OPW Fluid Transfer Group Europe BV

Probe safety manual

For the 2- and 5-wire probe product line

Engineering Department
4-1-2022

Revision A.0

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1. Introduction

1.1. General

There are seven different probe models. Table 1.1 lists them all. Throughout this document the descriptor “the probe” will be used for all models. SIL capable probes are marked with the text “SIL 2 – IEC 61508”

Probe model	Probe type	Description
5300E	5-wire overfill	5-wire probe with European wire colors
5300N	5-wire overfill	5-wire probe with North-American wire colors
5350E	2-wire overfill	2-wire ROM probe with red/black wires
5650E	2-wire overfill	2-wire RACK probe with black/white wires
5650U	2-wire overfill	2-wire RACK probe with gray/gray wires
5030U	2-wire retain	2-wire retain probe with gray/gray wires, low frequency
5000E	2-wire retain	2-wire retain probe with red/black wires, high frequency

Table 1.1 probe model overview

1.2. Purpose of this document

This document contains information and safety instructions that you will require when using the probe in safety-instrumented systems.
It is aimed at system planners, constructors, service and maintenance engineers and personnel who will commission the device.

1.3. Additional documentation

This documentation is exclusively for the safety function of the probe. Table 1.2 shows which other documents are important with respect to the probe.

Document	Purpose
DS00450_A8	Installation and technical documentation
EN13922:2020	Working principle and signal compatibility

Table 1.2 Additional documents

1.4. Change history

Table 1.3 shows all the released versions of this document.

Edition	Document name	Notes	Date
A.0	H7290_A0	First edition	04-Jan-2022

Table 1.3 document change history

1.5. Further information

The instructions in this document won’t add to or modify any existing agreement, commitment or legal relationship. Any statements contained in this document do not create new warranties.

2. General safety instructions

2.1. Safety instrumented system

2.1.1. Safety instrumented system

A safety instrumented system is responsible for executing the safety functions that are required to achieve a safe status in a system. A safety instrumented system consist of a sensor, logic unit or control system and a final controlling element.

A typical example for the probe:
A system made up of multiple probes connected to a RACK monitor (sensor), a PLC to read the RACK status (control system) and a control valve (final controlling element).

2.1.2. Safety function

A defined function executed by a safety instrumented system with the objective of achieving or maintaining a safe state. The safe state takes a defined dangerous occurrence into account.

2.1.3. Dangerous undetected failure

Failure with the potential of causing a dangerous state in the safety instrumented system. This document exclusively describes the probe as part of a safety function.

2.1.4. Function

The probe sends out an IR pulse and measures it back with a prism. When the prism get's wet the breaking index of the prism changes. The probe can measure this and will go to a non-permissive state when this happens.

2.2. Safety Integrity Level (SIL)

Four discrete Safety Integrity Levels (SIL) are defined in the IEC 61508:2010. The rating is given over the entire safety instrumented system. A higher SIL rating of the safety instrumented system means a higher probability the required safety function will be executed correctly.
The achievable SIL rating is determined by the following characteristics:

- Average probability of dangerous failure of a safety function in case of demand (PFD_{AVG})
- Hardware fault tolerance (HFT)
- Safe failure fraction (SFF)

Table 2.1 shows the relation between PFD_{AVG} and the SIL rating.

SIL	PFD_{AVG}
4	$\geq 10^{-5} \ldots < 10^{-4}$
3	$\geq 10^{-4} \ldots < 10^{-3}$
2	$\geq 10^{-3} \ldots < 10^{-2}$
1	$\geq 10^{-2} \ldots < 10^{-1}$

Table 2.1 Safety Integrity Levels

Table 2.2 shows the achievable SIL for the entire safety instrumented system for type B systems depending on the safe failure fraction (SFF) and the hardware fault tolerance (HFT). Type B systems contain complex components. For example a microcontroller. See IEC61508:2010 section 2.

SFF	HFT		
	0	1	2
< 60%	Not allowed	SIL 1	SIL 2
60% … 90%	SIL 1	SIL 2	SIL 3
90% … 99%	SIL 2	SIL 3	SIL 4
> 99%	SIL 3	SIL 4	SIL 4

Table 2.2 Relation SFF and HFT for type B systems

3. Device specific safety instructions

3.1. Applications

The probe specifies the requirements in terms of functional safety to SIL 2 in accordance with IEC 61508:2010 and IEC 61511-1:2017.

3.2. Safety function

The probe is designed for applications to detect an overfill of hydrocarbons. The optic head and the oscillating output are part of the safety function. A dangerous undetected failure occurs when the output of the probe still oscillates and the optic head became wet from a hydrocarbon or water.

3.3. Installation

Sensors must be installed according to the DS00450 installation manual by qualified personnel. The wires should be properly connected and sealed to avoid corrosion and loose wires. The extension tube and junction box should be free from any liquid intrusions.

3.4. Behavior in case of faults

In case of a dangerous undetected failure the probe will always give a permissive signal on the output, although the optic head is wet. For all other failures the output will give a non-permissive signal.
In case of a safe failure the optic head should be checked for any residue and cleaned. The mean time for maintenance in this case is the time it takes to unmount and remount the device in the truck. If the failure persists after cleanup, or no residue is visible on the probe, return the probe to the vendor with a return material authorization (RMA) form. Repair is not possible.
When ordering replacement devices specify the probe model needed. The model can be found on the probe in the bottom right of the engraved image.

Please note that in the case of 5-wire probes searching for faults isn't always straightforward. For example consider a tank-truck with two probes. If the output of the first probe is broken any testing equipment will indicate a fault in compartment 2. To validate the source of the fault it's recommended to measure the output of probe 1 and look at the LED pattern of probe 2. Also check the wiring between the probes as this is a common source of failure. Table 3.1 shows the relation between the output, the LED pattern and the conclusion.

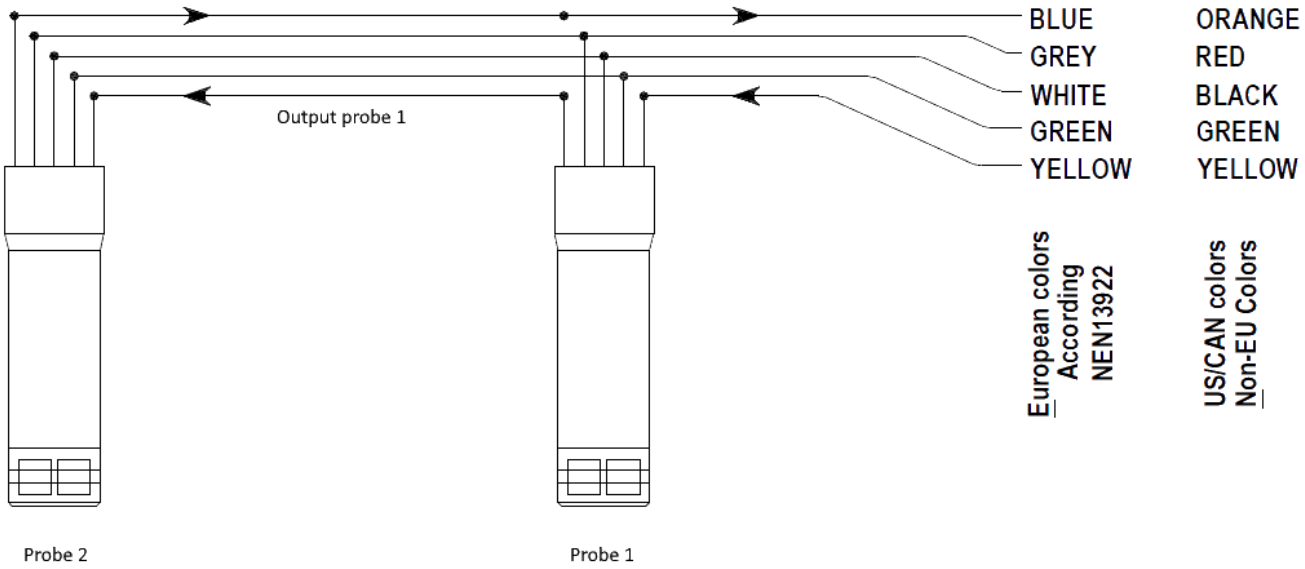

Figure 3.1 Example probe setup

Probe 1 output signal	Probe 2 LED pattern	Conclusion
Non-permissive	Blinking RED	Both probes faulty
Non-permissive	Blinking RED - GREEN	Probe 1 faulty
Permissive	Any	Probe 2 faulty

Table 3.1 Searching for faults in 5-wire systems

3.5. Maintenance

It's recommended to check the safety function of the probe once every four years. Table 3.2 and Table 3.3 show the recommended test procedure. The useful lifetime of the device is 15 years.

Step	Action
1	Connect any EN13922 compatible rack monitor, onboard monitor or sensor test equipment
2	Validate that the test equipment indicates a permissive state for all probes and replace any probes that are faulty.
3	Make the optic head of a probe in a single compartment wet.
4	Check if the correct compartment went to non-permissive according to the test equipment. When no probe compartment is detected as non-permissive replace the probe that was just tested. When the wrong probe is detected as non-permissive check wiring.
5	Return to step 3 until all probes are tested

Table 3.2 Probe test procedure 2-wire

Step	Action
1	Connect any EN13922 compatible rack monitor, onboard monitor or sensor test equipment
2	Validate that the test equipment indicates a permissive state for all probes and replace any probes that are faulty.
3	Make the optic head of a probe in a single compartment wet.
4	Check if the correct compartment went to non-permissive according to the test equipment. When no probe compartment is detected as non-permissive replace the probe that was just tested. When the wrong probe is detected as non-permissive check probe outputs and LED's as described in paragraph 3.4 and replace the faulty probe.
5	Return to step 3 until all probes are tested

Table 3.3 Probe test procedure 5-wire

3.6. Safety characteristics

The safety characteristics necessary for use of the system are listed in the SIL declaration of conformity (see Appendix A). These values apply under the following conditions:

- The optic head of the probe has 50 mm of free space on all sides, see Figure 3.2.
- The RACK monitor used the read the probe status is EN13922 compatible.
- The work area where the probe operates is free from IR radiation.
- Probes are designed for liquid measurement of liquid hydro carbons, hydro carbon ethanol mixes and water only.
- Electrical characteristics of probe as specified in DS00450 are not to be exceeded.
- Temperature range: -40 °C … +70 °C (-40 °F … 158 °F)
- Maximum operating pressure in a compartment: 1 barg.

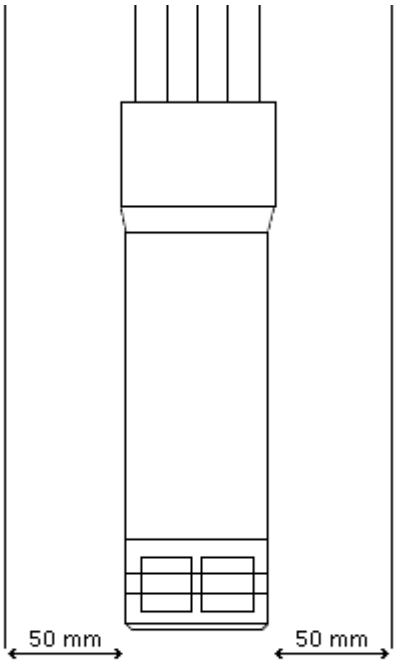

Figure 3.2 Recuired clear space

Appendix A

SIL Declaration of conformity

CONSILTANT

Certificate of compliance

Optic liquid level sensors

OPW Fluid Transfer Group Europe BV

Product identification	- 5-wire models 5300E and 5300N - 2-wire models 5350E, 5650E, 5650U, 5030U and 5000E
Certification basis	- IEC 61508:2010, parts 1, 2 and 3 - IEC 61511:2017, part 1 - EN 13922:2020
Assessment basis	- FMEA studies - Feedback from the installed base - Audit which confirms OPW's implemented management system
Assessment results	
Architecture type	B
SFF	>90%
Systematic capability	SC 2
λ_{DU}	$1.1 \cdot 10^{-9}$ / hour
PFD_{avg}	$3 \cdot 10^{-5}$ (single sensor, test interval: 4 years)
Condition	The output signal of the sensors is pulsed. The pulsed signal disappears if the sensor is wetted. Sensor failure leads as well to loss of the pulsed signal. The Monitor (convertor unit between sensor(s) and Clients safety system) shall detect disappearance of the pulsed signal and immediately switch over to non-permissive status.
Sensor integrity	**SIL 2**
Reference documents	doc. 21040-1 SIL assessment report doc. H72790 Probe safety manual
Certificate number	21040A
Issue date	4 January 2022
Expire date	4 January 2027

Herman Jansen
TÜV certified FS expert

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