Introduction.

The Industrial gas regulator has been around since the turn of the century. During that time, its initial design has changed very little.

This design has served the industries of the past so well, that it tended to be overlooked by the consumer, "just throw it on and forget it", was the general impression. However with demands for increased performance, advances in welding processes and with the move towards improved safety, the traditional designs are now falling short of the industries requirements.

The lack of awareness by consumers of what is required of a regulator, has initiated the manufacturers to strive to reduce the costs of these items, to become competitive. The development of the compact regulator and the arrival of Asian product have made the industrial gas regulator, a throw away item.

When we examine current welding procedures, for example MIG welding, we know that extensive research and development has gone into and is still going into the gases, the machines, the consumables, the torches and even the gas cylinders (as the manufacturers strive to increase cylinder contents). The results are plain to see, however the gas regulator, which is the heart of the gas supply system, has been overlooked.

In the majority of cases, gas is the most expensive consumable of the welding process. Many thousands of dollars worth of gas is controlled by the regulator during its working life so it makes sense to control it in the safest, most economic and efficient way.

The Gasflow Technology engineering team have designed the PMC 200/350 industrial gas regulator series. These Regulators not only met the industry demands but caters for future requirements as gas pressures increase to 5000psi.The Gasflow series of gas regulators are setting new trends in safety and reliability. They will provide fine precise control, ideally suited for flow and low pressure applications, while still being able to deliver large volumes of gas at high pressures for heavy heating and cutting operations.

A pressure reducing regulator is a device which reduces a high source pressure, such as 20,000 KPa, to a lower working pressure, such as 250 KPa, suitable for user application.

The regulator will attempt to maintain the outlet pressure within required limits as other conditions vary. Source pressure and media flow (gas or liquid) are examples of some of these varying conditions. How successful the regulator will be at its function is determined by the design of its key components.

Most regulators have three main areas which govern the accuracy, stability, volume and pressure of a delivered media, these being;

The load mechanism provides the means by which the operator is able to set the force that determines the outlet pressure.

The sensing element senses the changes in the outlet pressure. This sensing element is also the link between the loading element and the control element.

The control element reduces the inlet pressure to a lower working pressure and maintains it by increasing or decreasing the inlet orifice size.

1. LOADING.

This is the first basic part of the regulator mechanism; it is the means that determines the desired outlet pressure. The load provides the force that is transmitted through the sensing device to the control facility, in turn giving the desired outlet pressure.

The spring is the most popular and common loading device in industrial gas regulators, due to its dependability and low cost. The load is determined by the amount of pressure placed on the spring by the operator. The operator simply turns the adjusting screw to the desired pressure, which in turn compresses the load spring, placing more pressure on the sensing device.

There are many advantages in using springs. Springs are simple, therefore little can go wrong with them, and they take up little space enabling the regulator to be compact and light. Springs can be purchased from many sources, ensuring competitive pricing.

The disadvantage of springs is that the spring forces vary with compression, this gives inconsistency in load. In addition springs are susceptible to the effects of shock, vibration, temperature and corrosion.

2. SENSING

The diaphragm is the most common of the sensing systems. They are usually manufactured from Neoprene/rubber. The biggest advantage with the rubber type compounds in the manufacture of diaphragms, is that they are inexpensive to manufacture and readily available from a wide range of sources. Rubber is relatively low in strength, which means that it is susceptible to failure; for example opening a full cylinder with full adjustment on the spring will often damage a rubber compound diaphragm. Due to the low strength of this material it has to be supported by a metal disc. This reduces the working area of the diaphragm, which in turn causes wear in that area and ultimately leads to failure. With rubber type diaphragms the choice of the correct compound for the appropriate gas is critical as a mistake or mix-up can not only lead to failure, but can jeopardise safety. Stainless Steel has been used in the past for diaphragms and has led to increased acceptance of the diaphragm in many applications. However due to increased production costs, they have mainly been restricted to the speciality regulators. Stainless steel has relatively high strength; therefore it is far less prone to rupture by abuse or inexperienced operators. The high strength also means that no disc is required for support, allowing a far larger surface area to be utilised, giving greater sensitivity, movement and control. As well as its high strength advantages, stainless steel has excellent resistance to corrosion. This has advantages in corrosive environments and also ensures that one diaphragm is suitable for most gases, ensuring high safety and compatibility of spares.

The disadvantages of stainless steel diaphragms, is that they have a tendency to pivot at the point of anchor, this eventually leads to metal fatigue and failure. To overcome this problem, the PMC 200/350 series regulators uses a combination of a diaphragm and a bellows, this is called a convoluted diaphragm. Unlike the flat diaphragms, this device has a series of convolutes or corrugations in it. The advantage of this construction is that it increases the surface area, allowing for greater sensitivity and movement and distributes the stress evenly throughout the diaphragm, considerably reducing metal fatigue. Therefore we have combined the benefits of bellows and diaphragm type sensing elements to produce a cost effective result.

3. CONTROL.

Control is achieved by the use of a valve which opens and closes it, to give you more or less flow. There are two main types of valve designs common to industrial gas regulators, the flat seat design and the tapered seat design.

The most common style of valve system used is the flat seat design. The advantage of a flat seat is that it is inexpensive to manufacture and simple to assemble. It has been generally accepted in the welding industry as the standard. Although functional and "has done the job" over the years, there are three main disadvantages with this design;

Turbulence.

Turbulence results in a regulators inability to deliver large volumes of gas, especially over long distances. It creates pressure drops and loss of velocity, increases oxygen consumption in cutting, and causes premature seat wear. The flat seat design creates considerable turbulence.

Low pressure control.

The flat seat requires a large initial force to lift the valve off the seat, limiting low pressure control. This is similar to someone trying to force a door open when it is jammed and suddenly it opens, you have very little control as to how far it will open. A further limiting factor in low pressure control is that a small movement of the valve from the seat exposes a large surface area, allowing a large quantity through the valve. Less than 15 years ago, poor low pressure control did not pose any problems as most work was done in the mid range. However with modern Mig and Tig applications, poor low pressure control is one of the main reasons for excess gas consumption.

Flow applications.

To ensure constant flows at low pressure a regulator has to have a precise control element such as a tapered seat. To overcome this, manufacturers who use a flat seat design in their product construction, introduce a restriction somewhere downstream from the valve/seat assembly, normally a small hole from 0.7mm to 1.2mm diameter. This creates a back pressure, raising the working pressure of the regulator to the mid range where it is effective and can ensure constant and reliable flows. This would be satisfactory if all Mig and Tig applications were uninterrupted, however most are stop-start and it is in this stop-start function that excessive waste of gas can occur. Pressure in the line from the regulator, to the Valve on the Tig torch or the solenoid valve on the Mig machine, increases to the working pressure of the regulator (in some cases as much as 300KPa or 45psi). When the torch is operated again the pressure build up creates a surge of gas that not only is wasted, but can also cause the following problems;

Cold starts in Mig applications, especially aluminium.

Turbulence, which reduces the purity of the gas by sucking in ambient gases, which then contaminate the welding process.

Instability of Arc.

The high pressure can also cause premature solenoid failure and inconsistency of the gas shield supply.

The Tapered valve overcomes all the problems associated with the flat seat design. It requires very little force to initiate movement and at the same time a small amount of movement of the valve exposes a small service area, this in turn only allows a small amount of gas to flow through the valve. This valve has excellent low pressure control. The tapered valve design also has excellent turbulence characteristics as it allows the gas to flow smoothly. However this type of design is considerably more expensive to manufacture and assemble and is normally used in instrumentation and other "high tech." applications. Another disadvantage with this type of design is the relatively low flow rates generated at the top end of the flow range. This is overcome by selecting a regulator for specific working ranges; however this is not always a practical option. To overcome the disadvantages of both the above mentioned valve systems, the PMC 200/350 series of regulators uses a different system altogether.

The PMC spherical system combines all of the advantages of the tapered system without having any of the disadvantages. Similar to the tapered design system, it requires very little force to initiate movement, and a small movement of the valve exposes a small surface area. This system creates excellent low pressure characteristics, without losing the top range flow deliveries. The spherical surface ensures very smooth gas flows with very little turbulence. These smooth flows eliminate the erosion and seat wear and most of the problems encountered by operators. It also enables higher delivery volumes of gas with the single valve then is commonly available in other valve designs.

a) LINE PRESSURE SURGE CONTROL.

This demonstration simulates a welding torch being turned of and on, and compares the relative line pressures between the regulators, and highlights the low pressure control of our multistage regulators.

First of all go up to a competitor's regulator on a cylinder, turn off the gas and back the regulator control knob off.

Disconnect the hose currently on the regulator and connect the tester to the outlet nipple of the regulator.

Turn the gas on and wind the regulator control knob clockwise until the tester flow meter reads 10 lpm, shut the valve on the tester and note the pressure reading on the gauge. Point out to the client that this high shut off pressure is in fact the working pressure of the regulator and this is built up and released every time you start-stop a weld. It is this pressure that creates the associated problems. (note. Some regulators run at very high pressures, so be aware of them exceeding the maximum pressure of the gauge on the tester.)

When this has been completed, turn the gas off, remove the regulator and replace with the PMC 350 series regulator. Repeat steps ii and iii and point out to the client the differences in line pressure, note that even with the low pressure that the PMC 350 series regulator is still maintaining accurate and steady gas flows.

b) BOTTLE PRESSURE DECAY ELIMINATION.

As a gas cylinder is emptied, regulators produce a symptom called bottle pressure decay, the effect being that as the cylinder pressure drops the regulator outlet pressure increases which in turn causes excessive gas to be used. To demonstrate this, proceed as follows.

As in the line pressure surge control test connect the tester to the outlet nipple of the competitors regulator which will be mounted on a gas cylinder.

Turn the cylinder on. (The higher the cylinder pressure the more effective this test becomes) and adjust the regulator to read 5 lpm on the testers flowmeter.

Slowly turn the cylinder valve off to simulate the gas being used and the cylinder emptying. Point out to the client the increase in flow shown by the ball rising in the flow tube. It is this increase in flow (up to 200%) that is gas wasted.

When this test has been completed, turn the gas cylinder valve off, remove the regulator and replace with the PMC 350 series regulator.

Repeat steps ii and iii and note the steady accurate flows produced by a multistage regulator. The bottle pressure decay syndrome has been eliminated.

These tests show the effect of regulating high pressure cylinder gases twice. This principal is the important concept to install in your sales team, as it can be applied in any situation.

As the main reason for using bottled gas in a welding situation is to produce an inert gas shield around the weld pool to prevent oxidation, which will occur if the molten pool has contact with the atmosphere. Our aim is to produce this shield using the least amount of gas possible and we need to understand that the low pressures our regulators produce can in some cases cause weld problems, if the wrong type of regulation system is given to a customer. The three main scenarios are explained as follows;

Long distances between the regulator outlet and the welding torch or solenoid. i.e. Separate wire feed units, Push pull guns, and reticulated workshops. It is important that distance between the regulator and the torch is kept to a minimum (6 to 8 meters is alright). If the distance is longer than this we recommend "splitting" the regulator in two. To achieve this we have developed a series of Separate wire feed kits or we can supply individual reticulation regulators. The important principal to maintain is to insure that the gas is regulated at least twice. The pressure between the two regulating stages is not important but we find that 500 KPa is the ultimate pressure to re-regulate. Flow meters do not regulate they only provide a flow restriction. If a reticulation system has one regulator at the cylinder bank and flow meters at each station, there will also be a need for an auxiliary regulator as close as possible to the welding torch or mounted just before the gas solenoid.

Windy conditions, i.e. site welding or large workshops with big open doors can often experience porosity caused by the gas shield being blown away. To prevent this, obviously the first thing to do is to provide a barrier around the work piece, or even by closing the doors. If this is not practical then you may need to increase the working pressure of the regulator which will in turn increase the flow of gas to the weld pool.

PMC multistage regulators work on low pressure so make sure any physical restriction is eliminated, i.e. small holes in the solenoids, damaged liners, O-rings etc. This is easily detected by setting your new PMC regulator at say 15 lpm without anything attached to the outlet (flowing to the atmosphere) then fitting your machine gas line to the regulator outlet, and without adjusting the regulator controls operate the welding machine. If the flow drops below 5 lpm then you need to check for a restriction. Any drilled holes in the gas solenoid should be a minimum of 1.9 mm diameter.

The secret is to make sure that any high pressure gas cylinder (200 Bar or more) has at least two regulation points before the welding machines gas solenoid or valve. Whether this is a compact single unit as in our 350 series or in two or more separate units as in a reticulation system or in a kit form, is immaterial as long as the system decided on suits the clients work conditions. Remember we will supply or design a multistage system for any application.

Introducing a Gas Control System for Bulk Supply Systems

To introduce an efficient Control System into factories that already have a purpose built gas supply either in the form of a bulk liquid or palletised cylinders with a common manifold, is an area we have enjoyed developing a range a specific products. We must always remember the three elements which govern the accuracy, stability, volume and pressure of the delivered gas to the weld pool, these being;

1) The load mechanism provides the means by which the operator is able to set the force that determines the outlet pressure.

2) The sensing element senses the changes in the outlet pressure. This sensing element is also the link between the loading element and the control element.

3) The control element reduces the inlet pressure to a lower working pressure and maintains it by increasing or decreasing the inlet orifice size.

The interesting thing about adding to a system that is already in place is that, these elements have been addressed to some degree, so we need to assess the supply system and then create a strategy to improve the Gas Control to an even higher level of efficiency. This is generally not a complicated procedure. Any bulk supply will be supplying what we will call a 'Ring Main' (RM) with a regulated pressure, anywhere between 40 psi and 120 psi, this will depend on;

a) Type of supply. Bulk Liquid or Cylinder Packs.
b) Number of welding machines to feed
c) The floor area of factory it is feeding
d) The installer

The RM will then generally ring the area to be supplied with droppers coming down to supply each individual welding bay or machine or even a bank of machines. We have seen RM supplying only four machines but more commonly twenty and up. At the end of the droppers, will be an isolation valve and some form of control. Some would use a flowmeter and others a regulator.
So we need to establish;

1) Ring Main pressure. This can be often read off the regulator on the bulk system. If this is not possible then you can use the tester to check the line pressure.
2) The control type at the end of the dropper.

Once these points are established then we can create the strategy to give your client the advantages of a complete Gas Control System. So going back to our main points and what we have done with our Compipe series of gas controllers, to provide the strategy needed;

1) Loading.

This is the first basic part of any regulator mechanism; it is the means that determines the desired outlet pressure. The load provides the force that is transmitted through the sensing device to the control facility, in turn giving the desired outlet pressure. The Compipe series uses a specifically loaded spring designed to load a control element sealing between 5psi and 200psi, and sense the movement of a 1 ¾" dia. Diaphragm.

2) Sensing.

We have opted to use a reinforced rubber product to manufacture the diaphragm for the Compipe series. The increased sensitivity of this product makes this a good option. The down side of using a rubber compound is its relative low strength when compared to Stainless Steel, but we have designed the Compipe series to shut down if the supply pressure exceeds 400 psi, which is well within the pressure rating of the diaphragm. This diaphragm will sense and react to pressure changes as low as 0.25 psi.

3) Control.

Control is achieved by the use of a valve which opens and closes, to give you more or less flow. This is the real secret of the Compipe series because by combining the valve design and the loading and sensing elements we have achieved what has proved to be difficult to do by traditional means that is to provide consistently low pressure, low turbulence, and consistent flow control. The Compipe series use a spherical valve seating on a pre-tensioned high density seat which is especially machined to provide point contact only. As the seat opens this is carefully monitored by the seat shape to expose flow area exponentially. This valve design provides smooth gas paths which reduce turbulence, especially noticeable in Aluminium or Galvanised welding situations. The seat has a very low coefficient of friction which enables it to reseat at less than 2% of flow pressure.

4) Installation.

We have added another element to the factors behind successful Gas Control, and this is by no means something that should be taken lightly. **INSTALLATION.** It is very important that we understand what we are trying to achieve when it comes to controlling the gas shield to a weld pool.

We need an inert gas to protect the molten weld pool from contamination from the atmosphere. This shield needs to be adequate to do its job but not to the point that it can create other problems. The shield needs to be consistent in flow; if a flow is inconsistent operators tend to increase the flow to cover all situations. And we don't want surges of pressure; either at the start of a weld or during a welding pass.

So we need to provide the shield gas at the correct flow at the lowest possible pressure. To achieve this you need to regulate at least twice and the last regulation point as close as possible to the gas solenoid as possible. The Compipe series comes complete with a mounting kit and either adjustable, Lockable or preset models, so you can mount just before the solenoid. Remember our Compipe series will give you 15CFH of gas at a regulated pressure of less than 3psi. If for safety reasons you cannot mount this close to the gas solenoid then the hose length should not exceed nine feet and the internal diameter of the hose should not exceed 7/32". Any hose or pipe downstream from the last regulation point should be viewed as a storage reservoir which empty's out every time you open the gas solenoid and then fills up again when you close it.

Correct gas control will result in;

1) Lower gas flows needed
2) Lower amperes needed
3) Less clean-up time
4) Faster response times
5) Longer lasting solenoids
6) And substantial Gas Savings

This dialogue is by no means meant to express the whole idea behind gas control but only to outline the basic principals that we need to understand to begin this pathway to total efficiency