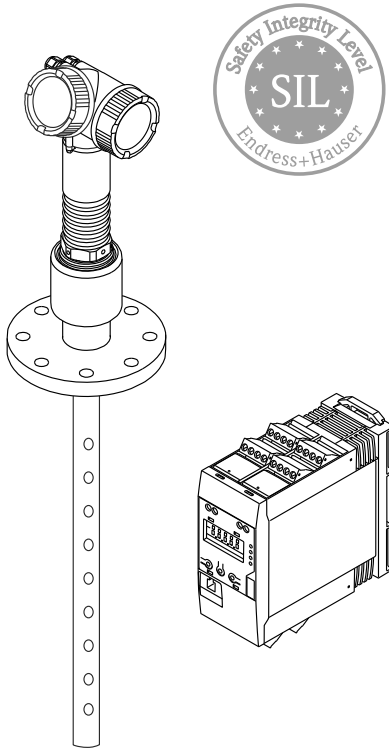


# Planning instructions for steam boiler approval **Levelflex FMP54 and FMP54** with process transmitter **RMA42**

Guided level radar as a limiting device  
for low water and high water levels



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## Introduction

### Supplementary device documentation

Documentation	Contents	Comment
SD00349F/00/EN	Levelflex FMP54, Levelflex FMP54 and process transmitter RMA42 or RMA422 – Guided level radar as a limiting device for low water and high water levels	Safety instructions for steam boiler approval
SD00326F/00/EN	Levelflex FMP50/51/52/53/54/55/56/57 – Guided level radar for liquids and bulk solids with 4 to 20 mA output signal	Functional Safety Manual
SD00025R/09/EN	RMA42 – Process transmitter	Functional Safety Manual
TI01001F/00/EN	Levelflex FMP51, FMP52, FMP54 – Guided level radar Level and interface measurement in liquids	Technical Information

## Wiring scheme options



The following standards define the requirements for the equipment of steam boiler systems, in particular for water level limiters for low water levels (LWL) and high water levels (HWL):

- EN 12952-7: "Water-tube boilers and auxiliary installations - Part 7: Requirements for equipment for the boiler"
- EN 12953-6: "Shell boilers - Part 6: Requirements for equipment for the boiler"

The standards EN 12952-11, section 4.1.1 and EN 12953-9, section 4.1.1 stipulate that: A limiter must be designed in such a way that a single error in any of the assigned components does not result in the loss of the safety function.

For this reason, the following wiring scheme options are possible:

Architecture	Number of FMP54 or FMP54 and RMA42
1oo2	<ul style="list-style-type: none"> <li>▪ 2x FMP54</li> <li>▪ 2x FMP54 and 2x RMA42</li> </ul>
2oo3	<ul style="list-style-type: none"> <li>▪ 3x FMP54</li> <li>▪ 3x FMP54 and 3x RMA42</li> </ul>

In general, for system availability reasons, the wiring scheme with three Levelflex devices is recommended.



Thanks to a signal comparison, "Predictive maintenance" is also possible, regardless of the safety function!

**Typical examples of wiring schemes**

The following diagrams show some (schematic) examples of the wiring scheme for the FMP54 or FMP54 and RMA42 when used in limiting devices. Additional wiring schemes, which are in compliance with the certificate (→ SD00349F/00/EN), are possible.



Where the devices are used as both controllers and limiters:

Absence of reaction as per EN 12952-11 or EN 12953-9, section 4.1.2:

Limiters must function independently of each other and independently of the control equipment, except in cases where the safety function cannot be compromised by these other devices.

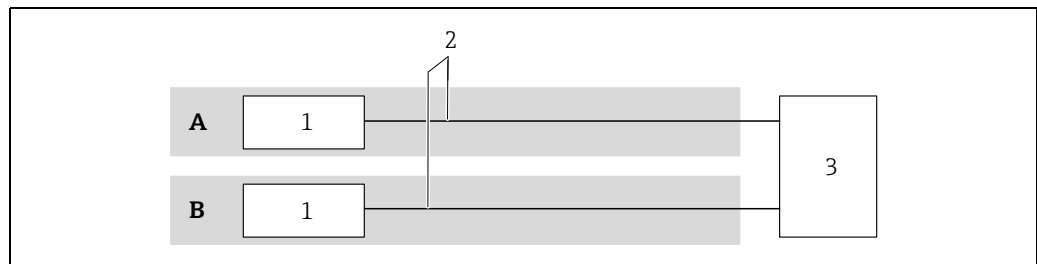
Extract from VDI/VDE 2180-3, section 2.2.1:

It is advisable to have a strict division between the protection functions and the functions of the PCS operating and monitoring equipment. If, however, there is an overlap, there must be no feedback from the non-safety-related component to the protection function.

Absence of reaction is guaranteed for the RMA42 because the output channels are galvanically isolated from each other.

**1oo2 architecture**

**Example 1a + 1b**



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**A** Channel 1

**B** Channel 2

**1a: 1x low water level (LWL), 1x high water level (HWL)**

1 Levelflex FMP54 (2-wire/4-wire)

2 4 to 20 mA wire

3 Safety PLC

1oo2 architecture:

- 1x low water level (LWL)
- 1x high water level (HWL)
- Signal comparison recommended

**1b: 2x low water level (LWL), 1x high water level (HWL)**

1 Levelflex FMP54 (2-wire/4-wire)

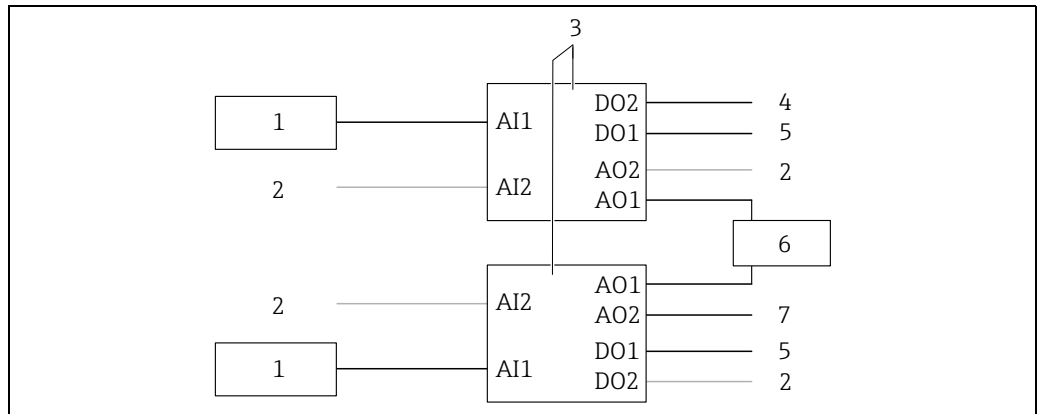
2 4 to 20 mA wire

3 Safety PLC

1oo2 architecture:

- 2x low water level (LWL)
- 1x high water level (HWL)
- Signal comparison necessary  
(comparison of channel 1 with channel 2)

**Example 1c**

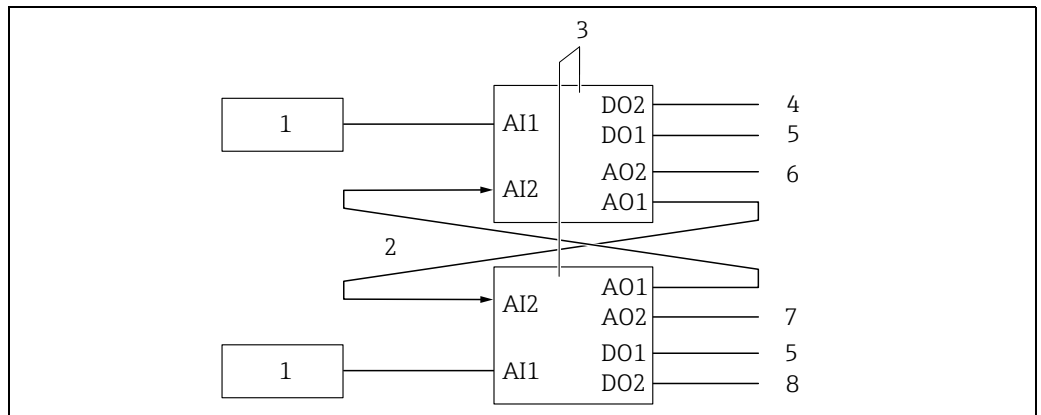


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**1c: 2x low water level (LWL), 1x high water level (HWL), level control**

- 1 Levelflex FMP54 (2-wire/4-wire)
  - 2 Not assigned
  - 3 RMA42
  - 4 High water level (HWL)
  - 5 Low water level (LWL)
  - 6 Signal comparison in safety PLC
  - 7 4 to 20 mA for level control
- AI Analog input  
 AO Analog output  
 DO Relay output

**Example 1d**



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**1d: 2x low water level (LWL), 1x high water level (HWL), level control**

- 1 Levelflex FMP54 (2-wire/4-wire)
  - 2 Signal comparison
  - 3 RMA42
  - 4 High water level (HWL)
  - 5 Low water level (LWL)
  - 6 4 to 20 mA (e.g. difference between sensor AI1 and sensor AI2) for predictive maintenance
  - 7 4 to 20 mA for level control
  - 8 Relay (e.g. difference between sensor AI1 and sensor AI2) for switch-off in the event of deviations between the sensor signals
- AI Analog input  
 AO Analog output  
 DO Relay output

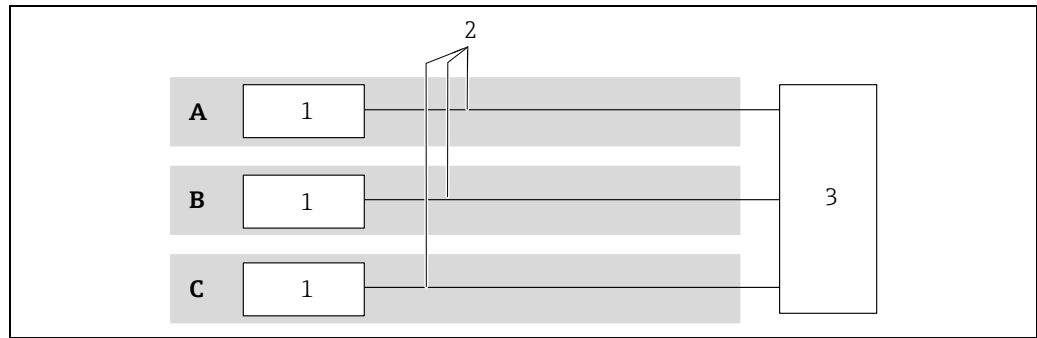
For these wiring scheme options, the use of an additional safety PLC is not required.

**2oo3 architecture**

This allows a possibly defective device to be replaced by blocking it off (bypass solution) while continuing to operate the boiler. The has the benefit of increased availability.

Alternatively, in the case of in-boiler instrumentation, a 1oo2 wiring scheme can be used until the next scheduled shutdown.

**Example 2a + 2b**



- A Channel 1
- B Channel 2
- C Channel 3

**2a: 1x low water level (LWL), 1x high water level (HWL), increased availability**


- 1 Levelflex FMP54 (2-wire/4-wire)
  - 2 4 to 20 mA wire
  - 3 Safety PLC
- 2oo3 architecture:
- 1x low water level (LWL)
  - 1x high water level (HWL)
  - Signal comparison recommended

**2b: 2x low water level (LWL), 1x high water level (HWL), increased availability**

- 1 Levelflex FMP54 (2-wire/4-wire)
  - 2 4 to 20 mA wire
  - 3 Safety PLC
- 1oo2 architecture:
- 2x low water level (LWL)
  - 1x high water level (HWL)
  - Signal comparison necessary
- (Comparison of channel 1 with channel 2, comparison of channel 2 with channel 3, comparison of channel 1 with channel 3)

## Application example

The following topics serve as the basis for key questions concerning the design of the system. An example is provided in each case for illustration purposes.

 This procedure can be applied in the same way to other applications.

### Function


Key question:  
What is the required function ?


Example:  
A limiting function (2x low water level (LWL), 1x high water level HWL) is required as well as a control function.

### Choosing the wiring scheme

Key question:  
How will the individual devices in the safety system be wired?

Example:  
In this example, the simplest possible instrumentation is favoured.


For this reason, the use of a safety PLC should be dispensed with, and the number of devices should be kept as small as possible.  
A 1oo2 architecture is chosen as the wiring scheme in accordance with example 1d (→  5) with 2x FMP54 and 2x RMA42.

 Alternatively, a 2oo3 wiring scheme could have been chosen here, which affords increased availability.

### Mounting location

Key question:  
Will the devices be installed directly in the boiler or in a bypass?

Example:  
To achieve the simplest possible instrumentation, they should be installed directly in the boiler.

 Alternatively, bypass instrumentation could have been chosen which, in the event of a revision, allows the measuring device to be closed off and replaced without switching off the system.

Key question:  
Is gas phase compensation required?

Example:  
The boiler is operated at 264 °C (507 °F) and 50 bar (750 psi). The measured error without gas phase compensation would, according to the table (→ TI01001F, "Performance characteristics" section, "Influence of gas layer" subsection), be 9.2% of the measured distance.  
The normal water level is 1200 mm (47.2 in) below the flange (reference point of FMP54). The measured error would therefore be 1200 mm (47.2 in) x 9.2% = 110 mm (3.94 in).

With gas phase compensation and using a reference length of 550 mm (21.7 in), the expected measured error at the same temperature is only 9 mm (0.35 in). Using a reference length of 300 mm (11.8 in), it is only 15 mm (0.59 in) (→ TI01001F, "Performance characteristics" section, "Gas phase compensation with reference signal" subsection).

Due to the higher level of accuracy, gas phase compensation with a reference length of 550 mm (21.7 in) is chosen in this case. In this situation, where the devices are installed freely in the boiler, the use of coaxial probes is required.

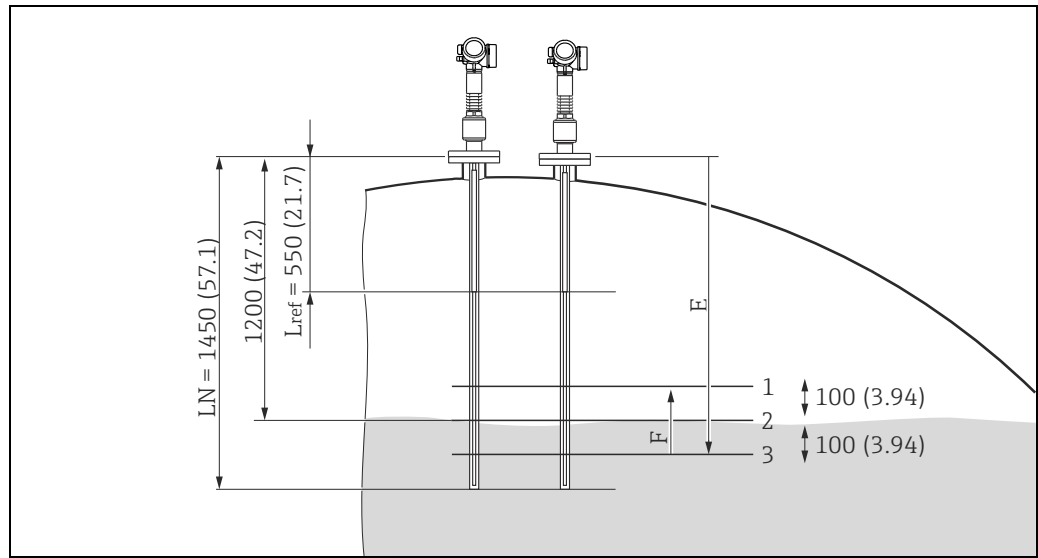
**Measuring range and switch points**

Key question:  
Where will the switch points and the control range be in relation to the mounting flange?

Example:

In this example, the normal water level is 1200 mm (47.2 in) below the flange. The high water level (HWL) and the low water level (LWL) are each at a distance of 100 mm (3.94 in) from the normal water level (NWL).

The control range shall be between the high water level (HWL) and the low water level (LWL). The reference distance ( $L_{ref}$ ) of 550 mm (21.7 in) is at a sufficient distance from the high water point (→ SD00349F/00/EN). The probe length selected is 1450 mm (57.1 in), which is somewhat greater than the low water level (LWL). This is because higher measurement uncertainties occur directly at the probe tip (→ TI01001F/00/EN).



- Dimensions: mm (in)
- LN Probe length
- Lref Reference distance
- 1 High water level (HWL)
- 2 Normal water level (NWL)
- 3 Low water level (LWL)
- E Empty calibration
- F Full calibration

When selecting the switch points (HWL and LWL), the following measured errors must be taken into account and added on:

- The application-related measurement uncertainty due to the gas phase is 9 mm (0.35 in) (→ TI01001F/00/EN).
- The measurement uncertainty of the safety-related output signal of the FMP54 is 2% of the span. Therefore,  $2\% \times 2 \times 100 \text{ mm} (3.94 \text{ in}) = 4 \text{ mm} (0.16 \text{ in})$  (→ SD00349F/00/EN).
- The measurement uncertainty of the safety-related output signal of the RMA42 is also 2% of the span. Therefore,  $2\% \times 2 \times 100 \text{ mm} (3.94 \text{ in}) = 4 \text{ mm} (0.16 \text{ in})$  (→ SD00025R/09/EN).

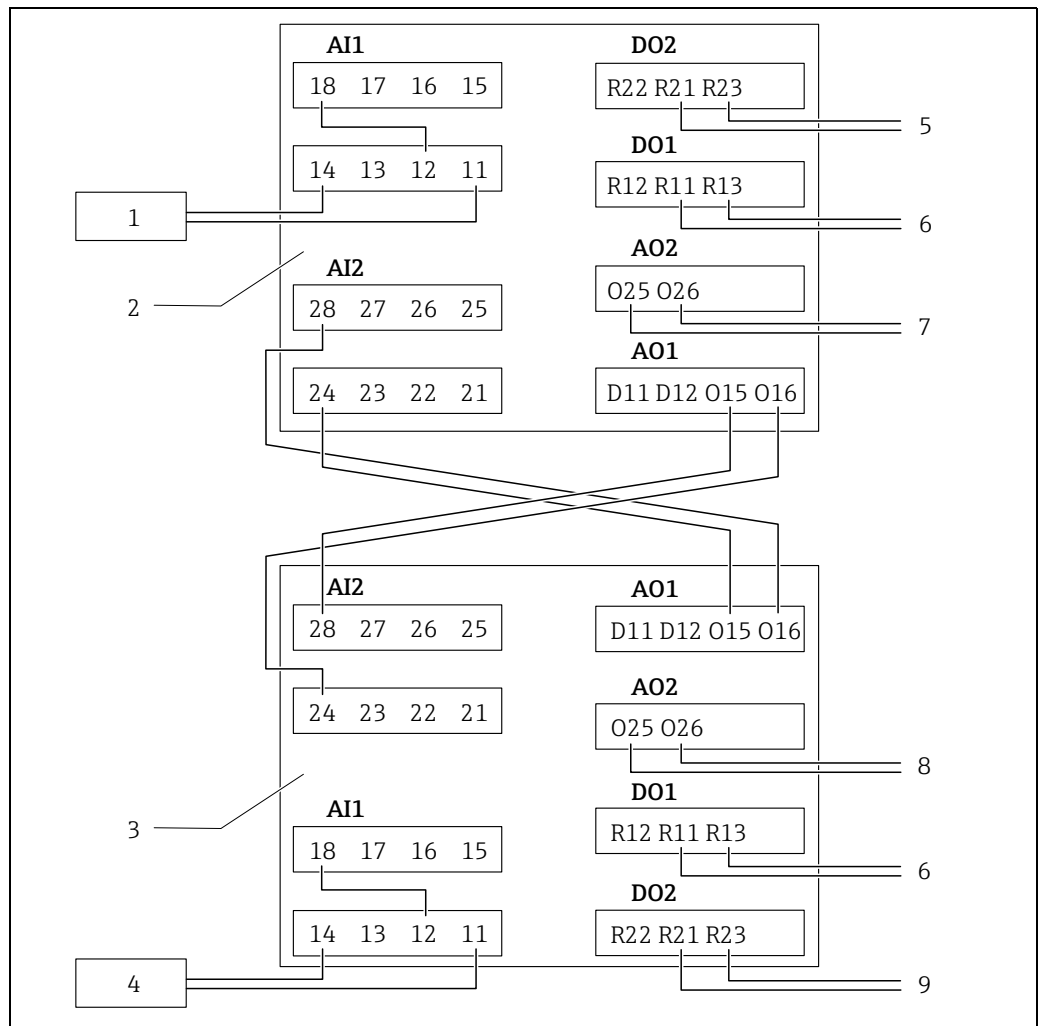
In the application example, this results in a possible measurement uncertainty of 17 mm (0.67 in).

The switch point for the low water level (LWL) must therefore be set to:  
 $100 \text{ mm} (3.94 \text{ in}) - 17 \text{ mm} (0.67 \text{ in}) = 83 \text{ mm} (3.27 \text{ in})$  below the normal water level (NWL).  
 And the switch point for the high water level (HWL) must be set to:  
 $100 \text{ mm} (3.94 \text{ in}) + 17 \text{ mm} (0.67 \text{ in}) = 117 \text{ mm} (4.61 \text{ in})$  above the normal water level (NWL).



**Wiring**

The wiring must be carried out as follows (→ BA00287R/09/EN):



- 1 Levelflex FMP54 no. 1
  - 2 RMA42 no. 1
  - 3 RMA42 no. 2
  - 4 Levelflex FMP54 no. 2
  - 5 High water level (HWL)
  - 6 Low water level (LWL)
  - 7 4 to 20 mA (e.g. difference between sensor AI1 and sensor AI2) for predictive maintenance
  - 8 4 to 20 mA for level control
  - 9 Relay (e.g. difference between sensor AI1 and sensor AI2) for switch-off in the event of deviations between the sensor signals
- AI Analog input  
 AO Analog output  
 DO Relay output



This wiring scheme applies to two-wire devices.

**FMP54 setup**

Both FMP54 devices must be calibrated in exactly the same way:

- Empty calibration: 1200 mm (47.2 in) + 100 mm (3.94 in) = 1300 mm (51.2 in)
- Full calibration: 2 x 100 mm (3.94) = 200 mm (7.87 in)

**RMA42 setup**
**Configuration of RMA42 no. 1**

Calibration in accordance with full and empty calibration of first Levelflex FMP54.

**Analog input 1: FMP54 no. 1**

**Analog input 2: Analog output 1 of RMA42 no. 2 (FMP54 no. 2)**

Parameter	Value	Customer value
Signal type	Current	
Signal range	4 to 20 mA	
Lower range	-100 mm	
Upper range	+100 mm	
Unit	mm	

Calculation of difference between output signals of Levelflex no. 1 and Levelflex no. 2.

**Calculated value 1: difference between FMP54 no. 1 and FMP54 no. 2**

Parameter	Value	Customer value
Calculation	Difference	
Tag	Diff. 1-2	
Unit	mm	
Factor	1	

Configuration of current output for level display and/or control.

**Analog output 1: to RMA42 no. 2**

Parameter	Value	Customer value
Assignment	Analog in 1	
Signal type	4 to 20 mA	
Lower range	-100 mm	
Upper range	+100 mm	

Output of difference between output signals from Levelflex no. 1 and Levelflex no. 2, e.g. for predictive maintenance.

**Analog output 2: difference between FMP54 no. 1 and FMP54 no. 2 on PLC**

Parameter	Value	Customer value
Assignment	Calc value 1	
Signal type	4 to 20 mA	
Lower range	-200 mm	
Upper range	+200 mm	

**Configuration of relay RMA42 no. 1**

Determining the switch point for the low water level for the first Levelflex FMP54. The maximum expected uncertainty is 17 mm. The switch point for the low water level (LWL) must therefore be set to 100 mm (3.94 in) - 17 mm (0.67 in) = 83 mm (3.27 in) below the normal water level (NWL).

**Relay 1: Low water level**

Parameter	Value	Customer value
Assignment	Analog in 1	
Function	min	
Set point	-83 mm	
Hysteresis	5 mm	

Determining the switch point for the high water level for the first Levelflex FMP54. The maximum expected uncertainty is 17 mm. The switch point for the high water level (HWL) must therefore be set to 100 mm (3.94 in) - 17 mm (0.67 in) = 83 mm (3.27 in) above the normal water level (NWL).

**Relay 2: High water level**

Parameter	Value	Customer value
Assignment	Analog in 1	
Function	max	
Set point	+83 mm	
Hysteresis	5 mm	

**Configuration of RMA42 no. 2**

Calibration in accordance with full and empty calibration of second Levelflex FMP54.

**Analog input 1: FMP54 no. 2**

**Analog input 2: Analog output 1 of RMA42 no. 1 (FMP54 no. 1)**

Parameter	Value	Customer value
Signal type	Current	
Signal range	4 to 20 mA	
Lower range	-100 mm	
Upper range	+100 mm	
Unit	mm	

Calculation of difference between output signals of Levelflex no. 2 and Levelflex no. 1.

**Calculated value 1: difference between FMP54 no. 2 and FMP54 no. 1**

Parameter	Value	Customer value
Calculation	Difference	
Tag	Diff. 1-2	
Unit	mm	
Factor	1	

## Configuration of current output for level control

**Analog output 1: to RMA42 no. 1****Analog output 2: level to PLC**

Parameter	Value	Customer value
Assignment	Analog in 1	
Signal type	4 to 20 mA	
Lower range	-100 mm	
Upper range	+100 mm	

**Parameterization of relay RMA42 no. 2**

Determining the switch point for the low water level for the second Levelflex FMP54.

The maximum expected uncertainty is 17 mm. The switch point for the low water level (LWL) must therefore be set to 100 mm (3.94 in) – 17 mm (0.67 in) = 83 mm (3.27 in) below the normal water level (NWL).

**Relay 1: Low water level**

Parameter	Value	Customer value
Assignment	Analog in 1	
Function	Min	
Set point	-83 mm	
Hysteresis	5 mm	

Determining the switch point from which the output signals of the two Levelflex FMP54 devices deviate too much from each other. With an expected measurement uncertainty of 17 mm (0.67 in) and a span of 200 mm (7.87 in), the difference between the two output signals must not exceed 34 mm (1.34 in).

**Relay 2: difference between FMP54 no. 2 and FMP54 no. 1**

Parameter	Value	Customer value
Assignment	Calc value 1	
Function	In-band	
Set point	-34 mm	
Set point 2	+34 mm	
Hysteresis	5 mm	


**Commissioning**

Commissioning is carried out in accordance with the description in SD00349F/00/EN, "Installation and commissioning" section.

If no further parameter settings are required, commissioning can be done in what is called "increased safety mode". This has the advantage that there is no need to change the level in the boiler during commissioning. Instead, it is sufficient to

- carry out an automated "device test" (→ SD00349F/00/EN, "Installation and commissioning" section, Operation subsection, step 3)
- simulate distance values which are slightly above or below the high water level (HWL) and low water level (LWL) switch points, in order to test the function of the entire safety system (→ SD00349F/00/EN, "Installation and commissioning" section, Operation subsection, step 6).

Ideally, the correct function of the actuator should be verified directly at the same time. This should be done initially while the first Levelflex operates as normal and the distance value is simulated at the second Levelflex, and subsequently while the second Levelflex operates as normal and the distance value is simulated at the first Levelflex. If the switch points are exceeded by one or both devices, this must cause the actuator to be switched (1oo2 wiring scheme).

As no application-related measured errors occur during a distance simulation (→  8, "Measuring range and switch points"), only the measurement uncertainties of the safety-related output signal of the FMP54 and RMA42 need to be taken into account i.e. 8 mm in total. Therefore, to test the LWL switch point at a distance of 1.283 mm (50.5 in) from the flange, the safety function must not yet be activated by a distance simulation value of 1.283 mm (50.5 in) – 8 mm (0.31 in) = 1.275 mm (50.2 in).

A distance simulation value of 1.283 mm (50.5 in) + 8 mm (0.31 in) = 1.291 mm (50.8 in) must cause the safety function to be activated. The same applies to the HWL switch point.

If, during testing, the safety loop between the RMA42 and the actuator needs to be interrupted or bridged for operational reasons, the relevant switch output of the RMA42 can be tested instead. In this case, independent measures must be taken to ensure the correct operation of the actuator.

The Levelflex FMP54 is included in the test using both procedures (testing with and without actuator). Separate testing of its current output is therefore not required.

**Proof-test**

The operativeness and safety of the limiter must be checked at regular intervals.

Perform the test so that correct functioning of the limiting device is verified in combination with all components. To do this, the measurement and activation function must be tested by lowering or raising the water level (→ SDO0349F/00/EN).

Procedure for this example:

Fill up to the HWL point 100 mm (3.94 in) above the normal water level (NWL), and verify that the safety function is activated for the high water level (HWL). Also, reduce to LWL point 100 mm (3.94 in) below the normal water level (NWL), and verify that the safety function is activated for the low water level (LWL).

Premature activation is permitted within the error limits, as the switch points have been set in a safety-oriented manner (→ 8, "Measuring range and switch points").

During testing it must be ensured that a dangerous system condition cannot occur.

If the functional capability is implemented through simulation (→ 13, "Commissioning" and SDO0326F/00/EN, Test sequence "C"), the requirements of the relevant standards must also be fulfilled.

For example, EN 12952-7, section 4.5.2 (for water tube boilers):

"It must be possible to carry out functional testing of the limiter at all times for each operating status, e.g. through simulation. If part of the functional test requires that the disconnecting and switching off of the heating system be delayed, the time delay must not exceed the value set by the manufacturer. For boilers with water level limiters, the time delay must not exceed the time taken for the water level to drop from the lowest water level monitored to the lowest water level (LWL) permitted during maximum continuous output..."





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