

The process industry recognises different sub-segments with specific demands such as for oil & gas, (petro) chemical, power, water & sewage, pulp & paper and pharmaceutical markets. Quality and reliability of process valves are of great importance for the safety and output of the production. This applies especially to the severe conditions in the offshore industry or on cold/hot spots around the globe. The solenoid pilot valve therefore, being a critical link in the process valve loop, should be carefully sized and selected to meet precisely the application needs. This catalogue is issued as a tool in doing so.

ACTUATOR INTERFACE TYPES AND PILOT VALVE FUNCTION

Pilot valve location and Interface

For pilot valves in this catalogue the following definition is used: Solenoid pilot valves are valves used to control the flow of air to pneumatic actuators which in turn are moving process valves to their required (open or closed) position.

Basically, three alternatives for mounting the pilot valve exist:

- Pilot valve directly mounted on the actuator
- Pilot valve remotely mounted/centralised
- Pilot valve integrated in the actuator or process valve

The first two possibilities are within the scope of this catalogue and will be described hereafter.

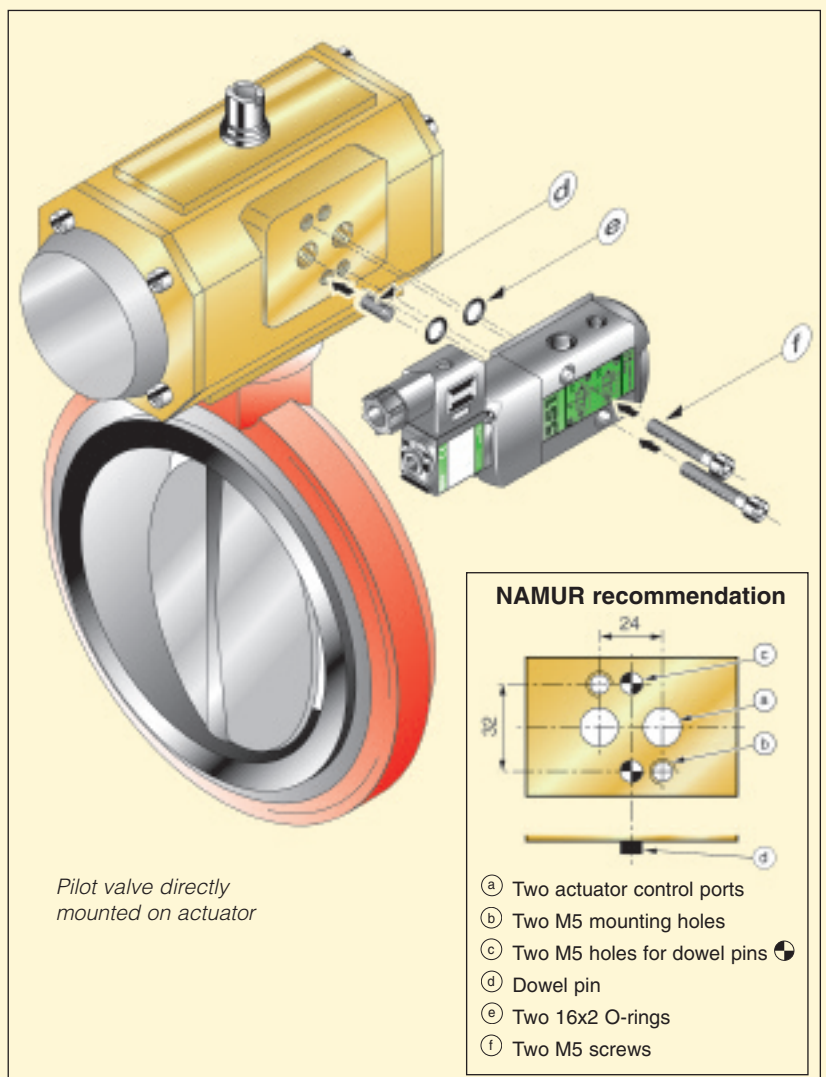
Pilot valve directly mounted on the actuator

In many cases the pilot valve is mounted on the actuator to control the air flow and thus the opening and closing of the actuator and process valve. To avoid time-consuming mounting and minimise the risk of technical problems with the traditional nipple/piping style mounting, interfaces for direct mounting were developed. In this situation the flow path thus flow and actuator speed are optimal. Users in Germany published in 1987 a NAMUR standard for the direct mounting of pilot valves on actuators. This standard has grown into a large market share and is now popular worldwide. For the end-users there are advantages such as compactness & economics, flexible choice of suppliers and easiness in specifying. For the 3/2 function the air to the actuator spring chambers also flows through the pilot valve, the so-called re-breather function, see also diagrams for further explanation. This prevents corrosion of the actuator springs and consequently malfunctions.

In November 2009 EN 15714-3 standard on interfaces between valves, actuators and auxiliary equipment was published. Next to the NAMUR style interface for quarter turn movement, a new interface for linear movement was introduced, see schematics. In this case the pilot valve has to be mounted on the positioner for quick and secured closing of the process valve. Two extra channels are specified here. Channel 1 funnels the positioning pressure sig-

nal from the positioner to the actuator. Channel 4 can be used to provide auxiliary air when pressure assisted pilot valves are used. Using direct acting valves the latter can be sealed off.

CEN - European Committee for standardisation has prepared this standard on part turn actuators where for direct mounted pilot valves also the NAMUR style interface is used. New is that for both, remote and direct mounted pilot valves, the size of the pressure connection depends on the actuator air volume (see table next page). The advantage is that pilot valves can also be mounted directly on large higher volume actuators and the flow and speed are not restricted by connections, which are too small.



Direct Mounted, CEN/NAMUR style interface

Actuator air volume "V" (l)	Actuator/solenoid pressure connection "T" (inch)
$V < 1$	1/8"
$0,5 < V < 10$	1/4"
$5 < V < 25$	3/8"
$10 < V < 50$	1/2"

Pilot valves remotely mounted/centralised

Besides direct mount constructions many pilot valves are mounted remote from the process valve. Precautions have to be taken on the selection of the pilot valve depending on the distance and diameter of the tubing/nipples used. All these factors will influence the flow and consequently the maximum actuator/process valve speed. In the standard, as mentioned before, the connections are specified depending on the actuator volume. A separate table in this standard is dedicated to remote mounted pilot valves using larger pilot valve connections.

Pilot valve manifolds/islands are often mounted in cabinets offering mechanical protection. Benefits are the centralised pressure

Remote Mounted pilot valve

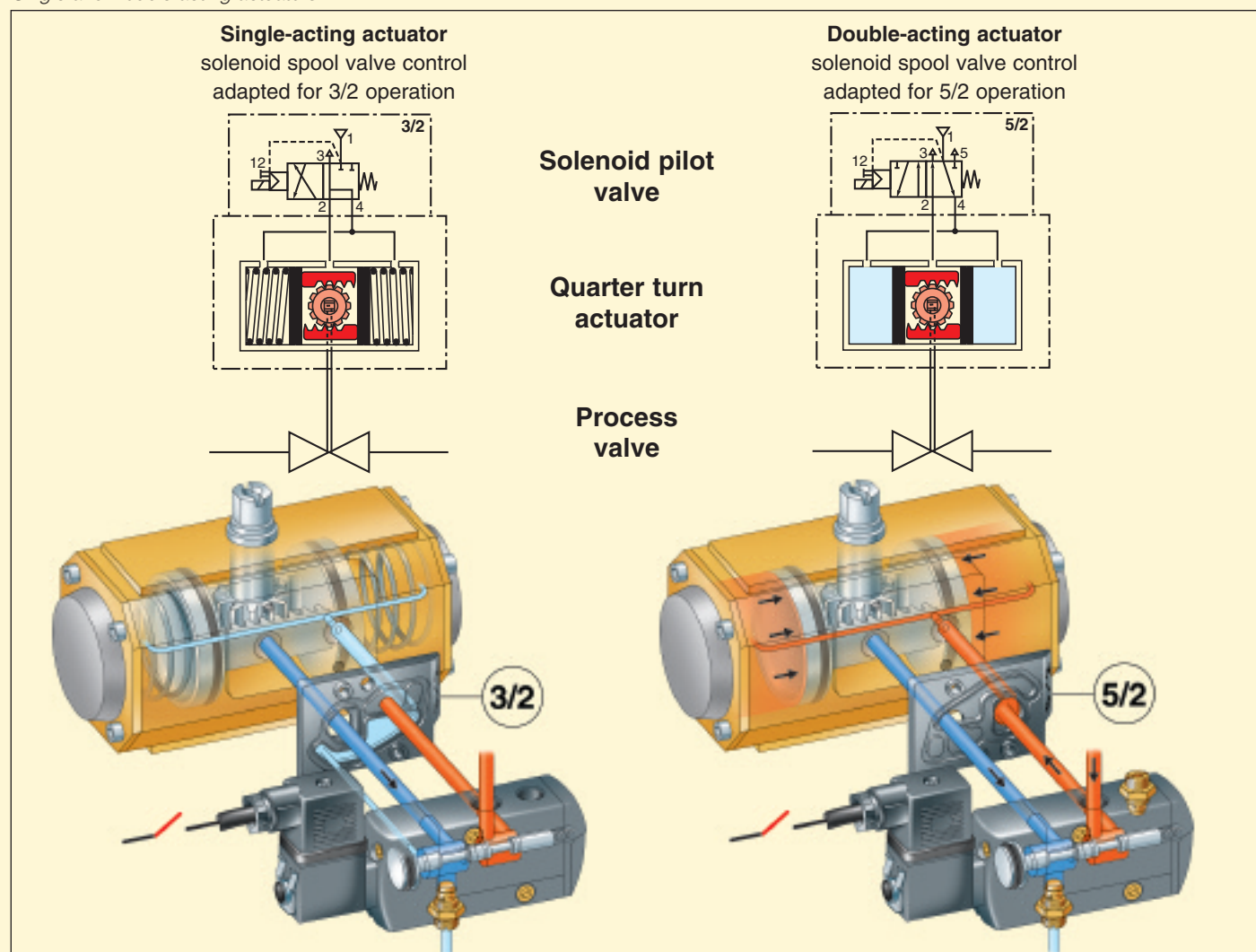
Actuator air volume "V" (l)	Actuator/solenoid pressure connection "T" (inch)
$V < 1$	1/8"
$0,5 < V < 10$	1/4"
$5 < V < 25$	3/8"
$10 < V < 50$	1/2"
$25 < V < 100$	3/4"
$V > 50$	1"

and electrical connection where the latter is especially beneficial when Fieldbus systems are used.

Functions for single or double acting actuators

A single acting (spring return) actuator requires a 3/2 control function while a double acting actuator requires a 4/2 or 5/2 function (see also the diagrams for further explanation). In the NAMUR standard next to the 3 standard connections for Pressure, Exhaust and Cylinder/Actuator, a fourth connection is used to collect the exhaust air/gas from the actuator spring-chambers and provides the so-called re-breather function.

Single and Double acting actuators

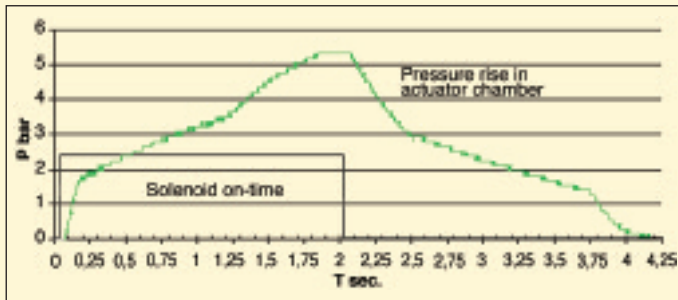


Mono-or bistable pilot valves

The majority of pilot valves are of the spring-return or mono-stable type usually providing a reliable return to the Normal Closed (NC) or Normal Open (NO) position. If the electrical signal is switched off the valve is returning to its "normal" position by the spring force. For pilot operated valves the same happens if the pressure drops below the minimum required pressure differential. Bistable solenoid valves have two solenoid operators which are energized one at a time to shift the valve to the other position. Usually the valve remains in its last position if the electrical signal or pressure is removed. See also the typical symbols on these various constructions.

Pilot valve flow values and actuator/process valve speed

The response time and stroke of a specific pneumatic actuator and process valve depend on the flow, which passes through the pilot valve and its connections at a certain pressure in a certain time. See figure for a pressure curve inside the actuator.



Besides the flow characteristics of the feeding lines/pilot valves the actuator volume and minimum operating (break-away) pressure etc. are important to determine the actuator/process valve response times. The European norm described before is a useful tool in the selection of pilot valves depending on the actuator size. To determine the actuator/process valve response times for e.g. fail safe applications a calculation has to be made involving the pilot valve flow factor, actuator volume, required torques etc.

TECHNOLOGY, DIRECT ACTING OR PILOT OPERATED / PRESSURE ASSISTED

One way to make a distinction in solenoid pilot valve technology is to split them into direct acting and pilot operated/pressure constructions. This choice has many consequences, see the table below:

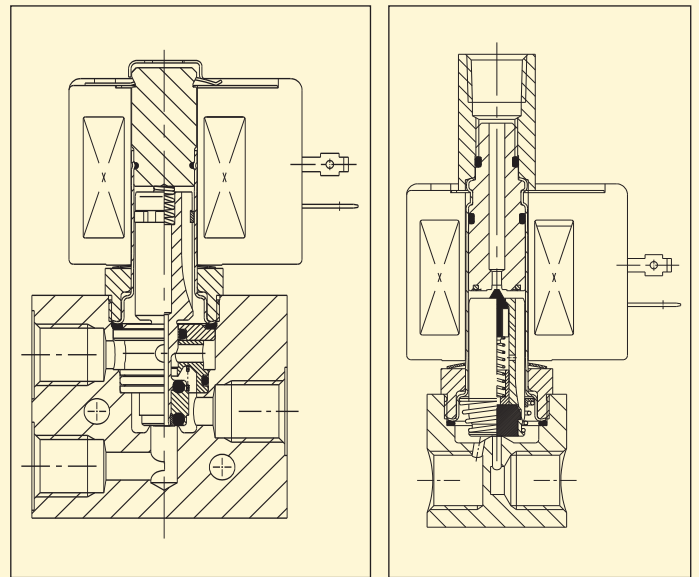
DIRECT ACTING

- All energy for the operation comes from the solenoid operator
- High electrical power level for high flows
- Operates from zero pressure differential (electrical power only)
- No bleed holes or bleed channels
- Less risk of malfunction
- Also selected for standardization

Direct acting pilot valves

With direct acting pilot valve all the energy for the operation is derived from electrical energy that is transformed into mechanical movement in the solenoid operator. Since the required force is equal to the surface times pressure ($F = P \times A$), the larger the orifice/flow the higher the required electrical power. The advantage is its simplicity and reliability. For small flows and 2/2 and 3/2 solenoid valves it is also very economical. For large flow levels the required solenoid operators become relatively big and less economical. See typical examples of direct acting pilot valves.

Typical direct acting solenoid valves



Pilot operated / pressure assisted pilot valves

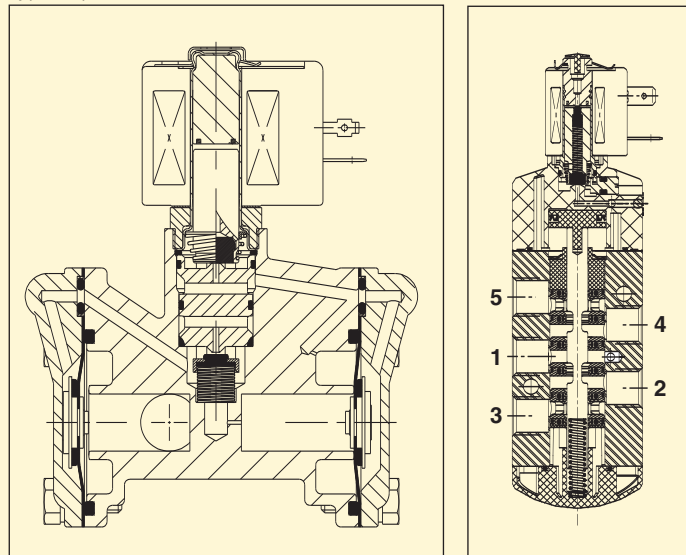
With pilot operated or pressure assisted solenoid valves the inlet pressure is used to provide energy to create a mechanical movement. Therefore, a minimum pressure differential is required between inlet and actuator port, usually with values between 0.7 and 2.5 bar, to operate the valve. The solenoid operator opens or closes the channel where the main pressure is guided to the spot where it is used for operation. The advantage is that for higher flow levels solenoids can be relatively small. A disadvantage can be that such pilot valves do not work on low-pressure signals e.g. used for "control valves" positioning. The bleed holes or channels to guide the pressure from the inlet are sometimes considered as a disadvantage

PILOT OPERATED

- Pressure is assisting the valve operation
- Lower electrical power level
- Needs minimum pressure differential for operation
- Bleed holes or channels
- More economical for higher flow values

since they can be blocked if the compressed air is of inferior quality. Refer to typical examples of pressure assisted pilot valves below.

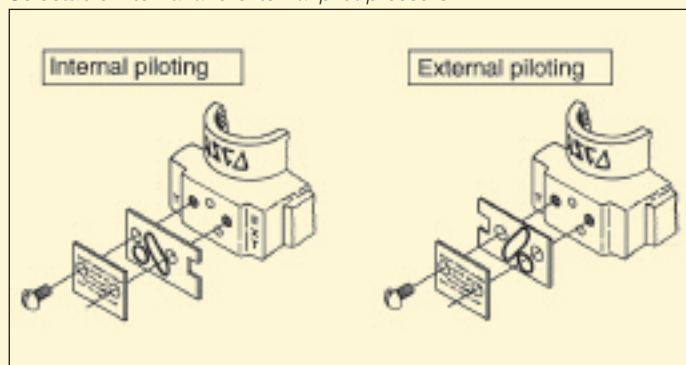
Typical pressure assisted solenoid valves



Auxiliary pilot pressure connection on pressure assisted valves

Some pressure assisted pilot valves have an (optional) auxiliary pilot pressure connection. If the minimum pressure to operate the valve can not be guaranteed on the main pressure inlet port an auxiliary pressure can be applied on an additional port. For some constructions one can make a selection between pilot pressure from the main supply or auxiliary external connection, by turning a seal.

Selectable internal and external pilot pressure



POWER CONSUMPTION AND DEGREE OF PROTECTION

For the power consumption of pilot valves the following subjects are of importance and will be described:

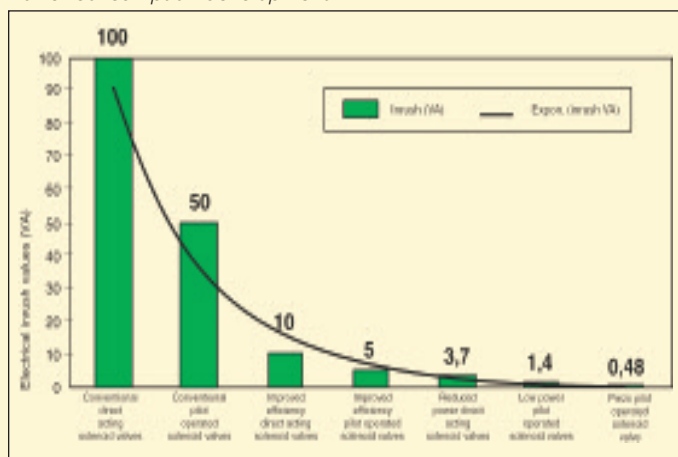
- Power consumption; a historical development
- Control by an AC or DC voltage source
- Temperature influence
- Peak voltage suppression

Power consumption development

To reduce the total cost of installations and to make the solenoids more reliable and suitable for Fieldbus control there is a strong trend towards lower power consumption. Lower power consumption also increases the safety in hazardous areas due to less heat dissipation. Since in most protection systems there is a strong relation between the generated heat of the coil and the solenoid surface temperature it will be easier to meet higher temperature classes.

While in the past, power levels of 30 Watt or more were not unusual, the minimum levels have been largely reduced to around 5-10 watt for typical direct acting pilot valves and 2 Watt for pressure assisted/pilot operated types. However, the reliability could still be increased. This has been achieved by using better materials, new techniques like TIG welding in the Electromagnet and the use of sophisticated 3D CAD software for magnetic analyses and thus optimising the shape of the magnetic circuit. Refer to the curve below for historical development of the solenoid power consumption. Utilising piezo technology, operators have been developed functioning on extreme low power levels.

Power consumption development

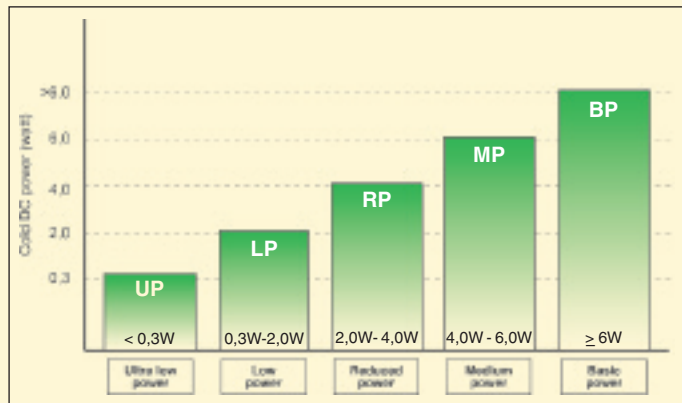


The required electrical power depends on the energy needed to deliver the solenoid driver force ($F=P \times A$) and also depends on the pressure differential and orifice. This is related to the pilot valve construction to be operated. As explained the selection for direct acting or pilot operated constructions has a big influence on the required solenoid energy.

For ease of communication 5 different power levels (cold) are throughout this catalogue:

- Ultra Low Power (UP) < 0.3 Watt
- Low Power (LP) ≥ 0.3 < 2 Watt
- Reduced Power (RP) ≥ 2 < 4 Watt
- Medium Power (MP) ≥ 4 < 6 Watt
- Basic Power (BP) ≥ 6 Watt

DC Power levels - cold electrical holding values (watt)



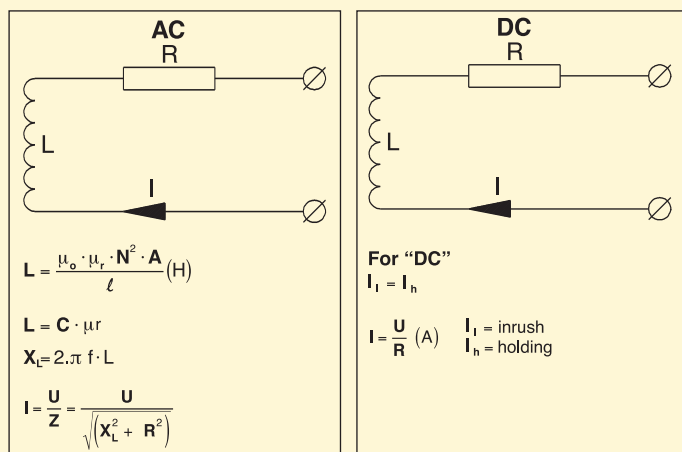
Control by an AC or DC voltage source

The current draw of AC (alternating current) coils is determined by coil impedance, not resistance alone. Impedance results from a combination of resistance and inductive reactance. AC (alternating current) electromagnets have a high inrush current and consequently high pull-force making it easy to overcome the stroke of the plug nut, which closes the air gap between the core and plug nut.

Current in DC (direct current) solenoids depends only on resistance, so inrush and holding current are no different.

Because of this AC solenoids have relatively lower nominal power levels but the inrush current peak has to be considered. Also because of this for the same pilot valve the nominal DC power rating or wattage is higher. AC solenoids are sensitive to blocking cores e.g. caused by dust since the air-gap and high current will remain resulting in coil burnout.

AC and DC calculations



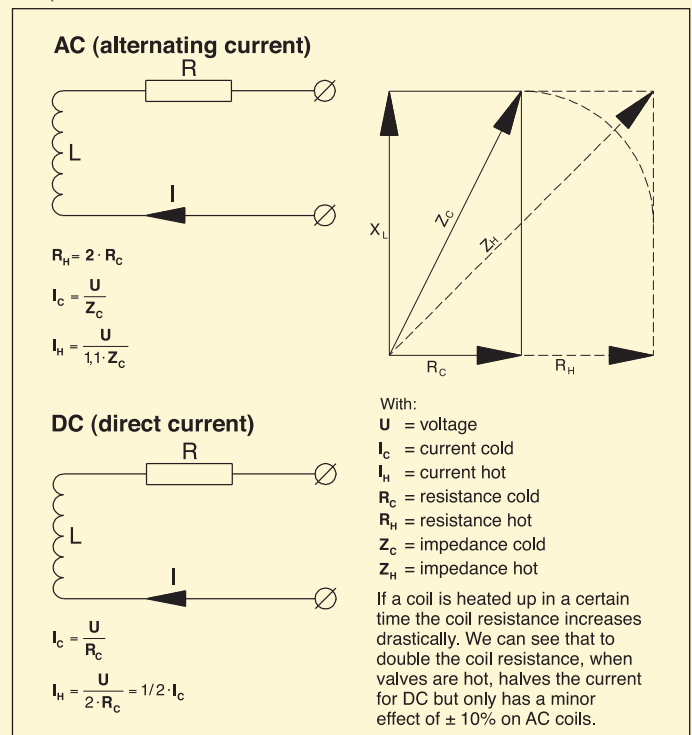
Temperature influence

The resistance of the copper windings in the coil changes with the temperature. At higher temperatures the ohmical resistance increases and consequently the current, power and solenoid strengths decrease. At AC current the ohmical resistance in the

coils is only a small part of the total resistance so the temperature influence is not significant. However, DC solenoids have only ohmical resistance so their strength decreases considerably at higher ambient temperatures.

If power ratings are given, especially on DC solenoids, it is important to know whether the data refer to cold or hot conditions. An example in this catalogue is a 327 type valve at DC which has 11.2 watt at normal ambient temperature (cold) which decreases to 9 watt at the maximum specified temperature. To avoid any risk ASCO NUMATICS specifies in this catalogue both hot and cold wattages while specifications such as maximum pressure etc. are based on the most unfavourable condition meaning hot. And at the same time values are based on the maximum under voltage, normally 85% of the nominal voltage.

Temperature influence on AC/DC coils
















Peak voltage suppression

Where a typical AC solenoid has a high inrush current a AC/DC solenoid has a switch-off peak voltage. Depending on the control system used, this peak voltage surge could damage the electronics. For that reason some solenoids have standard or optional electronic components such as diodes or varistors fitted (moulded in) to suppress the surge and protect the electronics.

Degree of electrical protection (IP Code)

The degree of protection provided by the electrical enclosures (IP Code) according to EN 60259 and IEC 529 is described as code letters IP (Ingress Protection) followed by two digits: e.g. IP65. The first characteristic numerical indicates the degree of protection of the solenoid against ingress of solid foreign objects.

Degrees of protection provided by electrical enclosures (IP codes)

1st NUMERAL	Abridged definition	Test	2nd NUMERAL	Abridged definition	Test
0	Non-protected		0	Non-protected	
1	Protected against solid foreign objects Ø 50 mm (e.g. accidental contact with the hand)		1	Protected against vertically falling water drops (condensation)	
2	Protected against solid foreign objects Ø 12,5 mm (e.g. finger)		2	Protected against vertically falling water drops when enclosure tilted up to 15°	
3	Protected against solid foreign objects Ø 2,5 mm (e.g. tools, wires)		3	Protected against spraying water up to 60° on either side of the vertical	
4	Protected against solid bodies Ø 1 mm (e.g. fine tools and small wires)		4	Protected against splashing water from any direction	
5	Dust-protected (no harmful deposit)		5	Protected against water jets from any direction	
6	Dust-tight		6	Protected against powerful water jets from any direction	
			7	Protected against the effects of temporary immersion in water	

The second index figure describes protection against ingress of water with harmful effects from all directions. Refer to table for further explanation.

PILOT VALVE (ISLANDS) COMMUNICATION THROUGH FIELDBUS AND REMOTE I/O

More and more field-instruments and valves are controlled over (Field)bus systems such as Profibus-DP or PA, AS-interface and Foundation Fieldbus. Some typical configurations controlling solenoid valve (islands) are:

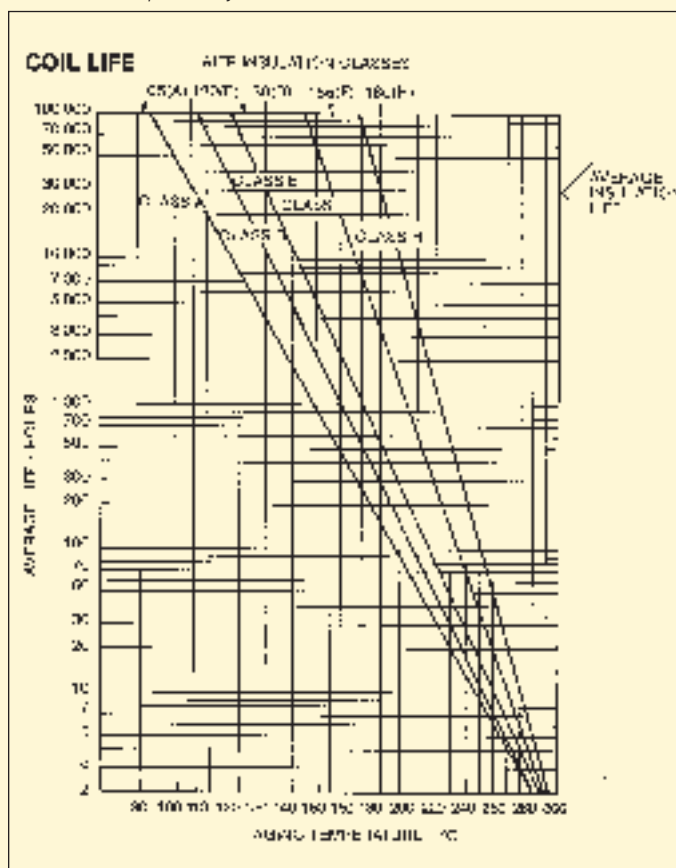
- Fieldbus control using remote I/O units or valve couplers.
- Fieldbus control to top-boxes controlling the solenoid valve
- Fieldbus control directly to solenoid valve(islands) with bus-chips integrated

Profibus-PA and Foundation Fieldbus are developed for the process industry. These bus systems are suitable for explosive atmospheres, using the FISCO (Fieldbus Intrinsically Safe Concept) model the bus is intrinsically safe. The connected intrinsically safe solenoid valve (islands) should be extreme low power since, depending on the environment, only 110-500 mA is available for the whole bus. Special valve couplers or remote I/O units for these buses have valve output levels with a minimum of 6V, 1.5 mA. Piezo operators listed in this catalogue are suitable for these applications. Refer to chapter 8 for various IS compatibility charts.

COIL VOLTAGE AND INSULATION CLASS

As listed on each catalogue page, a number of standard coil voltages are available in AC, usually 24-115 and 230V 50Hz and in DC 24 V.

Coil lifetime expectancy curves



In general the coils are in class F insulation meaning that the maximum coil temperature is calculated for 155°C. This temperature is the result of the sum of the surrounding ambient temperature, self heating, and potential transferred heat from the fluid through the valve.

In many cases optional H-class coils are available meaning the maximum coil temperature is 180°C. This means 25°C extra heat can be withstood compared to F which can be used e.g. for higher ambient temperatures or to increase the coil life time expectancy at the same temperature. Most of the solenoids listed in this catalogue are based on the U.S. standards for 30,000 hours continuous duty while European standards ask for 20,000 hours.

The result of increasing the total temperature, even above the maximum specified limit, is reduced lifetime expectancy, see also the graph.

FUNCTIONAL SAFETY

More and more emphasis is put on the safety of equipment. Especially for safety related systems it is essential that they will operate when required. To improve the performance, reliability and standardisation of safety systems, a number of national and international standards have been developed.

A description of functional safety and applicable standards will be given using the following topics:

- What is functional safety ?
- Safety systems in the Process Industry
- DIN 19250 & DIN 19251 standards
- IEC 61508 & IEC 61511 standards
- Safety standards and ASCO pilot valves

What is functional safety ?

First the definition of safety: This is freedom from unacceptable risk of physical injury or of damage to the health of people, either directly or indirectly as a result of damage to property or to the environment.

Functional safety is part of the overall safety that depends on a system or equipment operating correctly in response to its inputs.

Safety systems in the Process Industry

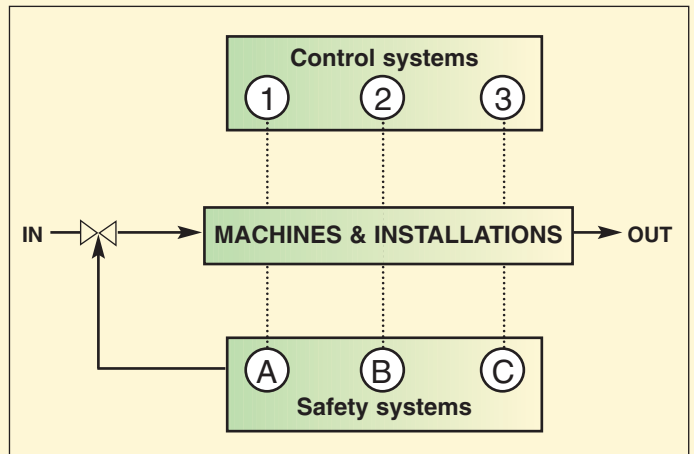
Installations in the Process Industry are generally controlled by means of 2 different systems.

As shown below, they contain:

Control systems: systems that control the installation under normal conditions.

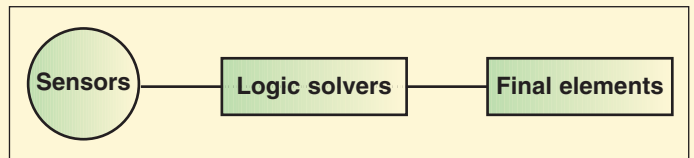
Safety systems: systems that bring the installation into a safe state in case of an emergency condition. Normally, this is done by shutting down the complete installation (ESD = Emergency Shutdown Devices)

Layout of control & safety systems within installations/machines



The safety system normally operates independently from normal process control systems and is only activated in case of dangerous situations. It has to fulfil a large amount of requirements that guarantee the safety of people, environment and installation in case of an emergency.

A safety system has an architecture of 3 parts: Sensors, Logic solvers and Final elements. Each part can be either a single device or a sub-system consisting of more single devices. The expertise field of ASCO Numatics lies within the "Final element" part, where a single solenoid valve or a process valve piloted by a solenoid valve can be used.



Configuration of devices/sub-systems within a safety system.

DIN 19250 & DIN 19251 standards

From the mid-nineties Germany had his local DIN 19250 and 19251 standards.

Depending on the consequences of failures for people, environment and equipment so called "AK-classes" (Anforderungsklassen) were defined.

- | | |
|-----------|---|
| DIN 19250 | Fundamental safety aspects to be considered for measurement and control equipment. (1994) |
| DIN 19251 | Measurement & control equipment; Requirements and measures for safeguarding functions. (1995) |

In these standards users/designers of safety systems first classify their systems into classes AK1 up to 7 conform DIN 19250. Next, the DIN 19251 standard specifies for every AK class, a package of technical /non-technical requirements to prevent potential causes of failure and/or mitigate the effects of such failures.

The total package can be divided into 2 part lists:

- One with requirements for the manufacturer of the safety system.
- One with requirements for the customer/user of the safety system.

Depending on the AK class, both lists show whether the prevention and mitigation of different kind of failures should be handled with a Low (E), Normal (N), Middle (M) or High (H) level of requirements.

With qualitative analysis using FMEA (Failure Mode Effect Analysis) methods it is established whether or not equipment is found suitable with or without taking precautions. To obtain a higher AK-class for solenoid valves, precautions to be taken are for example protecting the pressure inlet connections and exhaust ports, frequent testing and redundant, 2oo2 (two out of two) or 2oo3 (two out of three) configurations.

IEC 61508 & IEC 61511 standards

To improve performance, reliability and standardization of safety systems, a number of national and international standards have been developed.

IEC 61508 Functional safety of Electrical/Electronic/Program-mable electronic (E/E/EP) Safety Related Systems.

IEC 61511 Functional safety of Safety Instrumented Systems for the process industry.

IEC stands for International Electrotechnical Commission and is recognised all over the world. The standard IEC 61508 (1998) was written as the basic standard for safety systems in the industry in general, which forms the platform for industry specific standards in the future.

As a result IEC 61511 has been derived specifically for designers, integrators and users of safety systems in the process industry. For manufacturers and suppliers of single devices used in safety systems such as ASCO Numatics, IEC 61511 refers back to IEC 61508.

Four (4) Safety Integrity Levels (SIL) are defined. Each safety process loop has to be analyzed for the probability of failure per usage. Four levels exist with SIL 4 being the highest achievable safety level:

- Level 1: Minor property and production protection
- Level 2: Major property and production protection (possible people injury)
- Level 3: Employee and community protection
- Level 4: Catastrophic community impact

A SIL-level is given by the plant-owner for a complete functional safety loop. To determine whether a safety process loop fulfils a certain SIL-level a calculation should be made using for each component in the loop the PFD (Probability of Failure on Demand) factors. The PFD for the loop (PFD_{total}) can be determined by the sum of the PFD's of each sub-system. PFD_{total}

should meet the range of PFD, which belongs to the required SIL-value, see table.

SIL levels and PFD ranges

SIL level	PFD (total SIS) {Probability of Failure to perform its designed function on Demand}	Risk reduction
4	$1 \cdot 10^{-5} \leq \text{PFD} < 1 \cdot 10^{-4}$	High ↑ ↓ Low
3	$1 \cdot 10^{-4} \leq \text{PFD} < 1 \cdot 10^{-3}$	
2	$1 \cdot 10^{-3} \leq \text{PFD} < 1 \cdot 10^{-2}$	
1	$1 \cdot 10^{-2} \leq \text{PFD} < 1 \cdot 10^{-1}$	

Safety standards and ASCO pilot valves

Several ASCO pilot valves have certified reliability figures to be used for safety calculations. SIL certified series such as the 126, 327 and 551 valves can be ordered. Valves are standard supplied with the appropriate Installation & Maintenance sheet, certificate and exhaust protector(s). Detailed information can be found on the specific catalogue pages.

PRESSURE EQUIPMENT DIRECTIVE (PED) 97/23/EC

The pilot valves listed in this catalogue are subject to the PED 97/23/EC if applied at pressures above 0.5 bar. ASCO solenoid valves satisfy all relevant EC Directives and comply therefore also to the rules and regulations of the PED. Pilot valves not exceeding a pipe size of 1 inch (DN 25) applied with non-dangerous fluids like instrumentation air are concerned by Article 3.3 (Sound Engineering Practice). This group of valves is not listed in a PED category making it unnecessary to establish a technical file on each product.

The following abbreviations/definitions are indicated on the product nameplates and in this catalogue:

PS: Maximum allowable pressure in bar for which the valve is designed. ASCO specifies the M.O.P.D. (Maximum Operating Pressure Differential) being the PS.

DN: Nominal size of the connection ports (e.g. DN 25 = 1").

TS: Maximum allowable temperature in °C (ambient and/or fluid) for which the valve is designed.

The Installation & Maintenance Instructions packed with the product clearly indicate the compliance to this directive.

ENVIRONMENTAL CONDITIONS, BODY & SOLENOID HOUSING MATERIALS

Pilot valves mounted on process valves are often located in explosive and corrosive atmospheres. Pilot valves can also be mounted indoors or in cabinets. For this reason ASCO Numatics offers different valve body and solenoid housing materials. Depending on the type of pilot valve, bodies are available in anodized aluminium, brass and (316L) Stainless Steel. Solenoid housings are available in epoxy moulding, special treated low copper aluminium, cast iron, zinc plated coated steel and 316L Stainless Steel.

SEAL MATERIALS

The majority of pilot valves are used on instrument air for which the standard sealing materials used in pilot valves are suitable. Depending on the construction they are suitable for just air and neutral gas or also water and light oil. Refer to the specifications on the catalogue pages. For high and low temperature applications special sealing materials are often used. An example for the 327 series is the use of NBR (nitrile) for the standard -20°C to +80°C fluid temperature range while the same valve with FPM (fluoroelastomer) is specified for -20°C to +120°C and with FVMQ (silicone) for -50°C to +60°C.

QUALITY OF AIR

The sensitivity for inferior air quality depends on the valve and solenoid type. ASCO Numatics valves don't need lubrication. Bad air quality or PTFE (polytetrafluoroethylene) tape used for pipe sealing can cause malfunction of the valve. Most pilot valves / solenoids in this catalogue are suitable for filtration levels of 50 µm. However, some valves/operators (piezo operators) need finer filtration, e.g. down to 5 µm.

To ensure the quality of air is acceptable, air service equipment is recommended to prepare the air before being applied to the control system. ASCO Numatics offers a wide range of air treatment equipment to protect the valves.

EXPLOSION PROOF (ATEX) SOLENOIDS

In hazardous areas the risk of igniting an explosive gas or dust mixture by means of heat or sparks from electrical devices such as solenoids has to be reduced to a minimum. Depending on the risk whether an explosive gas-air or dust mixture is likely to occur in the EU countries the zone 0,1 and 2 classification, based on IEC 79-10, is used and in North America Divisions 1 and 2. In 1996 article 505 was added to the National Electric Code (NEC) in the U.S.A. followed by Canada (CEC) in 1998 allowing the use of the zone classification. Since 1999 the NEC (section 501-1) permits equipment listed for CENELEC/ATEX zones also in divisions with the same type of gas.

In Europe the ATEX Directive 94/9/EC is applicable. The direc-

tive covers equipment and protective systems endangered by potentially explosive atmospheres created by the presence of flammable gases, vapours, mists or dusts. The directive came into effect on voluntary basis on March 1996 and is mandatory as of July 1, 2003. Dust is a new issue and next to the gas zones, zones 20, 21 and 22 are defined for dust. See table for an overview of grouping, zones, categories and protection methods used for solenoids on the next page.

ATEX DUST

In many industrial branches dusty products are used in a manufacturing process as raw material, e.g. plastic powder, or it is waste out of the production process, e.g. wood dust. It is estimated that 80% of all industrial dust is considered to have an explosion risk.

The American standards ICS-6 ANSI/NEMA and UL Standards 429, 508 and/or 1002 give dedicated specifications for gas and dust approvals, the so-called NEMA type 7 for gas and NEMA type 9 for dust. The ASCO EF solenoid fully complies with these NEMA standards. In the European ATEX directive 94/9/EC Dust is also covered.

CATEGORIES / ZONE CLASSIFICATION

ATEX 137 defines the zones in which the apparatus can be installed. To comply with these ATEX regulations, the user must select an apparatus which is approved for the matching category (ATEX 95). Each apparatus has a label showing this category. The following table lists the Categories 1, 2 and 3 G for Gas and D for Dust and the zones in which this apparatus can be installed.

All the described ASCO explosion proof solenoid operators are also approved for dust Categories 2 and 3. Other products such as basic spade connector coils are approved for ATEX Dust Category 3 only. For details see chapter 8.

ATEX NON-ELECTRICAL

According to the ATEX Directive, non-electrical equipment to be installed in hazardous locations has to be examined. The EN 13463-1 standard is applicable to this. Consequently, ASCO Numatics has examined all solenoid and (solenoid) air operated valves in this catalogue to meet the ATEX directive regarding non-electrical Category 2 and 3 for Zone 1 or 2.

A limited range of brass and stainless steel series 551 valves is examined by an external Notified Body and is certified for ATEX non-electrical Category 1, Zone 0 applications. Using these valves in combination with an Intrinsically Safe solenoid which is also approved for ATEX Category 1, makes the complete assembled solenoid valve suitable for use in Zone 0.

	Zone 0	Zone 20
Category 1 G/D:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently
	Zone 1	Zone 21
Category 2 G/D:	A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally
	Zone 2	Zone 22
Category 3 G/D:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only

ATEX Flameproof “d” solenoid operators

In the past decades flameproof solenoids with safety code “d” are frequently used as a protection method in Zone 1 and 2 applications. This protection method is based on a construction



were the electrical parts are enclosed in an explosion-proof housing. The housing ensures that any ignition of the hazard inside the enclosure will not propagated to the atmosphere outside the enclosure.

The necessary strength, length of

flame paths and safety gap make the enclosure relatively bulky, heavy and expensive. The construction is rather sensitive as only a small scratch on the material in the flame path can cause an unsafe situation. The relevant standard is EN-IEC 60079-1.

ATEX encapsulated and increased safety “m” and “em” solenoid operators

The need for more compact and economical and at the same time safe and reliable protection methods led to the use of encapsulated solenoids with the safety code “m” based on the EN-IEC 60079-18. These solenoids are suitable for zone 1 and 2 applications. All electrical parts that could ignite an explosive atmosphere by either sparking or heating have to be encapsu-



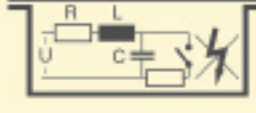

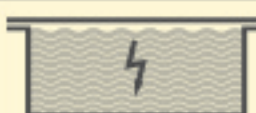


lated in a compound. Naturally, the maximum surface temperature may never exceed the one specified for the temperature class. Normally, a thermal cut-off, device fitted on the coil windings, de-energises the coil in case of excessive heating due to prolonged over-voltage or a blocked core.

Since the compact encapsulation has a relatively bad surface and heat dissipation, the maximum wattage and/or temperature classification is limited. However, combined with the lower



wattage levels which can be achieved now, this is not a real issue. Depending on the application a disadvantage can be the potted-in cable, which often asks for an additional ex-proof junction box. To overcome these aspects the

“m” protection has been combined with the increased safety protection with safety code “e”. This standard (EN-IEC 60079-7) describes a safe enclosure and cable entry. In combination with the “m” protection for the coil the result is a solenoid with “em” protection. In general this is a safe, compact and sturdy housing with a certified cable entry. The “em” enclosure features better heat dissipation, thus allowing a higher wattage and temperature class. Also the additional junction box and thermal fuse (in DC constructions), which increase the risk of failures, can be avoided in this construction.

Protection symbol		Zones			Description	Drawing
		0	1	2		
"d"			●	●	Type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive atmospheres surrounding the enclosure.	
"e"			●	●	Type of protection in which measures are applied so as to prevent with a higher degree of safety the possibility of excessive temperatures and of the occurrence of arcs or sparks in the interior and on the external parts of electrical apparatus, which does not produce them in normal service.	
"i"	"ia"	●	●	●	Type of protection when no spark or any thermal effect in the circuit, produced in the test conditions prescribed in the standard (which include normal operation and specific fault conditions), is capable of causing ignition.	
	"ib"		●	●		
"m"			●	●	Type of protection in which the parts which can ignite an explosive atmosphere are enclosed in a resin sufficiently resistant to the environmental influences in such a way that this explosive atmosphere cannot be ignited by either sparking or heating which may occur within the encapsulation.	
"n"				●	Method of protection for electrical equipment designed so that it will not ignite the surrounding explosive atmosphere in normal operation and under certain fault conditions specified in the standard. There are 5 categories of equipment: nA (non-sparking), nC (hermetically sealed), nR (restricted breathing), nL (limited energy) and nP (simplified pressurisation).	
"o"			●	●	Type of protection in which the electrical apparatus is immersed in oil.	
"p"			●	●	Type of protection in which the protective inert gas inside the enclosure is maintained at a higher pressure than that of the surrounding atmosphere.	
"q"			●	●	Type of protection in which the enclosure is filled with a material in a finely granulated state.	

ATEX and solenoid protection methods

ATEX "n" type solenoid operators

An ATEX protection method specific for category 3 applications to be installed in zone 2 only is protection type "n" based on EN-IEC-60079-15. This standard, first published in 1999, covers different sub-protection methods allowing compact and economical designs:

- nA Non-sparking apparatus
- nC Sparking apparatus protected by:
 - Enclosed-break device

- Non-incendive components
- Hermetically sealed
- Sealed or encapsulated device
- nL Limited-energy apparatus and circuits
- nR Restricted-breathing enclosures
- nP Simplified pressurisation enclosure

Since the above mentioned protection methods are intended for the least risky explosive atmospheres the demands on construction are less compared with other protection methods.



The ZN, WPZN and WSZN operators of ASCO are certified according to ATEX Non-sparking, EEx nA. The ZN solenoid operator has a spade plug connector (DIN plug) while the WPZN and WSZN have a cable gland and screw terminals inside the housing.



or remote I/O unit needs to have sufficient output power, voltage and current to operate the valve.

To meet extreme low power demands more and more piezo technology will be used for piloting valves in explosive atmospheres. These products are listed in this catalogue. For further information on ATEX and explosive atmospheres please refer to the specific chapters in this catalogue.

ATEX Intrinsically Safe “i” solenoid operators

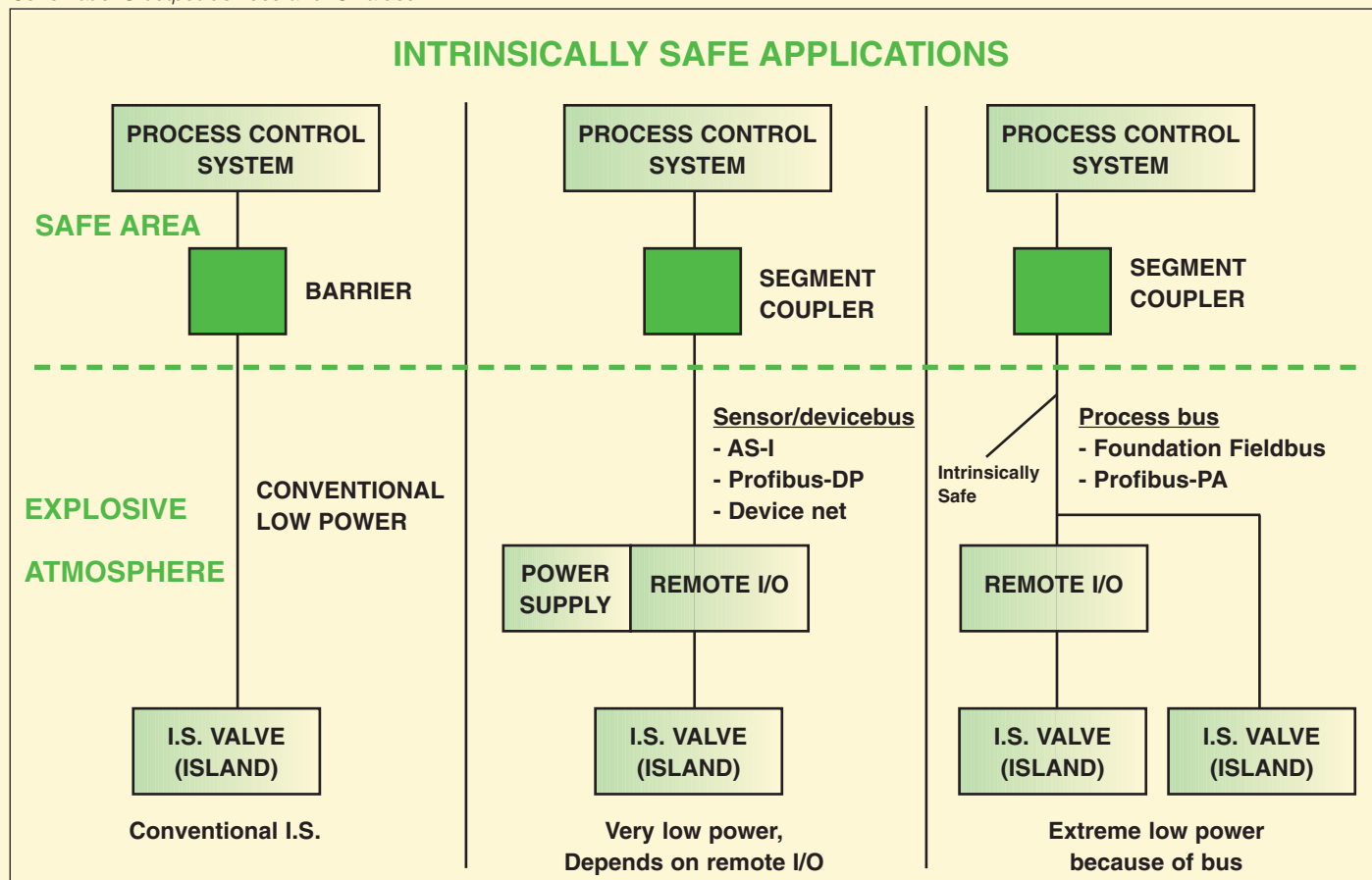
The safety of intrinsically safe solenoids with safety code “i” is based on limiting the power level in the loop to such a low level that not enough energy is generated to cause unsafe conditions in the field. Therefore, safety barriers or galvanic separators are used to limit the energy. For intrinsically safe bus systems special bus couplers are applied for this purpose. In an increasing number of applications remote I/O units or valve couplers control the pilot valves and also here the safety values have to be examined. The certificate of the barrier, separator or I.S. remote I/O unit at one side and the solenoid valve on the other side has to state the maximum current, voltage and power. The solenoid valve values should be higher than the maximum, which can be generated by the barrier. On the other hand, the barrier, separator

SPECIAL FUNCTIONS

Manual Operator

A Manual Operator is used to operate the valve manually when electric power is off. Different executions are a screw type (MS) or push type (MS). A third type is the so-called push-turn type where mechanical operation can only be performed with the combination of manually push and turn. Furthermore a manual operator can be of a mechanically held or impulse type.

Schematic IS output devices and IS values



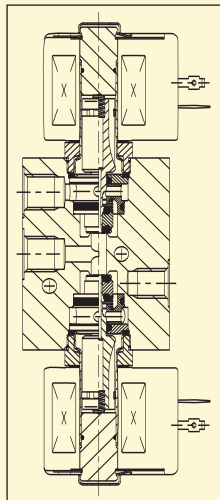
Manual Reset

A Manual Reset function is for safety and should not be confused with a manual operator. The purpose is that a person has to go there and has to manually reset (set free) the valve in order to be able to electrically operate it again. This because the valve will be mechanically latched (locked) and has to be reset. So it will not work on solenoid power, electricity only. This is for safety reasons. Basically there are three types:

Electrically tripped - Valve moves to the latched position when the solenoid is de-energized, trips when it receives a continuous or momentary (at least 0.3 seconds) electrical signal. When tripped, it can be manually cycled open/closed, but must be reset when the solenoid has once again been de-energized.

No Voltage release - Valve moves to latched position when the solenoid is energized, trips when the power is interrupted. When tripped, it can be manually cycled open/closed, but must be reset when the solenoid has once again been energized.

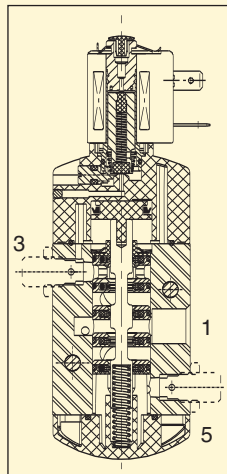
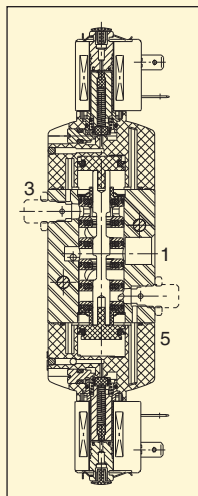
Free Handle - Valve moves to latched position when the solenoid is energized, trips when de-energized. It cannot be manually cycled open/closed when de-energized. It can be manually open/closed or reset only when energized.



Series 327 redundant solenoid valve

Redundant

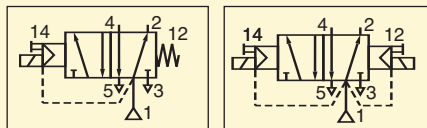
For higher reliability sometimes 2 or 3 pilot valves are used in redundant, two out of two (2oo2) or two out of three configurations (2oo3), especially in critical applications such as Emergency Shut Down systems. This catalogue features a special 327 valve configuration with 2 valves sharing one body. This simplifies the connections and reduces the risk of wrong or bad connection.



Dual pilot or bi-stable pilot valves

Most pilot valves used to control process valves are of a mono-stable, spring return design. This means there is one solenoid taking care of the shifting, usu-

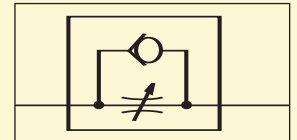
ally from closed to open position. A spring is taking care of shifting the valve to the closed position. A dual pilot or bi-stable valve, however, contains a second solenoid, so one solenoid for shifting in the first position and the second to shift back in the other position. This construction requires two electrical control signals.



ACCESSORIES

Speed controllers

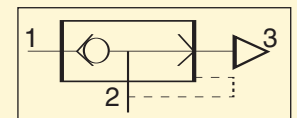
Speed controllers are usually mounted in the pilot valve exhaust ports and can restrict the airflow and thus the actuator/process valve speed. In 3/2 and 4/2 pilot valves there is only one exhaust port and consequently only one speed controller can be used. In a 4/2 pilot valve on a double acting actuator this means that the speed is adjusted in two directions and can not be adjusted separately. In a 5/2 pilot valves two exhaust ports are available and the speed can be adjusted independently in two directions.



ISO symbol speed controller

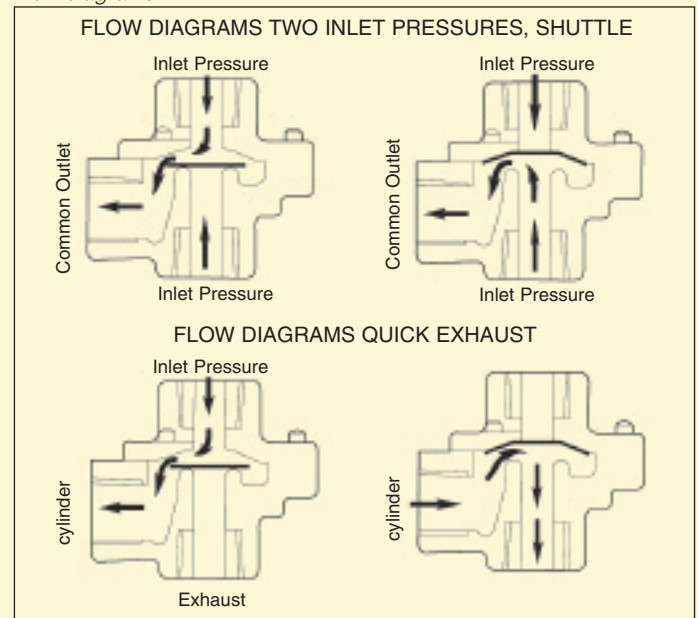
Booster block / Quick exhaust valves

For fast closing of actuators/process valves, pneumatic boosters or quick exhaust valves are used. Fast closing of actuators is sometimes required for safety applications. ASCO pilot valves have a much higher flow capacity on the exhaust port versus the inlet.



ISO symbol quick exhaust valve

Flow diagrams



Exhaust protection

Depending on the environmental conditions, the way of mounting and the type of pilot valve used, the protection of the exhaust can be very important to prevent malfunction. This applies to both the exhaust of the solenoid operator if a 3/2 function is used and to the main exhaust port(s). In the chapter "accessories" of this catalogue some protectors are listed, in practice also elbows

with a piece of tube pointing downwards are used. Spool valves are quite sensitive to the entry of particles and fluids (water) thus if they are mounted outside and/or in dusty environments pre-

cautions have to be taken. However, poppet valves, especially the ones listed for water and light oil are not very sensitive to contaminated air.