SVF FLOW CONTROLS
WHITE PAPER

Selecting Valve Automation Devices for Quarter-Turn Valves in Chemical Applications

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Introduction

Every industry has specific requirements for equipment used in the process areas and systems. The requirements may be driven by many potential factors:

- Integration with the process control system
- Area ratings for electrical equipment
- Industry standards
- Environmental considerations, such as corrosion, humidity, temperature
- Access to electrical or compressed air supplies
- The unique processing conditions
- Routine wash downs
- AC or DC voltages, etc.

What to Know Up Front

Most types of valves can be fitted with pneumatic or electric actuators to allow the valves to be controlled remotely or by an automation system for flow regulation or on/off service. Actuators can be outfitted with a variety of features, such as open/closed position feedback switches, analog positioners and position feedback outputs, visual position indicators, travel time adjustments, battery backups for power failure response, and more.

The function of the actuator is also important. Engineers must consider the torque required, rated duty cycle, movement rate, inputs and outputs available for control, materials, IP or NEMA rating, and cost. If a problem is encountered that can only be solved by replacing or upgrading the valve or actuator, the replacement may mean much more than the cost of the parts, including labor, down time, lost production, and potential fitment issues after an installation is complete and running. In many cases, replacing a valve can necessitate fully draining a process system if isolation is not possible or practical. For these reasons, proper advance consideration of all factors to correctly select application-specific valve and actuator types is essential.

This article is divided into three major sections:

- Actuator Selection
- Controls Selection
- Hazardous-Area Classification Methods and Equipment

It provides an overview of the pneumatic and electric actuators, controls and feedback devices that are available for integrating automated quarter-turn valves into a control system in the chemical industries.

It is assumed that the quarter-turn valve type and materials for a specific application(s) has already been made.

1

Understanding Valve Actuator Selection

1.1 Making the Decision

The decision to automate a valve is usually based on some or all of the following considerations.

- SAFETY
- RELIABLE OPERATION
- CONTROL & PROCESS SYSTEM PERFORMANCE & INTEGRATION
- INACCESSIBLE OR REMOTE VALVE LOCATION
- COST
- EXCESSIVE VALVE TORQUE
- EMERGENCY RESPONSE & WHETHER IT IS FAIL-SAFE

1.2 The Distinct Purpose

1

Move the valve closure member

(disc, ball, or plug) to the desired position. Not only must the actuator provide enough torque or thrust to move the closure member under the most severe conditions, it must also be fitted with the appropriate controls to direct it.

2

Hold the valve closure member in the desired position.

Particularly in throttling applications where fluids may create a dynamic torque, actuators should have adequate spring or fluid power or mechanical stiffness to overcome this phenomenon.

3

Seat the valve closure member with sufficient torque to provide the desired shutoff specification.

A butterfly valve for instance is fully seated (closed) when the disc is positioned in a resilient liner (seat). In this rotary position the valve stem torque is at its highest. Actuator sizing for torque-seated butterfly valves may require special accessories particularly on electric actuators to ensure that sufficient torque is sustained in the closed position.

4

Provide a failure mode in the event of system failure.

This may be fully opened, closed, or as-is depending upon the application. Certain failure mode requirements may eliminate electric actuators yet be ideal for pneumatic or electrohydraulic units.

5

Provide the required rotational travel (90°, 180°, etc).

Valves requiring more than 90° of rotation include multi-ported valves. A few pneumatic actuator manufacturers offer 180° actuators. For greater than 180°, electric actuators are usually preferred because they are electrically, not mechanically, limited in rotation.

6

Provide the required operating speed.

All actuators may be regulated in cycle speed depending on the control circuit elements used.

1.3 Actuator Speeds

Pneumatic

Fast cycle speeds (less than one-half the standard actuator cycle time) require careful valve selection. The physical shocks associated with fast cycling can damage the valve parts—especially when combined with high cycle rates. Special preparation of pneumatic actuators—including special solenoids, piping, and quick-exhaust valves—may be required to achieve high cycle speeds.

Pneumatic actuators can be slowed using speed control valves in the air piping. One speed control valve will slow speed in one direction, while two are required to slow speed in both directions. Speed controls do not affect the output torque of pneumatic actuators.

Electric

Because they are geared motors, the cycle speeds of electric actuators cannot be increased, only slowed. This is easily accomplished with the specification of either special cycle times or with the addition of an electronic speed control card.

Special cycle times are achieved with a different gearing mechanism which also affects output torque. The electronic speed control is infinitely adjustable and can reduce the effective actuator speed up to 20 times without the need for special gearing. Output torque of the actuator is not affected where speed cards are used.

Pneumatic and Electric Actuators Compared

At times it is necessary for a process engineer to choose between a pneumatically or an electrically actuated valve for a process system. There are advantages to both styles, and it is valuable to have data available to make the best choice.

Compatibility (Power Source)

First and foremost, in the selection of an actuator type (pneumatic or electric) is to determine the most effective power source for the actuator.

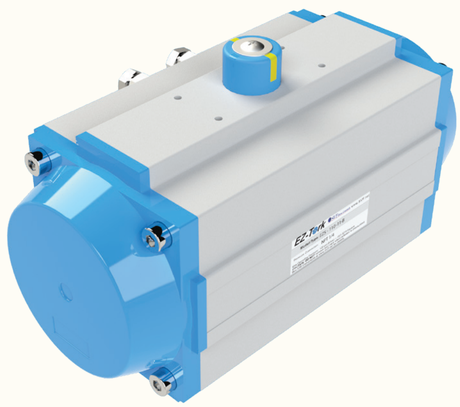
Points to consider are:

- Power source availability
- Torque at the valve stem
- Failure mode
- Control accessories
- Speed of operation
- Frequency of operation
- Plant environment
- Size of valve
- System component costs
- System maintenance

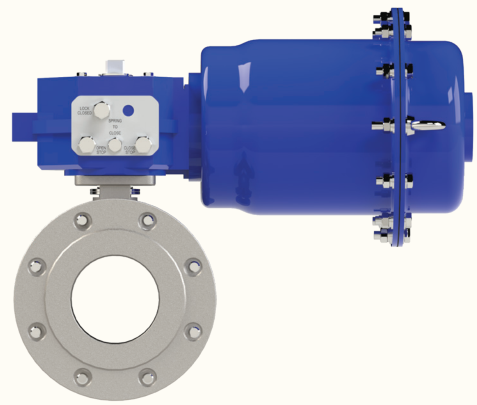
The most practical pneumatic actuators utilize an air pressure supply of 40 to 120 psi (3 to 8 bar). Generally, they are sized for a supply pressure of 60 to 80 psi (4 to 6 bar). Higher air pressure is usually difficult to guarantee (even potentially dangerous) and lower pressures require a very large diameter piston or diaphragm to generate desirable operating torque.

Electric actuators are often used with a 110 VAC power supply but are available with a wide variety of AC and DC motors in single phase and three phase.

1.4 Types of Quarter-Turn Pneumatic Actuators



Double Rack & Pinion



Spring & diaphragm

Temperature range

Both pneumatic and electric actuators may be used in a wide temperature range. The standard temperature range of a pneumatic actuator is from -4 to 174°F (-20 to 80°C) but may be extended to -40 to 250°F (-40 to 121°C) with optional seals, bearings and grease. If control accessories are used (limit switches, solenoid valves etc.) they may not have the same temperature rating as the actuator, and this should be considered in all applications.

In low temperature applications the quality of the supply air in relation to dew point should be considered. Dew point is the temperature at which condensation occurs in air. Condensate may freeze and block air supply lines making the actuator inoperable.

Electric actuators are available in a temperature range of -40 to 150°F (-40 to 65°C). When used outdoors an electric actuator should be sealed from the environment to prevent the introduction of moisture to the internal workings. Condensation may still form inside, if drawn from the power supply conduit, which may have captured rainwater prior to installation. Also, since motors warm the inside of the actuator enclosure when it is operating and cools it when it is not, temperature fluctuations may cause environmental “breathing” and condensation. For this reason, all electric actuators used outdoors should be fitted with a heater.

Hazardous Areas

It is sometimes difficult to justify the use of electric actuators in a hazardous environment, but if compressed air is not available or if a pneumatic actuator will not provide the operating characteristics required, then an electric actuator with a properly classified enclosure may be used.

NEMA guidelines

The National Electrical Manufacturers Association (NEMA) has set up guidelines for the construction and installation of electric actuators (and other electrical devices) for use in hazardous areas. The NEMA VII guideline reads:

> VII Hazardous Location Class I (Explosive Gas or Vapor) Meets application requirements of National Electrical Code; conforms with specifications of Underwriters' Laboratories, Inc., used for atmosphere containing gasoline, hexane, naphtha, benzene, butane, propane, acetone, benzol, lacquer-solvent vapors, and natural gas.

Almost all electric actuator manufacturers have an option for a version of their standard product line that conforms with NEMA VII. Another source for hazardous area guidance is available from ATEX.

See Section #3

On the other hand, pneumatic actuators are inherently "explosion-proof". When electric controls are used with pneumatic actuators in hazardous areas, they are generally more cost effective than electric actuators. Solenoid- operated pilot valves (which are electrical devices) may be mounted and powered in a non-hazardous area and piped to the actuator. Limit switches -for position indication- may be housed in a NEMA VII enclosure. The inherent safety of pneumatic actuators in hazardous areas makes them a practical choice in these applications.

Spring Return

Another safety accessory widely specified in the process industries on valve actuators is the spring-return (fail-safe) option. Upon power or signal failure a spring-return actuator drives the valve to a pre-determined safe position. This is a practical and inexpensive option with pneumatic actuators and is an important reason for the wide use of pneumatic actuators throughout the industry.

Electric actuators are available with a spring return option or a battery backup system to provide predictable "failure" positioning.

Performance characteristics

Before specifying a pneumatic or electric actuator for valve automation it is important to consider a few of the key performance characteristics of each.

Duty cycle

Pneumatic actuators have a 100 percent duty cycle. In fact, the harder they work, the better they work. Electric actuators are most commonly available with 25 percent duty cycle motors. This means that to prevent overheating in high cycle applications the motor must rest frequently. Because most on-off automated valves remain idle 95 percent of the time duty cycle is not usually an issue. With optional motors and/or capacitors an electric actuator may be upgraded to 100 percent duty cycle.

Stalling

Pneumatic actuators may be stalled indefinitely without overheating.

Electric actuators should not be stalled. Stalling an electric actuator draws excessive current, which generates heat in the motor and can cause damage. Torque switches or heat and current sensors are often installed in electric actuators to protect the motor.

Modulating control

In modulating service an electric actuator interfaces well with existing electronic control systems and eliminates the need for electro-pneumatic controls. A pneumatic or electro-pneumatic positioner is used with pneumatic actuators to provide a means of controlling the valve position.

Speed control

The ability to control the speed of a pneumatic actuator is an important advantage of the design. The simplest way to control the speed is to fit the actuator with a variable orifice (needle valve) at the exhaust port of the air pilot. Since electric actuators are geared motors it is impossible to make them cycle faster unless a gearing change is made. For slower operation a pulsing circuit may be added as an option.

Torque-to-weight ratio

Electric actuators have a high torque-to-weight ratio above 4,000 lbf.in. (450 Nm). Pneumatic actuators have an excellent torque-to-weight ratio below 4,000 lbf.in.

Summary of pneumatic and electric actuators

This table of characteristics summarizes the comparison of pneumatic and electric actuators.

	PNEUMATIC	ELECTRIC
HAZARDOUS AREAS/NEMA	Inherently explosion-proof, spark-proof	Available with NEMA VII enclosure for hazardous damage
SPRING RETURN	Spring-Return (fail-safe) option is practical and economical	Available in Spring-Return or Battery Backup configurations
DUTY CYCLE	**100%** duty cycle	**25%** standard duty cycle. May be upgraded.
STALLING	May be stalled indefinitely	Should not be stalled
SPEED CONTROL	Simple, accurate, and inexpensive speed control	A pulsing circuit may be added to slow the operating speed
TORQUE - to - WEIGHT RATIO	Averages **123:1** at 1500 lbf • in (170 N • m)	Averages **44:1** at 1500 lbf • in (170 N • m)

1.5 Addressing Corrosive Environments

For applications in corrosive environments pneumatic and electric actuators are available with some or all of these solutions. Basic actuator coatings are typically hard anodized aluminum but can also be produced with coatings such as polyurethane or epoxy. They are also available in non-metallic or stainless steel.

1.6 Actuator Sizing

The most important step in developing an automated valve specification is to determine a sizing criterion. If a valve is to operate in a process handling clean liquids at moderate pressures and temperatures, the manufacturer's published operating torque is usually adequate for actuator sizing. Under certain conditions, however, the torque required to operate a valve may increase. In this case a sizing safety factor may need to be applied based on the following guidelines:

MEDIA & SERVICE FACTORS			
MEDIA	Multiplier	SERVICE	Multiplier
Clean, particle free, non lubricating (water, alcohol, etc)	1	Simple On & Off Operations	1
Clean, particle free, lubricating (oils, hydraulic fluid, etc)	0.8	Manual Throttling Service	1.25
Slurries or heavily corroded and contaminated systems	2	Positioner Control	1.5
Gas or saturated steam, clean and wet	1	Once per day operations (on/off)	1.2
Gas or superheated steam, clean and dry	1.3	Once every two days or a "Plant Critical" operation (on/off)	1.5
Gas dirty unfiltered (natural gas, chlorine)	1.5	Once per month or less frequently (on/off)	2
Liquid, black liquor, lime slurry	1.8	Applications below -20˚F	1.25
Liquid, viscous, molasses	1.3		

NOTE: Consult the valve manufacturer for Specific Safety Factors recommendations

1.7 Control and Connect

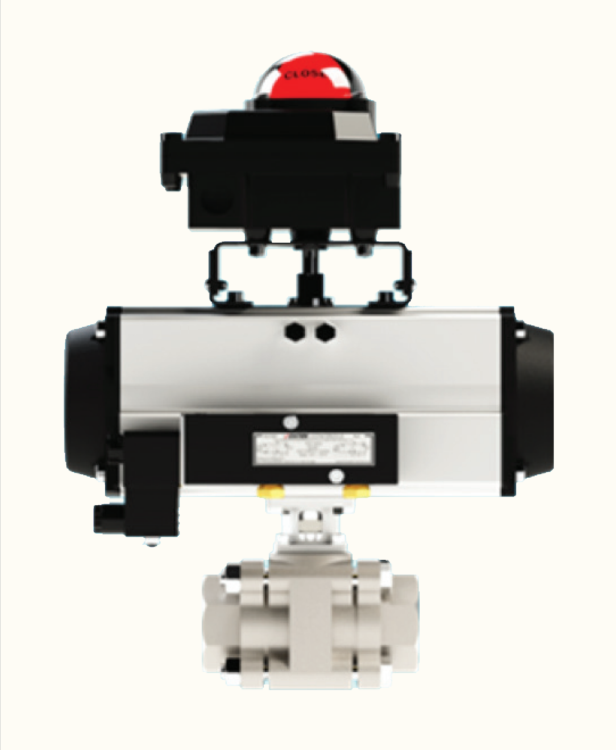
Once an actuator type has been chosen the next step is to determine the type of control and feedback that is required for the process control system.

See Section #2 "Selecting Automation Accessories for Valves".

2

Selecting Automation Accessories for Valves

Today's process controls range from complete computer systems to the staff-monitored electromechanical type



Automated valve shown with limit switch and pilot valve

(push buttons, heavy-duty relays, etc). In the process area, there may also be pressure switches temperature controllers, or other process-monitoring devices that must tie into the control valve and therefore the actuator.

The pneumatic actuator is the workhorse for the automation of quarter-turn valves. When selecting a pneumatic rotary actuator for valve control in process applications, it is important that it be compatible with other components of the control system (power medium, control signals, etc), the environment (corrosion, temperature), the system (speed, cycle frequency, fail mode), and, of course, the valve.

To work well with an existing control network, the pneumatic actuator must be available with a few basic control accessories.

Solenoid Valve — *As a pilot device, available in various voltages and construction for the area classification*

Limit Switches — *For indicating valve position, sequence cycling, alarms, etc*

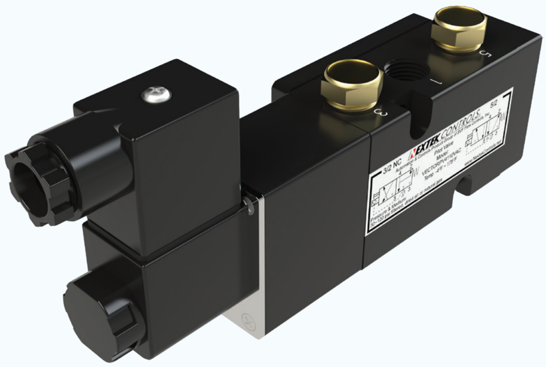
Positioners — *To throttle the valve in response to a varying control signal*

For environmental compatibility, the actuator should be available with corrosion-resistant (anodized, stainless-steel) trim, various coatings (polyurethane, epoxy, etc.), and weatherproof, hazardous-area, or intrinsically safe control accessories.

Pilot Valve

A pilot valve for a pneumatic actuator is a control device that receives a manual or power signal and then directs air pressure to the air inlet ports of the actuator to drive it to the desired position. The most common type of pilot device is the solenoid-operated valve. As an electric device, it readily interfaces with widely used control systems and may also be supplied with low-wattage coils for compatibility with computer control signals.

Pilot valves for pneumatic actuators are categorized by the number of port openings or ways air may flow through them.



For instance, a three-port (three-way) valve has a pressure port, output port, and exhaust port. The three-way valve is a logical choice for ***spring-return pneumatic actuators*** because only one air chamber is alternately pressurized or exhausted in normal operation.

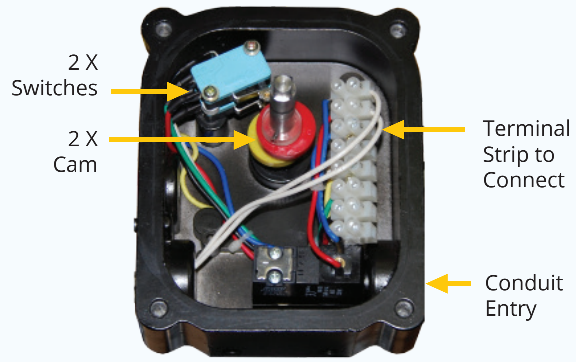
A four-way valve has a pressure port, two output ports, and an exhaust function. The two output ports will pressurize one or the other chambers of a ***double-acting cylinder*** and so it is used with these types of pneumatic actuators.

Limit Switches

For a pneumatic actuator, the term limit switch may be a misnomer. The term more properly applies to electric rotary actuators that are fitted with limit switches to interrupt the power to the motor when the actuator has reached its desired limit of rotation. As a functional term, "position-indicating switch" (or Feedback Switch) is more properly applied to limit switches when they are used with pneumatic actuators.

Indeed, a switch fitted to a pneumatic actuator does not limit its travel but instead indicates (through switches) when the actuator has reached, or has not reached, a specified point of rotation.

Also referred to as a switch box, the position-indicating switch box encloses the switch elements, cams, and terminal strip and has a rotating input shaft that is fitted to the auxiliary shaft of the actuator to pick up rotary motion.



The switch housing is composed of an input shaft that externally couples to the actuator's auxiliary drive shaft and is fitted internally with adjustable cams, snap-acting switches that are mounted to align with the cams and a terminal strip for incoming wiring. As the actuator cycles, the input shaft of the switch box rotates, and the cams actuate the switches. When the switches are used to indicate the limits of the cycle, the cams are adjusted to operate the switch when the desired position is reached.

Position-indicating switches are used for a variety of applications: light indication (powering indicator lamps on a control panel), system sequence cycling, alarms, electrical interlocking, etc. Some switch enclosures may be fitted with other devices, such as a potentiometer or position transmitter for continuous feedback of the valve's position.

When the switches are connected to signal lights, they should be arranged so that both lights are on in mid-travel, with one or the other being extinguished at the ends of travel. This helps the operator avoid being misled by a burned-out lamp.

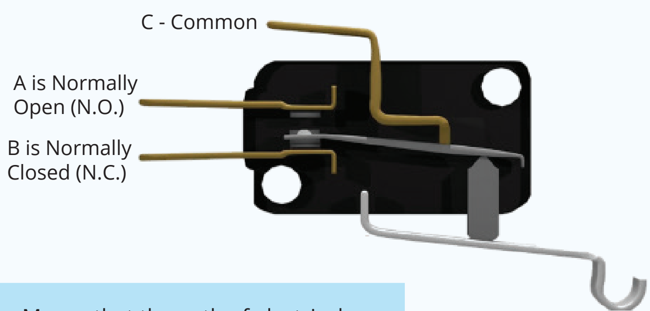
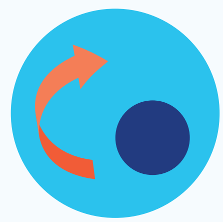
Switch boxes for pneumatic actuators are often specified by the type and quantity of switches required. Examples of the types of switches available are mechanical (snap acting) and proximity.

Mechanical Switches

These switches are also called "**Snap Acting**" switches as there is a distinct sound (snap) as the contacts shift within the switch.

Mechanical switches are usually expressed in terms of the number of poles and throws they contain. A pole is a component of the switch that is moved by the switch action to make or break electric contact. The possible electric connections that can be made by a given pole are called throws.

There are four configurations of electric limit switches: single-pole-single-throw; single-pole-double-throw; double-pole-single-throw; and double-pole-double-throw.

SPDT Switch *(Single Pole Double Throw)*	 	
Normally* **OPEN**	Means that the path of electrical flow (circuit) between the '**C**' contact and '**A**' is "open" when the switch is at rest.	
Normally* **OPEN**	Means that the path of electrical flow (circuit) between the '**C**' contact and '**B**' is "made" when the switch is at rest.	

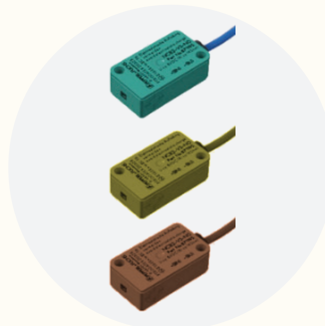
**Normally - there is no contact by the cam, or at rest.*

Proximity Switches

These switches/sensors operate when a metallic or magnetic object is brought into proximity with the switch sensing area. These switches are inherently protected against dust and moisture and some require a power circuit. Two types of proximity switches are the proximity sensor and reed switch.

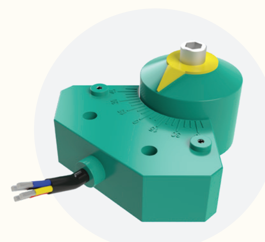
Inductive Sensors

Inductive sensors are switches that operate when a metallic object is brought into proximity with the sensing face. Most inductive sensors comply with several NEMA ratings. The sensors are protected against dust, moisture, and oil. Internal solid-state circuitry prevents shock and vibration from affecting sensor operation. They require power to operate as the sensing area is a field of electro-magnetism.



Reed Switches

Another low-current proximity switch (250 to 500 mA) is the reed switch. Action is initiated when a ***magnet*** is placed in the proximity of the sensing area. ***Reed switches do not require a power supply***.



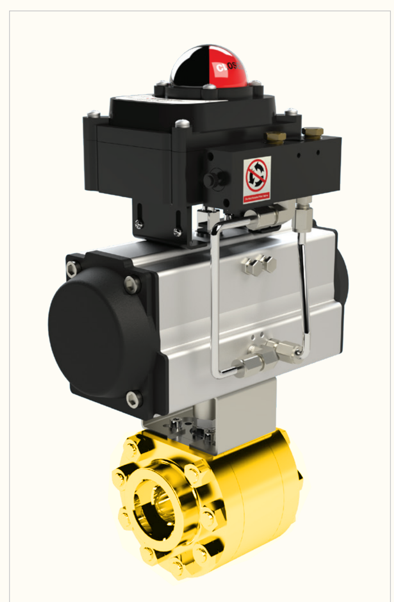
Major advantages of reed switches:

- Fully hermetically sealed metal contact.
- Reed switches can operate in moist and dust ambient conditions
- Temperature variation from -60°C to +155°C. (-76°F to 311°F)
- Zero power to operate

A Fully Integrated Solution

Because it is common that both a feedback limit switch and a pilot valve are part of a typical automated valve package, there are fully integrated devices that incorporate both of these elements into one enclosure. A good example is the ***Nexus-LP*** from ***SVF Flow Controls***.

At least one advantage of this product is that the field wiring connects through a single conduit entry tying both the pilot valve power wiring and the feedback terminals of the limit switches.



Nexus-LP from SVF Flow Controls integrates the limit switch and pilot valve into a single enclosure

Other methods of position indication

If continuous monitoring of an actuator's position is required, as in modulating or "jogging" applications, a switch box may be fitted with a potentiometer. As the shaft of the switch box rotates, it likewise rotates the input shaft of the potentiometer. The continuously decreasing or increasing resistive signal may then be converted into a valve position at the control panel. When the actuator is located far from the control system, the result may be an unreliable resistive signal due to the inherent resistance of the long wire. In this case a resistance-to-current transducer circuit may be preferred. The circuit board is usually installed in the switch box with the potentiometer and provides a 4-to-20 mA signal to continuously indicate valve position. See "Transducers" below.

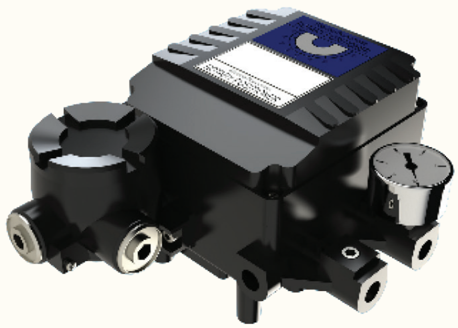
Electrical Enclosures

Switch boxes designed for use in explosive environments (hazardous areas) must be able to withstand an internal explosion without igniting the explosive mixture surrounding the switch enclosure. The enclosure is thus designed to withstand the maximum expected internal explosion pressure without damage or excessive distortion and to provide venting for the pressure through channels of such dimensions that gases will be cooled below the ignition temperature before reaching the surrounding atmosphere. Thus, the design of a hazardous area switch enclosure involves careful consideration of housing thickness, cover fit, and tolerances.

Many switch enclosures incorporate multiple construction standards that are listed by the National Electrical Manufacturers Association (NEMA IV, VII, IX, etc.) to satisfy a wide range of applications. Hazardous area device selection and area definitions are also covered by ATEX.

Selecting Controls for Modulating Valve Applications

Pneumatic Positioners



When a valve is used for modulating/throttling rather than simple on-off service, it may be considered a rotary control valve. ***A control valve is a process control element that varies the flow of fluid as required by a process in response to a system control signal***. To provide fast, sensitive, and accurate positioning in response to a control signal, an actuator must be fitted with a pneumatic positioner. A pneumatic positioner is basically a relay that senses and compares an instrument signal and the valve stem position. Because it is usually mounted to the top of a rotary actuator it senses valve position through the actuator shaft.

Most basic positioners have linear characterization. This means that the input signal to output rotation is directly proportional, which enables the process engineer to select a valve that will provide system characteristics. Standard ball valves, for example, provide equal percentage flow like many other quarter-turn valves do.

TERMS ASSOCIATED WITH POSITIONERS

Direct Acting
Increasing input signal opens the valve (increases flow).

Reverse Acting
Increasing input signal closes the valve (decreases flow).

Resolution
The smallest possible change in valve position.

Deadband
The maximum range through which the input signal can be varied without initiating change in valve position.

Hysteresis
The maximum difference in valve position for a given input signal during a full range traverse in each direction.

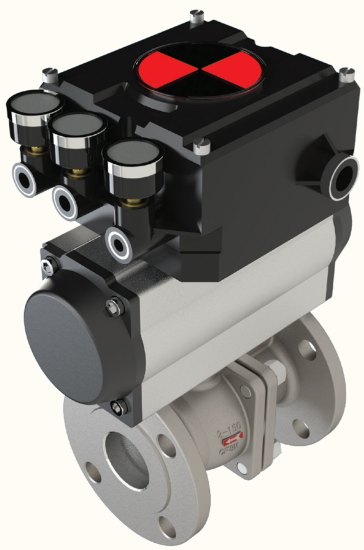
Transducers

A transducer is a device that converts one signal type to another. In the case of control instrumentation, a current-to-pneumatic transducer accepts an analog milliamp control signal from a field instrument and converts it to a proportional pneumatic signal for the positioner. The most common conversions used with control valves are for systems being controlled and monitored with electronic instrumentation but with pneumatically actuated control valves. The use of a transducer is the most practical method for interfacing the two types of equipment. As an electromechanical device, a transducer must be carefully selected for environmental compatibility, hazardous areas, sensitivity, vibrations, etc.

One drawback of transducers is that it is sometimes difficult to locate them near the positioner, which may then require long runs of wire or pneumatic tubing. To satisfy this, some manufacturers have integrated the transducer into the positioner. These hybrids are known as ***electro-pneumatic positioners***.

Standard instrument signals

Instrument signals are used to interface between various elements in the control process. Information may be transmitted from a sensor to a controller, or a controller to an actuator, etc. Standard instrument signals allow a wide variety of products made by different manufacturers to work together. Common standard instrument signal ranges are shown below.



The high end of a standard instrument signal range is usually 5 times the value of the low end. For instance, 20mA is 5 × 4 mA, 15 psi is 5 × 3 psi, etc. The low end usually does not have a value of zero. This provides a positive method of determining the difference between a device that is indicating the low end of a range and a device that is not functioning. ***This is known as live zero***.

The main exceptions to these conventions are resistance-type inputs which usually have a low end of zero and various values of high ends.

Split ranges are usually fractions of standard instrument signals. For example, 3 to 15 psi is often split into 3 to 9 psi and 9 to 15 psi, each of which is half of the standard range. Split ranging is a process by which the input signal range [3 to 15 psi (0.2 to 1 bar)] is used to pilot two control valves. In practice, the first control valve cycles through its full stroke in the range 3 to 9 psi (0.2 to 0.6 bar), and the second valve strokes through the 9 to 15 psi (0.6 to 1 bar) range.

In pneumatic devices, pressure [psi (bar)] is the usual variable for instrument signals. In electric devices, the variable may be current (mA), DC voltage (VDC), or resistance [ohms (O)]. The following table gives instrument signal ranges for pneumatic and electric devices.

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Instrument Signal Ranges		
RANGE TYPE	STANDARD	SPLIT
Pneumatic Pressure (PSIG)	3 to 15	3 to 9 9 to 15
Electric DC Current, mA	4 to 20	4 to 12 12 to 20
Voltage VDC	1 to 5 10 to 50	1 to 3 3 to 5 10 to 30 30 to 50
Resistance, Ohms	0-10k 0-5k 0-135	

Uses of a pneumatic positioner

1. Temperature control
2. Level Control
3. Split ranging
4. Loops with slow response
5. Reverse action relative to actuator

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Positioners are available in a variety of materials of construction, accessories, characterized cams, position transmitters, and integral transducers.

Manual override devices for pneumatic valve actuators

In this era of automation, it is possible to have more control over a process system than ever before. In fact, when the decision is made to automate a valve for a specific function or functions in a system, one important reason is to have even more complete control over the process by providing feedback, sequencing, and rapid response and by eliminating human error.

Interfacing an automated valve with a control system may require that an actuator be equipped with a solenoid-actuated pilot valve, positioner, limit switches, a mechanical position indicator, transducer, and so many other control accessories that if there is a loss of power to the actuator, or if the actuator fails to operate for any reason, it may be rendered inoperable and therefore useless, becoming a potential hazard or causing an unnecessary shutdown of the production process. In effect, control of the valve and possibly the entire process may be lost.

The simplest and most reliable method for guaranteeing the continued operability of an automated valve in the event of a system failure is to use a manual override device. As more quarter-turn valves are being incorporated into expanded process control systems, there is an increased concern over the ability to operate these traditionally manual valves in the event of actuator or power failure. This concern has been recognized and addressed by actuator manufacturers. There are currently a number of manual override provisions available for pneumatic quarter-turn actuators.

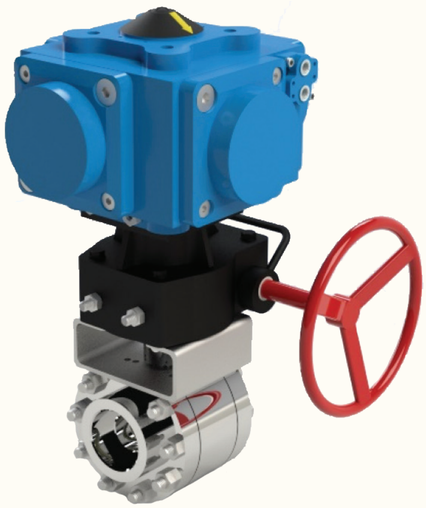
Wrench override

A wrench override is simply a handle with an engagement provision that fits to the auxiliary drive shaft of the actuator. Upon failure, the wrench may be applied to the flats of the shaft to manually override the actuator. This method should be used only with double-acting actuators as it is difficult to override and hold spring-return actuators in position. Torque should be limited to about 1500 lbf-in (170 Nm).

The wrench is usually attached to the actuator or mounting bracket with a cable or chain to prevent loss. It may also be available with a locking provision to hold smaller spring-return actuators in position until the problem is resolved. A wrench override should never be permanently attached to the drive shaft of the actuator because, when it operates automatically, it may cause injury to personnel working near the equipment.

Disengageable gear manual override

The disengageable gear override is a modular component that fits between the valve and the actuator and offers simple, reliable manual positioning. The self-locking worm gear design provides for safe and easy operation and positive manual positioning even with spring-return actuators. Rotating the clutch lever, located at the base of the handwheel, 180° immediately engages the worm gear with the output drive sleeve to permit operation. Manual override modules may be adapted in the field to existing control valves with a slight modification to the actuator.



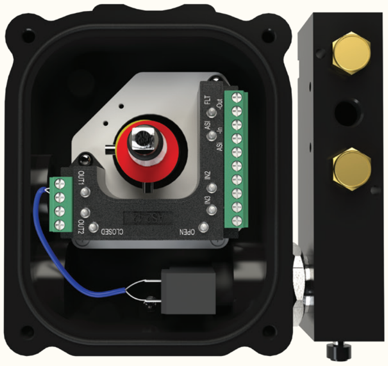
Manual overrides have proven to be an accessory requiring greater consideration in many applications. Modular construction, immediate operation, and adaptability to standard actuators are important to consider.

About Bus Protocol

Wiring of automated valves can be done by hard wiring each input and output to the process automation system or by a network or bus system, such as Modbus, PROFIBUS, DeviceNet, or Ethernet. Using networking solutions can be highly advantageous, especially with large numbers of valves and multiple control inputs and outputs per valve.

Two-Wire Control (As-I)

An increasingly common technique for controlling and communicating with automated valves in process areas is Two-Wire Control.



Based on various bus protocols (DeviceNet, As-I etc.) there are a variety of systems that cover simple on/off valve control to full system integration, diagnostics and control. The choice becomes a plant/platform-wide decision.

AS-Interface (Actuator Sensor Interface, AS-I) is designed for connecting simple field I/O devices (such as actuators and valve position sensors) in discrete process applications using a single 2-conductor cable. AS-Interface is an 'open' technology supported by a multitude of automation equipment vendors.

It is a networking alternative to the hard wiring of field devices, and it can be used as a partner network for higher level fieldbus networks such as Profibus, DeviceNet, Interbus and Industrial Ethernet. It offers a low-cost remote I/O solution.

Applications

Systems that utilize 8 or more valve actuators can benefit from Bus Technology. Typically these systems have automated valves controlled by a programmable logic controller (PLC).

AS-Interface vs. Conventional System

AS-Interface is a versatile, low cost alternative to traditional hard wired I/O. It can replace traditional point-to-point wiring with a better, more flexible solution that is easier to install, operate and maintain and easier to re-configure.

Conventional System

Typical batching valve wiring networks attach each of the inputs and outputs (I/O) to a central location resulting in multiple wire runs for each field device. Large expenditures are needed for cabling conduit, installation and I/O points. Space for I/O racks and cabling must be accommodated in order to attach only a few field devices.

AS-Interface Network

A simple gateway interfaces the network into the field communication bus. Data and power are transferred over the two-wire network to each of the AS-Interface compatible field devices.

Each valve communication module contains an AS-Interface ASIC and other electronics to gather open or closed position status and power solenoid or other ancillary devices on or off. Other AS-Interface modules are available to gather inputs and switch power outputs.

FEATURES

- Ideally suited for on/off batch process valves and other discrete applications
- 62 field devices per network master
- Simple electronics for economical and robust performance
- Transfer medium is unshielded two-wire cable for both data and power supply
- Signal transmission has high tolerance to EMI
- Easy to install providing the greatest cost savings with the least complexity
- Free choice of network topology allows optimized wiring network
- Variety of gateways available to seamlessly tie into high level bus networks

3 Hazardous-Area Classification Methods and Equipment

The term hazardous location once meant a place within a petrochemical or some other equally volatile plant.

The term hazardous location once meant a place within a petrochemical or some other equally volatile plant. Today, hazardous manufacturing processes include coatings, adhesives, and flammable liquids in parts-cleaning tanks and dry-cleaning plants. Even food processing and other agricultural-related industries are becoming familiar with hazardous designations by the nature of the processes involved, such as grain elevators or flour and feed mills.

Textile mills and any plant that creates sawdust also fall into the hazardous category.

Selecting equipment that may be used in such locations requires an understanding of how hazards are classified. The NEMA, Underwriters' Laboratories, and the National Fire Protection Association have categorized hazardous environments by the following classes with divisions similar to European ATEX zones.

Classification of hazardous areas varies slightly between the United States and other countries. The European classification of hazardous areas generally follows that of the International Electrotechnical Commission (IEC)/ATEX *(note: I will use this IEC/ATEX relationship to reflect the harmonization of their work)* and is affiliated with the International Organization for Standardization (ISO), as its electro-technical division. The IEC classifications are as follows.

A HAZARDOUS AREA IS DIVIDED INTO ZONES – *Ex Zone Definitions*			
ZONES	GAS, MISTS, & VAPORS	ZONES	DUST
Zone 0	An atmosphere where a mixture of air and flammable substances in the form of gas, vapors, or mist ***is present frequently, continuously or for long periods.***	Zone 20	An atmosphere where a cloud of combustible dust in the air ***is present frequently, continuously or for long periods.***
Zone 1	An atmosphere where a mixture of air and flammable substances in the form of gas, vapors, or mist ***is likely to occur in normal operation occassionally***.	Zone 21	An atmosphere where a cloud of combustible dust in the air is ***ikely to occur in normal operation occassionally***.
Zone 2	An atmosphere where a mixture of air and flammable substances in the form of gas, vapors, or mist is ***not likely to occur in normal operation occassionally***.	Zone 22	An atmosphere where a cloud of combustible dust in the air is ***not likely to occur in normal operation but, if it does occur, will persist for only a short period.***

Two other safety aspects are commonly included in the classification of devices for use in hazardous areas—***gas groupings*** and ***temperature classification***. The gas grouping takes account of the maximum amount of energy which can be released under operating or fault conditions, whereas the temperature classification is concerned with the maximum temperature which can be attained by the external surface of the device.

In general, hazardous locations in North America are separated by classes, divisions, and groups to define the level of safety required for equipment installed in these locations.

Classes

The classes defines the general nature of hazardous material in the surrounding atmosphere.

CLASS	*Hazardous Material in Surrounding Atmosphere*
Class I	Hazardous because flammable gases or vapors are present in the air in quantities sufficient to produce explosive or ignitable mixtures.
Class II	Hazardous because combustible or conductive dusts are present.
Class III	Hazardous because ignitable fibers or flying's are present, but not likely to be in suspension in sufficient quantities sufficient to produce ignitable mixtures. Typical wood chips, cotton, flax and nylon. Group classifications are not applied to this class.

Divisions

The divisions defines the ***probability*** of hazardous material being present in an ignitable concentration in the surrounding atmosphere.

DIVISION	*Presence of Hazardous Material Surrounding Atmosphere*
Division 1	The substance referred to by class is present ***during normal*** conditions.
Division 2	The substance referred to by class is present ***only in abnormal*** conditions, such as container failure or system breakdown.

Groups

The divisions defines the hazardous material in the surrounding atmosphere.

GROUP	*Hazardous Material in Surrounding Atmosphere*	
Group A	Acetylene	*Apply to Class I locations*
Group B	Hydrogen, fuel ad combustible process gases containing more than 30% hydrogen by volume or gases of equivilent hazard such as butadiene, ethylene, oxide, propylene oxide and acrolein.	*Apply to Class I locations*
Group C	Carbon monoxide, ether, hydrogen sulfide, morphline, cyclopropane, ethyl and ethylene or gases of equivalent hazard.	*Apply to Class I locations*
Group D	Gasoline, acetone, ammonia, benzene, butane, cyclopropane, ethanol, hexane, methanole, methane, vinyl chloride, natural gas, naphtha, propane or gases of equivalent hazard.	*Apply to Class I locations*
Group E	Combustible metal dust, including aluminum, magnesium, and their commercial alloys or other combustible dusts whose particle size, abrasiveness and conductivity present similar hazards in connection with electrical equipment.	*Apply to Class II locations*
Group F	Carbonaceous dusts, carbon black, coal black, charcoal, coal or coke dusts that have more than 8% total entrapped volatiles or dusts that have been sesitized by other material so they present an explosion hazard.	*Apply to Class II locations*
Group G	Flour dust, grain dust, flour, starch, sugar, wood, plastic, and chemicals.	*Apply to Class II locations*

Temperature classification

Gas-air mixtures can be ignited by contact with a hot surface. Consequently, all electrical equipment used in hazardous atmospheres must be classified according to its maximum surface temperature. The table on the following page shows the ignition temperature to be taken into consideration in Europe (EEC) and the United States (NEC) for the gases and vapors stipulated there.

All temperature classifications, unless otherwise specified, are assessed with reference to a maximum ambient temperature of 40°C (104°F). If the equipment is used in a temperature higher than this, then its temperature classification should be reassessed.

TEMPERATURE CLASSES					
IEC/ATEX		NEC			
Temperature Class	Max. surface temperature, °C	Temperature identification number	Max. surface temperature °C	°F	Ignition temperature of gases or Vapors °C
T1	450	T1	450	842	>450
T2	300	T2	300	573	>300
		T2A	280	536	>280
		T2B	260	500	>260
		T2C	230	446	>230
		T2D	215	419	>215
T3	200	T3	200	392	>200
		T3A	180	356	>180
		T3B	165	329	>165
		T3C	160	320	>160
T4	200	T4	135	275	>135
		T4A	120	248	>120
T5	200	T5	100	212	>100
T6	200	T6	85	185	>85

Gas or apparatus grouping

The same gas groupings are used for flameproof and intrinsically safe equipment, and tables are available showing the equipment classification which can be used with particular groups of gases. The table below gives some examples with the IEC and North American classifications. Gas groups E, F, and G (not shown) are concerned with hazards associated with the presence of dust.

EXAMPLES OF GASES	IEC	NORTH AMERICA (group)
Hydrocarbons such as alkenes, including propane, benzenoids, alkenes, gasoline	IIA	D
Oxygen compounds such as carbon monoxide, alcohols and phenols, some aldehydes, ketones, esters		
Halogens		
Nitrogen compounds such as ammonia, amines, amides		
Natural gas	IIB	C
Hydrocarbons such as ethylene propylene		
Oxygen compounds such as ethyl ether, aldehydes ***Hydrogen sulfide***		
Hydrogen Carbon disulfide	IIC	B
Acetylene (with special material limitations	IIC	A

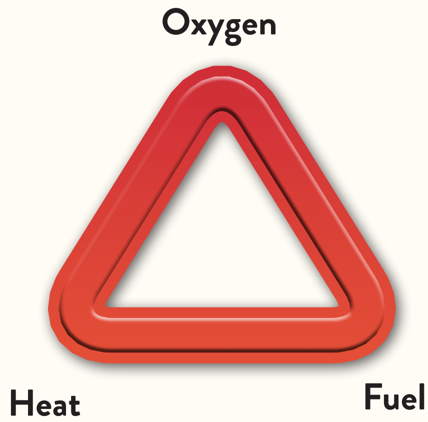
Note: These are approximate correlations

The overall term used in Europe covering all methods of protection is explosion-proof, and the symbol Ex is used. In the United States engineers tend to use the term explosion-proof as being synonymous with the European term flameproof and this often causes confusion.

METHODS OF EXPLOSION PROTECTION	
TYPE OF PROTECTION	METHOD
Ex d Flameproof Enclosure	Designed to prevent any ignition from spreading
Ex q Powder Filing	
Ex i Intrinsic Safety	Designed to limit the ignition energy of the circuit
Ex e Increased Safety	Designed to prevent any ignition from arising
Ex N or **Ex nA** Non Sparking	
Ex m Encapsulation	Designed to prevent the flammable mixture reaching a means of ignition
Ex p Pressurisation	
Ex o Oil immersion	
Ex N or **Ex nR** Restricted Breathing	

Methods for Safe Control

Understanding design methods for operating equipment in hazardous areas starts with the ***combustion triangle***. Fuel, oxygen, and a source of ignition (spark or temperature) must be present at the same time (and in the necessary proportions) for combustion to occur.



One approach to creating a safe environment for hazardous areas is confinement; isolating the area reduces the possibility of accidents. Isolation involves removing or confining any possible element which could create a spark and ignite an explosion. There are three common methods of providing safety within a hazardous location, categorized by the power technology used; (1) pneumatic, (2) explosion-proof, and (3) intrinsically safe systems.

Pneumatic systems

Pneumatic systems are, by their nature, a safe means of control because they are powered by air. Pneumatic systems are generally clean and easy to service, but the number of control operations performed by pneumatic sequencers is limited. This can be augmented by an electro pneumatic interface which enables pneumatics to be controlled by a Programmable Logic Controller.

The drawbacks to pneumatic systems are in distance and reaction times. Where installations are spread over a wide area, the slow reaction time of pneumatic systems increases control reaction time. The length of control circuits in a total pneumatic system must be limited for the control cycle time to remain short.

"Explosion-Proof" Enclosures - NEMA classifications

Explosion-proof housings provide a simple means to adapt electric and electromechanical and electro-pneumatic controls to hazardous locations, Explosion-proof housings are designed to withstand the explosion of a mixture inside the enclosure and to prevent the spread of the flame to the outside. These enclosures are effective, especially for interrupting high currents to motors using limit switches. However, this method lacks flexibility in the use of sensing techniques because of the size of the devices. In addition to the space required for explosion-proof devices, material and labor costs for installation and service may be high.

NEMA CLASSIFICATIONS	
I	GENERAL PURPOSE Protects against indirect splashing of dust and light but not dusttight; primarily prevents contact with live parts; usded in-doors and under normal atmospheric conditions.
II	DRIPTIGHT Similar to type I, with addition of drip shields or equivalent; used where condesation may be severe as in cooling rooms and laundries.
III	WEATHER RESISTANT Protects against weather hazards such as rain and sleet; used outdoors in ship docks, for construction work, and in tunnels and subways.
IV	WATERTIGHT **(weatherproof)** Must exclude at least 65 gal/min (247 L/m) of water from 1-in (25-mm) nozzle delivered from a distance of not less than 10ft (3m) for 5 min. Used outdoors on ship docks, in dairies, and in breweries.
V	DUSTTIGHT Provided with gaskets or equivalent to exclude dust; used in steel mills and cement plants.
VI	SUBMERSIBLE Design depends on specified conditions of pressure and time; used for submerssion in water, as in quarries, mines, and manholes.
VII	HAZARDOUS LOCATIONS **(explosive gas or vapor)** Meets application requirements Class I of National Electrical Code; conforms with specifications of Underwriter's Laboratories, Inc.; used for atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, acetone, benzol, lacquer, solvent vapors, and natural gas.
TYPE 8 enclosures	**HAZARDOUS LOCATIONS (oil-immersed)** Type 8 enclosures are for indoor or outdoor locations classified as Class I, Groups A, B, C, or D, as defined in the National Electrical Code.
TYPE 9 enclosures	**HAZARDOUS LOCATIONS (dust-ignition proof)** Type 9 enclosures are for use in indoor locations classified as Class II, Groups E, F, or G, as defined in the National Electrical Code.
IX	**HAZARDOUS LOCATIONS (combustible dust)** Meets application requirements Class II of National Electrical Code; conforms with specifications of Underwriter's Laboratories, Inc.; used for atmospheres containing metal dusts, carbon black, coal or coke dust, flour, starch or grain dusts.

Ingress Protection (IP)

Ratings-specifying the environmental protection the enclosure provides. This is not a system of hazardous area classification.

The IP rating normally has two numbers:

1. ***Protection from solid objects or materials***
2. ***Protection from liquids (water)***

IP (Ingress Protection) & NEMA Protection Rating Information

An IP number contains two numbers (ie-IP65) in most instances which relate to the level of protection provided by an enclosure or housing.

FIRST NUMBER RELATES TO PROTECTION FROM SOLIDS		SECOND NUMBER RELATES TO PROTECTION FROM LIQUIDS	
0	No special protection	**0**	No special protection
1	Protected against solid object up to 50mm in diameter	**1**	Protected against dripping water
2	Protected against solid object up to 12mm in diameter	**2**	Protected against dripping water when tilted up to 15˚ from normal position
3	Protected against solid object up to 2.5mm in diameter	**3**	Protected against spraying water
4	Protected against solid object up to 1mm in diameter	**4**	Protected against splashing water
5	Dust protected	**5**	Protected against water jet spray
6	Dust tight	**6**	Protected against heavy jet spray
		7	Protected against the effects of immersion
		8	Protected against submersion

EXAMPLE

IP66 = Dust tight and protected against heavy water jet spray

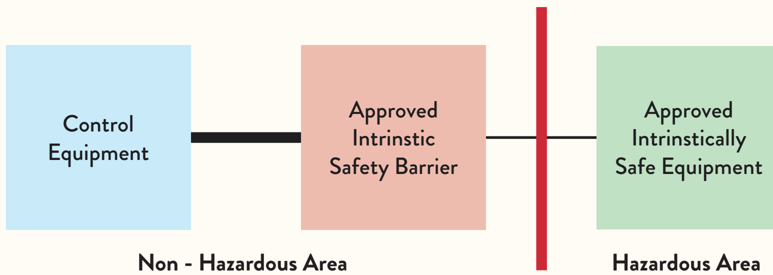
NEMA 1 = IP10	**NEMA 4x =** IP66
NEMA 2 = IP11	**NEMA 16 =** IP67
NEMA 3 = IP54	**NEMA 12 =** IP52
NEMA 4 = IP56	**NEMA 13 =** IP54

NEMA (National Electrical Manufacturers Association) ratings can be approximately compared to of those of the IP, Other factors such as corrosion protection are also involved in the NEMA system, please refer to official

Intrinsic safety

Intrinsic safety implies that there is insufficient electric energy in a circuit to ignite the most readily flammable mixture of a gas and air. As mentioned in relation to classification, the energy can appear as a spark resulting from its sudden release or in thermal form from the temperature rise of a surface. The equipment design must consider fault conditions as well as normal operation.

According to the National Electrical Code, "Intrinsically safe equipment and wiring shall not be capable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific flammable or combustible atmosphere mixture in its most easily ignitable concentration."



There is a fundamental difference between intrinsic safety and the other equipment application techniques. None of the others aims at preventing release of energy at a dangerous level.

Instead they avoid the possible effects in a number of ways:

1. **Ensuring that when a spark occurs, it is prevented from reaching an explosive mixture**
2. **Ensuring that any explosion is contained**
3. **Reducing the hazard by diluting the gas mixture to a safe level**
4. **Protecting against excessive temperature or spark which occurs exceptionally**

Intrinsic safety, on the other hand, deals with the root cause and ensures that there is insufficient energy available, whatever happens, to cause an explosion. It is, therefore, considered by some to be the safest and most technically elegant approach. It has a number of practical advantages, offering compact design, reliability, low cost, simple installation and the possibility, not available with flameproof equipment, of on-line maintenance, if required. The principal disadvantage is the relatively low amount of power available, although this has been largely overcome by a growing range of specially designed components and equipment. For all practical purposes, intrinsic safety is the only safe technique suitable for zone 0 and is often the preferred approach for zone 1 (division 1).

There are two standards on intrinsic safety in IEC countries:

1. **"ia" being the higher standard where safety is maintained with up to two faults**
2. **"ib" where safety is maintained with up to one fault**

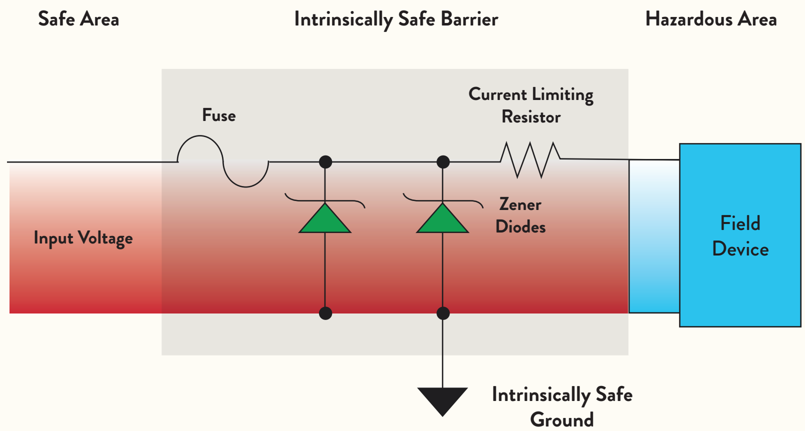
Equipment certified to "ib" standards is generally acceptable in all zones except zone 0, and "ia" equipment is suitable for use in all zones. In America there is only one standard, and all hazardous area equipment must maintain safety with up to two component faults.

Intrinsically safe elements in an automated valve package

Background

Pneumatic actuators for process valve automation are well suited for low-power or intrinsically safe system integration. Where electric motors or other high-power devices do not directly interface with today's computer-controlled systems, pneumatic actuators when properly sized and fitted with compatible control accessories can satisfy a variety of computer-direct process control requirements. When used in an intrinsically safe system, pneumatic actuator control accessories must be connected to a properly selected and approved barrier.

What are intrinsic safety barriers?



Intrinsic safety barriers are current-and voltage-limiting assemblies which are designed and constructed to requirements as described by ANSI/UL 913 (formerly NFPA 493) in the United States and CSA 22.2 number 157M in Canada.

When operating conditions are abnormal, the intrinsic safety barriers circuit is designed to divert excessive current to ground. This diversion is accomplished by the Zener diodes, while current limiting is provided by a resistor. If voltage higher than the maximum allowed by the safety barrier is applied across the barrier, the Zener diode would then conduct that excess current to ground. Should current continue to increase, the fuse will open the circuit arresting current flow altogether.

Advantages of low power.

All other methods of protection—e.g., pressurization, use of explosion-proof enclosures, or oil filling—rely on the maintenance of a physical barrier between the explosive atmosphere and the electric circuit. Out on the plant and difficult to monitor, a hazardous area enclosure has only to be breached at one point for protection to become nonexistent. In contrast, intrinsically safe elements provide inherent protection by restricting the energy at its source and as a result offer some advantages.

Some advantages include:

- ***Economy.*** **Enclosures are lighter, less cumbersome, and economical. Costly screwed conduits can be replaced by ordinary wiring. Thermocouples, resistors, switches, and other non-energy storing field equipment can be constructed to ordinary (weatherproof) specifications.**
- ***Live maintenance.*** **It is not necessary to cut power before calibrating or otherwise adjusting field equipment. Glanded or magnetically coupled controls through flameproof housings are not needed.**
- ***Reliability.*** **The system remains safe if seals fail, cables are severed, or the covers of enclosures or conduit boxes are improperly replaced. Switches do not require long, thin flame-retarding air gaps which are prone to corrosion and seizure.**
- ***Safety.*** **Personnel cannot be harmed by the low voltages used in intrinsically safe circuits.**

There are three common electric components that are used with pneumatic valve actuators: the solenoid valve, limit switch, and transducer (or electro-pneumatic positioner). Each of these devices is manufactured in a version that allows them to be classified as low-power and are therefore appropriate elements for use in an intrinsically safe system.

It must be emphasized that a component with an intrinsically safe approval will only be safe either when installed within the terms of the approval documents and of the relevant codes of practice or when the system configuration has been given prior expert approval.

Typically, the cost of an intrinsically safe component is comparable or slightly higher than the standard explosion-proof device. When one considers that explosion-proof fittings and conduits are no longer needed, on the average the installed system may be less costly for intrinsically safe devices. Also, operating costs are lower as power consumption is negligible. Plus, an intrinsically safe system can be serviced in hazardous areas while the power is on, something which cannot be done with standard explosion-proof devices.

Finally, when an intrinsically safe system is installed correctly, it is always explosion-proof. When standard explosion-proof housings are damaged or there are errors in installation that allow a flame path to develop, the system is no longer explosion-proof. Some insurance companies have rewarded companies who install intrinsically safe systems by charging them lower premiums.

In Closing

A process control scheme will likely be developed for very specific outputs, rates and materials. It may also need to address pressure and temperature conditions and hazardous area locations. With the many options, classifications and control solutions available today it is always a good idea to work with a highly experienced automation supplier.

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This white paper is derived from the technical book, ***Valve and Actuator Technology*** by Wayne Ulanski.

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