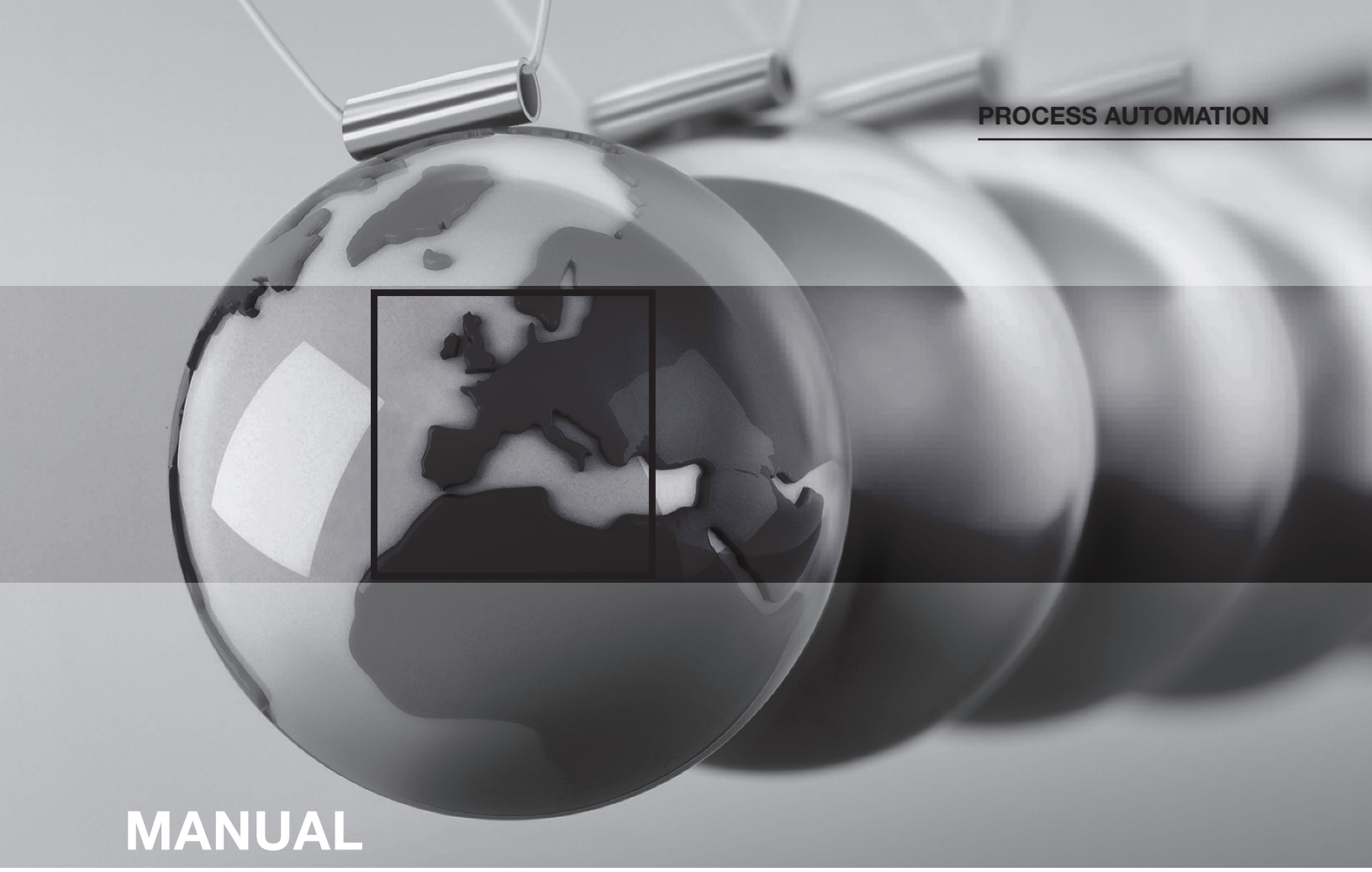

PROCESS AUTOMATION

# MANUAL

# Functional Safety
# 6500 Purge and Pressurization System

SIL
IEC 61508/61511

ISO9001

CE

SIL 2

Ex

PEPPERL+FUCHS

With regard to the supply of products, the current issue of the following document is applicable:

The General Terms of Delivery for Products and Services of the Electrical Industry, published by the Central Association of the Electrical Industry (Zentralverband Elektrotechnik und Elektroindustrie (ZVEI) e.V.) in its most recent version as well as the supplementary clause: "Expanded reservation of proprietorship".

# Contents

# 1 Introduction

## 1.1 General Information

This manual contains information for application of the device in functional safety related applications.

The corresponding datasheets, operation/installation manual, system description, Declaration of Conformity, the EC-Type-Examination Certificate, the functional Safety Assessment and applicable certificates (see datasheet) are integral parts of this document.

The documents mentioned are available from www.pepperl-fuchs.com or by contacting your local Pepperl+Fuchs representative.

Mounting, commissioning, operation, maintenance and dismantling of any parts of this device may only be carried out by trained, qualified personnel. The operation/installation manual must be read and understood.

When it is not possible to correct faults and some alarms, the system must be taken out of service and action taken to protect against accidental use. Devices shall only be repaired directly by the manufacturer. De-activating or bypassing safety functions or failure to follow the advice given in this manual (causing disturbances or impairment of safety functions) may cause damage to property, environment or persons for which Pepperl+Fuchs will not be liable.

***Note!***
This document does not substitute the instruction manual.

***Note!***
For full information on the product, refer to the instruction manual and further documentation on the Internet at www.pepperl-fuchs.com

The documentation consists of the following parts:
- Manual
- Datasheet
- EC-Type of examination
- EU declaration of conformity
- Certificates – IECEx, UL/cULus
- Control drawings
- FMEDA report

## 1.2 Safety Information and Intended Use

**Target Group, Personnel**
Responsibility for planning, assembly, commissioning, operation, maintenance, and dismounting lies with the plant operator.

Only appropriately trained and qualified personnel may carry out the above tasks. The personnel must have read and understood the instruction manual and the further documentation.

**Intended Use**
The device is only approved for appropriate and intended use. Ignoring these instructions will void any warranty and absolve the manufacturer from any liability.

The device is developed, manufactured and tested according to the relevant safety standards.

Use this device only
- For the application described
- With specified environmental conditions
- With devices that are suitable for this safety application

For additional information, refer to the manual and www.pepperl-fuchs.com.

**Improper Use**
Protection of the personnel and the plant is not ensured if the device is not used according to its intended use.

## 1.3 Manufacturer Information

Pepperl+Fuchs GmbH
Lilienthalstrasse 200
68307 Mannheim/Germany

## 1.4 Relevant Standards and Directives

**Standards**
IEC 61508-1:2010 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – General Part
IEC 61508-2:2010 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Requirements for safety-related systems
IEC 61508-3:2010 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Software requirements
SN 29500 parts 1 – 13, Failure rates of components
FMD-91, RAC 1991 Failure Mode / Mechanism Distributions
FMD-97, RAC 1997 Failure Mode / Mechanism Distributions

## 1.5 Symbols Used

This document contains symbols for the identification of warning messages and of informative messages.

**Warning messages**
You will find warning messages in instances when danger may arise from your actions. It is mandatory that you observe these warning messages for your personal safety and in order to avoid property damage.
Depending on the risk level, the warning messages are displayed in descending order as follows:


***Danger!***
This symbol indicates an imminent danger.
Non-observance will result in personal injury or death.

***Warning!***
This symbol indicates a possible fault or danger.
Non-observance may cause personal injury or serious property damage.

***Caution!***
This symbol indicates a possible fault.
Non-observance could interrupt the device and any connected systems and plants, or result in their complete failure.

**Informative symbols**

***Note!***
This symbol brings important information to your attention.

***Action***
This symbol indicates a paragraph with instructions. You are prompted to perform an action or a sequence of actions.

# 2 Product Description

## 2.1 Function

The 6500 series purge and pressurization system protects general-purpose equipment mounted in a standard enclosure. This allows the enclosure to be located and the equipment to operate in a hazardous area. The hazardous area classification can be Zone 1 or 21. The 6500 series operates by controlling and monitoring compressed instrument air or inert gas through the protected enclosure(s) to remove and prevent the accumulation of flammable gas, vapors, or dust.

### 6500 Control Unit

The 6500 system consists of the control unit, which houses the EPCU (electronic protection control unit), the UIC (user-interface controller), the terminal connections, and the EPV6500 enclosure protection vent.

The features of the 6500 control unit include the following:

- User selectable for pxb or pyb applications
- User-interface (UIC) is intrinsically safe and is touch controlled
- Universal power requirement, 20 ... 30 VDC / 100 ... 240 VAC
- Input for 2-wire PT100 RTD for automatic temperature control monitoring
- Automatic pressure control
  - Digital manifold with min/max set-points for pressurization
  - Proportional valve using user configured set-points
- Automatic flow control for dilution applications with the proportional valve and EPV-6500 continuous vent
- User-selectable input functions
  - Door switch (immediate shutdown of system)
  - Bypass control with maintenance or commissioning selections
  - Enclosure contacts
  - Auxiliary contacts for alarms, low/max pressures, control valve
- RS-485 com port with HART protocol available through PACTware or other AMS systems. DTM/DD/EDDL's available.
- Bluetooth® connectivity with APP programs option

The power for the solenoid valve on the manifold unit, inputs, the user interface controller (UIC), and EPV-6500 vent are provided by the EPCU through the internal galvanically isolated intrinsic safety barrier. No additional intrinsic safety barrier is required.

### EPV-6500 vent

The EPV-6500 vent is required with the 6500 system for proper operation. The features of the EPV-6500 vent include the following:

- Measures enclosure pressure
- Measures flow rate through the vent
- As required, it functions as a pressure relief device
- Has a spark arrestor as required for hazardous-area operation

### X Purge 6500-Assessed Devices

The following devices are allowed for use within this safety system:

| | |
|---|---|
| Control unit | 6500-01-EXT-PNO-LNO * |
| Control unit | 6500-01-PM1-PNO-LNO * |
| Control unit | 6500-01-PM2-PNO-LNO * |
| EPCU | 6500-01-EPCU-PNO-LNO * |
| User interface | 6500-01-UIC-PM0 |
| User interface | 6500-01-UIC-EXT |
| Vent | EPV-6500-AA-01 ** |
| Vent | EPV-6500-AA-03 ** |
| Vent | EPV-6500-AA-05 ** |
| Vent | EPV-6500-AA-07 ** |
| Vent | EPV-6500-AA-08 ** |
| Vent | EPV-6500-SS-01 ** |
| Vent | EPV-6500-SS-03 ** |
| Vent | EPV-6500-SS-05 ** |
| Vent | EPV-6500-SS-07 ** |
| Vent | EPV-6500-SS-08 ** |

* Note: "PNO" and PLO" indicate that there is no cable gland. Other nomenclature indicates approved cable glands.
** Note: "AA" indicates aluminum. "SS" indicates stainless steel. Other materials may be selected.

## 2.2 I/O Interfaces

The device has the following safety-relevant interfaces:

- Temperature input: 2-wire RTD PT100
- Switch input
- Proportional valve output
- Digital valve output
- EPV-6500 vent
- UIC customer-configurable display
- RS-485
- Auxiliary contact output
- Enclosure power contact output, dry contacts
- Enclosure power contact input, dry contacts

***Note!***
For corresponding connections, see the 6500 installation and operation manual.

## 2.3 System Overview

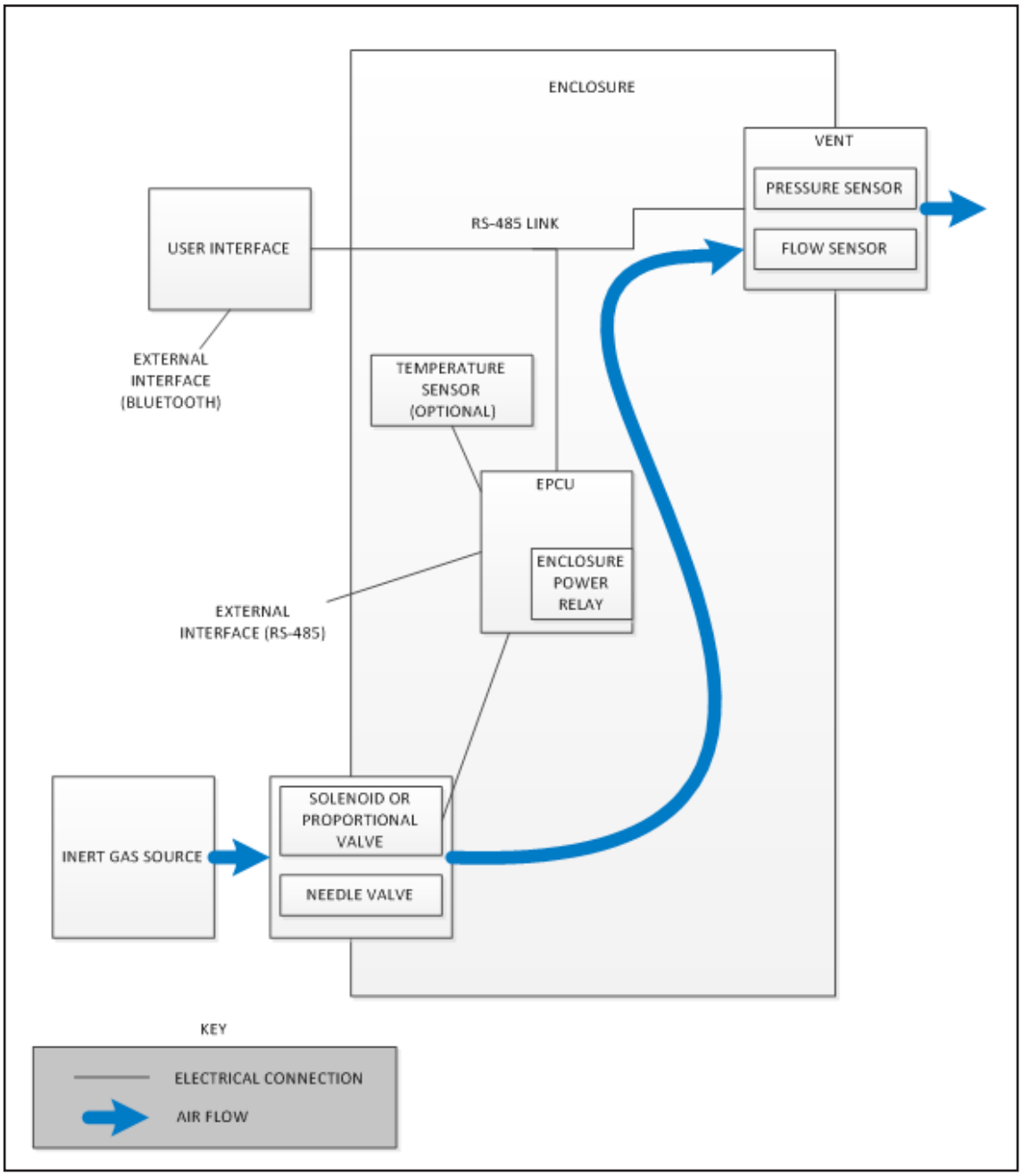


Figure 2.1 Block Diagram

## 2.4 Markings

The following markings are for both the 6500 control unit and the EPV-6500 vent.


| | |
|---|---|
| **Control unit model number ***<br>6500-01-EXT-PNO-LNO<br>6500-01-PM1-PNO-LNO<br>6500-01-PM2-PNO-LNO | Up to SIL 2 |
| **EPV vent model number ****<br>EPV-6500-AA-01<br>EPV-6500-AA-03<br>EPV-6500-AA-05<br>EPV-6500-AA-07<br>EPV-6500-AA-08<br>EPV-6500-SS-01<br>EPV-6500-SS-03<br>EPV-6500-SS-05<br>EPV-6500-SS-07<br>EPV-6500-SS-08 | Up to SIL 2 |

* Note: "PNO" and PLO" indicate that there is no cable gland. Other nomenclature indicates approved cable glands.
** Note: "AA" indicates aluminum. "SS" indicates stainless steel. Other materials may be selected.

# 3 Planning

## 3.1 Assumptions for the Assessment

The following assumptions have been made during the failure modes, effects, and diagnostic analysis of the X Purge 6500 system:

- The safety-related device is considered to be of type B element with a hardware fault tolerance of 0.
- For a SIL 2 application operating in high-demand mode, the total PFH value of the SIF must be smaller than $10^{-6}$ per hour.
- Since the safety loop has a hardware fault tolerance of 0 and it is a type B element, the SFF must be > 90 % according to table 3 of IEC 61508-2 for a SIL 2 (sub)system.
- Failure rates based on the Siemens standard SN29500.
- Failure rates are constant, wear is not considered.
- External power supply failure rates are not included.
- The device will be used under average industrial ambient conditions, which are comparable with the classification “stationary mounted” in MIL-HDBK-217F. Alternatively, ambient conditions are assumed to follow IEC/EN 60654-1 Class C (sheltered location) with temperature limits in the range of the manufacturer’s specifications and an average temperature of 40 °C over a long period. The humidity level is within manufacturer’s rating. For a higher average temperature of 60 °C, the failure rates must be multiplied by a factor of 2.5 based on experience. A similar factor must be used if frequent temperature fluctuations are expected.
- Observe the useful lifetime limitations of the output relays according to the datasheet. The auxiliary relay may not be loaded to more than 1 A if used in safety applications.
- Observe that environmental conditions within the enclosure stay within the limits given in the data sheets for the individual devices installed.
- The display function and the displayed values are not part of the safety function.
- The user must introduce the parameters by a certain method that is described within the safety manual. All relevant safety parameters must be programmed correctly.
- It was assumed that the appearance of a safe error (e.g., output in safe state) would be repaired within 8 hours (e.g., remove sensor burnout).
- During the absence of the device for repairing, measures have to be taken to ensure the safety function (for example: substitution by an equivalent device).

The sensors are never exposed to high temperature variation and will only detect a slightly higher temperature than ambient when covered under a layer of dust. This is why the low stress configuration is considered suitable for the evaluation. Burn-out and short circuit are detected as measured values are not plausible.

## 3.2 Safety Function and Safe State

### Safe State

For **px mode**, the safe state is reached when one contact of the two enclosure power relays (with two contacts each) switches to off (de-activated) state.
In **py mode**, the enclosure power relays are off when starting the system as safe state. After enclosure power is enabled, the safe state is reached by switching the AUX relay normally open contact to off (de-activated) state, enabling an alarm.

### Safety Function

There are three safety functions:

- When the enclosure is pressurized in a px system, a drop in pressure below a threshold de-activates the enclosure power relays.
- When the enclosure is pressurized in a py system, a drop in pressure below a threshold de-activates the auxiliary relay.
- When a rapid exchange function is started, the enclosure power relays are in safe state. The safe state is kept until a predetermined volume of atmosphere was exchanged. After this, the enclosure power may be activated.

The safety path switches off the relays immediately (< 2 seconds). Under fault conditions, switching to the safe state may take up to 300 seconds, which is considered adequate as process safety time for purge systems.

The safety reaction may also be delayed if a shutdown delay is programmed.

***Warning!***
The shutdown delay function can risk that too long of a reaction time for a safety function is implemented. The user must ensure that delay times are suitable for the intended application.

The sensors are never exposed to high temperatures or temperature variations and will only detect a slightly higher temperature than ambient when covered under a layer of dust. This is why the low stress configuration is considered suitable for the evaluation. Burn-out and short circuit are detected as measured values are not plausible.

Note that ‘inert gas’ used in this document equates to the description provided in IEC 60079-2 section 3.16 and paraphrased here: nitrogen, carbon dioxide, argon or any gas when mixed with oxygen in a ratio of 4 parts to 1 part of oxygen to not make ignition and flammability more onerous.

***Note!***
For py mode, it is intended to use the NO contact of the auxiliary relay for activating the alarm (OPEN in case of alarm). If the NC contact is used, precautions must be taken to ensure that energy flows to the alarm device under all circumstances, which includes protection of the wiring and terminals against open circuits, choice of suitable fuses (opening fuses are dangerous!) and power supplies for the alarm that are not shut down in case of an alarm.

A description of the safety function is given in IEC 60079-2.

## 3.3 Characteristic Safety Values

***Note!***
See chapter 8 for a list of abbreviations.

| Parameters acc. to EN/IEC 61508:2010 | Rapid Exchange | Minimum Pressure | Minimum Pressure |
|---|---|---|---|
| Assessment type and documentation | Full assessment | | |
| Device type | B | | |
| Mode of operation | High-demand mode | | |
| HFT | 0 | | |
| SIL | 2 | | |
| **Safety output** | **Enclosure power relay** | | **Auxiliary relay** |
| $\lambda_s$ [1] | 514 FIT | 523 FIT | 448 FIT |
| $\lambda_{dd}$ [2] | 533 FIT | 391 FIT | 296 FIT |
| $\lambda_{du}$ [3] | 44.8 FIT | 65.1 FIT | 76.2 FIT |
| $\lambda_{total\ (safety\ function)}$ [1] | 1092 FIT | 983 FIT | 820 FIT |
| $\lambda_{no\ effect}$ [3] | 594 FIT | 625 FIT | 560 FIT |
| $\lambda_{not\ part}$ | 2576 FIT | 2658 FIT | 2881 FIT |
| $\lambda_{total}$ | 4261 FIT | 4261 FIT | 4261 FIT |
| SFF[1] | 95.90 % | 93.35 % | 90.72 % |
| MTBF[4] | 27 years | 27 years | 27 years |
| PFH | 4.48 * $10^{-8}$ 1/h | 6.51 * $10^{-8}$ 1/h | 7.62 * $10^{-8}$ 1/h |
| Reaction time[5] | < 2 s | | |

[1] 'No effect' failures are not influencing the safety function. They are therefore not included in SFF and safety function failure rate.

[2] This value contains annunciation detected failures.

[3] This value contains 5 % of the annunciation undetected values. The rest is considered to have no effect as worst case.

[4] Acc. to SN29500. This value includes failures which are not part of the safety function. For one safety function path only. MTTR = 24h.

[5] Time for the safety function to be switch off the respective relay. In case of a fault, the fault detection and reaction time is 300 s.

## 3.4 Useful Lifetime

Although a constant failure rate is assumed by the probabilistic estimation, this only applies provided that the useful lifetime of components is not exceeded. Beyond this useful lifetime, the result of the probabilistic calculation is meaningless as the probability of failure significantly increases with time. The useful lifetime is highly dependent on the component itself and its operating conditions – temperature in particular (for example, the electrolytic capacitors can be very sensitive to the working temperature).

This assumption of a constant failure rate is based on the bathtub curve, which shows the typical behavior for electronic components.

Therefore, it is obvious that failure calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is assumed that early failures are detected to a huge percentage during the installation period and therefore the assumption of a constant failure rate during the useful lifetime is valid.

However, according to IEC 61508-2, a useful lifetime, based on experience, should be assumed. Experience has shown that the useful lifetime often lies within a range of about 8 ... 12 years.

As noted in DIN EN 61508-2:2011 note N3, appropriate measures taken by the manufacturer and operator can extend the useful lifetime. Our experience has shown that the useful lifetime of a Pepperl+Fuchs product can be higher if the ambient conditions support a long lifetime, for example if the ambient temperature is significantly below 60 °C.

Please note that the useful lifetime refers to the (constant) failure rate of the device. The effective lifetime can be higher.

# 4 Mounting, Installation, and Commissioning

Refer to the 6500 installation and operation manual for information on mounting, programming, and commissioning this system.

## 5 Parameterization

When powering the device for the first time, the desired language and a password must be entered. The password must be entered twice to confirm it, and afterwards the safety-relevant parameters are available. More details on how to program the X Purge 6500 are given in the installation and operation manual.

The following parameters must be entered to complete the safety relevant data necessary for executing the safety function correctly:

| No. | Parameter | Limitation |
|---|---|---|
| 1 | ENVIRONMENT_CONFIG<br>(Environment type) | Gas, dust, gas and dust |
| 2 | SAFE_PRES_DATA<br>(Safe Pressure) | 0.32 .. 10.00 in H2O<br>0.88 mbar .. 25 mbar |
| 3 | PXPY_CONFIG (Purge Type) | Px, Py |
| 4 | SHUT_DELAY_CONFIG<br>(delay after sensor input is set) | 0 ... 300 seconds |
| 5 | ENCL_VOLM_DATA<br>(Enclosure volume) | 0.35 $ft^3$ .. 450.26 $ft^3$<br>10 L .. 12.800 L |
| 6 | NUMB_EXCHG_CONFIG<br>(Number of Exchanges) | > 4 |
| 7 | Password | No same key twice followed by start/set |

After entering all safety-relevant parameters, the entered variables need to be read back over the user interface per menu entry.


***Danger!***
It is important to read back the parameters, because the safety function is not executed correctly with wrong parameters. It is necessary to read the parameters from a different device then write the parameters to ensure that the entry was understood correctly.

***Action***
For safety purposes, it is recommended to create a review record for the entered parameters in case the correct programming is doubted.


***Danger!***
The shutdown delay function can risk that too long of a reaction time for a safety function is implemented. The user must ensure that delay times are suitable for the intended application.


***Danger!***
The bypass function must be disabled for a safety application.

# 6 Operation

## 6.1 General Information

***Danger!***
The display can be rotated +90 or -90 degrees as shown in the installation manual. Rotation of the display is not allowed when the I.S. cable/connector of the UIC is directly over the non-I.S. wiring terminals. See the 6500 installation and operation manual.

***Danger!***
Unused cable entries will require a properly rated hazardous-location plug.

***Danger!***
EN and IEC 60079-2 standards do not state the requirements for hazardous gas and dust atmospheres. Special consideration is needed and an appropriate certification body or AHJ will have to be consulted.

***Danger!***
For implementing a bypass function, this should be done only when the area is safe. Energizing the enclosure contacts before purging, cleaning the enclosure and safe enclosure pressure is dangerous.

***Danger!***
When an inert gas is used, a warning shall be affixed to the enclosure showing the risk of asphyxiation.

***Warning!***
Non-observance of conditions of safe use will result in personal injury or death.

***Warning!***
When using customer-supplied electrical valves, follow the entity parameters of the valve and the output of the 6500 control unit.

***Warning!***
When using customer-supplied cable glands and blanking plugs, check for the required certification and installation of the selected cable glands for proper installation.

***Warning!***
When using customer-supplied cable glands, check for the required certification and installation of the selected cable glands for proper installation.

***Warning!***
When mounting the 6500 control unit to a wall, the mounting method should be able to handle 4 times the gross weight of the 6500 unit.

***Warning!***
The 6500 control unit EPCU is powder filled and is not user serviceable. This unit must be sent back to the factory for replacement/repair.

***Warning!***
The reaction to a loss of pressure is taking up to 2 seconds. In case of a fault, the fault detection and reaction time is up to 300 seconds. This is not considered a problem for a purge system as the device will not be exposed to explosive atmosphere continually and the time until ignitable gas or dust enters a closed cabinet and reaches hot surfaces in ignitable amount is considered small. Nonetheless, the user should consider whether his needs for the application are satisfied.

For constraints and limitations of the system, refer to the 6500 installation and operation manual.

### Operation in Gas-Hazardous Locations

- Seal enclosure
- Pressure is set to a value above the minimum overpressure set-point in the user interface menu for the purge settings. This pressure cannot be set below 0.88 mbar (0.35” w.c.)
- Purging enclosure is required. This will be manual or automatic, depending on the purging mode (semi-automated or fully automated mode)
- After a successful purging, with the pressure in the enclosure above the minimum overpressure set-point, the enclosure is considered safe and power to the enclosure can be energized.
- If the enclosure pressure drops below the minimum overpressure set-point, then action is required.

For ‘pxb’, enclosure contacts will be de-energized. For ‘pyb’, enclosure contacts can remain on but an alarm must be initiated. This is done with the normally open contact of the auxiliary relay.

***Note!***
Do not use the normally closed contact for introducing the safe state. See ratings of contacts so that external fuses can be selected to protect the circuit.

### Operation in Dust-Hazardous Locations

- The pressurized enclosure must be cleaned out of all combustible dust and sealed. Purging cannot be done to clean out the enclosure.
- Set the enclosure pressure above the minimum overpressure set-point. Minimum pressure is 0.88 mbar (0.35 in H2O)
- With the enclosure pressure above the minimum overpressure set-point, it is considered safe and power to the enclosure can be energized.
- If the enclosure pressure drops below the minimum overpressure set-point, action is required.

## 7 Maintenance

***Danger!***
If the safety loop is put out of service, the safety function is deactivated.
- Do no bypass the safety function, unless the area is known to be safe of hazardous atmosphere
- Do not repair, modify, or manipulate the device

The X Purge 6500 is only for high-demand applications so that a proof test is not necessary. However, an inspection of the setup must be implemented to find clogged openings, missing supply, unusual dust covers as a precaution measure. The user must choose an inspection interval depending on the environmental conditions that the system is used in. See also points 6 and 7 below.

**Maintaining, Repairing, or Replacing the Device**

In case of maintenance, repair, or replacement of any of the devices of the 6500 system, proceed as follows:

1. Implement appropriate maintenance procedures for regular maintenance of the safety loop when deemed necessary.
2. Ensure the proper function of the safety loop while the device is being maintained, repaired, or replaced.
3. Do not repair a defective component of the 6500 system. A defective component must only be repaired by the manufacturer.
4. Replace a defective component only with a component of the same type.
5. Correct any occurring safe failures within 24 hours. Take measures to maintain the safety function while the device is repaired.
6. The wiring at the terminals of the 6500 control unit must be checked regularly so that loosening of the screw does not affect the safety function. The operator will determine the regularity of checking based on vibration and other environmental conditions.
7. The purge gas supply must be checked regularly for proper usage. Filters and driers may have to be replaced or cleaned to maintain proper gas. See maintenance schedule for protective gas supply machinery in the installation and operation manual.

## 8 List of Abbreviations

| Abbreviation | Meaning |
|---|---|
| $\lambda_s$ | Rate of safe failure |
| $\lambda_{dd}$ | Rate of dangerous detected failure |
| $\lambda_{du}$ | Rate of dangerous undetected failure |
| $\lambda_{no\ effect}$ | No effect on the safety function. The no effect failure is not used for calculation of SFF. |
| $\lambda_{not\ part}$ | Rate of failure of components that are not in the safety loop |
| $\lambda_{total}$ | Failure rate of the device |
| AVG | Average |
| EMC | Electromagnetic compatibility |
| EPCU | Electronic protection control unit |
| EPV-6500 | Enclosure protection vent for the 6500 system |
| EHSR | Essential health and safety requirements |
| FMEDA | Failure mode, effects, and diagnostics analysis |
| HFT | Hardware fault tolerance |
| FIT | Failures in time in $10^{-9}$ 1/h |
| MTBF | Mean time between failures |
| PFD | Probability of dangerous failure on demand |
| PFDavg | Average probability of dangerous failure on demand |
| PFH | Average frequency of dangerous failure per hour |
| PLC | Programmable logic controller |
| PTC | Proof test coverage |
| RTD | Resistive temperature device |
| SC | Systematic capability |
| SFF | Safe failure fraction |
| SIF | Safety instrumented function |
| SIL | Safety integrity level |
| SIS | Safety instrumented system |
| $T_1$ | Proof test time |
| UIC | User-interface controller |

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