Safety Manual

Product:

AV Automatic Valve Spool Valves (pneumatic)
Series “D, I, L”
with optional adaptor
with CNOMO interfaced solenoids

Typ:

3/2, 5/2, 5/3 Way Valves (CC, OC, PC)

Manufacturer:

Automatic Valve Industrial LLC
950 Woodward Heights
Ferndale Michigan 48220 USA

V 1.0

Revisionsindex

Index	Date	Section	Change description	Changed by
V 0.1	2021-06-14	All	Initial draft release	Dietrich Warmbier, ROSS Controls
V 0.2	2021-07-19	1.1 2 3.1.1 3.1.2.1 3.5 3.6 3.11	Deleted ISO 13849 Deleted ISO 13849 Deleted ISO 13849 Leakage added Deleted ISO 13849 Added part movement times Added details	Dietrich Warmbier, ROSS Controls
V 0.3	2021-08-26	Appendix B	Added	Dietrich Warmbier, ROSS Controls
V 1.0	2021-09-20	2.0	Adding TUV certificate	Dietrich Warmbier, ROSS Controls

Document ID:
Revision: 1.0

Table of Contents

Tables

Images

1 Introduction

1.1 Purpose

Purpose of the safety manual is to describe the application of the SIL-certified pneumatic AV AUTOMATIC VALVE spool valves of the D, I, L series in safety instrumented systems according to IEC 61508.

The safety manual is in addition to the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products.

1.2 Scope of application

The safety manual applies for all AV AUTOMATIC VALVE spool valves of the D, I, L for the defined type variants please remark the type code in section 3.2.

The different ordering/ series codes are used to describe different features like size of pipe adapter, flow rate and other features (e.g., IP protection class, EX proof, etc.) which all rely on identical safety principle. So, the different features have no influence on the safety concept of the valves.
The framework and conditions defined by the intended use of the AV AUTOMATIC VALVE spool valves as described in the installation and maintenance guidelines have to be mandatory fulfilled using the valves in safety applications.

1.3 Warning

 This symbol is used if special requirements, remarks or precautions have to be considered by using the valves.
Disregarding remarks pointed out with this symbol can result in injury of the operational personnel or third persons or/and in damages to the equipment.

1.4 Applicable documents

 The safety manual is to use together with the following documents:
Installation and maintenance guidance for AV AUTOMATIC VALVE pneumatic products.

 All services for the pneumatic spool valves have to be done by trained and authorized personnel. The personnel have to be trained, instructed and authorized to install and service the valves properly.

1.5 Used acronyms

HFT	Hardware Fault Tolerance
SIL	Safety Integrity Level
PL	Performance Level
NC	Normally closed
NO	Normally opened
SFF	Safe Failure Fraction
DC	Diagnostic Coverage
MTTR	Mean time to repair
PFDavg	Averaged probability of failure on demand of the safety function of a safety system.

Table 1: List of acronyms

1.6 Definition of Safe State and Failure Definition

For common understanding of failures following items are defined:

Safe State	Status/position which is defined as safe for the System.
Safety function	Function responsible to maintain or achieve the safe state from the actual position/mode of operation after request of the safety function within the safety time.
Process safety time	Maximal tolerated time between a failure that has the potential to give rise to a hazardous event, (for components: the time point of demand of safety function) and the finally reached safe state to prevent the hazardous event occurring. The safety time is part of the safety function.
Dangerous failure	Failure which prevents, that the safe state will be reached in the safety time.
Dangerous detected failure	Failure which is detected by diagnosis and repaired within a specified time frame.
Dangerous undetected failure	Dangerous failure which is not detectable and could result in a dangerous state or will prevent reaching the safe state.
Safe failure	Spurious failure leading to the safe state of the system or raises probability of a spurious failure leading to the safe state.
No effect failure (not relevant failure)	Failure not effecting the execution or function of the safety functions.
Fail safe principle	Design principle that a failure of a component always results in the safe state of the subsystem.

Table 2: Definition of Safety Items according to IEC 61508-4:2010

2 SIL-Certificate

The AV AUTOMATIC VALVE spool valves in the D, I, L series described in the safety manual are certified by SGS-TÜV Saar in accordance to IEC 61508 safety integrity level 2 (SIL 2) in singular application with HFT = 0 and SIL 3 and PL e in redundant application with HFT ≥ 1.

SGS TÜV SAAR

CERTIFICATE NO FS/71/220/21/0747 **PAGE 1/1**
ZERTIFIKAT NR.: SEITE(N)

LICENCE HOLDER
GENEHMIGUNGSINHABER

Automatic Valve Industrial LLC
950 Woodward Heights
Ferndale MI 48220
USA

MANUFACTURING PLANT
FERTIGUNGSSTÄTTE

Automatic Valve Industrial LLC
950 Woodward Heights
Ferndale MI 48220
USA

PROJECT NO/-ID PROJEKT-NR/-ID	LICENSED TEST MARK GENEHMIGTES PRÜFZEICHEN	TECHN. REPORT NO. TECHNISCHER BERICHT NR.
S1MC	SGS TÜV SAAR FUNKTIONALE SICHERHEIT GEPRÜFT / FUNCTIONAL SAFETY APPROVED	S1MC0001

Tested according to *Geprüft nach*	IEC 61508:2010 Ed.2
Certified product(s) *Zertifizierte(s) Produkt(e)*	Spool Valve type series D, I, L
Model(s) *Model(le)*	Namur Interface Valves: D06; D20; ISO Spool Valves: I15; I20; I45; Compact Spool Valves: L20; L65; Top Mount Spool Valves: L21; L45
Technical Data and Parameter *Technische Daten und Parameter*	The products fulfil the requirements of functional safety acc. to IEC 61508:2010. The products can be used with a hardware fault tolerance HFT = 0, e.g. in a 1oo1 architecture up to SIL 2 with SC 3, and HFT ≥ 1, e.g. in a 1oo2 architecture up to SIL 3 with SC 3.
Specific Requirements *Spezifische Anforderungen*	This certificate confirms the achievement of the requirements of functional safety based on the following proofs: - Proof of systematic safety integrity for defined phases of the life cycle - Proof of the required safety-related parameters (failure rate, PFD and SFF by means of FMEDA) - Proofs that processes and methods are established at the manufacturer guaranteeing that unexceptionable processes in terms of risk analysis, design, production, validation, change management and quality management comply with the safety-related standard (see S1MC0001).

Certification Body for Functional Safety SGS-TÜV Saar GmbH
Zertifizierungsstelle für Funktionale Sicherheit

Munich, 2021-09-20

Robert Sammer

The test mark regulation is an integral part of this certificate.
Die Prüf- und Zertifizierordnung ist integraler Bestandteil des Zertifikates

SGS-TÜV Saar GmbH, Hofmannstraße 50, 81379 München

Website www.sgs-tuv-saar.com E-mail fs@sgs.com

SGS TÜV SAAR

CERTIFICATE

3 Safety Aspects

3.1 Application of AV AUTOMATIC VALVE spool valves D, I, L series in safety related applications

3.1.1 Functional principle of AV AUTOMATIC VALVE spool valve D, I, L series

The AV AUTOMATIC VALVE spool valves D, I, L series is suitable to following applications based on the safety principle:

- To be used as part of actor of safety instrumented systems.
- In singular application with HFT = 0 the valves fulfill the requirements for SIL 2 acc. IEC 61508 .
- In redundant application with HFT = 1 the valves fulfill the requirements for SIL 3 acc. IEC 61508 .

3.1.2 The exact functional principle of each type variant is described by the application specific type designation for each valve. General description of product function

3.1.2.1 General overview

Type designation:
AV AUTOMATIC VALVE spool valve for pipe and base mounting "D, I, L" series.
3/2, 5/2, 5/3- (CC, OC, PC) way valves

Leakage:
0,6ml / min

Optional Activations:
Pneumatic control, single solenoid pilot valve, double solenoid pilot valve

Optional Adapter:
D-series: Transition Plate, 90° Mounting plate

The AV AUTOMATIC VALVE spool valves are used in various safety loops to open or close control and supply lines. For this purpose, an electrical or pneumatic switching signal by the control instrumentation is transformed in the required valve position.


In general:

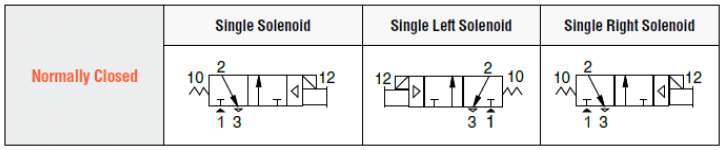
- the home position of the 3/2 and 5/2 valves with single pilot operation (solenoid or air actuation) is reached by spring force without any energy supply. Thus, for activating the valve (moving out of the safe home position) external control energy is required (pneumatic pressure, or by solenoid).
- the 5/2 valves with double pilot operation (solenoid or air actuation) will stay in the actual position. Thus, for activating the valve (moving out of the safe home position) external control energy is required (pneumatic pressure, or by solenoid).
- the 5/3 valves with double pilot operation (solenoid or air actuation) is reached by spring force without any energy supply. Thus, for activating the valve (moving out of the safe home position) external control energy is required (pneumatic pressure, or by solenoid).


In general, for the safety function following boundary conditions are defined:

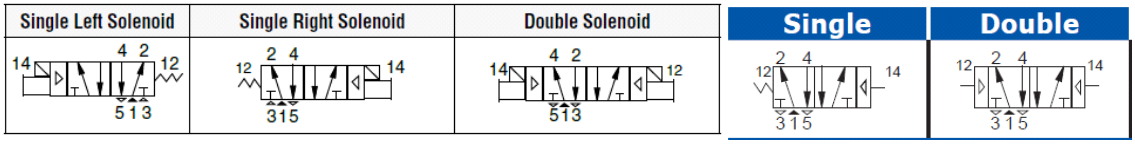
1. The electrical or pneumatic control signal has to be shutoff safely in case of demand of the safety function by the user
2. The operating medium must be in respect to any specific properties.
3. It is not allowed to close/reduce the bleeder of the valve in any case.

3.1.2.2 Overview Valve types

3-Way 2 Position valves



5-Way 2 Position Valves



5-Way 3 Position Valves

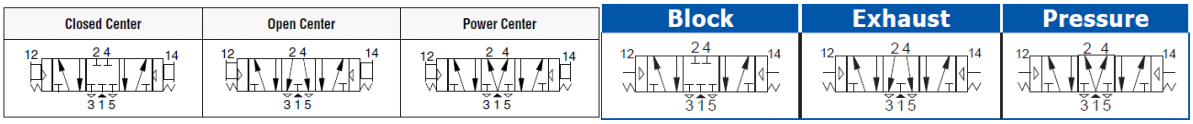


Image 1: Schematics of the AV Automatic Valve spool 3/2, 5/2, 5/3- (CC, OC, PC) way valves series "D, I, L"

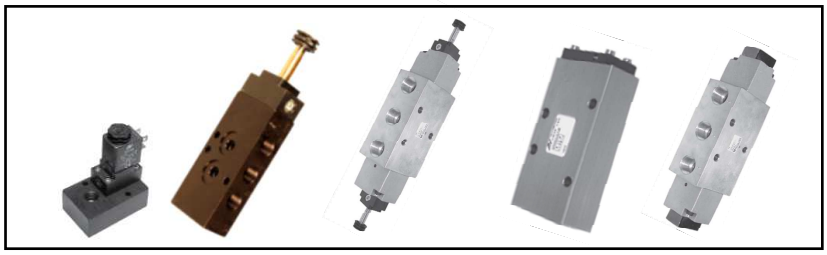


Image 2: Example of AV Automatic Valve spool valve, type "D, I, L" with and w/o pilot valve

3.1.2.3 Overview Activations

Pneumatic Control: Consists of an air end-cap with various connection threads for pneumatic pressure supply.

Abbildung 3.1-3: Pneumatische Ansteuerung

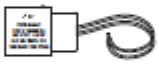
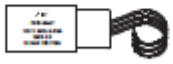
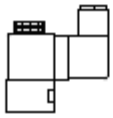
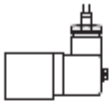
Figure 3.1-3: Pneumatic Control (single/ double) I-/ L-series

Solenoid pilot valves: These are CNOMO interfaced solenoid pilot valves. These are available in different versions.

example Pilot valve assembly and part number

L2003AAWR + Explosion-Proof 1/2" Conduit with 24" Leads 7019-9**Y = L2003AAWR-**Y

Part Numbers

Description		Operator Type	Instructions	Wt. Kg(lb)	Coil Part Number **=Voltage
Weather-Proof DIN 43650 Industrial Form B Connection NEMA 4X		X	Order coil separately (specify voltage code from below)	0,05 (0.12)	7019-9**
Weather-Proof 18" Leads NEMA 4X		X	Order coil separately (specify voltage code from below)	0,05 (0.12)	7019-9**G
Weather-Proof 1/2" Conduit with 30" Leads NEMA 4X		X	Order coil separately (specify voltage code from below)	0,05 (0.12)	7019-9**C 7019-9**CT (high temp 82°C max)
Explosion-Proof 1/2" Conduit with 24" Leads CSA & FM Approved CL. I; Zone1 Ex m II T4; AEx m II CL. I; Div.1; GR. A, B, C, D CL. II; GR. E, F, G CL. III T4 Ta=-20°C to +60°C NEMA 4, 4X, 7C, 7D, 9		X	Order coil separately (specify voltage code from below)	0,20 (0.44)	7019-9**Y
Intrinsically-Safe Strain Relief Ex ia CL. I; GR. A,B,C,D CL. II; GR. E,F,G CL. III; Div.1; T5		V	Coil and Connector included with valve (24VDC only)	0,21 (0.46)	A7106-374-DB
		A7106-374 Must be Used with an Intrinsically-Safe Barrier For more information refer to "Intrinsic Safety" insert on Page D7.			
Explosion-Proof 3m Cable & Strain Relief Ex m II T5 PTB 03 ATEX 2018 X Ex II 2 G EEx m II T5 Ex II 2 D IP65 T95°C		Z	Order coil separately (specify voltage code from below)	0,36 (0.78)	7152-9**

Voltage Codes (Lower wattage options available, consult factory)

** Code	Voltage +/-10%		Current (Amps)								Resistance (OHMS @ 25°C)				Power (AC=VA, DC=Watts)			
			Inrush				Holding											
	Operator Type:		X		V	Z	X		V	Z	X		V	Z	X		V	Z
	NEMA 4	NEMA 7,9 & ATEX	NEMA		ATEX		NEMA		ATEX		NEMA		ATEX		NEMA		ATEX	
			4, 4x	7, 9	Exia	Exm	4, 4x	7, 9	Exia	Exm	4, 4x	7, 9	Exia	Exm	4, 4x	7, 9	Exia	Exm
DA	24/50 24/60	-	.36	-	-	-	.24	-	-	-	32	-	-	-	6.9	-	-	-
AA	120/50 120/60	120/60	.08	.10	-	.04	.05	.05	-	.03	840	530	-	1664	6.9	6.5	-	3.4
AB	230/50 230/60	240/60	.04	.05	-	.02	.03	.03	-	.01	3310	2345	-	6730	6.4	6.8	-	3.3
DA	12 VDC	12VDC	.38	.38	-	.27	.38	.38	-	.27	32	32	-	45	4.8	4.5	-	3.5
DB	24 VDC	24VDC	.20	.19	.05	.14	.20	.19	.05	.14	121	128	275	177	4.8	4.5	1.6	3.5
AB	125 VDC	-	.04	-	-	-	.04	-	-	-	3310	-	-	-	5.9	-	-	-

Image 3: Pilot solenoid valve types

3.1.2.4 Overview Adaptors

3.1.2.4.1 Adaptor: Speed control valve:

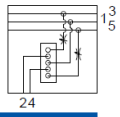
It is not allowed to use the adaptor to adjust the safety time this means to delay the safety function!

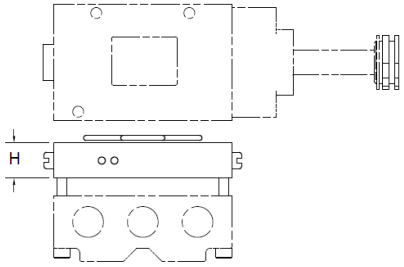
This adaptor could restrict air flow from port 2 to port 3 and from port 4 to port 5.
Needs to be mounted between the valve and the manifold.

Accessories

Interposed Flow Control L-series

- Restricts air flow from port 2 to port 3 and from port 4 to port 5.
- Mounts between the valve and the manifold.

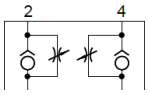


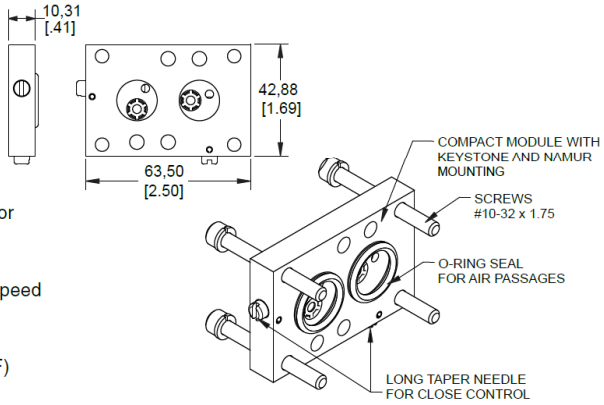


Series	Model Number	Dimension H	Weight Kg (lb)
L07	B7106-005	12,7 0.50	0,06 (0.14)
L20	B8022-005	12,7 0.50	0,09 (0.19)

SPEED CONTROL VALVE (Bar Stock Models Only) Namur interface

Model Number:
A7106-554





- Mounts between the Directional Control Valve and the Actuator
- Mounts on the NAMUR pad
- Functions as a flow control for both cylinder ports
- Is easily adjustable, turn the needles clockwise to decrease speed and counterclockwise to increase speed
- Normal operating pressure: 2 to 10 bar (35 to 150 psig)
- Normal operating temperature: -18°C to +52°C (0°F to +125°F)
- Approximate weight: 0.07 kg (0.16 lb)

Image 4: Adaptor flow control

3.1.2.4.2 Adaptor: Transition Plate:

The Transition Plate is designed for use in situations where the sealing face of the solenoid valve extends beyond the mounting surface.

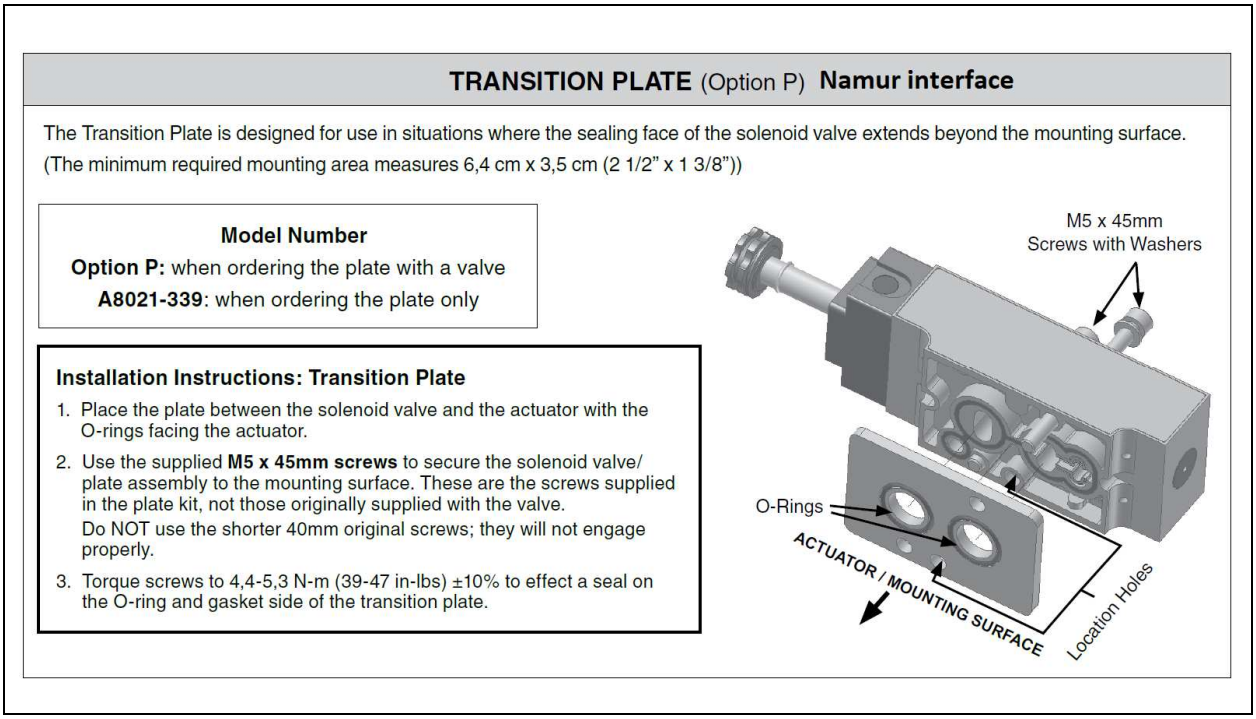


Image 5: Transition plate

3.1.2.4.3 Adaptor: 90° Mounting Plate

Allows horizontal installation of the directional control valve
Orientates the outlets of the valve 90° to the actuator

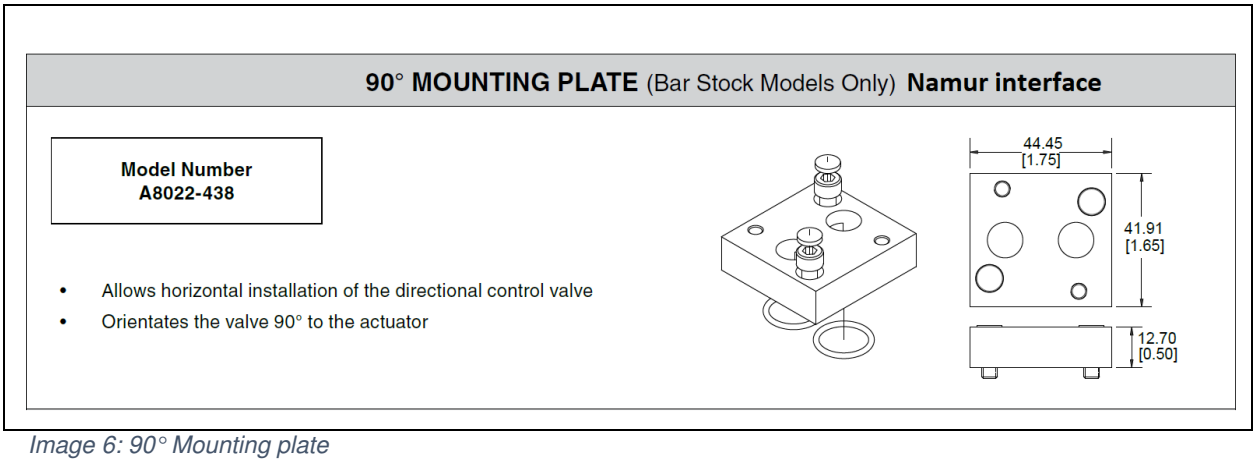


Image 6: 90° Mounting plate

3.1.2.5 Requirements for application of AV AUTOMATIC VALVE spool valves series D, I, L


If an AV AUTOMATIC VALVE spool valve of the D, I, L series is used in a safety related application the following requirements have to be met:

- The shutoff of the electrical or pneumatic control of the AV AUTOMATIC VALVE spool valve has to be guaranteed in case of demand of the safety function.
- The safety time of the AV AUTOMATIC VALVE spool valve varies depending on the application. The parametrizing of the safety time has to be verified in the final application.


There is no online diagnosis available for the AV AUTOMATIC VALVE spool valve of the D, I, L series according to the requirements given by IEC 61508.
Hereby see chapter 3.11 online diagnosis.

The responsibility of the manufacturer is limited to the manufacturing by specification and delivery of the valves.


The user is responsible for:

- The usage of the valves acc. to the intended use.
- The connections to the valves have to be installed by the user according to the installation guidelines for the AV AUTOMATIC VALVE spool valves.
- The operating medium supported by the user has to fulfill and guarantee the requirements for level of purity and lubricant.
- The requirements defined by the technical data sheet and the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products have to be met.
- The electrical control of the pilot valves has to be supported by the user according to the requirements of the interface.
- The shutoff of the pneumatic control pressure or the electrical control signal has to be supported by the user acc. the requirements of the safety application where the valves are used in.
- The safety time and safety function have to be verified by the user before commissioning and after defined time periods. The result of the functional test has to be documented.
- The intended use of the AV AUTOMATIC VALVE spool valves is given by the type designation description.

3.2 Valid variants of the AV AUTOMATIC VALVE spool valves D, I, L series for safety applications

The variants are defined in the type code. The type code is defined below considering the generic type designation.
D, I, L: 3/2, 5/2, 5/3 spool valves, standard

The features of the AV AUTOMATIC VALVE spool valves can be identified by the following type code:

ISO-series valve part numbers

Model Numbers

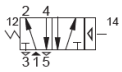
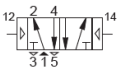
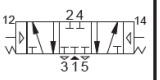
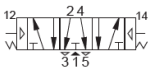
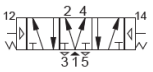
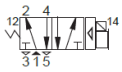
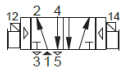
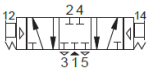
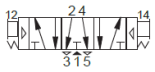
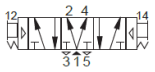
Series	ISO Size	Port Loc'n	Flow l/min (C_V)		5/2		5/3			Mat'ls		Wt Kg (lb)
					Single	Double	Block	Exhaust	Pressure	Body	Seal	
			5/2	5/3								
I15	1	Base	1480 (1.5)	1154 (1.2)	I1500AAAR	I1500ABAA	I1500CBADA	I1500DBADA	I1500EBADA	Aluminum	NBR	0,4 (0.9)
I20	2		1970 (2.0)	1537 (1.6)	I2000AAAR	I2000ABAA	I2000CBADA	I2000DBADA	I2000EBADA			0,7 (1.5)
I45	3		4430 (4.5)	3455 (3.5)	I4500AAAR	I4500ABAA	I4500CBADA	I4500DBADA	I4500EBADA			0,9 (2.0)

Image 7:: Type code of AV Automatic Valve air piloted spool valves ISO series in safety applications.

Model Numbers

Series	ISO Size	Port Loc'n	Flow l/min (Cv) 5/2	Flow l/min (Cv) 5/3	5/2 Single	5/2 Double	5/3 Block	5/3 Exhaust	5/3 Pressure	Mat'ls Body	Mat'ls Seal	Wt Kg (lb)
												
I15	1	Base	1480 (1.5)	1154 (1.2)	I1500AAXR-**	I1500ABXX-**	I1500CBXDX-**	I1500DBXDX-**	I1500EBXDX-**	Aluminum	NBR	0,4 (0.9)
I20	2		1970 (2.0)	1537 (1.6)	I2000AAXR-**	I2000ABXX-**	I2000CBXDX-**	I2000DBXDX-**	I2000EBXDX-**			0,7 (1.5)
I45	3		4430 (4.5)	3455 (3.5)	I4500AAXR-**	I4500ABXX-**	I4500CBXDX-**	I4500DBXDX-**	I4500EBXDX-**			0,9 (2.0)

** = Coil Voltage Code. Coils sold separately. Refer to "Electrical Information" at the end of this Section for additional information.

Options (Add the suffix to the end of the model number in alpha-numeric order)

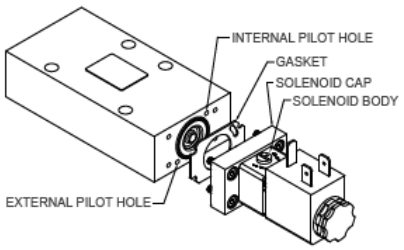
Suffix	Option	Description
A	Fluoroelastomer Seals	For applications where fluid media or ambient conditions are not compatible with nitrile seals. *Note: Fluorocarbon seals do not increase the effective temperature range of the valve. For high temperature applications, consult the factory.*
B	External Pilot	For solenoid applications where the pressure to port one is less than 2 BAR (35 PSIG). See example below for field conversion. **Field Conversion** • Remove solenoid and cap from the valve body. • Rotate the gasket 180° so that the internal pilot hole in the valve body is covered by the gasket. • Refasten the gasket, cap and solenoid to the valve body. Make sure the gasket completely covers the internal pilot hole before tightening the M3 screws. Torque to 1,02 N-m (9 in-lbs) ±10%. • Remove the 1/8 NPTF pipe plug from the base and make the external pilot connection. 
C	Conduit Coil	Refer to the "Electrical Information" page in this section for details.
CT	Conduit Coil High Temperature	With 30" Leads. Refer to the "Electrical Information" page in this section for details.
D	Dustproof	For applications in extremely dusty and contaminated environments. Vent ports are plugged and spring pad breather vent is eliminated.
G	Coil With 18" Leads	Refer to the "Electrical Information" page in this section for details.
LL2	Lowest Watt Coil with Extended Turn-Locking Override	Power Consumption = 0.7 Watts. Solenoid cap provides an extended override that is turned to lock in the "on" position.
W	G Threads	All ports tapped to metric "G" standard. (Sub-bases and manifolds only)
Y	Explosion-Proof Coil (CSA, FM)	Refer to the "Electrical Information" page in this section for details.
Z	Explosion-Proof Coil (Atex, PTB)	Refer to the "Electrical Information" page in this section for details.
5	Extended Push Non-Locking Override	Solenoid cap provides an extended override that is pushed in to actuate and does not lock in the "on" position.

Image 8: Type code of AV Automatic Valve solenoid operated spool valves ISO series in safety applications

L-series valve part numbers

Model Numbers

Series	Port Size	Flow l/min (Cv) 5/2	Flow l/min (Cv) 5/3	5/2 Single	5/2 Double	5/3 Block	5/3 Exhaust	5/3 Pressure	Body Materials	Seal Materials	Wt kg (lb)
L20	1/4	1770 (1.8)	1381 (1.4)	L2003AAAR	L2003ABAA	L2003CBADA	L2003DBADA	L2003EBADA	Aluminum	NBR	0,5 (0.9)
	3/8			L2004AAAR	L2004ABAA	L2004CBADA	L2004DBADA	L2004EBADA			
L65	3/4	8860 (9.0)	6911 (7.0)	L6506BAAR	L6506BBAA	L6506CBADA	L6506DBADA	L6506EBADA	Aluminum	NBR	1,86 (4.1)
	1 (1,2,4) 3/4 (3,5)	9350 (9.5)	7293 (7.4)	L6507BAAR	L6507BBAA	L6507CBADA	L6507DBADA	L6507EBADA			
L21	1/4	1770 (1.8)	1381 (1.4)	L2103AAAR	L2103ABAA	L2103CBADA	L2103DBADA	L2103EBADA	Aluminum	NBR	0,5 (1.1)
L45	1/2	4755 (4.8)	3709 (3.7)	L4505AAAR	L4505ABAA	L4505CBADA	L4505DBADA	L4505EBADA			0,8 (1.7)

Image 9: Type code of AV Automatic Valve air piloted spool valves L-series in safety applications.

Model Numbers

Series	Port Size	Flow l/min (Cv) 5/2	Flow l/min (Cv) 5/3	5/2 Single	5/2 Double	5/3 Block	5/3 Exhaust	5/3 Pressure	Body Material	Seal Material	Weight kg (lb)
L20	1/4	1770 (1.8)	1381 (1.4)	L2003AAWR-**	L2003ABWW-**	L2003CBWDW-**	L2003DBWDW-**	L2003EBWDW-**	Aluminum[1]	NBR	0,5 (0.9)
	3/8			L2004AAWR-**	L2004ABWW-**	L2004CBWDW-**	L2004DBWDW-**	L2004EBWDW-**			
L65	3/4	8860 (9.0)	6911 (7.0)	L6506BAWR-**	L6506BBWW-**	L6506CBWDW-**	L6506DBWDW-**	L6506EBWDW-**	Aluminum	NBR	1,86 (4.1)
	1 (1,2,4) 3/4 (3,5)	9350 (9.5)	7293 (7.4)	L6507BAWR-**	L6507BBWW-**	L6507CBWDW-**	L6507DBWDW-**	L6507EBWDW-**			
L21	1/4	1770 (1.8)	1381 (1.4)	L2103AAWR-**	L2103ABWW-**	L2103CBWDW-**	L2103DBWDW-**	L2103EBWDW-**	Aluminum	NBR	0,5 (1.1)
L45	1/2	4755 (4.8)	3709 (3.7)	L4505AAWR-**	L4505ABWW-**	L4505CBWDW-**	L4505DBWDW-**	L4505EBWDW-**			0,7 (1.6)

** = Coil Voltage Code. Coils also sold separately. Refer to "Electrical Information" at the end of this Section for additional information.
[1]Body Available in 303 or 316 Stainless Steel (L20 only). Refer to "Options" at the end of this Section for additional information.

Image 10: Type code of AV Automatic Valve solenoid piloted spool valves L-series in safety applications.

*** options see next page*

Options (Add the suffix to the end of the Model Number in alpha-numeric order)

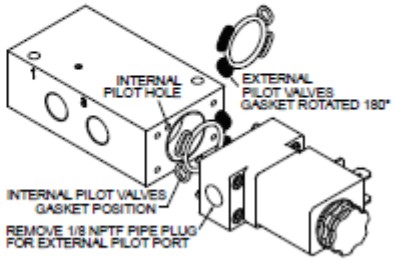
Suffix	Option	Description
A	Fluoroelastomer Seals	For applications where fluid media or ambient conditions are not compatible with nitrile seals. *Note: Fluorocarbon seals do not increase the effective temperature range of the valve. For high temperature applications, consult the factory.*
B	External Pilot	For solenoid applications where the pressure to port one is less than 2 BAR (35 PSIG). See example below for field conversion. **Field Conversion** • Remove solenoid and cap from the valve body. • Rotate the gasket 180° so that the internal pilot hole in the valve body is covered by the gasket. • Refasten the gasket, cap and solenoid to the valve body. Make sure the gasket completely covers the internal pilot hole before tightening the M3 screws. Torque to 1,02 N-m (9 in-lbs) ±10%. • Remove the 1/8 NPTF pipe plug from the cap and make the external pilot connection. 
C	Conduit Coil	Refer to the "Electrical Information" page in this section for details.
CT	Conduit Coil High Temperature	Refer to the "Electrical Information" page in this section for details.
D	Dustproof	For applications in extremely dusty and contaminated environments. Vent ports are plugged and spring pad breather vent is eliminated.
G	Coil With 18" Leads	Refer to the "Electrical Information" page in this section for details.
L	Low Watt Coil	Power Consumption = 2.5 Watts. Standard as Push Non-Locking Override. Also available with Option 2, Extended Turn-Locking Override.
LL	Lowest Watt Coil	Power Consumption = 0.7 Watts. Standard as Extended Turn-Locking Override.
S	303 Stainless Steel	303 Stainless Steel body, all other external parts are corrosion resistant; for corrosive environment applications. (L20 only)
SS	316 Stainless Steel	316 Stainless Steel body, all other external parts are corrosion resistant; for corrosive environment applications. (L20 only)
W	G Threads	All ports tapped to metric "G" standard (for 3/8", 3/4", 1"). Not required for 1/8" or 1/4" ports, which use a universal G/NPT tap.
Y	Explosion-Proof Coil (CSA, FM)	Refer to the "Electrical Information" page in this section for details.
Z	Explosion-Proof Coil (Atex, PTB)	Refer to the "Electrical Information" page in this section for details.
1	Push Turn-Locking Override	Solenoid cap provides an override that is pushed in and turned to actuate & lock in the "on" position.
2	Extended Turn-Locking Override	Solenoid cap provides an extended override that is turned to lock in the "on" position.
4	No Override	Solenoid cap does not provide a manual override.

Image 11: Options Type code of AV Automatic Valve solenoid piloted spool valves L-series in safety applications

D20-series valve part numbers

5-Way 2-Position Valves

Choose your options (in red) to configure your valve model number.

D20 | 03 | A | CWR | – | DB | ☐

Series

Port Size/Body Type		
1/4	Cast Aluminum	03
	Bar Stock Aluminum	13

Function/Actuation: 5/2 Valves

Solenoid	
Single Left	CWR
Single Right	AWR
Double	BWW

Voltage*	
110 volts AC, 50 Hz 120 volts AC, 60 Hz	AA
200 volts AC, 50 Hz 240 volts AC, 50/60 Hz 125 volts DC	AB
22 volts AC, 50 Hz 24 volts AC, 50/60 Hz 12 volts DC	DA
24 volts DC	DB

* For other voltages consult AVI.

Options*	
Fluoroelastomer Seals	A
External Pilot Connection	B
Conduit Coil	C
Conduit Coil High Temp.	CT
Dustproof	D
18" Flying Leads	G
Low Watt Coil (2.5 Watts)	L
Lowest Watt Coil (0.7 Watts) with Type 2 override only (24 VDC only)	LL
Transition Plate	P
Closed Loop	Q
303 Stainless Steel Body (D20 Bar Stock)	S
316 Stainless Steel Body (D20 Bar Stock)	SS
G (BSPP)Threads	W
Push Turn-Locking Override	1
Extended Turn-Locking Override	2
No Override	4
10-24 Mounting Kit	8
10-32 Mounting Kit	9
No Options (Leave Blank)	

5-Way 3-Position Valves

Choose your options (in red) to configure your valve model number.

D20 | 03 | C | BWDW | – | DB | ☐

Series

Port Size/Body Type		
1/4	Cast Aluminum	03
	Bar Stock Aluminum	13

Function/Actuation		
5/3 Valves	Closed Center	C
	Open Center	D
	Power Center	E

Solenoid: Double

Voltage*	
110 volts AC, 50 Hz 120 volts AC, 60 Hz	AA
200 volts AC, 50 Hz 240 volts AC, 50/60 Hz 125 volts DC	AB
22 volts AC, 50 Hz 24 volts AC, 50/60 Hz 12 volts DC	DA
24 volts DC	DB

* For other voltages consult AVI.

Options*	
Fluoroelastomer Seals	A
External Pilot Connection	B
Conduit Coil	C
Conduit Coil High Temp.	CT
Dustproof	D
18" Flying Leads	G
Low Watt Coil (2.5 Watts)	L
Lowest Watt Coil (0.7 Watts) with Type 2 override only (24 VDC only)	LL
Transition Plate	P
Closed Loop	Q
303 Stainless Steel Body (D20 Bar Stock)	S
316 Stainless Steel Body (D20 Bar Stock)	SS
G (BSPP)Threads	W
Push Turn-Locking Override	1
Extended Turn-Locking Override	2
No Override	4
10-24 Mounting Kit	8
10-32 Mounting Kit	9
No Options (Leave Blank)	

Image 12:Type code of AV Automatic Valve solenoid piloted spool valves D20-series in safety applications

D06-series valve part numbers

3-Way 2-Position Valves

Choose your options (in red) to configure your valve model number.

D06 | 03 | G | AWR | – | DB | ☐

Port Size	Series
1/4	D06
1/4	D20

Port Size
1/4

Function/Actuation
3/2 Valves Normally Closed

Series	Solenoid	
D06	Single	AWR
	Single Left	CWR
D20	Single Right	AWR

Voltage*	
110 volts AC, 50 Hz 120 volts AC, 60 Hz	AA
200 volts AC, 50 Hz 240 volts AC, 50/60 Hz 125 volts DC	AB
22 volts AC, 50 Hz 24 volts AC, 50/60 Hz 12 volts DC	DA
24 volts DC	DB
* For other voltages consult AVI.	

Options*	
Fluoroelastomer Seals	A
External Pilot Connection (D20 only)	B
Conduit Coil	C
Conduit Coil High Temp.	CT
Dustproof (D20 only)	D
18" Flying Leads	G
Low Watt Coil (2.5 Watts)	L
Lowest Watt Coil (0.7 Watts) with Type 2 override only (24 VDC only) (D20 only)	LL
G (BSPP)Threads	W
Push Turn-Locking Override	1
Extended Turn-Locking Override	2
No Override	4
10-24 Mounting Kit	8
10-32 Mounting Kit	9
No Options (Leave Blank)	

D06/ D20 special valve part numbers

D06-001
D20-018
D20-024

Image 13: Type code of AV Automatic Valve solenoid piloted spool valves D06-series in safety applications

Following designations are common for the SIL-certified AV AUTOMATIC VALVE spool valves:

- VH – D, I, L type body.
- AV AUTOMATIC VALVE - Spool Valves for Line Mounting Series “D, I, L”

3.3 Inputs/Outputs of AV AUTOMATIC VALVE spool valves series D, I, L

The AV AUTOMATIC VALVE spool valves have the following interfaces depending on installed features:

- Mechanical interfaces:
  - Threads for pressure supply, bleeder and pneumatic control
  - Installation interfaces for installation on mounting plates, walls, devices, etc.
  - Installation interface for actuation
- Electrical interfaces (in case of solenoid pilot valve)
  - Control interface (electrical)

3.4 Safety function

In accordance to IEC 61508 the safety function is defined in the following:
All valves of the AV AUTOMATIC VALVE spool valve D, I, L series have the following described safety function (SF):
Table 3.4-1: Safety function of AV AUTOMATIC VALVE spool valves D, I, L series

SF No.	Description	Safe State
SF1	[SFZ01] **3/2-and 5/2 single pilot** In case of demand of the safety function the AV AUTOMATIC VALVE spool valves will be shutoff and the valve will reach the safe position (home position) within the specified time by spring force. The safe state can be valve opened (home position „normally open“ NO) or closed (home position „normally closed“ NC) 3/2 NO: - at safe home position there will be flow from port 1 to port 2, port 3 will be blocked. 3/2 NC: - at safe home position be port 1 will be blocked, port 2 will exhaust via port 3. 5/2: - at safe home position there will be flow from port 1 to port 2, port 3 will be blocked, port 4 will exhaust via port 5. **5/2 double pilot** In case of demand of the safety function the AV AUTOMATIC VALVE spool valves will be shutoff and the valve will stay in the actual position. **5/3 double pilot** In case of demand of the safety function the AV AUTOMATIC VALVE spool valves will be shutoff and the valve will reach the safe position (home position) within the specified time by spring force. The safe position will be the middle position, which could be block, exhaust or pressure 5/3 block: - at safe home position port 1 will be blocked, port 2 will be blocked, port 3 will be blocked, port 4 will be blocked, port 5 will be blocked 5/3 exhaust: - at safe home position port 1 will be blocked, port 2 will exhaust via port 3, port 4 will exhaust via port 5 5/3 pressure: - at safe home position port 1 will pressurize port 2 and port 4, port 3 will be blocked, port 5 will be blocked	[SZ1] **3/2-and 5/2 single pilot** The valve is in the home position and the position is remained by spring force. **5/2 double pilot** The valve stays in the actual position **5/3 double pilot** The valve is in the middle position and the position is remained by spring force.

Table 3: Safety function

3.5 IEC 61508 Safety Integrity Level (SIL): Safety related parameters

For design of safety loops the safety related parameters for the AV AUTOMATIC VALVE spool valves D, I, L series shown in appendix B can be used.

The AV AUTOMATIC VALVE spool valves D, I, L series fulfill the requirements SIL 2 acc. IEC 61508.
Using AV AUTOMATIC VALVE spool valves in safety architectures with HFT ≥ 1 the requirements for SIL 3 acc. IEC 61508 are met.

For calculation of safety relevant parameters of safety loops where the AV AUTOMATIC VALVE spool valves are used in a beta factor has to be considered in case of safety architectures with HFT ≥ 1. See appendix B.
It is remarked, that the SIL information given in appendix B is exemplarily. The final evaluation of the usage of AV AUTOMATIC VALVE spool valves D, I, L series in each safety application and e.g., needed safety related architecture in combination with diagnostic measures is in the field of responsibility of the user (e.g., plant engineering).

The safety relevant parameter shown in the datasheet can be used as basis for evaluation and initial values for further calculations of safety parameters of application specific safety architectures.

It is also user's responsibility to define adequate proof test intervals for detection of undetected dangerous failures (e.g., which could not be detected by regular diagnosis). The user could take into account the manufacturer information on inspection intervals in the user documentation defined for maintenance.

Also, it is user responsibility to take care of the specified conditions. In case of deviation of the specified conditions for the AV AUTOMATIC VALVE-Spool Valves the manufacturer must be consulted. In that case the manufacturer estimates the validity of the calculated safety relevant parameters under changed conditions or if corrections are required.

3.6 Safety time

Depending on each application the safety time varies (the time starting from demand of the safety function until the safe state is reached). Main influences are the forces exerting by medium and environmental pressure, pipping, fittings and other influences from the installation and applications.
Parts movement time is the time, all components need to change state (before a reaction could be detected at the ports).

Parts movement times by series:

Actuating:		De-actuating	
D06:	0,030 s	D06:	0,043 s
I15:	0,012 s	I15:	0,030 s
I20/ D20/ L20/ L21:	0,010 s	I20/ D20/ L20/ L21:	0,044 s
I45/ L45:	0,020 s	I45/ L45:	0,055 s

Specific parts movement times can be provided by AV Automatic valve on request.


The safety time has to be defined specifically for each application. The manufacturer responsibility is limited to the verified compliance of the AV AUTOMATIC VALVE spool valves with the specification of each variant.


The specified safety time has to be verified by the user for each single application

3.7 Installation


The AV AUTOMATIC VALVE spool valves have to be installed in accordance to the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products.


Especially the safety relevant activations of the valves (pneumatic, electrical) and adaptors have to be installed according to the requirements.

3.8 Parametrization of AV AUTOMATIC VALVE spool valves


For the AV AUTOMATIC VALVE spool valves of the D, I, L series optional adaptors (e.g., adaptor: speed control valve) may be installed. The changeable parameters e.g., the delay time shall not be part of the safety time. This means in applications where the safe home state of the valve will be reached by spring force, the adaptor speed control valve may not be used to delay the safety time in any case. The time adaptor is only to use to delay of the non-safety time.

3.9 Commissioning

The AV AUTOMATIC VALVE spool valves of the D, I, L series are pneumatic control valves in general. The valves are used in safety loops to control actors. The valves should be commissioned as part of the safety loop where they are used in.


The installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products are to respect.
Improper treatment or non-compliance with the commissioning instructions serious threats to the commissioning personnel may occur

3.10 Offline Proof Test

To perform proof test for AV AUTOMATIC VALVE spool valves D, I, L series the machine/plant has to be in standstill and secured against unintentional restart.
The proof test is to define for each specific application considering overall design of the safety loop. Following basic information are to take into account:

- Execution of functional test as in commissioning
- Execution of visual inspection respect to the maintenance guidelines
- Renewal/replacement of components which have malfunction or which are identified during visual inspection
- Execution of additional functional test before re-commissioning

Verification of safety time.


For AV AUTOMATIC VALVE-spool valves of the D, I, L series every 5 years or after 5 million cycles a proof test has to be performed. By performing an offline proof test potentially dangerous failures can be detected which are undetected during normal operations or which cannot be detected by online diagnosis.


The proof test must be carried out by manufacturer or qualified personnel.


Faults affecting the safety function have to be reported to the manufacturer. Safety relevant faults of the AV AUTOMATIC VALVE spool valves are:

- Faults which have prevented / may have prevented the specific execution of the safety function
- Faults which have prevented / may have prevented the execution of diagnosis measures if the diagnosis is used to detect dangerous failures of the application.

Faults have to be reported to the contact address, see chapter 4.

3.11 Online Diagnostics

For AV AUTOMATIC VALVE spool valves D, I, L series no online diagnostics are provided and need to be implemented by the integrator/user/OEM in accordance with the standards.

3.12 Inspection, repair and maintenance


Repair and maintenance of the AV AUTOMATIC VALVE spool valves D, I, L series have to be done respecting the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products.
In case of malfunction a fault analysis and troubleshooting according to the chapter “troubleshooting” of the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products has to be carried out.


During inspections, repair, maintenance and other service no changings of the system may be made which have an impact on the safety concept and/or safety function.


Faults affecting the safety function have to be reported to the manufacturer. Safety relevant faults of the AV AUTOMATIC VALVE spool valves are:

- Faults which have prevented / may have prevented the specific execution of the safety function
- Faults which have prevented / may have prevented the execution of diagnosis measures if the diagnosis is used to detect dangerous failures of the application.

Faults have to be reported to the contact address, see chapter 4.

3.13 Decommissioning

The decommissioning has to be made respecting the installation and maintenance guidelines for AV AUTOMATIC VALVE pneumatic products. No further requirements and measures are defined from safety point of view.


During decommissioning and dismounting the valve potential risks can emanate from the system where the valve is installed in. Information given by the system manufacturer especially by the operating and maintenance manuals has to be considered.

4 Contact Address for queries related to safety

Queries and information about safety of AV AUTOMATIC VALVE spool valves D, I, L series can be sent to the manufacturer:

Automatic Valve Industrial LLC

950 Woodward Heights

Ferndale Michigan 48220

USA

Email: av@automaticvalve.com

Appendix A: Return form for manufacturer inspection

Return Form for SIL-certified Components

To:

Automatic Valve Industrial LLC

950 Woodward Heights

Ferndale Michigan 48220

USA

The valve should:

☐	Be tested
☐	Be repaired
☐	Be first diagnosed with followed by consultation

Sender:

_____

_____

_____

_____

Tel. No. for queries: _____

E-mail for queries: _____

Type designator: _____

Number or operating hours: _____

Number of cycles: _____

Description of fault:

_____

_____

_____

_____

Appendix B: Safety related parameters

Set of Components/Component Safety Data
(acc. IEC 61508)

Set of Components/Component	**Pneumatik Namur-/ISO-/Kompakt-/Top Mount- Schieber-Ventile (Magnetbetätigt oder pneumatisch vorgesteuert)** **Pneumatic Namur-/ISO-/Compact-/Top Mount- Spool Valves (Standard Solenoid or Pneumatic Pilot Pressure)**	
Type /Series	Namur Interface Valves: D06; D20; ISO Spool Valves: I15; I20; I45; Compact Spool Valves: L20; L65; Top Mount Spool Valves: L21; L45	
Manufacturer	AVI Automatic Valve Industrial/Ross Controls	
Component Type	Type A	Ref. IEC 61508-2
Mode of Operation	Low / high demand operation	
Safety Function	Spool valve maintains or switches in safe position by spring force within specified safety time or remains in last/actual position.	
Safe State	Spool valve maintains in the safe position (NO, NC, middle position (safe home position)) or in the last/actual position.	

Failure Rates [failure/10^9 hrs = FIT] *(values in brackets are for double acting valves)

Failure Rate Distribution	λ_{total}	λ_{safe}	$\lambda_{dangerous\ detected}$	$\lambda_{dangerous\ undetected}$	$\lambda_{don't\ care}$	SFF [%]
SUM (with diagnostic test) *	247 (469)	29 (49)	153 (295)	**65 (125)**	307 (586)	74 (73)
SUM (without diagnostic test)*			0	**218 (420)**		12 (10)

Specification of component Architecture

Architecture	**1oo1**	is the architecture of a single set of components/component of the analyzed type.
Hardware Fault Tolerance HFT	**0**	Due to HFT=0, one failure has impact on the safety function of a single set of components/component of the analyzed type.
MTTR [h]	**32**	MTTR is the time required for repair of the set of components/component in case of failure. MTTR has marginal influence on the pfd-value.
Diagnostic Coverage (DC)	**63 %**	In case of missing automatic diagnosis: DC = 0 %. In case of implemented diagnostics: DC > 0% (value depends on efficiency of diagnosis). Safe Failure Fraction SFF increased by higher DC.
Diagnostic Test	**VT**	Diagnostic test used to detect dangerous failures during operation. Valve Test (VT): The valve moves out of the safe position or the last/actual position and switches back. A binary sensor (or position transducer) recognizes the valve moving and achieving of the safe/last position.
Diagnostic Test Interval	**24 h**	Max diagnostic test interval to perform online diagnostics to detect potential dangerous failures during operation.
Beta Factor	β_{Int} = 5% β_{Diag} = 2%	Beta factor, which has to be considered if the components/component are used in safety relevant architectures with a HFT ≥ 1. Detailed beta factor has to be calculated for each individual application. The beta factor depends on the exact architecture where the components/component is used in. See IEC 61508-6, table D.5 how to calculate beta factor. βD Common cause failures which are detected by diagnostic tests.
Systematic Capability (SC)	**SC = 3**	Systematic Capability acc. IEC 61508-1 for functional safety management (FSM) and of IEC 61508-2, route 1S. SC 3 shows, that the component is qualitative suitable to be used in safety related application up to SIL 3

Verification of SIL Capability (examples considering diagnostic test)
(see comments on next page/backside of this page); *(values in brackets are for double acting valves)

Proof Test Interval	6 months	1 year	2 years	3 years	5 years
PFD (avg.) (IEC 61508-6, B3.2.2; λ_{DU} from FMEDA)	1.42 E-04 (2.74 E-04)*	2.85 E-04 (5.48 E-04)*	5.69 E-04 (1.10 E-03)*	8.54 E-04 (1.64 E-03)*	1.42 E-04 (2.74 E-03)*
Single component application (**HFT = 0**) Max. achievable SIL acc. Route 2_H (IEC 61508-2-7.4.4.3.1)	**SIL 2**				
Redundant component application (**HFT = 1**) Max. achievable SIL acc. Route 2_H (IEC 61508-2-7.4.4.3.1)	**SIL 3**				

Calculated (company/name/date/signature)	INGENIEURBÜRO URBAN Anzinger Str. 24 D-85604 Pöring	Pöring, 2021-08-21	

B210119_V10_SIL-Data Sheet_ROSS AVI_Spool Valves Series L,L_D — Seite 1 von 2

INGENIEURBÜRO URBAN – Dipl.-Ing. J. Urban
Öffentl. Bestellung u. Vereidigung • Zeichen für Sachverstand • Unabhängigkeit • Unparteilichkeit
Publicly certified • The mark of quality in the expert profession • Independence • Impartiality
Certificación pública • Señal de competencia • Independencia • Imparcialidad

Table B-4: B210119, Version 1.0, safety related parameter of AVI spool valves

Explanations to the Data Sheet

The data sheet is divided in 4 areas:

- Common technical description of the set of components/component (blue)
- Failure rates (light green)
- Specification of architecture of the set of components/component (light orange)
- Verification of SIL capability (examples) (grey)

General description of the Part / Component:

- Information on the set of components/component, type of component and component designator
- Manufacturer information
- Component type (Type A or Type B) acc. IEC 61508-2/7.4.4.1.2 und 7.4.4.1.3)
- Mode of operation of the set of components/component (acc. IEC 61508-1)
- Description of the safety function of the set of components/component
- Description of the safe state of the set of components/component

Failure Rates and Failure Rate Distribution

The failure rates and failure rate distribution are the results of the reliability calculation of the set of components/ component and the Failure Modes Effects and Diagnostic Analysis (FMEDA). The failure rates can be used for further quantitative analysis of the set of components/component as pfd/pfh-calculation, Markov-Analysis, Fault Tree Analysis, and due to this for a quantitative evaluation of SIL-capability of the set of components/component.

Based on the failure rate distribution the Safe Failure Fraction (SFF) is calculated according the formula SFF [%] = $(\lambda_S + \lambda_{DD}) / (\lambda_S + \lambda_{DD} + \lambda_{DU})$.

Specification of Component Architecture

The architecture of the set of components/component is described by following parameters:

- Structure/architecture (single-channel, multi-channel expressed by 1oo1, 1oo2, 2oo3, etc.)
- Hardware-Fault-Tolerance (HFT) (number of failures acceptable without dispatch on the safety function of the set of components/component)
- Mean Time to Repair (MTTR): Mean time to repair the set of components/component in case of failure
- Diagnostic Coverage: The diagnostic coverage is resulting from the diagnostic test for the set of components/component in case of application of automatic diagnosis (e.g. partial stroke test). The diagnostic coverage is considered in the FMEDA and the quantitative results of the analysis (see failure rates).
- Diagnostic Test: The type of installed on-line automatic diagnostic test to detected dangerous failure during operation. The diagnostic test has to fulfill requirements acc. IEC 61508-2.
- Diagnostic Test Interval: Interval between diagnostic tests to detect dangerous failures. Longer diagnostic test intervals as specified in the datasheet has to be considered separately in safety parameter calculations, see IEC61508-2, 7.4.9.4.
- Beta Factor: If the components/component is used in safety relevant architecture with a HFT ≥ 1 a beta factor has to be considered in safety loop calculations. The beta factor for the component is initial (β_{int}). To estimate the final beta factor for a specific application the effects of the architecture have to be considered. Thus the beta factor has to be calculated individual according IEC 61508-6, table D.5.
- Beta Factor Diagnostics: β_D is the fraction of dangerous common cause failures if the components/component is used in safety relevant architectures, which can be detected by diagnostic tests. β_D can be assumed as $\beta/2$, see IEC61508-6, table B1.

Verification of SIL-capability (examples)

The SIL verification consists of two steps:

- Step (1) = quantitative verification by calculation of the pfd-value / pfh-value depending from the defined Proof Test Interval and used architecture. The max. reachable SIL for the calculated safety loop within the component is used can be estimated according IEC 61508-1 table 2 (for low demand operation) or table 3 (for high demand operation)
- Step (2) = qualitative verification based on the architectural information of the set of components/component according route 2_H, the qualitative max. SIL is defined in IEC 61508-2, 7.4.4.3.1.

The final achievable SIL is the minimum resulting SIL-value of step (1) and step (2): MIN {(1) ; (2)}. The final achievable SIL is only relevant for the final safety loop not for a single component used in the safety loop.

Further remarks using safety relevant parameters

- If operating medium is required (oil, air, etc.), failure rate of operating medium is not considered in the safety related parameter shown in this datasheet.
- Failure Rates considering diagnostic measures with DC > 0 may only be used if diagnosis with sufficient quality is installed in the application.
- Common cause failures, which can occur using the analyzed component in architectures, have to be considered by the user in safety loop calculations.
- If the subsystem is used in application with architectures, e.g. in a 1oo2 architecture, a beta-factor for the subsystem derived from βint acc. IEC 61508-6, table D.5 has to be considered in the safety loop calculation of the application.

B210119_V10_SIL-Data Sheet_ROSS AVI_Spool Valves Series I_L_D		Seite 2 von 2

INGENIEURBÜRO URBAN – Dipl.-Ing. J. Urban
Öffentl. Bestellung u. Vereidigung • Zeichen für Sachverstand • Unabhängigkeit • Unparteilichkeit
Publicly certified • The mark of quality in the expert profession • Independence • Impartiality
Certificación pública • Señal de competencia • Independencia • Imparcialidad

Table B-5: B210119, Version 1.0, safety related parameter of AVI spool valves – remarks to the data sheet

Safety architecture

The following block diagrams showing the architecture of AVI spool valves in a 1oo1 architecture (HFT = 0) and for redundant applications in a safety related 1oo2 architecture (HFT = 1) are shown.

The architectures are limited to the single element here the AVI spool valve. The actor controlled by the AVI spool valve or the peripheral equipment (pneumatic supply, electronic control, etc.) are not considered in the safety related parameters.

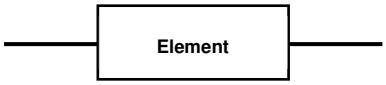


Image B-14: Reliability block diagram for 1oo1 architecture

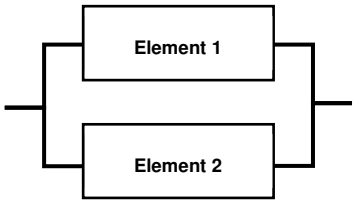


Image B-15: Reliability block diagram for 1oo2 architecture

Information for usage of AVI spool valve in safety architectures:

If AVI spool valves are used in safety relevant architectures with HFT ≥ 1 (e.g. in a 1oo2 architecture) the beta factor has to be considered in calculation of safety relevant parameters:

$$\beta_{int} = 5\%$$

β_{int}: Rate of undetected common cause failure for calculation of the beta factor β depending on the architecture of application (See IEC 61508-6, table D.5).

$\beta_{D\,int}$: Rate of common cause failure which can be detected by diagnostics ($\beta_{D\,int}$ = DC x β_{int})

If AVI spool valves are used in safety related architectures in combination with other valves from other manufactures the beta factor for the application has to be determined acc. IEC 61508-6.

The beta factor shown above can be used as reference if the valve combined with AVI spool valves of the type series 27 and 21 fulfills following requirements:

- The exchange of information between components is possible (e.g. by common pneumatic supply)
- The safety principle is similar (e.g. spring return force)
- The safety function is independent of the control electronics
- The valve is conservatively designed
- A field fault analysis was done for the component
- For the component safety relevant parameter are determined based on a systematical fault analysis (e.g. FMEDA, FTA)
- In case of failure the component can be identified and is replaceable/repairable
- The operational conditions and operational environment are known and proven in use for component application
- If applicable: For the component an EG declaration of conformity exists
- The design of the component is verified and validated in application.

MooN		N			
		2	3	4	5
M	1	β_{int}	0,5 β_{int}	0,3 β_{int}	0,2 β_{int}
	2		1,5 β_{int}	0,6 β_{int}	0,4 β_{int}
	3			1,75 β_{int}	0,8 β_{int}
	4				2 β_{int}

Table B-6: Calculation of the beta factor β depending on the safety relevant architecture

Information for the user of AVI spool valves with common pneumatic supply:

The pneumatic supply containing process gas, oiling system, de-hydration system, filters, conditioning, etc. is not considered in the safety related parameters of the AVI spool valves.

If the analysis of the safety loop within the AVI spool valves are used in result in that the pneumatic supply is safety relevant, e.g. the purity of the process gas, the pneumatic supply has to be considered in addition in safety loop calculations.

If the analysis of the safety loop within the AVI spool valves are used in result in that the pneumatic supply is used for valves in a safety related architecture with HFT ≥ 1 (e.g. common pneumatic supply for valves in a 1oo2 architecture), the common cause of the pneumatic supply has to be considered separately in the calculation of the safety loop. This is not considered in the beta factor given for the AVI spool valve.

Information for application of AVI spool valves in safety instrumented systems acc. IEC 61511-1:

The safety related parameter of appendix B for AVI spool valves can be used to calculate failure rates of safety instrumented systems acc. IEC 61511-1.

The qualitative requirements to the hardware fault tolerance (HFT) acc. IEC 61511-1 differ from the requirements defined in IEC 61508. This has to be considered separately in each application.

The qualitative requirements for hardware fault tolerance shown in this report are in accordance to IEC 61508-2, Route 2_H.

This page has been intentionally left blank.