



**SIL 1**  
IEC 61508

**SIL 2**  
IEC 61511

**PL d**  
ISO 13849



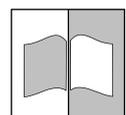
**RoHS II**  
COMPLIANT



## Safety manual

### DE45

Digital differential pressure transmitter  
with colour-change LCD



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# 1 Functional security (IEC 61508 / IEC 61511)

## 1.1 Scope and standards



### NOTICE

#### Safety instructions

This Safety Manual should only be used in conjunction with the operating instructions of the respective unit. Pay attention to the safety instructions in the operating instructions.

This Safety Manual applies for the differential pressure transmitter of the series DE45 with the analogue outputs 4...20 mA in 3-conductor circuit. This corresponds to the following product number keys.

- DE45#####PK###
- DE45#####FK###

The DE45 underwent a function test by an independent institute (Risknowlogy®) to check its functional safety. The safety-specific coefficients were determined using a part analysis (FMEDA) and the following calculations. The results were recorded in the FMEDA Report 930.347.1/2017-02-02.

The transducers have been developed and tested in line with the following standards.

Functional safety (unit-specific/manufacturer)	<b>IEC 61508: 2010</b> Functional safety of safety-related electrical/ electronic/programmable electronic systems
Functional security (system-specific/user)	<b>IEC 61511: 2016</b> Functional safety - safety systems for the pro- cess industry
Part failure rate	<b>SN 29000: 2013</b> Failure rates (Siemens)

## 1.2 Description of the Device and Field of Application

### 1.2.1 Safety function

The differential pressure transmitter sends the input signal (pressure) to a standardised analogue 4...20 mA output signal. There is one measuring channel available.



### WARNING

#### Other unit functions

Some models have other functions such as switch outputs or signal outputs (0...20 mA, 0...10 V) that can be activated through configuration. These functions are not part of the safety function and therefore may not be used for safety-relevant purposes.

### 1.2.2 Definition of a safe state

Output signal $I_{out}$	Safe state	Comment
4...20 mA	$3.92 \text{ mA} \leq I_{out} \leq 20.08 \text{ mA}$	Impressed current

### 1.2.3 Parameters



#### **⚠ WARNING**

##### **Parameter change**

The device is configured in the factory before delivery. Only the operator of the system or personnel he names and briefs may carry out the configuration work.

The unit configuration is protected by a password before delivery. This password is handed over on delivery and must be changed by the operator during commissioning. There is more information about the password in the operating instruction of the respective unit.

There are two ways to complete the configuration.<sup>(1)</sup>

- Using the unit's keyboard
- Remote configuration using the transmitter PC interface

The following transmission errors are possible during remote configuration. Therefore, it is essential to verify all parameters and the safety function on the unit after transfer.

### 1.3 Notes on Planning

#### 1.3.1 Intended use

The unit underwent a function test by an independent institute (Risknowlogy®) to check its functional safety in compliance with IEC 61508 and IEC 61511. The results were recorded in the FMEDA Report 930.347.1/2017-02-02.

- **IEC 61508**  
The unit is suitable for use in safety circuits with an SIL 1 classification.
- **IEC 61511**  
The unit is suitable for use in safety circuits with an SIL 2 classification (prior use).

#### 1.3.2 Operating mode

The unit is used with a low demand rate operating mode. The demand rate is less than once a year and no more than twice the frequency of the repeat test. The associated variable is the PFD value.

#### 1.3.3 Equipment type

This is a Type B unit (complex operating equipment).

#### 1.3.4 Inspection intervals

Conduct a proof test after commissioning and then after 5 years at the latest.

The following table shows the average probability of a malfunction in case of demand depending on the inspection interval and the system architecture.

Architecture		Inspection interval ( $T_1$ )			
		1 year	2 years	5 years	10 years
1oo1	PFD <sub>avg</sub>	$6.8 \times 10^{-4}$	$1.4 \times 10^{-3}$	$3.4 \times 10^{-3}$	$6.8 \times 10^{-3}$
1oo2	PFD <sub>avg</sub>	$3.49 \times 10^{-5}$	$7.07 \times 10^{-5}$	$1.85 \times 10^{-4}$	$3.98 \times 10^{-4}$

<sup>(1)</sup> Please see the information in the operating instructions.

### 1.3.5 Lifetime

The lifetime starting from the production date is 10 years.

If the lifetime is exceeded, the error rates can gradually increase due to wear and aging, and the calculated PFD values can no longer be used. In worst cases, this leads to a loss of the SIL classification.

### 1.3.6 Assembly and installation

Pay attention to the assembly instructions in the operating instructions.

## 1.4 Repeat tests

### 1.4.1 Maintenance

Proof tests are an integral part of the safety concept to detect dangerous failures. The proof test checks the following aspects of a safety-critical component:

- Functionality
- do the components satisfy the prevailing application conditions
- are the interfaces to other components OK

All critical parts need to be tested with the proof test. Spot checks are sufficient for parts that are not critical for safety.

### 1.4.2 Function test

The operator is responsible for defining the proof test procedure for the entire safety system.

The following function test must be carried out on the safety component DE45.

1. Check the function of the input values within the measuring range.
2. Check the error signal for input values outside the measuring range.
3. Check that the error signal is recognised correctly by the overriding safety control system.

The test pressure should be generated independently with the safety system (SIS), if this is possible. In this case steps could be taken at the same time to check whether the signals from the overriding safety control system are processed correctly and forwarded via the actuator.

Otherwise, the DE45 needs to be removed and wired to a pressure calibrator, ammeter and a settable power supply as follows.

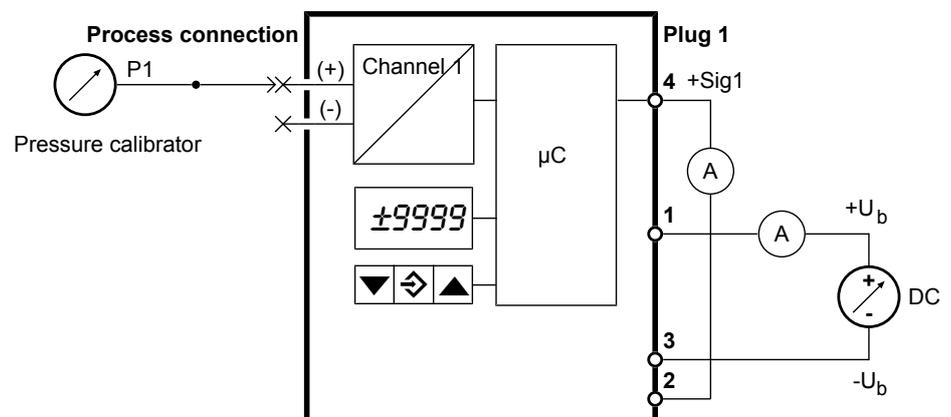


Fig. 1: Function test

**Test equipment list**

Test equipment	Usage	resolution
Pressure calibrator ( $\pm 1$ bar)	Input signal	0.1% of final value
Multimeter	Absorbed current	1 mA
Multimeter	Output signal	1 $\mu$ A
Power supply	Can be set between 12 ... 32 V DC	0.1V

**Input values within the measuring range**

1. Set an operating voltage of  $24V \pm 0.1V$ .
2. Use the pressure calibrator to set an input signal that corresponds to the start of the measuring range.
3. Check the output signal.  
The output must deliver a signal of  $4 \text{ mA} \pm 0.08 \text{ mA}$ .
4. Use the pressure calibrator to set an input signal that corresponds to the end of the measuring range.
5. Check the output signal.  
The output must deliver a signal of  $20 \text{ mA} \pm 0.08 \text{ mA}$ .
6. Check the absorbed current. The absorbed current may not exceed a value of 125 mA.

**Input values outside the measuring range**

1. Use the pressure calibrator to set an input signal that lies well below the start of the measuring range.
2. Check the output signal.  
The output must deliver a signal of less than 3.92 mA.
3. Use the pressure calibrator to set an input signal that lies well above the start of the measuring range.
4. Check the output signal.  
The output must deliver a signal in excess of 20.08 mA.

**Check the error signal in the SIS**

1. Wire the DE45 to the overriding safety controls system.
2. Use the pressure calibrator to set an input signal that lies well below the start of the measuring range so that an error signal is generated.
3. Check that the error signal is recognised correctly by the safety control system.

This marks the end of the function test. If the unit does not pass the function test, please send it to our repair department.

**1.4.3 Repair work**

Only the manufacturer may repair units.

All defective or faulty devices should be sent directly to our repair department. Please coordinate all shipments with our sales department.

**WARNING****Process media residues**

Process media residues in and on dismantled devices can be a hazard to people, animals and the environment. Take adequate preventive measures. If required, the devices must be cleaned thoroughly.

Return the device in the original packaging or a suitable transport container.

## 1.5 Safety-relevant variables

### 1.5.1 Safety coefficients

Percentage of non-dangerous faults	<b>SFF</b>	62 %
Equipment type		Type B
<b>Failure rates</b>		<b>FIT</b>
Non-dangerous faults	$\lambda_s$	109
Detectable safe faults	$\lambda_{sd}$	0
Non-detectable safe faults	$\lambda_{su}$	109
Dangerous faults	$\lambda_d$	304
Detectable dangerous faults	$\lambda_{dd}$	148
Non-detectable dangerous faults	$\lambda_{du}$	156

#### Safety integrity level according to IEC 61508

	SIL 1	SIL 2
Required units	1	2
System architecture:	1oo1	1oo2
Hardware Failure Tolerance HFT:	0	1

#### Safety integrity level according to IEC 61511

	SIL 2
Required units	1
System architecture:	1oo1
Hardware Failure Tolerance HFT:	0

#### Inspection intervals

		Inspection interval ( $T_1$ )			
Architecture		1 year	2 years	5 years	10 years
1oo1	$PFD_{avg}$	$6.8 \times 10^{-4}$	$1.4 \times 10^{-3}$	$3.4 \times 10^{-3}$	$6.8 \times 10^{-3}$
1oo2	$PFD_{avg}$	$3.49 \times 10^{-5}$	$7.07 \times 10^{-5}$	$1.85 \times 10^{-4}$	$3.98 \times 10^{-4}$

### 1.5.2 Safety integrity level (SIL)

The following table shows the probability of a dangerous failure of the safety function depending on the SIL level and the operating mode.

#### Low Demand Mode

SIL	PFD	Max. 1 dangerous failure per
SIL4	$\geq 10^{-5}$ to $< 10^{-4}$	10000 demands
SIL3	$\geq 10^{-4}$ to $< 10^{-3}$	1000 demands
SIL2	$\geq 10^{-3}$ to $< 10^{-2}$	100 demands
SIL1	$\geq 10^{-2}$ to $< 10^{-1}$	10 demands

#### High Demand Mode

SIL	PFH	Max. 1 dangerous failure per
SIL4	$\geq 10^{-9}$ to $< 10^{-8}$	100,000,000 demands
SIL3	$\geq 10^{-8}$ to $< 10^{-7}$	10,000,000 demands
SIL2	$\geq 10^{-7}$ to $< 10^{-6}$	1,000,000 demands
SIL1	$\geq 10^{-6}$ to $< 10^{-5}$	100,000 demands

The SIL Level for the entire safety system (SIS) is the sum of the PFD values for the individual components. The following picture is that of a system of this kind comprising a sensor, safety control system and an actuator.

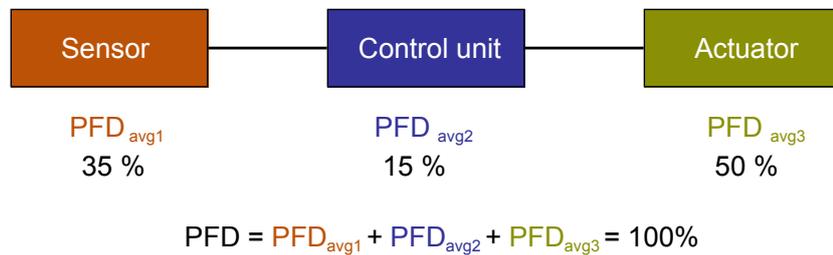


Fig. 2: PFD division

### 1.5.3 Architectural limitations (SFF, HFT)

The following table shows the maximum level of safety integrity that can be reached; this is the sum of SFF and HFT depending on the unit type of the components used. The SFF is calculated according to IEC 61508.

#### Type A – simple operating equipment

Safe Failure Fraction SFF	HFT (Hardware Failure Tolerance)		
	0	1	2
< 60 %	SIL 1	SIL 2	SIL 3
60 % ... < 90 %	SIL 2	SIL 3	SIL 4
90 % to < 99%	SIL 3	SIL 4	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

#### Type B – complex operating equipment

Safe Failure Fraction SFF	HFT (Hardware Failure Tolerance)		
	0	1	2
< 60 %	not allowed	SIL 1	SIL 2
60 % ... < 90 %	SIL 1	SIL 2	SIL 3
90 % to < 99%	SIL 2	SIL 3	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

## 2 Safety of Machinery (ISO 13849)

### 2.1 Scope and standards



#### NOTICE

##### Safety instructions

This Safety Manual should only be used in conjunction with the operating instructions of the respective unit. Pay attention to the safety instructions in the operating instructions.

This Safety Manual applies for the differential pressure transmitter of the series DE45 with the analogue outputs 0/4...20 mA und 0...10 in a 3-conductor circuit and two switch outputs. The corresponds to the following product number key.

- DE45 ##00###K####

The DE45 underwent a function test by an independent institute (Risknology®) to check its functional safety. The safety-specific coefficients were determined using a part analysis (FMEDA) and the following calculations. The results were recorded in the Report 930.436.1 Version 1/2018-10-31 version.

The transducers have been developed and tested in line with the following standards.

Safety of Machinery	<b>EN ISO 13849-1:2015</b> Safety of machinery - Safety-related parts of control systems - Part 1: General design principles
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### 2.2 Description of the Device and Field of Application

#### 2.2.1 Safety function

The differential pressure transmitter sends the input signal (pressure) to a standardised analogue 0/4...20 mA and/or 0... 10 V output signal. There are also two or four switch outputs that can be programmed for the over-pressure or under-pressure display.

PL d (Cat3) can be reached if the assembly and installation information is observed.

#### 2.2.2 Definition of a safe state

Output signal	Safe state
0...20 mA	$0.00 \text{ mA} \leq I_{\text{out}} \leq 20.1 \text{ mA}$
4...20 mA	$3.92 \text{ mA} \leq I_{\text{out}} \leq 20.08 \text{ mA}$
0...10 V	$0.00 \text{ V} \leq U_{\text{out}} \leq 10.05 \text{ V}$
Switching outputs	OFF

#### 2.2.3 Parameters



#### ⚠ WARNING

##### Parameter change

The device is configured in the factory before delivery. Only the operator of the system or personnel he names and briefs may carry out the configuration work.

The unit configuration is protected by a password before delivery. This password is handed over on delivery and must be changed by the operator during commissioning. There is more information about the password in the operating instruction of the respective unit.

There are two ways to complete the configuration.<sup>(2)</sup>

- Using the unit's keyboard
- Remote configuration using the transmitter PC interface

The following transmission errors are possible during remote configuration. Therefore, it is essential to verify all parameters and the safety function on the unit after transfer.

## 2.3 Notes on Planning

### 2.3.1 Intended use

The unit underwent a function test by an independent institute (Riskknowlogy®) to check its functional safety in compliance with ISO 13849-1. The results were recorded in the Report 930.436.1 Version 1/2018-10-31 version.

- **ISO 13849-1**

The unit may be used in exhaust gas monitoring systems to monitor the exhaust air flow. Performance level d, category 3 is reached with the redundant measurement and a cross-comparison in a downstream safety control system.

### 2.3.2 Operating mode

The unit is used with a high demand rate operating mode. The demand rate is once a year.

### 2.3.3 Inspection intervals

Conduct a proof test after commissioning and then after 5 years at the latest.

### 2.3.4 Lifetime

The lifetime starting from the production date is 20 years.

If the lifetime is exceeded, the error rates can gradually increase due to wear and aging.

### 2.3.5 Assembly and installation

Please also observe the assembly instructions in the operating instructions.

The effective pressure inputs of both differential pressure transmitters need to be switched so that both transmitters measure the same input pressure. The outputs of both transmitters need to be connected to a downstream safety control unit so that transmitter malfunctions can be recognised in a cross-comparison.

**NOTICE! Please note that the downstream safety control system (SRP/CS) must compare the signals by the downstream safety control system. In case of a deviation, the safe state needs to be adopted.**

The connection scheme applies equally for switch outputs and also analogue outputs. If both output types are used at the same time for the safety function, the safety control unit must be installed twice, i.e. for the switch output and also for the analogue output, according to the following illustrated connection diagram.

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<sup>(2)</sup> Please see the information in the operating instructions.

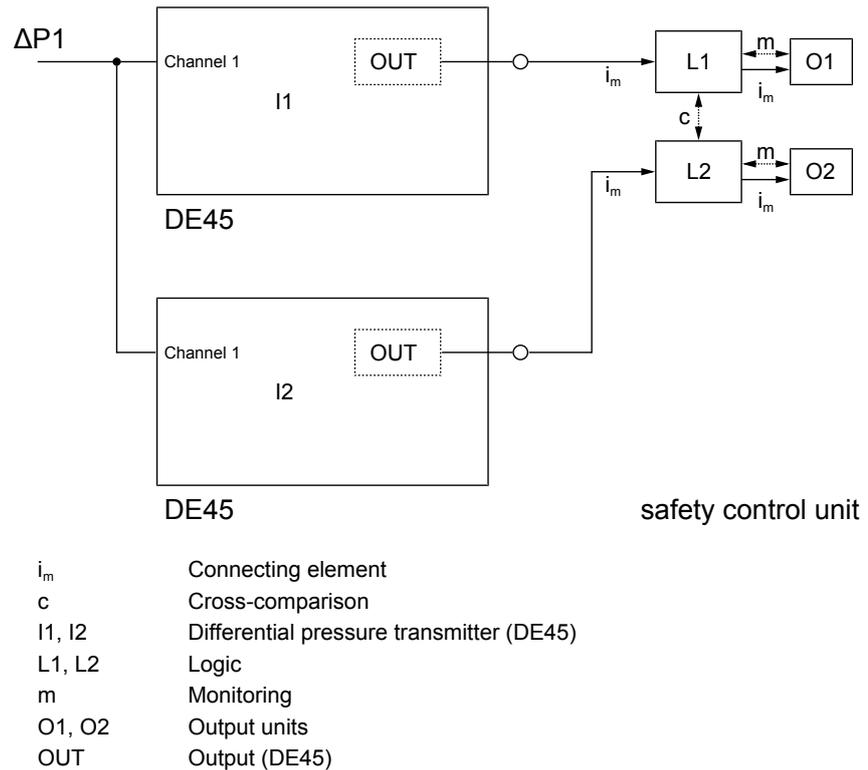


Fig. 3: Wiring diagram

## 2.4 Repeat tests

### 2.4.1 Maintenance

Proof tests are an integral part of the safety concept to detect dangerous failures. The proof test checks the following aspects of a safety-critical component:

- Functionality
- do the components satisfy the prevailing application conditions
- are the interfaces to other components OK

All critical parts need to be tested with the proof test. Spot checks are sufficient for parts that are not critical for safety.

### 2.4.2 Function test

**NOTICE! The EMC and environmental conditions must correspond to the tested level of the EMC Directive 2014/30/EU.**

The operator is responsible for defining the proof test procedure for the entire safety system.

The following function test must be carried out on the safety component DE45.

1. Check the function of the input values within the measuring range.
2. Check the switch points

The test pressure should be generated independently with the safety system (SIS), if this is possible. In this case steps could be taken at the same time to check whether the signals from the overriding safety control system are processed correctly and forwarded via the actuator.

Otherwise, the DE45 needs to be removed and wired as follows. The terminal numbers for the version with four switch outputs are stated in the operating instructions.

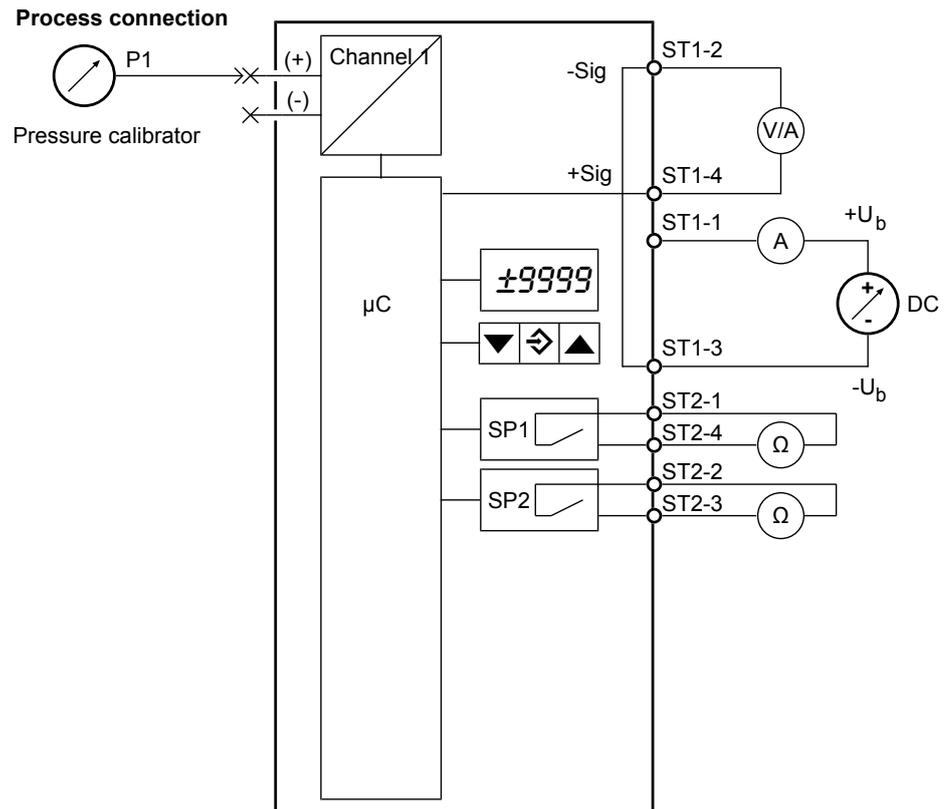


Fig. 4: Function test

### Test equipment list

Test equipment	Usage	Resolution
Pressure calibrator (±1 bar)	Input signal	0.1% of final value
Multimeter	Absorbed current	1 mA
Multimeter	Output signal	1 µA (10 mV)
Continuity tester	Switch output 1 and 2	
Power supply	Can be set between 12 ... 32 V DC	0.1 V

### Input values within the measuring range

- Set an operating voltage of  $24V \pm 0.1V$ .
- Use the pressure calibrator to set an input signal that corresponds to the start of the measuring range.
- Check the output signal. Depending on the version, the output must supply one of the following signals:
  - 0 mA  $\pm 0.10$  mA for output signal 0 ... 20 mA
  - 4 mA  $\pm 0.08$  mA for output signal 4 ... 20 mA
  - 0 V  $\pm 0.05$  V for output signal 0 ... 10 V
- Use the pressure calibrator to set an input signal that corresponds to the end of the measuring range.
- Check the output signal. Depending on the version, the output must supply one of the following signals:
  - 20 mA  $\pm 0.10$  mA for output signal 0 ... 20 mA
  - 20 mA  $\pm 0.08$  mA for output signal 4 ... 20 mA
  - 10 V  $\pm 0.05$  V for output signal 0 ... 10 V
- Check the absorbed current. The absorbed current may not exceed a value of 125 mA.

### Input values outside the measuring range

1. Use the pressure calibrator to set an input signal that lies well below the start of the measuring range.
2. Check the output signal. Depending on the version, the output must supply one of the following signals:  
0 mA +0.10 mA for output signal 0 ... 20 mA  
< 4 mA -0.08 mA for output signal 4 ... 20 mA  
0 V +0.05 V for output signal 0 ... 10 V
3. Use the pressure calibrator to set an input signal that lies well above the start of the measuring range.
4. Check the output signal. Depending on the version, the output must supply one of the following signals:  
> 20 mA -0.10 mA for output signal 0 ... 20 mA  
> 20 mA -0.08 mA for output signal 4 ... 20 mA  
> 10 V -0.05 V for output signal 0 ... 10 V

### Check the switch points

1. Set the pressure calibrator to the first switch point and use the continuity tester to check whether the switch output has changed its state.
2. Repeat this process with the following switch point.

#### 2.4.3 Repair work

Only the manufacturer may repair units.

All defective or faulty devices should be sent directly to our repair department. Please coordinate all shipments with our sales department.



### **WARNING**

#### Process media residues

Process media residues in and on dismantled devices can be a hazard to people, animals and the environment. Take adequate preventive measures. If required, the devices must be cleaned thoroughly.

Return the device in the original packaging or a suitable transport container.

## 2.5 Safety-relevant variables

### 2.5.1 Safety coefficients

<b>HFT = 0 (1-channel system)</b>			<b>ISO Level</b>
Mean operating duration up to failure	<b>MTTF<sub>D</sub></b>	329 years	high
Diagnostic coverage	<b>DC<sub>AVG</sub></b>	48.6%	none
Achievable performance level	<b>PL</b>	c Cat 1	
<b>Failure rates</b>		<b>FIT</b>	
Non-dangerous faults	$\lambda_S$	109	
Dangerous failures	$\lambda_D$	304	
Detectable dangerous faults	$\lambda_{dd}$	148	
Non-detectable dangerous faults	$\lambda_{du}$	156	

<b>HFT = 1 (redundant system)</b>			<b>ISO Level</b>
Mean operating duration up to failure	<b>MTTF<sub>D</sub></b>	395 years	high
Diagnostic coverage	<b>DC<sub>AVG</sub></b>	70%	low
Achievable performance level	<b>PL</b>	d Cat 3	
<b>Failure rates</b>		<b>FIT</b>	
Non-dangerous faults	$\lambda_S$	122	
Dangerous failures	$\lambda_D$	253	
Detectable dangerous faults	$\lambda_{dd}$	176	
Non-detectable dangerous faults	$\lambda_{du}$	77	

Note: The failure rates of HFT=1 are based on the assumption that the machine control system carries out a diagnosis by comparing the signal.

## 3 Attachments

### 3.1 Glossary

Fig. (↓<sup>A</sup>/<sub>Z</sub>)

	Definition
<b>DC</b>	<p><b>Diagnostic Coverage Factor</b></p> <p>The DC parameter shows the ratio of the number of detected dangerous failures (<math>\lambda_{DD}</math>) to the total number of dangerous failures (<math>\lambda_D</math>) an.</p> $DC = \frac{\sum \text{erkannter gefährlicher Fehler}}{\sum \text{gesamter gefährlicher Fehler}} = \frac{\sum \lambda_{DD}}{\sum \lambda_D}$
<b>FIT</b>	<p><b>Failure in Time</b></p> <p>Failure rate with respect to the time interval <math>10^9</math> hours.</p> $1 \text{ FIT} = 1 \times 10^{-9} \frac{1}{h}$
<b>FMEDA</b>	<p><b>Failure Mode Effect and Diagnostic Analysis</b></p> <p>Procedure to determine causes of failures and their impact on the system</p>
<b>HDM</b>	<p><b>High Demand Mode</b></p> <p>Operating mode with high or continuous demand on the safety function. The demand rate to the safety system is greater than once a year or greater than twice the frequency of the repeat test.</p>
<b>HFT</b>	<p><b>Hardware Fault Tolerance</b></p> <p>The hardware fault tolerance states how many dangerous failures are possible due to the architecture without endangering the execution of the safety function.</p> <ul style="list-style-type: none"> <li>• HFT = 0 The occurrence of a dangerous failure will lead to a failure of the safety function.</li> <li>• HFT = 1 Only the occurrence of two dangerous failures will lead to a failure of the safety function.</li> </ul>
<b>LDM</b>	<p><b>Low Demand Mode</b></p> <p>The safety function will only be carried out on demand to bring the system into a defined safe state. The demand rate is less than once a year and less than twice the frequency of the repeat test.</p>

<b>MooN</b>	<p><b>Architecture with M out of N channels</b></p> <hr/> <p>System architecture MooN with the variables M and N:  Classification and description of safety-related systems with regard to redundancy and applied selection procedures.</p> <ul style="list-style-type: none"> <li>• N - is the total number of redundant channels of a safety-related architecture and/or safety circuit.</li> <li>• M - determines the number of channels that must operate correctly to carry out the safety function.</li> </ul>
<b>MTBF</b>	<p><b>Mean Time Between Failures</b></p> <hr/> <p>Mean operating duration between two failures.</p>
<b>MTTF<sub>d</sub></b>	<p><b>Mean Time To Dangerous Failures</b></p> <hr/> <p>Operating duration up to a dangerous fault.</p>
<b>MRT</b>	<p><b>Mean Repair Time</b></p> <hr/> <p>Average time for the repair.</p>
<b>MTTR</b>	<p><b>Mean Time To Repair</b></p> <hr/> <p>Average time between the occurrence of a failure and restoration of the system.</p>
<b>PFD</b>	<p><b>Probability of Failure on Demand</b></p> <hr/> <p>Probability of a dangerous failure on demand of the safety function for an operating mode with a low demand rate.</p>
<b>PFH</b>	<p><b>Probability of a dangerous Failure per Hour</b></p> <hr/> <p>Frequency of a dangerous failure of the safety function for an operating mode with a high or continuous demand rate (high demand).</p>
<b>PFS</b>	<p><b>Probability of Failure Spurious</b></p> <hr/> <p>Frequency of failure due to a false alarm that leads to an unintentional process shutdown by the safety system. The smaller the value, the higher the system availability.</p>
<b>SFF</b>	<p><b>Safe Failure Fraction</b></p> <hr/> <p>This is the result of the rate of safe failures plus the diagnosed and/or detected failures as a ratio to the total system failure rate.</p>
<b>SIF</b>	<p><b>Safety Instrumented Function</b></p> <hr/> <p>The safety function (SIF) is a protective measure that is only activated in the event of an incident to prevent injuries, damage and pollution.</p>

<b>SIL</b>	<p><b>Safety Integrity Level</b></p> <p>One of four discrete levels to assess the requirements relating to the reliability of the safety functions in safety systems. SIL 4 is the highest and SIL 1 the lowest safety integrity level. Each level corresponds to a probability range for the failure of a safety function.</p>
<b>SIS</b>	<p><b>Safety Instrumented System</b></p> <p>Safety system for performance of one or several safety functions. A system of this kind comprises at least a sensor, an overriding safety control system and an actuator.</p>
<b>T<sub>1</sub></b>	<p><b>Proof Test Interval</b></p> <p>The safety system must always be in a state that guarantees the defined safety integrity. The proof test is carried out to confirm this. The test interval states the intervals in which a proof test needs to be carried out to guarantee the safety function.</p>

**3.2 Failure rates**

The error rates differ in principle as follows:

- Safe failures
- Dangerous failures

These failure types are then further divided into detectable and undetectable failures.

The safe failures, be they detectable or undetectable, do not impact on the safety function. In contracts, dangerous failures put the system into a dangerous state. The following diagram provides an overview.

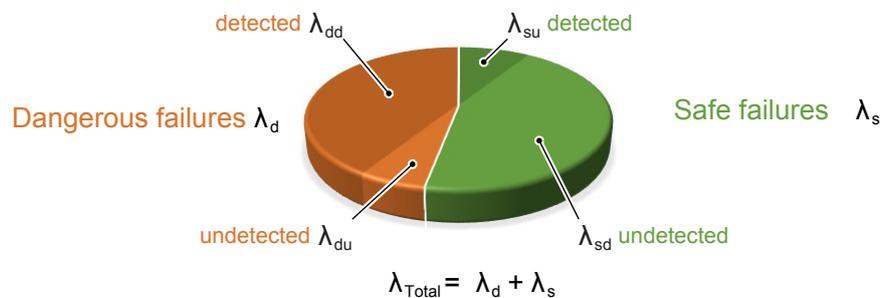


Fig. 5: Failure rates

$\lambda_d$	<b>Dangerous failure rate</b>
$\lambda_{dd}$	<b>Dangerous detected failure rate</b>
$\lambda_{du}$	<b>Dangerous undetected failure rate</b>
$\lambda_s$	<b>Safe failure rate</b>
$\lambda_{sd}$	<b>Safe detected failure rate</b>
$\lambda_{su}$	<b>Safe undetected failure rate</b>

Type A	<b>3.3 Unit types</b> <b>Simple operating equipment</b>
	<p>Type A units are 'simple' units for which the failure behaviour of all parts used and the behaviour under failure conditions is completely known.</p> <p>This includes e.g. relays, resistors and transistors, however no complex electronic parts, e.g. microcontrollers.</p>
Type B	<b>Complex operating equipment</b>
	<p>Type B units are 'complex' units for which the failure behaviour of all parts used and the behaviour under failure conditions is not completely known.</p> <p>These units contain electronic parts such as microcontrollers, microprocessors or ASICs. In these parts and, in particular for software-controlled functions, it is difficult to fully determine all failures.</p>

### 3.4 Pictogram explanation



#### **DANGER**

##### Type and source of danger

This indicates a **direct** dangerous situation that could lead to death or **serious injury** (highest danger level).

- a) Avoid danger by observing the valid safety regulations.



#### **WARNING**

##### Type and source of danger

This indicates a **potentially** dangerous situation that could lead to death or **serious injury** (medium danger level).

- a) Avoid danger by observing the valid safety regulations.



#### **CAUTION**

##### Type and source of danger

This indicates a **potentially** dangerous situation that could lead to slight or serious injury, damage or **environmental pollution** (low danger level).

- a) Avoid danger by observing the valid safety regulations.



#### **NOTICE**

##### Note / advice

This indicates useful information of advice for efficient and smooth operation.

### 3.5 Address



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