azbil

CM2-ATT082-2003

Advanced Temperature Transmitter with HART protocol Model ATT082

Functional Safety Manual

Azbil Corporation

NOTICE

While the information in this manual is presented in good faith and believed to be accurate, Azbil Corporation disclaims any implied warranty of merchantability or fitness for a particular purpose and makes no express warranty except as may be stated in its written agreement with and for its customer.

In no event shall Azbil Corporation be liable to anyone for any indirect, special or consequential damages. This information and specifications in this document are subject to change without notice.

Safety

Precautions for Use

For safe use of the product, the following symbols are used in this manual.

⚠WARNING	Warnings are indicated when mishandling the product might result in the death or serious injury of the user.
⚠CAUTION	Cautions are indicated when mishandling the product might result in minor injury to the user or damage to property.

■ In describing the product, this manual uses the icons and conventions listed below.

Use caution when handling the product.

The indicated action is prohibited.

Be sure to follow the indicated instructions.

Handling Precautions:

Handling Precautions indicate items that the user should pay attention to when handling the ATT.

To use this product correctly and safely, always observe the following precautions.
We are not responsible for damage or injury caused by the use of the product in violation of these precautions.

Handling Precautions for This Product

Installation Precautions

	⚠WARNING
	When installing, use proper fittings and proper tightening torque for connections to the process and to the exhaust. Gas leakage is dangerous because process gas and calibration gas are flammable. Please refer to the leak check instructions in this manual and verify that there is no gas leakage.
	Do not use the product except at the rated pressure, specified connection standards, and rated temperature. Use under other circumstances might cause damage that leads to a serious accident.
	For wiring work in an explosion-proof area, follow the work method stated in the explosion-proof policy.

⚠CAUTION
After installation, do not step or stand on this unit. Doing so may damage the device or cause injury.
Bumping the glass of the display with a tool may cause damage or injury. Be careful.
Install the device correctly. Incorrect or incomplete installation will cause output errors and violation of regulations.
This product is quite heavy. Protect your feet with safety shoes when working.
Do not subject the product to shock or impact.

Wiring Precautions

⚠WARNING
Do not do wiring work with wet hands or while electricity is being supplied to the product. There is a danger of electric shock. When working, keep hands dry or wear gloves, and turn off the power.

⚠CAUTION
When wiring, check the specifications carefully and make sure to wire correctly. Incorrect wiring can cause device damage or malfunction.
Supply electric power correctly according to the specifications. Supplying power that differs from the specifications can damage the device.
Use a DC power supply that has overload protection.

Maintenance Precautions

⚠WARNING
When removing this device for maintenance, be careful of residual pressure or residual process gas. Leakage of process gas is dangerous.
When working on the vent, check its direction so that people do not come into contact with vented gas. There is a danger of burns or other physical harm.
When the device is being used in an explosion-proof area, do not open the cover. Opening the cover may cause an explosion.

⚠CAUTION
This product was kept under carefully controlled conditions until it was shipped. Never try to modify this device. Doing so could damage it.

Certificate

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 14 06 12833 002

Holder of Certificate: **Endress + Hauser Wetzer GmbH + Co. KG**
Obere Wank 1
87484 Nesselwang
GERMANY

Factory(ies): 12833

Certification Mark:

Product: **Temperature measuring equipment**

Model(s):
Temperature Transmitter
TMT82 - xx A x x xx xx xx xx - xx xx xx LA xx xx xx xx xx xx
For nomenclature see attachment

Parameters:

Software:	SIL3
Structure-SIL:	1oo1 - SIL2
Power supply:	11 ... 32V
Output:	4 ... 20mA
Leakage Current:	<=3.6mA or >=21.0mA
Class of Protection:	IP20
Temperature range:	-40 ... +70°C

Tested according to:
IEC 61508-1:2010
IEC 61508-2:2010
IEC 61508-3:2010
IEC 61508-4:2010

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. See also notes overleaf.

Test report no.: EN85473T

Date, 2014-07-10

(Günter Greil)

584207

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TÜV SÜD Product Service GmbH · Zertifizierstelle · Ridlerstraße 65 · 80339 München · Germany

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Chapter 1. SIL key figures

General			
Safety-related output signal	4...20mA		
Fault current	3.58 mA		
Process variable/function	Temperature, voltage, resistance		
Safety function(s)	min., max., range		
Device type acc. to IEC 61508-2	☐ Type A	☑ Type B	
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Valid Hardware-Version	Head transmitter: 01.00.06 or higher DIN Rail transmitter: 01.00.04 or higher		
Valid Software-Version	01.01.08 or higher (Dev.Rev.:2 or higher)		
Type of evaluation (check only <u>one</u> box)	☑	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of "Proven-in-use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of HW/SW field data to verify "prior use" acc. to IEC 61511	
	☐	Evaluation by FMEDA acc. to IEC61508-2 for devices w/o software	
Evaluation through	TÜV SÜD Product Service GmbH, Germany		
Test documents	development documents, test reports, data sheets		

SIL - Integrity			
Systematic safety integrity		☐ SIL 2 capable	☑ SIL 3 capable
Hardware safety integrity	Single channel use (HFT = 0)	☑ SIL 2 capable	☐ SIL 3 capable
	Multi-channel use (HFT ≥ 1)	☐ SIL 2 capable	☑ SIL 3 capable

FMEDA	
Safety function	min., max., range
λ_{DU} [1)]	40 FIT
λ_{DD} [1)]	258 FIT
λ_{SU} [1)]	129 FIT
λ_{SD} [1)]	4 FIT
SFF - Safe Failure Fraction	91%
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$1.75 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$8.76 \cdot 10^{-4}$
PFH	$4.0 \cdot 10^{-8} \cdot 1/h$
PTC [3)]	96%
MTBF [4)]	71 years
Diagnostic test interval [5)]	32 min
Fault reaction time [6)]	< 10.7 s
Process safety time [7)]	53 h

Declaration	
☑	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future

1) FIT = Failure In Time, Number of failures per 10^9 h
2) Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied
3) PTC = Proof Test Coverage
4) MTBF (Mean time between failures) is the predicted elapsed time between inherent failures of a system during operation in accordance to Siemens SN29500
5) All diagnostic functions are performed at least once within the Diagnostic test interval
6) Maximum time between error recognition and error response
7) The Process safety time is: Diagnostic test interval x 100 (calculated acc. to IEC 61508)

Useful lifetime of electrical components:
The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

Chapter 2. Permitted devices types

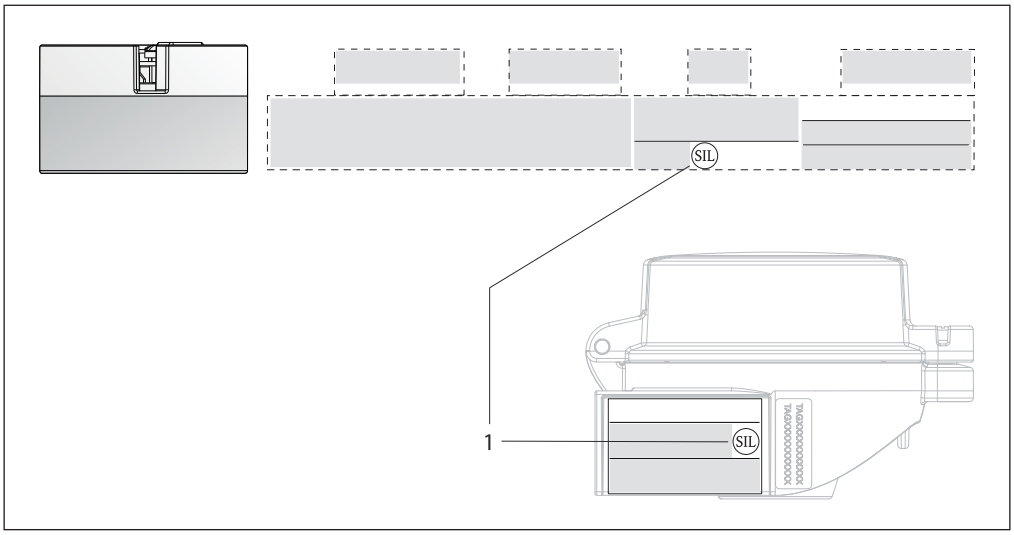
The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified firmware and hardware versions. Unless otherwise specified, all subsequent versions can also be used for safety instrumented systems.

A modification process according to IEC 61508 is applied for any device modifications. Valid device versions for safety-related use:

Feature	Designation	Version
010	Approval	All
...	...	...
590	Additional approval	LA
...	...	...

Order code:

ATT082 x x x x x x x x + x x x x **LA** x x x x x A0026614 The full order code is saved electronically in the device. It is shortened on the nameplate due to space limitations.	Valid firmware version	as of 01.01.07
	Valid hardware version (electronics)	as of 01.00.06
	Valid device drivers	DTM as of version 1.0.2.1 DD as of revision 03



1 SIL symbol

Note: SIL certified devices are marked with the SIL symbol on the nameplate.

Chapter 3. Safety functions

3-1. Definition of the safety function

Permitted safety functions of the device are:

- Limit value monitoring
- Safe measurement

3-1-1. Safety-related output signal

The safety-related signal of the device is the analog output signal 4 to 20 mA according to the NAMUR NE43. All safety precautions refer to this signal exclusively.

The safety-related output signal will be relayed to a downstream logic unit (e.g. PLC, limit signal switch) where it is monitored on:

- ascertain whether it exceeds or drops below predefined limit value.
- occuring an error, e. g. error current (≤ 3.6 mA, ≥ 21 mA, cable open circuit or short circuit of the signal wires).

Note: In the SIL mode the transmitter cannot be configured for inverse value display at the current output.

3-1-2. Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this functional safety manual but is still in the range of 4 to 20 mA, is considered a dangerous, undetected failure.
(Refer to page 7)

3-1-3. Limit value monitoring

This safety function provides the monitoring of the measured value. In the SIL mode, an error current is output in the event of a measurement outside a user-defined temperature interval (X_{min} …X_{max}). This error current depends on the configuration of the parameter "Out of range category" (F, S, M).

Here for example: I_{min} = -100 °C, I_{max} = 400 °C

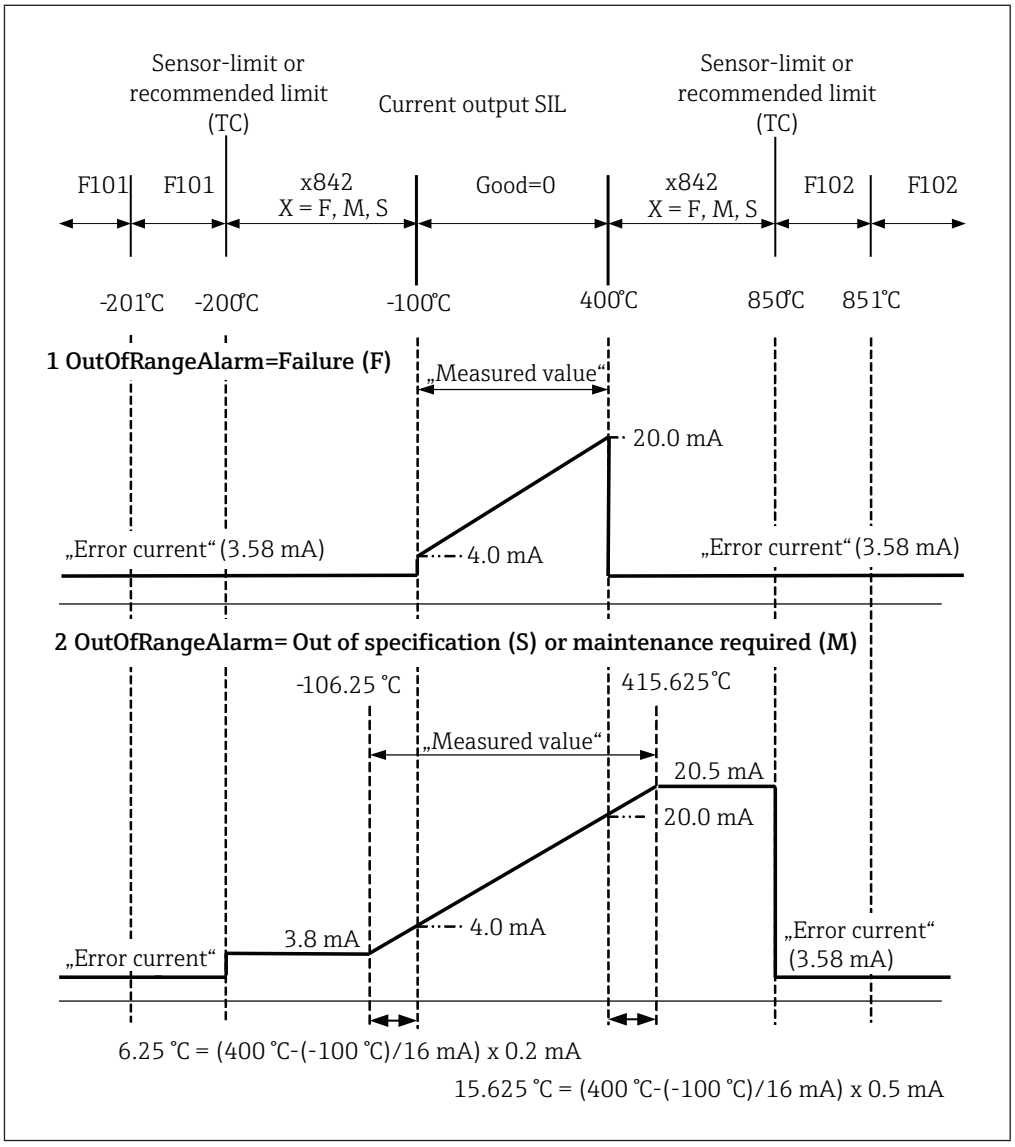


Fig. 2-1.

1 Curve OutOfRangeAlarm = status signal for failure (F)

2 Curve OutOfRangeAlarm = status signal for out of specification (S) or maintenance required (M)

3-1-4. Safe measurement

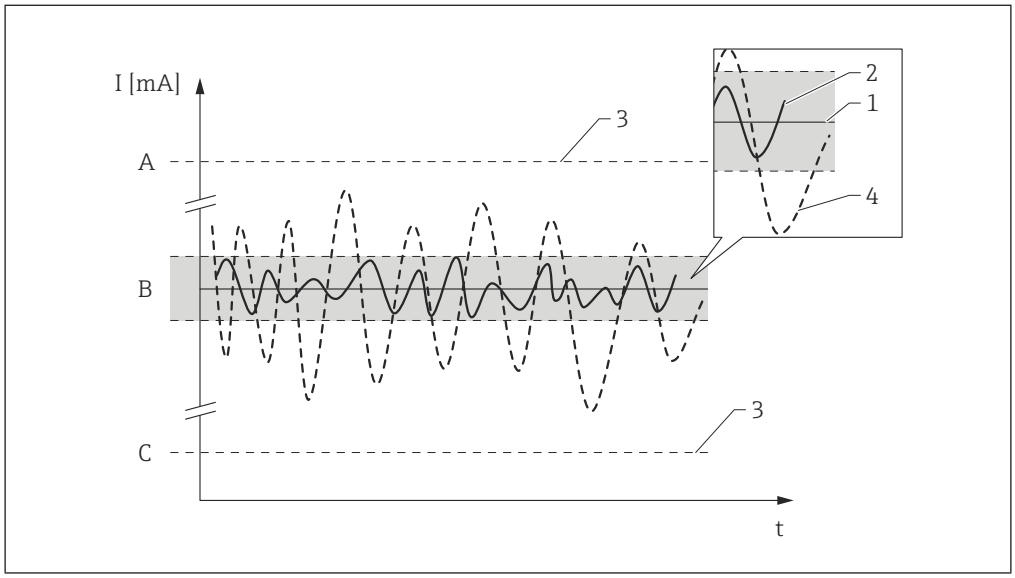
The safety function comprises an transmitted current output signal proportional to the voltage, resistance or temperature value. To be able to use this safety function, the device must be parameterized safely via a operating tool and set to the SIL-mode. (Refer to page 13)

All safety functions can be used in combination with all sensor configurations from the section 'Structure of the measuring system' (Refer to page 30). Only the measured value of one sensor or the output of a function (e. g. the averaging or differential function) can ever be displayed via the current output. A limit value monitoring can be set up for both inputs seperately.

3-2. Restrictions for use in safety-related applications

- Pay attention to a designated use of the measuring system in consideration of the medium properties and the environmental conditions. Carefully follow instructions from the Operating Instructions pertaining to critical process situations and installation conditions. The application-specific limits have to be observed.
- Information to the safety-related signal. (Refer to page 5)
- The technical specifications from the User's manual must not be exceeded.
- The following restrictions also applies to safety-related use:
  The specified error range (safety measured error) is sensor specific and is defined according to FMEDA (Failure Modes, Effects and Diagnostic Analysis) on delivery. It includes all influental factors described in the Technical Information TI (non-linearity, nonrepeatability, hysteresis, zero drift, temperature drift, EMC influences). According to IEC / EN 61508 the safety related failures are classified into different categories, see the following table. The table shows the implications for the safety related output signal and the measuring uncertainty.

Safety related error	Description	Implications for the safety related output signal (position, see following figure)
No device error	Safe: No error	1 Is within the specification
λ_{SD}	Safe detected: Safe failure which can be detected	3 The output signals an error (Refer to page 13)
λ_{SU}	Safe undetected: Safe failure which cannot be detected	2 Is within the defined error range (Refer to page 8)
λ_{DD}	Dangerous detected: Dangerous failure which can be detected (Diagnostic within the device)	3 The output signals an error (Refer to page 13)
λ_{DU}	Dangerous undetected: Dangerous failure which cannot be detected	4 May be outside the defined error range (Refer to page 13)



A High-alarm ≥ 21 mA
B Error range (Refer to page 18)
C Low-alarm ≤ 3.6 mA

3-3. Safety measured error

Thermocouples

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), –40 to +70 °C (–40 to +158 °F)	Measured error (D/A)	Longterm drift in °C/ year or µV/year [1)]
IEC 60584-1	Type A (W5Re-W20Re) (30)	50 K (90 °F)	0 to +2 500 °C (+32 to +4 532 °F)	12 K (21.6 °F)	0.5 % of the span	1.42
	Type B (PtRh30-PtRh6) (31)	50 K (90 °F)	+500 to +1 820 °C (+932 to +3 308 °F)	5.1 K (9.2 °F)		2.01
	Type E (NiCr-CuNi) (34)	50 K (90 °F)	–150 to +1 000 °C –238 to +1 832 °F)	4.9 K (8.8 °F)		0.43
	Type J (Fe-CuNi) (35)	50 K (90 °F)	–150 to +1 200 °C (–238 to +2 192 °F)	4.9 K (8.8 °F)		0.46
	Type K (NiCr-Ni) (36)	50 K (90 °F)	–150 to +1 200 °C (–238 to +2 192 °F)	5.1 K (9.2 °F)		0.56
	Type N (NiCrSi-NiSi) (37)	50 K (90 °F)	–150 to +1 300 °C (–238 to +2 372 °F)	5.5 K (9.9 °F)		0.73
	Type R (PtRh13-Pt) (38)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.58
	Type S (PtRh10-Pt) (39)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.59
	Type T (Cu-CuNi) (40)	50 K (90 °F)	–150 to +400 °C (–238 to +752 °F)	5.2 K (9.4 °F)		0.52

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), –40 to +70 °C (–40 to +158 °F)	Measured error (D/A)	Longterm drift in °C/ year or µV/year [1]
IEC 60584-1; ASTM E988-96	Type C (W5Re-W26Re) (32)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.6 K (13.7 °F)	0.5 % of the span	0.94
ASTM E988-96	Type D (W3Re-W25Re) (33)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.1 K (12.8 °F)		1.14
DIN 43710	Type L (Fe-CuNi) (41)	50 K (90 °F)	–150 to +900 °C (–238 to +1 652 °F)	4.2 K (7.6 °F)		0.42
	Type U (Cu-CuNi) (42)	50 K (90 °F)	–150 to +600 °C (–238 to +1 112 °F)	5.0 K (9 °F)		0.52
GOST R8.8585-2001	Type L (NiCr-CuNi)(43)		–200 to +800 °C (–328 to +1 472 °F)	8.4 K (15.1 °F)		0.53
Voltage transmitter (mV)		5 mV	–20 to 100 mV	200 µV		27.39

1) Values at 25 °C, values may need to be extrapolated to other temperatures.

RTD sensors

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), –40 to +70 °C (–40 to +158 °F)	Measured error (D/A)	Long-term drift in °C/ year or Ω/ year [1]
IEC 60751:2008	Pt100 (1)	10 K (18 °F)	–200 to +600 °C (–328 to +1 112 °F)	1.1 K (2.0 °F)	0.5 % of the span	0.23
	Pt200 (2)	10 K (18 °F)	–200 to +600 °C (–328 to +1 112 °F)	1.6 K (2.9 °F)		0.92
	Pt500 (3)	10 K (18 °F)	–200 to +500 °C (–328 to +932 °F)	0.9 K (1.6 °F)		0.38
	Pt1000 (4)	10 K (18 °F)	–200 to +250 °C (–328 to +482 °F)	0.6 K (1.1 °F)		0.19
JIS C1604:1984	Pt100 (5)	10 K (18 °F)	–200 to +510 °C (–328 to +950 °F)	1.0 K (1.8 °F)		0.32
DIN 43760 IPTS-68	Ni100 (6)	10 K (18 °F)	–60 to +250 °C (–76 to +482 °F)	0.4 K (0.7 °F)		0.22
	Ni120 (7)		–60 to +250 °C (–76 to +482 °F)	0.3 K (0.54 °F)		0.18
GOST 6651-94	Pt50 (8)	10 K (18 °F)	–180 to +600 °C (–292 to +1 112 °F)	1.3 K (2.34 °F)		0.61
	Pt100 (9)	10 K (18 °F)	–200 to +600 °C (–328 to +1 112 °F)	1.2 K (2.16 °F)		0.34
OIML R84: 2003, GOST 6651-2009	Cu50 (10)	10 K (18 °F)	–180 to +200 °C (–292 to +392 °F)	0.7 K (1.26 °F)		0.46
	Cu100 (11)	10 K (18 °F)	–180 to +200 °C (–292 to +392 °F)	0.5 K (0.9 °F)		0.23

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), –40 to +70 °C (–40 to +158 °F)	Measured error (D/A)	Long-term drift in °C/year or Ω/year [1]
OIML R84: 2003, GOST 6651-2009	Ni100 (12)	10 K (18 °F)	–60 to +180 °C (–76 to +356 °F)	0.4 K (0.72 °F)	0.5 % of the span	0.21
	Ni120 (13)	10 K (18 °F)	–60 to +180 °C (–76 to +356 °F)	0.3 K (0.54 °F)		0.18
OIML R84: 2003, GOST 6651-94	Cu50 (14)	10 K (18 °F)	–50 to +200 °C (–58 to +392 °F)	0.7 K (1.26 °F)		0.45
Resistance transmitter Ω	400 Ω	10 Ω	10 to 400 Ω	0.5 Ω		0.096
	2 000 Ω	100 Ω	10 to 2 000 Ω	2.1 Ω		0.51

1) Values at 25 °C, values may need to be extrapolated to other temperatures.

For these values no deviations caused by EMC interference are considered. In the event of non-negligible EMC interference, an additional error of 0.5% must be added to the values above.

Validity of information on the safety measured errors:

- Total temperature range of the transmitter in the SIL-mode.
- Defined range of the supply voltage.
- Limited safety measuring range of the sensor element.
- The accuracy already contains all the round-off errors in the software due to linearization and calculations.
- Follow the minimum span for each sensor.
- The values are 2σ values, i.e. 95.4 % of all the measured values are within the specifications.

3-4. Restrictions of the device specifications for the safety operation

- Compliance with the ambient conditions as per IEC 61326-3-2, appendix B is mandatory.
- The permitted voltage range for the SIL-mode: V_{cc} = 11 to 32 V
- The power supply must be short-circuit proof and ensure that the upper error current can still be output at any time.
- It is not permitted to use the transmitter in a radioactive environment (except naturally occurring radioactivity).
- Permitted storage temperature: –50 to +100 °C (–58 to +212 °F)
- Permitted ambient temperature: –40 to +70 °C (–40 to +158 °F)
- Only via HART® communication is for the safe parameterization.
- The mains frequency filter must be set correctly to either 50 Hz or 60 Hz.
- Maximum permitted sensor cable resistance in the event of voltage measurement: 1000 Ω.

Handling Precautions:

HART® communication

▶ The transmitter also communicates via HART® in the SIL mode. This comprises all the HART® features with additional device information. HART® communication is not part of the safety function. Detailed information see appendix, chapter 'Safe HART' (Refer to page 40).

Note: It is advisable to only use shielded power supply cables (see also the associated User's manual).

Chapter 4. Use in protective systems

4-1. Behavior of device during operation and in case of error

4-1-1. Behavior of device during power-up

After power-up, the device runs through a diagnostic phase. The current output is set to the error current (low alarm) during this time.

During the diagnostic phase, no communication is possible via the service interface (CDI) or via HART®.

Behavior of device during power-up depending on device parameterization

'SIL HART mode' parameter	'SIL startup modus' parameter	
	On	**Off**
On	Approx. 30 s start time → SIL measuring mode	Wait to enter SIL checksum
Off	Approx. 120 s start time → SIL measuring mode During this time, it is possible to cancel the SIL mode by entering a SIL checksum = 0.	Wait to enter SIL checksum

4-1-2. Behavior of device during normal operation (SIL measuring mode)

The device outputs a current value which corresponds to the measured value to be monitored. This value must be monitored and processed further in an attached automation system.

4-1-3. Device behavior in safety function demand mode

In the demand mode, the current is ≤ 3.6 mA (low alarm - safe state)

4-1-4. Safe states

Safe state	
Active safe state	Passive safe state
Output error current, ≤ 3.6 mA (= low alarm)	Output error current, ≤ 3.6 mA (= low alarm) System reset is triggered automatically.
In the active safe state it is still possible to communicate with the transmitter via HART® but the current output permanently outputs an error current. This state remains until the transmitter is rebooted. All the parameters can be read and non-safety-related parameters can be modified.	In the passive safe state it is not possible to communicate with the transmitter via HART®. The system stops immediately and reboots after 0.5 seconds at the very latest. The device does not display any more error messages. Parameters can no longer be modified.

The system assumes one of the two states depending on the error detected. The active safe state is the only state in which the system continues working without a restart being triggered automatically.

4-1-5. Behavior of device in event of alarms and warnings

In an alarm condition the output current is ≤ 3.6 mA. In some cases, (e.g. short-circuit in the supply line) output currents ≥ 21 mA occur irrespective of the error current defined. The downstream logic unit must be able to detect high alarms (≥ 21 mA) and low alarms (≤ 3.6 mA) for alarm monitoring.

Alarm and warning messages

The alarm and warning messages output on the device display or in the operating tool in the form of diagnostic events and the associated event text are additional information.

Note: An overview of the diagnostic events can be found in User's manual.

The following diagnostic events, which can be configured in the normal mode, result in the active safe state in the SIL mode and therefore in the error current being output:

- Permitted device ambient temperature exceeded/undershot (diagnostic message F925)
- Sensor corrosion (diagnostics F042)

! Handling Precautions:

When the device switches to the SIL mode, additional diagnostics are activated (e.g. the output current that is read back is compared against the rated value). An error current is output if one of these diagnostics causes an error message (e.g. F041 Sensor failure).

The device must be restarted once the error has been eliminated.

- ▶ For this, briefly disconnect the device from the power supply or
- ▶ Send a command to this effect via HART® or run a comparable function in the operating tool.

When the device is then restarted, a self-check is carried out, and the error message is reset where applicable.

4-2. Parameter configuration for safety-related applications

Configuration of the measuring point

The transmitter is configured using guided safe parameterization with a limited parameter set which is performed with a suitable operating tool.

Safe parameterization

The user interface can differ from the screens shown here depending on the operating tool used and the selected language.

Handling Precautions:

If safe parameterization is performed it must be documented! The 'Commissioning or proof test report' is suitable for documenting this information. A master copy of this document can be found at the end of this manual.

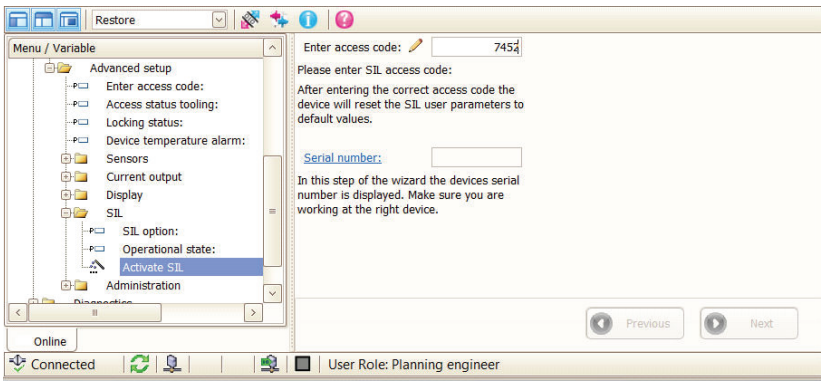
- Enter the configured parameters in the 'Set value' column. The date, time and the SIL checksum of the safe parameterization that is subsequently displayed must be documented. The time stamp entered at the end of safe parameterization can be called via the Timestamp SIL configuration parameter. (Refer to page 34)
- Each parameter, having been transmitted to the device, is read out anew and displayed. Afterwards it is necessary to confirm that the value displayed matches the value entered. The value that is read back also contains the text '#END' at the end. A table with the assignment of the code numbers to the parameters is provided in the Appendix to this Safety Manual. (Refer to page 43)
- Prior to commencing safe parameterization, make sure that the device is not in the Burst mode.

The transmitter outputs an error current ≤ 3.6 mA (low alarm) during the safe parameterization process. If an error occurs during safe parameterization, or if parameter verification returns a negative result, safe parameterization has not been performed successfully and must be repeated.

Safe parameterization: sequence of steps

1. Safe parameterization can only be performed in the online mode. In the submenu Setup → Extended setup → SIL, start safe parameterization Activate SIL.
   The Access code window opens

2.

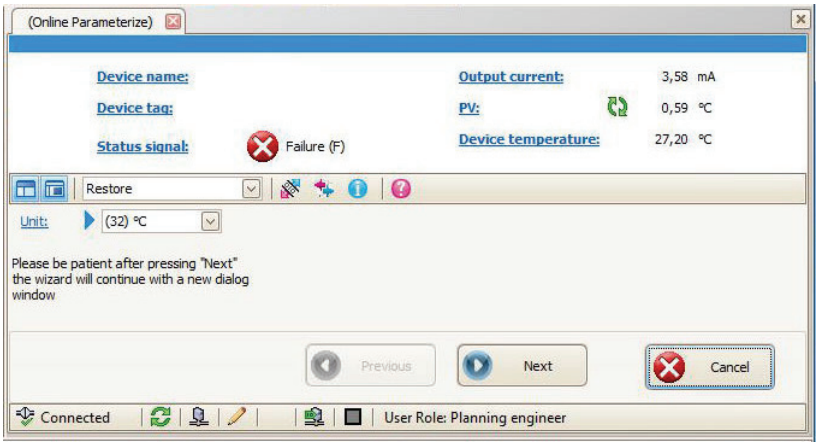


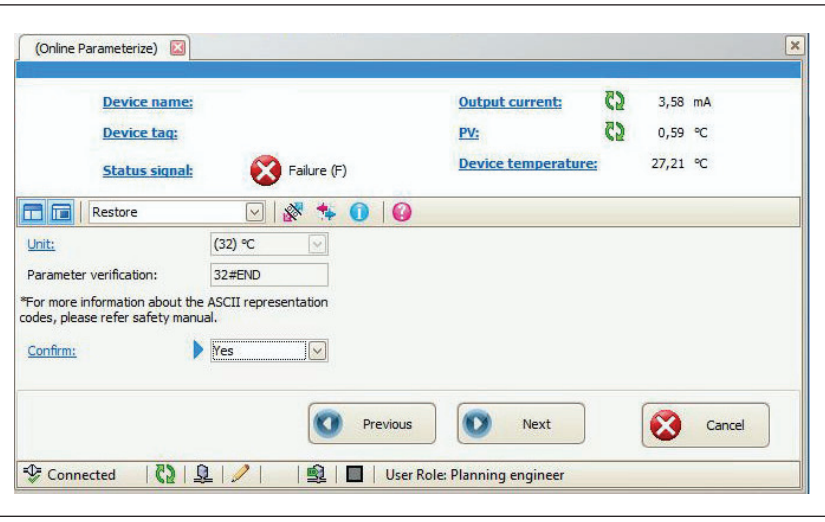
In the Enter access code input window, enter 7452 and press ENTER to confirm. Then press NEXT to continue.

The parameters that are relevant for safety are reset to the factory setting. See the 'Parameters and default settings for safe parameterization' table in the Appendix. (Refer to page 36)

After this, the input windows for device settings open, starting with the unit of the measured variables. The order of how these windows open is fixed.

3.





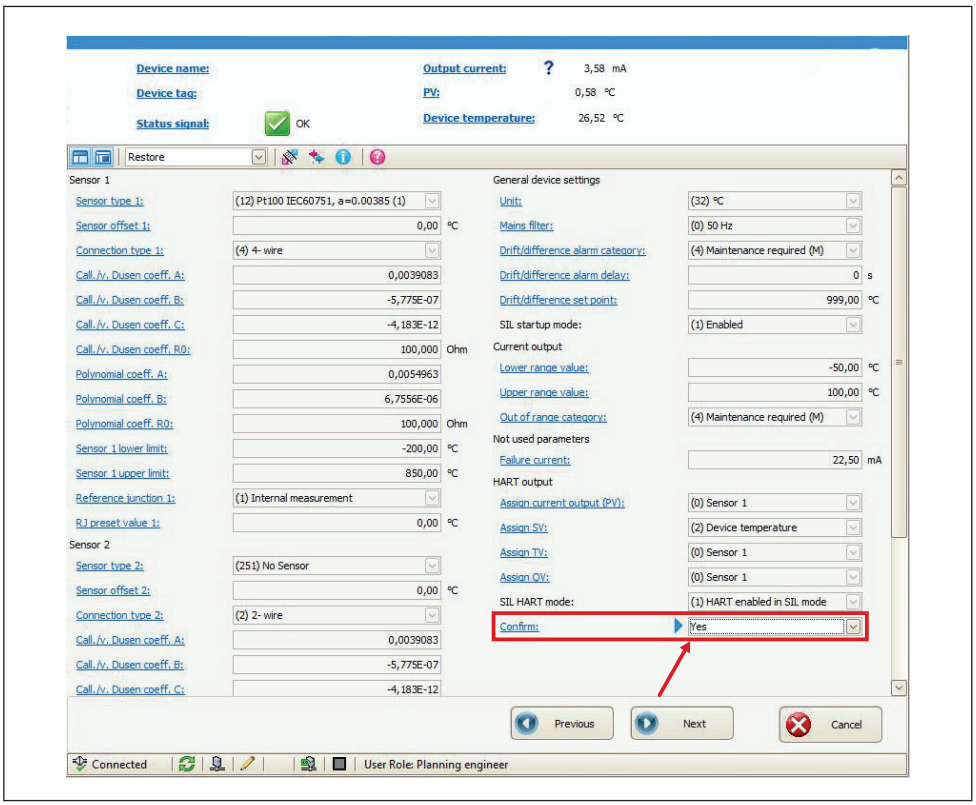
Verify the parameters entered in the subsequent window. If the parameters are correct, select YES for Confirm and press ENTER to confirm. Press 'NEXT' to continue.

Handling Precautions:

- If the Fahrenheit (°F) or Rankine (°R) unit is selected for Callendar/Van Dusen or polynomial copper/nickel sensors, during parameter verification the saved parameter value may deviate by 0.01 °F or °R from the parameter value entered. This deviation can occur with the following parameters: lower measuring range (4 mA), upper measuring range (20 mA), sensor offset, drift/difference mode, upper sensor limit and lower sensor limit.

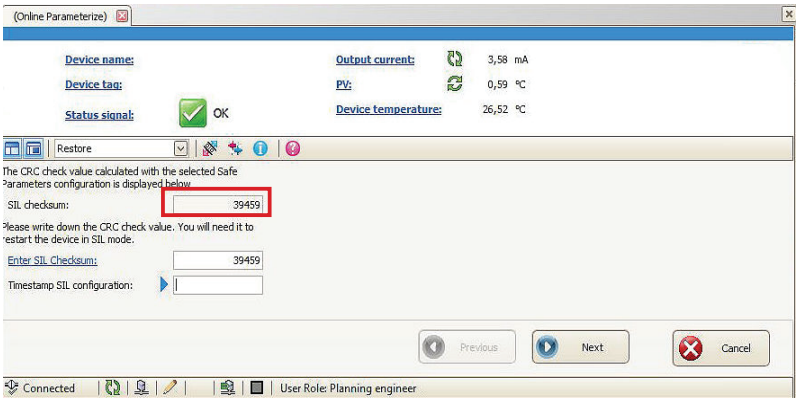
Once all the safety-related parameters have been entered, an overview of all the uneditable default values appears. Following confirmation, all the safety-related parameters that have been entered are displayed so the user can check them once again.

1.



If all the settings are correct select YES for Confirm and press ENTER to confirm. Press 'NEXT' to continue.

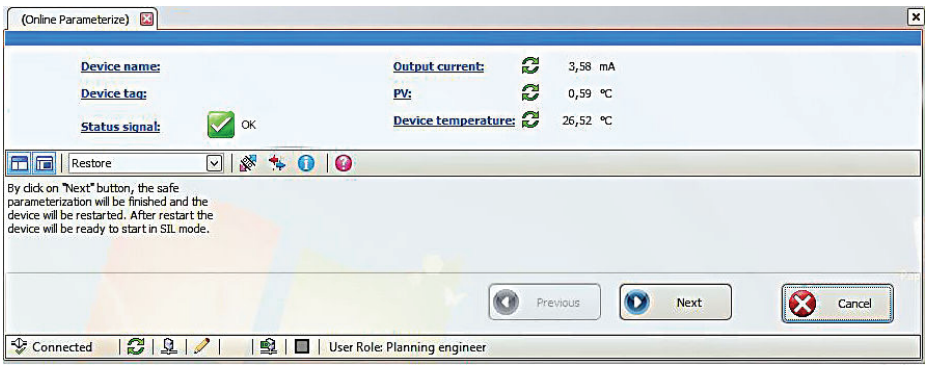
2.



Handling Precautions:

This value displayed for the SIL checksum is needed to activate the SIL mode if the 'SIL startup mode' parameter has been set to DISABLED. Make sure to jot down the value displayed for the SIL checksum in the documentation for this measuring point.

Enter the SIL checksum displayed in the Enter SIL checksum field and fill in the current date and time in the Timestamp SIL configuration field. Press ENTER to confirm your entries. Press 'NEXT' to continue.



Safe parameterization is completed. Once the 'Next' button is pressed, the device automatically restarts in the SIL mode. (Refer to page 13)

Note: Check the operational state of the transmitter (active SIL mode) before use!

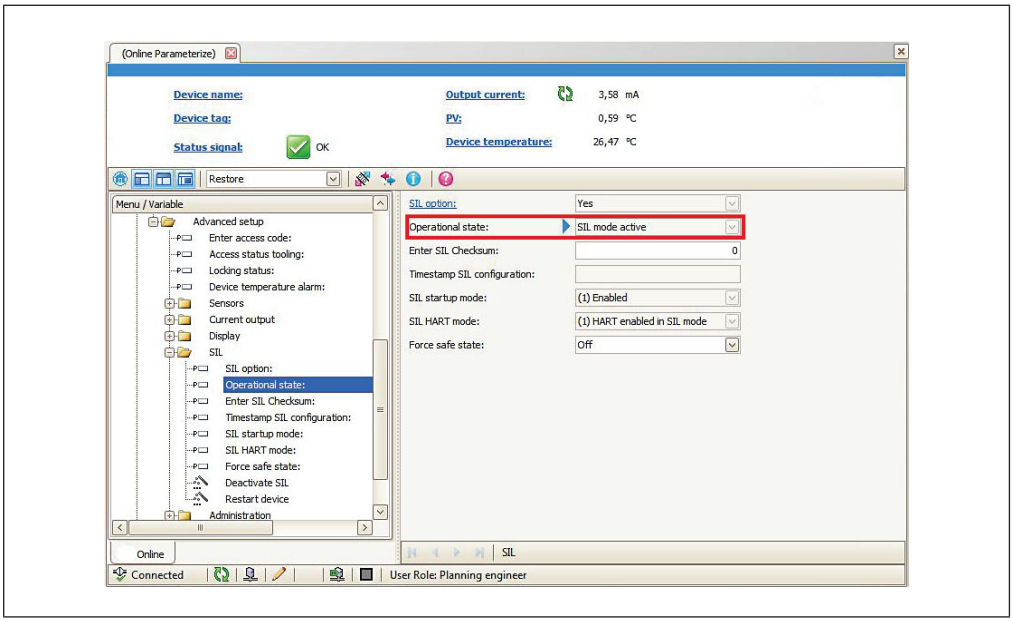


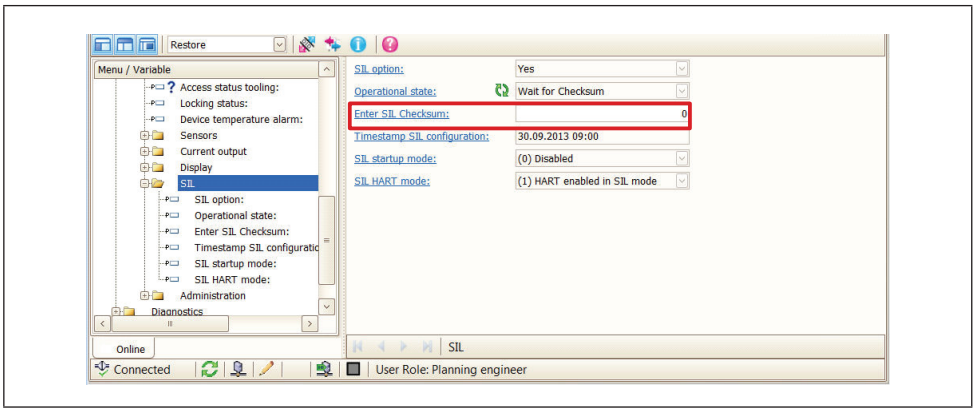
Fig. 3-1. Operational state displayed

Disabling the SIL mode

There are two ways (A or B) to disable the SIL mode. Switch off transmitter hardware write protection where necessary.

Note: The procedure for doing so is described in User's manual.

1.



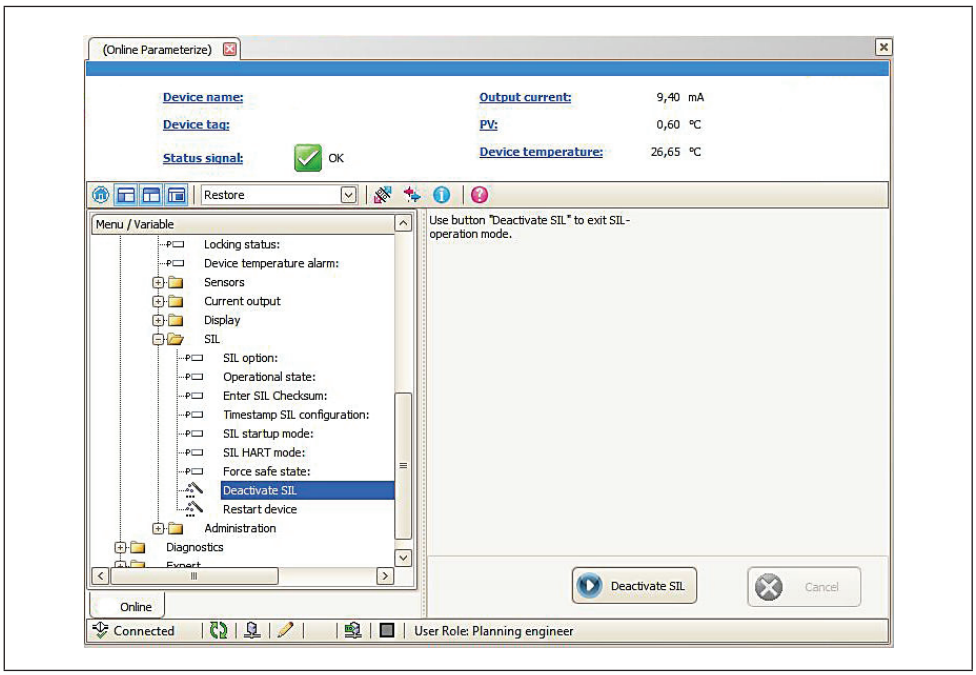
A) Enter the number 0 in the Enter SIL checksum field.

2. Press ENTER to confirm.

3. Restart the device: run the Restart device function or interrupt the supply voltage for the transmitter.

After rebooting, the device is in the unsafe mode (normal mode). To switch back to the SIL mode, on the other hand, the user must start safe parameterization once again. (Refer to page 15)

1.



B) Start the Deactivate SIL function in the submenu: Setup → Extended setup → SIL.

2. Activate the Deactivate SIL field once again.
   After automatic rebooting, the device is in the unsafe mode (normal mode).

Handling Precautions:

When the SIL mode is ended, diagnostics are disabled and the device can no longer perform the safety function. Therefore suitable measures must be taken to ensure that no danger can occur during the time the SIL mode is disabled.

- If HART communication is switched off in the SIL mode, ('SIL HART mode' parameter = disabled), restart the device. In the transmitter startup phase, deactivation methods A and B are available for 90 seconds. (HART is active during this time). To return to the SIL mode, the user must perform safe parameterization once again. (Refer to page 15)

4-3. Commissioning test and proof testing

The functional integrity of the transmitter in the SIL mode must be verified during commissioning and at appropriate intervals.

Handling Precautions:

The safety function is not guaranteed during a commissioning or proof test. Suitable measures must be taken to guarantee process safety during the test.

- The safety-related output signal 4 to 20 mA may not be used for the protective system during the test.
- Any test performed must be documented. The template in the Appendix can be used for this purpose. (Refer to page 32)

4-3-1. Proof testing the safety function

1. Check the functional integrity of the safety function at appropriate intervals.

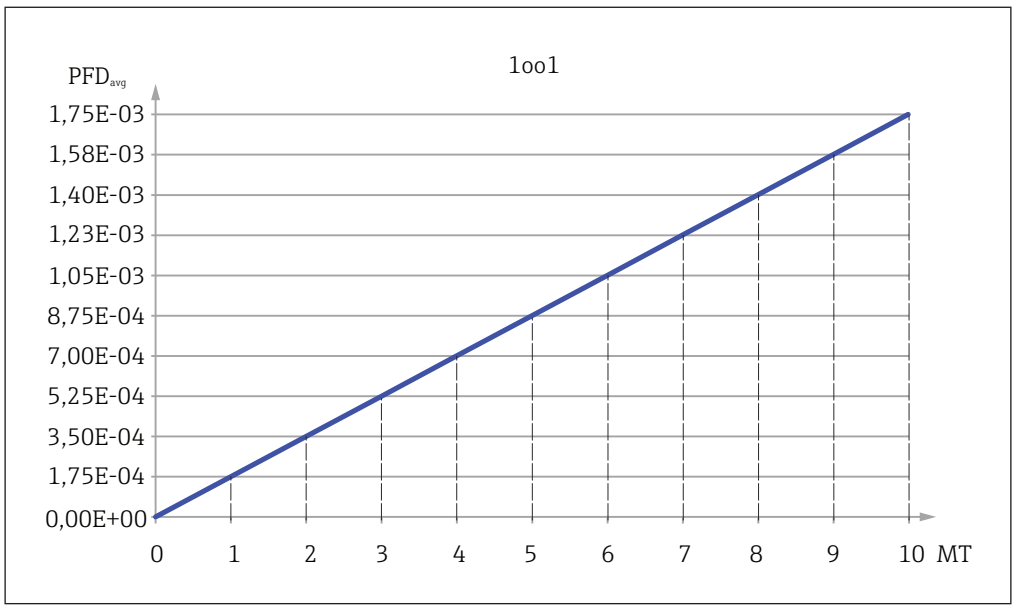
2. The operator specifies the testing interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.
   In the case of a single-channel system architecture, the average probability of failure (PFD_{avg}) of the sensor is derived from the proof-test interval T_i, the failure rate for dangerous undetected failures λ_{du}, the proof test coverage PTC and the assumed mission time by close approximation as follows:
   $PFD_{avg} \approx \lambda_{du} \times (PTC/2 \times T_i + (1 - PTC) / 2 \times MT)$ [1)]

   1) with MT = Mission Time, PTC = Proof Test Coverage and T_i = Test Interval

3. The operator also specifies the procedure for proof-testing.

Handling Precautions:

- According to IEC 61511, an independent proof-test of subsystems - such as the transmitter - is permitted as an alternative to checking the safety function of the entire system.
  Average probability of failure and mission time PFDavg for single-channel system (without performing proof testing).



MT: Mission time in years
PFD_{avg}: Average probability of dangerous failure on demand
1oo1: Single-channel architecture

4-3-2. Transmitter commissioning or proof test

If no operator-specific proof testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

The device can be tested as follows:

- Test sequence A: complete test with HART operation
- Test sequence B: complete test without HART operation (with attachable TID10 display)
- Test sequence C: simplified test with or without HART operation

Handling Precautions:

Note the following for the test sequences:

- The transmitter can be tested without a sensor using an appropriate sensor simulator (resistance decade, reference voltage source, etc.). Changing the connection triggers a sensor error which causes the transmitter to go to the safe state and the transmitter must be restarted.
- The accuracy of the measuring device used must meet the transmitter specifications.
- If both transmitter input channels are used, the test for the second sensor must be repeated accordingly.
- A three-point calibration must be performed when customized linearization (e.g. with CvD coefficients) is used.

Test sequence A

1. Two-point calibration

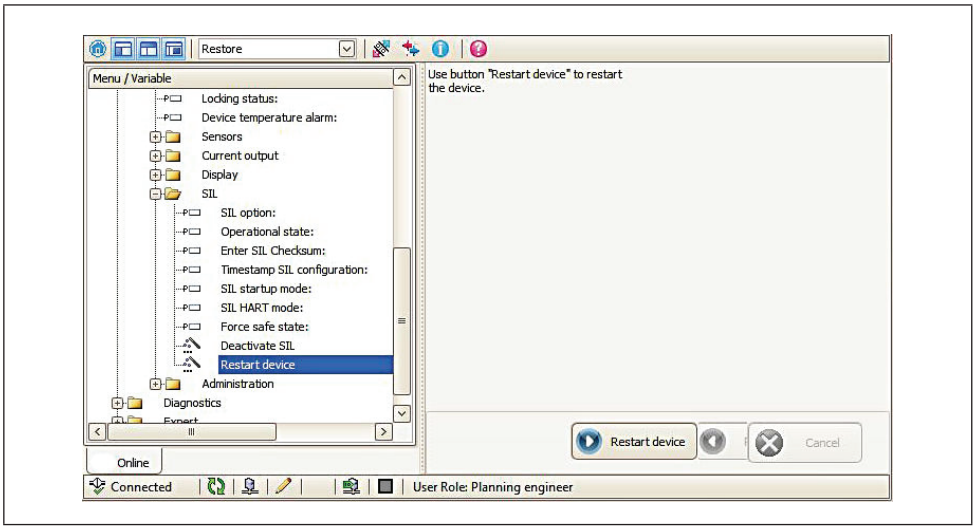
   Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. For the lower range value, select 4 mA to +20 % of the span and for the upper range value, select 20 mA to up to –20 % of the span.

   The measurement results must be within the specified safety inaccuracy range.

   Otherwise the test has not been passed.

2. Check the safe state (low alarm)

   Provoke a sensor error to force the transmitter safe state (e.g. by a cable open circuit or by short-circuiting the sensor cables). Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA).

3. 

   Trigger a device restart using the appropriate function in the operating tool used or via HART command 42.

96% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.96). During the test sequence, the device current output typically behaves as illustrated in (Refer to fig 5, Refer to page 25).

Test sequence B

1. Two-point calibration

   Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. For the lower range value, select 4 mA to +20 % of the span and for the upper range value, select 20 mA to up to –20 % of the span.

   The measurement results must be within the specified safety inaccuracy range.

   Otherwise the test has not been passed.

2. Check the safe state (low alarm)

   Provoke a sensor error to force the transmitter safe state (e.g. by a cable open circuit or by short-circuiting the sensor cables). Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA).

3. NOTICE! If the display will remain attached to the transmitter for the rest of the application, the setting of the DIP switches must be changed again after the test sequence.

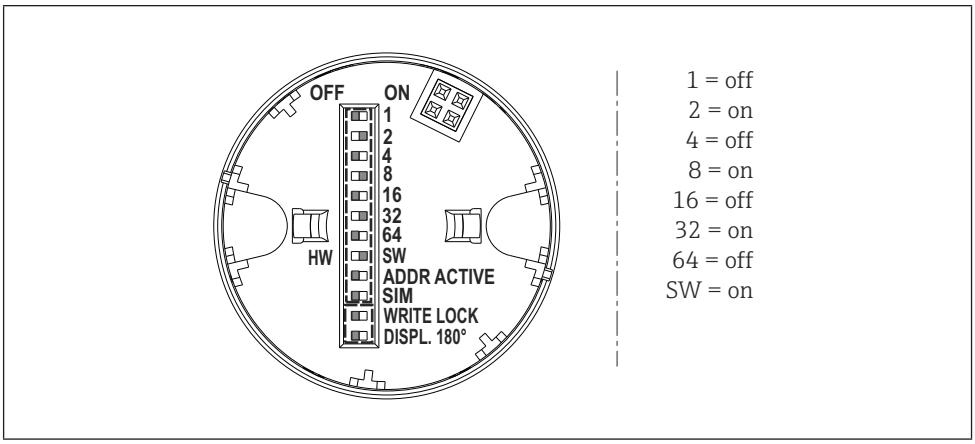


Fig. 3-2. Setting for the DIP switches on the plug-in display

Trigger a device restart by plugging in a display and setting the DIP switches at the back to the appropriate position.

When the device is restarted the following start-up sequence appears on the plugin display:

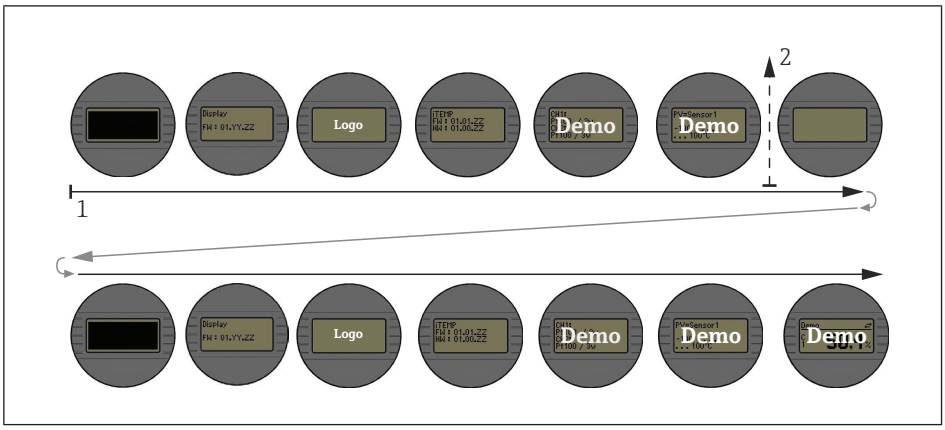


Fig. 3-3. Device start-up sequence on the display

1 Start of sequence
2 Device restart

The start-up sequence on the display indicates whether the restart is being performed correctly.

94% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.94). During the test sequence, the device current output typically behaves as illustrated in (Refer to fig 3-4, Refer to page 25).

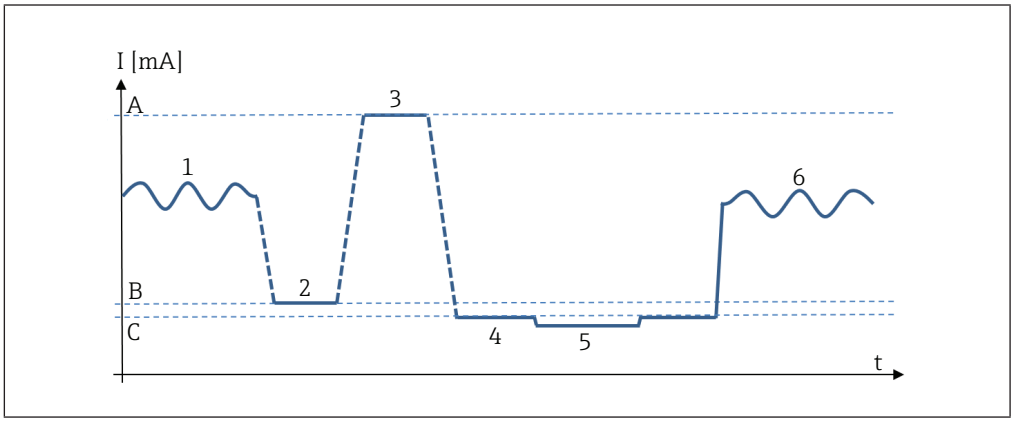


Fig. 3-4. Current pattern during proof test A and B

A 20 mA
B 4 mA
C ≤ 3.6 mA
1 Operation
2 Lower range value adjustment (two-point calibration)
3 Upper range value adjustment (two-point calibration)
4 Low alarm test
5 Transmitter restart (via HART or plug-in display)
6 Operation

Test sequence C

1. Check the plausibility of the current measuring signal. The measured value must be assessed on the basis of empirical values deriving from the operation of the device. This is the responsibility of the operator.

2. NOTICE! Setting of the DIP switches on the plug-in display. If the display will remain attached to the transmitter for the rest of the application, the setting of the DIP switches must be changed again after the test sequence.
   Trigger a device restart by plugging in a display and setting the DIP switches at the back to the appropriate position (Refer to fig 3-2, Refer to page 24). The sequence on the display indicates whether the restart is being performed correctly. (see test sequence B, point 3.)
   Alternatively: Trigger a device restart using the appropriate function in the operating tool used or via HART command 42.

3. Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA). See the following diagram.

58% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.58). Test sequence C is not permitted for a commissioning test.

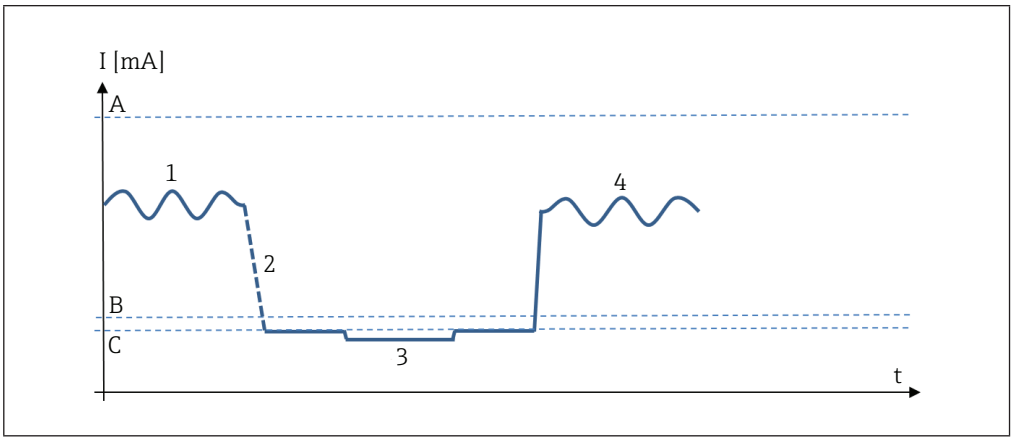


Fig. 3-5. Current pattern during proof test C

A 20 mA
B 4 mA
C ≤ 3.6 mA
1 Operation
2 Transmitter restart (via HART or plug-in display)
3 Low alarm test
4 Operation

Handling Precautions:

For test sequences A, B, C: the plug-in display can only be used in conjunction with the head transmitter design! The influence of systematic errors on the safety function is not fully covered by the test. Systematic faults can be caused, for example, by medium properties, operating conditions, build-up or corrosion.

- ▶ Take measures to reduce systematic errors.
- ▶ If one of the test criteria from the test sequences described above is not fulfilled, the transmitter may no longer be used as part of a protective system.

Chapter 5. Life cycle

5-1. Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must meet the following requirements:

- ▶ Trained, qualified specialists must have a relevant qualification for this specific function and task
- ▶ Are authorized by the plant owner/operator
- ▶ Are familiar with federal/national regulations
- ▶ Before starting work, read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application)
- ▶ Follow instructions and comply with basic conditions

The operating personnel must meet the following requirements:

- ▶ Are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- ▶ Follow the instructions in this manual.

5-2. Installation

The mounting and wiring of the device and the permitted orientations are described in the User's manual pertaining to the device.

5-3. Commissioning

The commissioning of the device is described in the User's manual pertaining to the device.
A commissioning check must be performed before operating the device in a safety system.

5-4. Operation

The operation of the device is described in the User's manual pertaining to the device.

5-5. Maintenance

Maintenance instructions are provided in the User's manual associated with the device. Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

5-6. Repair

The following components may be replaced by the customer's technical staff if genuine spare parts are used and the appropriate installation instructions are followed:

Component	Checking the device after repair
Display	Visual inspection as to whether all the parts are present and mounted correctly and whether the device is in a proper condition.
Housing cover	
Seal kits for housing covers	
Safety clamps, housing	

The replaced component must be sent to the manufacturer for the purpose of fault analysis if the device has been operated in a protective system and a device error cannot be ruled out. In this case, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in protection system" when returning the defective device. Please refer to the "Return" section in the User's manual.

5-7. Modification

Modifications are changes to SIL devices that are already delivered or installed. Modifications to SIL devices are usually performed in the manufacturing center. Modifications to SIL devices on site at the user's premises are possible if approved beforehand by the manufacturer. In this case, the modifications must be performed and documented by a service technician of the manufacturer.

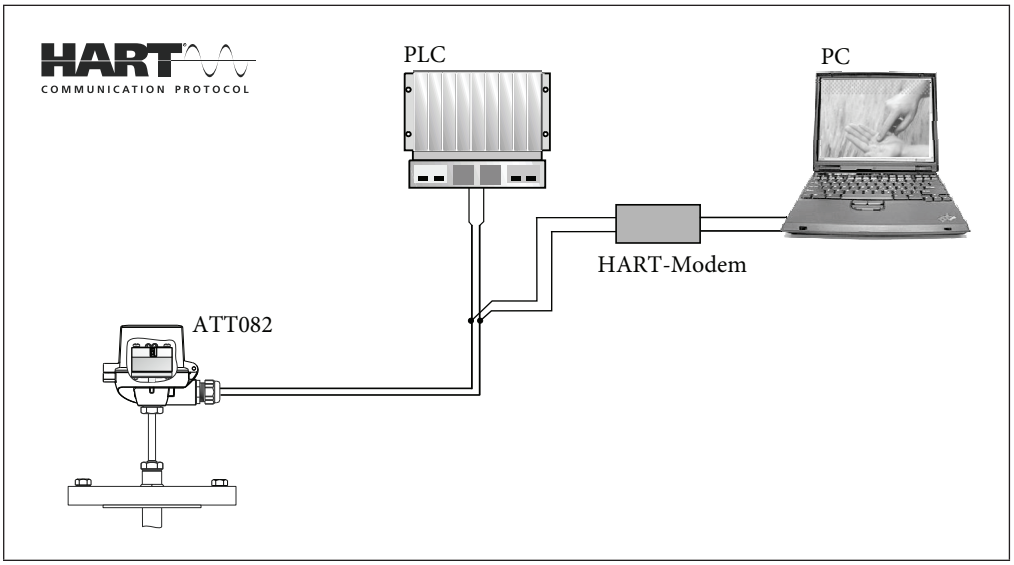
! Handling Precautions:

▶ Modifications to SIL devices by the user are not permitted.

Chapter 6. Appendix

6-1. Structure of the measuring system

The measuring system's devices are displayed in the following diagram (example).



An analog signal (4 to 20 mA), which is proportional to the sensor value, is generated in the transmitter and relayed to a downstream logic unit (e.g. PLC, limit signal switch) where it is monitored to ascertain whether it exceeds or drops below a predefined limit value. For fault monitoring, the logic unit must recognize both high alarms (≥ 21.0 mA) and low alarms (≤ 3.6 mA).

Handling Precautions:

- The optional attachable display is not part of the safety function. Neither the hardware nor the software of the display have a verifiable influence on the defined safety functions of the transmitter. The CDI interface is not safe and therefore may not be used in safetyrelated applications. The interface cannot be used for the safe parameterization of the system.

6-1-1. Measurement function

The following connection versions and functional possibilities of the transmitter can be used for the SIL mode as part of a safety function: [1)]

Sensor input 2	**Sensor input 1**		
	RTD or resistance transmitter, 3-wire	RTD or resistance transmitter, 4-wire	Thermocouple (TC), voltage transmitter, always 2-wire
RTD or resistance transmitter, 3- wire	☑	-	☑
Thermocouple (TC), voltage transmitter	☑	☑	☑
Inactive	☑	☑	☑

1) Two-wire resistance sensors are not supported in the SIL mode.

! Handling Precautions:

Galvanic isolation

▶ When two sensors are connected to the transmitter, make sure the sensors are galvanically isolated from one another.

Two-channel functions

Two sensors can be connected to the transmitter and the transmitter can be operated in the following safe functions:

- Two independent measurements:
  Here, two (possibly different) sensors are connected to the transmitter, e.g. TC and 3-wire RTD. The two measuring channels can be used for safety-related functions. To analyze the measured values of both sensors, it is necessary to work with the safe proprietary HART® protocol extension. (Refer to page 40)
- Averaging function:
  The measured values M1, M2 of the two sensors are output as an arithmetic average (M1+M2)/2.
- Difference function
  The measured values M1, M2 of the two sensors are output as a difference (M1-M2).
- Backup function:
  If one of the sensor fails, the transmitter automatically switches to the other measuring channel. For this the sensor types must be identical, e.g. two 3-wire RTD Pt100 sensors. The backup function is used to increase availability or improve the diagnostic capabilities.
  Therefore the following types of sensor are permitted in the SIL mode:
  – 2x thermocouple (TC)
  – 2x RTD, 3-wire
- Sensor drift function
  If redundant sensors are used, the long-term drift of a sensor can be detected, for instance. This is a diagnostic measure as the signal of the second sensor is only used for this diagnostic. If identical sensors are used, the backup function can also be used.

Note: The configured drift difference limit value should be at least twice the safety accuracy value.

SIL 3 configuration: homogeneous redundancy

Two temperature transmitters with one sensor per transmitter are required for a SIL 3 measuring point. The measured values of the two transmitters are evaluated in a logic unit using a safe voter. (Refer to fig 5-1, Refer to page 31)

The measured values can be transmitted either via the 4 to 20 mA signal and/or the safe HART® protocol). (Refer to page 40)

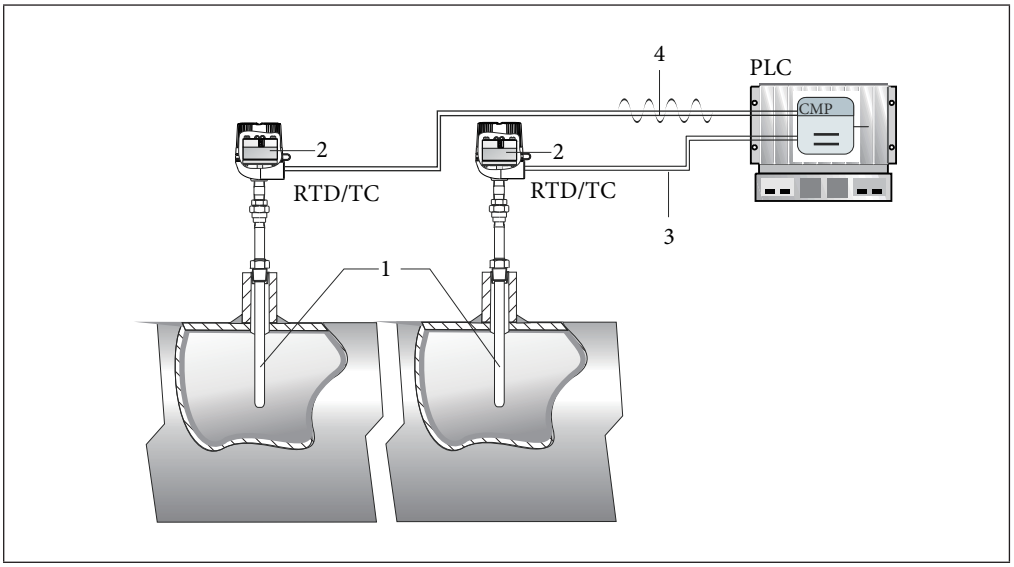


Fig. 5-1. Example with current output at the first transmitter and current output or safe HART® signal at the second transmitter. PCS voting of the two sensor values: SIL 3

1 2 temperature sensors
2 2 temperature transmitters (head transmitter design)
3 4 to 20 mA current output
4 4 to 20 mA current output, optionally with safe HART® communication

6-2. Commissioning or proof test report

Company / contact person	/
Tester	

Device information	
Facility	Measuring point/TAG no.:
Device type/Order code	
Serial number	Firmware version
Access code (if individual to each device)	SIL checksum

Verification information
Date / time
Performed by

Verification result		
Overall result	☐ Passed	☐ Failed

Comment:

Date _____ Signature of customer _____ Signature of tester _____

Type of safety function
☐ Limit value monitoring MIN ☐ Limit value monitoring MAX ☐ Safe measurement

Commissioning / proof test
☐ Test sequence A ☐ Test sequence B ☐ Test sequence C ☐ Commissioning

Proof test report			
Test step	Set point	Actual value	Passed
1. Lower range value adjustment			☐ Passed ☐ Failed
2. Upper range value adjustment			☐ Passed ☐ Failed
3. Current value alarm			☐ Passed ☐ Failed
4a. Restart via HART			☐ Passed ☐ Failed
4b. Restart via plug-in display			☐ Passed ☐ Failed

Comment:

6-2-1. Parameter settings for safe parameterization

Parameter name	Factory setting	Set value	Tested
Lower measuring range (4 mA)	0		
Upper measuring range (20 mA)	100		
Out of range category	Maintenance required (M)		
Sensor type 1	Pt100 IEC60751		
Sensor type 2	No sensor		
Upper sensor limit 1 [1)]	+850 °C		
Lower sensor limit 1 [1)]	–200 °C		
Upper sensor limit 2 [1)]	-		
Lower sensor limit 2 [1)]	-		
Sensor offset 1	0		
Sensor offset 2	0		
Connection type 1	4-wire (RTD)		
Connection type 2	2-wire (TC)		
Reference junction 1,2	Internal measurement (TC)		
RJ preset value 1,2	0 (for setting preset value)		
Call./v. Dusen coeff. A, B and C sensor 1 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -5.780000e-007		
Call./v. Dusen coeff. A, B and C sensor 2 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -5.780000e-007		
Call./v. Dusen coeff. R0 sensor 1 [1)]	100 Ω		
Call./v. Dusen coeff. R0 sensor 2 [1)]	100 Ω		
Polynomial coeff. A, B sensor 1 [1)]	A = 5.49630e-003		
Polynomial coeff. A, B sensor 2 [1)]	B = 5.49630e-003		
Polynomial coeff. R0 sensor 1 [1)]	100 Ω		
Polynomial coeff. R0 sensor 2 [1)]	100 Ω		
Unit	°C		
Mains filter	50 Hz		
Drift/difference mode	Off		
Drift/difference alarm category	Maintenance required (M)		
Drift/difference set point	999		

Parameter name	Factory setting	Set value	Tested
SIL HART mode	HART active		
SIL startup mode	Active		
Assign current output (PV)	Sensor 1		
Assign SV	Device temperature		
Assign TV	Sensor 1		
Assign QV	Sensor 1		

1) Only for Call./v. Dusen or polynomial Cu/Ni sensors

6-3. Other

6-3-1. Parameters and default settings for safe parameterization

Parameters and default settings for safe parameterization	
Firmware version	Use this function to view the device firmware version installed. Max. 6-digit character string in the format xx.yy.zz. The firmware version that is currently valid can be taken from the nameplate or the User's manual associated with the device.
Serial number	Use this function to display the serial number of the device. It can also be found on the nameplate. Max. 11-digit character string comprising letters and numbers.
Enter access code	Use this function to enable the service parameters via the operating tool. Factory setting: 0
Device reset	Use this function to reset the device configuration - either entirely or in part - to a defined state. Factory setting: not active
Hardware revision	Use this function to display the hardware revision of the device.
Simulation current output	Use this function to switch simulation of the current output on and off. The display alternates between the measured value and a diagnostics message of the "function check" category (C) while simulation is in progress. Factory setting: off (cannot be changed in safe parameterization)
Value simulation current output	Use this function to set a current value for the simulation. In this way, users can verify the correct adjustment of the current output and the correct function of downstream switching units. Factory setting: 3.58 mA (cannot be changed in safe parameterization)
Current trimming 20 mA	Use this function to set the correction value for the current output at the end of the measuring range at 20 mA. Factory setting: 20.000 mA (cannot be changed in safe parameterization)
Current trimming 4 mA	Use this function to set the correction value for the current output at the start of the measuring range at 4 mA. Factory setting: 4 mA (cannot be changed in safe parameterization)
Lower range value	Use this function to assign a measured value to the current value 4 mA. Factory setting: 0
Upper range value	Use this function to assign a measured value to the current value 20 mA. Factory setting: 100
Failure current	Use this function to set the value the current output adopts in an alarm condition. SIL mode: 3.58 mA (cannot be changed in safe parameterization)
Failure mode	Use this function to select the signal on alarm level of the current output in the event of an error. Factory setting: min (cannot be changed in safe parameterization)

Parameters and default settings for safe parameterization	
Out of range category	Use this function to select the category (status signal) as to how the device reacts when the value is outside the set measuring range. Factory setting: maintenance required (M)
Minimum span	A span is the difference between the temperature at 4 mA and 20 mA. The minimum span is the minimum permitted setting or the setting that makes sense for a sensor type with this difference in the transmitter.
HART® address	Definition of the HART® address of the device. Factory setting: 0 (cannot be changed in safe parameterization)
Device revision	Use this function to view the device revision with which the device is registered with the HART® Communication Foundation. It is needed to assign the appropriate device description file (DD) to the device. Factory setting: 2 (fixed value)
Measuring mode	Possibility of inverting the output signal. Options: standard (4 to 20 mA) or inverse (20 to 4 mA). Factory setting: standard (cannot be changed in safe parameterization)
Sensor type n	Use this function to select the sensor type for the sensor input n in question: ▪ Sensor type 1: settings for sensor input 1 ▪ Sensor type 2: settings for sensor input 2 Factory setting: ▪ Sensor type 1: Pt100 IEC751 ▪ Sensor type 2: no sensor
Sensor n upper limit	Displays the maximum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: +850 °C (+1 562 °F) ▪ Sensor type 2 = no sensor
Sensor n lower limit	Displays the minimum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: –200 °C (–328 °F) ▪ Sensor type 2 = no sensor
Sensor offset n	Use this function to set the zero point correction (offset) of the sensor measured value. The value indicated is added to the measured value. Factory setting: 0.0
Connection type n	Use this function to select the connection type for the sensor. Factory setting: ▪ Sensor 1 (connection type 1): 4-wire ▪ Sensor 2 (connection type 2): 2-wire
Reference junction n	Use this function to select reference junction measurement for temperature compensation of thermocouples (TC). Factory setting: Internal measurement

Parameters and default settings for safe parameterization	
RJ preset value n	Use this function to define the fixed preset value for temperature compensation. The Preset value parameter must be set if the Reference junction n option is selected. Factory setting: 0.00
Call./v. Dusen coeff. A, B and C	Use this function to set the coefficients for sensor linearization based on the Callendar/Van Dusen method. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the Sensor type parameter. Factory setting: ▪ Coefficient A: 3.910000e-003 ▪ Coefficient B: -5.780000e-007 ▪ Coefficient C: -4.180000e-012
Call./v. Dusen coeff. R0	Use this function to set the R0 Value only for linearization with the Callendar/Van Dusen polynomial. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the Sensor type parameter. Factory setting: 100 Ω
Polynomial coeff. A, B	Use this function to set the coefficients for sensor linearization of copper/nickel resistance thermometers. Prerequisite: The RTD poly nickel or RTD copper polynomial option is enabled in the Sensor type parameter. Factory setting: ▪ Polynomial coeff. A = 5.49630e-003 ▪ Polynomial coeff. B = 6.75560e-006
Polynomial coeff. R0	Use this function to set the R0 Value only for linearization of nickel/copper sensors. Prerequisite: The RTD poly nickel or RTD copper polynomial option is enabled in the Sensor type parameter. Factory setting: 100 Ω
Sensor trimming	Use this function to select the linearization method to be used for the connected sensor. Factory setting: FactoryTrim (cannot be changed in safe parameterization)
Unit	Use this function to select the engineering unit for all the measured values. Factory setting: °C
Mains filter	Use this function to select the mains filter for A/D conversion. Factory setting: 50 Hz

Parameters and default settings for safe parameterization	
Drift/difference mode	Use this function to choose whether the device reacts to the drift/difference limit value being exceeded or undershot. Can only be selected for 2-channel operation. Factory setting: Off
Drift/difference alarm category	Use this function to select the category (status signal) as to how the device reacts when a drift/difference is detected between sensor 1 and sensor 2. Prerequisite: The Drift/difference mode parameter must be activated with the Out band (drift) or In band option. Factory setting: Maintenance required (M)
Drift/difference set point	Use this function to configure the maximum permissible measured value deviation between sensor 1 and sensor 2 which results in drift/difference detection. Prerequisite: The Drift/difference mode parameter must be activated with the Out band (drift) or In band option. Factory setting: 999.0
Drift/difference alarm delay	Alarm delay for drift detection monitoring. Prerequisite: The Drift/difference mode parameter must be activated with the Out band (drift) or In band option. Factory setting: 0 s (cannot be changed in safe parameterization)
Device temperature alarm	Use this function to select the category (status signal) as to how the device reacts when the electronics temperature of the transmitter is exceeded or undershot < –40 °C (–40 °F) or > +82 °C (+180 °F) Factory setting: Failure (F) (cannot be changed in safe parameterization)
SIL HART mode	Setting for HART® communication in the SIL mode. The setting HART not active in SIL mode disables HART® communication in the SIL mode (only 4 to 20 mA communication is active). Factory setting: HART active in SIL mode
SIL startup mode	Setting for repeated automatic device startup in the SIL mode, e.g. after a power-cycle. Factory setting: Active
Force safe state	During the commissioning or proof test, this parameter is used to test error detection and the safe state of the device. Prerequisite: The Operational state parameter displays SIL mode active. Factory setting: Off

Parameters and default settings for safe parameterization	
Assign current output (PV)	Use this function to assign a measured variable to the primary HART® value (PV). Factory setting: Sensor 1
Assign SV	Use this function to assign a measured variable to the secondary HART® value (SV) Factory setting: Device temperature
Assign TV	Use this function to assign a measured variable to the tertiary HART® value (TV). Factory setting: Sensor 1
Assign QV	Use this function to assign a measured variable to the quaternary HART® value (QV). Factory setting: Sensor 1
Damping	Use this function to set the time constant for current output damping. Factory setting: 0.00 s (cannot be changed in safe parameterization)
Burst mode	Activation of the HART® burst mode for burst message X. Message 1 has the highest priority, message 2 the second-highest priority, etc. Factory setting: Off (cannot be changed in safe parameterization)

6-3-2. Safe HART®

The safe HART® protocol is a proprietary extension that is compatible with the HART® standard. It is used to safely transmit additional information from the transmitter to a connected process control system via the HART® protocol (up to SIL3). The HART ® protocol itself must be considered unsafe, i.e. the transmission channel is seen as a "gray channel".
There is a proprietary HART® command for safe transmission which packages the information with backup data in the payload data block of the HART® commands. The safe HART® protocol is considered safe according to EN50159-1 specifications. It is presumed that there are otherwise no unknown users on the bus. This must be verified by the user accordingly.

Note: For a detailed description of the safe HART® protocol for use in a process control system, please contact your local sales office as this functionality is patented by Rockwell Automation.

6-3-3. Use as a safe measuring system

The temperature transmitter must be combined with a suitable sensor to implement a safe measuring system. The code numbers required for the system design must be taken from the following tables.

Single channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}	Device type
Transmitter	40.0 FIT	258.0 FIT	129.0 FIT	4.0 FIT	91%	1.8E-04	B

Sensor elements (thermocouple / resistance thermometer)

	low stress		high stress		low stress		high stress		
	closed coupled				extension wire				
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	94%	2.6E-05	94%	5.2E-04	89%	4.8E-04	89%	9.5E-03	A
RTD 3-wire	81%	3.9E-05	81%	7.9E-04	79%	4.3E-04	79%	8.7E-03	A
RTD 4-wire	94%	1.2E-05	94%	1.2E-05	94%	1.4E-04	94%	2.8E-03	A

Sensor combined with transmitter (validation type B)

Transmitter + Thermocouple	SIL2	2.0E-04	SIL2	7.0E-04	SIL2	6.5E-04	SIL1	9.7E-03	B
Transmitter + RTD 3-wire	SIL2	2.1E-04	SIL2	9.7E-04	SIL2	6.1E-04	SIL1	8.8E-03	B
Transmitter + RTD 4-wire	SIL2	1.9E-04	SIL2	1.9E-04	SIL2	3.2E-04	SIL1	3.0E-03	B

SFF	Typ	A			B		
	HFT	0	1	2	0	1	2
< 60%		SIL1	SIL2	SIL3	---	SIL1	SIL2
60% - < 90%		SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% - < 99%		SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
>99%		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}

- < 2.5×10^{-3}
- > 2.5×10^{-3}
- > 1×10^{-2}

Two channel operation

	λ_{-du}	λ_{-dd}	λ_{-su}	λ_{-sd}	SFF	PFD_{avg}			Device type
Transmitter	40.0 FIT	258.0 FIT	129.0 FIT	4.0 FIT	91%	1.8E-04			B

Sensor elements (thermocouple / resistance thermometer)

	low stress		high stress		low stress		high stress			
	closed coupled				extention wire					
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}		
2 x TC	95%	4.8E-05	98%	3.3E-04	91%	7.6E-04	91%	1.5E-02	w/o diagnostics	A
	95%	4.4E-05	99%	2.5E-04	94%	5.4E-04	94%	1.1E-02	with diagnostics	A
2 x RTD 3-wire	89%	4.5E-05	89%	9.0E-04	88%	4.9E-04	88%	9.8E-03	w/o diagnostics	A
	98%	7.2E-06	98%	1.4E-04	98%	7.5E-05	98%	1.5E-03	with diagnostics	A
TC + RTD 3-wire	95%	3.2E-05	95%	6.3E-04	92%	5.4E-04	92%	1.1E-02	w/o diagnostics	A
	96%	2.7E-05	96%	5.4E-04	95%	3.2E-04	95%	6.3E-03	with diagnostics	A

Sensor combined with transmitter (validation type B)

Transmitter + 2 x TC	SIL2	2.2E-04	SIL2	5.1E-04	SIL2	9.3E-04	SIL1	1.5E-02	w/o diagnostics	B
		2.2E-04	SIL2	4.2E-04		7.1E-04		1.1E-02	with diagnostics	B
Transmitter + 2 x RTD 3-wire	SIL2	2.2E-04	SIL2	1.1E-03	SIL2	6.7E-04	SIL1	1.0E-02	w/o diagnostics	B
		1.8E-04	SIL2	3.2E-04		2.5E-04		1.7E-03	with diagnostics	B
Transmitter + TC + RTD 3-wire	SIL2	2.1E-04	SIL2	8.1E-04	SIL2	7.1E-04	SIL1	1.1E-02	w/o diagnostics	B
		2.0E-04	SIL2	7.2E-04		4.9E-04		6.5E-03	with diagnostics	B

Note:
- Low stress: < ⅔ utilization of the maximum permissible thermometer acceleration
- High stress: > ⅔ utilization of the maximum permissible thermometer acceleration
- Closed coupled: < 30 cm
- Extension wire: > 30 cm
- Diagnostics: sensor drift

6-3-4. Assignment of code numbers to parameters

Integer value	Parameter	Parameter value
8	Out of range category	Out of specification (S)
4		Maintenance required (M)
1		Failure (F)
12	Sensor type	Pt100 IEC60751, a=0.00385 (1)
13		Pt200 IEC60751, a=0.00385 (2)
14		Pt500 IEC60751, a=0.00385 (3)
15		Pt1000 IEC60751, a=0.00385 (4)
22		Pt100 JIS C1604, a=0.003916 (5)
72		Ni100 DIN 43760, a=0.00618 (6)
73		Ni120 DIN 43760, a=0.00618 (7)
248		Ni100 OIML/GOST 6651-09, a=0.00617 (12)
249		Ni120 OIML/GOST 6651-09, a=0.00617 (13)
246		Type A (W5Re-W20Re) IEC60584-2013 (30)
131		Type B (PtRh30-PtRh6) IEC60584 (31)
132		Type C (W5Re-W26Re) IEC60584 (32)
133		Type D (W3Re-W25Re) ASTM E988-96 (33)
134		Type E (NiCr-CuNi) IEC60584 (34)
136		Type J (Fe-CuNi) IEC60584 (35)
137		Type K (NiCr-Ni) IEC60584 (36)
138		Type N (NiCrSi-NiSi) IEC60584 (37)
139		Type R (PtRh13-Pt) IEC60584 (38)
140		Type S (PtRh10-Pt) IEC60584 (39)
141		Type T (Cu-CuNi) IEC60584 (40)
142		Type L (Fe-CuNi) DIN43710 (41)
148		Type L (NiCr-CuNi) GOST R8.8585-01 (43)
143		Type U (Cu-CuNi) DIN43710 (42)
241		Pt50 GOST 6651-94, a=0.00391 (8)
242		Pt100 GOST 6651-94, a=0.00391 (9)
243		Cu50 GOST 6651-09, a=0.00428 (10)
105		Cu100 OIML/GOST 6651-09, a=0.00428 (11)
244		Cu50 OIML R84:2003, a=0.00428 (10)
245		Cu50 OIML/GOST 6651-94, a=0.00426 (14)
3		RTD Platinium (Callendar/van Dusen)
240		RTD Poly Nickel (OIML R84, GOST 6651-94)
247		RTD Polynomial Copper (OIML R84:2003)
1		10...400 Ohm
2		10...2000 Ohm
129		-2...100 mV
251		No Sensor
2	Connection type	2-wire
3		3-wire
4		4-wire
0	Reference junction	No compensation
1		Internal measurement
3		Fixed Value
4		Sensor 2 value

Integer value	Parameter	Parameter value
32	Unit	°C
33		°F
35		K
34		°R
37		Ohm
36		mV
0	Mains filter	50 Hz
1		60 Hz
12	Drift/difference mode	Off
0		Out band (drift)
1		In band
0	SIL HART mode	HART disabled in SIL mode
1		HART enabled in SIL mode
0	SIL startup mode	Disabled
1		Enabled
0	Assign current output (PV, SV, TV, QV)	Sensor 1
1		Sensor 2
2		Device temperature
3		Average
4		Difference
5		Sensor 1 (Backup Sensor 2)
6		Sensor switching
7		Average with backup

Terms and Conditions

We would like to express our appreciation for your purchase and use of Azbil Corporation's products. You are required to acknowledge and agree upon the following terms and conditions for your purchase of Azbil Corporation's products (system products, field instruments, control valves, and control products), unless otherwise stated in any separate document, including, without limitation, estimation sheets, written agreements, catalogs, specifications and instruction manuals.

1. Warranty period and warranty scope

1.1 Warranty period

Azbil Corporation's products shall be warranted for one (1) year from the date of your purchase of the said products or the delivery of the said products to a place designated by you.

1.2 Warranty scope

In the event that Azbil Corporation's product has any failure attributable to azbil during the aforementioned warranty period, Azbil Corporation shall, without charge, deliver a replacement for the said product to the place where you purchased, or repair the said product and deliver it to the aforementioned place. Notwithstanding the foregoing, any failure falling under one of the following shall not be covered under this warranty:

(1) Failure caused by your improper use of azbil product (noncompliance with conditions, environment of use, precautions, etc. set forth in catalogs, specifications, instruction manuals, etc.);
(2) Failure caused for other reasons than Azbil Corporation's product;
(3) Failure caused by any modification or repair made by any person other than Azbil Corporation or Azbil Corporation's subcontractors;
(4) Failure caused by your use of Azbil Corporation's product in a manner not conforming to the intended usage of that product;
(5) Failure that the state-of-the-art at the time of Azbil Corporation's shipment did not allow Azbil Corporation to predict; or
(6) Failure that arose from any reason not attributable to Azbil Corporation, including, without limitation, acts of God, disasters, and actions taken by a third party.

Please note that the term "warranty" as used herein refers to equipment-only-warranty, and Azbil Corporation shall not be liable for any damages, including direct, indirect, special, incidental or consequential damages in connection with or arising out of Azbil Corporation's products.

2. Ascertainment of suitability

You are required to ascertain the suitability of Azbil Corporation's product in case of your use of the same with your machinery, equipment, etc. (hereinafter referred to as "Equipment") on your own responsibility, taking the following matters into consideration:

(1) Regulations and standards or laws that your Equipment is to comply with.
(2) Examples of application described in any documents provided by Azbil Corporation are for your reference purpose only, and you are required to check the functions and safety of your Equipment prior to your use.
(3) Measures to be taken to secure the required level of the reliability and safety of your Equipment in your use
Although azbil is constantly making efforts to improve the quality and reliability of Azbil Corporation's products, there exists a possibility that parts and machinery may break down.
You are required to provide your Equipment with safety design such as fool-proof design, *1 and fail-safe design*2 (anti-flame propagation design, etc.), whereby preventing any occurrence of physical injuries, fires, significant damage, and so forth. Furthermore, fault avoidance, *3 fault tolerance,*4 or the like should be incorporated so that the said Equipment can satisfy the level of reliability and safety required for your use.

*1. A design that is safe even if the user makes an error.
*2. A design that is safe even if the device fails.
*3. Avoidance of device failure by using highly reliable components, etc.
*4. The use of redundancy.

3. Precautions and restrictions on application

Azbil Corporation's products other than those explicitly specified as applicable (e.g. azbil Limit Switch For Nuclear Energy) shall not be used in a nuclear energy controlled area (radiation controlled area).
Any Azbil Corporation's products shall not be used for/with medical equipment.
The products are for industrial use. Do not allow general consumers to install or use any Azbil Corporation's product. However, azbil products can be incorporated into products used by general consumers. If you intend to use a product for that purpose, please contact one of our sales representatives.
In addition,
you are required to conduct a consultation with our sales representative and understand detail specifications, cautions for operation, and so forth by reference to catalogs, specifications, instruction manual, etc. in case that you intend to use azbil product for any purposes specified in (1) through (6) below.
Moreover, you are required to provide your Equipment with fool-proof design, fail-safe design, anti-flame propagation design, fault avoidance, fault tolerance, and other kinds of protection/safety circuit design on your own responsibility to ensure reliability and safety, whereby preventing problems caused by failure or nonconformity.

(1) For use under such conditions or in such environments as not stated in technical documents, including catalogs, specification, and instruction manuals

(2) For use of specific purposes, such as:
* Nuclear energy/radiation related facilities
[For use outside nuclear energy controlled areas] [For use of Azbil Corporation's Limit Switch For Nuclear Energy]
* Machinery or equipment for space/sea bottom
* Transportation equipment
[Railway, aircraft, vessels, vehicle equipment, etc.]
* Antidisaster/crime-prevention equipment
* Burning appliances
* Electrothermal equipment
* Amusement facilities
* Facilities/applications associated directly with billing

(3) Supply systems such as electricity/gas/water supply systems, large-scale communication systems, and traffic/air traffic control systems requiring high reliability
(4) Facilities that are to comply with regulations of governmental/public agencies or specific industries
(5) Machinery or equipment that may affect human lives, human bodies or properties
(6) Other machinery or equipment equivalent to those set forth in items (1) to (5) above which require high reliability and safety

4. Precautions against long-term use

Use of Azbil Corporation's products, including switches, which contain electronic components, over a prolonged period may degrade insulation or increase contact-resistance and may result in heat generation or any other similar problem causing such product or switch to develop safety hazards such as smoking, ignition, and electrification.
Although acceleration of the above situation varies depending on the conditions or environment of use of the products, you are required not to use any Azbil Corporation's products for a period exceeding ten (10) years unless otherwise stated in specifications or instruction manuals.

5. Recommendation for renewal

Mechanical components, such as relays and switches, used for Azbil Corporation's products will reach the end of their life due to wear by repetitious open/close operations.
In addition, electronic components such as electrolytic capacitors will reach the end of their life due to aged deterioration based on the conditions or environment in which such electronic components are used.
Although acceleration of the above situation varies depending on the conditions or environment of use, the number of open/close operations of relays, etc.
as prescribed in specifications or instruction manuals, or depending on the design margin of your machine or equipment, you are required to renew any Azbil Corporation's products every 5 to 10 years unless otherwise specified in specifications or instruction manuals.
System products, field instruments (sensors such as pressure/flow/level sensors, regulating valves, etc.) will reach the end of their life due to aged deterioration of parts.
For those parts that will reach the end of their life due to aged deterioration, recommended replacement cycles are prescribed. You are required to replace parts based on such recommended replacement cycles.

6. Other precautions

Prior to your use of Azbil Corporation's products, you are required to understand and comply with specifications (e.g., conditions and environment of use), precautions, Prior to your use of Azbil Corporation's products, you are required to understand and comply with specifications (e.g., conditions and environment of use), precautions, and instruction manuals to ensure the quality, reliability, and safety of those products.

7. Changes to specifications

Please note that the descriptions contained in any documents provided by azbil are subject to change without notice for improvement or for any other reason.
For inquires or information on specifications as you may need to check, please contact our branch offices or sales offices, or your local sales agents.

8. Discontinuance of the supply of products/parts

Please note that the production of any Azbil Corporation's product may be discontinued without notice.
For repairable products, we will, in principle, undertake repairs for five (5) years after the discontinuance of those products. In some cases, however, we cannot undertake such repairs for reasons, such as the absence of repair parts.
For system products, field instruments, we may not be able to undertake parts replacement for similar reasons.

9. Scope of services

Prices of Azbil Corporation's products do not include any charges for services such as engineer dispatch service.
Accordingly, a separate fee will be charged in any of the following cases:
(1) Installation, adjustment, guidance, and attendance at a test run
(2) Maintenance, inspection, adjustment, and repair
(3) Technical guidance and technical education
(4) Special test or special inspection of a product under the conditions specified by you

Please note that we cannot provide any services as set forth above in a nuclear energy controlled area (radiation controlled area) or at a place where the level of exposure to radiation is equivalent to that in a nuclear energy controlled area.

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