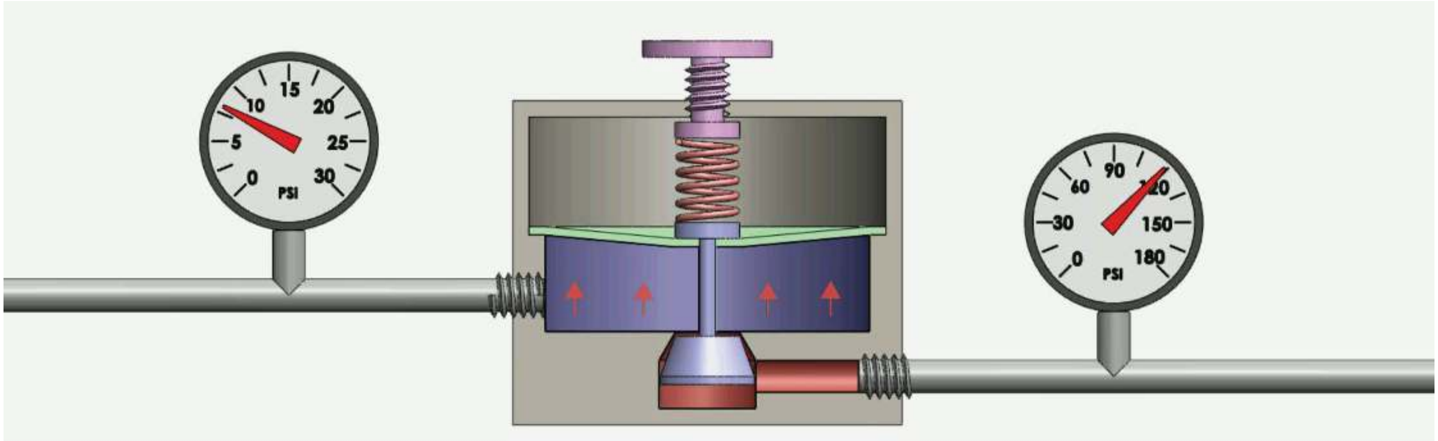
PRESSURE REGULATORS - DESIGN SELECTION IS KEY

CHOOSING THE BEST PRESSURE REGULATOR for an application can become a daunting task. There are many different options and design styles available, and each has its own set of strengths and weaknesses. So how does one decide which one to use? Before specifying a regulator, it is important to consider the following parameters:

Selection Parameters Include:
Operating Pressures
Flow Requirements
Material of Construction and Compatibility
Temperature Compatibility
Other Considerations



OPERATING PRESSURES

A pressure regulator is designed to reduce fluid pressure coming in from a high pressure source, such as a compressor or gas cylinder, down to the required delivery pressure. Each pressure regulator will have a specification for the maximum allowable inlet pressure. Over pressure can potentially lead to leakage or cause damage to internal components within the regulator, so it is important to select one with ample pressure capacity for the application. If a tank of compressed gas is used as the source, one should keep in mind that the pressure within the tank may increase significantly at elevated temperatures

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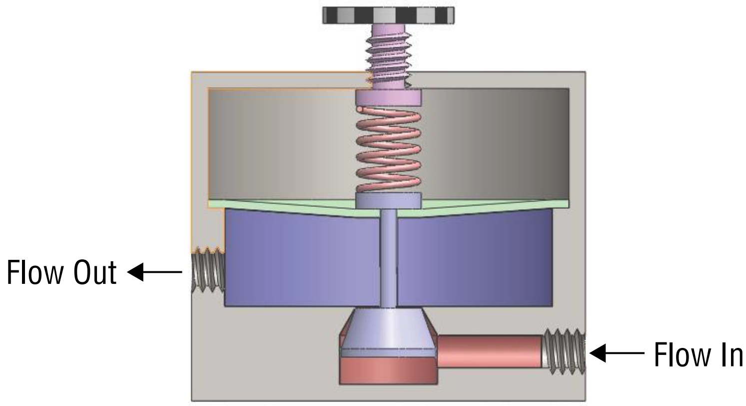
SINGLE STAGE PRESSURE REGULATOR



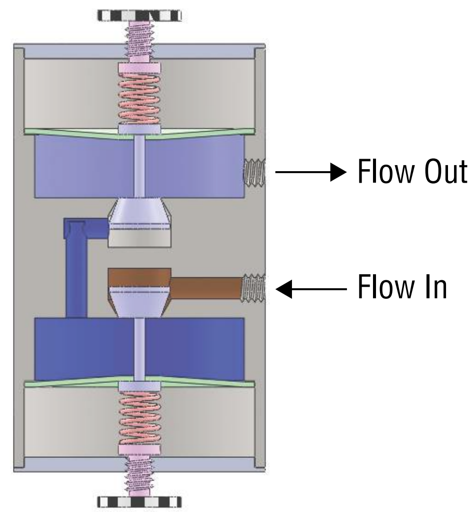
SINGLE-STAGE REGULATOR

Single stage regulators are a good choice for applications where the supply pressure will be relatively consistent over time, such as when the source is coming from a compressor. Often single stage pressure regulators are incorporated into automated machinery, leak test equipment, machine tools, test stands, and linear actuators, to name a few. With most single stage regulators, a large fluctuation in supply pressure will alter the force balance within the regulator, resulting in a small change in the outlet pressure set point.

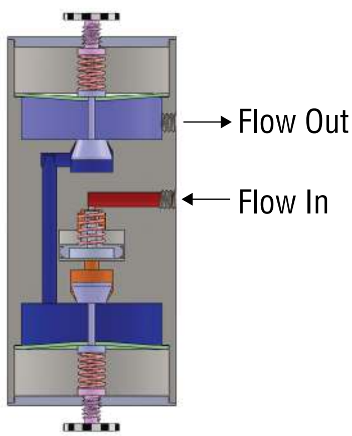
TWO-STAGE (DUAL-STAGE) REGULATOR

In cases where the supply pressure will be fluctuating a great deal or decaying over time, a two-stage, or dual stage, design may be better suited for the application. A two-stage regulator essentially incorporates two pressure regulators in series, allowing the regulator to reduce the supply pressure down over two discreet steps. In a two stage design, the droop characteristic of each stage is canceled out. This results in a more stable outlet pressure from the second stage, even with significant changes in the inlet pressure or flow.

TWO-STAGE PRESSURE REGULATOR



THREE-STAGE PRESSURE REGULATOR



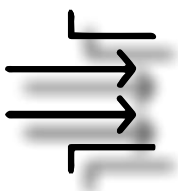
THREE-STAGE REGULATOR

Regulators with three or more stages are also available. These can typically handle significantly higher maximum supply pressures. They are a good fit for applications where the end user wants to reduce high pressure gas coming from a gas cartridge or storage cylinder to a much lower pressure with a single device. Some examples include: portable analytical instruments, hydrogen fuel cells, UAVs, and medical devices

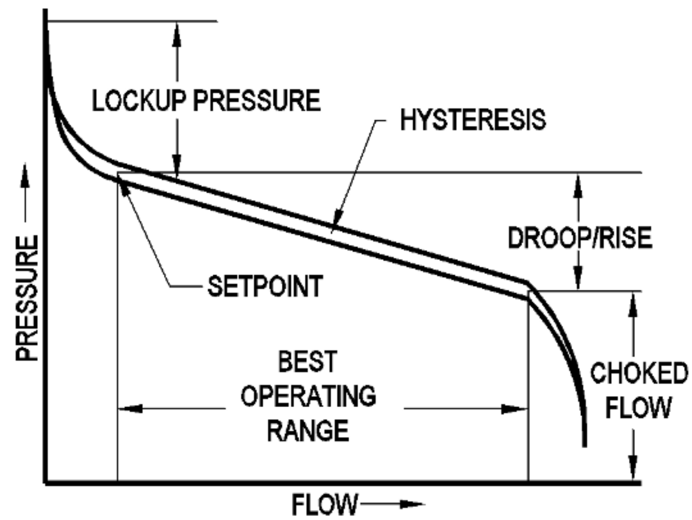
Each regulator is also designed for a specific outlet pressure or range of outlet pressures, if the regulator is adjustable. Most adjustable regulators will work best in the middle of their intended operating range. Accuracy of the outlet pressure is typically a function of the size and type of sensing area used within the regulator. Piston style regulators are fairly robust, and are typically capable of regulating relatively high outlet pressures; however the friction forces between the piston seal and inner body of the regulator will result in some hysteresis in the outlet pressure during operation. Some regulators contain an elastomeric diaphragm sensing element instead of a piston. These are essentially frictionless designs, which allow for a more stable outlet pressure over time, however they are more delicate than a metallic piston and are typically better suited for lower outlet pressure settings.

FLOW REQUIREMENTS

The range of flow rates expected during operation is another important consideration, as the pressure downstream of the regulator is also a function of flow. As flow rates increase, the outlet pressure will decrease, and vice versa. Each regulator has a unique flow curve with three distinct regions.



If a regulator does not have sufficient flow capacity for the application, the valve element will spend most of its time in the wide open position trying to keep up with demand. In this range the regulator serves as a choke point, and is not able to perform optimally.



DIRECT ACTING
PRESSURE REGULATOR
OPERATING MAP

As flow rates approach zero another phenomenon will occur. The pressure downstream of the regulator will begin to increase more sharply. This is because a certain amount of pressure is required over and above the set point in order to overcome internal forces within the regulator and close the regulating valve completely. This is known as lock-up pressure. With applications involving very low fluid flow rates, very small changes in flow can result in large fluctuations in the outlet set point if the regulator's lock-up pressure requirement is high.

Typically the middle section of the regulator's flow curve, between the choked flow and lock-up pressure regions, will be much more linear and level. This is the ideal operating flow range for the regulator under the given set of inlet/outlet conditions.

In the event of an overpressure downstream, a non-relieving regulator would remain in the closed position until the excess pressure downstream is consumed. If the downstream line will be dead ended (no flow) or have very low flows, a self-relieving style regulator may be of interest. A relieving regulator allows excess pressure in the downstream line to be vented quickly, even when there is no flow. Typically the excess pressure is exhausted to atmosphere through the atmospheric reference port on the regulator. These styles may not be a good fit if the media passing through the regulator is a liquid or hazardous, flammable, or expensive gas. Some relieving regulators have a threaded exhaust port. This allows the user to connect a tubing line, and pipe the exhaust to a safer area. Exhausted fluids should always be vented appropriately, and in accordance with all safety regulations.

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MATERIAL OF CONSTRUCTION AND COMPATIBILITY

A wide range of materials are available to handle various fluids and operating environments. Common regulator component materials include brass, plastic, aluminum, and various grades of stainless steel. Springs used inside the regulator are typically made of music wire (carbon steel) or stainless steel.

Before selecting a regulator material, chemical compatibility between the fluid that will be passing through the regulator and the wetted materials within it must be considered. External environmental conditions should also be considered. For example, if the pressure regulator will be used on a ship at sea, then salt in the water and air may corrode the regulator if the proper materials are not selected.

Even if a media is not particularly corrosive, it may still require special consideration. High pressure compressed CO_2 for example, requires careful selection of seal materials, due to the possibility of explosive decompression and evaporative cooling as the media transitions from liquid to gas. Trace oils within gas cylinders or compressors may also become miscible with liquid CO_2. These oils can then be deposited within the regulator when the CO_2 evaporates. Seal compatibility with these oils must also be considered when selecting a regulator. Applications involving pure oxygen or breathing gas service require special attention to the cleanliness of the products selected, as well as a review of the lubricants/ greases used in the assembly. Special lubricants may be required inside the regulator in order to reduce flammability and outgassing potential. When in doubt, it is always best to contact the manufacturer and discuss compatibility concerns.

If the fluid coming into the regulator could contain debris, it is good practice to install a filter to protect the regulator. Some regulators come with integrated filter elements, while others would require a separate filter installed in front of the regulator. Without a filter, particulate matter could become lodged in the valve seat or damage the seals, preventing the regulating valve from fully closing. This would lead to a slow increase, or upward “creep” in outlet pressure over time.

TEMPERATURE COMPATIBILITY

The materials selected for the pressure regulator not only need to be compatible with the fluid, but also must be able to function properly at the expected operating temperature. The primary concern is whether or not the elastomer chosen will function properly throughout the expected temperature range. Additionally, the operating temperature may affect flow capacity and/or the spring rate in extreme cases.

OTHER CONSIDERATIONS

Mechanical designs are becoming smaller, more compact, and lighter in weight. Beswick Engineering is the leader and innovator in miniature pressure regulator technology. If your high technology application requires a high performance pressure regulator in a miniature package, please contact one of the mechanical engineers in our applications engineering department to discuss your requirements.

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