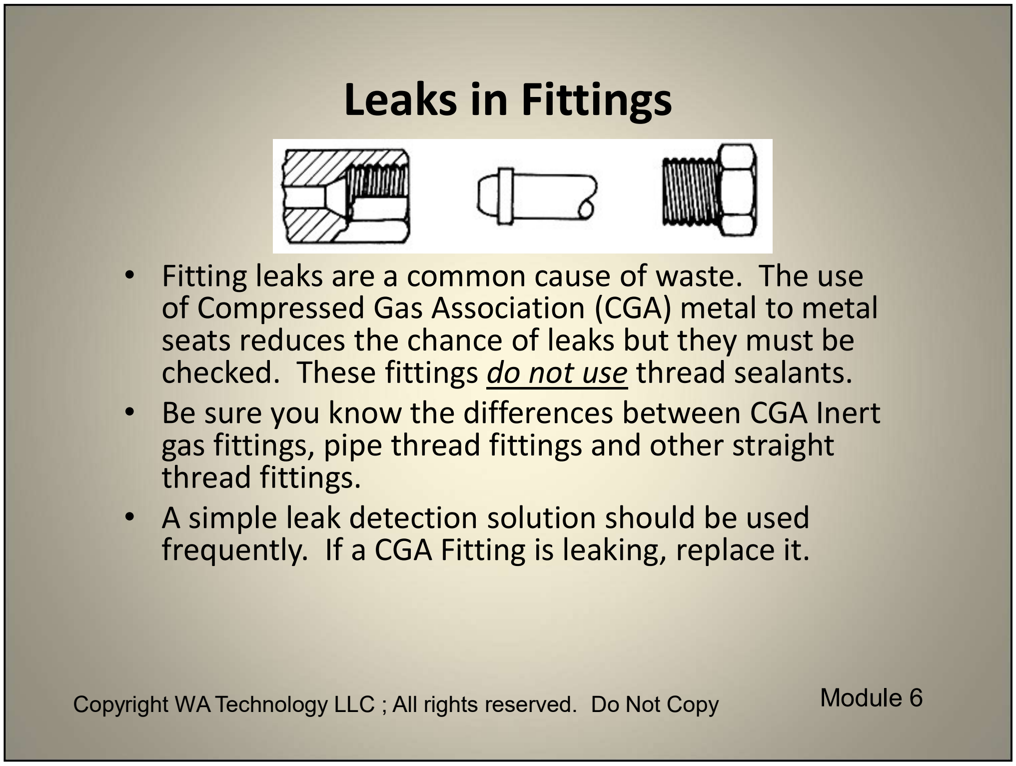
The comments are **NOT MEANT TO BE COMPREHENSIVE** in regard to the use of the welding equipment employed. Please carefully read and follow the equipment manufactures instructions. Also refer to publications on safe practices for welding and cutting available from the American Welding Society, 550 NW Lejeune Rd., Miami, Fla 33126 including "Safety in Welding and Cutting" – ANSI/AWS Z49.1.

Leaks in Internal Feeder Fittings

- Leaks in the feeder are somewhat less of a problem since these connections are exposed to lower pressures.
- Internal fittings may be more difficult to access but should be checked by plugging the gun nozzle with a rag. Be careful about possible electrical shock if you must have the power turned on for this check.

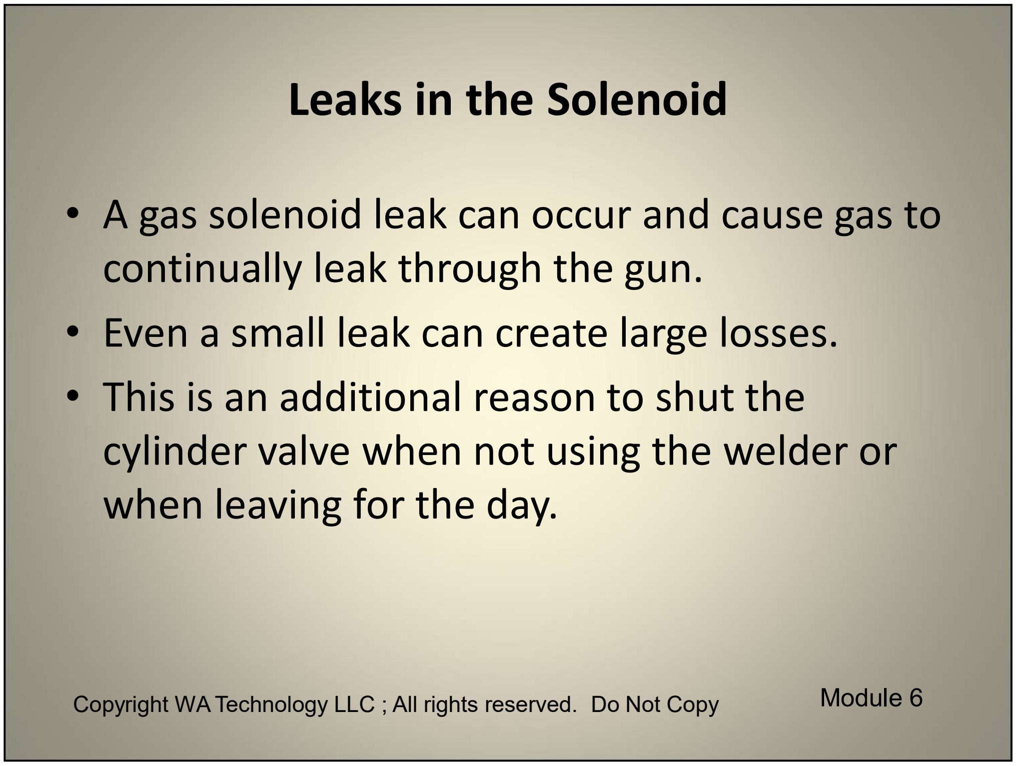
Module 6

Internal connections are more difficult to test since the pressure is low during operation. Plugging the gun nozzle with a rag will increase the pressure so the leaks are more readily detectable. Keep in mind, the gas will still flow, back though the wire inlet, around the back of the gun nozzle etc. Although the wire feed rolls may have to be disconnected for this test (if a flow purge switch is not on the feeder) be sure to keep the wire in the system to reduce backflow though the wire inlet to that which occurs when wire is present.



Fitting leaks are the simplest to check for leaks and a leak test should be conducted anytime a fitting is installed. A periodic maintenance check should also be conducted. At that time also check all hoses for abrasion and leaks, replace as needed. Be sure you know the difference between a Compressed Gas Association (CGA) metal to metal seat and one using a pipe thread. A CGA 032 Inert Gas fitting is used on most American built wire feeders and most regulators and flowmeters.

Putting incompatible fittings together can cause significant leaks and no amount of tightening will solve the problem.



A leak in the gas solenoid, even a small one will cause shielding gas to leak through the weld gun even when your not welding

Gun Leaks (page 1 of 2)

- One major leak area is where the gas enters the gun. This is particularly a problem with quick connect gun assemblies where small tubes with very small "O" Rings are used.

Small "O" Ring on gas connector

 Module 6

This is one of the biggest areas for leaks to occur. We'll cover the areas prone to leaks and discuss a means to check.

One of the major area for leaks is the gun and especially where the gun connects to a quick disconnect fitting. Replace these often (and lubricate if recommended by gun manufacturer). All systems will leak gas out the back of the gun through the wire inlet. However this backflow should not become excessive.

Gun Leaks (page 2 of 2)

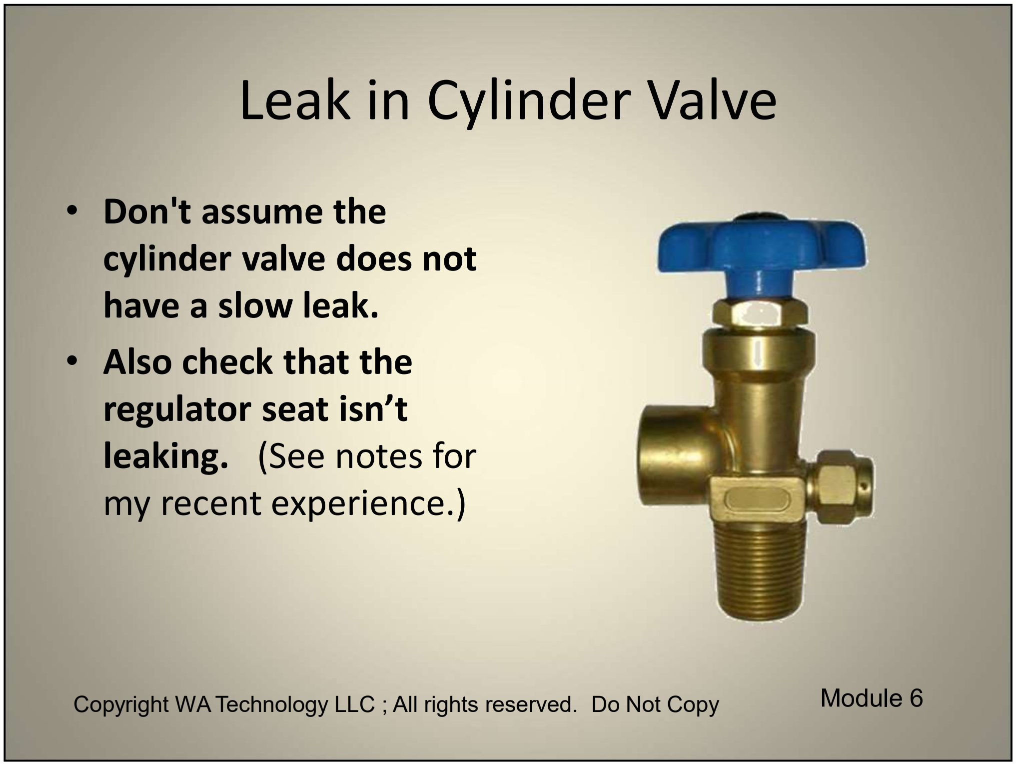
- A way to check for leaks from the gas solenoid to the gun cup is also an excellent way to maintain a record of each MIG system:
  - Use a portable flow tester to measure the gas flow out of the gun.
  - Then disconnect the gas delivery hose from the feeder and measure the gas flow leaving the gas hose.

Module 6

Comparing the flow rate at the gun with the flow rate at the end of the gas delivery hose will tell you what the gun leaks are as well as those other possible internal leaks, Since your using the same gauge the results are accurate and repeatable.

This high quality portable gas flow gauge is available from WA Technology

@ www.NetWelding.com



Just because the cylinder valve looks good on the outside, internally it may have a slow leak. Check the contents pressure when you install the regulator to be sure it is full.

A recent experience is worth noting. A brand new regulator was installed on a cylinder and checked for leaks with a leak detection solution; as you always should. It had a leak, actually quite a few bubbles. Thinking it might be the new regulator seat so it was tightened slightly more - -same leak. Still believing it may have been a faulty seat on the new regulator, an older regulator was installed- - same leak. The cylinder was returned to the distributor, he as expected, wanted to blame the "new" regulator. He went and got a regulator from his shelf and put it on- - guess what- - same leak. He didn't need a leak detect solution, he just listened and said, "It must be a bad valve."

	A	B	C	D	E	F
1	Insert Data; Leave 0 if None		Answer	Insert Special Pipe Diamter - if Needed		
2						
3	**Pipe Size ID inches**	**ID Volume ft³** Per Foot of Pipe	**Input Number of Feet of Pipe in System**	**Total Physical ft³** in Piping System	**Total ft³** of Gas at STP At 50 psi	**Total ft³** 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 ft³ 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; ft³ =	182	802	678
16						
17			ft³ 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

Module 6

A method to quantify the amount of gas leaking from a pipeline is a pressure drop test. This is an overview of how it is done:

Details of preparing the spread sheet are on the next page. If you would like an Excel copy you can email: *TechSupport@NetWelding.com*

1. Calculate the physical volume of the pipeline and gas delivery hoses from the gas source to the wire feeder.
2. With all systems closed, i.e. welders not operating, shut off the valve coming from the gas source to the pipeline. Typically the gas pressure in pipelines is 50 psi so we use that as an example. The gas volume at Standard Temperature and Pressure in the lines is the Physical Pipe and Hose Volume (P&HV) * (50 psi + 14.7 psi)/14.7 psi =P&HV * 4.40.
3. Record the time it takes for the pressure in the pipeline to reduce to 40 psi, i.e. volume of gas at 40 psi = P&HV * (40 psi + 14.7 psi)/14.7 psi = P&HV * 3.72.
4. Therefore the gas lost is P&HV * (4.40 - 3.72) = P&HV * 0.68. Assume it took 5.5 minutes to reduce from 50 psi to 40 psi then the gas loss = (P&HV * 0.68*60min/hr)/ 5.5 min) = 40.8/ 5.5 minutes P&HV * 7.42 CFH

Equations to Make Spreadsheet

Location	Equation	Similar Equations	Copy Cell
B4	=((3.1416*(A4)^2)*4)*12/12^3	B5 through B10	Copy B4
		B12 through B14	Copy B4
D4	=B4*C4	D5 Through D10	Copy D4
E4	=D4+64.7/14.7	E5 Through E10	Copy E4
F4	=D4+54.7/14.7	F5 Through F10	Copy F4
D11	=SUBTOTAL(D4:D10)	E11 & F11	Copy D11
D18	=D11+D12+D13+D14	E18 & F18	Copy D18
F17	=E15-F15		
F19	=(F20/F21)*60		

 Module 6

The above shows the equations that can assist in developing a Spreadsheet:

Reviewing the copy of the Spreadsheet shown in the previous page;

1. Type the equations shown in the Column Labeled “Equation” in the Cell Location Noted.
2. In the Column Labeled Similar Equations Copy the Cell noted into the Range of Cells listed.

In the example on the previous page, the total cubic feet of pipe is:

1) 400 feet of 2 inch pipe delivering to each weld station,
2) 2) 150 feet of 1 inch pipe bring the gas down from the ceiling to each drop and
3) 3) 20 feet of a 4 inch diameter pipe header 4) 200 feet of ¼ inch ID gas delivery hose from the flowmeter at the pipeline drop to the wire feeders.
4) The total cubic feet of Pipe & Hose = 183 CF.

Multiply the 183 CF Pipe & Hose Volume times 40.8 = 7466

Then divide 7466 by 5.5 minutes to reduce pressure = 1357 CFH Leak Rate.

Gas Use to Wire Use Ratio

- An excellent way to monitor gas usage is to track the gas volume use versus the wire use (actually an estimate by using purchases.)
- The first step is to define the wire deposition rate you are using. Even if your using several types of wire and several welding amperages (wire feed speeds) a weighted average is not difficult to calculate.

This method of monitoring gas usage is easy and accurate over a long period, such as 6 months. By plotting a rolling average ratio each month, loss trends can be detected. Posting the plot in the shop also makes everyone aware of gas losses. It reminds them that they have a key role in controlling waste.

Gas Use to Wire Use Ratio Continued

- Wire usage:
  - Define the amperage you are using on average on each welder.
  - Use the table below to define the wire deposition rate (not weld metal)
  - If there are significant differences make a weighted average (see notes)
  - If your typically making the same products the estimate only needs to be approximate.

 Module 6

The following table can be used to define weld wire deposition rate if you know the welding amperage.

Type---Size---Amp----Lbs/hr

Solid--- 0.035---150------**4.1**

Solid--- 0.035---200------**6**

Solid----0.045---200------**5.5**

Solid----0.045---250------**7.6**

Cored---0.045---250------**8**

Cored---0.045—300-----**11.6**

Cored---1/16---300-------**8.6**

Cored--1/16----350------**11.9**

To make a weighted average multiply the deposition rate in lbs/hr by the approximate duty cycle then define the average deposition rate for the shop.

Example if on average your depositing 6 lbs/hr and your flowmeters are set for 30 CFH then the ratio of gas to wire is 30CFH/6 lbs/hr = 5 CF of gas/lb wire.

Need specific data for your wire? Email: guttrachi@aol.com

Gas Use to Wire Use Ratio Continued

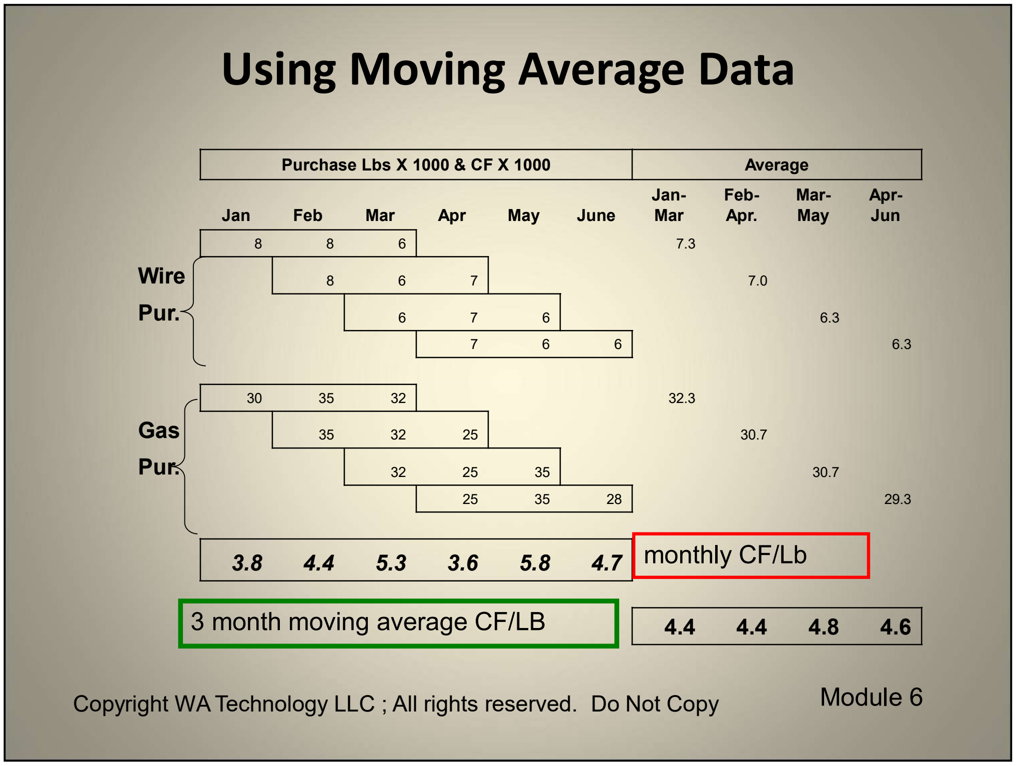
- From the previous notes page you now know the theoretical gas to wire ratio you should have.
- Having purchasing provide the actual gas and wire purchases in cubic feet and pounds not dollars. Your suppliers should have that data readily at had if you do not.
- It is suggested you use a 3 to 6 month average to eliminate inventory changes. If needed you can use a 6 month rolling average (see notes)
- Compare your ratio's with those on the next 7 pages.

 Module 6

In the past 6 months if you purchased 30 cylinders of gas with each cylinder having 320 CF of gas, you consumed 9600 CF of gas. If in that same time period you purchased 750 pounds of wire, you used 9600/750 =12.8 CF of gas for each pound of wire.

From the previous page you found you were welding with a theoretical ration of 5 CF/lb. Therefore 12.8 - 5 = 7.8 CF were mostly wasted. Some extra gas is needed at the start so you should use more than 5CF/lb but not 12.8. However according to the published data your probably below the average shop!

To keep a rolling record of use, ask purchasing to provide purchase figures each month (they can have the vendor supply so its not much extra work.) Then average 6 months of data by dropping the first month and adding the new data. It's best to plot the data and look for trends.



If a plot of the monthly purchases of Gas / Wire purchase is made, the data is difficult to interpret since the usage will vary from the actual use amounts. Note, in this example the monthly average ranges from 3.8 to 5.8 CF Gas/ Lb Wire. This is a 5.8-3.8 = 2/3.8= 53% difference.

However if a 3 month moving average is made it reduces this variation and is probably more reflective of the actual usage. Therefore if too small an amount is purchased in a given month it will likely lead to a larger amount being purchased the next month. The variations are averaged. The range is reduced from 4.4 to 4.8 in this example or 4.8-4.4= 0.4/4.4 = 9% difference. Plotting this data will provide a good estimate of usage and can provide a trend that can be acted upon.

Unfortunately Leaks Are Often Accepted

- **Unfortunately many shop personnel know gas leaks exist but do not fully understand how much they are costing.**
- **While touring one of the companies many fabricating plants, one senior executive would throw out a handful of quarters on the floor. When asked what he was doing, he'd say; "That's what your doing everyday with shielding gas waste due to leaks!" He'd leave the quarters!!**

An 0.035 wire size diameter leak can cost over $14,500/year even with a low gas cost of $0.03/CF.

Module 6

A leak as small as an 0.035 inch diameter wire in a 50 psi pipeline or hose connected to it will flow 55 CFH of shielding gas. Since it will leak for 24/7 that's 482,000 CF/yr! If gas cost is $3.00/100CF ($0.03/CF) that's $14,500/year !! That's a good example to put on a bulletin board in the shop! Check your cost for shielding gas, it may be significantly higher.

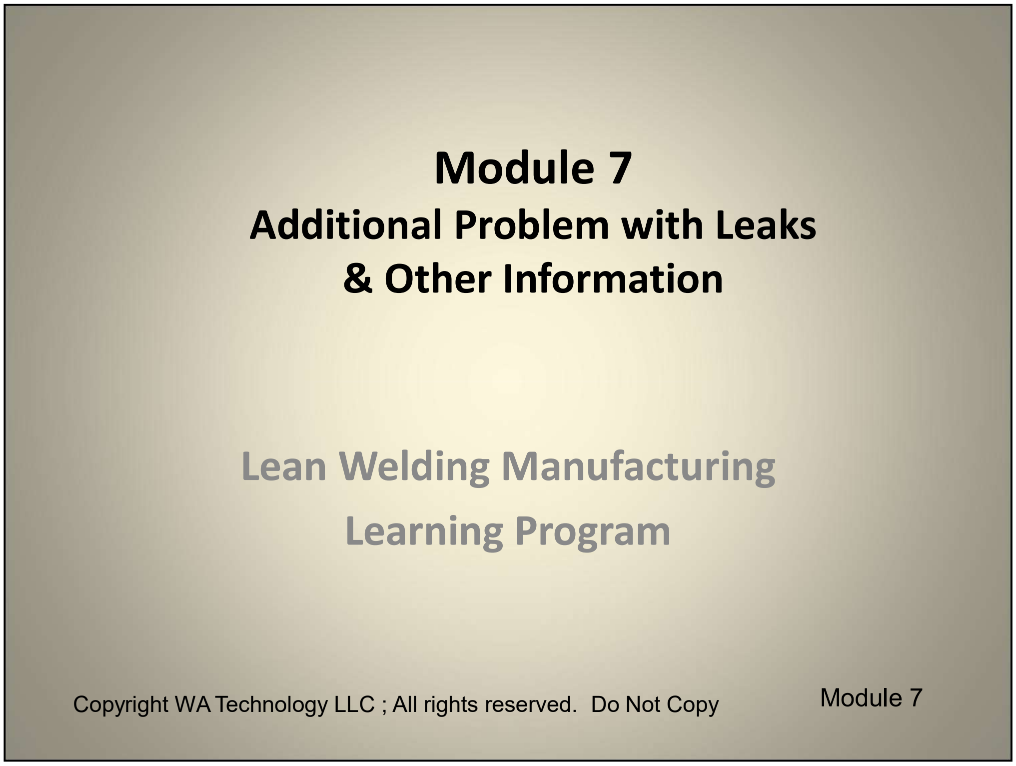
If the leak is pinhead size (1/16 inch diameter) it will flow 170 CFH. That's 1,490,000 CF of gas/year! If gas cost is $3.00/100CF ($0.03/CF) that's $44,700/year !!

Ultrasonic Leak Detector

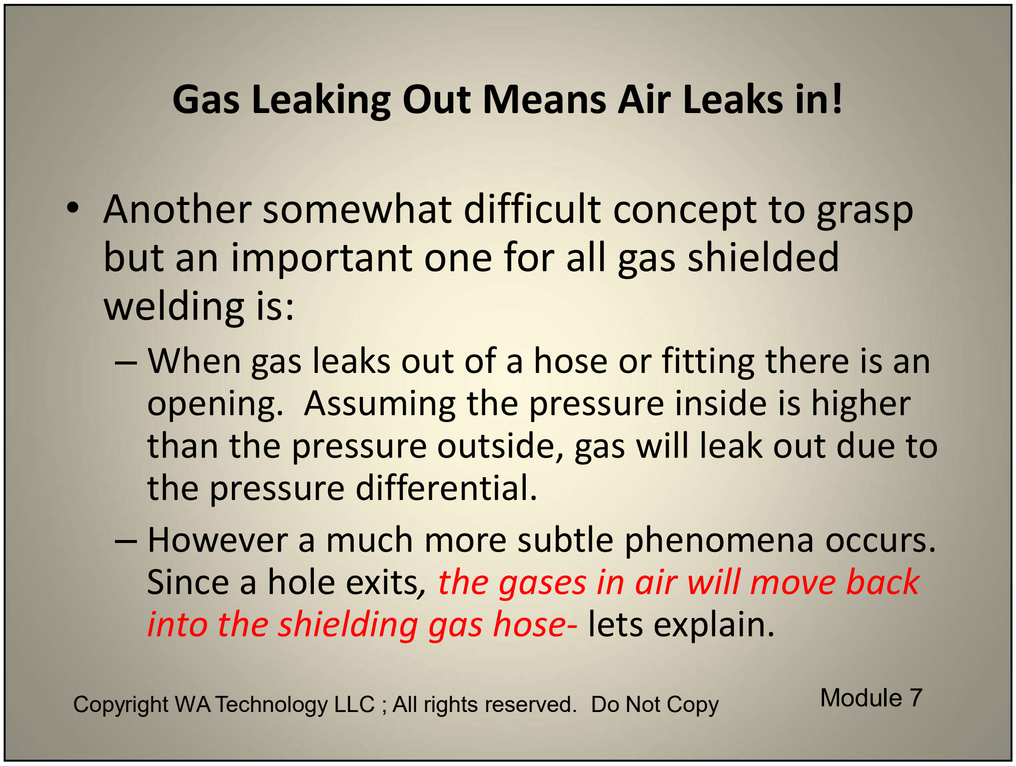
Model We Use Includes Earphone. Device Makes Sound of Leak Audible to Human Ear

- Once an expensive tool-prices are now under $500
- Ultrasonic Detectors make high frequency leak sound audible.
- We have found it also picks up arc sounds including plasma cutting.
- Must use in none-work times.

To find leaks in pipelines an Ultrasonic Leak Detector can be employed. Once very expensive, these devices now are priced under $500. We have found they are very sensitive and can detect even small leaks. They can detect leaks from 15 to 20 feet away. We use a leak detect solution once a leak is detected with our device. However we have found the Ultrasonic Leak Detector also picks up other high frequency sounds and confounds them with leaks. One is a welding arc! Even plasma cutting confuses the sounds. If a air line is in the area it may have to be shut down as those leaks are confused with shielding gas leaks. In one recent case the leak in an airline was sufficient to confound shielding gas leaks in a 50 foot area near the air leak. The literature also notes electric motor brushes create confounding sounds. If these devices and arc welding are not operating, say on a weekend or 2nd or 3rd shift they can be useful devices.



Additional items to consider.



A phenomena called the law of partial pressures was developed by John Dalton (who was born 1766, those fellows were sure ahead of their time in the 1700's!). He found that a mixture of gases behaves as if each were separate. Therefore since there is no Nitrogen in our shielding gas hose the partial pressure of Nitrogen in the hose is 0. Since there is 78% Nitrogen in the surrounding air, the partial pressure of Nitrogen is 14.7 psia x .78 =11.5 psia. Therefore there is a driving force for the Nitrogen to reach equilibrium of 11.5 psia into the hose leak! It will not move as fast as the Argon coming out which may have a driving force of say 25 psig + 14.7 psi = 39.7 psia versus 0.009 x 14.7= 0.13 in the air. Or a driving force of 39.6 psia which is 3.4 times as much but recall we do not need much Nitrogen in the gas stream to cause problems. Welding a material needing a low hydrogen deposit? Paying extra for an H4 rated filler metal? If you have leaks in your gas lines, hoses or fittings your adding hydrogen to the shielding gas! Check the dew point.

Another way to think about Oxygen, Nitrogen or water vapor going back through the hole in our gas delivery hose where an Argon or CO_2 based shielding gas is leaking out is to consider Dalton's statement.

"The gas molecules are spread far apart. The Oxygen, Nitrogen or H_2O vapor will not likely hit an Argon or CO_2 molecule on its journey through the hole! In fact, considering the diffusion phenomena, it doesn't even care about the Argon or CO_2. To provide a picture of how far apart say Argon atoms are at atmospheric pressure as they escape from a leak consider: The density of Argon at room temperature and atmospheric pressure is 787 times less than liquid Argon. Therefore the spacing between Argon atoms in the gas is 787 times larger than in Argon Liquid! Pretty far apart!

Law of Partial Pressures
John Dalton born 1766.

- Defined pressure in a gas mixture:
  $P_{mixture} = P_{gas1} + P_{gas2}$
- Example: pressure of Oxygen in an Argon Shielding Gas Hose = 0
- Therefore if a small hole occurs in the hose the outside pressure for Oxygen being higher will cause it to flow back through the hole.
- You can assume large spaces between gas molecules and the Oxygen molecule flowing in won't even see the Argon coming out!

Module 7

Dalton's Gas Law: John Dalton studied the effect of gases in a mixture. He observed that the Total Pressure of a gas mixture was the sum of the Partial Pressure of each gas.

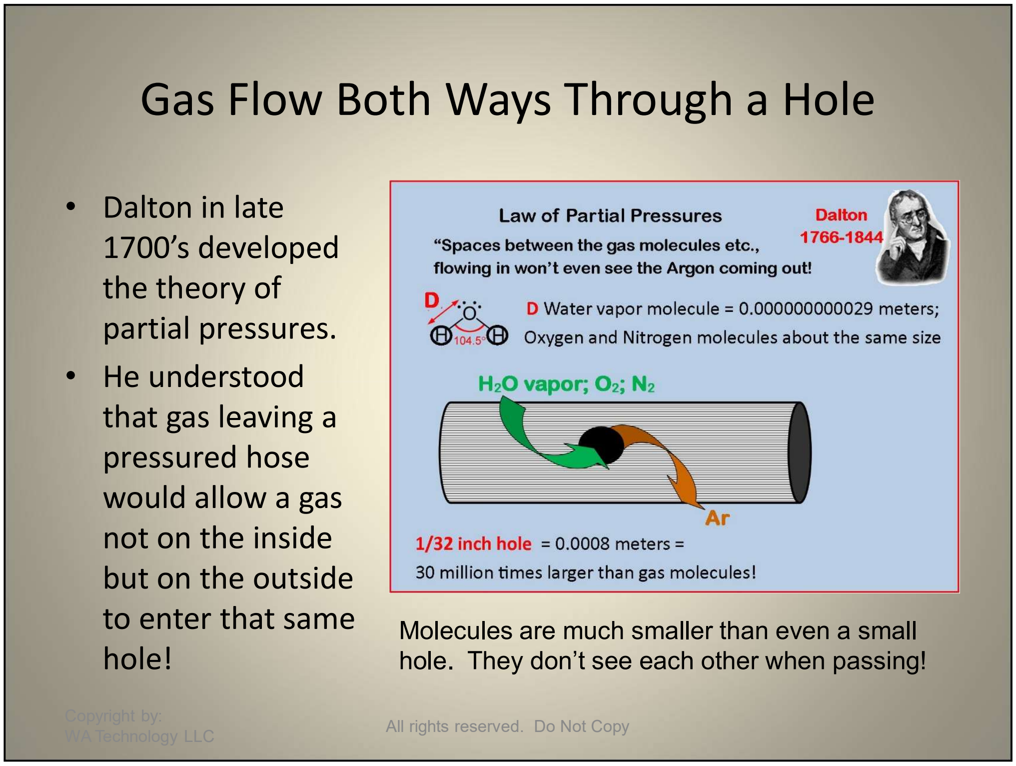
P total = P1 + P2 + P3 + ...Pn

The Partial Pressure is defined as the pressure of a single gas in the mixture as if that gas alone occupied the container. In other words, Dalton maintained that since there was an enormous amount of space between the gas molecules within the mixture that the gas molecules did not have any influence on the motion of other gas molecules, therefore the pressure of a gas sample would be the same whether it was the only gas in the container or if it were among other gases.

Another way to think about Oxygen, Nitrogen or water vapor going back through the hole in our gas delivery hose where an Argon or CO_2 based shielding gas is leaking out is to consider Dalton's statement.

"The gas molecules are spread far apart. The Oxygen, Nitrogen or H_2O vapor will not likely hit an Argon or CO_2 molecule on its journey through the hole! To provide a picture of how far apart say Argon atoms are at atmospheric pressure as they escape from a leak consider: The density of Argon at room temperature and atmospheric pressure is 787 times less than liquid Argon. Therefore the spacing between Argon atoms in the gas is 787 times larger than in Argon Liquid! Pretty far apart!

Considering the diffusion phenomena, it doesn't even care about the Argon or CO_2. However that involves Graham's Diffusion Law (Thomas Graham was born in 1805) which is more than we have time for or you probably have the desire to understand!!

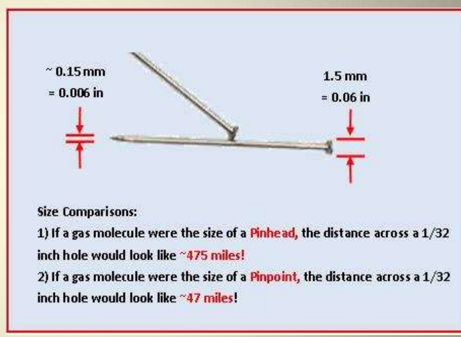


Dalton's Gas Law: The distance between gas molecules is huge! Even in a small hole the Argon gas leaving will not see the Nitrogen, Oxygen and water vapor entering. At first hard to understand how a pressured hose would allow atmospheric gases at 14.7 psi absolute pressure, called psia, can flow to the higher internal pressure. But if considering what Dalton found in the 1700's the pressure of say Nitrogen inside the hose is essentially 0 while outside it is 14.7psia. Then the driving force for Nitrogen is 14.7 psia into a 0 psia environment, initially in the hose. The flow rate will not be as high as Argon leaving that has a driving force of a typical pipeline 50 psi + 14.7 psi or a total of 64.7 psia flowing out to 14.7 psi x 0.09% = 1.3 psi partial pressure outside the hole.

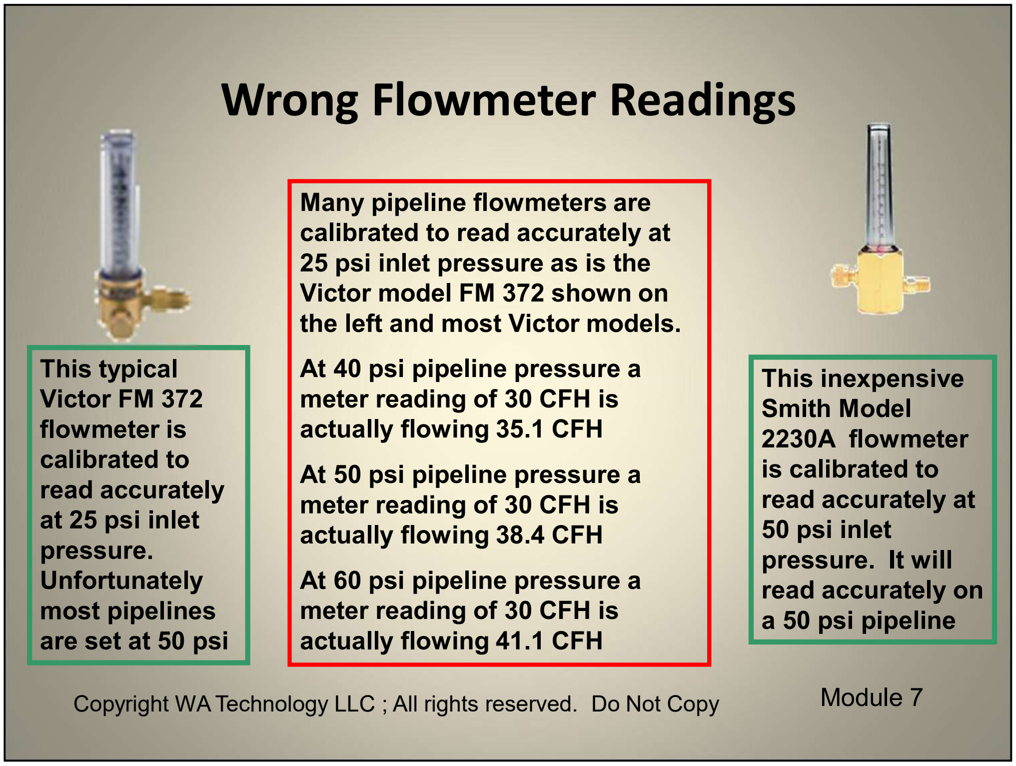
Relative Size of Gas Molecules

The picture left provides some size prospective:

- Using a straight pin size analogy, if a gas molecule were equal to the size of a pinhead - a 1/32 inch hole would be 475 miles across!
- If the size of a pinpoint the hole would look like it was 47 miles across!



Using a straight pin to provide perspective of the size of a molecule relative to a small hole. Note, even a small hole would look to be 475 miles wide if a gas molecule were the size of a pinhead and about 47 miles if the size of a pin point!



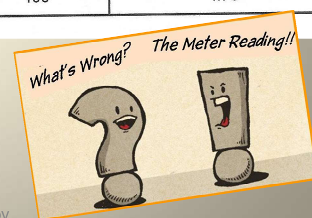
Many shops are using flowmeters on their pipelines. Many flowmeters are calibrated to read accurately at an inlet pressure of 25 psi. When the inlet presume is increased above the 25 psi the actual flow reading will be higher than the reading. For a typical 50 psi pipeline pressure, a reading of 30 CFH will actually be flowing 41.1 CFH! That's 37% higher than what is being read on the flowmeter. Some manufacturers of these meters supply graphs or tables that provide the correction factor that should be employed– use it or purchase one calibrated for 50 psi if that's what your using.

Chart Shows Correction Factor for 25 psi Calibrated Flowmeters (most) on 50 psi (or other pressure) Pipelines

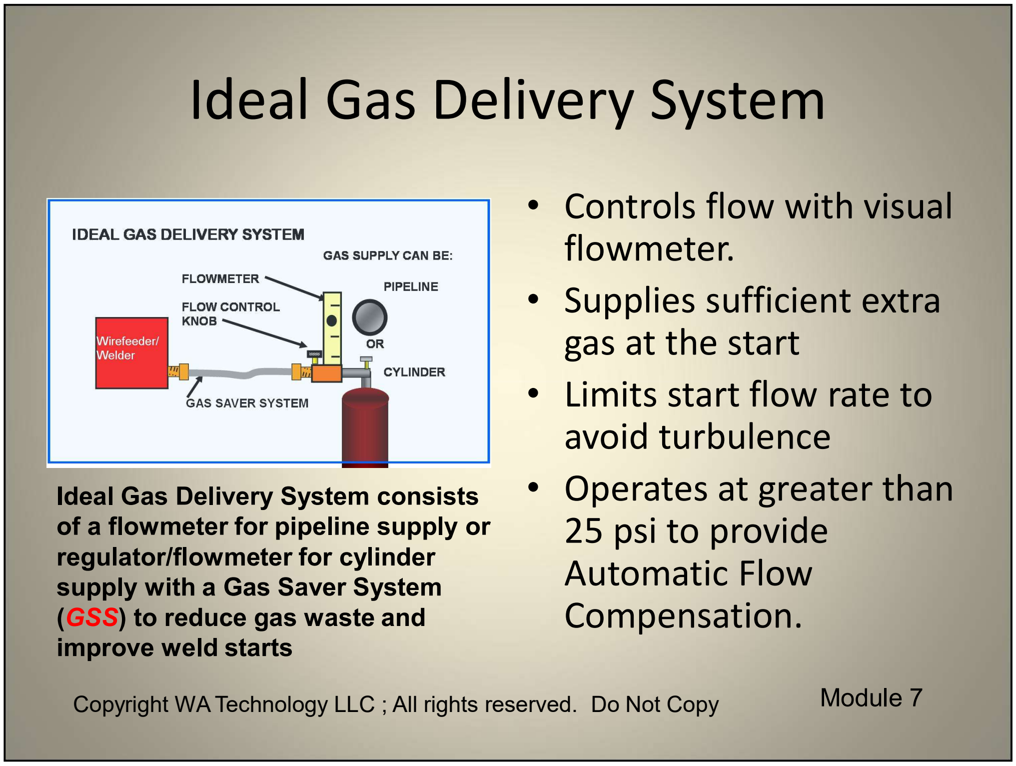
Example: If using a 25 psi calibrated flowmeter (most) on a 50 psi pipeline and reading 35 CFH on the flowmeter - the actual flow is: 35 CFH X 1.28 = 45 CFH.

If on a 80 psi pipeline the actual flow is: 35 CFH X 1.54 = 54 CFH! Big waste of shielding gas!

Inlet Pressure psig	Pressure Correction Factor 25 psig Calibrated Flowmeter
15	0.86
25	—
30	1.06
40	1.17
50	1.28
60	1.37
70	1.46
80	1.54
90	1.62
100	1.70



No need to buy new flowmeters but you must use the correction facture to define the actual flow. In a shop with 150 GSS's they were using 25 psi calibrated flowmeters on a 50 psi pipeline. I just used a black marker and marked a line on their desired flow!



The ideal gas delivery system: 1) Uses a flowmeter so accurate flow rates can be seen. 2) Provides a controlled amount of extra gas to purge the gun nozzle and weld start area of air. 3) Limits weld start gas flow rate to avoid excess turbulence (note we have measured flow rates of 125 to 150 CFH on commercial flowmeters when the flow ball is pinned to the top of the flow tube.) 4) Operates at greater than 25psi before the needle valve to provide Automatic Flow Compensation to maintain flow when the inevitable flow restrictions occur in production.

Orifice Used to Control Flow

- For pipeline supply and Orifice can be used to set gas flow.
- We have a patented system called an OGSS that incorporates an orifice flow control with a GSS and can be connected to the end of ***any length existing*** gas delivery hose.

Email for Details:
Jerry_Uttrachi@NetWelding.com

An orifice can be used at a pipeline gas drop after an OSHA required shut-off valve. The orifice size and pipeline pressure define the flow rate. This flow control approach works well with our GSS.

We also offer a system for very long gas delivery hoses as used in shipyards etc. It utilises an orifice to control flow rate and a GSS to limit peak flow and provide a controled amount of extra gas at the weld start. If interested see web page: http://www.netwelding.com/Orifice_Flow_Control.htm for details.

For many more details about our gas savings products and other welding related information visit our web site, www.NetWelding.com.

We also have a number of YouTube video's that provide a quick summary of some key features.

Thank you.

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