OKPD2 28.14.11

Series 327 Valves

Operation Manual
Appendix D

METRAN

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D 1. Introduction

This Appendix provides the necessary information for the design, installation, inspection and maintenance of the 327 Series Valves as part of the system with a safety instrumented function (SIF), and presents the necessary requirements for compliance with functional safety standards GOST R IEC 61508 or GOST R IEC 61511.

D 1.1 List of Terms and Abbreviations

D.1.1.1 **Solenoid valve** is a valve with an integrated or remote electromagnetic actuator.

D.1.1.2 **Electromagnetic actuator** is an electric actuator in which the conversion of electric energy into mechanical energy is carried out by a device based on the interaction of an electromagnetic field and a ferromagnetic core.

D.1.1.3 **Three-way valve** is a multiway valve in which the fluid enters two nozzles and exits one or enters one nozzle and exits two or alternately one of the two nozzles.

D.1.1.4 **Safety** is freedom from unacceptable risk.

D.1.1.5 **Functional safety** is part of the overall safety relating to the EUC (equipment under control) and the EUC control system which depends on the correct functioning of the E/E/PE (electrical and/or electronic, and/or programmable electronic) safety-related systems and other risk reduction measures.

D.1.1.6 **Functional safety assessment** is an investigation, based on evidence, to judge the functional safety achieved by one or more E/E/PE safety-related systems and/or other risk reduction measures.

D.1.1.7 **Safe state** is state of the EUC when safety is achieved.

D.1.1.8 **Fault tolerance** is the ability of a functional unit to maintain its functionality even when failures and fault conditions occur.

D.1.1.9 **Dangerous failure** is a failure that impedes or disables a given safety action.

D.1.1.10 **Undetected dangerous failure** is a failure undetected by the diagnostic tests, proof test, operator intervention (for example, physical inspection and manual tests), or through normal operation.

D.1.1.11 **Detected dangerous failure** is a failure detected by the diagnostic tests, proof test, operator intervention (for example, physical inspection and manual tests), or through normal operation.

D.1.1.12 **Safe failure** is a failure of an element with safety functions without negative consequences for the safety function.

D.1.1.13 **Low demand mode** is mode of operation where the Safety Instrumented Function (SIF) is only performed on demand, in order to transfer the process into a specified safe state, and where the frequency of demands is no greater than one per year.

D.1.1.14 **Safety Instrumented Function** is a safety function to be implemented by a Safety Instrumented System (SIS).

D.1.1.15 **Safety Instrumented System** is an instrumented system used to implement one or more SIFs.

D.1.1.16 **Safety function** is a function implemented by one or several protection layers intended to achieve or maintain a safe state for the process in respect of a specific hazardous event.

D 1.2 Abbreviations

D.1.2.1 **HFT** is hardware fault tolerance.

D.1.2.2 **PFD_{AVG}** is average probability of dangerous failures on demand.

D.1.2.3 **SFF** is safe failure fraction: the ratio of the average failure rates of safe plus dangerous detected failures.

D.1.2.4 **SIF** is safety instrumented function: it is implemented by the equipment system (SIF loop) that ensures reduction of certain risks.

D.1.2.5 **SIL** is safety integrity level: discrete level (one out of possible four); specifies the safety integrity requirements in terms of the safety functions that electrical, electronic, programmable electronic safety-related systems must have, where safety integrity level 4 has the highest level of safety integrity and safety integrity level 1 has the lowest.

D.1.2.6 **SIS** is safety instrumented system.

D 2. Development of a Safety Instrumented Function (SIF) System with Series 327 Valve

D 2.1 Safety Function

D.2.1.1 Series 327 valve (valve) is a solenoid valve, which is a three-way valve according to the operating principle.

D.2.1.2 When the electromagnetic actuator is de-energized, the valve switches to the fail-safe state.

D.2.1.3 The valve can be normally closed or normally open depending on the connection method and the process in which it is used.

D.2.1.4 The valve is connected to the process according to the Operation Manual and the admissible required function.

D.2.1.5 The valve is intended for inclusion in a finite element subsystem in accordance with GOST R IEC 61508. The designer shall check the SIL of the function to be developed.

D 2.2 Operating Restrictions

D.2.2.1 Operating restrictions are given in 2.1 of the Operation Manual.

D.2.2.2 During design, it is important to check the compatibility of the materials used in the valve for resistance to the supply conditions and chemical components of the fluid at the site. If the valve is used in violation of the operating restrictions or with an incompatible fluid, the reliability data provided becomes invalid.

D 2.3 Safety Indicators

D.2.3.1 The Safety Integrity Level (SIL) provided by the entire Safety Instrumented Function (SIF) shall be verified by PFD_{AVG} calculation taking into account the architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and specific failure rate data for all products included in the SIF. Each subsystem shall be tested for compliance with the minimum hardware fault tolerance (HFT) requirements.

D.2.3.2 When a valve is used as a backup, a common cause factor of 5% shall be included in the safety integrity calculations.

D.2.3.3 The failure rates given in Table D.1 are only valid for the lifetime of the valve. After this period, the failure rate increases. The results of reliability calculation based on these data for operation of equipment beyond the useful lifetime may not provide the calculated safety integrity level.

Table D.1. Failure Rates in FIT*

Model	Configuration	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
327B0/8327G…	De-energize to trip, normally closed	0	416	0	58
	De-energize to trip, normally open	0	368	0	96
	Energize to trip, normally closed	0	9	0	199
	Energize to trip, normally open	0	48	0	160
327B1…, 327B2…, 327H	De-energize to trip, normally closed	0	174	0	58
	De-energize to trip, normally open	0	126	0	96
	Energize to trip, normally closed	0	9	0	162
	Energize to trip, normally open	0	48	0	123
327B3	De-energize to trip, normally closed	0	130	0	58
	De-energize to trip, normally open	0	82	0	96
	Energize to trip, normally closed	0	9	0	144
	Energize to trip, normally open	0	48	0	105
327B3NFIS… & 327B3WSCRIS…	De-energize to trip, normally closed	0	168	0	64
	De-energize to trip, normally open	0	120	0	103
	Energize to trip, normally closed	0	14	0	188
	Energize to trip, normally open	0	53	0	150
327A	De-energize to trip, normally closed	0	395	0	57
	De-energize to trip, normally open	0	367	0	87
	Energize to trip, normally closed	0	13	0	173
	Energize to trip, normally open	0	43	0	138

Table D.1 (Continued)

Redundant 327B0	De-energize to trip, normally closed	0	57	0	315
	Energize to trip, normally closed	0	151	0	36
Redundant 327B1, B2, H	De-energize to trip, normally closed	0	30	0	315
	Energize to trip, normally closed	0	151	0	33
Redundant 327B3	De-energize to trip, normally closed	0	20	0	315
	Energize to trip, normally closed	0	151	0	27
MO option	De-energize to trip, normally open and normally closed	0	45	0	39
NVR option	De-energize to trip, normally open and normally closed	0	45	0	59
*FIT – 1 failure / 10^9 hours					

D 2.4 Safety Integrity

D.2.4.1 Safety Integrity against Systematic Failures

The valves comply with the requirements for safety integrity level SIL 3. The requirements are aimed at ensuring sufficient safety integrity against systematic design faults of the manufacturer. The safety instrumented function (SIF) developed for this product may not be used for safety integrity levels higher than the declared safety integrity level without prior end-user approval or process design redundancy.

D.2.4.2 Safety Integrity against Random Failures

The valve is a Type A element. Therefore, if only one element in the finite element subsystem is used, the design meets the requirements of SIL 3 at HFT=1, and SIL 2 at HFT=0.

If the system consists of several elements (solenoid valve, pressure relief valve, actuator, shut-off valve, etc.), the SIL must be confirmed for the entire system using failure rate of each element. Hardware fault tolerance and architectural constraints must be taken into account in this analysis.

D 3. Installation and Commissioning

D 3.1 Installation

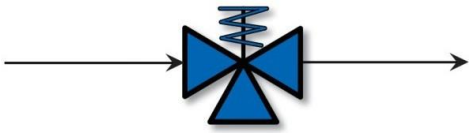
D.3.1.1 The necessary information on installation and commissioning of the valve is specified in 2.2-2.4 of the Operation Manual.

D.3.1.2 It must be ensured that ambient conditions correspond to those specified in the Operation Manual for a particular model.

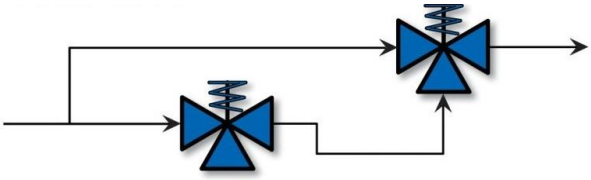
D.3.1.3 It shall be possible to visually inspect the valve during installation.

D.3.1.4 Piping options:

a. 1 of 1 is the most common configuration



b. 2 of 2 - this configuration is mainly used for high availability equipment. In the event of a false emergency shutdown of one valve, the second valve continues to maintain the operating position of the system and the process valve. Both valves must be closed for the system and the process valve to switch to the off-state.



D 3.2 Response Time

D.3.2.1 Valve response time depends on the valve version and the specific application in the designed process.

D.3.2.2 Response time is influenced by the following factors: time of valve stroke, valve orifice size, operating pressure, connected pipe size, connected equipment size, distance between valve and actuator, and the torque required to open or close the valve.

D.3.2.3 It is the end user's responsibility to use a control valve to ensure that the process valve opens and closes at the time required for equipment operation.

D.3.2.4 Time of valve stroke is given in Table 1 of the Operation Manual.

D 4. Operation and Maintenance

D 4.1 Proof Tests without Automatic Tests

D.4.1.1 The purpose of the proof tests is to detect faults in the valve which are not detected by the automatic system diagnostics. Particular attention shall be paid to undetected failures that do not allow the safety function to be performed.

D.4.1.2 The frequency of proof tests and the interval between them shall be determined when calculating the reliability of the safety instrumented functions for which the solenoid valve is used. Proof tests shall be performed periodically, as calculated, to maintain the required safety integrity of the safety instrumented function.

D.4.1.3 The proof tests described in Table D.2 are recommended. Report any detected faults that affect the functional safety of the equipment to the manufacturer.

Table D.2. Steps for Proof Test

Step	Action
1	Install a PLC-based bypass line for emergency protection or take other actions to avoid a false trip in in accordance with the organizational change management procedure.
2	Inspect the solenoid valve for contamination on external surfaces, clogged passages and other mechanical faults. Do not disassemble the valve.
3	De-energize the coil of the solenoid valve, make sure that the actuator and valve parts move freely. After moving the valve slightly, energize the solenoid valve.
4	Inspect the solenoid valve for contamination, corrosion and excessive moisture. If necessary, clean the valve and piping. This is necessary to prevent initial failures due to contamination of the fluid.
5	It is recommended that all failures are recorded in the company's SIF inspection database. Restore full functionality of the loop.
6	Remove the bypass line of the PLC-based emergency protection or otherwise restore normal operation of the equipment.

This test detects approximately 99% of possible dangerous solenoid valve failures that are not diagnosed by automatic test stroke (proof tests coverage).

D.4.1.4 Persons conducting solenoid valve proof tests shall be familiar with the rules for working with SIS, as well as procedures for installing bypass lines, solenoid valve maintenance, and organizational change management procedures. No special tools are required.

D 4.2 Proof Tests with Automatic Partial Valve Stroke Tests

D.4.2.1 Automatic partial valve stroke test, in which the full solenoid valve stroke is performed and the valve travel time is measured, is capable of detecting the most potentially dangerous failure modes.

D.4.2.2 Visual inspection (step 2 of Table D.1) is recommended to be carried out regularly at intervals determined by the operating conditions of the unit. The inspection shall be carried out at least once every five years, provided that the recommended annual inspection is carried out.

D 4.3 Repair and Replacement

D.4.3.1 The lifetime according to section 7.4 of IEC 61508-2 shall be determined based on experience. General industry practice suggests that the acceptable maximum service life for the vast majority of solenoid valves with timely maintenance is up to 24 years, but may be longer depending on the valve model and other factors.

D.4.3.2 It is the end user's responsibility to arrange for preventive maintenance to replace solenoid valves before the end of their useful life.

D 4.4 Notification of Failures

D.4.4.1 Please report any failures detected that affect functional safety of the equipment to the manufacturer's specialists.