WA Technology
Welding Accessories Technology

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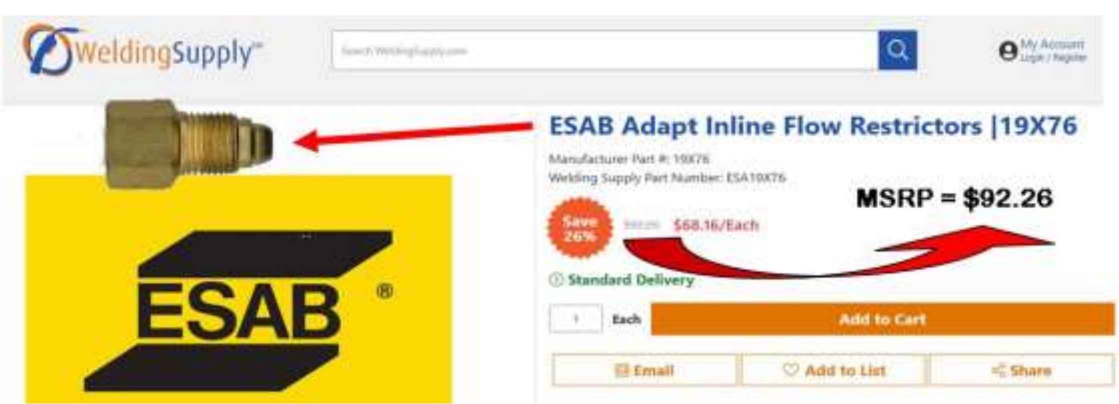
Controlling Peak Shielding Gas Flow at MIG Weld Start

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 was known to pull air into the shielding gas stream. But much higher gas surge flow occurs at weld starts. The high peak flow is caused by excess shielding gas stored whenever welding stops. That gas surge creates excess spatter and possibly internal weld porosity. Peak gas flow surge has been measured at over 200 CFH.

In the 1960's, MIG Welding often used small, 0.023 and 0.030 wires with nozzle sizes of 3/8-inch and 1/2-inch ID. The maximum desired peak flow with those nozzle sizes is 30 and 40 CFH respectively.

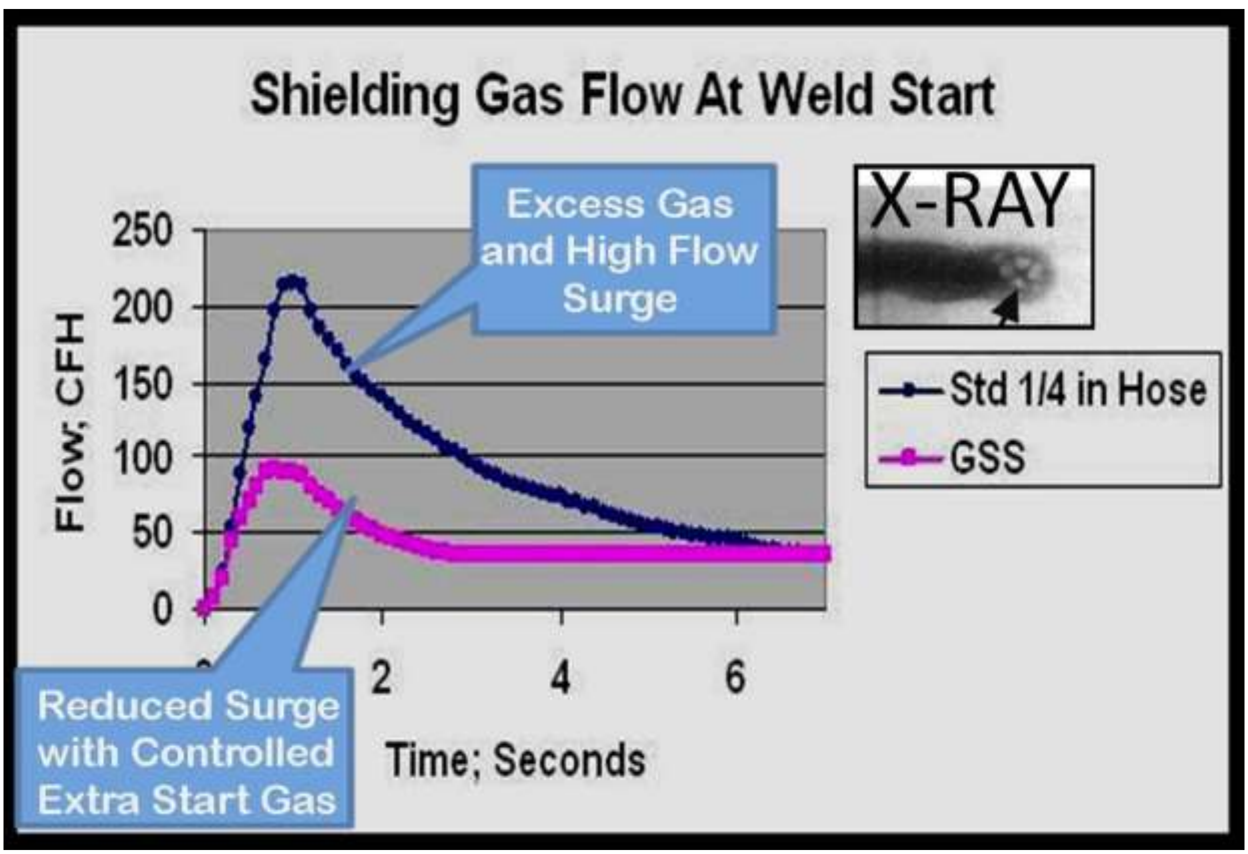
To improve starts, Linde sold a peak flow-limiting restrictor with CGA Inert gas female inlet and male outlet. It was screwed into the MIG wire feeder gas inlet. The restrictor size is designed for small gun nozzle, low flows. The old part number, 19X76, continues to be sold by ESAB who acquired Linde's welding business. Some fabricators still 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 use it to set flow at pipeline drops, but it supplies higher steady state flow than needed, wasting gas. Fabricators, understanding the problems caused by high peak gas flow at weld starts, buy this $92 MSRP 19X76 for the Peak Flow Restrictor Feature. This is a Pic from an Internet supplier *Welding Supply who also shows a discounted price:*



Our ***GSS*** Gas Saver System stores ~80 to 85% less gas when welding stops. The BWR hose fitting for the MIG wire feeder hose end also has a Weld Start Peak Flow Restrictor in the hose barb. It quickly provides sufficient purge gas needed for today's typical Industrial MIG nozzle sizes. It ***DOES NOT*** control the steady state flow. That is set by any quality gas flow control on cylinder or pipeline gas supply. Our ***GSS*** BWOR fitting is at that hose end. The BWR includes: hose Barb, hose Clamp, Nut and Mylar label for that hose end. The BWR restrictor is sized to provide the needed extra shielding gas to purge the MIG gun nozzle and weld start area of moisture laden air. It limits peak flow velocity and turbulence.

The BWR Peak Flow Restrictor is designed to work with MIG nozzle sizes in use today. It is less than half the cost of the ESAB 19X76.

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.



Flow curves show the reason this early user of our patented *GSS*, not only documented a 41% shielding gas saving BUT the welder was very thankful for the improved weld starts. They make high pressure pipe and he was frequently having porosity detected at weld starts by the required Ultrasonic Testing. That required rework. He told me he knew the cause was the high initial gas surge. You can see from the graph the high, peak flow was 225 CFH and excess lasted for about 5 seconds. After welding with the *GSS* for ~6 months, the welder said that his prior frequent UT rejections were eliminated.

Another Customer Testimonial:

Anel Corp is a custom fuel tank fabricator. They reported these results after their test of a *GSS on a MIG robot*: *"Immediately the arc starting problems went away. There have been little to none of the intermittent arc starts caused by the initial gas surge since converting over to the GSS. With our standard setup, approximately 1 out of every 3 arc starts had the "popping" arc starts associated with the gas surge and purge issues."*

They purchased 50 *GSS*'s.

Technical information regarding controlling shielding gas flow at the weld start follows in the attached Appendices:

Appendix A: *High Gas Hose Pressure at Weld Stop Causes Initial Gas Surge*

Appendix B: *Some Extra Gas is Needed at Each Weld Start to Purge Air*

Appendix C: *Any Device Setting Flow at MIG Wire Feeder Causes Problems*

Appendix D: *Low Pressure Regulator at MIG Wire Feeder Causes Problems*

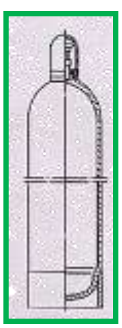
Appendix E: *What Is Choked Flow? Why it is Required*

Appendix A

High Pressure Causes Initial Gas Surge

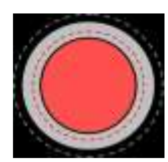
"Choked Flow" is a unique phenomenon employed to maintain preset gas flow when inevitable production flow restrictions. These occur from bends in the shielding gas delivery and MIG gun cable gas hoses. Also when Mig gun nozzle and gas ports are blocked with spatter. In the 1950s, the developers of the MIG welding process knew compensating for restrictions was necessary, see details in Appendix E. Choked Flow requires a minimum of 25 psi above the flow control needle valve or fixed flow control orifice to provide automatic flow compensation, without moving parts. But the required pressure at a MIG wire feeder inlet to achieve 30 to 40 CFH can be as low as 3 psi. The gas delivery hose pressure will reduce to that needed to flow the volume set by the flow control device at gas supply source, through wire feeder, MIG gun cable and nozzle. But when welding stops, gas continues to flow through the flow control device at the gas source. That flow continues to fill the gas delivery hose until the regulator pressure (*or if on pipeline supply, the pipeline pressure*) is reached. Pressure in cylinder gas flow control regulators or pipeline gas supply can be as high as 80 psi. The higher pressure over the typical 3 to 8 psi range needed causes an excess quantity of gas to be stored in the gas delivery hose from gas supply to gas flow control solenoid in wire feeder or MIG Robot. The amount of excess is dependent on the absolute pressure difference and the hose volume. If the absolute pressure increases 5 times, then the stored gas volume increases 5-fold as well.

Consider a typical gas cylinder holding 310 Cubic Feet (CF) of gas, 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) the gas volume will be 2515/14.7 times 1.8 (physical) CF = 310 CF (*that is what you pay for.*)



The shielding gas delivery hose is subjected to the same pressure/volume relationship as the cylinder.

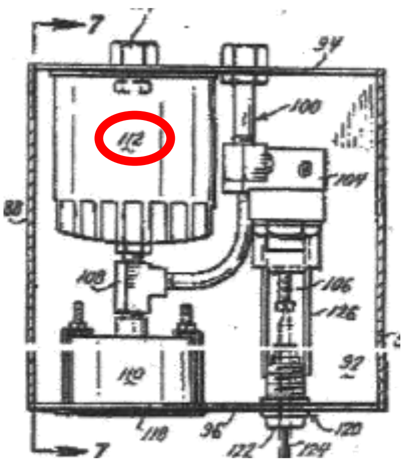
In addition, our tests show a standard 1/4-inch ID gas delivery hose expands ~13% when subjected to the higher pressure. Combined with the increased pressure volume, the amount of excess gas can be more than 6 times the physical hose volume. Every time the MIG gun start trigger is pulled, this excess gas is rapidly expelled out the gun nozzle. Most of the excess is wasted and causes air to be pulled into the arc.



Appendix B

Some Extra Gas is Needed at Each Weld Start

It's important not to have an excessive gas flow rate to avoid turbulence causing moisture laden air mixing with the shielding gas stream. However, some extra gas *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 1982 patent, 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 flow control device that mounted near the wire feeder that could provide little extra purge gas. He added a reservoir (*item 112, red circle, in his patent figure)* to store some initial gas to be expelled at the weld start.



Two Fabricator Examples of Lack of Starting Purge Gas

We observed fabricators where insufficient starting purge gas excess weld start spatter. Two were making Bar Joists where a number of welders stand side by side making short welds.

1St Bar Joist Fabricator Example

Observed the problems associated with lack of purge gas at the weld start in a survey made of a bar joist fabrication shop where needle valve control flowmeters were placed at the gas inlets on 100 MIG wire feeders to eliminate starting gas surge. The flowmeter had a scale calibrated at 50 psi inlet, which was the pressure in their bulk shielding gas pipeline.

The maximum flow scale on the flowmeter was 70 CFH. With that mounting position there was NO extra gas flow at the weld start. Similar to starting in air.

When examining flow rates:

- **About 50% 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!**
- **Our Lab tests of that brand flowmeter showed with the float ball pinned to the top it can be 150 CFH at the MIG gun nozzle.**

From this and other fabricator observations, IMO welders were trying to compensate for the lack of sufficient starting gas purge by setting higher steady state flow rates. That is only a partial help! They were actually causing gas waste and inferior weld starts!

2nd Bar Joist Example

The welding engineer at another Bar Joist Manufacturer with 50 MIG welders wanted to evaluate our *GSS* to see if it might help satisfy some welders wanting more gas flow than the 45 to 50 CFH they were using. They had placed fixed flow orifices at the MIG wire feeder that set flow at 45/50 CFH as measured with a portable flowmeter at the MIG gun nozzle. That was more than sufficient but welders wanted more flow. 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 close to each other. With the fixed orifice at the feeder, there was no 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 try a simulated lower pipeline pressure, and lower steady state flow rate by using a regulator on a cylinder gas supply. Flow was set to 35 CFH and the *GSS* was still quickly supplying a controlled amount of start gas. After testing to assure it worked in all draft conditions (*which it did,*) all 50 welders were equipped with *GSS* systems and flow control placed back at the pipeline drop. They lowered the pipeline pressure to 45 psi from the prior 55 psi.

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!

Appendix C

Any Device Setting Flow at MIG Wire Feeder Causes Problems

Setting flow at a MIG wire feeder does eliminate the initial gas surge giving the "*perception*" it is saving gas. BUT that provides no extra purge gas as Stauffer defined in his patent as needed. To achieve a quality weld start, our Lab tests and fabricator observations also shows the purge gas is needed to quickly displace the moisture laden air in the MIG gun nozzle and weld start area. OR, IT'S LIKE STATING IN AIR! Many of us, as most welders when using cylinder gas supply, have seen what happens starting without shielding gas when we forgot to open the cylinder when starting to MIG weld!

Orifices Placed Directly at Wire Feeder

Simple orifices can be placed at the wire feeder or MIG Robot to set the steady state flow rate. Welders often complain when orifices,

flowmeters or regulators are installed at the wire feeder to set flow! Management frequently believes the welders just don't care about saving gas. Frankly, in the past I might support their assessment! In the last ~15 years, visiting a number of fabricators and running gas saving tests, I now understand why the welders complain! They observe the result of lack of extra gas quickly supplied to purge air from the weld start area. They may not know the technical reason but see the result!

Regulators Placed Directly at The Wire Feeder Gas Inlet.

Some products reduce the "gas blast" but have the same lack of

purge gas as a simple orifice. (Examples are the Victor SLR 100, left and Airgas Model SLRG Surge Limiter right.) These are regulator flow controls. Unlike low pressure devises (the worst described in Appendix D) they use pressures above 25 psi so can automatically maintain the flow setting.

However just like a simple orifice, these devices *DON'T* provide the needed extra gas to purge the weld start area and MIG nozzle. Some are adjustable so welders may increase the steady state flow trying to compensate for the lack of start gas. The weld starts may be somewhat better but cannot match the needed, higher extra gas provided from the gas delivery hose at weld starts. Our *GSS* hose, attached to the wire feeder with its peak flow rate limited by the BWR flow restrictor, supplies that small amount, but needed purge gas.

Appendix D

Test of Low Pressure Regulator Mounted at MIG Wire Feeder

If the pressure above the needle valve or fixed orifice is less than minimum 25 psi, any changes in restriction of gas hose or the small gas passage in the MIG gun cable will result in changes in flow.

That is why all shielding gas *"quality flow control systems"* have used a minimum pressure above 25 psi since the 1950's when MIG was introduced. A few gas apparatus manufacturers who were NOT in the early MIG and TIG system development apparently did not appreciate the need and attempted to utilize low pressure to "solve the gas waste problem." Most have not lasted long in the market since users and welders find the problems they cause.

Low Pressure Device TEST:

The following table provides test results with a **conventional** flow control device (left) that operates at 25 psi and a commercial **low-pressure** Harris Gas Guard 301-RF system (right) subjected to varying restrictions. Both were initially set to flow 31 CFH as noted in **Blue**. The controls were left at the initial settings as if they were padlocked. MIG gun restrictions were then added and removed (*as if the gas ports were alternately clogged and cleaned*) to vary the amount of restrictions. Resulting flow rates, measured at the MIG Gun nozzle exit using a portable flowmeter, are shown in the table below.

Flow Control System Pressure	< Typical **Production Restriction Range in psi** >					
	3 psi	**4 psi**	**5 psi**	**6 psi**	**7 psi**	**8 psi**
Conventional = 25 psi	**31 CFH**	**31 CFH**	**31 CFH**	**31 CFH**	**31 CFH**	**31 CFH**
Harris 301-RF Low Pressure = 9 psi	**37 CFH**	**34 CFH**	**31 CFH**	**27 CFH**	**23 CFH**	**16 CFH**

The **Conventional System** was a standard regulator/flowmeter with an outlet pressure of 25 psi upstream of the flow control needle valve. Note the shielding gas flow remained at the preset, desired level of 31 CFH even when the restrictions in the feeder/gun system ranged as low as 3 psi to as high as 8 psi, the typical range found in production.

The Harris Gas Guard low pressure regulator flow control device tested installs at the wire feeder and is sold to reduce the shielding gas surge at the start and ***"safe gas."*** Note the gas flow (*which, as mentioned above was set at 31 CFH at the nominal 5 psi restriction in the system and then locked in place*) varied from 16 CFH to 37 CFH as restrictions were added and removed from the system. The **flow control settings and regulator pressure** did not change; it remained at 9 psi in this case. **Unfortunately, the flow calibrated pressure gauge included with the Harris model 301 is only reading the 9-psi pressure so it did not change either! It read about 31 CFH for all the tests**! ***This gives the false impression*** that the flows remained constant. Flow can be out of the flow range defined in Welding Procedure Qualifications and not know it! Only a measurement at the gun nozzle reveals the error.

Fabricators Report Problems with The Low-Pressure Device Tested

A number of fabricators have found these Harris Gas Guard devices create problems and have them removed and discarded. The following four fabricators reported these experiences:

Automotive OEM Supplier

A welding engineer in a plant who purchased 32 of the Harris 301-RF low pressure Gas Guard flow control devices, same one we tested, stated:

"After purchasing and using 32 low pressure "so called" gas saving devices 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. He also 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

Harris 301-RF was discovered after extensive testing. This fabricator had two plants making the exact same part. Both used the same MIG solid wire, gas, welding conditions etc. However, one was getting porosity and the other none. The welding engineer gave me a very detailed, 30 variable "Root Cause and Effect Fishbone Analysis" he developed to review because he felt the porosity was caused by a shielding gas issue. Turned out it was! The key problem was the plant having porosity was using low-pressure regulator, Harris Gas Guard 301's mounted at the feeder! They were removed and the issue resolved.

Bar Joist Manufacturer Discards 50 Low Pressure "Gas Guards"

A Bar Joist manufacturer purchased low-pressure Harris Gas

Guards. They found welders were continually setting excessive flow rates. The welding engineer said they were removed because of poor performance. When touring the plant, one Model Harris 301-RF was still installed, which surprised the welding engineer since they were all to be discarded. It was set at 80 CFH, about the highest possible setting! Appears the welder was trying to compensate for the lack of extra starting gas.

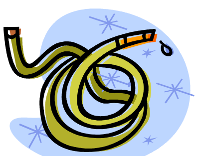
Catalytic Converter Production

A manufacturer of catalytic converters had 70 new robotic MIG welding cells installed. The systems integrator installed a model of low-pressure Harris Gas Guard flow control regulators at each pipeline drop. The welding engineer quickly observed flow variations were occurring when measured at the gun nozzle on the MIG welding robots. He called Harris who could not fix the problem and blamed his robot welders! After seeing information on our website, he called and said although they blamed my robot welders, I had two Miller semiautomatic welders with the same flow variations! I recommended he replace the Harris low pressure regulators with conventional flowmeters mounted at the pipeline, flows remained at preset levels during production. That solved all shielding gas flow problems! To save gas waste our ***GSS*** could be installed after those quality flow control devices!

Appendix E

What Is Choked Flow and Why Is It Important?

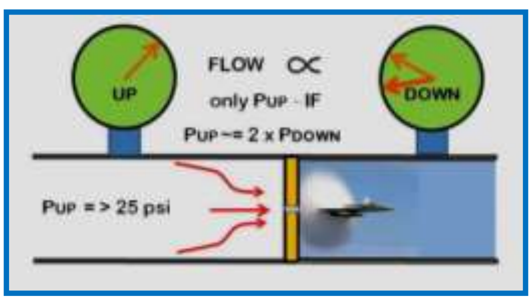
AUTOMATIC COMPENSATION MANAGES FLOW RESTRICTIONS



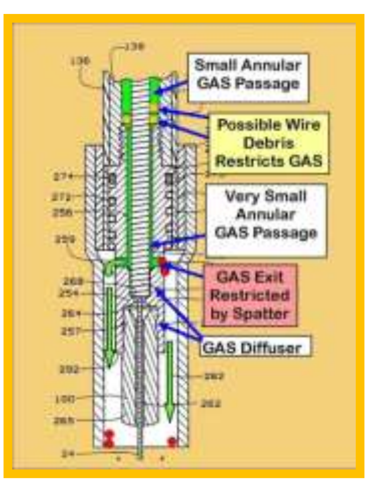
Shielding gas flow rate ***will not change*** with flow restriction changes ***IF*** the pressure upstream of the flow controlling device, beit needle valve or orifice, is more than 2.1 times the downstream pressure.

It's interesting that Sir Isaac Newton in 1700rds (*the dude with the falling apple!)* would understand "choked flow" since he measured the speed of sound and investigated the speed of light. He helped define ***"Why you see Lightening before you hear Thunder!"*** The key is the pressure wave that causes sound to reach your ear can only travel at the speed of sound (770 mph.)

"Choked Flow" provides a simple flow rate control system that compensates for the shielding gas flow restrictions. Restrictions occur, mainly in the MIG gun and cable as welding progresses. It does that with NO MOVING parts. If the pressure upstream of the flow control needle valve or orifice in a cylinder regulator/flowgauge is above 2.1 times the downstream pressure than the flow is determined NOT by the pressure differential BUT only the upstream pressure. Then flow restrictions can vary and flow remains fixed.



(*Note, pressures are all measured in absolute pressure, i.e. gauge reading + 14.7 psi, shown as psia*). This phenomenon is caused by gas flow not being able to exceed the speed of sound in the small orifice or needle valve passage. ***The same reason you see lighting before you hear thunder!***



Automatic flow compensation is very important since as the welder moves, the shielding gas delivery hose may become twisted, contain bends, or even be partially closed, creating a pressure drop. Also, the gas passage in the MIG gun and cable doubles as the hose holding the wire spiral liner and will partially clog with debris. Spatter builds in the MIG gun gas diffuser and nozzle; increasing pressure drop. However, as long as the restrictions do not exceed essentially half the absolute pressure above the flow control, ***no flow change will occur***.

Any pressure drops are **compensated for automatically** since the regulator or pipeline pressure is sufficiently high. With those pressures the gas velocity in the orifice or small gas passage in the needle valve will reach the speed of sound and cannot flow faster!

What Minimum Pressure is Needed to Achieve Automatic Flow Compensation?

The bottom line is 25 psi (40 psia) is needed; here's why. The pressure needed to flow gas at normal welding rates in a MIG system though the solenoid, wire feeder gas fittings, gun gas line, gas diffuser and out the torch nozzle can vary from as low as 3 psi to as high as 8 psi. For the typical 5 psi average, to assure automatic compensation for restrictions that occur in production, the pressure upstream of the flow control device should be twice 5 psi stated in absolute pressure (*usually labeled psia.*) Or the absolute pressure needed at the feeder, = 5 psi + 14.7 psi atmospheric pressure = **19.7 psia**. The pressure upstream of the flow control device must be 2 X 19.7 psia = **39.4 psia**. To put it back to gauge pressure, which is usually displayed, 39.4 psia - 14.7 psi = **24.7 psi. Therefore 25 psi (*as measured on a gauge*) is the minimum pressure that should be available.** It is no coincidence that this pressure (*or higher*) is designed into quality shielding gas flow control flowmeters, regulator/flowmeters or regulator/flowgauge systems! Also, gas pipeline pressures are usually about 50 psi, well above the minimum 25 psi needed. It was designed that way for MIG and TIG about the time these processes were invented by engineers who understood the inevitable flow restrictions found in use!

These companies also designed, developed, and marketed MIG welding systems. They were NOT just in the business of making gas apparatus. Those who introduced low pressure systems perhaps may not have understood the MIG flow restriction issues!

If the pressures used are lower than this minimum 25 psi, any changes in restriction will result in changes in flow rate. If this occurs on a device having a flow calibrated pressure gauge to display flow rate (as the Harris 301-RF,) the welder will not even know the flow changed. Since the flow calibrated pressure gauge is reading upstream pressure it would still read the same and not the changed flow rate!

That is why all shielding gas *"quality flow control systems"* have used minimum pressures above 25 psi since the 1950's when MIG (and TIG) were introduced. A few gas apparatus manufacturers who were NOT in the MIG and TIG system design business apparently did not appreciate the need and attempted to utilize low pressure to "solve the gas waste problem." Most have not lasted long in the market since users and welders find the problems they cause.