Safety Manual
00809-0200-4140, Rev CB
December 2023

Rosemount™ 2140:SIS Level Detector

Vibrating Fork

ROSEMOUNT™

EMERSON™

Safety messages

NOTICE

Read this manual before working with the product. For personal and system safety, and for optimum product performance, ensure you thoroughly understand the contents before installing, using, or maintaining this product.

For technical assistance, contacts are listed below:

Customer Central

Technical support, quoting, and order-related questions.

- United States - 1-800-999-9307 (7:00 am to 7:00 pm CST)
- Asia Pacific- 65 777 8211

North American Response Center

Equipment service needs.

- 1-800-654-7768 (24 hours a day — includes Canada)
- Outside of these areas, contact your local Emerson representative.

⚠ WARNING

Failure to follow safe installation and servicing guidelines could result in death or serious injury.

Ensure the level detector is installed by qualified personnel and in accordance with applicable code of practice.

Use the level detector only as specified in this manual. Failure to do so may impair the protection provided by the level detector.

The weight of a level detector with a heavy flange and extended fork length may exceed 37 lb. (18 kg). A risk assessment is required before carrying, lifting, and installing the level detector.

For installations in hazardous locations, the level detector must be installed according to the Rosemount 2140 and 2140:SIS Level Detectors Product Certifications document.

⚠ WARNING

Explosions could result in death or serious injury.

Verify that the operating atmosphere of the level detector is consistent with the appropriate hazardous locations certifications.

Before connecting a handheld communicator in an explosive atmosphere, be sure that the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

In explosion-proof/flameproof and non-incendive installations, do not remove the housing covers when power is applied to the level detector.

Both housing covers must be fully engaged to meet flameproof/explosion-proof requirements.

⚠ WARNING

Electrical shock could cause death or serious injury.

Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

Ensure the power to the level detector is off, and the lines to any other external power source are disconnected or not powered while wiring the level detector.

Ensure the wiring is suitable for the electrical current and the insulation is suitable for the voltage, temperature, and environment.

⚠ WARNING

Process leaks could result in death or serious injury.

Ensure the level detector is handled carefully. If the process seal is damaged, gas might escape from the vessel (tank) or pipe.

⚠ WARNING

Physical access

Unauthorized personnel may potentially cause significant damage to and/or misconfiguration of end users' equipment. This could be intentional or unintentional and needs to be protected against.

Physical security is an important part of any security program and fundamental in protecting your system. Restrict physical access by unauthorized personnel to protect end users' assets. This is true for all systems used within the facility.

⚠ CAUTION

The products described in this document are NOT designed for nuclear-qualified applications.

Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Emerson nuclear-qualified products, contact your local Emerson Sales Representative.

⚠ CAUTION

Hot surfaces

The flange and process seal may be hot at high process temperatures. Allow to cool before servicing.

Contents

1 Before you begin

1.1 About this document

This document provides information about how to install, commission, and proof test a Rosemount 2140:SIS Level Detector to comply with Safety Instrumented Systems (SIS) requirements.

Note
The following conditions must apply:

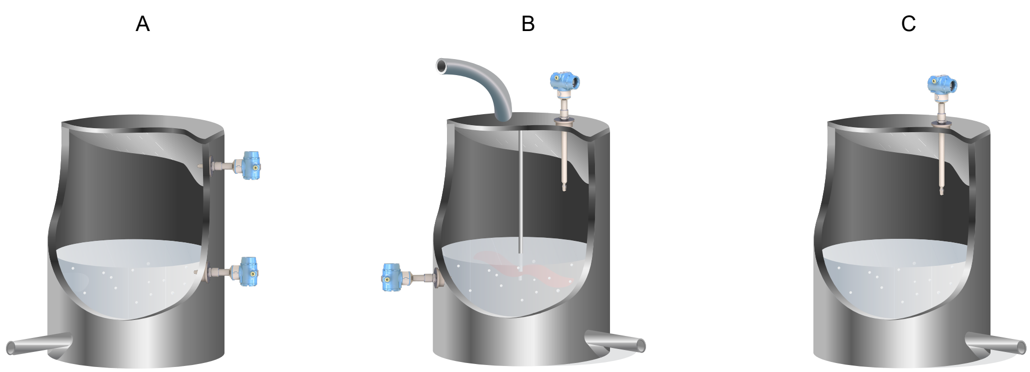
- The level detector has been installed correctly and completely according to the instructions in the Reference Manual and Quick Start Guide.
- The installation complies with all applicable safety requirements.
- The operator is trained in local and corporate safety standards.

1.2 About this product

The Rosemount 2140:SIS Level Detector consists of a tuned fork with a driver and receiver element, and integral interface electronics. The level detector is based on the principle that the resonant frequency of a tuned fork changes when it is immersed in a liquid. The frequency change is detected and used to switch an electronic output. The device output is 4-20 mA.

1.2.1 Application examples

Figure 1-1: Example Level Detection Applications



A. High and low alarm
B. Pump control
C. Overfill prevention

1.3 Related documents

You can find all product documentation at Emerson.com/Rosemount.

For more information, see the following documents:

Table 1-1: Related Documentation

Document	Document type
00809-0100-4140	Reference Manual
00813-0100-4140	Product Data Sheet
00825-0100-4140	Quick Start Guide
00825-0200-4140	Product Certifications

2 Installation and commissioning

2.1 Safety Instrumented System (SIS) certification

For safety instrumented systems usage, the 4-20 mA analog output is used as the primary safety variable. It is configured to activate the alarm function if an error occurs. The Rosemount 2140:SIS may be used in high level or low level safety related applications.

The measurement signal used by the logic solver must be the discrete current levels set at the instrument output used to indicate the sensor condition. A change in liquid level through the switch point of the level detector results in the user configured discrete current value being set at the output by the instrument. The HART® protocol must only be used for setup, calibration, and diagnostic purposes, not for safety critical operation.

2.1.1 Functional safety

The Rosemount 2140:SIS is IEC 61508 certified to:

- Type B low-demand device
- SIL 2 @ HFT = 0
- SIL 3 @ HFT = 1

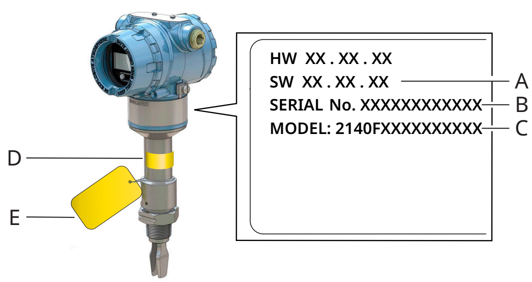
2.2 Safety certified identification

All Rosemount 2140:SIS Level Detectors must be identified as safety certified before installing into SIS systems.

Procedure

1. Verify the model code starts with "2140F".
2. Verify the software (SW) is V01.01.00 or later.

Figure 2-1: Identification



A. SW version
B. Model code
C. Serial number
D. Yellow stripe for locating device from distance
E. Yellow tag for locating device from distance

2.3 Installation

Refer to the Rosemount 2140 and 2140:SIS Product Data Sheet for the specifications and Reference Manual for installation instructions.

2.4 Configuration

2.4.1 Hardware configuration for SIS applications

Related information

High and low alarm levels

Alarm and security switches

Alarm level switch

Under alarm conditions, the output current is forced to a high or low level beyond the normal 4 mA to 20 mA operating range.

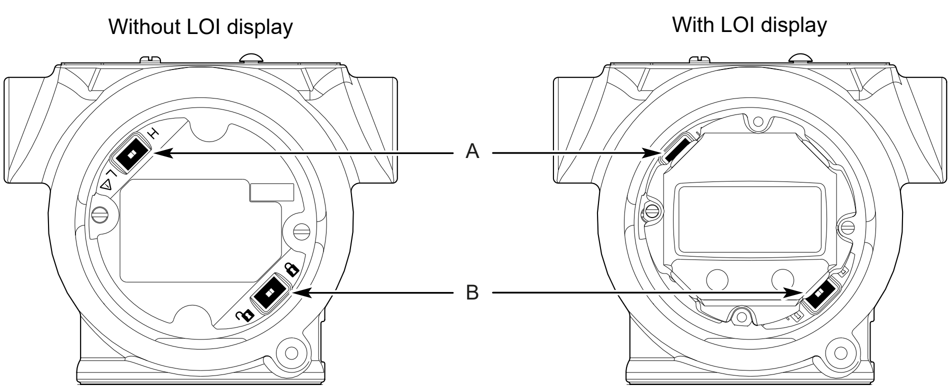
The Alarm Level hardware switch is set to a 'H' or 'L' position to determine if it is the high or low alarm current. Figure 2-2 shows the Alarm Level switch inside the housing.

Security switch

The security switch is set to the Locked position to prevent configuration changes using the optional Local Operator Interface (LOI) or HART® interfaces.

Figure 2-2 shows the security switch inside the housing.

Figure 2-2: Alarm Level and Security Switches



A. Alarm level switch
B. Security switch

2.4.2 Software configuration for SIS applications

Sensor operating mode

The level detector has three sensor operating modes:

Table 2-1: Sensor Operating Modes

Option	Description
Normal	Sensor fault detection is not enabled. Do not select this option for SIS applications.
Enhanced, Fault=Wet	The level detector is forced to indicate a wet fork in a fail-safe state.
Enhanced, Fault=Dry	The level detector is forced to indicate a dry fork in a fail-safe state.

Sensor output delay

When there is a detected change in the condition of the fork, from wet-to-dry or dry-to-wet, the **Sensor Output Delay** parameter can action a delay of up to 3600 seconds before the change of state is indicated. The default delay is one second.

Depending on the application, a suitable delay can prevent constant switching of the output current. If, for example, there are waves in a tank, then there may be splashes causing intermittently detected changes in process conditions. The sensor output delay ensures that the fork is dry or wet for a suitable period before switching the output current.

Media density

The media density parameter is used to specify the specific gravity of the process medium.

Table 2-2: Media Density Settings

Setting	Range
0.4 – 0.6 SG	400 to 600 kg/m^3
0.5 – 0.9 SG	500 to 900 kg/m^3
0.8 – 1.3 SG	800 to 1300 kg/m^3

Sensor fault delay

When the level detector is operating in Enhanced Mode and detects a fork sensor fault, the **Sensor State** parameter indicates a fault state after a delay.

The default setting is 5 seconds. It can be set to a value in the range 0 to 3600 seconds.

Note
When the level detector is operating in Normal mode, a fork sensor fault is not detected and Sensor State continues to indicate a valid state.

Current output operating mode

Options to select are:

- Dry on
- Wet on

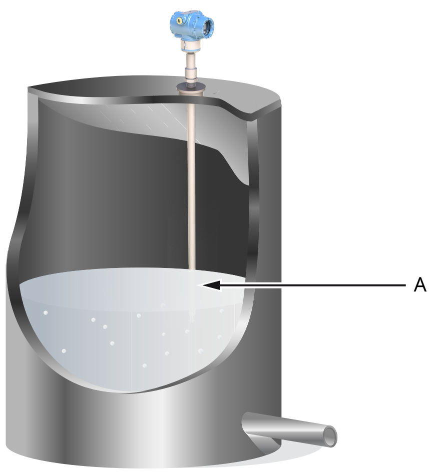
The Sensor State variable uses these settings of "Dry on" and "Wet on" to associate with when the Output State variable is indicating ‘on’ (1.0).

Configuration examples

Empty-vessel detector application

Figure 2-3 shows an empty-vessel detector application where a low level alarm can be indicated by the output being switched on. This should also be the fail-safe state when a fault occurs (dry=fault). The output switches off again when the liquid level rises and immerses the fork.

Figure 2-3: Low Level Alarm ('Dry On' Configuration)

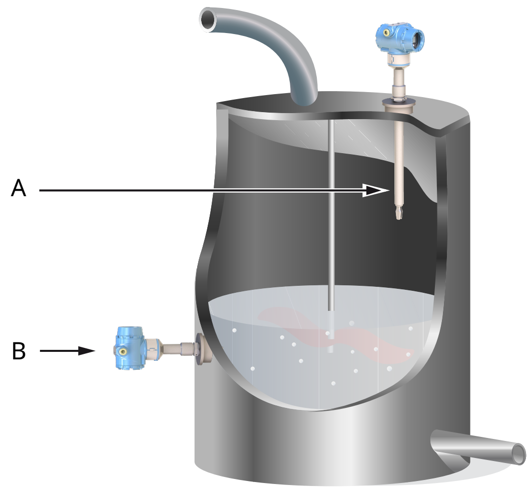


A. When configured to operate in 'Dry On' mode, the output switches 'on' when the liquid level falls below the fork.

Application with a full-vessel detector and an empty-vessel detector

Figure 2-4 shows an application with a full-vessel detector and an empty-vessel detector. Level alarms are indicated by a Rosemount 2140:SIS switching its output off. The top-mounted level detector should be configured to have a fail-safe state of a wet fork (wet=fault). The side-mounted level detector needs a fail-safe state of a dry fork (dry=fault).

Figure 2-4: High and Low Level Alarms ('Wet On' and 'Dry On' Configurations)



A. *The level detector is configured to operate in 'Dry On' mode. When the liquid level rises above the fork, the system output is switched off.*
B. *The level detector is configured to operate in 'Wet On' mode. When the liquid level falls below the fork, the system output is switched off.*

Current output type

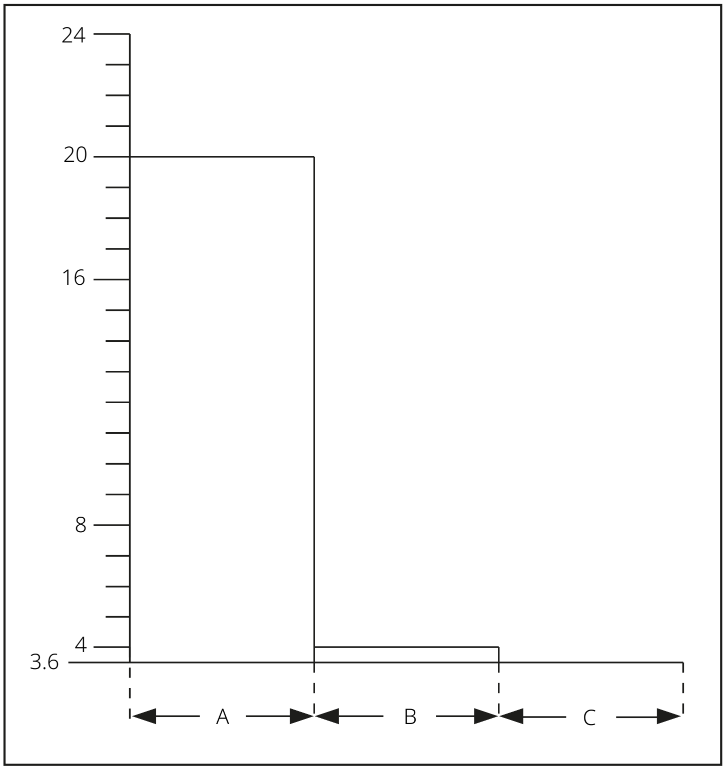
The current output can be configured to switch between standard instrument levels 8 and 16 mA and 4 and 20 mA. In addition, a custom mode is provided, where the user can define, between 4 and 20 mA, custom current levels via the **Custom On Current** and **Custom Off Current** parameters to indicate wet and dry conditions, dependent on the setting of the **Current Output Operating Mode**.

Switched 4 and 20 mA output

The **Current Output Type** parameter can be configured to switch the output current between 4 mA and 20 mA levels.

Figure 2-5 shows the effects on the current output when the **Current Output Type** is set to '4 and 20 mA'. The **Current Output Operating Mode** is 'Dry On', custom alarm levels are selected and set to 3.6 mA, and the alarm level hardware switch is set to 'L'.

Figure 2-5: Current Output Type Set to 4 and 20 mA



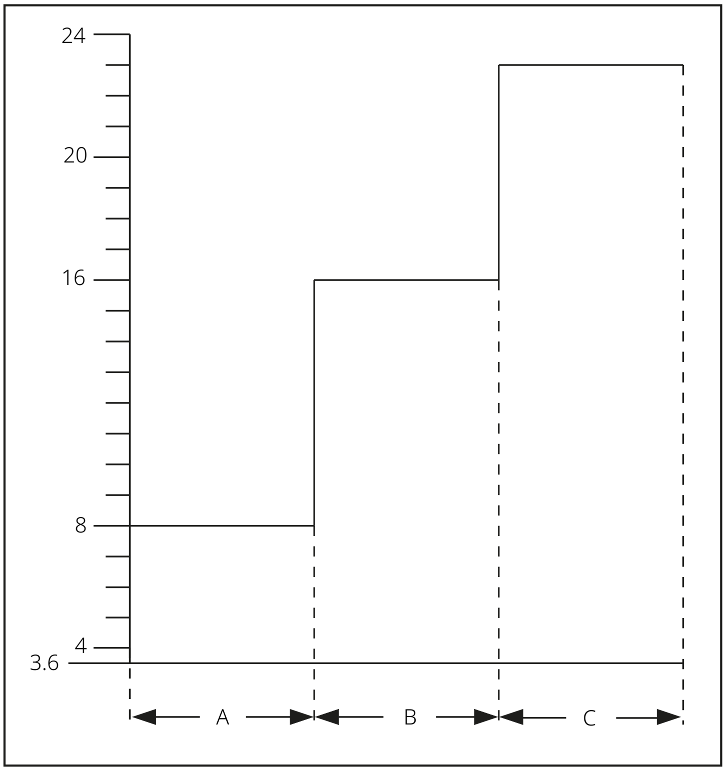
A. *Output is 'on' when the fork is dry*
B. *Output is 'off' when the fork is wet*
C. *Output is in a fail-safe state (fault=wet)*

Switched 8 and 16 mA output

The **Current Output Type** parameter can be configured to switch the output current between 8 mA and 16 mA levels.

Figure 2-6 shows the effects on the current output when the **Current Output Type** parameter is set to '8 and 16 mA'. The **Current Output Operating Mode** is 'Wet On', custom alarm levels are selected and set to 23 mA, and the alarm level hardware switch is set to 'H'.

Figure 2-6: Current Output Type Set to 8 and 16 mA



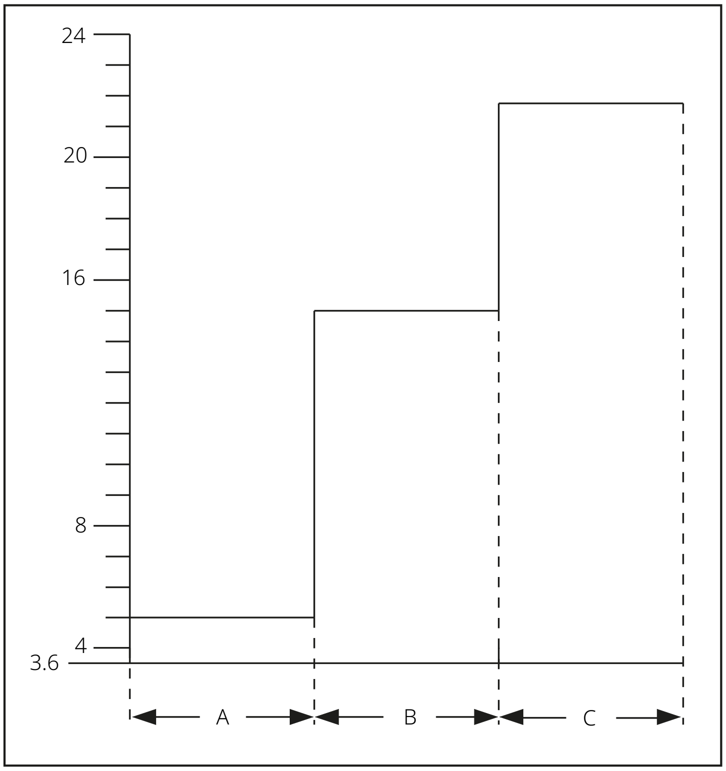
A. Output is 'off' when the fork is dry
B. Output is 'on' when the fork is wet
C. Output is in a fail-safe state (fault=wet)

Custom switched output

The **Current Output Type** parameter can be configured to switch the output current between two customer-defined levels.

Figure 2-7 shows the effects on the current output when the **Current Output Type** parameter is set to 'Custom'. The **Current Output Operating Mode** is 'Wet On', the **Custom Off Current** is 5 mA, the **Custom On Current** is 15 mA, Rosemount alarm levels are selected, and the Alarm Level hardware switch is set to 'H'.

Figure 2-7: Current Output Type Set to Custom



A. Output is 'off' when the fork is dry
B. Output is 'on' when the fork is wet
C. Output is in a fail-safe state (fault=wet)

High and low alarm levels

The software settings in Table 2-3 are used together with the Alarm Level hardware setting to specify a fixed output current under an alarm condition.

The "NAMUR" and "Rosemount" alarm levels have preset fixed values that cannot be edited. When “Custom” alarm levels is selected, fixed output current values must be entered using High and Low Alarm Current parameters.

Table 2-3: Alarm Current Levels

Alarm and saturation type	Low alarm level (mA)	High alarm level (mA)
NAMUR	≤ 3.6 (option code C5)	≥ 22.5 (option code C4)
Rosemount	≤ 3.75 (option code C8)	≥ 21.75 (default)
Custom (option code C1)	3.6 – 3.8	20.2 – 23.0

3 Proof tests

3.1 Overview

The Rosemount 2140:SIS must be tested at regular intervals to reveal faults which are undetected by automatic diagnostics. It is the user's responsibility to choose the type of testing and the frequency of these tests.

Results from periodic proof tests shall be recorded and periodically reviewed. If an error is found in the safety functionality, the device shall be put out of operation and the process shall be kept in a safe state by other measures.

Note
For a valid result, always perform the proof test on the product that will be stored in the tank while the device is in operation.

3.1.1 Suggested proof tests

The following proof tests are suggested:

- (A) Comprehensive proof test
- (B) Partial proof test

Table 3-1 can be used as a guidance for selecting the appropriate proof test.

Table 3-1: Suggested Proof Tests

Proof test #	Device(1)	Proof test coverage (%) of DU	Remaining dangerous, undetected failures	Test coverage			Can be performed remotely
				Output circuitry	Measurement electronics	Sensor	
A	2140:SIS T0 Dry On	55%	7 FIT	Yes	Yes	Yes	No
	2140:SIS T0 Wet On	59%	7 FIT				
	2140:SIS T1 Dry On	54%	5 FIT				
	2140:SIS T1 Wet On	56%	6 FIT				
B	2140:SIS T0 Dry On	20%	12 FIT	Yes	Yes	No	Yes
	2140:SIS T0 Wet On	26%	12 FIT				
	2140:SIS T1 Dry On	26%	9 FIT				
	2140:SIS T1 Wet On	26%	10 FIT				

(1) *T0 = Standard terminal block*

T1 = Transient protection terminal block

Related information

Comprehensive proof testing
Partial proof-testing

3.1.2 Proof test interval

The time intervals for proof testing are defined by the SIL verification calculation (subject to the PFD_{AVG}). The SIL verification calculation is an analytical method to calculate an appropriate proof test interval for the specific safety function based on equipment's reliability and required risk reduction for the specific SIF.

The proof tests must be performed more frequently than or as frequently as specified in the SIL verification calculation, in order to maintain the required safety integrity of the overall SIF.

3.1.3 Tools required

- HART host/communicator
- Current meter
- Safety logic solver

3.2 Comprehensive proof testing

Comprehensive proof-testing requires a different method to local and remote partial proof-testing. It takes several hours to perform with all safety measures being followed.

3.2.1 Impact on SIF and process

In order to achieve the product safe state, the sensor must be either removed from or immersed in the process medium, depending on the operating mode. The process cannot be allowed to operate whilst the proof test is being performed.

3.2.2 Perform comprehensive proof test

The suggested testing consists of setting the output to a maximum and minimum, and checking the sensor and associated analog output levels.

Procedure

1. Inspect the accessible parts of the level detector for any leaks or damage.
2. Bypass the safety function and take appropriate action to avoid a false trip.
3. Using Loop Test, simulate the high alarm current output, and verify that the analog current reaches that value.
4. Using Loop Test, simulate the low alarm current output, and verify that the analog current reaches that value.
5. Change process conditions for the fork to experience the configured alarm condition, and verify the analog output reaches the configured 'off' output current within the expected time period.

   See Transmitter response time for help with this.
6. Change process conditions for the fork to experience the normal (dry on or wet on) condition, and verify the analog output reaches the configured 'on' output current within the expected time period.

   See Transmitter response time for help with this.
7. Remove the bypass and otherwise restore normal operation.

Related information

Loop testing

3.2.3 Loop testing

Start a loop test

Procedure

1. Select **Service Tools** → **Simulate**.
2. Select **Loop test** and follow the on-screen instructions.

Start a loop test using a LOI

Procedure

1. Press any LOI configuration button to activate the menu.
2. Scroll down (↓) and then select **TEST** (↵).
3. Scroll down (↓) and then select **LOOP TEST** (↵).
4. Select **SET 4MA**, **SET 20MA**, or **SET CUSTOM**.
5. Follow on-screen instructions to perform the loop test.
6. Exit the menu system by either waiting one minute for the **EXIT MENU?** prompt, or scrolling down menus to find and select **BACK TO MENU** and **EXIT MENU**.

3.3 Partial proof-testing

The level detector has local and remote partial proof-testing support as standard.

3.3.1 Impact on SIF and process

The process cannot be allowed to operate whilst the proof test is being performed.

3.3.2 Perform partial proof test

The suggested testing exercises the signal processing and output, but does not test the sensor.

Procedure

1. Inspect the accessible parts of the level detector for any leaks or damage.
2. Bypass the safety function and take appropriate action to avoid a false trip.
3. Start the partial proof-test procedure.
4. Verify the analog output reaches the configured:
    a) Low alarm current - for one quarter of the proof-test duration.
    b) 'Off' output current - for one quarter of the proof-test duration.
    c) 'On' output current - for one quarter of the proof-test duration.
    d) High alarm current - for one quarter of the proof-test duration.
5. Remove the bypass and otherwise restore normal operation.

Related information

Start the local partial proof test
Start the remote partial proof test
Duration of the proof test routine

Start the local partial proof test

By default, the partial proof testing sequence is not started at every power-up. It can be started by an operator using the Local Operator Interface (LOI).

Procedure

In the menu system, select **TEST** → **PROOF TEST** or, when no LOI is not fitted, by using the single external push-button fitted to the top of the level detector (underneath the movable nameplate).

Start the remote partial proof test

Procedure

1. Select **Service Tools** → **Maintenance** → **Test**.
2. Select **Partial Proof-Test** and follow the on-screen instructions.

3.3.3 Configure the proof test function

Procedure

1. Select **Configure** → **Manual Setup** → **Operation** → **Proof Test**.

2. Set the **Duration** as desired.
3. In the ***Start-up Proof-Test*** list, select **Enabled** or **Disabled**.

Configure proof test function using the LOI

Procedure

1. Press any LOI configuration button to activate the menu.
2. Scroll down (↓) and then select **EXTENDED MENU** (↵).
3. Scroll down (↓) and then select **PROOF TEST** (↵).
4. Choose the proof-test parameter to change:
   a) Select **DURATION** for setting how long the partial proof-test lasts.
   b) Select **START-UP** for setting if partial proof-testing at start-up is enabled or disabled
5. Exit the menu system by either waiting one minute for the **EXIT MENU?** prompt, or scrolling down menus to find and select **BACK TO MENU** and **EXIT MENU**.

Duration of the proof test routine

The Proof-Test Duration parameter determines the duration of the whole partial proof-testing sequence.

Four steps performed are:

- Low Alarm Current step
  — The analog output current is overridden to the Low Alarm level (as configured).
- Off Current step
  — The analog output current is overridden to the level of the 'off' switched output state (as configured).
- On Current step
  — The analog output current is overridden to the level of the 'on' switched output state (as configured).
- High Alarm Current step
  — The analog output current is overridden to the High Alarm level (as configured).

Note
Setting a value of "0 s" (zero seconds) results in the analog output not being exercised during the proof-test. Only a diagnostic check of the device is performed in this case.

4 Operating constraints

4.1 Specifications

The Rosemount 2140:SIS must be operated according to the functional and performance specifications provided in the Rosemount 2140 and Rosemount 2140:SIS Product Data Sheet.

4.1.1 Failure rate data

The FMEDA report includes failure rate data, assessment details, and assumptions regarding failure rate analysis.

4.1.2 Transmitter response time

The Rosemount 2140 Level Switch worst case response time shall be considered to be the larger of 10 seconds plus the switch setting for response mode of operation.

Table 4-1: Transmitter response time

Current Output Type	Supply voltage	Safety alarm levels (leakage currents)(1)	Transmitter response time(2)	Switch point (water)(3)	Switch point (other liquid)(4)
4-20 mA	10.5 to 42.4 Vdc	3.6 mA	10 s minimum	11 to 15 mm	0 to 30 mm

(1) *Logic solver trip levels should be set higher than these values in order to ensure reliable trips.*
(2) *The Rosemount 2140 Level Switch worst case response time shall be considered to be the larger of 10 seconds plus the switch setting for response mode of operation.*
(3) *Operating (switching) point measured from lowest point of fork when liquid is water.*
(4) *Operating (switching) point measured from lowest point of fork when liquid is not water.*

Related information

Sensor output delay

4.1.3 Diagnostic test interval

< 60 min

4.1.4 Useful lifetime

50 years

- based on worst case component wear-out mechanisms
- not based on wear-out of process wetted materials

4.2 Product repair

The Rosemount 2140:SIS is repairable by major component replacement. All failures detected by the device diagnostics or by the proof test must be reported. Feedback can be submitted electronically at Go.EmersonAutomation.com/Contact-Us (Contact Us).

A Terms and definitions

λ_{DU}	Dangerous Undetected failure rate
λ_{DD}	Dangerous Detected failure rate
λ_{SU}	Safe Undetected failure rate
λ_{SD}	Safe Detected failure rate
Diagnostic test interval	The time from when a dangerous failure/condition occurs until the device has set the safety related output in a safe state (total time required for fault detection and fault reaction).
Element	Term defined by IEC 61508 as “part of a subsystem comprising a single component or any group of components that performs one or more element safety functions”
FIT	Failure In Time per billion hours
FMEDA	Failure Modes, Effects and Diagnostic Analysis
HART® protocol	Highway Addressable Remote Transducer
HFT	Hardware Fault Tolerance
High demand mode	The safety function is only performed on demand, in order to transfer the EUC (Equipment Under Control) into a specified safe state, and where the frequency of demands is greater than one per year (IEC 61508-4).
Low demand mode	The safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year (IEC 61508-4).
PFD_{AVG}	Average Probability of Failure on Demand
PFH	Probability of dangerous Failure per Hour: the term "probability" is misleading, as IEC 61508 defines a rate.
Proof test coverage factor	The effectiveness of a proof test is described using the coverage factor which specifies the share of detected dangerous undetected failures (λ_{DU}). The coverage factor is an indication of a proof test’s effectiveness to detect dangerous undetected faults.
Safety deviation	The maximum allowed deflection of the safety output due to a failure within the device (expressed as a percentage of span). Any failure causing the device output to change less than the Safety Deviation is considered as a "No Effect" failure. All failures causing the device output to change more than the Safety Deviation and with the device output still within the active range (non-alarm state) are considered dangerous failures. **Note** The Safety Deviation is independent of the normal performance specification or any additional application specific measurement error.
SIF	Safety Instrumented Function
SIL	Safety Integrity Level – a discrete level (one out of four) for specifying the safety integrity requirements of the safety instrumented functions

to be allocated to the safety instrumented systems. SIL 4 has the highest level of safety integrity, and SIL 1 has the lowest level.

SIS	Safety Instrumented System – an instrumented system used to implement one or more safety instrumented functions. An SIS is composed of any combination of sensors, logic solvers, and final elements.
Systematic capability	A measure (expressed on a scale of SC 1 to SC 4) of the confidence that the systematic safety integrity of an element meets the requirements of the specified SIL, in respect of the specified element safety function, when the element is applied in accordance with the instructions specified in the compliant item safety manual for the element.
Transmitter response time	The time from a step change in the process until transmitter output reaches 90% of its final steady state value (step response time as per IEC 61298-2).
Type B device	Complex device using controllers or programmable logic, as defined by the standard IEC 61508.
Useful lifetime	Reliability engineering term that describes the operational time interval where the failure rate of a device is relatively constant. It is not a term which covers product obsolescence, warranty, or other commercial issues. The useful lifetime is highly dependent on the element itself and its operating conditions (IEC 61508-2).

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For more information: **Emerson.com/global**

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