Safety Manual
MS-00809-0200-4860, Rev AA
June 2024

Rosemount™ 8600D Series Vortex Flow Meter Safety Manual for Safety Instrumented Systems (SIS)

ROSEMOUNT™

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Contents

1 Before you begin

1.1 Emerson Flow customer service

Email:

- Worldwide: flow.support@emerson.com
- Asia-Pacific: APflow.support@emerson.com

1.2 About this document

This document provides information about how to install, commission, and proof test the Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter to comply with Safety Instrumented Systems (SIS) requirements.

The information in this document assumes that users understand:

- Basic flow meter installation, configuration, and maintenance concepts and procedures
- Safety Instrumented System (SIS) operations, including bypass procedures, flow meter maintenance, and company Management of Change procedures
- All corporate, local government, and national government safety standards and requirements that guard against injuries or death

1.3 Related documents

You can find all product documentation via the Rosemount product documentation DVD shipped with the product or at Emerson.com/vortex. For more information, see any of the following documents:

- *Rosemount™ 8600D Series Vortex Flow Meter Product Data Sheet*
- *Rosemount™ 8600D Series Vortex Flow Meter Quick Start Guide*
- *Rosemount™ 8600D Series Vortex Flow Meter Reference Manual*
- Report No. ROS 06/03-34 R001 V5R0; FMEDA report for Rosemount 8600D Vortex Flow Meter Prepared for Emerson by exida.com LLC

1.4 Terms and definitions

BPCS	Basic Process Control System
λ_{DU}	Dangerous Undetected
λ_{DD}	Dangerous Detected
λ_{SU}	Safe Undetected
λ_{SD}	Safe Detected
CPT	Comprehensive Proof Test
Diagnostic Coverage	[DC] Percentage of detectable faults

Diagnostic Test Interval	Time during which all internal diagnostics are carried out at least once.
Fail-safe state	Failure that causes the device to go to the defined fail-safe state without a demand from the process.
Fail dangerous	Failure that deviates the process signal or the actual output by more than the safety deviation specification, drifts away from the user defined threshold (Trip Point) and that leaves the output within the active scale.
FIT	Failure In Time per billion hours
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 output to go to the defined fail-safe state without an input from the process.
FMEDA	Failure Modes, Effects and Diagnostic Analysis
HART®	Highway Addressable Remote Transducer
HFT	Hardware Fault Tolerance as defined by 61508-2 7.4.4.1.1
High demand mode	The safety function is only performed on demand, in order to transfer the Equipment Under Control (EUC) 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.
PPT	Partial Proof Test
Random Integrity	The SIL limit imposed by the architectural constraints that must be met for each element.
Safety Demand Interval	The expected time between safety demands.
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 as per 61508-4
SFF	Safe Failure Fraction
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 (SIS) - 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.
Type B device	Complex device using controllers or programmable logic, as defined by the standard IEC 61508.

1.5 Skill level requirement

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

1.6 Documentation and standards

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

Documents	Purpose of documents
IEC 61508-2: 2010	*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*
ROS 06/03-34 R001 V5R0	*FMEDA Report Version V5, Revision R0, or later, for the Rosemount 8600D Series Vortex Flow Meter*
00813-0100-4860	*Rosemount™ 8600D Series Vortex Flow Meter Product Data Sheet*
00809-0100-4860	*Rosemount™ 8600D Series Vortex Flow Meter Reference Manual*
00825-0100-4860	*Rosemount™ 8600D Series Vortex Flow Meter Quick Start Guide*

2 Installation and commissioning

Use this chapter to install and commission the Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter. The safety certified output of the Rosemount 8600D is the 4–20 mA output. This output provides a signal proportional to process flow, between low flow cutoff and the Upper Range Value (URV). Detected faults are indicated by an offscale output (see Set failure mode). The safety logic solver should be configured to detect offscale output levels. While the pulse output may be used, it is not a safety certified output. Devices ordered without SI option may not be certified per IEC 61508.

2.1 Identification of SIS certified transmitter

IEC 61508 relevant requirements

The Rosemount 8600D is certified per the relevant requirements of IEC 61508.

Systematic capability	Safety Integrity Level (SIL) 3 capable
Random capability	Low Demand: • Type B element • SIL 2 capable @ HFT≥0 (single transmitter) • SIL 3 capable @ HFT≥1 (multiple single transmitters) High Demand: • Type B element • SIL 2 or 3 capable @ HFT≥1 (multiple single transmitters)

Failure rates per IEC 61508 in FIT

Table 2-1: Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter

Failure categories	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
Low Flow Trip	0	76	387	74
High Flow Trip	0	32	387	119

SIS-certified versions

All Rosemount 8600D Vortex Flow Meters must be identified as safety certified before installing into SIS systems.

To identify a safety certified Rosemount 8600D Vortex flow meter, requirements 1 and 2, or requirements 2 and 3 must be satisfied. The requirements are:

1. Verify the option code "SI" in the model code. The SI code will appear somewhere after the 16th character of the model code (after the required fields.) Note that the optional options, including SI, can appear in any order and be valid. Please refer to A of Figure 2-1.
   - For example: 8600D................SI

2. Verify 4-20 mA marking on the transmitter housing nameplate. Please refer to B of Figure 2-1.

3. Confirm firmware revision is one of the revisions listed in Table 2-2.

Note
Software version information may be verified in the device from the Field Communicator: **Overview → Device Information → Revision Number**.

Figure 2-1: Example of transmitter nameplate

A. SI option code
B. 4–20 mA Output

Table 2-2: Rosemount 8600D SIS revisions and versions

Device	Display tag	Safety certified version combinations	
		1	2
8600D firmware	Universal revision	5	7
	Transmitter revision	2	1
	Software revision	1	1
8600D hardware	Hardware revision	1	1

Safety precautions

Prior to making any changes to the flow meter, such as changing the configuration or replacing the transmitter hardware or sensor:

- Take appropriate action to avoid a false trip by electronically bypassing the safety logic solver.
- Prior to placing the meter online and removing the bypass from the safety logic solver, verify the transmitter configuration and all safety parameters per Set up the flow meter.

Important
Ensure alternate means are in place to maintain the process in a safe state.

2.2 Set up the flow meter

Use the following procedure to make sure the flow meter is installed and configured for SIS applications.

You can use ProLinkIII software, AMS Device Manager,or the Field Communicator to verify, or configure these settings. For more information, see the product reference manual.

The flow meter does not require special installation other than the standard installation procedures in the reference manual.

Note
Transmitter output is not safety-rated during the following: Configuration changes, loop test mode, simulation mode, multidrop operation, temperature compensation of the process fluid, saturated steam or mass flow with temperature compensation. Alternative means should be used to ensure process safety during configuration and maintenance activities.

Procedure

1. Verify that the software revision running is one of the revisions listed in Table 2-2.

ProLink III Software	**Device Tools → Device Information → Software Revision**

2. Verify all safety parameters.
   a. Verify that all appropriate flow calibration parameters are set (Reference K-Factor, Process Fluid, Fixed Process Temperature, Fixed Process Density).
   b. Verify that the Lower Range Value (LRV) and the Upper Range Value (URV) for the 4-20 mA output is configured

2.3 Enable transmitter write protection

Write-protection helps protect the transmitter against accidental changes to configuration. When the transmitter is write-protected, no changes to the transmitter configuration will be accepted.

Tip
Write protecting the transmitter prevents accidental changes to configuration. It does not prevent normal operational use. You can always disable write protection, perform any required configuration changes, then re-enable write protection.

The SECURITY jumper enables write protection.

- If the jumper is in the **ON** position, write protection is enabled.
- If the jumper is in the **OFF** position, write protection is disabled.

Procedure

1. If you are in a hazardous area, power down the transmitter.
2. **⚠ WARNING**

   Never remove the transmitter housing cover in a hazardous area when the transmitter is powered up. Failure to follow these instructions may result in an explosion.

   Remove the transmitter housing cover (opposite of the terminal block).
3. Move the two-pin SECURITY jumper to the ON position.

   The location of the security switch depends upon whether or not the transmitter has the (M5) optional display.

Figure 2-2: SECURITY jumper location without M5 optional display

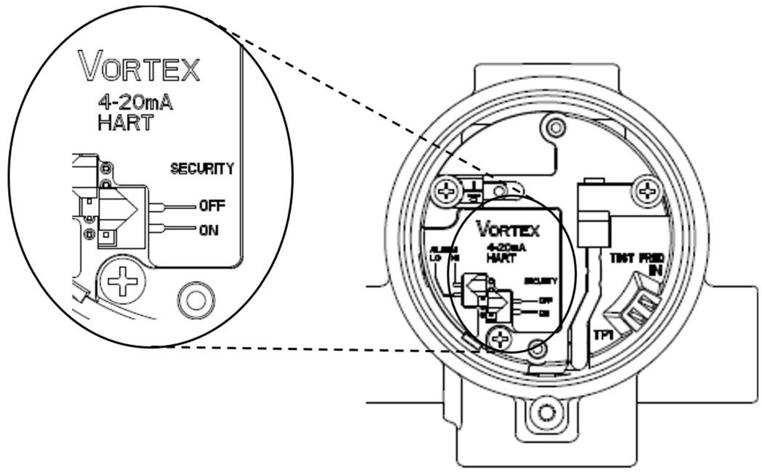
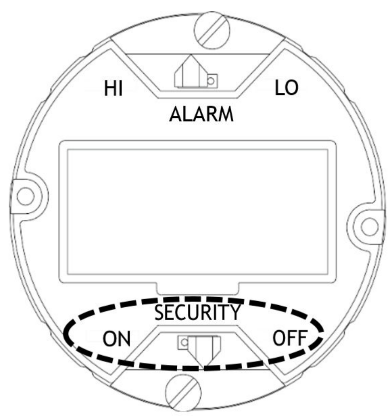


Figure 2-3: SECURITY jumper location with M5 optional display



4. Replace the transmitter housing cover.
5. Power up the transmitter.

2.4 Set failure mode

As part of normal operations, the flow meter continuously runs a self-diagnostic routine. If the routine detects an internal failure, the failure mode setting determines whether the flow meter output is driven to a low or high alarm level.

The failure mode setting is controlled by the ALARM jumper, which is set at the factory per the Configuration Data Sheet (CDS); the default setting is **HI**.

- If the ALARM jumper is in the **HI** position, the flow meter output will be driven to a high alarm level in the event of a failure.
- If the ALARM jumper is in the **LOW** position, the flow meter output will be driven to a low alarm level in the event of a failure.

Note
For exact alarm values, see the product reference manual.

Procedure

1. If you are in a hazardous area, power down the transmitter.
2. **⚠ WARNING**

   Never remove the transmitter housing cover in a hazardous area when the transmitter is powered up. Failure to follow these instructions may result in an explosion.

   Remove the transmitter housing cover (opposite of the terminal block).
3. Move the two-pin ALARM jumper to the HI or LOW position, as desired.

   The location of the ALARM jumper depends upon whether or not the transmitter has the (M5) optional display.

   Figure 2-4: ALARM jumper location without (M5) optional display

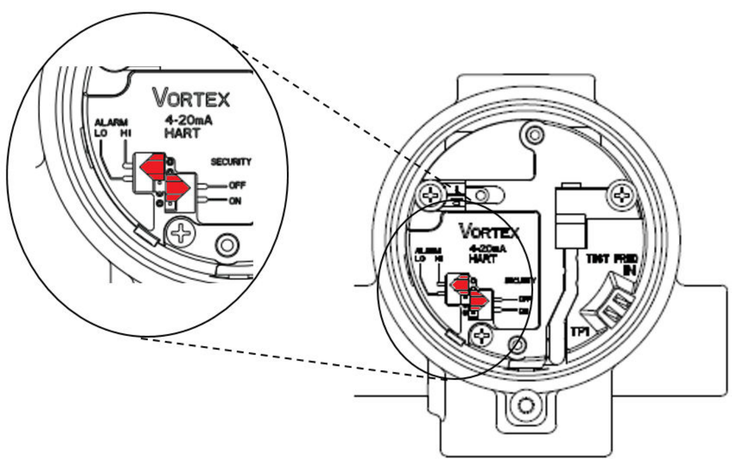
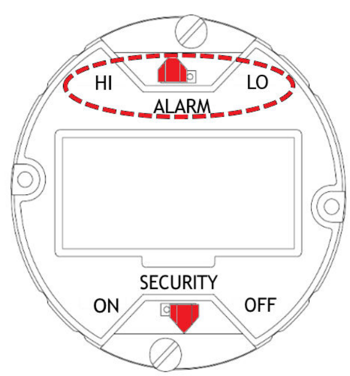
   

   Figure 2-5: ALARM jumper location with (M5) optional display

4. Replace the transmitter housing cover.
5. Power up the transmitter.

2.5 Diagnostics

The Rosemount 8600D has multiple diagnostic features related to transmitter operation and performance. The transmitter performs each diagnostic at least every 60 seconds. If the diagnostics detect a failure or fault condition, the transmitter will change the 4-20 mA analog output if applicable. The applicable product manual provides a complete list of these diagnostics and corresponding changes.

2.6 Flow simulation diagnostic

Performing an internal flow simulation ensures the current calibration state of the transmitter by carrying out a verification of the electronics board stack to indicate the health of the various components on the board stack. Failure may indicate a need to replace the electronics. Every transmitter comes with internal flow simulation capabilities.

Note
For the Flow Simulation Function to operate, Primary Variable must be set to Velocity Flow, Volume Flow, or Mass Flow and the write protection must be disabled (see Enable transmitter write protection).

Procedure

1. Ensure that the write protection is disabled (see Enable transmitter write protection).
2. Read the calculated Shedding Frequency at URV.

ProLink III Software	**Device Tools → Configuration → Process Measurement → Signal Processing**

3. Navigate to **Flow Simulation**.

ProLink III Software	**Device Tools → Diagnostics → Testing → Flow Simulation**

4. Select **Internal Flow Simulation**, **Fixed Flow**, **Percent of Range** and enter `50% flow`.
5. Verify that flow rate output is 50% of full scale and Frequency is 1/2 of calculated Frequency at URV.
    a. If the flow rate output is 50% of full scale, the electronics are working properly.
    b. If the flow rate output is not 50% of full scale, see the troubleshooting information in the product reference manual.

Note
Optional: Verify shedding frequency from internal signal generator is the same as displayed on handheld communicator, Prolink III, or AMS Device Manager. This can be accomplished by connecting a device such as a Fluke multi-meter with frequency measurement capability to the test points behind the display labeled "TP1" and Ground (using the universal ground symbol). Connect the positive lead of the digital multi-meter to TP1 and the negative lead to the Ground lug. The frequencies should match to a plant specified tolerance that is no less than the tolerance of the device used to read the frequency.

- If the shedding frequency is 50% of full scale, the electronics are working properly.

- If the shedding frequency is not 50% of full scale, see the troubleshooting information in the product reference manual.

6. Exit simulation by selecting **Normal Flow Measurement** or **Exit**.
7. Enable write protection (see Enable transmitter write protection).

2.7 Replace equipment

If you need to replace hardware, purchase all spare parts from Emerson. You cannot use user-supplied components on any Rosemount printed circuit assemblies.

Procedure

1. Replace the hardware by contacting your local Emerson or Emerson affiliated sales representative to obtain the correct part number.

   Use the product reference manual or quick start guide for proper maintenance guidelines.

2. Verify the transmitter configuration and all safety parameters (see Set up the flow meter).
3. Enable write protection (see Enable transmitter write protection).
4. Set the failure mode (see Set failure mode.)

3 Proof tests

3.1 Proof test requirement

During operation, a 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.

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

3.2 Repair and replacement

Repair procedures in the product reference manual must be followed.

3.3 Notification of failures

In case of malfunction of the system or SIF, the Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter shall be put out of operation and the process shall be kept in a safe state by other measures.

Emerson must be informed when the Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter is required to be replaced due to failure. The occurred failure shall be documented and reported to Emerson using the contact details on the back page of this functional safety manual. This is an important part of Emerson SIS management process.

3.4 Proof test interval

The time intervals for proof testing are defined by the SIL verification calculation (subject to the PFDAVG). 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.

Results from periodic proof tests shall be recorded and periodically reviewed. For the specification of customer requirements required to fulfil this SIS requirement, please see IEC-61511.

3.5 Tools required

- HART® host or Field Communicator
- mA meter

3.6 Proof test options

The flow meter has two proof tests you can use to detect failures. Proof tests can be performed using ProLink III software or the Field Communicator.

Table 3-1: Proof test options

Device	Proof test	Description	DU failure detection
8600D	Partial	• Low/High alarm checks (see Table 3-2) • Visual inspection of flow meter • Single point verification (see Table 3-3 for sample test points) • Checking for alarms • Checking configuration	High flow trip: 85% Low flow trip: 77%
	Comprehensive	• Low/High alarm checks (see Table 3-2) • Visual inspection of flow meter • 3-point verification (see Table 3-4 for sample test points) • Checking for alarms • Checking configuration	High flow trip: 94% Low flow trip: 92%

Table 3-2: Low and high alarm values (Rosemount Standard and NAMUR)

Rosemount Standard Alarm Values			NAMUR Compliant Alarm Values		
Level	**4–20 mA Saturation value**	**Acceptance value (mA)**	**Level**	**4–20 mA Saturation value**	**Acceptance value (mA)**
Low	3.9 mA	3.51 – 4.29 mA	Low	3.8 mA	3.42 – 4.18 mA
High	20.8 mA	18.72 – 22.88 mA	High	20.5 mA	18.45 – 22.5 mA

3.7 Partial proof test

The partial proof test is recommended for all Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meters.

This procedure assumes that you are familiar with plant procedures. For details on how to do any of the following steps, see the product reference manual.

Procedure

1. Take appropriate action to avoid a false trip by electronically bypassing the safety Programmable Logic Controller (PLC).
2. Inspect flow meter for any leaks, visible damage or contamination.
3. Verify that the transmitter does not indicate alarms or warnings using HART® host or LCD.
4. Cycle power and use HART communications to retrieve any diagnostics and take appropriate action.
5. Disable write protection (see Enable transmitter write protection).

6. Using the Loop Test function, send a HART command to the transmitter to go to the high alarm current output and verify that the analog current reaches that value.
   - Loop Test can be found at **Service Tools → Simulate → Analog Output → Loop Test**.
   - High alarm and low alarm levels can be found in the product reference manual.

   This step tests for compliance voltage problems, such as low voltage on the loop power supply, or increased wiring resistance.
7. Send a HART® command to the transmitter to go to the low alarm current output and verify that the analog current reaches that value.

   This step tests for possible failures related to quiescent current.
8. Exit fixed current mode.
9. Compare the process flow with the Low Flow Cutoff, and do one of the following:

Option	Description
Process flow greater than Low Flow Cutoff	Confirm measured flow compares reasonably to an independent measurement.
Process flow less than Low Flow Cutoff	Check output at 2 points using internal flow simulation, with at least one point between LFC and URV.

10. Verify all safety-critical configuration parameters (see Set up the flow meter).
11. Enable write protection (see Enable transmitter write protection).
12. Remove the bypass and otherwise restore normal operation.
13. Document the results of this proof test as part of your plant safety management procedures.

Table 3-3: Partial proof test verification (sample test points)

Percent of range	Nominal current (mA)	Acceptable current (mA)
50%	12 mA	11.88 – 12.12 mA

3.8 Comprehensive proof test

The comprehensive proof test is recommended for all Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meters.

This procedure assumes that you are familiar with plant procedures. For details on how to do any of the following steps, see the product reference manual.

Procedure

1. Take appropriate action to avoid a false trip by electronically bypassing the safety Programmable Logic Controller (PLC).
2. Inspect flow meter for any leaks, visible damage or contamination.
3. Verify that the transmitter does not indicate alarms or warnings using HART host or LCD.
4. Cycle power and use HART communications to retrieve any diagnostics and take appropriate action.

5. Disable write protection (see Enable transmitter write protection).
6. Using the Loop Test function, send a HART command to the transmitter to go to the high alarm current output and verify that the analog current reaches that value.
    - Loop Test can be found at **Service Tools** → **Simulate** → **Analog Output** → **Loop Test**.
    - High alarm and low alarm levels can be found in the product reference manual.

    This step tests for compliance voltage problems, such as low voltage on the loop power supply, or increased wiring resistance.
7. Send a HART command to the transmitter to go to the low alarm current output and verify that the analog current reaches that value.

    This step tests for possible failures related to quiescent current.
8. Exit fixed current mode.
9. Perform a 3 to 5-point calibration check of the transmitter and flow meter against a reference standard.
10. Verify all safety-critical configuration parameters (see Set up the flow meter).
11. Enable write-protection (see Enable transmitter write protection).
12. Remove the bypass and otherwise restore normal operation.
13. Document the results of this proof test as part of your plant safety management procedures.

Table 3-4: Comprehensive proof test verification (sample test points)

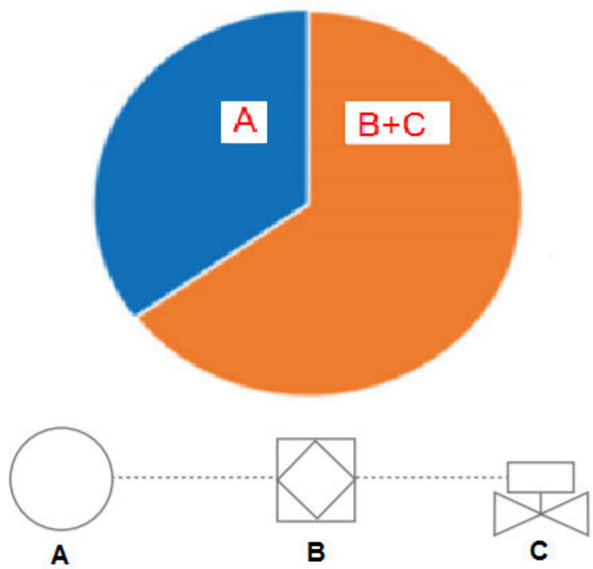
Percent of range	Nominal current (mA)	Acceptable current (mA)
0%	4 mA	3.96 – 4.04 mA
50%	12 mA	11.88 – 12.12 mA
100%	20 mA	19.80 – 20.20 mA

3.9 SIS example

The following figures illustrate the indicative benefits of using a combination of comprehensive and partial proof tests to manage the level of risk associated with a particular SIS Installation. Figure 3-1 shows a typical 1oo1 safety system configuration. Figure 3-2 through Figure 3-5 illustrate the benefit of implementing a combination of comprehensive and partial proof tests on the system's PFD.

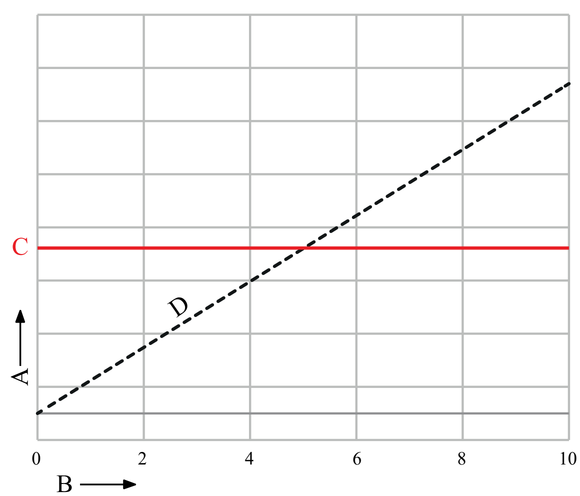
Note
It is assumed that the sensor typically contributes ~30% to the systems SIL 2 PFD budget, with the logic solver and actuator the remaining ~70%.

Figure 3-1: Single use 1oo1 (1 out of 1) for SIL 2 low demand (SIL 2@HFT=0)



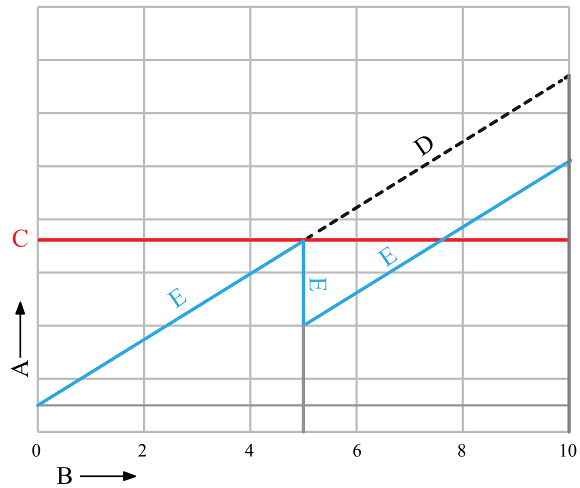
A. Sensor (Rosemount 8600D)
B. Logic solver
C. Actuator

Figure 3-2: PFD and PFD average of system when no proof testing applied



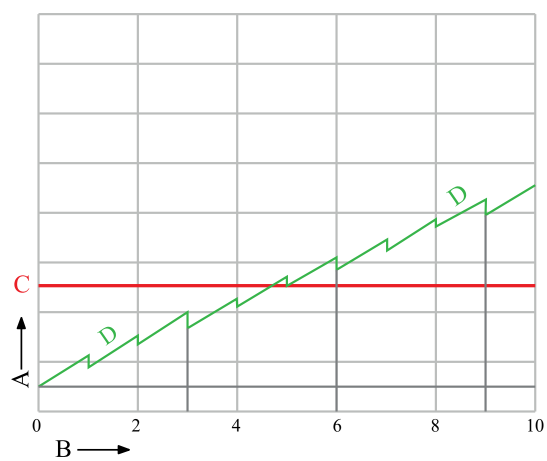
A. PFD (Probability of failure on demand)
B. Mission time (years)
C. PFD_{AVG} (average probability of failure on demand)
D. Predicted PFD

Figure 3-3: Unit subjected to either no proof test or a comprehensive proof test every 5 years



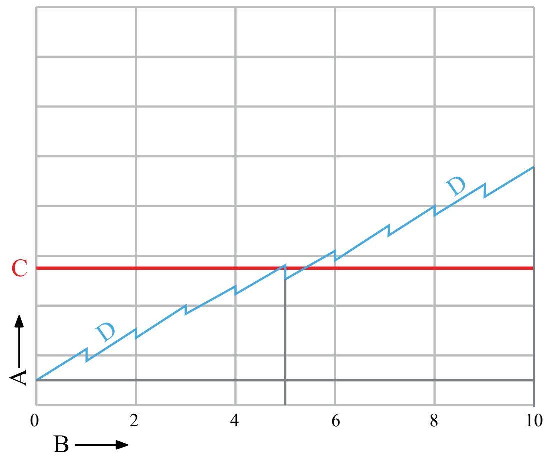
A. PFD (Probability of failure on demand)
B. Mission time (years)
C. PFD_{AVG} (average probability of failure on demand)
D. Predicted PFD
E. Predicted PFD + CPT (comprehensive proof test)

Figure 3-4: Unit subjected to a partial proof test every year and a comprehensive proof test every 3 years



A. PFD (Probability of failure on demand)
B. Mission time (years)
C. PFD_{AVG} (average probability of failure on demand)
D. Predicted PFD + PPT (partial proof test) + CPT (comprehensive proof test)

Figure 3-5: Unit subjected to a partial proof-test every year and a comprehensive proof test every 5 years



A. *PFD (Probability of failure on demand)*
B. *Mission time (years)*
C. *PFD_{AVG} (average probability of failure on demand)*
D. *Predicted PFD + PPT (partial proof test) + CPT (comprehensive proof test)*

4 Operating Constraints

4.1 Reverse flow

Use appropriate means to ensure only zero or forward flow through the meter, as indicated by the arrow on the meter body. Reverse flow operation may result in erroneous non-zero flow indication.

4.2 Reliability data

The Rosemount 8600D Series SIL 2/3 Capable Vortex Flow Meter:

- Has a specified safety deviation of 2%. Internal component failures are listed in the device failure rate if they will cause an on-scale error of 2% or greater.
- Reports an internal failure within 30 minutes of fault occurrence – worst case scenario.
- Has a self-diagnostic test interval of at least once every 60 seconds.
- Generates a valid signal within 6 seconds plus configured damping response of a power-on startup.

FMEDA report

The Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is used to calculate the failure rate. A FMEDA report for a Vortex Flow Meter with a Rosemount 8600D transmitter contains:

- All failure rates and failure modes
- Common cause factors for applications with redundant devices that should be included in reliability calculations
- The expected lifetime of your flow meter and transmitter, as the reliability calculations are valid only for the lifetime of the equipment

Obtain a FMEDA report at Emerson.com/vortex.

Environmental and application limits

See the product data sheet for environmental and application limits.

Using the flow meter or transmitter outside environmental or application limits invalidates the reliability data in the FMEDA report.

4.3 Report failures

If you have detected any failures that compromise safety, contact the Flow Solutions Group Product Safety Officer.

Contact the Product Safety Officer through the Flow Solutions Group customer service. Customer service is available 24 hours a day, seven days a week. Contact information is located in Emerson Flow customer service.

MS-00809-0200-4860
Rev. AA
2024

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

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