ESD VALVE SELECTION GUIDE
GENERAL ESD VALVE DEFINITION

ESD/ESV valves are the final defence against process misreactions. These valves have a function which requires much more reliable performance than standard remotely operated on-off valves. Still today ESD valves are ranked often as ordinary shut-off valves in specifications. Valves as such may still remain the same but being a part of Safety Instrumented Function (SIF) the performance expectations are much higher. There must be a prove for a reliable long term performance. MTBF (Mean Time Between Failure) number needs to be given to Safety calculations (SIL).
ESD / ESV valves are in modern systems connected to Programmable Locig Controller (PLC) and are together with sensors forming a Safety Loop. Whenever sensors identity an upnormal dangerous process situation PLC disconnects the power to ESD valve solenoid and the valve goes to desired fail safe mode by means of spring force (fail close or fail open).

This is the most critical situation for valves. Unless the valve is not frequently tested there is no guarantee that it is available and does the desired safety function. This can cause a major catastrophe.

1. **STANDARDS**
   - IEC 61508
   - IEC 61511
   - DIN 19250
   - ISA SP84.1
   - application standards (e.g. furnace)
2. **SPECIFICATIONS**
   - how to identify ESD valve
   - process duty description
   - tag number
3. **VALVES**
   - selection process
   - typical valves
4. **ACTUATORS**
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   - torque output / safety margins
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   - typical ESD connection diagrams
6. **MATERIALS**
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   - NACE materials
7. **FIRE PROTECTION**
8. **SAFETY INTEGRITY LEVEL (SIL)**
   - MTBF, DC, PFD, SIL
9. **TOTAL LIFE CYCLE**
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metso automation

1. STANDARDS

MIL

DIN -> IEC 61508

ISA S84.1

IEC 61508 is a globally recognised new safety standard specific to process industry. Very strong guidelines are given there to process operators to test and prove the availability and functional safety of the safety loop including the final elements and ESD valves. This standard gives practical tools for Safety Design process. As well it is a tool for Auditors to review plants Safety efforts. Very typically Insurance companies would utilize this standard to review if all Safety measures are taken. This can have a great impact to Insurance fees being either lowered or increased.

Compliance to IEC 61508

Part 1 of the IEC 61508 demands certain documentation requirements for the development of safety critical devices. As basis documents, the SRS (Safety Requirements Specification) and the V&V Plan (Validation and Verification Plan) were prepared.
For the specific requirements of part 2 (system architecture, safe failure fraction, diagnostic, measures against systematic faults and measures to avoid failures during design and development) and part 3 (software), the finally selected measures meet the requirements of SIL 3.

Regarding the control of failures, the following results were estimated:
1. Hardware fault tolerance is 0
2. Safe failure fraction of the pneumatic part is > 90 % (low complex component)
3. Safe failure fraction of the electronic part: No hardware/software fault could lead to a dangerous failure in case of a demand.
From this point of view the Neles ValvGuard system could be used up to and including SIL 3.
For the PFD calculation the final valve is dominant for the result. The diagnostic coverage of a final valve could be between 75 % and > 90 % depending on the type of valve. The failure rate, safe failure fraction resp. diagnostic coverage of the final valve and the automatic test time interval have to be used for the PFD calculation.
Depending on this calculation and the required hardware fault tolerance of the application (some applications require a hardware fault tolerance of 1) the max. SIL level is defined. If the PFD calculation does not reach SIL 3 and/or a hardware fault tolerance of 1 is required, a dual redundant configuration has to be used as described in the ValvGuard safety manual.

2. SPECIFICATIONS

2.1 How to identify an ESD valve

ESD valves are part of Safety System. The function can be clearly specified in the specification. Quite often specification requires certain safety margins for actuator sizing. Some of above mentioned Safety related standards can be mentioned.

2.2 Duty description

Data sheets describe the valve to be an ESD / ESV or Emergency valve.

2.3 Tag number is XV or XCV or ZV

2.4 Jammer or latching devices are specified

2.5 Volume tanks are specified for emergency function e.g three strokes in cause of supply air failure

2.6 Strict operating times are specified

2.7 Strict safety margins in actuator sizing is requested

3. VALVES

3.1 Valve series to be considered

Ball Valves

150 lbs	1" – 8"	**X**-serie, floating, FB or RB, Bulletin 1X20, 1X21
150 lbs	08" – 16"	**X**-serie, trunnion, FB or RB, Bulletin 1X22
300 lbs	1" – 6"	**X**-serie, floating, FB or RB, Bulletin 1X20, 1X21
300 lbs	02" – 16"	**X**-serie, trunnion, FB or RB, Bulletin 1X22
150/300/600 lbs	02" – 36"	**D**-serie, trunnion, FB or RB, Bulletin 1D20
Alternative series **Top 5** (1,5" – 16"), Bulletin 1T520		
Soft seated alternative see bulletins; 1X24 and 1X25.		

Butterfly valves

150/300 lbs, wafer/lug	3"- 16"	**LW/LG** series, Bulletin 2LW20
150/300 lbs, wafer/lug	18"- 48"	**L1C/L1D** series, Bulletin 2L121
150 – 600 lbs, flanged	4" – 64"	**L6** series, Bulletin 2L621
Soft seated alternative Wafer-Sphere (3" –60"), Bulletin 2WS21, 2WS22		

3.2 Selection process

Application type	Emergency closing or venting, note if selected valve is capable for partial stroke testing (eg. venting vs. buttefly)
Pressure	Shut-off pressure, operating pressure, see temperature relation tables, remember shaft strenght
Temperature	Soft parts, body material, coatings, seat construction bearings, high temp. extension, low temp./cryogenic
Fluid	Corrosive, solids, toxic, explosive (O2)
	Viscosity, errosion, corrosion, solidifying, coke build-up
Materials	CF8M, WCB, LCC, C5, note temperature, chemical resistancy, NACE
Valve type	Ball valve reduced bore or full bore, butterfly valve, fail open or close, tightness, operating speed, floating or trunnion
Actuator type	Spring return or double acting, operating speed, handwheel, jammer, seel cylinder, fre box
Fire safety	API 607, BS6755
Accessories	SOV, LS, Booster, QEV, PPS, VT
Area clasification	EExi, EExd, EExn, FM, CSA, Cenelec
Power supply	Supply pressure, SV voltage

3.3 Torque tables / safety margins

Preferable method of selecting actuator is to use Nelprof sizing program. Nelprof gives automatically actuator load factor % and Safety margin therefore can be seen. Printout of calculation is the calculation document to be handed to client. Safety margins are typically between 50 – 100%. Note that actuator oversizing specially at elevated temperatures may lead to shaft strength study.

Sample of Nelprof sizing sheet indicating actuator load

Seat	Gland pack	Bearings	T-factor	Unit	DP Shutoff
std_Metal	Graphite	Metal	1	bar	10

	Code	Size	Unit	Supply press	Spring rate
Actuator	BC	AUTOM	barG	5	4

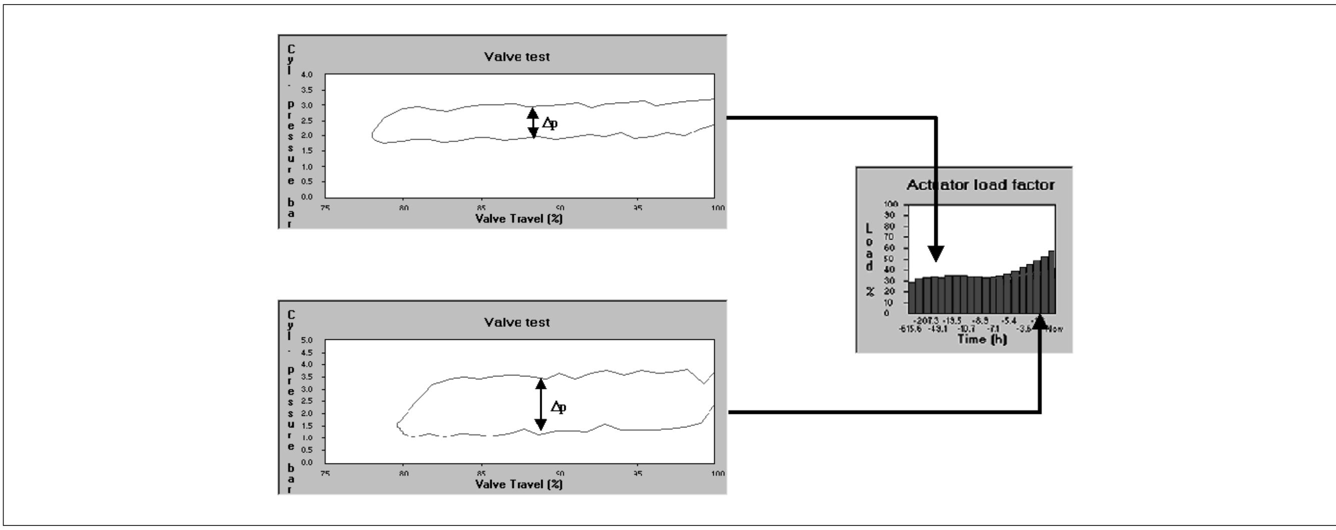
Torques					
To open	Nm	704	To close	Nm	704
Opening LF	%	62	Closing LF	%	62
Control open	Nm	343	328		
Ctrl open LF	%	28	26		
Control close	Nm	306	287		
Cntl close LF	%	25	22		

Actuator sizing results for rotary valves.

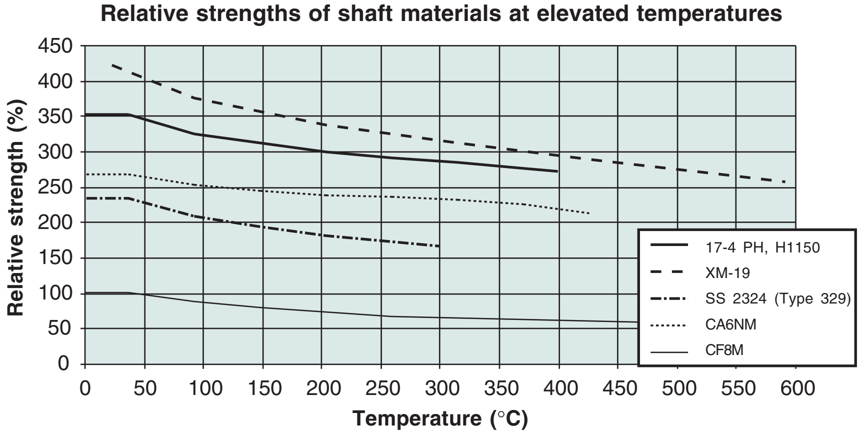
To open Torque required to begin opening the valve. Breakaway torque for eccentric valves and friction torque for concentric valves. Calculated with dp Shutoff.

Opening LF Opening load factor. Load factor is the required torque divided by the available torque. A value of 62 means that 62% of the torque given by the actuator output torque is needed to open the valve. The opening load factor should be below 50 to allow some safety margin in the selection.

Actuator load factor development via Neles ValvGuard diagnostic



Relative strengths of shaft materials at elevated temperatures



For further torque information use product bulletin.

3.4 Floating vs. trunnion ball valves

Main reason for this consideration is trim / seat surface pressure. Too high surface pressure can cause trim / seat damage within a few strokes. Very expensive coatings can be easily avoided.
Floating valves are recommended to be used only for sizes below 8" in ANSI 150 lbs and below 6" in ANSI 300 lbs. ANSI 600 must always be a trunnion design. Always concider the required operating torque (including safety margin) difference between floating and trunnion design. Actuator size can be remarkably smaller with trunnion valves.

3.5 Design standards

Ball Valves	ANSI 16.34, DIN 3840
Butterfly Valves	ANSI 16.34, DIN 3840

4. ACTUATORS

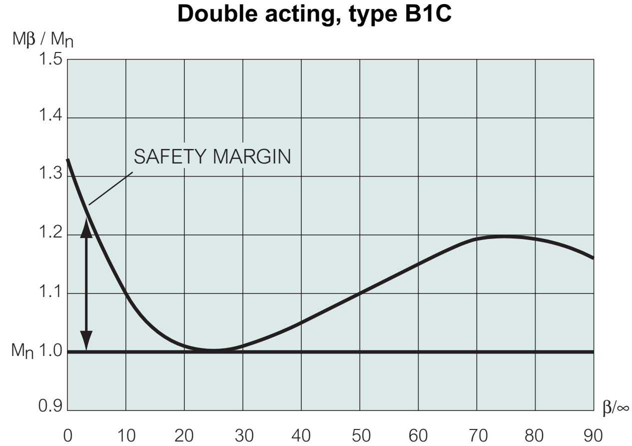
4.1 Actuators to be considered

Spring return	B1J, B1JA, B1JAR, or same with "K" or "V" spring. B1J + jammer option (unless Neles ValvGuard is used).
Double acting	B1C (not to be used with ValvGuard)
Material	Steel cylinder

4.2 Selection process

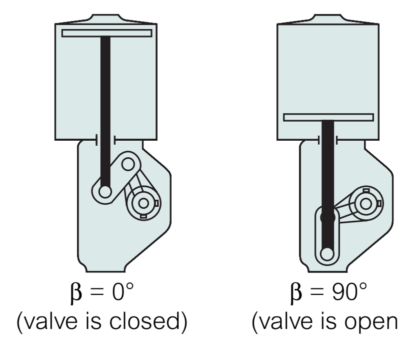
Actuator type	Pneumatic double acting, pneum. spring return, rolling diaphragm spring return or double acting, electric, hydraulic
Fail safe function	Fail to close, fail to open, fail in place
Supply pressure	min 3,5 bar, max. 8,5 bar
Operating speed	See below for actuators, use QEV's or AOV's to speed operation, also large size SOV is alternative
Manual hand wheel	Manual hand operation possibility. Top mounted up to B1J16 . Side mounted for larger sizes.
Hydraulic manual operation	Available as option. Note operating speed.
Cylinder material	Normal cylinder material aluminium. As an altenative steel cylinders are available
Mechanical limits	Mechanical limits can be adjusted to only partially close or open if desired
Fire protection	Firebot or K-mass give total fire resistancy.

Double acting, type B1C

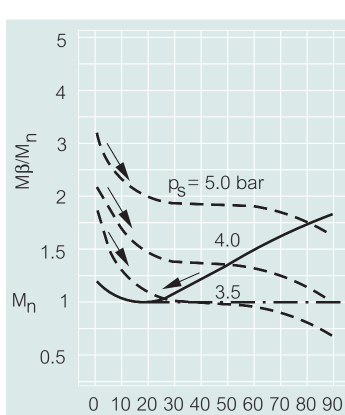


Output torque as a function of turning angle.

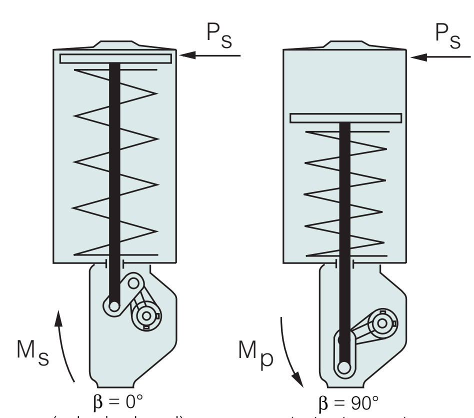
B1C



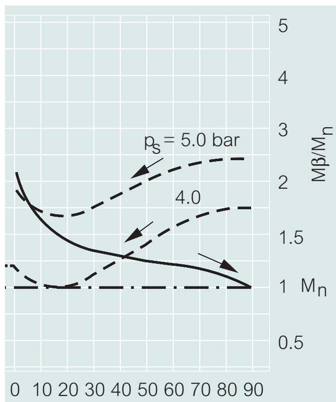
Spring to close, type B1J



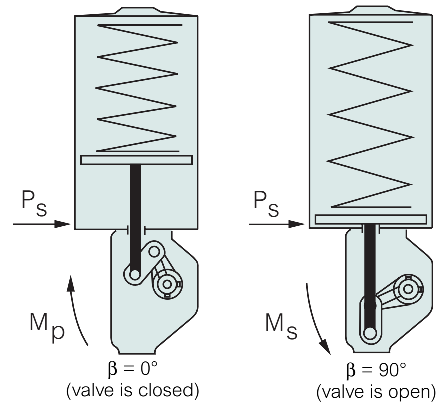
B1J



Spring to open, type B1JA



B1JA



4.3 Operating times

Actuator B1J(A)	Stroking speed	Cylinder connection	Piping metric/imperial
B1J8	< 1 sec	3/8"NPT	6mm or 1/4"
B1J10	1 sec	3/8"NPT	10mm or 3/8"
B1J12	1,5 sec	1/2"NPT	10mm or 3/8"
B1J16	2 sec	1/2"NPT	10mm or 3/8"
B1J20	3 sec	3/4"NPT	12mm or 1/2"
B1J25	4 sec	3/4"NPT	12mm or 1/2"
B1J32	5 sec	1"NPT	12mm or 1/2"
B1J322	10 sec	1"NPT	12mm or 1/2"

Bare actuator with std. connection size

Typical ESD-valve actuation
Double-acting actuator

Actuator B1C	Stroking time	Cylinder connection	Piping metric/imperial
32	5	3/4"NPT	12mm or 1/2"
40	7	3/4"NPT	20mm or 3/4"
50	10	1"NPT	20mm or 3/4"
502	20	1"NPT	20mm or 3/4"

When stroking times are specified by the customer, component sizing must be made properly. All components must be considered to have enough capacity for air flow. Also tubing and fittings must have sufficient capacity.

Typical ESD-valve actuation
Spring-return actuator

System 303012				
Actuator	Solenoid + QE-valve		Typical speed, max	
B1J(A)	SOV	QE	Spring	Air
8	1/4"	1/4"	<2 secs	<2 secs
10	1/4"	1/4"	<3 secs	<4 secs
12	1/4"	1/2"	<3 secs	<6 secs
16	1/4"	1/2"	<3 secs	<10 secs
20	3/8"	3/4"	<3 secs	<10 secs
25	3/8"	3/4"	<4 secs	<15 secs
32	1/2"	1"	<5 secs	<20 secs
322	1/2"	2 x 1"	<7 secs	<40 secs

System 303013					
Actuator	Solenoid + pilot valve			Typical speed, max	
B1J(A)	SOV	CV	AOV(NC)	Spring	Air
8	1/4"	1/4"	3/8"	<1 secs	<1 secs
10	1/4"	1/4"	3/8"	<1,5 secs	<1,5 secs
12	1/4"	1/4"	1/2"	<2 secs	<2 secs
16	1/4"	1/4"	1/2"	<2,5 secs	<2,5 secs
20	1/4"	1/4"	3/4"	<3 secs	<3 secs
25	1/4"	1/4"	3/4"	<4 secs	<4 secs
32	1/4"	1/4"	1"	<5 secs	<5 secs
322	1/4"	1/4"	2 x 1"	<10 secs	<10 secs

For component specification contact your nearest Metso Automation representative.

Note: When quicker operating times are needed than listed on typical speed column, consult the factory.
Note that supply pressure has some effect on stroking speeds. Valve construction and coatings must be considered in case of fast operating speeds are used. Please consult the factory for details.

SOV = Solenoid Valve
CV = Check Valve
QE = Quick-Exhaust valve
AOV = Air Operated Valve

Sizing hints:
System
303012 Solenoid valve capacity has effect on air-stroke speed. QE-valve capacity has effect on spring-stroke speed.
303013 Air operated valve capacity has effect on both air-stroke and spring-stroke speeds.

Actuator BC	Cylinder connection	Typical speed, max	Piping metric/imperial	Note
		Air		
32	3/4"NPT	<5 secs	12mm or 1/2"	
40	3/4"NPT	<7 secs	20mm or 3/4"	
50	1"NPT	<10 secs	20mm or 3/4"	
502	1"NPT	<20 secs	20mm or 3/4"	Double cylinder

System 302034								
Actuator	Solenoid + pilot valves + volume tank						Typical speed, max	
B1C	SOV	CV	AOV(NC)	AOV(NO)	PPS	VT	Air	Air
32	1/4"	1/4"	3/4"	3/4"	1/4"	_x_ liters	<5 secs	<5 secs
40	1/4"	1/4"	3/4"	3/4"	1/4"	with	<7 secs	<7 secs
50	1/4"	1/4"	1"	1"	1/4"	accessories	<10 secs	<10 secs
502	1/4"	1/4"	2 x 1"	2 x 1"	1/4"		<20 secs	<20 secs

For component specification contact your nearest Metso Automation representative.

Note: When quicker operating times are needed than listed on typical speed column, consult the factory.

SOV = Solenoid Valve
CV = Check Valve
PPS = Pneum. Pressure Switch
VT = Volume Tank
AOV = Air Operated Valve

Sizing hints:
System

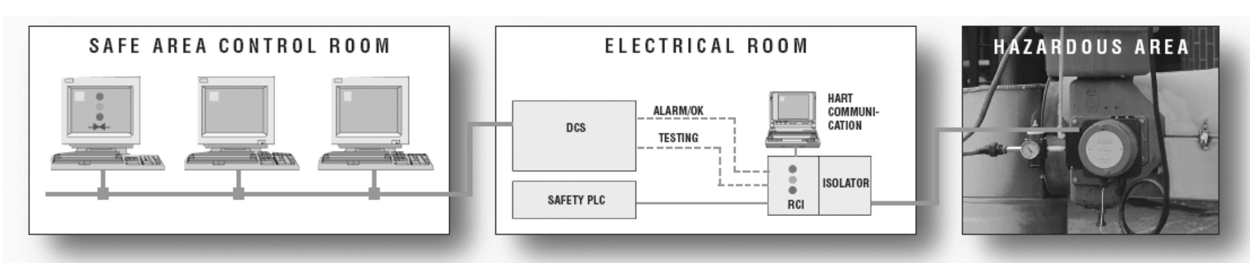
302034 Air operated valves capacity has effect on both air-stroke and spring-stroke speeds.

Note: Size filter regulator and other accessories acc. stroke-speed requirements.

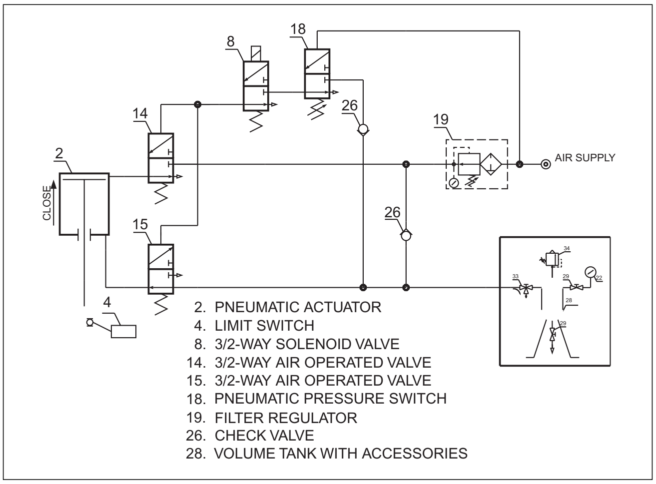
5. ACCESSORIES

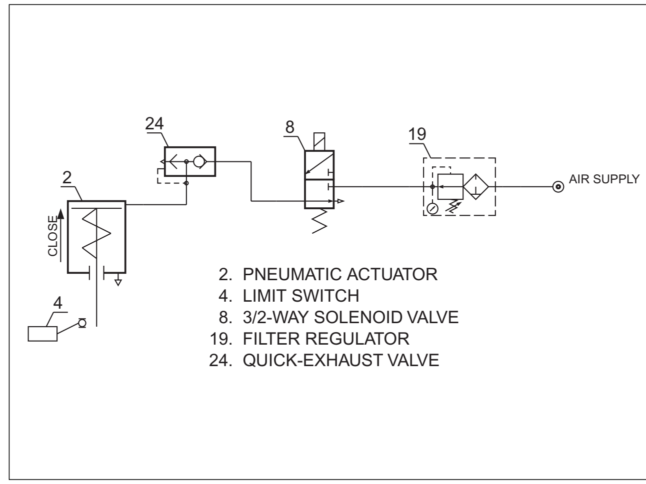
5.1 Neles ValvGuard

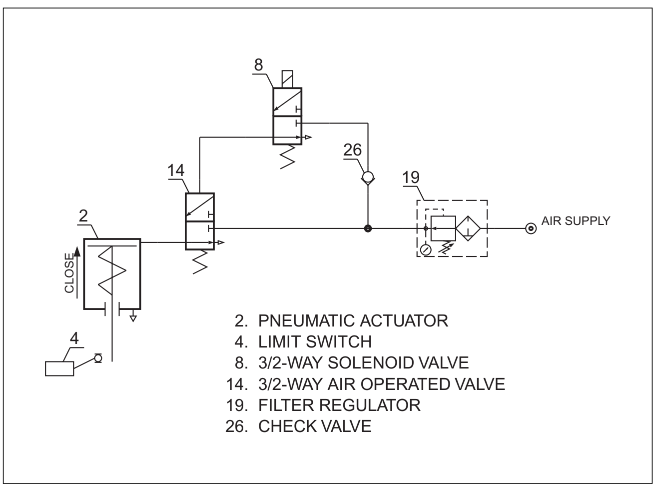
The Neles ValvGuard testing and monitoring system for emergency valve applications is a new generation safety management system that helps ensure that emergency shutdown (ESD) and venting (ESV) valves will operate properly despite long periods of idle service. Unlike traditional safety systems that require testing while the process is completely shut down, the Neles ValvGuard allows operators to reliably test valve performance on-line, anytime, without disturbing the process. With Neles ValvGuard, valve performance is monitored automatically on a continuous, real-time basis. Depending upon your specific process needs and the potential for danger, an on-line testing sequence can be defined from every few minutes up to once a year. The system automatically provides a warning in advance of any problem -- simple low-cost actions can then be implemented before a dangerous situation occurs. Because the exact status of the valve is known at all times, maintenance periods can be extended and unnecessary process shutdowns and repairs avoided.



5.2 Typical ESD connection diagrams







5.3 Solenoid valves

In case Neles ValvGuard is used no separate solenoid valve is needed. Consider the operating speed. NOTE : Neles ValvGuard is doing the function of SOV and a lot more.

5.4 Limit switches

Limit switches are sometimes required to indicate to DCS the valve position. They may be a part of Interlocking system as well. In case Flame Proof (Exd) Neles ValvGuard is used, side mounted separate limit switch unit must be installed. We have a standard offering for Neles Quartz limit switch including a rigid mounting bracket. The same can be used for position sensor unit. Intrinsically safe (Exi) Neles ValvGuard has an internal limit switch unit as standard option. Micro or inductive switches are available.
NOTE: together with Neles ValvGuard limit switches must be calibrated in such a way that it shall not cause unneccessary Interlocking chainreaction !
Calibrate corresponding LS to have greater switching angle than Neles ValvGuard test stroke size, or the indication from movement shall not ignite Interlocking system.

5.5 Operating speed control

Fail safe stroking times can be achieved either venting the air via Neles ValvGuard or SOV ports. In case of larger size actuators this is not sufficient for quick operation but additional exhaust methods must be used. E.g Quick Exhaust valve.

5.6 Additional instrumentation

If there is need to have information when a valve is fully open or fully closed, the actuator or Neles ValvGuard can be equipped with micro-mechanical or proximity sensor limit switches.
If there is need to close or open a valve very fast in the case of emergency, extra instrumentation may need to be used. The figures 11-14 illustrate accessories which are needed to achieve fast action as well as to allow partial valve stroke test. The exhaust valve is normally high capacity valve.
A filter-regulator is mandatory and port size should be related to tubing size between the Neles ValvGuard and actuator cylinder volume connections.

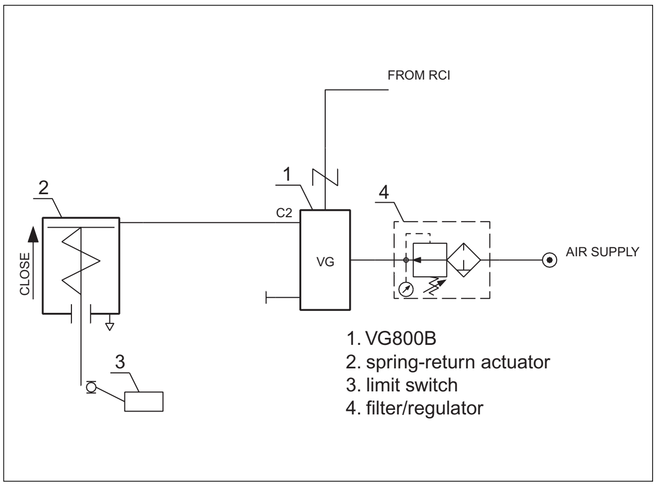


Fig. 11. Standard operation with ValvGuard

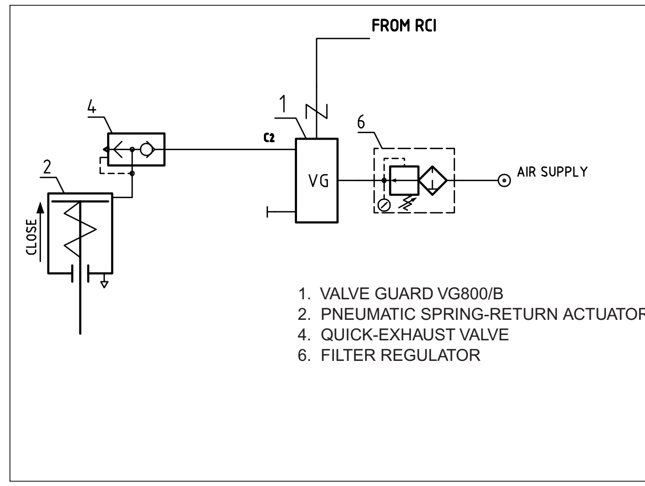


Fig. 13. Operation with quick exhaust valve (recommended solution)

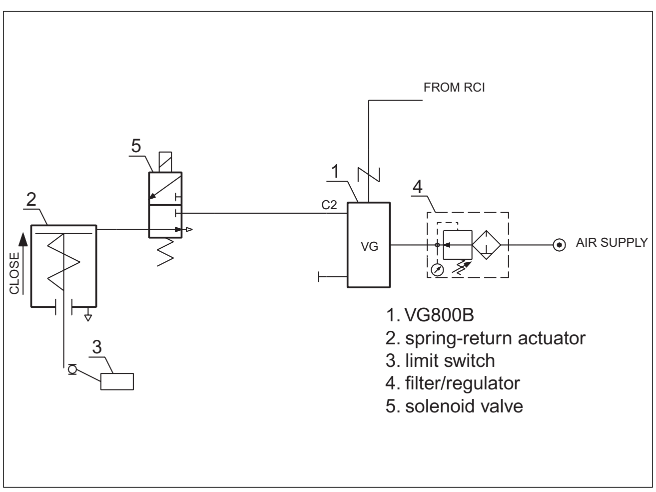


Fig. 12. Operation with solenoid valve (1oo2 system)

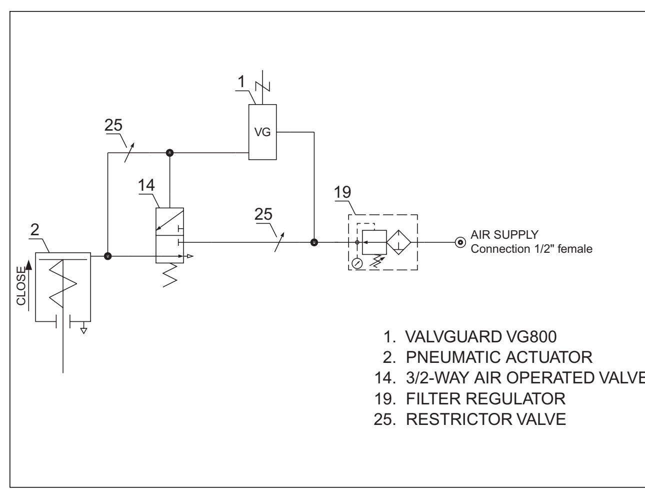


Fig. 14. Operation with air operated valve (not recommended)

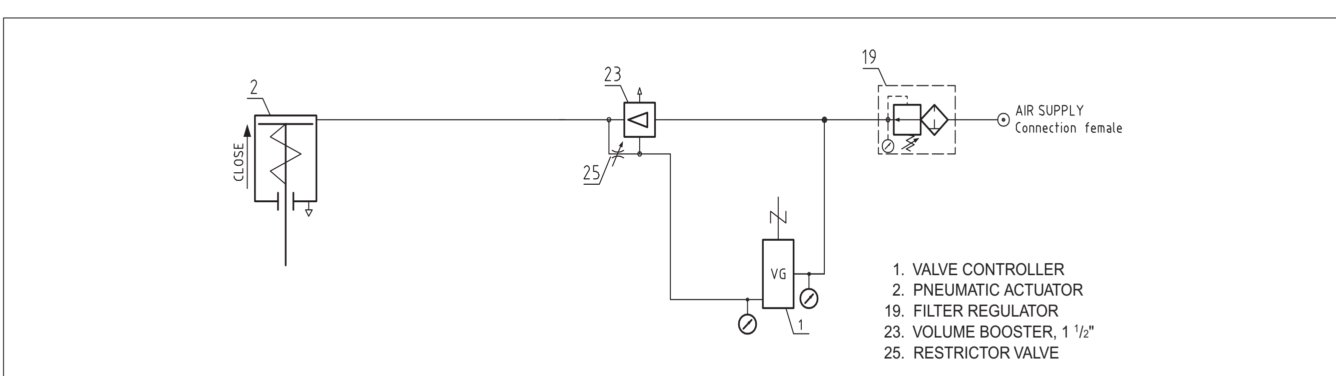


Fig. 15. Operation with volume booster

6. MATERIALS

6.1 Body material

Material certification EN 50049 3.1 (others on request)

The following materials used by Metso Automation are approved by NACE, MR0103* and MR0175**.

Body	ASTM A351 gr CF8M, ASTM A216 gr WCB, ASTM A352 gr LCC
Bonnet	ASTM A351 gr CF8M, ASTMA A216 gr WCB
Flange ring	ASTM A352 gr LCC, ASTM A105, ASTM A182 gr F316
Blind flange	ASTM A351 gr CF8M
Bolts and nuts	ASTM A193 gr B8M, ASTM A320 gr L7M, ASTM A453 gr 660, ASTM A194 gr 2HM
Closing member	ASTM A351 gr CF8M, ASTM A487 gr CA6NM, ASTM A182 gr F6NM, AISI 316
Bearings	Stellite, PTFE reinforced with stainless steel net
Seats for ball valves	AISI 316 + Cobalt base alloy
Seats for butterfly valves	ASTM B424 gr N08825, ASTM A182 gr F6NM
Shafts and pins	ASTM A479 gr XM-19, ASTM A564 gr 630
Coatings :	Hard Crome, Co- base alloys, NiBo, FeBo, Carbides, Nitrading
Springs :	Inconel X-750, Inconel 625 (N06625)

For detailed information see product bulletins.
NACE materials

* = MR0103 (refining) : Alloys for wetted parts shall meet hardness limits and they shall be in the right heat-treat condition given in the norm.
** = MR0175 (oil and gas) : In addition to metallurgical requirements the alloys' compatibility depends on process parameters like content of H2S, chlorides and sulphur, as well as temperature.

6.2 Coatings

List of trim / seat coatings including typical service conditions and applications

Ball coating properties

COATING	DESCRIPTION	HARDNESS, HRC/HV	THICKNESS, mm
HARD CHROMIUM	ELECTROLYTIC COATING	70/1000	<0.1
NiBo	Ni-BASE ALLOY (S&F)	55/600	0.5-1.0
SF6	Co-BASE ALLOY (S&F)	45/450	0.5-1.0
WC-Co	TUNGSTEN CARBIDE (HVOF)	70/1000	0.1-0.2
(W/Cr)C	TUNGSTEN CHROMIUM CARBIDE (HVOF)	70/1000	0.1-0.2
CrC	CHROMIUM CARBIDE (HVOF)	65/800	0.1-0.2
SM 2001	Ni-BASE ALLOY (HVOF)	55/600	0.1-0.2

THERMAL SPRAY PROCESSES

S&F: SPRAY AND FUSE
HVOF: HIGH VELOCITY OXYFUEL SPRAYING
PLASMA: PLASMA SPRAYING

6.3 Sliding properties

Ball valve sliding pairs

BALL	SEAT	MEDIUM	SERVICE
Hard chromium, HCr	Celsit, Alloy 50Nb	Liquid, Gas	Moderate pressure and temperature. Corrosion resistance nearly as good as that of 316.
Stellite, SF 6	Celsit, Alloy 50Nb	Liquid	Moderate pressure and temperature. Corrosion resistance equal to 316.
NiBo	Stellite 12, Alloy 12	Gas, up to 600°C	Moderate pressure and high temperature. Medium corrosion resistance.
Tungsten carbide, WC-Co	Tungsten carbide, WC-Co	Gas, up to 400°C	High pressure and moderate temperature. Poor corrosion resistance.
Tungsten chromium carbide, (W/Cr)C	Tungsten chromium carbide, (W/Cr)C	Liquid	High pressure. Good corrosion resistance.
Chromium carbide, CrC	SM 2001	Gas, up to 600°C	Moderate pressure and high temperature. Medium corrosion resistance.

7. FIRE PROTECTION

7.1 Fire safety

Metso Automation products are Fire tested according API 607 lated edition 4 and BS 6755 part 2. Certificates are available on reguest.

7.2 Fire boxes

For actuator and accessories protection separate fire boxes are available. Alternatives are a solid fire box (quite big in size) or product called K-mass which in case of fire due to heat creates a protective layer on actuator. Separate K-mass coated boxes are available for accessories.

8. SAFETY INTEGRITY LEVEL (SIL)

8.1 Neles ValvGuard MTBF value (Mean Time Between Failures)

MTBF for Neles ValvGuard is 55,3 years at ambient temperature. A complete ESD valve unit including trunnion mounted D or T series ball valve, B1J actuator and VG has been certified to SIL 3 safety service by Lloyds.

8.2 Typical MTBF values for Neles valves and actuators

Product series	MTBF (in years)	Remarks
D1F series ball valves	240	Metal seated
D2 series ball valves	240	Metal seated
X series ball valves	70	Metal seated
X series ball valves	30	Soft seated
L6 series butterfly valves	70	Metal seated
LW, LG series butterfly valves	50	Metal seated
B1 series actuators	420	Spring return and double actuator
VG valve controller	55,3	Certified by TUV

8.3 Diagnostic Coverage (DC factor)

Diagnostic Coverage is the fraction of failures detected by the system compared to all failures.

- Three components: valve, actuator and SOV
- Failure rate and diagnostic coverage estimates needed
- With Neles ValvGuard (see "safety manual" in IMO 9VG/B70):

Typical values in partial stroke testing :
ESD valve: DC = 77%
ESV valve: DC = 92%

- DIAGNOSTICS COVERAGE FOR DANGEROUS FAILURES

$$DC = \frac{\Sigma\lambda_{DD}}{\Sigma\lambda_{DD} + \Sigma\lambda_{DU}}$$

9. TOTAL LIFE CYCLE

9.1 Expert service is available when and where you need it

It takes more than highly-reliable products to keep the process running smoothly; it also takes reliable service and support. When you need training, diagnostic assistance, repairs or upgrades, Metso Automation can help by providing quick response from our worldwide network of service centers. Our family of services encompass the entire product life cycle, from the time of installation all the way through to planned replacement.

Our technical staff is expertly trained in problem-solving specifically for chemical, petrochemical and refinery processes. If needed, service personnel are available around the clock, on site if necessary, to make sure every repaired valve passes the same quality and performance testing as new Metso Automation products. At every step, our goal is to enhance your overall profitability and make the process safer.

9.2 Low cost of ownership

Metso Automation's automated on/off valves are engineered to lower ownership costs throughout the entire life cycle. Our low total cost solution starts with compact rotary designs that simplify installation, and continues through to the need for fewer spare parts and reduced maintenance requirements. Customers report that our installed valves have an average life of 10 years or more.

10. APPLICATIONS

Reference to separate application reports 2722/01/07, 2722/01/06.

11. QUALITY PACKAGE

11.1 Tightness comparison

Comparison of leakage rates (air)

4.6x	~MSS SP-72 (1992)
2x	
1.1x	MSS SP-72 (1970)
1x	**ISO 5208 Rate D, BS 6755 Part 1 Rate D, JIS B2003 Rate 1**
0.6x	
0.5x	~DIN 3230 Part 3 Rate 3
0.4x	
0.3x	~API 598 (1990) (metal seat >DN150 ≤300)
0.2x	
0.1x	ISO 5208 Rate C, BS 6755 Part 1 Rate C
0.06x	~ANSI/FCI 70.2 Cl VI (DN>400 ≤600)
0.05x	~DIN 3230 Part 3 Rate 2
0.04x	~ANSI/FCI 70.2 Cl VI (DN>200 ≤400), ~API 598 (1990) (metal seats >DN50 ≤300)
0.03x	~API 598 (1990) (metal seat >DN300 ≤500)
0.02x	~ANSI/FCI 70.2 Cl VI (DN>100 ≤200), ~API 598 (1990) (metal seats >DN500 ≤800)
0.01x	ISO 5208 Rate B, BS 6755 Part 1 Rate B, ~ANSI/FCI 70.2 Cl VI (DN>DN50 ≤100)
0.005x	~ANSI/FCI 70.2 Cl VI (DN ≤50), API 598 (1970) (metal seats >DN 50 ≤300)
0.004x	~API 598 (1970) (metal seat >DN300 ≤500)
0.003x	~API 598 (1970) (metal seat >DN500 ≤800)
0.0x	ISO 5208 Rate A, BS 6755 Part 1 Rate A, DIN 3230 Part 3 Rate 1,
	API 598 (all soft seats and metal seat ≤DN50)

Comparison of leakage rates (water)

5x	ANSI/FCI 70.2 Cl V/100 bar
4x	MSS SP-72 (1992)
3x	
2x	~DIN 3230 Part 3 Rate 3
1.1x	MSS SP-72 (1970), MSS SP-61
1x	**ISO 5208 Rate D, BS 6755 Part 1 Rate D, ANSI/FCI 70.2 Cl V/20 bar, JIS B2003 Rate 1**
0.9x	
0.8x	~API 598 (1970, 1990) (>DN50 ≤150)
0.7x	~API 598 (1970, 1990) (>DN150 ≤300)
0.6x	~API 598 (1970, 1990) (>DN300 ≤500)
0.5x	ANSI/FCI 70.2 Cl V/10 bar
0.4x	~API 598 (1970, 1990) (>DN500 ≤800)
0.3x	ISO 5208 Rate C, BS 6755 Part 1 Rate C
0.2x	~DIN 3230 Part 3 Rate 2
0.1x	ISO 5208 Rate B, BS 6755 Part 1 Rate B
0.0x	ISO 5208 Rate A, BS 6755 Part 1 Rate A, DIN 3230 Part 3 Rate 1,
	API 6D, API 598 (all soft seats and metal seat ≤DN50)

12. Terminology

For detailed and more definitions see IEC 61508 part 4

SIS	Safety Instrumented System (ESD,PSD,HIPPS)	The total safety system including Safety PLC, sensors and valves to prevent unsafe process conditions. SIL (1-4) defines the minimum performance level.
SIF	Safety Instrumented Function	Function to be implemented to achieve or maintain a safe state for process in case of hazardous event.
PFD	Probability of Failure on Demand	PFD (SIL) is the probability that a device fails to operate according process safety demand. Eg. SIL 1 = 1 out of 10 strokes fail or SIL 3 = one out of 1000 strokes fail as min. requirement.
SIL	Safety Integrity Level	Target level of Safety integrity presented as probability to fail per hour or demand (PFD) SIL 1 = 0.1-0.01 SIL 2 = 0.01-0.001 SIL 3 = 0.001-0.0001 SIL 4 = 0.0001-0.00001
BPCS	Basic Process Control System (known also as DCS)	A system which responds to input signals from the EUC or operators and generates output signals to EUC to operate as desired.
DCS	Distributed Control System	A system which responds to input signals from the EUC or operators and generates output signals to EUC to operate as desired.
PLC	Programmable Logic Controller	Independent system to prevent or mitigate the process to safe state in case on process upset. Normally energized and during trip de-energized.
EUC	Equiment Under Control	Equipment, machinery or plant receiving signal from DCS to make desired operation.
TSO	Tight Shut Off	Common definition for Emergency valve tightness.
λ	Failure Rate (per hour)	1/ MTBF Eg. 10 same type of valves operate under same conditions 4 years. => MTBF = 40 years. λ = 1:40 = 0.025
MTTF	Mean Time to Failure	The time between replaceable device failures.
MTBF	Mean Time Between Failures	The time between repairable device failures.
MTTR	Mean Time To Repair	Time used to repair a device.
DC	Diagnostic Coverage	Diagnostic Coverage means the percentage of failures that can be detected automatically by a system.
SFF	Safe Failure Fraction	Fraction of safe and dangerous detected failures over all failures.
Dangerous failure		Failure which has a potential to put the safety related system in a hazardous or fail-to function state.
Safe failure		Failure which does not have a potential to put the safety related system in a hazardous or fail-to function state.
Common cause		Failure which is a result of one or more events, causing coincident failures of two or more separate channels in a multiple channel system, leading to a failure. Redundant valves typically can have common cause failures.
1oo2	One out of Two	If one of, e.g. sensors fail, the system trips down.
TI	Test Interval	The period between device test (automatic or manual)or shut-down.
RCI	Remote Communication Interface	Interface card located in cross connection room. Facilitates HART protocol communication remotely with field device(eg. down load data or configurate).
IEC	International Electrotechnical Commission	Globaly regocnised Standardisation Committee.
HSE	Health and Safety Executive	UK based Safety Authority monitoring e.g. process industry to follow safety instructions.
ANSI/ISA S84.01	US based standard for design,installation,operation and maintenance of Safety Instrumented Systems	Mainly for process industry. IEC 61511 shall replace S84.1 in near future. Both include much of same elements.

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