NORGREN
Incorporating HERION

EMERGENCY SHUT-DOWN SOLUTIONS









PROCESS SAFETY, RELIABILITY & EFFICIENCY



Abstract

Safety in the Process Industry is currently playing an increasingly and vitally important role.

In a more complex and multidisciplinary engineering environment there is a growing need for engineers, technicians and management involved in process engineering to be aware of the implications of designing and operating safety-related systems.

During the 1970's there were a number of major accidents in Petrochemical Process Plants around the World. Bhopal in India, Seveso in Italy and Flixborough in the UK were 3 of the more commonly known. As a direct consequence standards for Emergency Shut Down components and systems were prepared by the major Standards organizations in Europe and the US.

Combined with the actuated shut down valve ESD Solenoid valves are the final defense against a plant failure causing a catastrophic accident. ESD solenoid valves are connected to a PLC and together with sensors form a Safety Loop. When ever the sensors detect a dangerous or hazardous situation it is essential for the solenoid valves to reliably exhaust air from the actuator in the shut down valve/s so that they return to a fail safe mode by means of spring force (fail close/open).

The Products used in these early days were standard "off the production line" type valves. Whilst they performed satisfactorily there was no statistical evidence for their performance.

Early in 1990's a group of Herion engineers believed that the products which were currently being used for ESD (Emergency Shut Down) Systems could meet DIN Standard (DIN 19251) which was a forerunner of IEC 61508. To obtain this approval required a large number of valves to be tested over a 5 year period in actual Plant conditions. A program was initiated and in June of 1997 Herion became the first Solenoid Valve Manufacturer to obtain TÜV Approval to DIN 19251 AK7 (AK 7 is equal to SIL4). As IEC 61508 became the International Standard (a development of DIN 19251) it was a natural progression for Norgren/Herion to apply for and obtain TÜV Approval to IEC 61508 for the 24011 Series valve, another world first for Norgren/Herion when TUV approval was issued in 2001 with SIL 4.

Working with the Petrochemical, Oil and Gas and other Industries where reliable and safe operating is required, Norgren/Herion continues to develop a series of safe reliable integrated solutions of the highest quality and reliability.

In this Paper Norgren Herion will provide a brief introduction to safety-related systems with the focus on ESD solenoid valve systems for your reference.

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Emergency shut-down system introduction

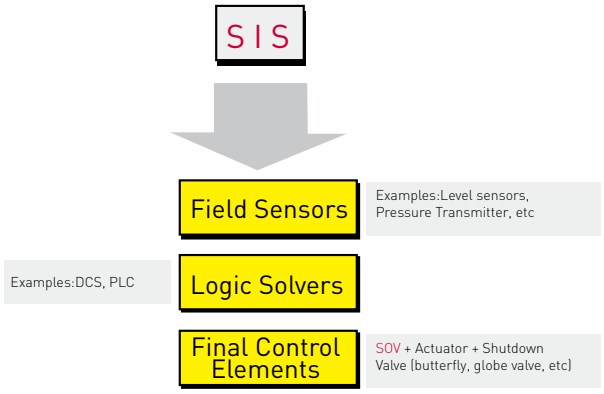
Emergency shut-down system ,or Safety instrumented systems (SIS), is defined as a system designed to respond to conditions in the plant which may be hazardous in themselves or,if no action was taken,could eventually give rise to a hazard. The SIS must generate the correct outputs to mitigate the hazardous consequences or prevent the hazard.

Failure and/or spurious trips could result in expensive procedural and downtime consequences. Thus, the reliability on safety and availability, need to be tested periodically before the next maintenance, but not interrupt the operation.

Due to the critical nature of such systems. ESD system are typically composed of sensors, logic solvers and final control elements. The actuated shutdown valve is expected to remain static in one position for a long period of time and reliably operate only when an emergency situation arises, i.e. to spring into safe mode position.

Emergency shutdown valves are the final defense against process abnormality. In a modern system, ESD valves are connected to PLC and with sensors forming a Safety Loop. (Figure 1)

Figure 1



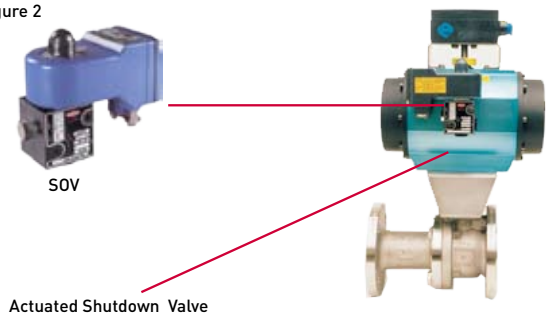
Being a part of SIS, expectation on long term performance reliability needs to be proven with safety calculation (SIL), on its MTBF.

The ESD valve is the Main Process Shut-off valve that controls the process fluid, e.g. steam, gases, liquid, etc. Usually spring loaded – single acting.

The solenoid operated valve, which controls pilot air to drive the rotary actuator, is the heart of the actuated shutdown valve system that requires a high level of reliability, availability and safety.

SOV ought to exhaust air to enable the ESD valve to return to fail safe mode by means of spring force (fail close/open), whenever sensors detect a dangerous process situation. (Figure 2)

Figure 2



Both ISA and IEC use Safety Integrity Level (SIL) to measure the reliability of a SIS, which reflects the criticality of the system in terms of required failure rates. The Safety Integrity Level selected will depend on that required for the entire system.

That means, the safety case must be comprehensive and cover all activities performed within, or related to, a plant or installation. Thus a system wide view should be implied and an integrated approach to risk assessment which would take full account of all hazards and the possible interactions between these.

Therefore industry is calling for flexible and cost-effective ESD solutions through integration , less frequent proof testing, and scalable architectures.

The newest system architectures also can offer the flexibility of hosting safety and process critical control applications in the same controller, providing logical separation of control and safety functions.

With integrated control and safety, users can choose the configuration that works best for their application. Each option protects the integrity of the process while providing engineering and operational efficiencies. These flexible architectures' integrated functionality provides physical or logical separation of control and safety for better safety system performance and process optimization.

All safety loops need to be examined and assessed to ensure safe operation of a plant and compliance with IEC 61508 or 61511. When determining a SIL, all devices need to be considered in each specific safety instrumented function (SIF) or field instrumentation, not just the logic solver. The most forward thinking suppliers have all elements of the loop covered with SIL certified instrumentation and logic solvers, from SIL1 through SIL3, protecting up to SIL4 with technology diversity.

IEC61508 clearly pointed out that the standards to

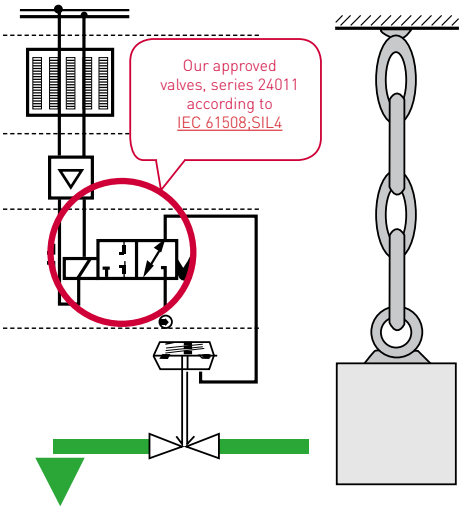
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meet the SIL system for the protection of the overall security assessment, must cover emergency shutdown valve and control system. The valve, actuator and especially the solenoid valve are most likely to have faults such as no switching,faulty motion, coil failure and air leakage, etc. In fact, this is the greatest single cause of dangerous failure situation.

However, for a long time, despite the Emergency Shutdown System's SIL level being continuously upgraded and improved, solenoid valve control systems used for emergency shutdown valves has not been given sufficient attention, thereby affecting the overall integrity of the SIL level. (Figure 3)

Figure 3





Norgren incorporating Herion has been the leading partner in industrial safety for many years. The protection of equipment and personnel within potentially explosive atmospheres is of the highest importance to Norgren and we have been continuously perfecting and extending its range of solenoids suitable for applications in harsh environments to ensure a high level of safety.

The ESD system is Norgren's response to the demands of customers in the chemical, and specifically the petrochemical industry. They are designed for easy integration into both newly developed and existing applications. Solenoid valve in this system are TÜV-approval based on IEC 61 508 complying with SIL 4, and DIN V 19 251 complies with AK7 for safety shutdown and critical control systems. ATEX and IEC Ex approval,high flow rate,maintenance free,functional test possible even during operation, switching position monitoring via color visual indicator or inductive proximity switch,total by-pass making replacement of solenoid valve(s) without interrupting the process possible.....Norgren Herion's ESD system has gained a worldwide reputation for extreme safety and availability.

Stainless steel solenoid coil and valves particularly suited for explosive atmospheres and corrosion resistant applications have also been developed to answer for customer's needs.

These competitive advantages are perfectly suited to contribute to the ability of our customers to maintain and extend their high level of safety. Whether you are looking for something off-the shelf or an engineered solution to meet application-specific needs, our specialists will be familiar with your operating environments and legislation issues. They will talk your language – in every sense of the word. And they will work harder to understand your business needs and processes, so they can really add value and help to make a difference .

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International functional safety standard

» Functional Safety

From 1970s there were a number of incidents involving chemical plants.In 1974 there was an explosion at a chemical plant in Flixborough, England, which killed some 28 people, caused considerable environmental damage and destroyed the plant itself.In 1976 there was a release of the gas dioxin from a chemical plant in Seveso, Italy.Over 200,000 people were evacuated, about 200 people suffered serious skin diseases and 70,000 animals were slaughtered. As a consequence of this accident, emergency shutdown systems have played a more and more important role all over the world.

Thus,due to the critical nature of such systems, OSHA recognizes compliance with the standard ANSI/ISA S84.01 - Application of Safety Instrumented System for the Process Industries - as a good engineering practice for safety instrumented systems. This is a consensus standard for the application of SIS for the process industries, which is based on international standards from the International Electrotechnical Commission (IEC). One of the standards is IEC 61508, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems, Parts 1-7, 1998. It is an umbrella standard applicable to all industries. IEC is in the process of developing a process-industry-specific version of IEC 61508 based on ANSI/ISA S84.01 i.e. IEC 61511, Functional Safety Instrumented Systems for the Process Industry Sector.

» Safety Integrity Level (SIL)

A Safety Integrity Level (SIL) is a statistical representation of the integrity of the SIS when a process demand occurs. It is used in both ANSI/ISA-S84.01 and IEC 61508 to measure the reliability of SIS. Both ISA and IEC have agreed that there are three levels of safety integrity: SILs 1, 2 and 3. IEC also includes an additional level, SIL 4, that ISA does not. The higher the SIL is, the more reliable or effective the system is.

SILs are correlated to the probability of failure of demand (PFD) which is equivalent to the unavailability of a system at the time of a process demand. PFD is another measure for evaluating in how far a device is suitable for use in safety relevant plant parts.This value indicates the probability of failure referred to a time interval.

Correlation of SIL and PFD

SIL	IEC 61508	ANSI S84.01	PFD	Availabilty Required	1/pfd
4	YES	NO	10^{-5} to 10^{-4}	>99.99%	100,000 to 10.000
3	YES	YES	10^{-4} to 10^{-3}	99.90 to 99.99%	10,000 to 1,000
2	YES	YES	10^{-3} to 10^{-2}	99.90 to 99.99%	1.000 to 100
1	YES	YES	10^{-2} to 10^{-1}	99.90 to 99.99%	100 to 10

» Low demand mode & high demand mode

A low switching frequency (low demand mode) exists when the frequency of the requirements made on the operation of the safety-related system is not greater than once a year and not greater than twice the test frequency of the system.

In all other cases a high switching frequency (high demand mode) in the sense of IEC 61508 exists.

From these determined probabilities SIL-classes (Safety Integrity Levels) for the electromagnetic valves are themselves determined. This however does not describe the risk potential of a plant in which the electromagnetic valves are deployed.

For the low demand mode, the allocation of the SIL classes is carried out on the basis of the determined PFD values in accordance with the following table:

SIL (Safety Integrity Level)	Low demand mode of operation (Average probability of failure to perform its design on demand)
4	greater or equal to 10^{-5} to smaller than 10^{-4}
3	greater or equal to 10^{-4} to smaller than 10^{-3}
2	greater or equal to 10^{-3} to smaller than 10^{-2}
1	greater or equal to 10^{-2} to smaller than 10^{-1}

SIL (Safety Integrity Level)	High demand mode of operation (Probability of dangerous failure per hour)
4	greater or equal to 10^{-9} to smaller than 10^{-8}
3	greater or equal to 10^{-8} to smaller than 10^{-7}
2	greater or equal to 10^{-7} to smaller than 10^{-6}
1	greater or equal to 10^{-6} to smaller than 10^{-5}

» Risk & Risk Graph

Safety can be defined as "freedom from unacceptable risk". This definition is important because it highlights the fact that all industrial processes involve risk. Absolute safety, where risk is completely eliminated, can never be achieved; risk can only be reduced to an acceptable level. Therefore all risks should be reduced to as low as reasonably practicable.

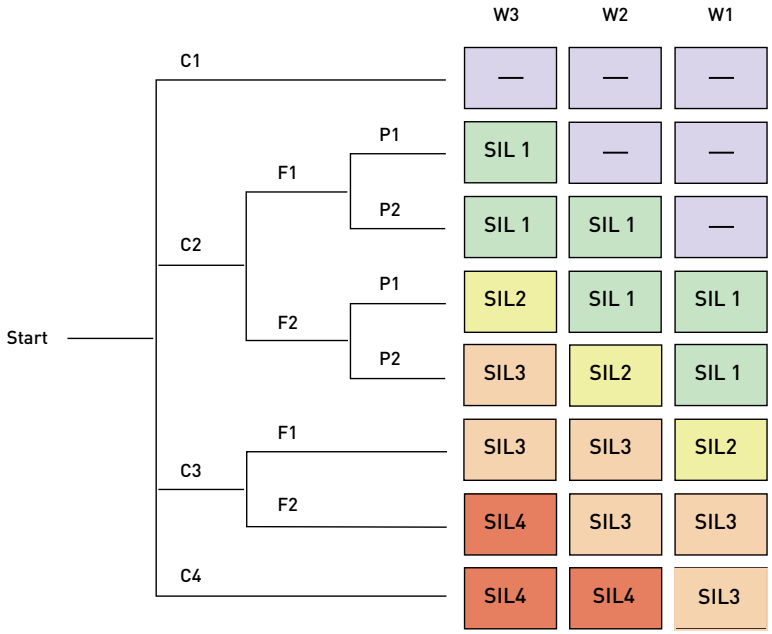
IEC 61508 provides an alternative to Risk Matrix, called Risk Graph. This method focuses on the evaluation of

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risk from the point of view of a person being exposed to the incident impact zone. It is consequence driven and four parameters are used to characterize a potential hazardous event: Consequence (C), Frequency of exposure (F), Possibility of escape (P) and Likelihood of event (W). The following is an example of Risk Graph.

RISK-GRAPH AND REQUIREMENT CLASSES ACCORDING TO:IEC 61 508 / 61 511

C= Extend of damage
C1: slight injury of a person
C2: severe, irreversible injury of one or several persons
C3: death of several persons
C4: catastrophic implication with many death persons
F= Duration of stay
F1: rarely or more often
F2: frequently up to permanent
P= Hazard prevention
P1: possible under certain conditions
P2: rarely possible
W= Probability with which undesirable incidents happen
W1: very low
W2: low
W3: relatively high
— = No safety requirement



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Norgren ESD system concept and principle

New developments in the ESD industry have given rise to a series of debates on whether safety or reliability is more important, whether safety or cost efficiency is more important.

Norgren has provided a set of solution for nearly all kinds of needs from our customers, by which you can find a balance according to your own application, especially 2oo3 Triple Redundant system,which has played a role as the ultimate solenoid valve solution to the level of availability and reliability required by the highest levels of SIL.

» SIL4 SOV–Single channel

The TÜV staff members witnessed Norgren Herion valves returning to there 'closed' position after 5 years energisation time. The examination following the above operation showed the valve functioning perfectly.

The valves are therefore suitable for utilisation in safety related systems with a Hardware Fault Tolerance of 1 or 2 up to and including SIL 4.

What does this mean to your safety requirement?

This means:

PFD = 0.986*10^{-4} = 0.0000986 possible failures / year

or under the assumption that a safety shutdown is carried out 1 times per annum:

1 failure in 9860 years is possible.



» Series 24011 » Series 24010

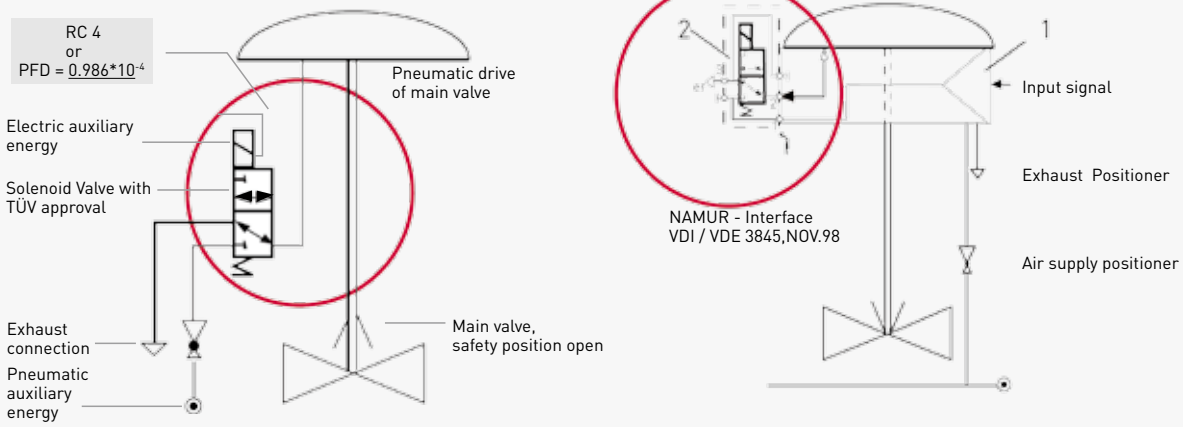


» Series 98015 » Series 98025



» Series 97105 Namur » Series 97105 Inline

Single channel



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» SIL4 EEx, 1 out of 2 Design–Double Channel Redundant System

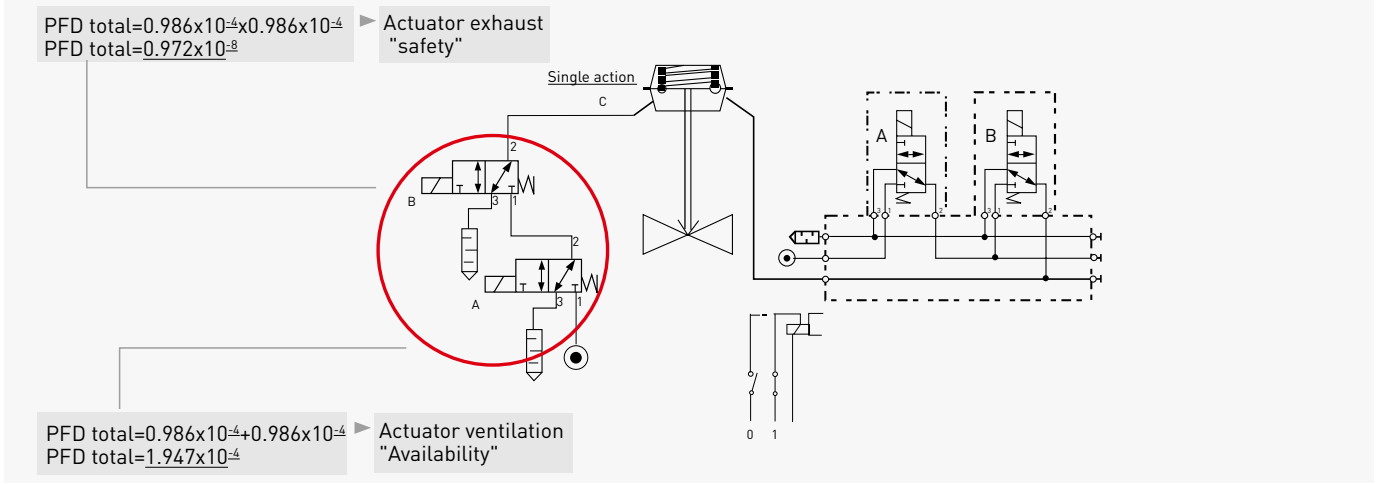
"1oo2" solenoid valve (SOV) control block design shall reduce the Safety PFD, but increase the Availability PFD.

If both SOV "A" and "B" de-energize, then result "C" is 0.

Pressurized Air in Actuator shall exhaust through SOV "B", can be through SOV A when SOV B failed.

Shut-Down Valve shall close by spring force (safe mode) and interrupt process.

1oo2 Double Channel Redundant System



Safety Logic Analysis

Condition	R1	R2	C
	A	B	
All functioning	0	0	0
ONE channel fail its function	1	0	0
	0	1	0

Availability Logic Analysis

Condition	R1	R2	C
	A	B	
All functioning	1	1	1
ONE channel fail its function	1	0	0
	0	1	0

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» Double Channel Redundant system–2 out of 2 Design

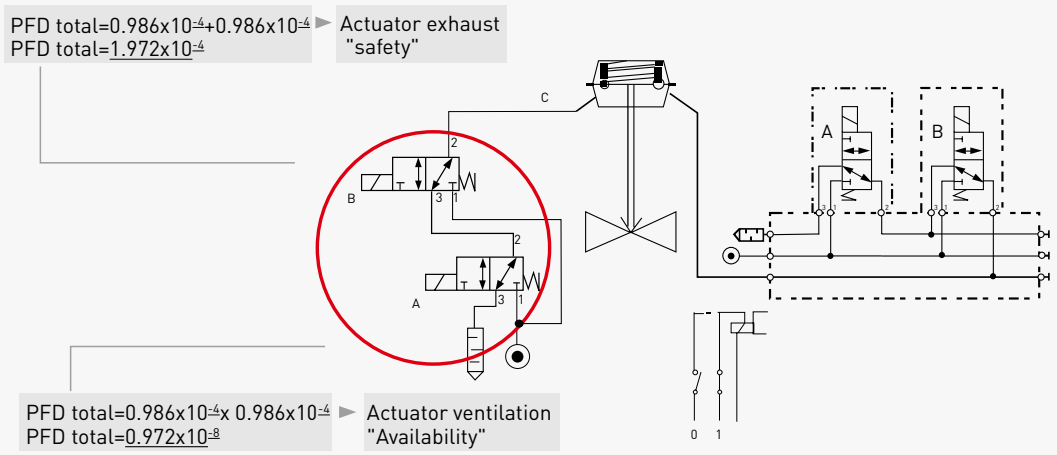
"2oo2" SOV control block design increases the Safety PFD but reduces the AvailabilityPFD.

If both SOV "A" and "B" de-energize, then result "C" is 0.

Pressurized air in Actuator shall exhaust through SOV "B" and SOV "A".

Shut-Down Valve shall close by spring force (safe mode) and interrupt process.

2oo2 Double Channel Redundant system



Safety Logic Analysis

Condition	R1	R2	C
	A	B	
All functioning	0	0	0
ONE channel fail its function	1	0	1
	0	1	1

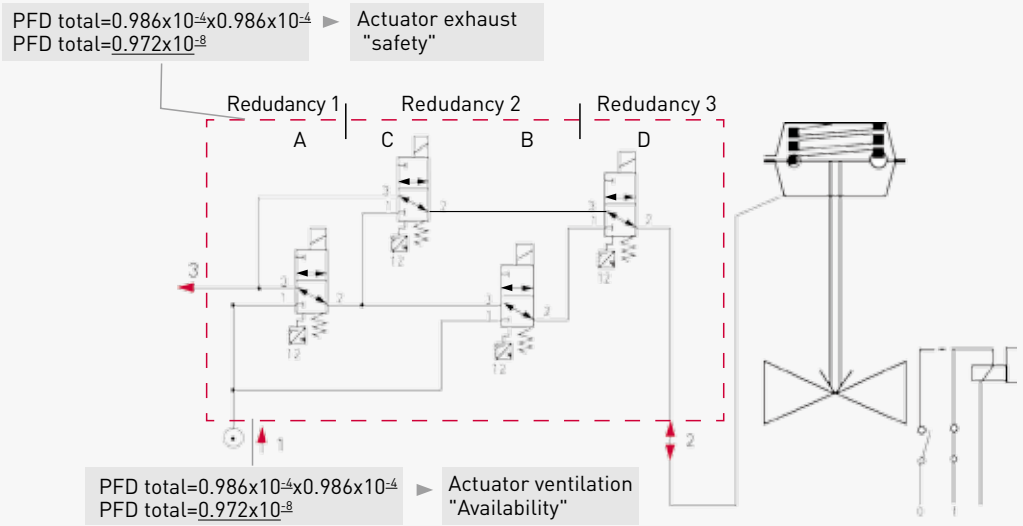
Availability Logic Analysis

Condition	R1	R2	C
	A	B	
All functioning	1	1	1
ONE channel fail its function	1	0	1
	0	1	1

» Triple redundant system–2 out of 3 Design

The "2oo3" control block design combines the strength of "1oo2" and "2oo2" thus increasing the reliability of both safety and availability functions.

2oo3 Triple Channel Redundant system



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Safety Logic Analysis

Condition	R1	R2		R3	(C)
	A	C	B	D	
All functioning	0	0	0	0	0
ONE channel fail its function	1	0	0	0	0
	0	1	1	0	0
	0	0	0	1	0

Safety requirement: when an emergency occur, SOV will be de-energized and switch to safe exhaust position by its spring force. If one of the SOVs/channels is stuck/ jammed at its unsafe-vent position, the visual indicator for that particular SOV will remain unchanged at green color and continues to operate safely on the other two channels.

Result of each SOV (A, B, C and D) after de-energized:
0 = SOV at safe-exhaust – fulfill safety function.
1 = SOV at unsafe-ventilate position – failed dangerously.

Result of (C) after the "2 out of 3" redundant SOV system de-energized ESD:
0 = Allow exhaust from actuator – fulfill safety function.
1 = Stop exhaust from acutuator – fail dangerously.

Availability Logic Analysis

Condition	R1	R2		R3	(C)
	A	C	B	D	
All functioning	1	1	1	1	1
ONE channel fail its function	0	1	1	1	1
	1	0	0	1	1
	1	1	1	0	1

Availability requirement: when spurious trip occur at one of the SOVs/channels, the visual indicator for that particular SOV or channel shall change from green to red color and continues to operate safely on the other two channels.

Result of each SOV (A, B, C and D) after spurious trip:
1 = SOV at available-ventilate position.
0 = SOV at unavailable-exhaust position.

Result of (C) after spruious trip(s) occurred within the "2 out of 3" redundant SOV system.
1 = Process running / plant operating.
0 = Shutdown without the presence of an emergency.

Reference

R1	Channel 1 / SOV A	Redundancy group 1	**A**
R2	Channel 2 / SOV B & C	Redundancy group 2	**B & C**
R3	Channel 3 / SOV D	Redundancy group 3	**D**
(C)	Combine Channel		

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Additional options

» Visual SOV pressure indicators

Switching position monitoring via color visual indicator (GREEN/RED)



2oo3Reference Chart for SOV monitoring during process, installation & testing

Solenoid Valve				Pressure Indicator				C
A	B	C	D	A	B	C	D	
0	0	0	0	●	●	●	●	0
0	0	0	1	●	●	●	*●	0
0	1	1	0	●	●	*●	●	0
1	0	0	0	●	●	●	●	0
0	1	1	1	●	●	*●	●	1
1	1	1	0	●	●	●	●	1
1	0	0	1	●	●	●	●	1
1	1	1	1	●	●	●	●	1

Indicator turn green "●"when pressurize;
Indicator turn red "●" when depressurized
"*●"caused by SOV A, it supplies air source to SOV C & D

» Add-on Bypass Kit

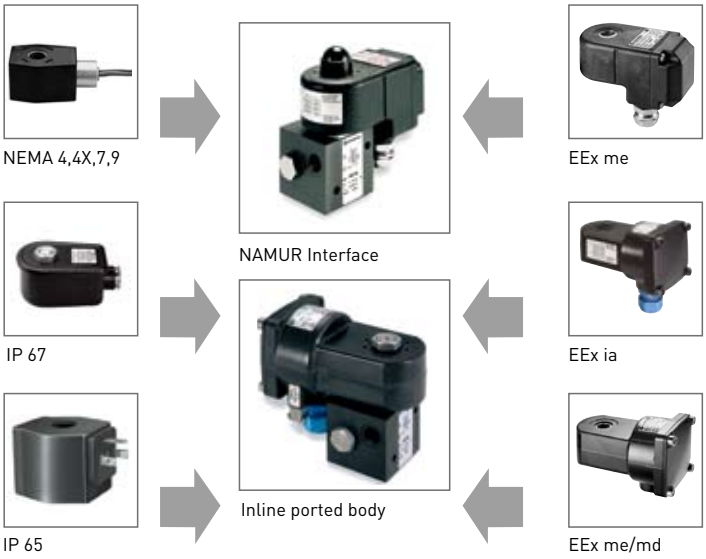
Total by-pass enable replacement of solenoid valve(s) without interrupting the process



» Various electronic protection range for ESD Application

IP protection can make your solenoids and valves suitable for outdoor use under critical environment conditions.

ATEX and IEC Ex approved solenoids and valves can protect you from the danger of explosion.



» Wide range of body material options

Multiple body material choices for different environments.



» Mounting option

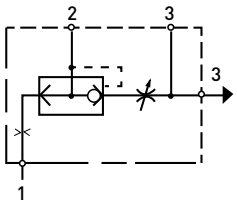


Mounting option

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» Quick exhaust module

For quicker response of the main valve, Q/E valves are available for NAMUR application. You may use Norgren Herion 40500 Quick exhaust module.It can be used as a quick exhaust module with integrated exhaust air feedback and as a bi-directional flow regulator module with optional flow regulator, suitable for outdoor use and extreme environmental conditions





Technical data

Medium: Compressed air, filtered, lubricated or non-lubricated, instrument air, nitrogen or other neutral dry fluids
Port size: G1/4, NAMUR
Operating pressure: 0.5 ~10bar
Ambient temperature: -25°C ~ +60°C

» Air preparation system

Norgren Excelon Family is a alternative modular air preparation system including general purpose filter, coalescing filter, regulator, combined filter/regulator, micro-fog and oil fog lubricators as well as shut-off valves. Although direct ported, thanks to a patented Quikclamp connection system, Excelon can be used where both stand alone units or modular assemblies are required. These highly reliable products, featuring high performance, system efficiency and innovative design, can provide maximum flexibility and adaptability for customers.

Norgren Ported stainless steel equipment can withstand arduous conditions and have NACE approval.





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Definitions related to ESD

For the purposes of this document, the following definitions are applied for your reference.

» Channel
Element or group of elements that independently perform(s) a function.

» Common cause failure
Failure, which is the result of one or more events, causing failures of two or more separate channels in a multiple channel system, leading to system failure.

» Common mode failure
Failure of two or more channels in the same way, causing the same erroneous result.

» Component
One of the parts of a system, subsystem, or device performing a specific function.

» Continuous mode safety instrumented function
Where in the event of a dangerous failure of the safety instrumented function a potential hazard will occur without further failure unless action is taken to prevent it.

» Dangerous failure
Failure which has the potential to put the safety instrumented system in a hazardous or fail to-function state.

» Dependent failure
Failure whose probability cannot be expressed as the simple product of the unconditional probabilities of the individual events which caused it.

» Error
Discrepancy between a computed, observed or measured value or condition and the true specified or theoretically correct value or condition.

» Failure
Termination of the ability of a functional unit to perform a required function.

» Fault
Abnormal condition that may cause a reduction in, or loss of, the capability of a functional unit to perform a required function.

» Fault avoidance
Use of techniques and procedures which aim to avoid the introduction of faults during any phase of the safety life cycle of the safety instrumented system.

» Fault tolerance
Ability of a functional unit to continue to perform a required function in the presence of faults or errors.

» Final element
Part of a safety instrumented system which implements the physical action necessary to achieve a safe state.

» Functional safety
Part of the overall safety relating to the process and the BPCS which depends on the correct functioning of the SIS and other protection layers.

» Harm
Physical injury or damage to the health of people, either directly or indirectly, as a result of damage to property or to the environment.
NOTE: This definition matches ISO/IEC Guide 51.

» Hazard
Potential source of harm

» Human error mistake
Human action or inaction that produces an unintended result.

» IEC
International Electrotechnical Commission.

» Independent department
Department which is separate and distinct from the departments responsible for the activities which take place during the specific phase of the safety life cycle that is subject to the functional safety assessment or validation.

» Input function
Function which monitors the process and its associated equipment in order to provide input information for the logic solver.

» ISA
Instrumentation, Systems and Automation Society.

» Logic solver
That portion of either a BPCS or SIS that performs one or more logic function(s).

» Module
Self-contained assembly of hardware components that performs a specific hardware function (i.e., digital input module, analogue output module), or reusable application program (can be internal to a program or a set of programs) that support a specific function e.g. portion of a computer program that carries out a specific function.

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» MooN
Safety instrumented system, or part thereof, made up of "N" independent channels, which are so connected, that "M" channels are sufficient to perform the safety instrumented function.

» Necessary risk reduction
Risk reduction required to ensure that the risk is reduced to a tolerable level.

» Output function
Function which controls the process and its associated equipment according to final actuator information from the logic function.

» PFD
Probability of failure on demand.

» Process risk
Risk arising from the process conditions caused by abnormal events (including BPCS malfunction).

» Programmable electronic system (PES)
System for control, protection or monitoring based on one or more programmable electronic devices, including all elements of the system such as power supplies, sensors and other input devices, data highways and other communication paths, actuators and other output devices.

» Proof test
Test performed to reveal undetected faults in a safety instrumented system so that, if necessary, the system can be restored to its designed functionality.

» Proven-in-use
When a documented assessment has shown that there is appropriate evidence, based on the previous use of the component, that the component is suitable for use in a safety instrumented system.

» Redundancy
Use of multiple elements or systems to perform the same function; redundancy can be implemented by identical elements (identical redundancy) or by diverse elements (diverse redundancy).

» Risk
Combination of the frequency of occurrence of harm and the severity of that harm.

» Safe failure
Failure which does not have the potential to put the safety instrumented system in a hazardous or fail-to-function state.

» Safe state
State of the process when safety is achieved

» Safety
Freedom from unacceptable risk.

» Safety function
Function to be implemented by an SIS, other technology safety related system or external risk, reduction facilities, which is intended to achieve or maintain a safe state for the process, with respect to a specific hazardous event.

» Safety instrumented control function
Safety instrumented function with a specified SIL operating in continuous mode which is necessary to prevent a hazardous condition from arising and/or to mitigate its consequences.

» Safety instrumented control system
Instrumented system used to implement one or more safety instrumented control functions.

» Safety instrumented function (SIF)
Safety function with a specified safety integrity level which is necessary to achieve functional safety and which can be either a safety instrumented protection function or a safety instrumented control function.

» Safety instrumented system (SIS)
Instrumented system used to implement one or more safety instrumented functions. An SIS is composed of any combination of sensor (s), logic solver (s), and final elements(s).

» Safety integrity
Average probability of a safety instrumented system satisfactorily performing the required safety instrumented functions under all the stated conditions within a stated period of time.

» Safety integrity level (SIL)
Discrete level (one out of four) for specifying the safety integrity requirements of the safety instrumented functions to be allocated to the safety instrumented systems. Safety integrity level 4 has the highest level of safety integrity; safety integrity level 1 has the lowest.

» Safety life cycle
Necessary activities involved in the implementation of safety instrumented function(s) occurring during a period of time that starts at the concept phase of a project and finishes when all of the safety instrumented functions are no longer available for use.

» Sensor
Device or combination of devices, which measure the process condition (for example, transmitters, transducers, process switches, position switches).

» System
Set of elements, which interact according to a design;

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an element of a system can be another system, called a subsystem, which may be a controlling system or a controlled system and may include hardware, software and human interaction.

» Target failure measure
Intended probability of dangerous mode failures to be achieved in respect of the safety integrity requirements, specified in terms of either the average probability of failure to perform the design function on demand (for a demand mode of operation) or the frequency of a dangerous failure to perform the SIF per hour (for a continuous mode of operation).

» Tolerable risk
Risk which is accepted in a given context based on the current values of society.

» Safety life cycle
Necessary activities involved in the implementation of safety instrumented function(s) occurring during a period of time that starts at the concept phase of a project and finishes when all of the safety instrumented functions are no longer available for use.

» Sensor
Device or combination of devices, which measure the process condition (for example, transmitters, transducers, process switches, position switches).

» System
Set of elements, which interact according to a design; an element of a system can be another system, called a subsystem, which may be a controlling system or a controlled system and may include hardware, software and human interaction.

» Target failure measure
Intended probability of dangerous mode failures to be achieved in respect of the safety integrity requirements, specified in terms of either the average probability of failure to perform the design function on demand (for a demand mode of operation) or the frequency of a dangerous failure to perform the SIF per hour (for a continuous mode of operation).

» Tolerable risk
Risk which is accepted in a given context based on the current values of society.



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Technical data

Integrated Shut-Down

Triple Redundant Design
Solenoid actuated
Port size
Female thread G1/4, NPT1/4



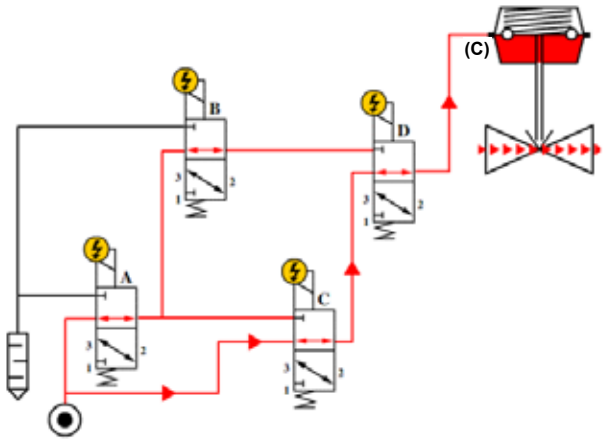
"2 out of 3" control block (triple redundancies)
Extreme safety and availability with standard solenoid valves
Each solenoid valve is TÜV-approval based on IEC 61 508 complies with SIL 4, and DIN V 19 251 complies with AK7 for safety shutdown and critical control systems. Approvals: DIN EN 161/3394 DVGW, group R and EN 13611
High flow rate
Maintenance free
Safety function in the event of power failure provided by mechanical return spring
Build-in pneumatic control interlock circuit
Functional test of solenoid valves is possible during operation
Switching position monitoring via color visual indicator (GREEN/RED) or inductive proximity switch (OPEN/CLOSE)
Total by-pass enable replacement of solenoid valve(s) without interrupting the process
Individual isolation enable replacement of solenoid valve without interrupting the process and ESD function
Solenoids available with ATEX, IEC Ex etc.

Technical data

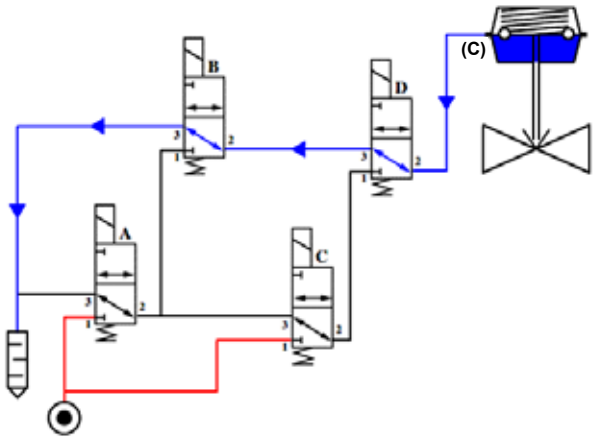
Medium:
Filtered, lubricated or non-lubricated compressed air, instrument air, nitrogen and other neutral fluids
Nominal diameter:
6 mm
Port size:
1/4 NPT
Operating pressure:
0 to 8 bar
Temperatures:
See solenoid table
Material:
Body – hard anodized aluminium & stainless steel
Seals – NBR (Perbunan)

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Interlock Circuit

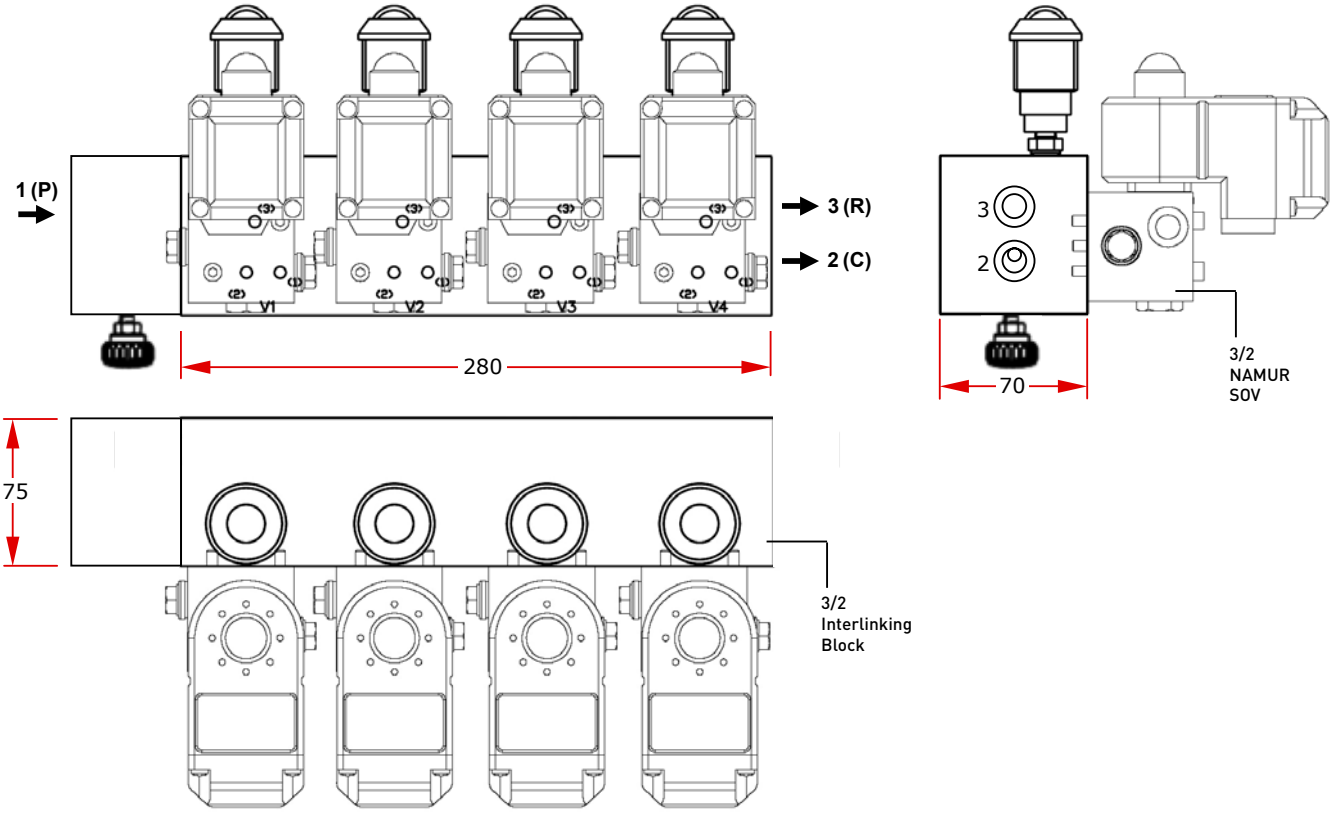


Process "ONLINE"



Process "SHUTDOWN"

Conceptual Drawing



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24011

3/2 Directional control valves
Direct solenoid operated poppet valves
Internal thread: G1/4, 1/4-18 NPT or flanged with NAMUR interface





Main application: single operated process actuators
TÜV-approval based on IEC 61 508, DIN V 19 251
Approvals: DIN EN 161/3394 DVGW, group Rm and EN 13611
Valves for safety systems to SIL 4 or AK 7
Standard NAMUR type
- manifold system for easy assembly
- redundancy: 1 of 2
2 of 3
- add-on manual override or inductive limit switches
Value switches at power failure into starting position (mechanical return spring)
Rest position in the event of power failure provided by mechanical return spring
Suited for outdoor use under critical environment conditions (see solenoid list)
Solenoids and valves are ATEX and IEC Ex approved (see solenoid table), additional protection class (FM, CSA) XP

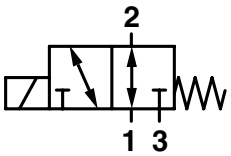
Technical data

Medium:
Neutral gaseous liquids or aggressive fluids
Operation:
Solenoid
Flow direction:
Optional
Flow rate:
340 l/min
Port size:
G1/4, 1/4 NPT or NAMUR interface
Orifice:
DN 5
Operating pressure:
0 ... 10 bar
Temperature:
Fluid: -25 ... +80°C (NBR)
-10 ... +120°C (FKM) – water up to +95°C
-40 ... +60°C (VMQ)
Solenoid temperature:
see solenoid table

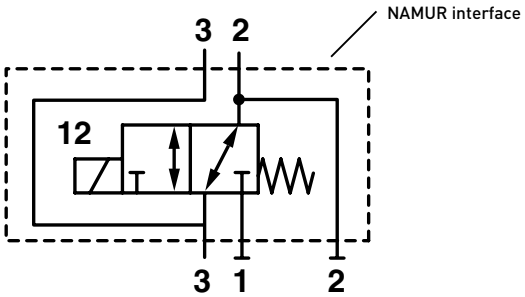
Mounting:
Optional, preferably vertical
Materials:
Body: stainless steel 1.4404/316, brass, hard anodized aluminium
Seat seal:
FKM, NBR (Perbunan), (VMQ) silicon
Inner parts: stainless steel, brass

Ordering information

3/2 Directional control valve, stainless steel, with seat seal FKM, port size G 1/4,
solenoid 24 V DC
Type: 2401127.4260.024.00
Cable gland: 0588819
TÜV-Certificate for each valve on request

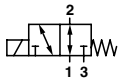


Switching function:
Pressure port at 1, 2 or 3

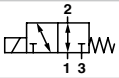


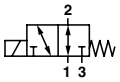
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With threaded connection
Brass valves

Symbol	Type *1	Solenoid group	Connection	Operating pressure (bar)*	Material Seat seal	Manual override	Weight (kg)	Test certificate IEC 61 508 *2)	Dimensions No.
	2401103	A + B	G 1/4	0 ... 10	NBR		0,65	X	1
	2401107	A + B	G 1/4	0 ... 10	NBR	push only	0,70		1
	2401119	A + B	G 1/4	0 ... 10	NBR	push and lock	0,70		1
	2401149	A + B	G 1/4	0 ... 10	NBR		0,65	X	1
	2401126	A + B	G 1/4	0 ... 10	FKM		0,65	X	1
	2401153	A + B	G 1/4	0 ... 10	Silicon *3)		0,65	X	1
	2401154	A + B	G 1/4	0 ... 10	Silicon *3)	semi-automatic	0,70		1
	2401138	A + B	1/4 NPT	0 ... 10	NBR		0,65	X	1
	2401148	A + B	1/4 NPT	0 ... 10	NBR	push only	0,70		1
	2401136	A + B	1/4 NPT	0 ... 10	NBR	push and lock	0,70		1
	2401140	A + B	1/4 NPT	0 ... 10	NBR	semi-automatic	0,70		1
	2401131	A + B	1/4 NPT	0 ... 10	FKM		0,65	X	1
	2401106	A + B	1/4 NPT	0 ... 10	Silicon *3)		0,65	X	1
	1025226	A + B	1/4 NPT	0 ... 10	Silicon *3)	semi-automatic	0,70		1

Stainless steel valves (1.4404) for aggressive environment

Symbol	Type *1	Solenoid group	Connection	Operating pressure (bar)*	Material Seat seal	Manual override	Weight (kg)	Test certificate IEC 61 508 *2)	Dimensions No.
	2401186	A + B	G 1/4	0 ... 10	NBR	–	0,65	X	1
	2401112	A + B	1/4 NPT	0 ... 10	NBR	–	0,65	X	1

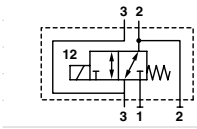
Symbol	Type *1	Solenoid group	Connection	Operating pressure (bar)*	Material Seat seal	Manual override	Weight (kg)	Dimensions No.
	2401127	A	G 1/4	0 ... 10	FKM		0,70	1
	2401170	A	G 1/4	0 ... 10	FKM	push only	0,70	1
	2401139	A	G 1/4	0 ... 10	FKM	push and lock	0,70	1
	2401155	A	G 1/4	0 ... 10	Silicon *3)		0,65	1
	2401147	A	1/4 NPT	0 ... 10	FKM		0,65	1
	2401146	A	1/4 NPT	0 ... 10	FKM	semi-automatic	0,70	1
	2401168	A	1/4 NPT	0 ... 10	Silicon *3)		0,65	1

***1) When ordering please indicate solenoid, voltage and current type (frequency)**
***2) Approval is not included in delivery, part No. 0695241**
*** Viscosity for gaseous or liquid fluids up to 40 mm2/s**
• Particulary for valves with TÜV approval and attachment in plants based on safety standards DIN V 19250, IEC 61511, taking into account to the operating and maintance instructions document 7503444.
• The responsibility for the maintance and repair of the solenoid valves lies with the users or the supervisory authority for these process systems.
***3) For ambient temperature down to -40°C**

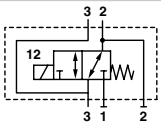
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With NAMUR interface

Aluminium valves anodized

Symbol	Type *1	Solenoid group	Connection	Operating pressure (bar)*	Material Seat seal	Manual override	Varlants	Weight (kg)	Test certificate IEC 61 508 *2)	Dimensions No.
	2401191	A + B	G 1/4	0 ... 10	NBR	add-on		0,55	X	2
	1025333	A + B	G 1/4	0 ... 10	NBR	add-on	with limit switch	0,70		2
	1025254	A + B	1/4 NPT	0 ... 10	NBR	add-on		0,55	X	2
	2401133	A + B	G 1/4	0 ... 10	Silicon *3)	add-on		0,55	X	2
	2401109	A + B	G 1/4	0 ... 10	NBR	add-on	P in flange interface 3	0,55	X	3

Stainless steel valves (1.4404) for aggressive environment

Symbol	Type *1	Solenoid group	Connection	Operating pressure (bar)*	Material Seat seal	Manual override	Varlants	Weight (kg)	Test certificate IEC 61 508 *2)	Dimensions No.
	2401196	A + B	G 1/4	0 ... 10	NBR	add-on		1,00	X	2
	2401142	A	G 1/4	0 ... 10	Silicon *3)	add-on		1,00		2
	1025212	A + B	G 1/4	0 ... 10	NBR	add-on	P in flange interface *4)	1,00	X	3
	1025328	A + B	1/4 NPT	0 ... 10	NBR	add-on	P in flange interface *4)	1,00	X	3

*1) When ordering please indicate solenoid, voltage and current type (frequency).
*2) Approval is not included in delivery, part No. 0695241
* Viscosity for gaseous or liquid fluids up to 40 mm2/s
Approval S 137/01, SIL 4 for low demand mode, SIL 3 for high demand mode,
Approval S 83/96, AK 7 (request from manufactor)
• Particulary for valves with TÜV approval and attachment in plants based on safety standards DIN V 19250, IEC 61511,
taking into account to the operating and maintance instructions document 7503444.
• The responsibility for the maintance and repair of the solenoid valves lies with the users or the supervisory authority for these process systems.
*3) For ambient temperature down to -40 °C
*4) Acc. to VDI/VDE 3845 port P in flange for attachment of positioners

Solenoid operators group A

	Type	Power consumption 24V DC (W)	Power consumption 230V AC (VA)	Rated current 24V DC (mA)	Rated current 230V AC (mA)	Protection class	Temperature range Ambient/Fluid °C	Electrical connection	Weight (kg)	Dimensions No.	Circuit diagram No.
	0800 *7)	16,9	-	703	-	IP00 w/o connector *5)	-25...+60	DIN EN175W301-803	0,33	6	1
						IP65 with connector *5)	Form A *6)				
	3803 *7)	-	18	-	185	P00 w/o connector *5)	-25...+60	DIN EN175W301-803	0,34	7	6
						IP65 with connector *5)	Form A *6)				
	4270 *8)	8,9	-	369		EEx me II T4/T5 *2)	-40....65/55	M20x1,5 *6)	0,6	8	4
						IP66 T130°C					
	4271 *8)	-	10		43	EEx me II T4/T5 *2)	-40....65/55	M20x1,5 *6)	0,6	8	7
						IP66 T130°C					
	4670 *8)	8,9	-	369		EEx md IIC T4/T6 *3)	-40....+65/55	1/2 NPT *6)	0,8	9	4
						EEx me IIC TT4/T6 *3)					
						IP66 T130°C					
	4671 *8)	-	10		43	EEx md IIC T4/T6 *3)	-40....+65/55	1/2 NPT *6)	0,8	9	7
						EEx me IIC TT4/T6 *3)					
						IP66 T130°C					
	4672 *8)	8,9	-	369		EEx md IIC T4/T6 *3)	-40....+65/55	M20x1,5 *6)	0,8	9	4
						EEx me IIC TT4/T6 *3)					
						IP66 T130°C					
	4673 *8)	-	10		43	EEx md IIC T4/T6 *3)	-40....+65/55	M20x1,5 *6)	0,8	9	7
						EEx me IIC T6 *3)					
						IP66 T130°C					
Stainless steel	4872	8,9	–	369	–	Ex mb d IIC T4/T6	Cat. II 2G (gas)	M20x1,5 *6)	1,2	10	12
							-40 ... +50 (T4)				
						or	-40 ... +40 (T6)				
	4873	–	10	–	43	Ex mb e II T4/T6	Cat. II 2D (dust) T100°C	M20x1,5 *6)	1,2	10	7
						Ex mbD 21 tDA21 IP66 T100°C *1)					
	3826	13,6	-	566	-	XP NEMA *4)	-20....+60	Flying leads	0,4	11	1
						4, 4X, 6, 6P, 7, 9		450 mm long			
	3827	-	15,7	-	68	XP NEMA *4)	-20....+60	Flying leads	0,4	11	5
						4, 4X, 6, 6P, 7, 9		450 mm long			

Standardvoltages 24V DC, 230V AC. other voltages on request. Design acc. to VDE 0580, EN 50014/50028.100% duty cycle.
*2) Categorie II 2 GD, EC-Type-Examination-Certificate KEMA 98 ATEX 4452 X
*3) Categorie II 2 GD, EC-Type-Examination-Certificate PTB 02 ATEX 2085 X
*4) CSA-LR 57643-6, FM approved, for hazardous locations: Div. 1 and 2, Class I, II, III
*5) Required connector: type 0570275.
*6) Connector cable gland not supplied
*7) IP65 according to DIN 40050/IEC 529 and DIN EN 600068-2-38
*8) This solenoid has a fuse with an appropirate rating.

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Solenoids operators group B

	Type	Power consumption 24V DC (W)	230V AC (VA)	Current 24V DC (mA)	230V AC (mA)	Protection class	Temperature range Ambient/Fluid °C	Electrical connection	Weight (kg)	Dimensions No.	Circuit diagram No.
	0827 *7)	6,8	-	282	-	IIP00 without plug *5)	-25...+60	DIN EN175W301-803	0,33	6	1
						IP65 with plug *5)		Form A *6)			
	3805 *7)	-	10,6	-	46	IP00 without plug *5)	-25...+60	DIN EN175W301-803	0,34	7	6
						IP65 with plug *5)		Form A *6)			
	4260 *8)	4	-	162		EEx me II T4/T6 *2)	-40...+80/+55	M20 x 1,5 *6)	0,6	8	4
						IP66 T130°C					
	4261 *8)	-	5,3		23	EEx me II T4/T6 *2)	-40...+80/+55	M20x1,5 *6)	0,6	8	7
						IP66 T130°C					
	4660 *8)	4	-	162		EEx md IIC T4/T6 *3)	-40...+80/+55	1/2 NPT *6)	0,8	9	4
						EEx me IIC T4/T6 *3)					
						IP66 T130°C					
	4661 *8)	-	5,3		23	EEx md IIC T4/T6 *3)	-40...+80/+55	1/2 NPT *6)	0,8	9	7
						EEx me IIC T4/T6 *3)					
						IP66 T130°C					
	4662 *8)	4	-	162		EEx md IIC T4/T6 *3)	-40...+80/+55	M20x1,5 *6)	0,8	9	4
						EEx me IIC T4/T6 *3)					
						IP66 T130°C					
	4663 *8)	-	5,3		23	EEx md IIC T4/T6 *3)	-40...+80/+55	M20x1,5 *6)	0,8	9	7
						EEx me IIC T4/T6 *3)					
						IP66 T130°C					
Stainless steel	4862	3,9	–	162	–	Ex mb d IIC T4/T6	Cat. II 2G (gas)	M20x1,5 *6)	1,2	10	12
							-40 ... +75 (T5)				
						or	-40 ... +55 (T6)				
	4863	–	5,3	–	23	Ex mb e II T4/T6	Cat. II 2D (dust) T100°C	M20x1,5 *6)	1,2	10	7
						Ex mbD 21 tDA21 IP66 T100°C *1)					
	3824	8,9	-	370	-	NEMA *4)	-20...+60	Flying leads	0,4	11	1
						4, 4X, 6, 6P, 7, 9		450 mm long			
	3825	-	9,5	-	41	NEMA *4)	-20...+60	Flying leads	0,4	11	5
						4, 4X, 6, 6P, 7, 9		450 mm long			

Standardvoltages 24V DC, 230V AC. other voltages on request. Design acc. to VDE 0580, EN 50014/50028.100% duty cycle.
***2) Categorie II 2 GD, EC-Type-Examination-Certificate KEMA 98 ATEX 4452 X**
***3) Categorie II 2 GD, EC-Type-Examination-Certificate PTB 02 ATEX 2085 X**
***4) CSA-LR 57643-6, FM approved, for hazardous locations: Div. 1 and 2, Class I, II, III**
***5) Required connector: type 0570275.**
***6) Connector cable gland not supplied**
***7) IP65 according to DIN 40050/IEC 529 and DIN EN 600068-2-38**
***8) This solenoid has a fuse with an appropirate rating.**

Accessories

Cable gland Protection class EEx e (Atex), MS nickel plated brass/stainless steel	Silencer	Connectors	Flange plate	Yoke
				
EEx e 0588819 (for solenoid 42xx / 46xx M20 x 1,5)	C/S2 1/4 NPT	0570275	0612790 (NAMUR single connection plate)	0540593
EEx d 0588851 (for solenoid 46xx M20 x 1,5)	M/S2 G 1/4		0612791 NAMUR rip use in combination with 0612790 (Alu)	
EEx d, EEx e 0588925 (for solenoid 46xx 1/2-14 NPT)				
II 2 G/D EEx d IIC 0589387 (for solenoid 48xx M20x1,5; Ø 10...14 mm)				
II 2 G/D EEx e II 0589385 (for solenoid 48xx M20x1,5; Ø 9...13 mm)				

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NOTES

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