Functional safety of globe valves, rotary plug valves, ball valves and butterfly valves
Competence in Functional Safety
Functional safety of globe valves, rotary plug valves, ball valves and butterfly valves

<table>
<thead>
<tr>
<th>SAMSON GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMSON</td>
</tr>
<tr>
<td>KT Elektronik</td>
</tr>
<tr>
<td>STAR LINE</td>
</tr>
</tbody>
</table>

2
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1 Scope

Valves and the associated actuators are used to isolate pipelines in safety-instrumented systems. Alternatively, they can also be used for pressure relief, i.e. by completely opening valves.

2 Validity of this manual

This manual applies to control valves manufactured by the following companies within the SAMSON GROUP:

- SAMSON AG
- LEUSCH GmbH Industriearmaturen
- Pfeiffer Chemie-Armaturenbau GmbH
- VETEC Ventiltechnik GmbH

Refer to the manufacturer’s declarations in Appendix 1 of this manual for the valve models concerned.

The individual versions of the valves can be identified by their nameplates.

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Example of a nameplate for a Type 3241 Valve with Type 3271 or Type 3277 Pneumatic Actuator manufactured by SAMSON AG.
3 Intended use of this manual

This manual is intended to assist planners and operators during the integration of control valves into a safety loop as part of the safety function and to enable them to safely operate control valves.

This manual contains information, safety-related characteristics and warnings concerning the functional safety in accordance with IEC 61508 and concerning the application in the process industry in accordance with IEC 61511. It does not contain any particular details on other safety requirements, such as explosion protection or electrical safety.

Safety-instrumented systems are to be commissioned and maintained by qualified personnel only. Refer to the corresponding mounting and operating instructions of the valve.
# General aspects of functional safety

## 4.1 Standards, terms and abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIL</td>
<td>Safety Integrity Level</td>
<td>One of four discrete levels for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems, where SIL 4 has the highest level of safety integrity and SIL 1 has the lowest.</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time Between Failures</td>
<td>Mean time between two failures</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time To Restoration</td>
<td>Mean time between the occurrence of a failure in a device or system and its repair</td>
</tr>
<tr>
<td>HFT</td>
<td>Hardware Fault Tolerance</td>
<td>Capability of a functional unit to continue executing the demanded function in case of faults or deviations.</td>
</tr>
<tr>
<td>$\lambda_{sd}$</td>
<td>Failure rate for all safe detected failures</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{su}$</td>
<td>Failure rate for all safe undetected failures</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{dd}$</td>
<td>Failure rate for all dangerous detected failures</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{du}$</td>
<td>Failure rate for all dangerous undetected failures</td>
<td></td>
</tr>
<tr>
<td>SFF</td>
<td>Safe Failure Fraction</td>
<td>Fraction of non-hazardous failures, i.e. the fraction of failures without the potential to set the safety-related system to a dangerous or impermissible state.</td>
</tr>
<tr>
<td>PFDavg</td>
<td>Average Probability of Failure on Demand</td>
<td>Average likelihood that a dangerous safety function failures occurs on demand.</td>
</tr>
<tr>
<td>$T_i$</td>
<td>Test interval between life testing of the safety function</td>
<td>Time interval between functional tests of the safety function</td>
</tr>
<tr>
<td>Low demand mode</td>
<td>Low demand mode of operation</td>
<td>Low demand mode is where the frequency of demands for operation made on a safety-related system is no greater than one per year and no greater than twice the proof test frequency.</td>
</tr>
</tbody>
</table>
**Abbreviation** | **Designation** | **Description**
--- | --- | ---
MooN | Voting “M out of N” (e.g. 2oo3) | Classification and description of the safety-related system regarding redundancy and the selection procedure used. • “N” indicates how often the safety function is carried out (redundancy). • “M” determines how many channels must work properly. Example: Pressure measurement in 1oo2 architecture A safety-instrumented system decides that a specified pressure limit has been exceeded if one of two pressure sensors reaches this limit. In a 1oo1 architecture, there is only one pressure sensor.

MooND | Voting “M out of N” with diagnostics

**Relevant standards**

<table>
<thead>
<tr>
<th>Norm</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61508 Parts 1 to 7</td>
<td>Functional safety of electrical/electronic/programmable electronic safety-related systems</td>
</tr>
<tr>
<td>IEC 61511 Parts 1 to 3</td>
<td>Functional safety – Safety instrumented systems for the process industry sector</td>
</tr>
<tr>
<td>VDI 2180 Parts 1 to 5</td>
<td>Safeguarding of industrial process plants by means of process control engineering</td>
</tr>
</tbody>
</table>

**Terms and definitions**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous failure</td>
<td>Failure with the potential to set the safety-related system to a dangerous or inoperative state.</td>
</tr>
<tr>
<td>Safety-related system</td>
<td>A safety-related system carries out the safety functions needed to establish or maintain a safe state, e.g. in a plant. Example: Pressure measuring instrument, logic unit (e.g. limit switch) and valve form a safety-related system.</td>
</tr>
<tr>
<td>Safety function</td>
<td>A defined function carried out by a safety-related system in order to establish or maintain a safe state of the plant, under consideration of a specified dangerous incident. Example: Pressure limit monitoring</td>
</tr>
</tbody>
</table>
4.2 Determining the safety integrity level

The achievable safety integrity level (SIL) is determined by the following safety-related characteristics:
- Average probability of failure on demand (PFDavg)
- Hardware fault tolerance (HFT)
- Safe failure fraction (SFF)

The following table in accordance with IEC 61508 and IEC 61511 shows how the safety integrity level (SIL) depends on the average probability of failure on demand (PFDavg). It is based on low demand mode of operation, i.e. the frequency of demands on a safety-related system is no greater than once per year.

<table>
<thead>
<tr>
<th>Safety integrity level (SIL)</th>
<th>PFDavg (low demand mode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>( \geq 10^{-5} \text{ to } 10^{-4} )</td>
</tr>
<tr>
<td>3</td>
<td>( \geq 10^{-4} \text{ to } 10^{-3} )</td>
</tr>
<tr>
<td>2</td>
<td>( \geq 10^{-3} \text{ to } 10^{-2} )</td>
</tr>
<tr>
<td>1</td>
<td>( \geq 10^{-2} \text{ to } 10^{-1} )</td>
</tr>
</tbody>
</table>

PFDavg in low demand mode of operation according to IEC 61508-1, Table 2

The sensor, logic unit and final element form a safety-related system that performs a safety function.

\[
\text{Sensor} \quad \text{e.g. pressure measuring instrument} \quad \xrightarrow{\text{Logic unit}} \quad \text{e.g. PLC} \quad \xrightarrow{\text{Final element}} \quad \text{e.g. valve}
\]

\[\text{PFDavg} \quad \leq X \% \quad \leq X \% \quad \leq X \%\]

The average probability of failure on demand (PFDavg = sum of sensor, logic unit and final element failures) must be within the range of the demanded safety integrity level (SIL) in case of demand as listed in the above table.
4.3 Hardware fault tolerance

In the process industry, the achievable SIL classes for sensors, final elements and non-programmable logic modules, such as isolating amplifiers and relays, are restricted in accordance with IEC 61511 as shown in the following table.

<table>
<thead>
<tr>
<th>Safety integrity level (SIL)</th>
<th>Minimum required hardware failure tolerance (HFT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Special requirements (refer to IEC 61508)</td>
</tr>
</tbody>
</table>

Minimum required hardware fault tolerance (HFT) according to IEC 61511-1, Table 6, for the process industry

The minimum required hardware failure tolerance can be decreased by one if the following requirements are met:

- The device is proven in use.
  - Take this into account when selecting devices!
- The device only allows process-relevant parameters to be set, e.g. measuring range, upscale or downscale function in case of failure.
  - Final elements do not have any configurable functions.
- The process-relevant parameters of the device are access-protected, e.g. by jumper or password.
  - Final elements do not have any configurable functions.
- The function requires a SIL less than 4.

A final element has a single-channel design, resulting in a hardware failure tolerance (HFT) = 0. This results in a single-channel application up to SIL 1 or up to SIL 2 for proven-in-use devices.

A HFT = 2, as required to achieve SIL 3, can be achieved by redundant architecture (several final elements with SIL 2).

A single-channel application in SIL 3 is only possible when special analysis of the application is made by applying additional measures (e.g. diagnostics).
5 Intended use of control valves in safety-instrumented systems

The reliability of mechanical components is significantly affected by the operating conditions and, as a result, by systematic failures. This needs to be taken into account when selecting and sizing devices.

Safety-instrumented function

During normal operation, the signal pressure is applied to the pneumatic actuator. To meet the requirements of the safety-instrumented function, the actuator is usually vented by a solenoid valve. The force of the actuator springs moves the valve to its end position, i.e. the valve is either completely opened or closed.

Reaching the end position of the valve must not be impeded under any circumstances by mechanical equipment, such as travel stops or handwheels.

When the signal pressure is applied to the actuator again, the valve moves to the corresponding position. If the actuator is to be locked after a case of demand, this must be ensured by the operator using suitable means.

Features of final elements

Contact with the process media may cause systematic failure and, as a result, affect the safety-related availability of the safety-instrumented systems. The influence of specific process conditions must be analyzed and taken into account during sizing and maintenance.

These conditions arise from process requirements. To rule out systematic failure, we recommend creating a loop data sheet according to the German standard VDI 2180-5, section 4 (recommendations for final elements).

In case of doubt, the manufacturer is to be consulted for valve sizing.
To reduce systematic failure, diverse redundancies may be advantageous (e.g. globe valve and ball valve).

The joint use of a control valve within the safety loop by a control loop of a basic process control system makes it possible to increase the diagnostic coverage of the safety-instrumented system. This joint use can lead to additional risk. This aspect must be taken into account in the risk analysis.

Online tests, such as the partial stroke test and other diagnostic processes integrated into the valve positioner, can be regarded as state-of-the-art test methods. They can be used to lengthen the proof test interval or to improve the safety margin (discovery of undetected systematic failures).

VDI 2180-5, section 4 provides special instructions.

**Avoiding systematic failure**

To avoid systematic failure, the user must take into account the following application-specific factors besides the manufacturer specifications:

- Corrosion (destruction primarily of metals due to chemical and physical processes)
- Material fatigue, e.g. in bellows seals
- Wear induced by the process medium
- Abrasion (material removed by solids contained in the process medium)
- Medium deposits
- Aging (damage caused to organic materials, e.g. plastics or elastomers, by exposure to light and heat)
- Chemical attack (organic materials, e.g. plastics or elastomers, which swell, leach out or decompose due to exposure to chemicals)

If no experience data exist for the devices used, a visual inspection of the safety equipment must be performed after a short time in operation.
5.1 General control valve requirements

For each application, the user must specify the following conditions:

- Maximum/minimum transit time OPEN ⇔ CLOSED or CLOSED ⇔ OPEN
- Permissible leakage rate
- Maximum/minimum supply pressure of the compressed air network
- Air capacity available in relation to pressure
  ⇒ Connecting pipe cross-sections must be adhered to.

### Nominal size (connection length ≤ 2 m)

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>KVS coefficient</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.16 · 0.32</td>
<td>1.4</td>
</tr>
<tr>
<td>1 and 3</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>≥ 1.4</td>
<td>≥ DN 6</td>
<td>≥ DN 8</td>
</tr>
<tr>
<td>≥ 2.5</td>
<td>≥ DN 4</td>
<td>≥ DN 8</td>
</tr>
<tr>
<td>≥ 6</td>
<td>≥ DN 4</td>
<td>≥ DN 6</td>
</tr>
</tbody>
</table>

Note: A larger nominal size is needed when the connection length exceeds 2 m.

Example: Connecting pipe cross-sections required for SAMSOMATIC Type 3963 Solenoid Valve

SAMSON uses calculation methods to predict the transit time and to size the pneumatic hook-up. SAMSON can support users in selecting devices on request.

The seat shut-off performance (leakage rate) must be tested at regular intervals by
- performing plausibility checks while the process is running or
- measuring it on a leakage test bench.

The type of test depends on the application.

The external leakage (fugitive emissions) must be tested at regular intervals, e.g. by spraying with foaming agent.

The conditions depend on the process requirements.
5.2 Globe valve requirements

- If there is a risk of solids contained in the process medium causing blockage, a strainer must be fitted.

Safety equipment with fail-open action must not be operated with strainers.

- To reduce friction, it is preferable to use spring-loaded stem packings. Adjustable stem packings are to be tightened by qualified staff only to prevent the stem from becoming blocked.

- To prevent corrosion of the actuator springs, measures must be taken to prevent water or moisture from entering the actuator. Such measures include fitting a venting pipe or air purging of the actuator’s spring chamber.

Example: Control and quick-acting shut-off valve with air purging of the actuator’s spring chamber

Example: On-off valve with air purging of the actuator’s spring chamber

- Suitable measures must be taken to ensure that the venting port of the solenoid valve is kept open.

Example: Venting pipe on the solenoid valve
It is essential to check the actuator forces to ensure that the valve can overcome the process pressures to reach its fail-safe position. This can be checked by the manufacturer if requested.

The actual actuator forces must not close the valve against a pressure which is 1.5 times above the nominal pressure (PN) of the plant or valve. If this actuator force restriction cannot be implemented, an excess pressure valve is necessary for valves connected in series to prevent that the permissible operating pressure is exceeded.

Example: Valves connected in series

It is essential to observe the prescribed direction of flow (arrow on the valve body) of globe valves.

Responsibility

Manufacturer/operator

Operator
5.3 Ball valve requirements

- Note for ball valves that higher initial breakaway torques arise as the differential pressure of the process medium rises, requiring higher actuator torques.

<table>
<thead>
<tr>
<th>Differential pressure $\Delta p$ (bar)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>10</th>
<th>16</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN</td>
<td>$M_{d,\text{max}}$ (Nm)</td>
<td>$M_d$ (Nm)</td>
<td>$M_{dl}$ (Nm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>60</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>25</td>
<td>240</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>40</td>
<td>450</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>26</td>
<td>35</td>
</tr>
<tr>
<td>50</td>
<td>450</td>
<td>15</td>
<td>30</td>
<td>30</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>80</td>
<td>750</td>
<td>25</td>
<td>60</td>
<td>60</td>
<td>66</td>
<td>72</td>
</tr>
<tr>
<td>100</td>
<td>750</td>
<td>40</td>
<td>90</td>
<td>90</td>
<td>105</td>
<td>120</td>
</tr>
<tr>
<td>150</td>
<td>3160</td>
<td>60</td>
<td>120</td>
<td>120</td>
<td>160</td>
<td>210</td>
</tr>
</tbody>
</table>

Max. permissible torque, required torques and initial breakaway torques

Example: Torque specifications for a ball valve

- Media, especially degreasing, swelling and fibrous media, may affect the torque.
- The operating conditions, e.g. switching interval and the medium temperature, have an effect on the torques.
- The mounting of the valve and actuator is of vital importance.
- The permissible torques for the ball valve shaft, shaft adapter and bridge have been verified by the manufacturer. As a result, the max. torque of the actuator (air or spring torque) must not exceed these torques under any circumstances. The corresponding specifications in accordance with DIN EN ISO 5211/DIN EN 15081 (NAMUR Recommendation NE 14) must be observed.

<table>
<thead>
<tr>
<th>Flange type</th>
<th>F03</th>
<th>F04</th>
<th>F05</th>
<th>F07</th>
<th>F10</th>
<th>F12</th>
<th>F14</th>
<th>F16</th>
<th>F25</th>
<th>F30</th>
<th>F35</th>
<th>F40</th>
<th>F48</th>
<th>F60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum torque of the attachment flanges (Nm)</td>
<td>32</td>
<td>63</td>
<td>125</td>
<td>250</td>
<td>500</td>
<td>1000</td>
<td>2000</td>
<td>4000</td>
<td>8000</td>
<td>16000</td>
<td>32000</td>
<td>63000</td>
<td>125000</td>
<td>250000</td>
</tr>
</tbody>
</table>

Maximum torque of the attachment flanges according to DIN EN ISO 5211
5.4 Butterfly valve requirements

- On sizing actuators for butterfly valves, note that the actuator must provide sufficient torque to overcome the breakaway torque and closing torque in closed position as well as the dynamic torque in open position.

- On mounting the actuator on the butterfly valve, the breakaway torque of the butterfly valve in relation to the differential pressure and the permissible torque of the butterfly valve shaft must be observed.

### Table: Butterfly valve requirements

<table>
<thead>
<tr>
<th>Nominal size</th>
<th>Perm. torque $M_{\text{b, max}}$ (Nm)</th>
<th>Breakaway torque $M_{\text{b}}$ in Nm at a differential pressure $\Delta p$ (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN NPS</td>
<td></td>
<td>0 bar</td>
</tr>
<tr>
<td>80 3</td>
<td>280</td>
<td>40</td>
</tr>
<tr>
<td>100 4</td>
<td>280</td>
<td>48</td>
</tr>
<tr>
<td>150 6</td>
<td>505</td>
<td>91</td>
</tr>
<tr>
<td>200 8</td>
<td>785</td>
<td>190</td>
</tr>
<tr>
<td>250 10</td>
<td>785</td>
<td>320</td>
</tr>
<tr>
<td>300 12</td>
<td>1591</td>
<td>370</td>
</tr>
<tr>
<td>400 16</td>
<td>3215</td>
<td>690</td>
</tr>
</tbody>
</table>

**Example:** Required manufacturer specifications

- Note that high dynamic torques can arise at high differential pressures in the process medium, pushing open the butterfly disc.

Dynamic torque of butterfly valves in relation to the opening angle
Media, especially degreasing, swelling and fibrous media, may affect the torque.

The operating conditions, e.g. switching interval and the medium temperature, have an effect on the torques.

The mounting of the valve and actuator is of vital importance.

The permissible torques for the butterfly valve shaft, shaft adapter and bridge have been verified by the manufacturer. As a result, the max. torque of the actuator (air or spring torque) must not exceed these torques under any circumstances. The corresponding specifications in accordance with DIN EN ISO 5211/DIN EN 15081 (NAMUR Recommendation NE 14) must be observed. See section 5.3 on ball valve requirements.
5.5 Rotary plug valve requirements

- On sizing actuators, note that the actuator must provide sufficient torque to overcome the closing torque in closed position as well as the dynamic torque in open position.

- Adjustable stem packings are to be tightened by qualified staff only to prevent the stem from becoming blocked.

- To prevent corrosion of the actuator springs, measures must be taken to prevent water or moisture from entering the actuator. Such measures include fitting a venting pipe or air purging of the actuator’s spring chamber.

- The proper mounting of the valve onto the actuator is of vital importance.

- The permissible torques for the valve shaft, shaft adapter and bridge have been verified by the manufacturer. As a result, the max. torque of the actuator (air or spring torque) must not exceed these torques under any circumstances. The corresponding specifications in accordance with DIN EN ISO 5211/ DIN EN 15081 (NAMUR Recommendation NE 14) must be observed. See section 5.3 on ball valve requirements.

5.6 Proof tests and service life

- The proof test interval and the extent of the test lie within the operator’s responsibility. This must be documented correspondingly.

- During the proof test, suitable means must be used to test the control valve to ensure its proper functioning. Worn components must be replaced by original spare parts from the manufacturer.

- The maximum service life must be specified.

- It is recommended to summarize the requirements of the proof test in a checklist. Refer to Appendix 2 for an example.
6 Installation, piping and wiring

6.1 Mechanical and pneumatic installation

- During mechanical and pneumatic installation, the mounting and operating instructions of the corresponding device must be observed. The pneumatic connection must only be connected to instrument air networks that meet the quality requirements in accordance with ISO 8573-1:2001, Class 3 or 4.

<table>
<thead>
<tr>
<th>Compressed air quality according to ISO 8573-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size and quantity</td>
</tr>
<tr>
<td>Class 4</td>
</tr>
<tr>
<td>≤ 5 μm and 1000/m³</td>
</tr>
</tbody>
</table>

- The required minimum cross-sections of the supply air lines must be observed. Refer to section 5.1 (General control valve requirements). After mounting, the position of the filters or filter check valves on the valve accessories, e.g. pilot valves, must be checked and, if necessary, corrected.

Example: Pilot-controlled Ex i solenoid valve (SAMSOMATIC)

- The prescribed mounting position of the devices must be observed.

- Booster valve ports not connected by pipe or hose must be protected properly against dirt, water etc. from entering the device by using appropriate filters.
6.2 Electrical installation

- Only cables with the prescribed outer diameter of the cable glands may be used.

- For EExi circuits the electrical cable data must comply with the data taken as the basis during planning.

- Cable glands and cover screws must be fastened tightly to ensure that the degree of protection is met.

- Only devices with suitable equipotential bonding may be connected.

- The installation regulations for the respective explosion protection measures must be observed.

- Prior to start-up, the voltage must be checked to ensure that it meets the permissible range.

- Prior to start-up, the necessary verifications (verification of intrinsic safety) must be available.

- The effect of disturbances to lines must be checked, especially
  - disturbance caused by EMC influences and
  - disturbance caused by capacitance influences when long lines are used (risk that a solenoid valve remains energized).

- The special conditions specified in the explosion protection certificates must be adhered to.

6.3 Installation of control valves

- Control valves must be installed free of stress and with low degrees of vibration.

- After installation, the flange joints must be checked for leaks.

- The pipeline must be rinsed prior to installing the control valve.
To ensure the control valve functions properly, the pipeline must be designed to be straight and without any manifolds or disturbances for a distance of at least six times the pipe size (DN) upstream and downstream of the valve.

It must be checked whether the mounting position of the control valve complies with the manufacturer’s specifications (operating instructions).

The devices used must be checked to ensure they are suitable for use under the prevailing ambient conditions (temperature, humidity etc.).

While installing the control valves, sufficient space must be left to remove the valve for maintenance.

The wiring and function of devices must be documented in a wiring plan.

Example: Wiring plan for a control valve with positioner, solenoid valve and limit signals
Applicable device documentation

Each control valve has a data sheet, mounting and operating instructions as well as a certificate of conformity in accordance with the European Pressure Equipment Directive (PED) 97/23/EC and, if applicable, an explosion protection certificate. These documents are available in various languages on the Internet at www.samson.de, www.vetec.de, www.pfeiffer-armaturen.com and www.leusch.de.

Appendix 1 – Manufacturer’s declarations

- Series 240 und 250 Globe Valves with Type 3271 and 3277 Pneumatic Actuators as listed in Volume 1 and 2 of the Control Valves for Industrial Processes catalog (valve manufacturer: SAMSON AG)

- Type LTR43 Butterfly Valve with actuator
  (valve manufacturer: Leusch GmbH Industriearmaturen)

- Series 1a and 1b Globe Valves with Type 3271 and 3277 Pneumatic Actuators
  (valve manufacturer: Pfeiffer Chemie-Armaturen GmbH)

- Series 20a and 20b Ball Valves with Series 31a Actuator as listed in the Rotary Valves for Industrial Processes catalog
  (valve manufacturer: Pfeiffer Chemie-Armaturen GmbH)

- Series BR 26d Ball Valve with Series 31a Actuator as listed in the Rotary Valves for Industrial Processes catalog
  (valve manufacturer: Pfeiffer Chemie-Armaturen GmbH)

- Series 14b and 14c Butterfly Valves with Series 31a or 30 Actuators as listed in the Rotary Valves for Industrial Processes catalog
  (valve manufacturer: Pfeiffer Chemie-Armaturen GmbH)

- Series 72 and 73 Rotary Plug Valves with Type AT, R and M Pneumatic Actuators as listed in the Rotary Valves for Industrial Processes catalog
  (valve manufacturer: VETEC Ventiltechnik GmbH)
Herstellererklärung

Hiermit bestätigt die Firma
SAMSON AG
Weismüllerstraße 3, 60314 Frankfurt am Main
Germany
für Stellventile der Bauart 240 und 250
und die dazugehörigen pneumatischen Antriebe, dass die Geräte der o.g. Bauart für die Verwendung in sicherheitserweiterten Systemen gemäß IEC 61508 und IEC 61511 einsetzbar sind. Die Geräte sind geeignet für den Einsatz in sicherheitserweiterten Anwendungen bis SIL 2 (einsilbiges Gerät) und SIL 3 (redundante Verschaltung) gemäß IEC 61508.

Der Nachweis erfolgte auf der Basis der Betriebserprobung (proven in use) mit der Anwendung der FMEDA. Das Ergebnis der Untersuchungen wurde von EXIDA verifiziert.

Sicherheitstechnische Kenndaten:
- Lambda safe, undetected: 8.6 * 10^-1 /h
- Lambda safe, detected: 0
- Lambda dangerous, undetected: 5.46 * 10^-1 /h
- Lambda dangerous, detected: 0
- PFD (a) mit jährlicher Prüfung: 2.4 * 10^-1
- HFT: 0
- Gerätetyp: A

Nutzbarer Lebensdauer: Nach IEC 61508-2:7.4.7.4 können 8 - 12 Jahre angenommen werden oder ein Wert benutzt werden, der sich durch Betriebserprobung des Anwenders ergibt.

Daraus ergeben sich:
- SFF: 94%
- MTBF: 125 Jahre
- MTTF: 2090 Jahre
- DC (Diagnostic coverage): 0

Bestimmungsgrößen für Verwendung sind zu beachten:
- Bedienungsanleitung
- Anordnung an Instrumentier-Quarzlöse (siehe Sicherheits-handbuch)

Sicherheitstechnische Ausarbeitung:
Im Stellventil wird der Antrieb enthalten, dadurch fassen das Ventil in die Sicherheitseinsatze.

Hinweis:
- Durch Einsatz eines Stellungsreglers kann eine umfangreiche Diagnose auch im laufenden Betrieb durchgeführt werden. Damit kann sich je nach Einsatzfall ein Diagnostikgrad (diagnostic coverage) für gefährliche Fehler von größeren 70 % ergeben.

Voraussetzungen:

Stephan Michlik
Head of Central Department Quality Management

Herstellererklärung
V4/HE-1079-2 DE_EN
geändert am: 02.01.2007
v/durch: V4/V5/V44/Thy
26.10.2009
2009-12-01
Herstellererklärung

LEUSCH GmbH
Ziegeleistraße 16, 61147 Neu-Isenburg
Germany

Hereby certify that Series LTR-43

Functional safety of butterfly valves with the corresponding pneumatic actuators are suitable for use in safety-related systems according to IEC 61508 and IEC 61512. The devices are suitable for use in safety-related applications up to SIL 2 (single device) and SIL 3 (redundant configuration) according to IEC 61508. The evidence is based on proven use combined with a PED-DA.

Bücherhalbtechnische Kennzahlen:
- Lambda safe undetected: 7.3E-07 1/hr
- Lambda safe detected: 0
- Lambda dangerous undetected: 2.4E-07 1/hr
- Lambda dangerous detected: 0

PFDoD bei maximaler Pforung HT
- Gertelek: A

Nutzdauer Laufender: Nach IEC 61508-2 7.4.7.4 können 8 - 12 Jahre argomentiert werden oder ein Wert berechnet, der sich durch Berechnung des Anwenders ergibt.

Daraus ergeben sich:
- MTBF: 75% 115 Jahre
- MTBFx: 75% 115 Jahre
- DC (Dignostic coverage): 0

Bestimmungsgemäß Unterzeichnet ist zu beachten:
- Bedeutungseinstellung
- Automatisierung von instrument-eigen Qualität (zehn Sicherheitstechnik)

Sicherheitstechnische Anmerkung:
Im Stab wird der Anwender erläutert, dass er die Verpflichtung zur Sicherheit übernimmt.

Hinweis:
- Durch Einsatz eines Drehungsmessers kann eine umfangreiche Diagnose auch ein außerplanmäßiges Betrieb durchgeführt werden. Damit kann es im Falle der Änderung des direkten (diagnostische coverage last) für gefährliche Fehler von größer 70 % ergibt.

Voraussetzungen:
- Der Regler soll klein gegenüber dem mittleren Aufwandsstelle
- Durchsichtige Beanspruchung in industrieller Umgebung durch Belastung und Umgebungsbedingungen
- Der Anwender ist für die betrieblich agenden Betrachtungszeit verantwortlich.

J. Herrmann
Qualitätssicherung / Quality Manager
Datum: 16.11.2009

LEUSCH GmbH Industriearmaturen
Ziegeleistraße 16, 61147 Neu-Isenburg

Phone: +49 611 706-0
Fax: +49 611 706-20
E-mail: sales@leusch.de

The manufacturer's declaration is certified by the manufacturer, confirming the suitability of the butterfly valves for use in safety-related systems according to IEC 61508 and IEC 61512.
Kompetenz in Funktionaler Sicherheit

Globale Ventile, Drehventile, Kugelventile und Schmetterlingventile

Herstellererklärung

PFEIFFER CHEMIE-ARMATURENBAU GMBH
Hooge Weg 41, 47906 Kempen
Germany


Sicherheitstechnische Kennwerte:
- Lambda safe, unbedeckt: 2,6E-06 1/hr
- Lambda safe, bedeckt: 0
- Lambda dangerous, unbedeckt: 1,3E-07 1/hr
- Lambda dangerous, bedeckt: 0
- PFD (avg) bei jährlicher Prüfung: 3,7E-04
- HFT
- Geräteart: A

Nutzbare Lebensdauer: Nach IEC 61508-2 7.4.7.4 können 8–12 Jahre angenommen werden oder ein Wert benutzt werden, der sich durch Betriebswahrheit des Anwenders ergibt.

Daraus ergeben sich:
- SFF 94%
- MTBF 53 Jahre
- MTBF dangerous 880 Jahre
- DC (diagnostic coverage) 0

Bestimmungsquelle und Verwendung zu beachten:
- Bedarfsanleitungen
- Anforderungen an Funktionsablauf-Qualität (siehe Sicherheitshandbuch)

Sicherheitstechnische Annahmen:
In einem Störfall wird der Antrieb entzündet, daher führt das Ventil in die Sicherheitsschaltung. (Falls Antrieb mono).

Hinweise:
Durch Einsatz eines Stellungsreglers kann eine umfangreiche Diagnose auch im laufenden Betrieb durchgeführt werden. Damit kann sich je nach Einsatzfall ein Diagnoseregel (diagnostic coverage factor) für gefährliche Fehler von größer 70 % ergeben.

Voraussetzung:

Dieter van den Ouden
Qualitätsicherung/Qualitätsmanagement Datum: 22.01.10
PFEIFFER Chemie-Armaturenbau GmbH Telefon: +49 (0)2152 2065-0
Hooge Weg 41 Telefax: +49 (0)2152 1309
47906 Kempen Geschäftsführer: Dipl.-Ing. Lorenz Beilstein

Disclaimer:

This results in:
- Safe failure fraction (SFF) 94%
- MTBF 53 Jahre
- MTBF dangerous 880 Jahre
- Diagnostic coverage (DC) 0

Intended use must be observed:
- Operation instructions
- Requirements for the instrument air quality

Safety-related assumptions:
In case of failure, the pneumatic actuator is vented, causing the valve to move to its fail-safe position (if actuator is mounted).

Note:
By using digital valves positions, the user has access to extensive diagnostic functions while the process is running. As a result the diagnostic coverage factor for dangerous failures can exceed 70% depending on the application.

Preconditions:
The mean time to repair is short compared to the average rate of demand. Normal exposure to industrial environments and fluids. The user is responsible for ensuring that the device is used as intended.

Andre Schnepper
Vertriebsleitung/Sales Management Datum: 22.01.10
PFEIFFER Chemie-Armaturenbau GmbH Telefon: +49 (0)2152 2065-0
Hooge Weg 41 Telefax: +49 (0)2152 1309
47906 Kempen Geschäftsführer: Dipl.-Ing. Lorenz Beilstein.
Competence in Functional Safety
Functional safety of globe valves, rotary plug valves, ball valves and butterfly valves
Competence in Functional Safety

Functional safety of globe valves, rotary plug valves, ball valves and butterfly valves
Competence in Functional Safety
Functional safety of globe valves, rotary plug valves, ball valves and butterfly valves

PFEIFFER
Chemie-Armaturenbau GmbH

Herstellererklärung
Hiermit bestätigt die Firma PFEIFFER CHEMIE-ARMATURENBAU GMBH Hooge Weg 41, 47908 Kempen Germany

Manufacter’s Declaration
The manufacturer hereby certifies that

Klappen/butterfly valves BR/Series 14bic

with the corresponding pneumatic actuators are suitable for use in safety Instrumented systems according to IEC 61508 and IEC 61511. The devices are suitable for use in safety-related applications up to SIL 2 (single device) and SIL 3 (redundant configuration) according to IEC 61508. The evidence is based on proven in use combined with a FMEDA. Device compliance with SIL 2 is hereby certified.

Safety-related data:

<table>
<thead>
<tr>
<th>Lambda safe, undetected</th>
<th>1.4E-06</th>
<th>1/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambda safe, detected</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lambda dangerous, undetected</td>
<td>1.3E-07</td>
<td>1/hr</td>
</tr>
<tr>
<td>Lambda dangerous, detected</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PFD (avg) bei Jährlicher Prüfung</td>
<td>5.5E-04</td>
<td></td>
</tr>
<tr>
<td>HFT</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Useful lifetime: According to IEC 61508-2 section 7.4.7.4 a useful lifetime of 8 – 12 years can be assumed. Other values can be based on the user’s experience.

Daraus ergeben sich:

<table>
<thead>
<tr>
<th>SFF</th>
<th>92%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTBF (gesamt)</td>
<td>73</td>
</tr>
<tr>
<td>MTBF (danger)</td>
<td>910</td>
</tr>
<tr>
<td>DC (Diagnostic coverage)</td>
<td>0</td>
</tr>
</tbody>
</table>

This results in:

| Safe failure fraction (SFF) | 92%   |
| MTBF (gesamt)               | 73    |
| MTBF (danger)               | 910   |
| Diagnostic coverage (DC)    | 0     |

Intended use must be observed:
- Operation Instructions
- Requirements for the instrument air quality (see safety manual)

Safety-related assumptions:
In case of failure, the pneumatic actuator is vented, causing the valve to move to its fail-safe position (if actuator is mounted).

Note:
By using digital valves positioners, the user has access to extensive diagnostic functions also while the process is running. As a result the diagnostic coverage factor for dangerous failures can exceed 70% depending on the application.

Preconditions:
The mean time to repair is short compared to the average time of demand. Normal exposure to industrial environments and fluids. The user is responsible for ensuring that the device is used as intended.

Dieter van den Eede
Qualitätssicherung/Quality Assurance |
Datum: 22.01.19

Andre Schnapper
Vertriebsleitung/Sales Management |
Datum: 22.01.19
Herstellererklärung
Manufacturer's Declaration
zur Betriebsbewährung nach IEC 61508/61511
for proven-in-use according to 61508/61511

The manufacturer

VETEC Ventiltechnik GmbH
Siemensstraße 12, D – 67346 Speyer
Germany

Hiermit bestätigt die Firma hereby certifies that Series

VETEC Ventiltechnik GmbH
Siemensstraße 12, D – 67346 Speyer
Germany

und die dazugehörigen pneumatischen Antriebe, dass die Control Valves with the corresponding pneumatic actuators are
Geräte der o.g. Baureihen für die Verwendung in suitable for use in safety instrument systems according to
sicherheitstechnischen Systemen nach IEC 61508 und IEC 61508 and IEC 61511. The devices are suitable for use in
61511 einsetzbar sind. Die Geräte sind geeignet für den Einsatz safety-related applications up to SIL 2 (single device) and SIL 3 (redundant configuration) according to IEC 61508. The
in sicherheitstechnischen Anwendungen bis SIL 2 (einzelnem evidence is based on proven in use combined with FMEDA. The
Gerät) und SIL 3 (redundante Verschaltung) gemäß IEC 61508. The results were verified by EXDA.
Der Nachweis erfolgte auf Basis der Betriebserprobung proves in use combined with FMEDA. The results were verified by EXDA.
(proven in use) kombiniert mit einer FMEDA. Das Ergebnis der Untersuchungen wurde von EXDA verifiziert.

Sicherheitstechnische Kennwerte:

- Lambda safe undetected: $6.7 \times 10^{-9}$ /h
- Lambda safe detected: 0
- Lambda dangerous undetected: $1.7 \times 10^{-9}$ /h
- Lambda dangerous detected: 0
- PFD (avg) bei fehlerhafter Prüfung: $7.4 \times 10^{-9}$
- HFT: 0
- Gleichlauf: A

Nutzbare Lebensdauer: Nach IEC 61508-2, 7.4.7.4 können 8-12 Jahre angenommen werden oder ein Wert benutzt werden, der sich durch Betriebserprobung des Anwenders ergibt.

Daraus ergeben sich:

- SFF: 80%
- MTBF$_{mean}$: 136 Jahre
- MTBF$_{Unplanned}$: 671 Jahre
- DC (Diagnostic coverage): 0

Bestimmungsgemäße Verwendung ist zu beachten:
- Bedienungsanleitung
- Anforderung an Instrumentenqualität (Sicherheitshandbuch)

Sicherheitstechnische Annahme:

Im Störfall wird der Antrieb entlüftet, dadurch fällt das Ventil in die Sicherheitstufe.

Hinweis:

Durch den Einsatz eines Steuerungsregeles kann eine umfangreiche Diagnose auch im laufenden Betrieb durchgeführt werden. Damit kann sich je nach -Einsatzzustand- ein Diagnosegrad (diagnostic coverage factor) für gefährliche Fehler von größer 70% ergeben,

Voraussetzungen:

Die Reparaturzeit ist kein gegenüber der mittleren Anforderungsgrenze, Durchschnittliche Reaktionszeit in industrielle Umgebung durch Medien und Umgangsbedingungen, Der Anwender ist für bestimmungsgemäßen Gebrauch verantwortlich.

Speyer, 19 Jan 2010 / 19-jan-10

Rembrandt Reul
GM - Geschäftsleitung / QA - Responsible

Norbert Hock
Geschäftsführer / Managing director
### Appendix 2 – Example of a checklist for a final element

#### Checklist for testing safety equipment

<table>
<thead>
<tr>
<th>Final element test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the tag documentation complete and up-to-date?</td>
</tr>
<tr>
<td>Are the connecting cables in good order?</td>
</tr>
<tr>
<td>Are the screw fittings in good order?</td>
</tr>
<tr>
<td>Is the labelling complete and in a readable state? Control room, on site, process control system and safety PLC</td>
</tr>
<tr>
<td>Are all connecting housings free of moisture, water, and dust? (solenoid valve, feedback etc.)</td>
</tr>
<tr>
<td>Are the actuator or solenoid valve free of corrosion? Paint finish in good order?</td>
</tr>
<tr>
<td>Visual inspection of the pneumatic system: Are all pneumatic connections in good order and leak-tight?</td>
</tr>
<tr>
<td>Are the bridges, yokes, stem connectors, fastening nuts free of corrosion and fastened properly?</td>
</tr>
<tr>
<td>Is the valve packing leak-tight? Are there any visible signs of the process medium?</td>
</tr>
<tr>
<td>Is the bellows seal/bellows monitoring still in good order?</td>
</tr>
<tr>
<td>Check of the exhaust parts of the solenoid valve</td>
</tr>
</tbody>
</table>

#### Fail-safe position check

<table>
<thead>
<tr>
<th>Fail-safe position check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open final element in process control system</td>
</tr>
<tr>
<td>P&amp;ID</td>
</tr>
<tr>
<td>Loop</td>
</tr>
<tr>
<td>Do the valve position and output signal match? Move valve to OPEN and CLOSED positions!</td>
</tr>
<tr>
<td>Does the actuator move smoothly to its operating position when signal pressure is applied?</td>
</tr>
<tr>
<td>Is there any leakage at the actuator?</td>
</tr>
<tr>
<td>Does the actuator move smoothly to its fail-safe position when moved by the springs?</td>
</tr>
<tr>
<td>Valve transit time</td>
</tr>
<tr>
<td>Closing time</td>
</tr>
<tr>
<td>Permissible leakage rate</td>
</tr>
</tbody>
</table>

To measure the leakage rate, the valve must be removed from the pipeline and tested in the workshop. Refer to DIN EN 12266-1 (A.4 Seat tightness) for the test procedures.

The following table contains the permissible leakage rates.

<table>
<thead>
<tr>
<th>Test medium</th>
<th>Leakage rate A</th>
<th>Leakage rate B</th>
<th>Leakage rate C</th>
<th>Leakage rate D</th>
<th>Leakage rate E</th>
<th>Leakage rate F</th>
<th>Leakage rate G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid</td>
<td>0.01 * DN</td>
<td>0.03 * DN</td>
<td>0.1 * DN</td>
<td>0.3 * DN</td>
<td>1.0 * DN</td>
<td>2.0 * DN</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>0.3 * DN</td>
<td>3.0 * DN</td>
<td>30.0 * DN</td>
<td>300 * DN</td>
<td>3000 * DN</td>
<td>6000 * DN</td>
<td></td>
</tr>
</tbody>
</table>

The leakage rates only apply when room temperature prevails at the outlet side. “No visible leaks found during test” means no visible moisture or formation of drops or bubbles. This corresponds to a lower leakage rate than leakage rate B.

Attach green label after the test has been completed.

Does repair work need to be performed on the system? If this is the case, write out a separate order.

Tester 1: Tester 2: Test date: Signature:
Checklist for testing safety equipment

Owner: ___________________________ Created/Revised by: ___________________________

Operation: ___________________________ Plant: ___________________________ Subplant: ___________________________ Tag no.: ___________________________

Operating state during test: ___________________________ PLC/DCS: ___________________________ Tester: ___________________________ Test date: ___________________________


Manufacturer: ___________________________ Manufacturer model: ___________________________ Body number/serial number/stamp number/ID: ___________________________

Site of installation: ___________________________ Barrier medium: ___________________________ +H551-14E2

Final element exists in the following SIL loops

SIF no.: ___________________________ ___________________________ ___________________________ ___________________________

Commissioning test: ☐ Proof test: ☐ Revision test: ☐

Final element test: ……… years Lockout test: ……… years

- An assessment of the process and safety hazards in the plant and installation is necessary.
- Obtain a permit to work!
- Wear suitable protection for the work! Observe explosion protection regulations!
- The person performing the work is responsible for using the appropriate maintenance methods according to the recognized codes of practice as well as for using suitable and tested tools!
- The person performing the work bears the compulsory insurance during the work!
  This includes, for example, the safeguarding of the workplace against unauthorized access or against accidental contact with unprotected electrical installations while temporarily leaving the workplace.
- Take precautionary measures to protect the plant against external influences, such as weather or other damaging environmental influences.

Measuring equipment list:

<table>
<thead>
<tr>
<th>Type/Manufacturer/model</th>
<th>Serial number</th>
</tr>
</thead>
<tbody>
<tr>
<td>________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>________________________</td>
<td>___________________________</td>
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<tr>
<td>________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>________________________</td>
<td>___________________________</td>
</tr>
</tbody>
</table>

Tester 1: ___________________________ Tester 2: ___________________________ Test date: ___________________________ Signature: ___________________________