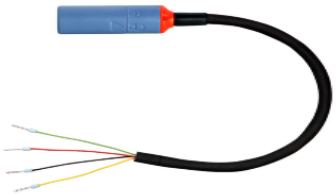
Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

Endress+Hauser
People for Process Automation

Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

Functional Safety Manual
Memosens Cable CYK10

Connection of a Memosens sensor with a Memosens transmitter



Application

Used to connect Memosens sensors and Memosens transmitters to satisfy the particular requirements for safety related systems as per IEC 61508.

The measuring device meets the following requirements:

- Functional safety in accordance with IEC 61508
- Explosion protection
- Electromagnetic compatibility in accordance with EN 61326 and NAMUR-recommendation NE 21
- Electrical Safety in accordance with IEC/EN 61010-1
- Ingress Protection IP68 in accordance with DIN EN 60529

Your benefits

- For all Memosens compatible systems up to SIL 3
- Independently assessed (Functional Safety Assessment) by TÜV Süd in accordance with IEC 61508
- Permanent self-monitoring
- Permanent connection monitoring

SD151C/07/EN/02.10 71107781

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

SIL Konformitätserklärung / SIL Declaration of Conformity

Funktionale Sicherheit nach IEC 61508 / Functional Safety according to IEC 61508

Endress+Hauser Conducta GmbH+Co. KG, Dieselstr. 24, D-70839 Gerlingen

erklärt als Hersteller die Richtigkeit der folgenden Angaben. /
declares as manufacturer the correctness of the following data

Gerät / Product	**CYK10**
Schutzfunktion / Safety function	sichere Durchleitung von Daten/ safe transmission of data
Hardware SIL / Hardware SIL	2
Systematischer SW SIL / Systematic SW SIL	3
HFT	0
Gerätetyp / Device type	B
Betriebsart / Mode of operation	Low demand mode
SFF / MTTR	90.4 % / 8 Stunden/hours
Prüfintervall / Proof test interval T_1	Empfohlen / recommended T_1 = 1 Jahr / year
λ_{SD} / λ_{SU}	0 FIT / 47 FIT
λ_{DD} / λ_{DU}	146 FIT / 21 FIT
PFD_{avg} T_1 = 1 Jahr / year	0.9×10^{-4}
MTBF / $MTBF_{DU}$ (reciprocal of λ_{total} / λ_{DU}, assuming constant failure rate)	535 / 5568 Jahre/years

Das Gerät wurde in einem vollständigen Functional Safety Assessment unabhängig bewertet.

The device was assessed independently in a complete Functional Safety Assessment.

In the event of device modifications, a modification process compliant with IEC 61508 will be applied.



Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

TABLE OF CONTENTS

1 Structure of a measuring system with the Memosens cable CYK10 SIL **5**

1.1 System Components 5

1.2 Description of the application as a safety related system 6

1.3 Valid device types 6

1.4 Applicable device documentation 6

2 Description of safety requirements and boundary conditions **7**

2.1 Safety Function – Safe measurement mode 7

2.2 Safety-related signal and safe state 7

2.3 Restrictions for the use in safety-related applications 7

2.4 Functional safety parameters 9

2.5 Behavior of the device when in operation and in case of failure 11

2.5.1 Behavior of the device when switched on 11

2.5.2 Behavior of the device on demand 11

2.5.3 Behavior of the device in the event of alarms and warnings 11

3 Installation **12**

4 Operation **12**

4.1 Calibrating the measuring point 12

4.2 Method of device parameterization 12

5 Maintenance, recalibration **12**

6 Proof test **13**

6.1 Proof test 13

6.2 Testing to ensure its safe functioning 13

7 Repair – safety relevant messages **14**

8 Notes on the redundant use of multiple cables for SIL 3 **14**

9 Proof test protocol example **15**

10 PFD_{avg} computation examples **16**

10.1 Example to calculate PFD_{avg} after a proof test 16

10.2 PFD_{avg} computation example for a pH measuring point 17

11 General and technical information about the Memosens cable CYK10 SIL **22**

11.1 General information 22

11.1.1 Maximum process safety 22

11.2 Technical information 22

11.2.1 Cable connection 22

11.2.2 Handling of sensor plug-in head and cable coupling 23

11.2.3 Environment 23

11.2.4 Electrical properties 24

11.2.5 Mechanical construction 24

11.2.6 Certificates and approvals 25

11.2.7 Order codes of the Memosens cable CYK10 26

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Note!

General information about functional safety (SIL) is available at www.endress.com/SIL and in the competence brochure CP002Z "Functional safety in the Process Industry – risk reduction with Safety Instrumented Systems".

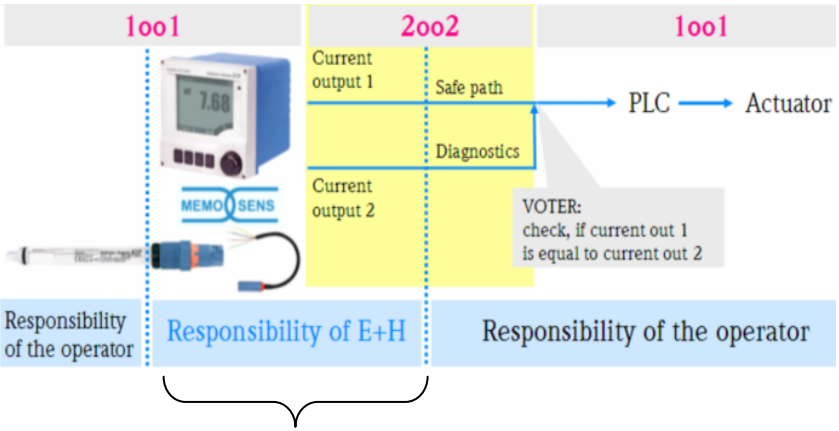
Note!

For general and technical information about the Memosens cable CYK10 please have a look at chapter 11.

1 Structure of a measuring system with the Memosens cable CYK10 SIL

1.1 System Components

A system using the cable CYK10 looks like the following:



This part, especially the cable, is covered by this document.

1. Memosens pH glass sensor, e.g. Orbisint CPS11D SIL
2. **Memosens cable CYK10 SIL**
3. Memosens transmitter Liquiline M CM42 SIL

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

The cable is only a small part of the complete safety function. The cable is a compliant item with IEC 61508.

1.2 Description of the application as a safety related system

To use the cable in a safety related system, you need a safe transmitter and a safe sensor, which both talk the safe Memosens protocol of the Endress+Hauser Conducta GmbH+Co. KG. The cable is reactionless for the digital communication on the cable and can be seen as a "grey channel" for the safety system.

1.3 Valid device types

The information in this manual pertaining to functional safety applies to the device versions listed below and is valid from the stated software and hardware versions.

Unless otherwise indicated, all subsequent versions can also be used for safety functions.

Device versions valid for use in safety-related applications: CYK10-G90/91x

Valid Hardware Version (electronics): produced after 1st Oct. 2010

Valid Firmware /Software Version: >= 2.0.0

Both versions are not visible to the customer. If in doubt, please contact your local Endress+Hauser Service.

The SIL cable CYK10 is distinguishable by the nameplate with the TÜV logo and the Endress+Hauser SIL logo and can be identified using the order code as shown in the picture below.

Order code: CYK10-G 90/91 1



In the event of device modifications, a modification process compliant with IEC 61508 will be applied.

1.4 Applicable device documentation

With the CYK10 Memosens Cable no additional documentation except this manual is delivered. A connection layout can be found in the Technical Information and the manual of the Liquiline M CM42 transmitter.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

2 Description of safety requirements and boundary conditions

2.1 Safety Function – Safe measurement mode

The safety function of the cable CYK10 SIL is the transmission of digital data in both directions between a sensor and a transmitter. The cable cannot guarantee that the data is correct, because the cable has no knowledge about the data transmitted between the parties. The data is just forwarded.

There is a very small delay of the data transmission related to the use of the cable, which is always below 100 µs. That means, that a bit physically sent at time t_1 at the transmitter arrives at the hardware of the sensor at the latest at t_1+100 µs and in the other direction it is the same. This does not take into account any delays of the bit interpretation (e.g. UART) components.

The cable is always in safe operation mode, there are no other modes.

Because the cable CYK10 SIL (its software) does not have a way of reading or tampering the data transmitted across the cable, the cable has to be recognized as a "grey channel" for the safety function of the complete measuring point.

2.2 Safety-related signal and safe state

The safety-related signal is the data transmitted.

The safe state is defined as:

- The data direction of the half duplex line is set from the transmitter to the sensor and is not changed anymore. No data communication from sensor to transmitter is possible anymore.
- The power of the sensor is switched off.

A restart is needed to leave the safe state.

2.3 Restrictions for the use in safety-related applications

The given environmental conditions have to be obeyed at all times. If used with the Liquiline M CM42 transmitter, the remarks and restrictions about the cable in the CM42 Technical Information and Operating Instructions have to be obeyed.

To reach the desired SIL level for the cable CYK10 SIL, the use of a safe transmission protocol (according to 50159-1) is mandatory. We recommend the use of the Memosens protocol in version V1.1 or higher. This protocol has been certified for Endress+Hauser Conducta GmbH & Co. KG for SIL2 and SIL3 applications (depending on safety message size) and works perfectly with the cable CYK10 SIL.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Additional mandatory restrictions for the use of the cable CYK10 in safety related applications:

- The installation, commissioning, operation and maintenance of the system must only be carried out by trained technical personnel. The personnel must be authorized to perform the necessary tasks.
- This safety manual must be read and fully understood by the technical personnel before working on/with the system.
- Use of the cable at an average environment temperature of 60°C/140°F (the calculations of the failure rates have been based on this assumption).
  If higher temperatures shall be applicable, please contact Endress+Hauser service.
- At installation time it has to be checked, that a SIL capable CYK10 cable is used (look for the nameplate with the SIL- and TÜV logo). This can not be checked by the transmitter or the sensor in operation.
- The minimum and maximum cable lengths have to be obeyed (3m…100m).
- The cable has to be checked for defects and damages before using it.
- Knots and bends are not allowed in the cable.
- Before going into operation, it has to be checked, if any metal masses are close to the cable head, which can influence the inductive transmission of the cable and the sensor.
- The connections of the cable to the transmitter and the sensor have to be checked thoroughly before entering operational state.
- The environmental conditions of IEC 61326-3-2 have to be obeyed.
- Storage temperature: 0°C/32°F … 80°C/176°F
- Environmental temperature: -15°C/ 5°F … 60°C/140°F for SIL applications
- Voltage supervision has to be realized in the transmitter the cable is connected to. Liquiline M CM42 fulfills this requirement.
- The maximum allowed electrical power is approx. 15 mW including the connected sensor. Liquiline M CM42 SIL in combination with an E+H SIL sensor fulfills this requirement.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

2.4 Functional safety parameters

The table shows the specific functional safety parameters for single channel device operation:

Parameters according to IEC 61508	**Memosens Cable CYK10**
Safety function	transmission of data
SIL	Hardware: 2, Software: 3 in homogenous redundancy: 2 or 3
HFT	0
Device type	B
Mode of operation	Low demand mode
SFF	90.4 %
MTTR (used for PFDavg calculation)	8 h
T_1 (Proof test interval)	Recommended: 1 year, see chart below
λ_{SD}	0 FIT
λ_{SU}	47 FIT
λ_{DD}	146 FIT
λ_{DU}	21 FIT
λ_{Total} *1	214 FIT
PFD_{avg} (for T_1 = 1 year) *4	0.9×10^{-4}
PFH	2.1×10^{-8}
MTBF / $MTBF_{DU}$ *1	535 years / 5568 years
Diagnostic test interval *2	< 5 min (RAM), otherwise < 10 s
Error reaction time *3	< 5 min (RAM), otherwise < 10 s
DC_D (Diagnostic coverage dangerous)	88 %

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

*1 According to Siemens SN29500 at 60°C/140°F. MTBF calculated as reciprocal of PFH/ λ_{Total} , assuming constant failure rate.

*2 During this time all diagnostic functions are completed at least once.

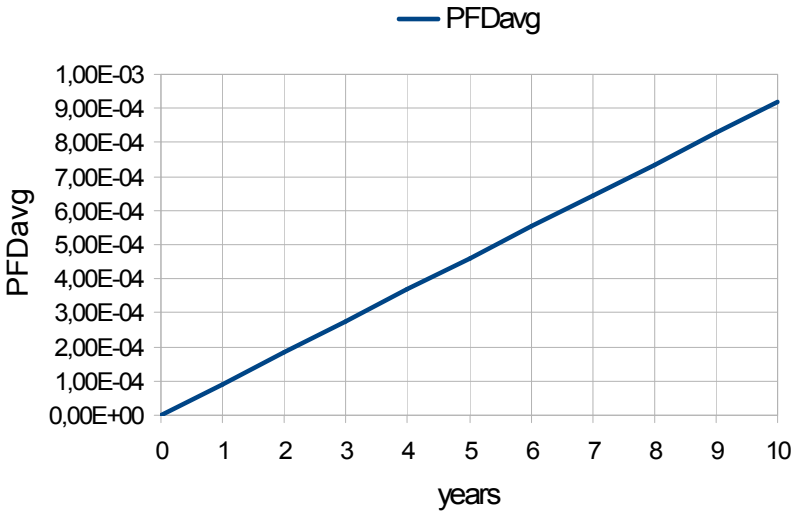
*3 Time between failure detection and failure reaction.

*4 Of course you can choose different (e.g. longer) proof test intervals. Choose the one suited for your application by using the chart given below.

Note!

For the calculation of the PFDavg a Markov model for a 1oo1D system was used.

External power supply failure rates are not included. Wear out mechanisms are not included, failure rates are assumed to be constant.



Proof test interval depending on PFDavg for the 1oo1D structure of the cable CYK10.

Years = examples of proof test intervals

Dangerous undetected failures in this scenario:

A dangerous undetected failure is defined as a tampered digital data signal, which is not detected by the protocol used.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Useful lifetime of electronic components:

The underlying failure rates apply within the useful lifetime according to IEC 61508-2 Clause 7.4.7.4 Note 3 [IEC61508:2000] or Clause 7.4.9.5 Note 3 [IEC61508:2010]. Other values can be used from experience of the previous use in a similar environment.

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

According to IEC 61508-2 section 7.4.7.4 a useful lifetime based on experience should be assumed.

Note!

The safe operation of the cable CYK10 SIL requires a correct installation according to chapter 2.3.

2.5 Behavior of the device when in operation and in case of failure

2.5.1 Behavior of the device when switched on

After the device is switched on, the cable is running all self diagnostics. This takes a maximum of 0.5 seconds.

During this time, the sensor is not supplied with power and no data is transmitted at all. After this initial start-up phase, the cable is in safe operation mode.

2.5.2 Behavior of the device on demand

If an internal error is detected, the cable enters the safe state within the error reaction time (see chapter 2.2). All other errors have to be detected by the sensor or the transmitter and have to be handled there.

2.5.3 Behavior of the device in the event of alarms and warnings

The cable CYK10 does not know of any alarms or warnings itself and therefore it can not communicate any alarms/warnings to its environment.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

3 Installation

Mounting, wiring and commissioning

The mounting, wiring and commissioning of the cable is described in chapter 11.

All remarks in chapter 2.3 have to be obeyed.

Orientation

There are no restrictions to the orientation of the cable, except the restrictions in chapter 2.3.

4 Operation

4.1 Calibrating the measuring point

Calibration of the cable is not necessary.

4.2 Method of device parameterization

There is no parameterization of the cable.

5 Maintenance, recalibration

If necessary (depending on the application), it is recommended to clean the cable occasionally, especially the cable head.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

6 Proof test

6.1 Proof test

Safety functions must be tested at appropriate intervals to ensure that they are functioning correctly and are safe.

The time interval must be defined by the operator (refer to chapter 2.4).

Proof testing must be carried out in accordance with the procedure described in the next chapter.

If several devices are used in MooN ("M out of N") votings, the proof test must be performed separately for each device.

In addition, checks must be carried out to ensure that all restrictions for the operation are still obeyed (see chapter 2.3).

6.2 Testing to ensure its safe functioning

You need a sensor and a transmitter capable of doing this test, e.g. a Liquiline M CM42 SIL with e.g. an Orbisint CPS11D SIL sensor.

- Connect the cable to the sensor and the transmitter, e.g. the Orbisint CPS11D SIL sensor and the Liquiline M CM42 SIL transmitter.
- Switch off the transmitter, so that the cable and the sensor are switched off, too.
- Switch on the transmitter and wait until the sensor has been identified by the transmitter showing information about the connected sensor.
- Start a special check routine ("cable proof test") on the transmitter (for details see safety manual of the transmitter) to start a dedicated communication check between the transmitter and the sensor using the cable. This will take less than 30 seconds.
    - During the test, the check routine of the transmitter counts the detected errors. If no errors have been detected, the cable has passed the proof test.
    - If errors are reported by the transmitter check routine, check if the sensor is connected correctly to the cable and repeat the proof test. If the proof test has failed again (or two times out of three tries), you have to replace the cable.

The proof test has to be documented with date, tester and the result (see example in chapter 9).

This test detects approx. 90 % (proof test coverage) of all possible dangerous undetected device failures.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

Note!

Please see also the section "Maintenance, recalibration" in chapter 5.

Note!

If one of the above described proof criteria is not met, you are not allowed to use the device as a part of a safety related system anymore.

The proof test is used to detect random failures. The influence of systematic errors on the safety function is not covered by this test and has to be considered separately. Systematic errors can for example be forced by medium properties, environmental conditions, corrosion, etc.

7 Repair – safety relevant messages

The device must not be repaired. In case your device does not work reliably (NOT caused by normal aging,) please fill in the form "Declaration of de-contamination" on **www.endress.com/service** - support - returned material or copy the last but one side of this manual and send it together with the clean device back to your local service address.

Our R&D will check the device then. If the reason for error is safety relevant we will replace your device.

8 Notes on the redundant use of multiple cables for SIL 3

The cable fulfils the requirements of SIL3, if it is used in a homogenous redundant setting with HFT 1 (for example as 1oo2 or 2oo3).

The common cause factors β and β_D indicated in the table below are minimum values.

These values should be used when calculating the failure probability of redundantly connected units as per IEC 61508-6.

The system-specific observation can return higher values depending on the actual installation and the use of other components (e.g. Ex barriers).

Minimum value β with homogeneous redundant use	5 %
Minimum value β_D with homogeneous redundant use	2 %

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

9 Proof test protocol example

You can use the following table for the documentation of the proof test.

Application Specific Data	
Company	
Measuring point	
Facility	
Device type: approx. length:	CYK10, SIL m/ft
Serial number	
Errors detected by transmitter?	O yes O no
Checked restrictions for use	O yes O no
PFD_{avg} value before proof test	
PFD_{avg} value after proof test	
Date of last proof test	
Date of next proof test (estimated)	
Name of tester	
Date	
Signature	

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

10 PFD_{avg} computation examples

In this chapter we provide some examples to compute the PFD_{avg} values of a measuring chain and the PFDavg value after doing proof tests.

Remark: $PFD_{avg}(T) = 1/T \int_0^T (\lambda_{DU}\, t)\, dt = ½\, \lambda_{DU}\, t$ (for a 1oo1D system, assuming constant and small failure rate λ_{DU}). Usually PFD_{avg} is given without a parameter T, which means this is the value of PFD_{avg} at time T of the mandatory proof test.

10.1 Example to calculate PFD_{avg} after a proof test

The aim of a proof test is to show, that the system does not have any dangerous undetected failures. The proof test coverage denotes the effectiveness of the proof test.

So after the proof test has been successfully finished, the systems PFD_{avg} value has been "improved" and you can determine when the next proof test has to be carried out.

Here we use the Memosens cable CYK10 SIL in a 1oo1D setting for the example.

Assumptions for this example:

Proof test is done after two years of operation, because the system is not allowed to have a higher PFD_{avg} than 1.80×10^{-4} at all times.

Initial PFD_{avg} of new cable: $PFD_{avg}(0) = 0$

PFD_{avg} of a two year old cable: $PFD_{avg}(2\ \text{years}) = 1.80 \times 10^{-4}$

assuming $\lambda_{DU} = 2.05 \times 10^{-8}$ 1/h (= 20.5 FIT) and

where $PFD_{avg}(t) = 1/2 \times t \times \lambda_{DU}$, t in hrs.

Then you do the proof test (follow the CM42 menu guidance) successfully.

Proof test coverage is (see Memosens cable safety manual): 90%.

New values **after the proof test** has been successfully finished:

New PFD_{avg} value after two years and after a successful proof test

$PFD_{avg}(2\ \text{years; proof test successful}) = 1.80 \times 10^{-4} \times (1.00 - 0.90) = 0.18 \times 10^{-4}$

PFD_{avg} value after two additional years (no additional proof test done yet):

$PFD_{avg}(4\ \text{years}) = 0.18 \times 10^{-4} + 1.80 \times 10^{-4} = 1.98 \times 10^{-4}$

Further questions:

What is the time period T, after which the $PFD_{avg}(t)$ value of this once "proof tested system" reaches again 1.80×10^{-4}?

Find T, where $PFD_{avg}(T) = 1.80 \times 10^{-4}$

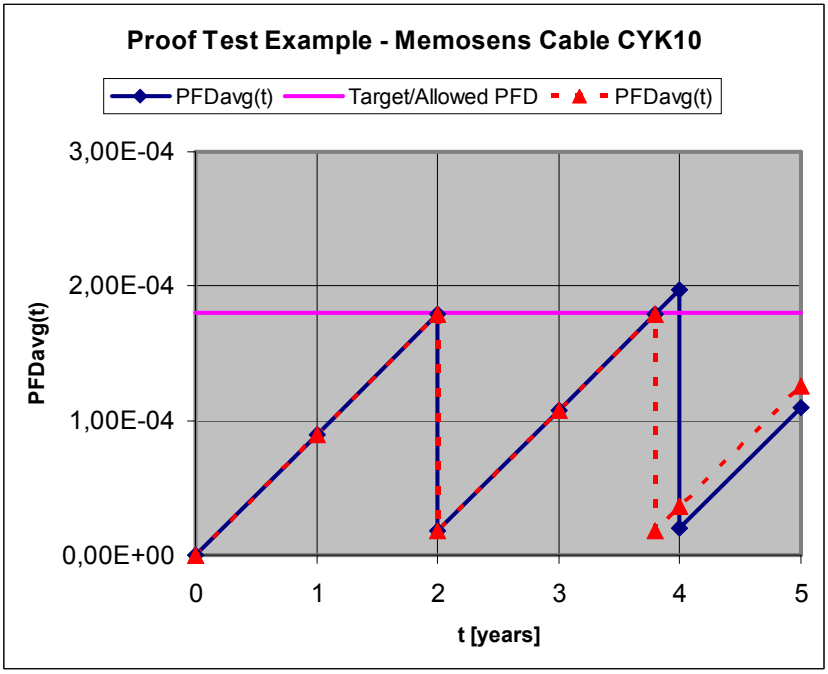
Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

$$=> 1.80 \times 10^{-4} = 0.18 \times 10^{-4} + 0.50 \times \lambda_{DU} \times T$$

$$=> T \text{ in years: } T = 0.9 \times 2.0 \text{ years} = 1.8 \text{ years} = 21.6 \text{ months}$$

And therefore the proof test interval T after the first "incomplete" proof test with a proof test coverage of 90%, will be smaller than two years.



The dotted line is the $PFD_{avg}(t)$ value, if the proof test is done after 2 years and 21.6 months. The solid line, if the proof test is done after 2 years and 4 years. And the straight horizontal line denotes the limit of the PFD_{avg} value given by the customer.

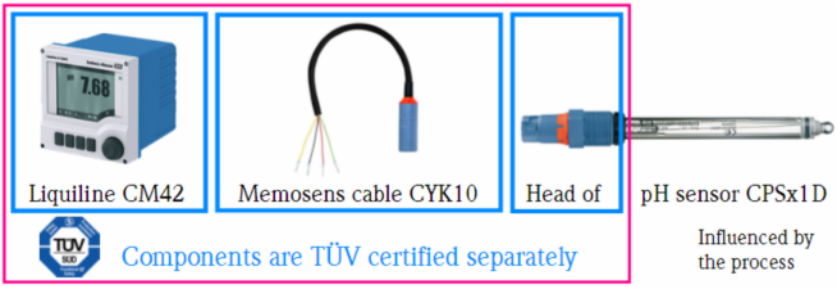
10.2 PFD_{avg} computation example for a pH measuring point

Note!

The following example can be used as the result for the safety parameters of the complete Endress+Hauser pH SIL measuring chain (see table at end of chapter).

Assume we have a measuring point consisting of the following components from Endress+Hauser:

1. Memosens pH glass sensor Orbisint CPS11D SIL
2. Memosens cable CYK10 SIL
3. Memosens transmitter Liquiline M CM42 SIL



The measuring chain is connected to a PCS (e.g. a PLC), which is itself connected to some kind of actor to activate the safe state.

You can calculate the PFD value of the complete chain (PFD_{avg} mc; mc means measuring chain) by summing up the individual PFD values of all components in the chain, including the communication protocol (here the Memosens protocol):

PFD_{avg} mc = PFD_{avg} sensor
+ PFD_{avg} cable
+ PFD_{avg} transmitter
+ PFD_{avg} Memosens protocol)

Then for a complete safety instrumented system (SIS) you get:

PFD_{avg} sis = PFD_{avg} mc
+ PFD_{avg} PCS
+ PFD_{avg} actor

As an example, the value of the complete (non-redundant) Endress+Hauser pH measuring chain, described at the beginning of this section, we get
(The Memosens protocol has been taken into account with 1% of the PFD SIL2 value = 1.0 E-4):

PFD_{avg} mc = 8.3 E-4 + 0.9 E-4 + 10.3 E-4 + 1.0 E-4 = **20.5 E-4**
(Proof test intervals are chosen to be 1 year for all devices)

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

According to IEC 61508 you need a maximum PFD_{avg} of 1E-2 to realize a SIL-2 SIS. So the just calculated value accords to about 21% of the SIL-2 PFD_{avg} value. That means the PCS and actors can use the remaining 79% of the SIL-2 PFD_{avg} value.

Of course, you also have to calculate and use the SFF given in the IEC 61508 to fulfil all requirements of the standard.

For the SFF of this specific chain you get:

SFF mc = **93.8 %** with

SFF_{sensor} = 92.3 %,

SFF_{cable} = 90.4 % and

$SFF_{transmitter}$ = 94.8 %.

The table shows the specific functional safety parameters for a single-channel device operation:

Parameters according to IEC 61508	E+H Memosens pH SIL measuring chain
Safety Function	1: pH limit monitoring 2: pH value measurement 3+4: safe calibration and adjustment
SIL	Hardware: 2, Software: 2 in homogenous redundancy: 2
HFT	0
Device Type	B
Mode of Operation	Low demand mode
SFF	93.8 %
MTTR (used for PFD calculation)	8 h
T_1 (Proof test interval)	Recommended: 1 / 1 / 1 year, (sensor / cable / transmitter)
λ_{SD}	688 FIT
λ_{SU}	1623 FIT
λ_{DD}	4473 FIT
λ_{DU}	447 FIT
λ_{Total} *1	7238 FIT
PFD_{avg} (for T_1 = 1 / 1 / 1 year) *4	19.6×10^{-4}
PFH	4.5×10^{-7}
MTBF *1	15 years
Diagnostic-Test-Interval *2	< 60 min
Error Reaction Time *3	< 10 seconds
DC_D (Diagnostic Coverage Dangerous)	91 %

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

[*1] According to Siemens SN29500 at 60°/100° Celsius. MTBF calculated as reciprocal of PFH/ λ_{Total}

[*2] During this time all diagnostic functions are completed at least once.

[*3] Time between failure detection and failure reaction.

[*4] Of course, you can choose different (e.g. longer) proof test intervals. Choose the one suited for your application.

Note!

These values do NOT include the PFD/SFF values of the used voter, used voltage supply and the sensor element in contact with the medium. Nor does it take into account any medium interactions with the sensor element.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

11 General and technical information about the Memosens cable CYK10 SIL

11.1 General information

11.1.1 Maximum process safety

The inductive and non-contacting measured value transfer of Memosens guarantees maximum process safety and offers the following benefits:

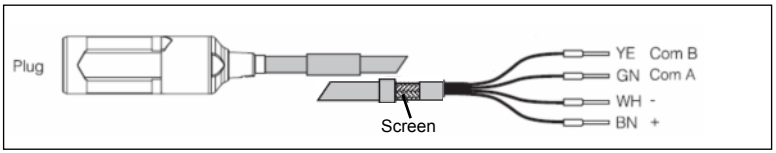
- All problems caused by moisture are eliminated
  - The plug-in connection is free from corrosion
  - Measured value distortion from moisture is not possible
  - The plug-in system can even be connected under water (IP68)
- The transmitter is galvanically decoupled from the medium. The result: no more need to ask about “symmetrically high impedance” or “unsymmetrical” or an impedance converter.



Memosens coupling, no open contacts

11.2 Technical information

11.2.1 Cable connection



Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

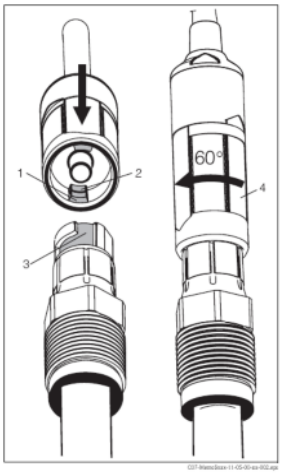
All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Please refer to the notes on sensor connection in the Operating Instructions of the used transmitter.

11.2.2 Handling of sensor plug-in head and cable coupling

To put the cable coupling onto the sensor plug-in head, please proceed as follows:

1. Rotate the lower part of the coupling in such a way that the two pairs of keys (pos. 1, 2) are located above each other.
2. Plug the coupling onto the plug-in head so that the keys engage in the slots of the plug-in head (pos. 3).
3. Turn the lower part of the coupling (pos. 4) clockwise as far as possible (approx. 60°). Doing so locks the coupling and prevents the connection from opening inadvertently. Open the connection in the reverse sequence of operations



Handling of sensor plug-in head and cable coupling

11.2.3 Environment

Ingress protection: IP68 (10m/32.18ft water column, 48 days, 1M KCl, 25°C/77°F)

Environmental temperature: -15°C/ 5°F … 135°C/275°F in general, for SIL applications: max. 60°C/140°F have to obeyed.

Storage temperature: 0°C – 80°C / 32°F - 176°F

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

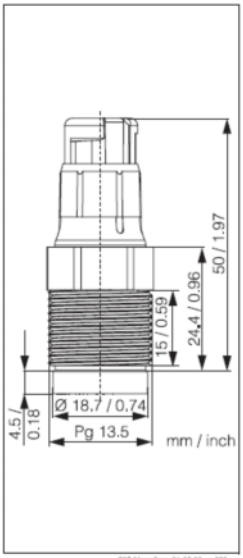
All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

11.2.4 Electrical properties

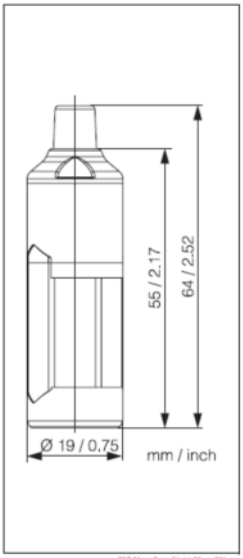
Input Voltage:	3.08 V ± 0.09 V
Inductance:	0.6 µH/m at 1 kHz
Capacitance:	42 nF/km at 1 kHz
Characteristic Impedance:	120 Ω
Input Power:	allowed 10 – 18 mW, optimum at 15mW (at 3.08V)

11.2.5 Mechanical construction

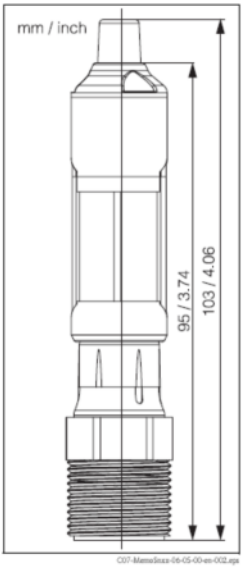
Dimensions



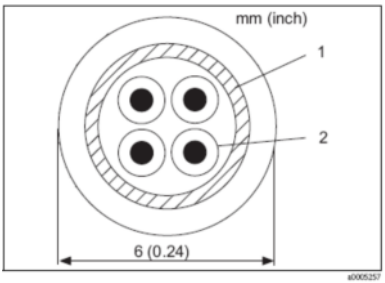
Dimensions of Memosens sensor plug-in head with HDA thrust collar



Dimensions of Memosens cable coupling



Dimensions of Memosens in plugged-in state



Materials	Coupling:	PEEK
	Sheath:	TPE
Cable specification	Diameter:	6 mm/0.24"
	Cores:	2x2 cores, twisted pair
	Length:	3 m up to 100 m/328 ft
	Tensible strength:	> 500N
	Cable weight:	about 43kg / km

The transmitter provides power supply for the plug-in system's electronics. If the cable is too long, the voltage drops, possibly resulting in a system failure. An alarm is triggered by the transmitter then.

11.2.6 Certificates and approvals

Ex approvals for SIL ATEX
FM/CSA/NEPSI pending
II 1G Ex ia IIC T3/T4/T6
IS/NI CL I DIV 1&2 GP ABCD
Further Ex approvals are available without SIL.

EMC compatibility Interference emission and interference immunity complies with EN 61326:1997/A1:1998 and IEC 61326-1:2006, IEC 61326-2-3:2006

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

11.2.7 Order codes of the Memosens cable CYK10

CYK10-				Complete order code
010	Approvals			
	A **G** L O S T V	Safe area **ATEX/FM/CSA/NEPSI** **II 1G Ex ia IIC T3/T4/T6** **IS/NI CL I DIV 1&2 GP ABCD** LABS free, safe area FM IS CL I DIV I Gr A-D CSA IS CL I DIV I Gr A-D TIIS Ex ib ATEX/NEPSI II 3G nL IIC		
020		Cable length		
		03 05 10 15 20 25 88 89 **90** **91**	3m 5m 10m 15m 20m 25m …m length …ft length **…m length, SIL** **…ft length, SIL**	
030			Cable connection	
			1 2	**Ferrules** M12 connector

Note!

Only the options printed in bold type are SIL certified.

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

Endress+Hauser

People for Process Automation

Declaration of Hazardous Material and De-Contamination

RA No. ☐☐☐☐☐☐☐

Please reference the Return Authorization Number (RA#), obtained from Endress+Hauser, on all paperwork and mark the RA# clearly on the outside of the box. If this procedure is not followed, it may result in the refusal of the package at our facility.

Because of legal regulations and for the safety of our employees and operating equipment, we need the "Declaration of Hazardous Material and De-Contamination", with your signature, before your order can be handled. Please make absolutely sure to attach it to the outside of the packaging.

Type of instrument / sensor _____ **Serial number** _____

☐ **Used as SIL device in a Safety Instrumented System**

Process data

Temperature _____ [°F] _____ [°C] Pressure _____ [psi] _____ [Pa]

Conductivity _____ [µS/cm] Viscosity _____ [cp] _____ [mm²/s]

Medium and warnings

	Medium /concentration	Identification CAS No.	flammable	toxic	corrosive	harmful/ irritant	other *	harmless
Process medium								
Medium for process cleaning								
Returned part cleaned with								

* explosive; oxidising; dangerous for the environment; biological risk; radioactive

Please tick should one of the above be applicable, include safety data sheet and, if necessary, special handling instructions.

Description of failure _____

_____

_____

Company data

Company _____ Phone number of contact person _____

Address _____ Fax / E-Mail _____

_____ Your order No. _____

"We hereby certify that this declaration is filled out truthfully and completely to the best of our knowledge. We further certify that the returned parts have been carefully cleaned. To the best of our knowledge they are free of any residues in dangerous quantities."

(place, date) Name, dept. (please print) Signature

Alle Rechte vorbehalten. Das Kopieren dieses Dokuments und die Verwendung von Teilen aus diesem Dokument ist ohne schriftliche Genehmigung der Endress+Hauser Conducta GmbH+Co. KG nicht erlaubt.

All rights reserved. Passing on and copying of this document, use and communication of its contents not permitted without written authorization from Endress+Hauser Conducta GmbH+Co. KG.

71107781