proportionair.com 877.331.1738 info@proportionair.com

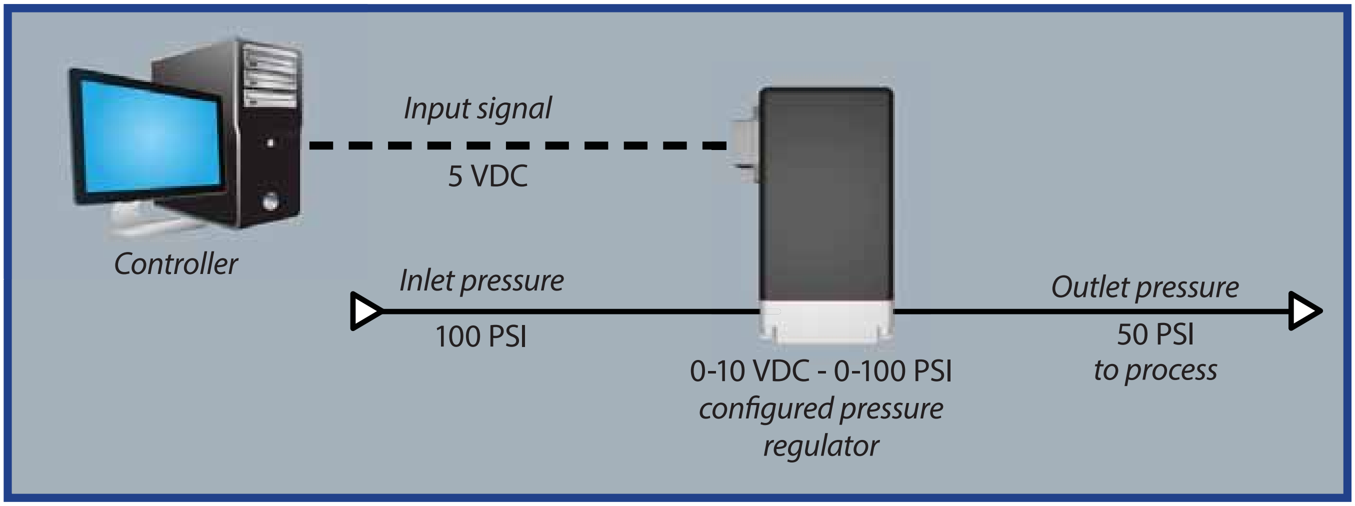
UNDERSTANDING ELECTRO-PNEUMATIC PRESSURE REGULATORS

- *Comparing and contrasting of manual versus electronic regulators*
- *An explanation of the basic functionality of an electro-pneumatic pressure regulator and other optional features.*
- *Descriptions of common applications where electro-pneumatic pressure regulators are used.*

QB2X Pressure Regulator

DEFINITION

An electro-pneumatic pressure regulator is an apparatus used to control compressed air or gas pressure for a pneumatic application. The regulator receives an electronic input signal from a programmable logic controller (PLC) or another device, and it adjusts its pneumatic output to proportionally match the input signal.



EXAMPLE

In this example diagram, a electro-pneumatic pressure regulator with a configuration range of 0-10 VDC input equals 0-100 PSI output is given a 5 VDC input signal. In this case, 5 VDC is 50% of the signal range and this relates proportionally to the output it will deliver, 50 PSIG. If the command signal was changed to 7.5 VDC, the unit would then supply 75 PSIG, 75% of its configured operational range. Even if the input supply pressure fluctuates, the pressure regulator will work to maintain output pressure.

MANUAL VS ELECTRONIC

There are many different types of pressure regulators, sometimes also known as control valves or simply referred to as valves. The main two categories of pressure regulators are determined by the method in which they are operated, **manual (mechanical)** or **electronic**.

Manual regulators are operated by hand, usually by a top-located adjustment screw or knob. The adjustment screw moves a spring, adjusting the pressure on the diaphragm or piston. We use similar mechanisms everyday, such as sink faucets, gas stove dials, propane tank valves, and the water hose on a side on a house. The correct setting(s) must be found, at least initially, by trial and error. The potential for over/undershoot and/or the need for extra adjustment/monitoring is a very real possibility. While fine-tuning may be a drawback, the advantage of a manual regulator is that once the correct setting is found, the device is essentially "set it and forget it," if the end application can tolerate some fluctuation in the output pressure.

Unfortunately, even when a correct setting is dialed in, manual regulators may have a tendency to allow incorrect output, or drift, over time or with fluctuations in inlet pressure. What are actual the benefits of using a manual regulator? The main assets of manual regulators are simplicity of design and operation, long lifespan, and relatively low upfront cost. Manual regulators require little to no installation training and no programming; or electronics to function. They can be a great fit for hazardous or dirty environments where an application only requires an on/off supply or gas or liquid that does not need to be precisely regulated.

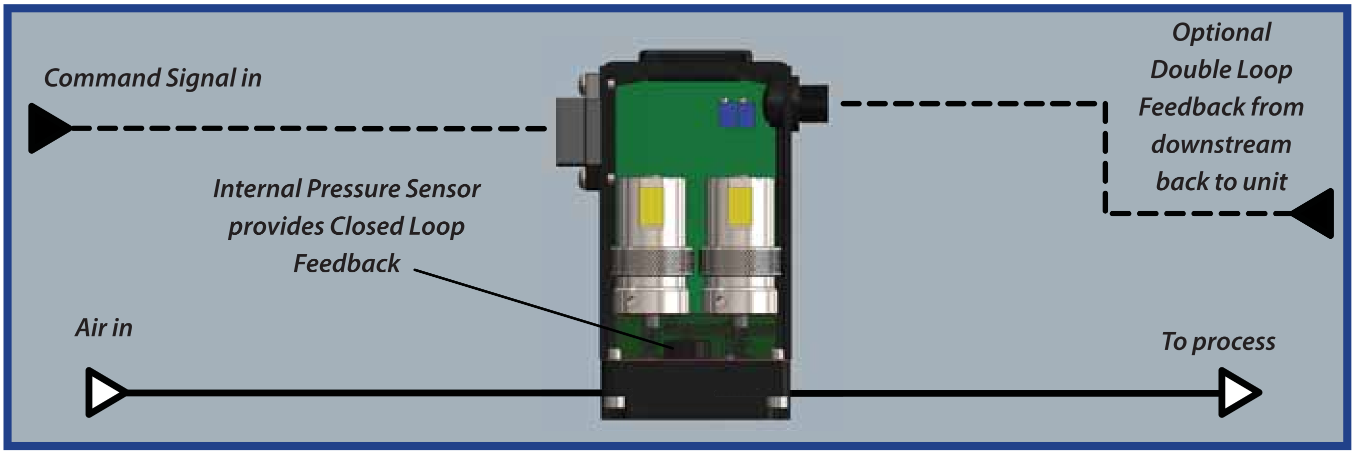
Manual Pneumatic Regulator

Manual pressure regulators have been in use since the early days of pneumatic devices. Since pneumatically-powered devices were used in industrial processes before electricity was widely available, the only manner in which to control their output was to alter supply pressure levels before the device. The primary use of these early regulators was simply to tame supply pressure for machinery that required significantly less operating pressure or flow. When electricity became a reliable, readily available power source, the ability to harness it in tandem with pneumatics led to even greater efficiency and ability to control machinery. One of the first electronic control devices for pneumatic applications are called I/P or E/P regulators.

They convert an electronic control signal from current (*I*) or voltage (*E*) to a pneumatic pressure (*P*). In a typical "flapper"-style I/P or E/P regulator, a flapper itself is a gate balanced like a fulcrum. One side has magnetic material and the other side has a stopper. When current is provided to the device a magnetic field is generated, which, causes the flapper to pivot. The movement of the flapper either blocks or opens to allow air to flow unrestricted. These kinds of devices are still in use today for simple, lower pressure and flow pneumatic applications where accuracy is less important.

But what if a process lacks consistent supply pressure and/or requires a range of different pressures? For example, take a "pick and place" application, where small parts are collected using vacuum and placed on a conveyor belt using positive pressure. A manual regulator is a poor choice for this scenario.

Dynamic applications with variable pressure ranges are where **electronically-controlled pressure regulators** really shine. In an electronically-controlled regulator, the device is sent an electronically-delivered control signal to tell it to automatically adjust the internal valves to change the output pressure level. Depending on the type of electronic pressure regulator, a PLC or other controller can be set up to run a custom program loop that will walk the regulator through a series of different pressure output in timed and stepped increments. This type of programming is perfect to maximize automation efficiency in a complex application such as the pick and place example.



Closed Loop Feedback and optional Double Loop Feedback

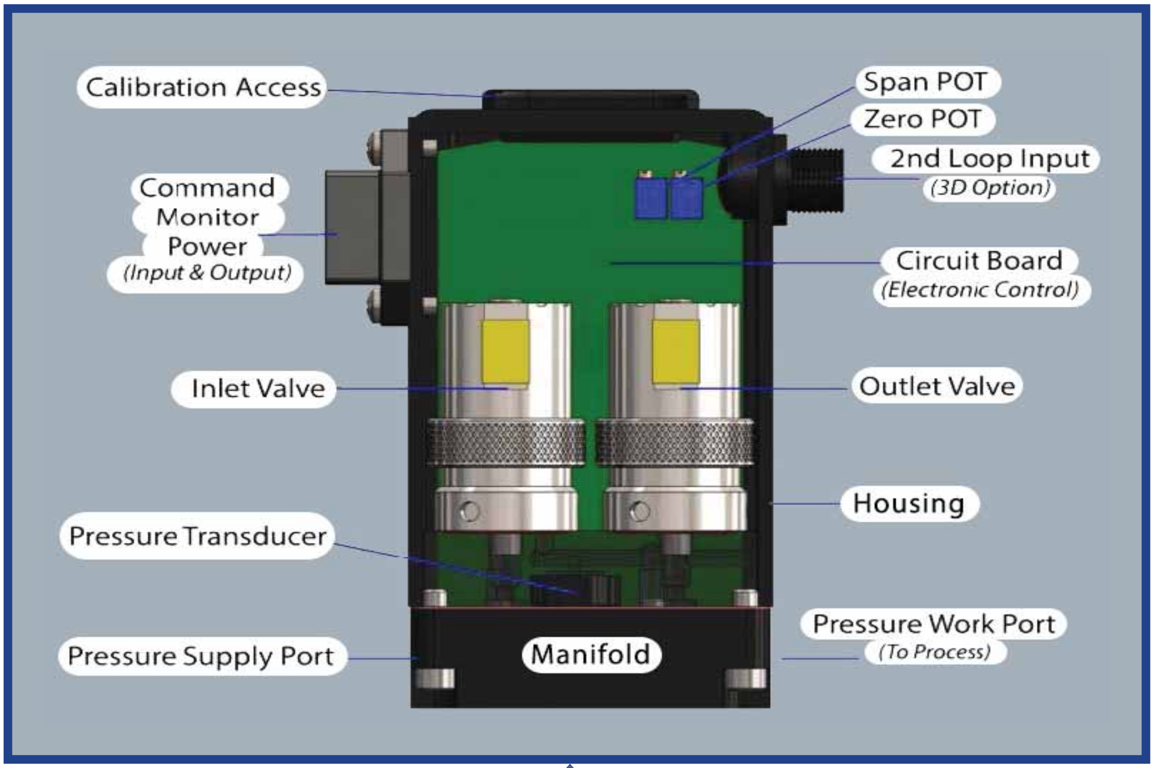
Electro-pneumatic pressure regulators are closed-loop devices. Whereas, I/P or E/P devices are single loop - they do not have sensors or receive feedback. Typical EPR components consist of valves, a manifold, an internal pressure transducer, and electronic controls. As mentioned, output pressure is proportional to an electrical signal input. Pressure is generally controlled by two valves. One valve functions as the inlet control, the other as exhaust. An internal pressure transducer measures the pressure output and provides a feedback signal to the electronic controls. This feedback signal is compared against the command signal input. A difference between the two signals causes one of the valves to open, allowing flow in or out of the system. Controlling these two valves maintains accurate pressure.

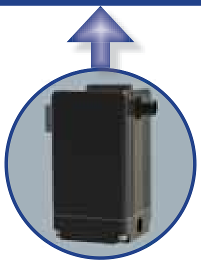
Electro-pneumatic regulators can be specified as standalone valves in static applications with low flow requirements. They can also pilot volume boosters (air-piloted regulators) in applications where the flow rate of the controlled pressure is higher than regulator's flow rate. The booster is a mechanical device with hysteresis, which results in less accuracy. An additional feedback loop can be used to account for the loss.

In these double loop control schemes, an external sensing device sends a feedback signal in addition to the internal transducer. The external signal functions as the primary feedback signal. This signal is compared against the command signal input. With the inner loop sensing the dome, and external loop sensing the output, greater accuracy can be achieved.

Since the external feedback signal is electrical, control is not limited to pressure. Using other types of sensors allows control over parameters such as force, flow, etc.

TYPICAL ELECTRO-PNEUMATIC PRESSURE TRANSDUCER INTERNAL COMPONENTS





- **Calibration Access** port allows the **Span** and **Zero Potentiometers** to be calibrated to a specific pressure range.
- **Command**/**Monitor Power** provides input signal and power to the unit and can also transfer data acquired from the operation back to the controller for storage or analysis.
- **Inlet** and **Outlet Valves** are the workhorses of a pressure regulator. They are electronically controlled to open or close to allow or block the flow of the media through the device.
- **Pressure Transducer** gathers pressure reading information to confirm the device is performing correctly.
- **Pressure Supply** and **Work Ports** are the main input and output ports for the media traveling through the device.
- **2nd Loop Input** is an optional feature that allows interface with an external sensor, usually a secondary **Pressure Sensor.** The sensor can send a signal back to the 2nd Loop Input and the device can adjust to ensure the correct pressure level is achieved and maintained further downstream and closer to the process.
- **Circuit Board** is responsible for connecting all sensors, routing signals and commands, and operating valves.

EXTERNAL MATERIAL AND MEDIA OPTIONS

Housings and manifolds

The housing is the largest part of an electronic pressure regulator. It covers the internal components and protects them from impact or a potentially dangerous or dirty environment. The bottom section that attaches to the housing is known as the manifold. This where the pneumatic input and output ports are located.

An MM electro-pneumatic pressure regulator has no housing, exposing the internal components. Note the brass manifold.

The internal routing of a manifold can be unique to the design. In an electro-pneumatic regulator the routing leads to and from the valves, which control flow through the unit. Many pressure regulators housings and manifolds are made from aluminum, as it tends to be lower weight and less expensive than other metals, yet still durable. Perhaps even more beneficial is aluminum's compatibility with nearly all non-corrosive fluids. One exception is oxygen, where there is a concern about the danger of combustible aluminum dust produced during the trimming or cutting of holes or ports in the regulator manifold. If the regulator is for oxygen use, a unit with a brass manifold may be suggested instead. Stainless steel manifolds are also used for dangerous or corrosive fluids. Some manufacturers might even use plastic housings on more basic pressure regulators in non-industrial environments.

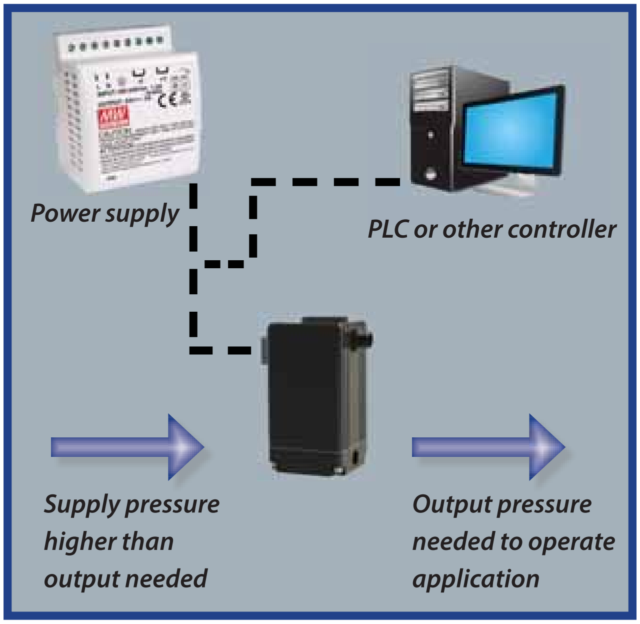
Media

Although compressed air is the most common media, pressure regulators can be used to control nearly any kind of fluid media. Nitrogen, helium, and argon are all common inert gases that are used for processes such as inflation, gas shielding, packaging, or product leak testing. When operating in hazardous locations or working directly with dangerous media, like natural gas, products with intrinsically safe or nonincendive approvals are often required.

WHAT YOU'LL NEED

To operate and control an electro-pneumatic regulator for your application, you'll need the following:

- A stable compressed air or gas supply that is a higher pressure than the application's requirement
- A power supply
- A command source, such as a PLC or computer
- The output pressure needed to properly run the application

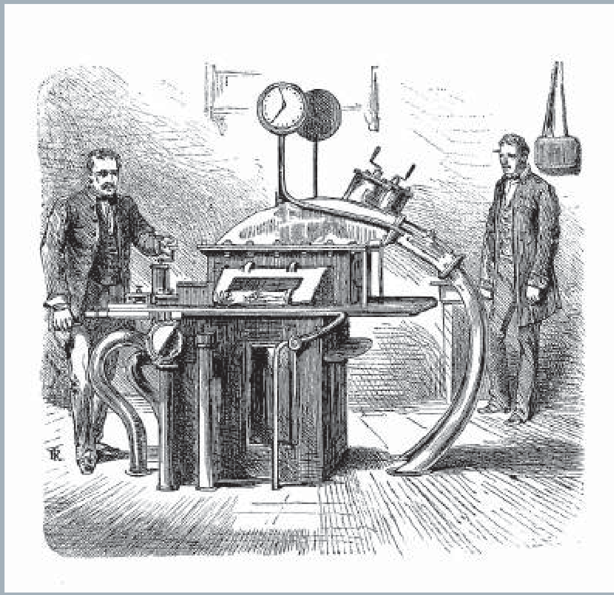


EVOLUTION OF PNEUMATICS

The ancient Greek mathematician and engineer Hero of Alexandria is one of the first known to have written about wind-powered machines, such as the pipe organ, in the 1st century AD. However, is it also well known that Hero drew upon a far older source. Many of the underlying principles of his designs are based on the writings of another Greek inventor, Ctesibius, who authored a work on the elasticity of air - *On Pneumatics*. Ctesibius died in 222 B.C. and is known as the father of pneumatics.

A SERIES OF TUBES

The earliest, most prolific pneumatic invention still in use today is the pneumatic tube system. The city of London was host to the first pneumatic dispatch in 1853, which moved messages between the London Stock Exchange and the city's main telegraph station. In the golden era of its use (late 19th to early 20th century) many cities all around the world had miles of pneumatic tubes running beneath their streets. Today, libraries, schools, banks, hospitals, and other facilities all over the world continue to use hollow tubes pressurized with compressed air as a means of conveyance to deliver small payloads to different locations, buildings, and even across cities for nearly 200 years.



A drawing of a pneumatic tube mechanism in use at the post office in Berlin in late 19th century. Cranks were used to pressurize the tube after the door is sealed.

Modern pneumatic tubes operate on exactly the same principle as their historic counterparts. A motor either forces air into the tube to push a canister or sucks air out to create vacuum which pulls the canister to it's destination.

ELECTRONIC PRESSURE REGULATORS TODAY

In the past, there was a common misconception that pneumatics lacked precision and at-scale operation required wasting a large amount of the compressed air energy produced because devices were always “on“, i.e. using air. This is known as “constant bleed“ and meant that a device would simply exhaust air if it didn’t require it for current operation. Some electronic pressure regulators and other “smart” pneumatic devices that can receive control signals, interpret external feedback, and report other operational data helped to change this perception. This kind of data acquisition and monitoring allows an electronic pressure regulator to automatically adjust its valves’ position(s) in order to conserve energy. This internal decision-making means some EPRs are capable of constantly adjusting to best meet the current needs of their application, reducing their need to constantly exhaust, or bleed, excess air, like many of their I/P forefathers.

Electro-pneumatic pressure regulators achieve the same end goal as I/P regulators - they convert an electronic signal into a pneumatic pressure output. However, EPRs are significantly faster, more accurate and they can be programmed to follow a series of sequential different pressure levels for a more complicated application.

Much of this progress is owed to the evolution of internal valves that do the actual air regulation. Modern electro-pneumatic valves have nearly immediate response times, usually requiring only fractions of a second to make a change in position.

A pneumatic robot arm assembles electronic parts on a computer circuit board.

The two types of valves commonly found in most EPRs are solenoid and proportional. The difference between the two is simply in their range of motion. A solenoid valve is either fully open or fully closed. A proportional valve can be fully open, fully closed, or any position in-between open and closed. The higher the resolution of a proportional valve, the higher the number of theoretically infinite positions it can assume.

An internal view of a typical pneumatic solenoid valve. The curled piece on the left moves up and down to allow or stop flow. The spider is inverted to show rubber valve seat.

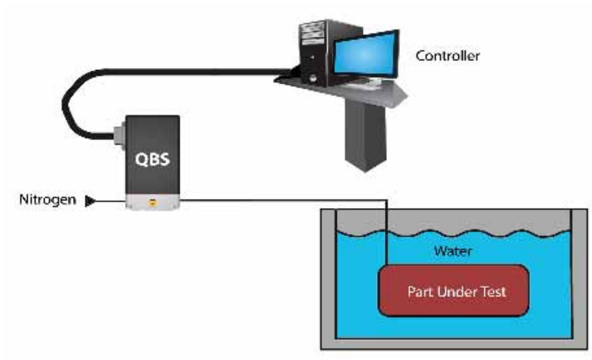
Presently, all kinds of pneumatic devices, including EPRs, can be found in nearly any industry and sector of manufacturing. Electro-pneumatically controlled robotic armatures have proven themselves to be a particularly versatile platform for all kinds of applications, such as assembly, gripping, spraying, and welding. As more facilities adopt automation and Industry 4.0 initiatives, electro-pneumatic control devices continue to be implemented where the advantages over pure electronic controls are important. Pneumatics are usually selected over full electronic devices for several reasons; to make use of an existing compressed air infrastructure, lower initial upfront costs, simplicity of installation and maintenance, environmental temperature tolerance, and overall relative safety of pneumatics.

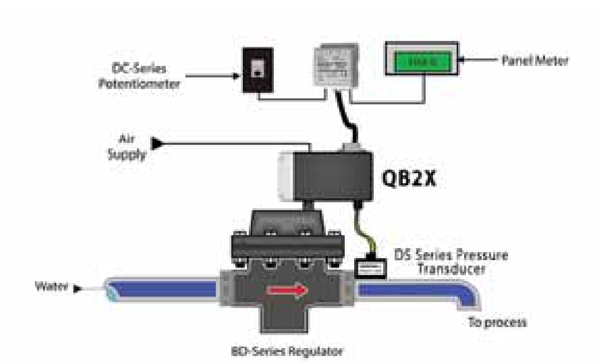
APPLICATION EXAMPLES

Electro-pneumatic pressure regulators are used in a multitude of different industries, especially the manufacture of components and consumer goods. Here is a look at some common applications where precision pressure control is an important piece of the production process.

HIGH PRESSURE LEAK TEST

In this example, a Proportion-Air QBS electro-pneumatic pressure regulator is pressurizing a part under test in a water tank. The controller sends a signal to the unit and the QBS steps up the amount of nitrogen passing into the part gradually over a timed test period. An operator then checks to see if the part is producing air bubbles from a leak.





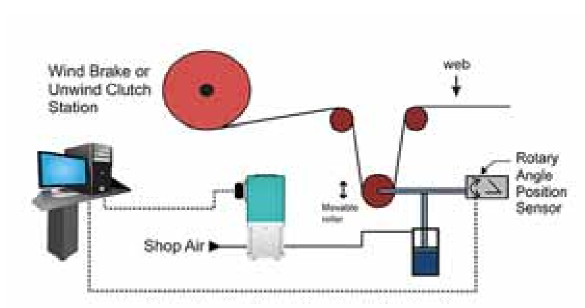
LIQUID PRESSURE CONTROL

In this application, a Proportion-Air QB2X electro-pneumatic pressure regulator is piloting a dome-loaded Burling Valve BD series pressure-reducing regulator, which is controlling the pressure of water going to a reservoir. The DST series stainless steel pressure transducer measures the pressure of the liquid and provides second loop feedback to the QB2X. This feedback becomes the main signal that is compared against the (user supplied) command signal provided to the QB2X. The monitor analog output line is connected to the panel meter to display the exact pressure going to the reservoir.

DANCER ARM TENSION CONTROL

A QB3 electronic pressure regulator is used in this example to control the tension of a dancer arm by controlling the pressure of a cylinder.

The position of movable roller indicates the amount of web tension. The position sensor sends a signal to the controller and the controller sends a signal to the rapid responding, self-venting QB3 pressure regulator to maintain position – which inevitably maintains tension in the web.



FOR MORE INFORMATION

Want more info on electro-pneumatic pressure regulators or other pneumatic control devices? Please contact our applications team at 317.335.2602 or **info@proportionair.com**.