

Rosemount 2130

Functional Safety Manual



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Section 1 Introduction

1.1 Scope and purpose of the safety manual

This safety manual contains the information to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Rosemount 2130 level switch.

The manual provides the necessary requirements to enable the integration of the 2130 level switch when showing compliance with the IEC 61508 or IEC 61511 functional safety standards. It indicates all assumptions that have been made on the usage of the Level Switch. If these assumptions cannot be met by the application, the SIL capability of the Rosemount 2130 may be adversely affected.

Note

For product support, use the contact details on the back page.

1.2 Skill level requirement

System design, installation and commissioning, and repair and maintenance shall be carried out by suitably qualified personnel.

1.3 Terms, abbreviations, and acronyms

Basic Safety

Freedom from unacceptable risk of harm.

BPCS

Basic Process Control System – a system which responds to input signals from the process, its associated equipment, other programmable systems and/or an operator and generates output signals causing the process and its associated equipment to operate in the desired manner but which does not perform any safety instrumented functions with a claimed SIL greater than or equal to 1.

Fail-safe State

State where switch output is in the state corresponding to an alarm condition. In this condition the switch contacts will normally be open.

Fail Dangerous

Failure that does not respond to an input from the process (i.e. not switching to the fail-safe state).

Fail Dangerous Detected

Failure that is dangerous but is detected.

Fail Dangerous Undetected

Failure that is dangerous and that is not detected.

Fail No Effect

Failure of a component that is part of the safety function but that has no effect on the safety function.

Fail Safe

Failure that causes the switch to go to the defined fail-safe state without an input from the process.

FMEDA

Failure Modes, Effects, and Diagnostics Analysis.

Functional Safety

Part of the overall safety relating to the process and the BPCS which depends on the correct functioning of the SIS and other protection layers.

HFT

Hardware Fault Tolerance.

Low demand

Mode of operation, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.

PFD_{AVG}

Average Probability of Failure on Demand.

SFF

Safe Failure Fraction – a fraction of the overall random failure rate of a device that results in either a safe failure or a detected dangerous failure.

SIF

Safety Instrumented Function – a safety function with a specified SIL which is necessary to achieve functional safety. Typically a set of equipment intended to reduce the risk due to a specified hazard (a safety loop).

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.

1.4 Documentation and standards

This section lists the documentation and standards referred to by this safety manual.

Table 1-1. Associated Documentation

Documents	Purpose of Documents
IEC 61508-2: 2000	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
MOB 08/08-57 R005	FMEDA Report Version V1, Revision R5 for the Rosemount 2130 Level Switch
00813-0100-4130	Rosemount 2130 Product Data Sheet
00809-0100-4130	Rosemount 2130 Reference Manual

Table 1-2. Associated Standards

Standards	Purpose of Standards
IEC 61508: 2000	Functional Safety of electrical/electronic/programmable electronic safety-related systems
IEC 61511 (ANSI/ISA 84.00.01-2004)	Functional safety - Safety instrumented systems for the process industry sector

Section 2 Product Description

2.1 Operation principle

The Rosemount 2130 level switch consists of a tuned fork with a driver and receiver element, and integral interface electronics. The 2130 level switch 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.

A range of output options are available to suit different applications.

Note

For all product information and documentation downloads, visit www.rosemount.com.

2.2 Level switch purpose

The Level switch indicates, by means of an electronic output, whether the level of a process liquid is above, or below, a certain point (the Switch Point).

Figure 2-1. Example Applications



2.3 Ordering information

Typical Model Number: 2130 L A 2 E S 9 N N B A 0000 1 N A Q T

The first option code after “2130” indicates the output type:

- L = Direct Load Switching (Mains two-wire)
- P = PNP/PLC Low Voltage (three-wire)
- D = DPCO Relay
- N = NAMUR
- M = 8/16 mA

Each output type has different Safety Instrumented System (SIS) parameters (see [Table 3-1 on page 9](#)). The other option codes in the model number refer to materials, fittings, and other mechanical options which do not affect SIS parameters.

Models with the QS option code are supplied with a manufacturer’s prior-use certificate of FMEDA data.

Models with the QT option, if available, are supplied with a third party certificate of SIL capability.

Section 3 Designing a Safety Function using the Rosemount 2130

3.1 Safety function

A change in liquid level through the *switch point* of the Rosemount 2130 level switch causes it to operate. It may be used in high level or low level safety related applications. It is important that the 2130 is user-configured for the correct application.

3.2 Environmental limits

The designer of the SIF (Safety Instrumented Function) must check that the Rosemount 2130 level switch is rated for use within the expected environmental limits. See the Rosemount 2130 product data sheet for environmental limits.

Note

For all product information and documentation downloads, see the on-line Rosemount 2130 web page at www.rosemount.com.

3.3 Application limits

It is very important that the SIF designer checks for material compatibility by considering process liquids and on-site chemical contaminants. If the Rosemount 2130 level switch is used outside the application limits or with incompatible materials, the reliability data and predicted SIL capability becomes invalid.

The construction materials of a Rosemount 2130 level switch are specified in the product data sheet and the product reference manual (see [Table 1-1 on page 3](#)). Use the model code on the product label, and the ordering information table and specification in these product documents to find out the construction materials.

3.4 Design verification

A detailed Failure Modes, Effects and Diagnostics Analysis (FMEDA) report for the Rosemount 2130 is available from Emerson Process Management. This report details all failure rates and failure modes as well as expected lifetime.

Note

The FMEDA report is available from the Safety quick link at www.rosemount.com. Select Product List, then Level tab, and finally select 2130. In the right-hand panel, there are SIL documents including the FMEDA report (and this safety manual).

The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer using a PFD_{AVG} calculation considering the architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time, and the specific failures rates of all equipment included in the SIF.

Each subsystem must be checked to assure compliance with minimum Hardware Fault Tolerance (HFT) requirements. When using the Rosemount 2130 level switch in a redundant configuration, a common cause factor of at least 5% should be included in the safety integrity calculations.

The failure rate data listed in the FMEDA report is only valid for the useful lifetime of the Rosemount 2130. The failure rates *increase* after this useful lifetime period has expired. Reliability calculations based on the data listed in the FMEDA report for mission times beyond the lifetime may yield results that are too optimistic, i.e. the calculated SIL will not be achieved.

3.5 SIL capability

3.5.1 Systematic integrity

The 2130 level switch has met manufacturer design process requirements of Safety Integrity Level 2 (SIL 2). These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer.

A Safety Instrumented Function (SIF) designed with the 2130 must not be used at a SIL higher than the statement without “prior use” justification by the end-user, or verification of diverse technology in the design.

3.5.2 Random integrity

The 2130 level switch is classified as a type B device according to IEC 61508, and the level switch has a Hardware Fault Tolerance (HFT) of zero.

Random Integrity for Type B device:

- Output Types N, P, and L: SIL 2 @ HFT=0
- Output Type D: SIL 1 @ HFT=0, SIL 2 @ HFT=1

3.5.3 Safety parameters

Table 3-1 on page 9 summarizes the Rosemount 2130 failure rates. For detailed failure rate information, including PFD_{AVG} and MTTR data, see the FMEDA report for the Rosemount 2130.

Table 3-1. 2130 Failure Rates

Output Type and Model Option Code		Mode	$\lambda_{SD}^{(1)}$	λ_{SU}	λ_{DD}	λ_{DU}	SFF %
NAMUR	N	DRY=On	0.0 FIT	195.5 FIT	151.2 FIT	17.5 FIT	95.20
NAMUR	N	WET=On	0.0 FIT	78.3 FIT	259.1 FIT	26.1 FIT	92.80
PNP/PLC	P	DRY=On	0.0 FIT	422.8 FIT	171.9 FIT	50.8 FIT	92.10
PNP/PLC	P	WET=On	0.0 FIT	307.6 FIT	283.8 FIT	53.5 FIT	91.70
Direct Load Switching	L	DRY=On	0.0 FIT	364.8 FIT	170.6 FIT	45.0 FIT	92.20
Direct Load Switching	L	WET=On	0.0 FIT	246.9 FIT	278.4 FIT	54.8 FIT	90.60
Relay	D	DRY=On	0.0 FIT	266.1 FIT	142.9 FIT	104.6 FIT	79.60
Relay	D	WET=On	0.0 FIT	146.6 FIT	240.9 FIT	116.9 FIT	76.80
8/16 mA	M	DRY=On	0.0 FIT	350.7 FIT	172.4 FIT	28.5 FIT	94.80
8/16 mA	M	WET=On	0.0 FIT	238.6 FIT	283.4 FIT	29.6 FIT	94.60

(1) FIT is the abbreviation for Failure In Time. One FIT is 1×10^{-9} failure per hour.

Note

The FMEDA report is available from the Safety quick link at www.rosemount.com. Select Product List, then Level tab, and finally select 2130. In the right-hand panel, there are SIL documents including the FMEDA report (and this safety manual).

3.6 Connection of the 2130 to the SIS logic solver

The Rosemount 2130 level switch should be connected to the safety-rated logic solver which is actively performing the safety function as well as automatic diagnostics (if any) designed to diagnose potentially dangerous failures within the level switch. In some cases, it may also be connected directly to the final element.

The Rosemount 2130 reference manual gives full installation details for the level switch. The logic solver trip levels must be compatible with (higher than) the sensor alarm levels given in the specifications section of this manual.

Note

For all product information and documentation downloads, see the on-line Rosemount 2130 web page at www.rosemount.com.

3.7 General requirements

- The system and function *response time* shall be less than the *process safety time*
The 2130 level switch will change to its defined safe state in less than this time with relation to the specific hazard scenario.
- All SIS components, including the 2130 level switch must be operational before process start-up
- The user shall verify that the 2130 level switch is suitable for use in safety applications by confirming the level switch *nameplate* and *model number* are properly marked

- Personnel performing maintenance and testing on the 2130 level switch shall first be assessed as being competent to do so
- Results from periodic proof tests shall be recorded and periodically reviewed
- The 2130 level switch shall not be operated beyond the useful lifetime as listed in the specification section of the product reference manual without undergoing overhaul or replacement

Note

For all product information and documentation downloads, see the on-line Rosemount 2130 web page at www.rosemount.com.

Section 4 Installation and Commissioning

Note

For all product information and documentation downloads, see the on-line Rosemount 2130 web page at www.rosemount.com.

4.1 Installation

The Rosemount 2130 level switch must be installed as described in the installation section of the product reference manual. Check that environmental conditions do not exceed the ratings in the specification section.

The 2130 level switch must be *accessible* for physical inspection.

4.2 Physical location and placement

The Rosemount 2130 level switch shall be *accessible* with sufficient room for cover removal and electrical connections, and allow for manual proof-testing to take place.

The switch point is determined by the location of the 2130 level switch, and consideration must be given to allow the safe proof-testing of the level switch by forcing liquid to put the switch into its Fail-Safe state.

4.3 Electrical connections

Wiring should be adequately rated and not be susceptible to mechanical damage. Electrical conduit is commonly used to protect wiring.

4.4 Configuration

4.4.1 Self-check setting

The Rosemount 2130 level switch must be user-configured to operate in the Self-check mode. This mode enables the internal diagnostic routines.

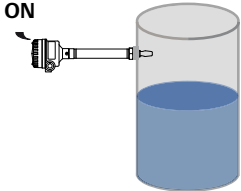
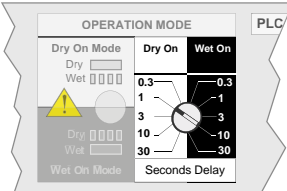
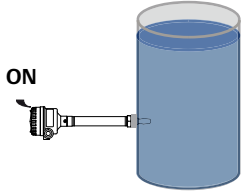
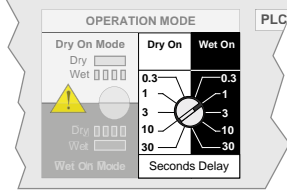
Self-check mode is indicated by the amber color of the LED on the electronics cassette. SIS-certified 2130 level switches (*dependent on model code*) are shipped with this mode pre-configured, but must be checked before first use, and periodically thereafter, as part of the proof-test routine.

4.4.2 Output mode setting

The Rosemount 2130 level switch must be user-configured for an application so that the output is ON in the Safe or Normal condition (see Table 4-1).

The response time (seconds delay) may be set to a convenient value to prevent trips that are spurious i.e. not due to a real condition. Note that the Safety Response Time is the greater of 10 seconds and the selected seconds delay using the switch setting (see Table A-1 on page 15).

Table 4-1. Output Mode Setting

Application	Switch Setting (Normal or Safe Condition)
<p style="text-align: center;">High Level Alarm</p> 	<p style="text-align: center;">Dry = On</p> 
<p style="text-align: center;">Low Level Alarm</p> 	<p style="text-align: center;">Wet = On</p> 

Section 5 Operation and Maintenance

5.1 **Proof-test requirement**

During operation, a low-demand mode SIF must be proof-tested. The objective of proof-testing is to detect failures within the equipment in the SIF that are not detected by any automatic diagnostics of the system. Undetected failures that prevent the SIF from performing its function are the main concern.

Periodic proof-tests shall take place at the frequency (or interval) defined by the SIL verification calculation. 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. A sample procedure is provided in Appendix B: Proposed Proof-test Procedure.

Results from periodic proof tests shall be recorded and periodically reviewed.

5.2 **Repair and replacement**

Repair procedures in the Rosemount 2130 level switch reference manual must be followed.

5.3 **Notification of failures**

In case of malfunction of the system or SIF, the Rosemount 2130 level switch shall be put out of operation and the process shall be kept in a safe state by other measures.

Emerson Process Management must be informed when the Rosemount 2130 level switch is required to be replaced due to failure. The occurred failure shall be documented and reported to Emerson Process Management using the contact details on the back page of this safety manual. This is an important part of Emerson Process Management's SIS management process.

Appendix A Specifications

A.1 General

In Table A-1, the safety response time for all output types is the greater of 10 seconds or the selected seconds delay using the switch setting.

Note

See Table 4-1 on page 12 for the switch setting feature.

Table A-1. General Specification

Output Type	NAMUR (Code N)	8/16 mA (Code M)	Direct Load (Code L)	PNP (Code P)	Relay (Code D)
Supply voltage	7 to 9 Vdc	11 to 36 Vdc	20 to 264 Vac 20 to 60 Vdc	20 to 60 Vdc	20 to 60 Vdc
Safety Alarm Levels (leakage currents) ⁽¹⁾	1.0 mA	< 3.7 mA	6 mA	100 µA	<i>Not Applicable</i>
Safety Response time ⁽²⁾	10 s minimum	10 s minimum	10 s minimum	10 s minimum	10 s minimum
Switch Point – Water ⁽³⁾	11 to 15 mm	11 to 15 mm	11 to 15 mm	11 to 15 mm	11 to 15 mm
Switch Point – Other Liquid ⁽⁴⁾	0 to 30 mm	0 to 30 mm	0 to 30 mm	0 to 30 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 safety response time is the greater of 10 seconds or the selected seconds delay using the switch setting. See Table 4-1 on page 12 for the switch setting feature.

(3) Operating (Switch) Point measured from lowest point of fork when liquid is water.

(4) Operating (Switch) Point measured from lowest point of fork when liquid is not water.

A.2 Useful life

Based on general field failure data and manufactures component data, a useful life period of approximately 18 years is expected for the Rosemount 2130 level switch at an ambient temperature of 55 °C. This decreases by a factor of two for every increase of 10 °C, and increases by a factor of two for every decrease of 10 °C.

A.3 Useful lifetime

According to Section 7.4.7.4 of the standard IEC 61508-2, a useful lifetime based on experience should be assumed.

Although a constant failure rate is assumed by the probabilistic estimation method (see FMEDA report), this only applies provided that the useful lifetime⁽¹⁾ of components is not exceeded. Beyond their useful lifetime, the result of the probabilistic calculation method is therefore meaningless as the probability of failure significantly increases with time.

The useful lifetime is highly dependent on the subsystem itself and its operating conditions. Specifically, the equipment contains electrolytic capacitors which have a useful life which is highly dependent on ambient temperature (see Safety Data in the FMEDA report).

This assumption of a constant failure rate is based on the bath-tub curve. Therefore, it is obvious that the PFDAVG calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is the responsibility of the end-user to maintain and operate the Rosemount 2130 level switch according to the manufacturer's instructions. Furthermore, regular inspection should show that all components are clean and free from damage.

For high-demand mode applications, the useful lifetime of the mechanical parts is limited by the number of cycles. The useful lifetime of the mechanical and electrical parts is greater than 200000 operations. When plant experience indicates a shorter useful lifetime than indicated, the number based on plant experience should be used.

(1) Useful lifetime is a 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.

Appendix B Proposed Proof-test Procedure

B.1 Suggested proof-test

According to Section 7.4.3.2.2 (f) of the standard IEC 61508-2, proof-tests shall be undertaken to reveal dangerous faults which are undetected by diagnostic tests. This means that it is necessary to specify how dangerous undetected faults which have been noted during the Failure Modes, Effects, and Diagnostic Analysis can be detected during proof-testing.

The suggested proof-tests (Table B-1 and Table B-2) consist of switch operation tests in-situ.

Table B-1. Suggested Proof-test (Low Level Alarm)

Step	Action
1	Inspect the accessible parts of the level switch for any leaks or damage
2	Bypass the safety function and take appropriate action to avoid a false trip
3	Disable any filling mechanism and drain the vessel to force the switch to the fail-safe state and confirm that the Safe State was achieved and within the correct time. INDEPENDENT PRECAUTIONS MUST BE TAKEN TO ENSURE THAT NO HAZARD CAN RESULT FROM THIS OPERATION.
4	Reinstate the filling mechanism so that the vessel refills and confirm that the normal operating state of the switch was achieved.
5	Remove the safety function bypass and otherwise restore normal operation

Table B-2. Suggested Proof-test (High Level Alarm)

Step	Action
1	Inspect the accessible parts of the level switch for any leaks or damage
2	Bypass the safety function and take appropriate action to avoid a false trip
3	Disable any drain mechanism and fill the vessel to force the switch to the fail-safe state and confirm that the Safe State was achieved and within the correct time. INDEPENDENT PRECAUTIONS MUST BE TAKEN TO ENSURE THAT NO HAZARD CAN RESULT FROM THIS OPERATION.
4	Reinstate the drain mechanism so that the vessel refills and confirm that the normal operating state of the switch was achieved
5	Remove the safety function bypass and otherwise restore normal operation

Appendix C Product Identification

C.1 Approved cassette part numbers

Table C-1 shows the part numbers of the electronic cassettes approved to IEC61508:2000.

Table C-1. IEC61508:2000 approved cassette numbers

Output Type	Part Numbers of Electronic Cassettes
NAMUR (Code N)	02130-1060-0001
PNP (Code P)	02130-1060-0002
Relay (Code D)	02130-1060-0003
Direct Load (Code L)	02130-1060-0004
8/16 mA (Code M)	02130-1060-0005

Rosemount World Headquarters

Emerson Process Management

6021 Innovation Blvd

Shakopee, MN 55379, USA

☎ +1 800 999 9307 or +1 952 906 8888

☎ +1 952 949 7001

✉ RFQ.RMD-RCC@EmersonProcess.com

North America Regional Office

Emerson Process Management

8200 Market Blvd.

Chanhassen, MN 55317, USA

☎ +1 800 999 9307 or +1 952 906 8888

☎ +1 952 949 7001

✉ RMT-NA.RCCRFQ@Emerson.com

Latin America Regional Office

Emerson Process Management

1300 Concord Terrace, Suite 400

Sunrise, Florida, 33323, USA

☎ +1 954 846 5030

☎ +1 954 846 5121

✉ RFQ.RMD-RCC@EmersonProcess.com

Europe Regional Office

Emerson Process Management Europe GmbH

Neuhofstrasse 19a P.O. Box 1046

CH 6340 Baar

Switzerland

☎ +41 (0) 41 768 6111

☎ +41 (0) 41 768 6300

✉ RFQ.RMD-RCC@EmersonProcess.com

Asia Pacific Regional Office

Emerson Process Management Asia Pacific Pte Ltd

1 Pandan Crescent

Singapore 128461

☎ +65 6777 8211

☎ +65 6777 0947

✉ Enquiries@AP.EmersonProcess.com

Middle East and Africa Regional Office

Emerson Process Management

Emerson FZE P.O. Box 17033,

Jebel Ali Free Zone - South 2

Dubai, United Arab Emirates

☎ +971 4 8118100

☎ +971 4 8865465

✉ RFQ.RMTMEA@Emerson.com

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