Safety Manual
00809-0600-4728, Rev AA
December 2021

Rosemount™ 644 Rail Mount Temperature Transmitter

With RK Option and HART® 7 Protocol

ROSEMOUNT™

EMERSON™

Safety messages

NOTICE

Read this document before working with the product. For personal and system safety, and for optimum product performance, make sure 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 Central Time)
Asia Pacific- 65 777 8211
Europe/Middle East/Africa - 49 (8153) 9390

North American Response Center

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

⚠ WARNING

Follow instruction

Failure to follow these installation guidelines could result in death or serious injury.

Ensure only qualified personnel perform the installation.

Explosion

Explosions could result in death or serious injury.

Do not remove the connection head cover in explosive atmospheres when the circuit is live.
Before connecting a handheld communicator in an explosive atmosphere, ensure that the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
Verify that the operating atmosphere of the transmitter is consistent with the appropriate hazardous locations certifications.
All connection head covers must be fully engaged to meet explosion-proof requirements.

Process leaks

Process leaks could result in death or serious injury.

Do not remove the thermowell while in operation.
Install and tighten thermowells and sensors before applying pressure.

Electric shock

Electrical shock could cause death or serious injury.

Use extreme caution when making contact with the leads and terminals.

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 Rosemount nuclear-qualified products, contact your local Emerson Sales Representative.

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 to protecting your system. Restrict physical access by unauthorized personnel to protect end users' assets. This is true for all systems used within the facility.

Contents

1 Introduction

1.1 Using this manual

This document provides information about how to install, commission, and proof test a Rosemount 644 Rail Mount Temperature Transmitter to comply with safety instrumented systems (SIS) requirements.

NOTICE

This manual assumes that the following conditions apply:

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

The following product variants are considered in this manual:

Description	Suffix
DIN rail mounted 2w programmable temperature transmitters	644R*QT*(1)
	644T*QT*(1)

(1) The "" represent various options and approvals which have no impact on the safety aspects of the device.*

Product purpose

This is a 2-wire HART® temperature transmitter for temperature measurement with TC and RTD sensors. True dual input with high density 7 terminal design allows measurement of two 4-wire RTDs. Sensor redundancy allows automatic switch to secondary sensor in the event of primary sensor failure and sensor drift detection issues an alert when sensor differential exceeds predefined limits. The device has been designed, developed and produced for use in SIL 2/3 applications according to the requirements of IEC 61508 : 2010

Related documents

All product documentation is available at Emerson.com.

1.2 Transmitter overview

The transmitter supports the following features:

- 4-20 mA/HART® protocol (Revision 7)
- Accepts either one or two inputs from a wide variety of sensor types (2-, 3-, and 4-wire RTD, thermocouple, mV and ohm)
- Optional Safety Certification (IEC 61508 SIL 2)

- Special dual-sensor features including Hot Backup™, Sensor Drift Alert, first good, differential and average temperature measurements, and four simultaneous measurement variable outputs in addition to the analog output signal
- Meets NAMUR NE21, NE43, NE44, NE89 and NE107 compliant diagnostics information.

Refer to the following literature for a full range of compatible connection heads, sensors, and thermowells provided by Emerson:

- Rosemount 214C Temperature Sensors Product Data Sheet
- Rosemount Volume 1 Temperature Sensors and Accessories (English) Product Data Sheet
- Rosemount DIN-Style Temperature Sensors and Thermowells (Metric) Product Data Sheet

Table 1-1: Change Summary: Rosemount 644 Rail Mount HART Device Revision

Release date	NAMUR software revision	NAMUR hardware revision	HART software revision(1)	Manual document number
May 2021	01.05.10	01.05.10	7	00809-0500-4728

(1) NAMUR software revision is located on the hardware tag of the device. HART software revision can be read using a HART communication tool.

2 Installation and commissioning

2.1 IEC 61508 relevant requirements

Table 2-1: Observed Standards

Standard	Description
IEC 61508	Functional Safety of electrical / electronic / programmable electronic safety-related systems
IEC 61508-2:2010	Part 2: Requirements for electrical / electronic / programmable electronic safety-related systems
IEC 61508-3:2010	Part 3: Software requirements
IEC 61326-3-1:2008	Immunity requirements for safety-related systems

2.2 Installation in SIS applications

Installations are to be performed by qualified personnel. No special installation is required in addition to the standard installation practices outlined in the applicable product manual.

Environmental and operational limits are available in the product manual.

2.2.1 Basic safety specifications

Ambient operating temperature range	-40...+80 °C
Storage temperature range	-50...+85 °C
Supply voltage, non-Ex	7.5(1)...48(2) VDC (at terminals)
Supply voltage, Ex ia	7.5(1)...30(2) VDC (at terminals)
Additional minimum supply voltage when using test terminals	0.8 V
Maximum internal power dissipation	≤ 850 mW
Minimum load resistance at > 37 V supply	(Supply voltage – 37) / 23 mA
Mounting area	Zone 0, 1, 2 / Division 2 or safe area
Mounting environment	Pollution degree 2 or better
Maximum wire size	1 x 1.5 mm^2 stranded wire
Screw terminal torque	0.5 Nm

(1) *The minimum supply voltage must be as measured at the terminals (i.e. all external drops must be considered).*
(2) *Ensure the device is protected from over-voltages by using a suitable power supply or by installing overvoltage protecting devices.*

2.2.2 Useful lifetime

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 (note 3), or as determined by user's own statistics. The device contains no components that are especially sensitive to environmental conditions, nor does it contain any unmanaged memory components with suspected retention times.

2.2.3 Safety accuracy

The analog output corresponds to the applied input within the safety accuracy.

Safety accuracy	±2%

Minimum span

The selected range (PV Upper Range - PV Lower Range) shall be larger or equal to the values below.

Configured input type	Minimum span	Unit
Pt100-Pt10000, Ni100-Ni1000, Cu100-Cu1000	25	°C
Pt50, Ni50, Cu50	50	°C
Pt20, Ni20, Cu20	125	°C
Pt10, Ni10, Cu10	250	°C
Cu5	500	°C
TC: E, J, K, L, N, T, U	100	°C
TC: Lr, R, S, W3, W5, B	400	°C
Voltage -20...100 mV	1.3	mV
Voltage -0.1...1.7 V	0.12	V
Voltage ±0,8 V	0.12	V
Linear Ohms 0...400 Ohm	10	Ohm
Linear Ohms 0...100 kOhm	1	kOhm
Potentiometer	10	%

Range limitations

For SIL applications, TC input type B shall not be used below +400 °C since the accuracy will be lower than the specified safety accuracy.

2.2.4 Associated equipment

RTD, or linear resistance sensor wiring

If *Input 1 Number of Wires* / *Input 2 Number of Wires* is configured to 2 or 3, and *Input Type 1* / *Input Type 2* is RTD, Ohm, or kOhm, the end user must ensure the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

Potentiometer sensor wiring

If *Input 1 Number of Wires* is configured to 3 or 4, and *Input Type* is Potentiometer, the end user must ensure the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

Sensor short circuit errors

Detection of short-circuited sensors, or short-circuited sensor wires, is ignored for both Input 1 and Input 2 if either of their Input Types is configured as listed below:

- Ohms or kOhms
- Pt50 or Ptx and RTD Factor < 100
- Nix and RTD Factor < 50
- Cu10, Cu50, or Cux and Sensor Custom RTD Resistance < 100
- Potentiometer and Input 1 Upper Limit (potentiometer size) < 18 Ohm

For Potentiometer there is no short circuit detection on potentiometer arm.

Detection of short-circuited sensor or short-circuited sensor wires is ignored for Input 1 or Input 2 if its Input Type is configured as listed below:

- Micro-volts, Milli-volts or Volts (bipolar or unipolar)
- Any TC type (detection of shorted External CJC sensor is NOT ignored)

If any of these input types shall be used in a Safety Application, the user must ensure the applied sensors, including wiring, have failure rates that qualify them, without detection of short-circuited sensors or wires.

Extension port

Only equipment designed specifically for connection to the extension port of the transmitter may be connected. This equipment will specify the applied maximum operating voltage drop; V_{EXT}. The user must make sure the supply voltage, minus any drops for external measurement or communication resistances, and minus the applied maximum drop for the equipment attached to the extension port, will be higher than the minimum specified supply voltage:

$V_{SUPPLY} > 7.5 + V_{EXT} + V_{DROP}$

Process calibration (input trimming)

If a process calibration on Input 1 or Input 2 has been carried out before entering SIL-mode operation, it is mandatory that the accuracy of the device (and sensor, if applicable) is tested by the end user after SIL-mode is entered, in addition to the normal functional test (see Process calibration (input trimming).

Analog output

The connected safety PLC shall be able to detect and handle the fault indications on the analog output of the transmitter by having a NAMUR NE43-compliant current input. The safety PLC must be able to detect and react to error signals according to NE43 within one second. If Output Limit Check is disabled (see Output) in SIL mode, the connected safety PLC shall also be able to detect and react to a current in the extended range according to NAMUR NE43, within one second. The limits for the detection shall be <20.5 mA and >3.8 mA.

Failure rates

The basic failure rates from the Siemens standard SN 29500 are used as the failure rate database. Failure rates are constant; wear-out mechanisms are not included. External power supply failure rates are not included.

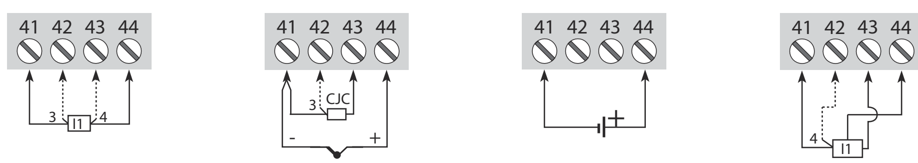
2.2.5 Installation considerations

The device must be installed as required for the SIL application according to Connections. All assumption and restrictions as described in Installation considerations must be observed.

Connections

Single input

2 w / 3 w / 4 w RTD or lin. R	TC (internal CJC or external 2 w / 3 w / 4 w CJC)(1)	mV	3 w / 4 w potentiometer

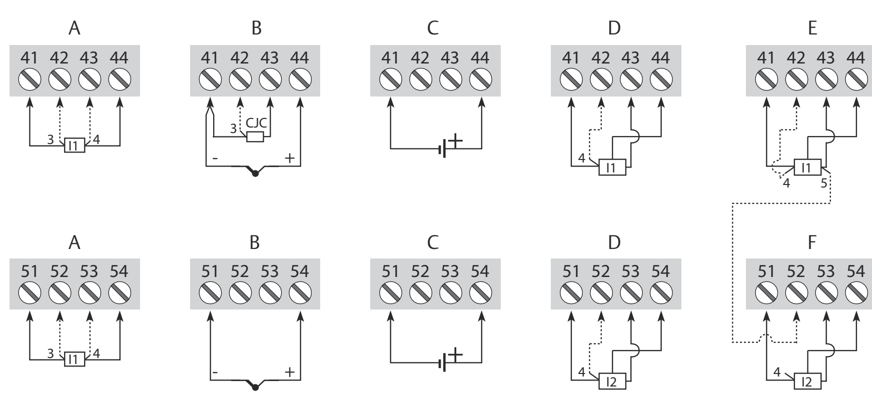


(1) When using thermocouple input, the transmitter can be configured for either constant, internal or external CJC via a Pt100 or Ni100 sensor. This must be selected during device configuration.

Dual inputs

Input 1

Input 2



A. 2 w / 3 w / 4 w RTD or lin. R

B. TC (internal CJC or external 2 w / 3 w / 4 w CJC)[3]

C. mV

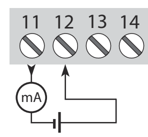
D. 3 w / 4 w potentiometer

E. 5 w potentiometer

F. 3 w potentiometer

Output

2-wire installation



2.3 Configuring in SIS applications

Use any HART® capable configuration tool to communicate with and verify configuration of the transmitter.

Note
Transmitter output is not safety-rated during the following: configuration changes, multidrop, and loop test. Alternative means should be used to ensure process safety during transmitter configuration and maintenance activities.

2.3.1 Safe parameterization

The user is responsible for verifying the correctness of the configuration parameters. After parametrization it is not possible to simulate any measurements or the analog output. The following restrictions applies to the configuration parameters.

Function/parameter	SIL requirements
Sensor 1/2 Input Type	Cannot be set to *Callendar Van Dusen* or *Custom*
Output Range 0%	Must be 4.0 mA
Output Range 100%	Must be 20.0 mA
Limit Check Configuration	Must be set to *Limit Check Enabled on Input Range* or *Limit Check Enabled on Input and Output Range*
Output Limit – Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled on output)
Output Lower Limit	Must be 3.8 mA
Output Upper Limit	Must be 20.5 mA
Sensor Error Action	Must be set to *Broken and Shorted*

(3) *When using thermocouple input, the transmitter can be configured for either constant, internal or external CJC via a Pt100 or Ni100 sensor. This must be selected during device configuration.*

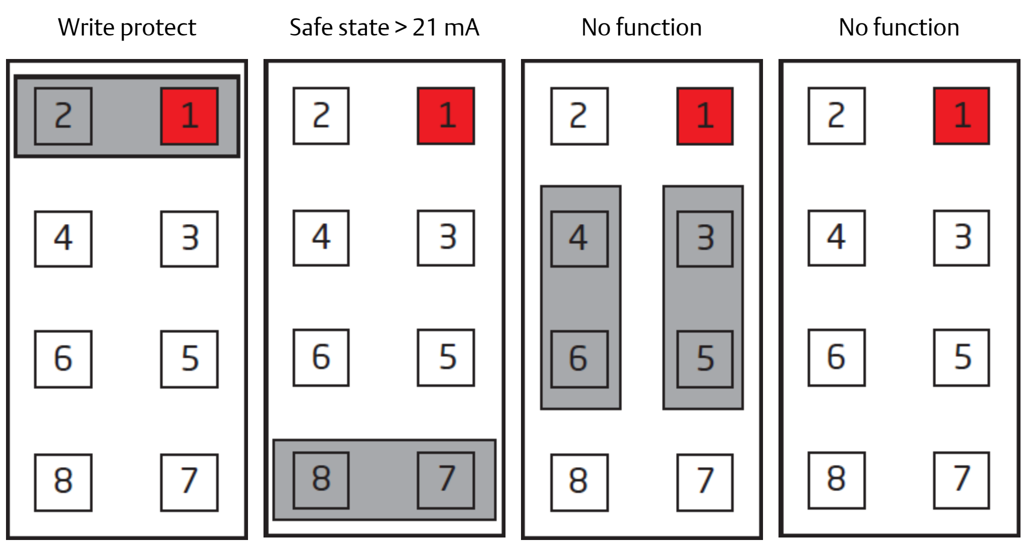
Function/parameter	SIL requirements
Broken Sensor – Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Shorted Sensor – Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Sensor Drift – Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled)
Input Limits – Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Analog Output Calibration Gain	Must be 1.0 (calibration of output current is not allowed)
Analog Output Calibration Offset	Must be 0.0 (calibration of output current is not allowed)
Loop Current Mode	Must be set to *Enabled*
Write Protection	Must be set to *The configuration is protected by Password*

For detailed description of the configuration parameters, see Safe parameterization - user responsibility.

2.3.2 HW jumper

For SIL applications, any detected device error must force the analog output to a value below 3.6 mA (i.e. in SIL mode, the HW jumper from P7-P8 may NOT be inserted). The HW write protection by inserting a jumper from P1-P2 can be applied as an extra write protection, after configuration and after SIL mode is entered.

Note
For SIL applications, the password write protection must be applied. (See Safe parameterization for more information).



2.3.3 Installation in hazardous areas

The IECEx Installation drawing, ATEX Installation drawing and FM Installation drawing shall be followed if the products are installed in hazardous areas.

2.3.4 FMEDA reports

The FMEDA reports are issued by exida. The reports can be downloaded from Emerson.com.

2.3.5 Device states

The states of the device are defined as shown, specific failure rates for each mode are included.

Device state	Description
Normal operation (4-20 mA)	The safe current output is within the defined safety accuracy range.
Detected failure (safe state)	The safe current output is ≤ 3.6 mA (defined as a failure signal) or ≥ 21 mA.
Dangerous state	Dangerous state applies when current output is within the range 4...20 mA and deviates from the correct process value by more than the defined safety accuracy range for longer than 60 seconds.

2.3.6 Device modes

The device can operate in various modes.

Normal mode Non-safety operation for use in non-safety related applications

SIL mode Safety operation and safety error for use in safety related applications

Mode	Description	SIL status	Current output value	Safe current output
Reset/ startup	The device has just been started up or reset, and is determining the next mode. The device will leave this mode after maximum two seconds.	INT	Failure signal ≤ 3.5 mA	Yes

Mode	Description	SIL status	Current output value	Safe current output
Non-safety operation (normal mode)	The device is operating without user-validated safe parameterization. The device may operate with factory default configuration, or with a specific ordered configuration. This mode is valid for use in non-safety related applications only. The user shall assign safety related parameters to the device in this mode.	OPEN	Operation signal (4 to 20 mA)	No
Safety validation mode (transfer from normal mode to SIL mode)	The device is in the process of validating the entered safety parameters and the safety function (see Safe parameterization - user responsibility for more information). The device will leave this mode when the user either accepts or rejects the safety parameterization.	INT	Failure signal ≤ 3.5 mA	Yes
Safety operation (SIL mode)	The device operates in safe mode and delivers safe measurement output on the current output. When operating in this mode, the device is valid for safety related applications.	LOCK	Operation signal (4 to 20 mA)	Yes
Safe parametrization failed	The device has failed the validation of the current configuration for safety operation.	FAIL	Failure signal ≤ 3.5 mA	Yes
Safety error (SIL mode)	The device enters this mode if the system detects a safety related error in Safety Operation mode. The possible errors are listed in the error list of the device.	LOCK	Failure signal ≤ 3.6 mA or ≥ 21 mA	Yes

2.3.7 Functional specification of the safety function

All safety functions relate exclusively to the analog 4...20 mA current output signal. Conversion of voltage signals, potentiometer, linear resistance, RTD sensor signals, or thermocouple sensor signals in hazardous areas to the output signal within specified accuracy. For RTD, potentiometer, and linear resistance inputs, cable resistances of up to 50 Ohm per wire can be compensated if 3- or 4-wire connection is configured (4- or 5-wire for potentiometer). For thermocouple sensors, cold junction temperature errors can be compensated, either by an internally mounted temperature sensor, by an external temperature sensor, or by a fixed temperature value. The selection of CJC measurement must be done and verified by the end user.

The transmitter will detect if any of the applied sensors or their connection wires are short-circuited or broken with the restrictions given in Sensor short circuit errors.

One or two inputs can be measured in combinations. The failure rates are determined by the FMEDA for the following configurations.

Single

Only one input is measured, the signal is evaluated to control the current output. For this transmitter, one of the inputs is not used.

Dual

Two (both) inputs are measured. The evaluation of the signals includes a mathematical combination such as difference or average of the two signals. The result of the evaluation controls the current output.

Redundant (sensor drift detection)

By setting *Sensor Drift Action* parameter to **Error**, as described in Analog output parameters, two (both) inputs are measured and evaluated. The two results are compared by the transmitter and the current output is set to the safe state if the difference between the evaluated values exceeds a defined (configured) limit, or if a sensor error is detected on any of the inputs.

2.3.8 Functional specification of the non-safety functions

LED outputs and process values delivered using HART® or extension port communication are not suitable for use in any safety instrumented function.

2.3.9 Safety parameters

All figures for probability of failures are specified in the FMEDA report issued by exida (see FMEDA reports).

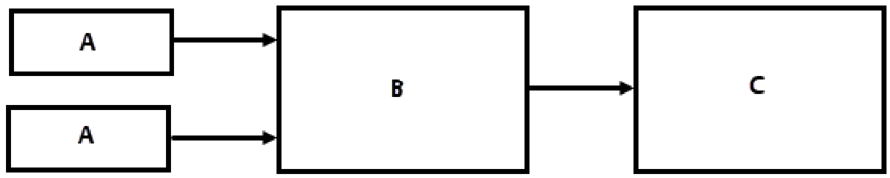
Common safety parameters

Demand response time (if ”Damping” is configured to 0.0 seconds)	< 75 ms
Demand mode	Low, high, or continuous
Mean Time To Repair (MTTR)	24 hours
Fault detection and reaction time	60 seconds
Process safety time	120 seconds
Systematic capability	SC 3
Component type (complexity)	B
Description of the “Safe State”, analog output	Output ≤ 3.6 mA or ≥ 21 mA

Proof test interval	Periodic proof testing is normally not required within the useful lifetime for obtaining required PFD_{AVG} figures

SIL 2 capability

Hardware Fault Tolerance (HFT)	0
Operation	Single transmitter operation 1oo1



A. Sensor (second sensor is optional)

B. Transmitter

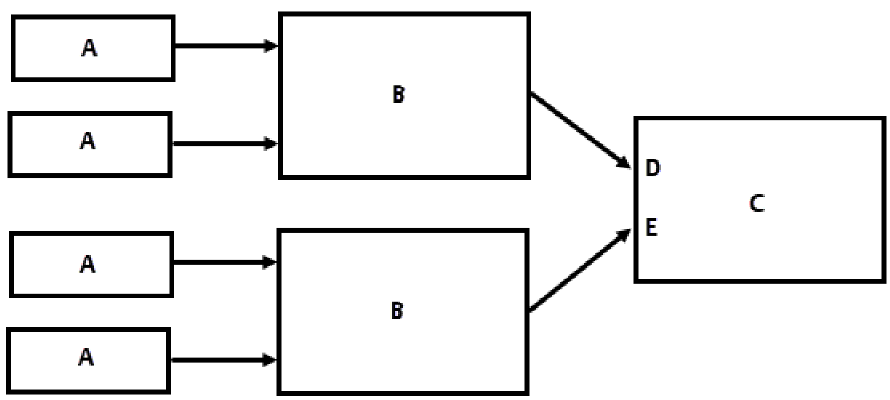
C. Safety PLC

SIL 3 capability

Due to the systematic capability of the transmitter for SC 3, it is possible to use the instrument in homogenous redundant systems up to SIL 3.

Hardware Fault Tolerance (HFT)	1
Operation	Two transmitter channel operation 1oo2

Note
The redundancy requires that the safety PLC compares the two inputs and reacts on inconsistency.



A. Sensor (second sensor is optional)

B. Transmitter

C. Safety PLC

D. Ain 1

E. Ain 2

2.3.10 Hardware and software configuration

All configurations of software and hardware versions are fixed from factory, and cannot be changed by the user or reseller. This manual only covers products labeled with the product version (or range of versions) specified in the title of this document.

2.3.11 Failure category

All failure rates and failure categories are specified in the FMEDA report issued by exida, see chapter 5.9.

2.3.12 Transmitter configuration

The transmitter can be configured by use of a HART® configurator or a HART modem used with other software tools supporting this transmitter.

Independent of the tools used, the configuration parameters are the same, and for safety applications all parameters described in Safety-related configuration parameters must be configured correctly.

Although most parameters are simple and the description is understandable, some parameters require special descriptions given in the following sections.

Password protection

Write protection of the configuration is possible using either HW jumper or using password protection. During configuration of the device parameters, both write protection mechanisms must be disabled. For valid SIL mode, the password protection must be set to active (see HART parameters) and entering SIL mode is not possible if this is not done. The configuration tool must support password protection if SIL mode is required.

After SIL mode is entered, it is optional to set the HW protection jumper for extra protection.

Changing password

The password used for write protection must consist of exactly eight characters. Any character specified in ISO Latin-1 (ISO 8859-1) can be used and will be supported by the configuration tool. The default configured password is "********" (8 character #42).

To change the password, locate the *Write Protection* menu in the configuration tool. Select **Change Password** or **New Password** depending on the tool used. When prompted, the current configured password must be entered for access.

Enabling password protection

For enabling write protection, locate the *Write Protection* menu in the configuration tool. Select **Enabled** or **Write protect** depending on the tool used. When prompted, the current configured password must be entered for access.

Disabling password protection

For disabling write protection, locate the *Write Protection* menu in the configuration tool. Select **Disabled** or **Write enable** depending on the tool used. When prompted, the current configured password must be entered for access.

The configuration tool will not support disabling password protection if the device is in SIL mode.

Note
If the device is in SIL mode, this will be exited if the password protection is disabled!

Process calibration (input trimming)

If a sensor is not accurate, or anything else in the process being monitored is affecting the measurement linearly, this can be compensated by the transmitter by entering up to two reference values for Input 1 and Input 2 independently.

A process calibration (input trimming) can be done by the end user. A known process signal must be applied for either low – or for both low and high **-** end of the input measurement range for each input.

NOTICE

Process calibration/input trimming is optional for SIL mode. If used, the required accuracy must be verified by the end user and it must be verified by test that the applied process calibration does not introduce failures exceeding the requirements for the safety application.

The procedures for trimming is not supported by all configuration tools.

Trim lower point (offset/taring)

Perform this task if only an offset adjustment or taring of the input shall be done.

Procedure

1. Remove the output current from any automatic control application.
2. In the *Calibration* menu of the configuration tool, select **Input zero calibration**.
3. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be trimmed.
4. Apply the input corresponding to 0% input (e.g. 0.0% for a potentiometer input).

   The input value must be within the configured limits for the input (Input 1 or Input 2).
5. Press **OK** to proceed.
6. Wait for the trimming to be performed.
7. Re-apply the output current to the control application.
8. Repeat the process for both inputs.

Trim upper and lower points

Perform this task if both the lower and upper range shall be trimmed.

Procedure

1. Remove the output current from any automatic control application.
2. In the *Calibration* menu of the configuration tool, select **Input calibration**.
3. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be trimmed.
4. Apply the input where the low point of the trimming range shall be performed (e.g. 10.03% for a potentiometer input).

   The input value must be within the configured limits for the input (Input 1 or Input 2).
5. Press **OK** to proceed.
   The previously trimmed lower point value is shown, and the currently applied input value is monitored continuously and shown (e.g. 10.47% for a potentiometer input).
6. Press **OK** to proceed.
7. Enter the reference value of the applied input value (e.g. 10.03% for a potentiometer input).
   The currently applied trimmed input value is monitored and shown.
8. Determine if value is matching the reference value.
   - If the value is matching the entered reference value, press **Yes** and proceed to next step.
   - If the value is not matching the entered reference value, press **No** and repeat steps Step 4 through Step 8.
9. Repeat steps Step 4 through Step 8 for the upper trim point of the trimming range (e.g. 90.04% for a potentiometer input).
10. If the other input should be trimmed at this time or if the trimming should be repeated, repeat steps Step 3 through Step 8 for the selected sensor.
11. Repeat the above procedure until both lower and upper point show the applied input value correctly for both inputs.

Note
The procedure can be aborted at any step, but after step Step 7, a partial calibration may have been applied causing the loss of a previous calibration (see Restore factory calibration).

Restore factory calibration

Any user-performed process calibration/input trimming can be reset to factory calibration values. This can be done independently for both Input 1 and Input 2.

NOTICE

Any performed process calibration/input trimming will be lost for the sensor selected

Procedure

1. In the *Calibration* menu of the configuration tool, select **Restore factory calibration**.

2. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be restored. Any previously performed upper and lower trim points are shown.
3. Press **Yes** to proceed or **No** to abort the operation.
   The resulting upper and lower trim points will be set to 0.

Limit check

Input

If the input that is mapped to PV, and thereby the analog output, exceeds either of the input range limits configured in the *Input 1 Lower/Upper Limit or Input 2 Lower/Upper Limit*, this will be indicated as an error on the analog output current. This is also the case if the input is indirectly mapped to PV (e.g. Average or Difference).

Note
In SIL mode, *Input Limit Check* must be enabled.

Output

If the calculated analog output value exceeds either of the *Output Lower Limit* or *Output Upper Limit* this will be indicated as an error on the analog output current (see restrictions described in Analog output).

Backup functionality

Applicable for variants of the Rosemount 644R Rail Mount Transmitter (dual input types).

If both Inputs are enabled (i.e. Input 2 Input Type is different from *None*), and the PV Mapped To parameter is configured to any of the DV 10 to DV 14, a backup function is enabled.

These DV's will all have:

- the value of Input 1 when a sensor error is detected on Input 2
- the value of Input 2 when a sensor error is detected on Input 1

If no sensor error is detected, their value will be as their name indicates (e.g. Input 1, Input 2, Average, Minimum, or Maximum).

The backup function will only work if sensor error detection is enabled (i.e. Sensor Error Action is different from *None*).

2.3.13 Safe parameterization - user responsibility

It is the responsibility of the user to configure the transmitter so it fits the required safety application. The safe parametrization can be done with assist from any tool that can configure and verify the parameters described, and that supports the procedures described in this section. The configuration tool must be specifically developed to support this (i.e. a generic HART® tool cannot be used, but a device specific DD or DTM running in a generic framework is acceptable).

It is the overall responsibility of the user that the tool used for safe parametrization fulfills all requirements specified in this section.

Safety-related configuration parameters

Input 1 parameters

Note
Only the input types listed are valid for SIL mode.

Table 2-2: Parameter Name: Input 1 Input Type, Verification User: 01 Input Type 1

Description	Input type	Minimum range	Maximum range	Units
Ohm	Ohms	0	100,000	Ohm
kOhm	kiloOhms	0	100	kOhm
Potm	Potentiometer	0	100	%
PtxIEC	RTD Pt x - IEC751, $10 \leq x \leq 10.000$(1)	-200	850	°C
Pt50IEC	RTD Pt 50 - IEC751	-200	850	°C
Pt100IEC	RTD Pt 100 - IEC751	-200	850	°C
Pt200IEC	RTD Pt 200 - IEC751	-200	850	°C
Pt500IEC	RTD Pt 500 - IEC751	-200	850	°C
Pt1000IEC	RTD Pt 1000 - IEC751	-200	850	°C
PtxJIS	RTD Pt x - JIS C1604-81, $10 \leq x \leq 10.000$(1)	-200	649	°C
Pt50JIS	RTD Pt 50 – JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
Pt100JIS	RTD Pt 100 - JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
Pt200JIS	RTD Pt 200 - JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
NixDIN	RTD Ni x - DIN43760, $10 \leq x \leq 10.000$(1)	-60	250	°C
Ni50DIN	RTD Ni 50 - DIN 43760	-60	250	°C
Ni100DIN	RTD Ni 100 - DIN 43760	-60	250	°C
Ni120DIN	RTD Ni 120 - DIN 43760	-60	250	°C
Ni1000DIN	RTD Ni 1000 - DIN 43760	-60	250	°C
CuxECW15	RTD Cu x - ECW No. 15, $5 \leq x \leq 1.000$(1)	-200	260	°C
Cu10ECW15	RTD Cu 10 - ECW No. 15 ($\alpha = 0.00427$)	-200	260	°C
Cu100ECW15	RTD Cu 100 - ECW No. 15 ($\alpha = 0.00427$)	-200	260	°C

Table 2-2: Parameter Name: Input 1 Input Type, Verification User: 01 Input Type 1 *(continued)*

Description	Input type	Minimum range	Maximum range	Units
Cu50GOST-94	RTD Cu 50 - GOST 6651-1994 (α = 0.00426)	-50	200	°C
Cu50GOST-09	RTD Cu 50 - GOST 6651-2009 (α = 0.00428)	-180	200	°C
Cu100GOST-09	RTD Cu 100 - GOST 6651-2009 (α = 0.00428)	-180	200	°C
Pt50GOST-09	RTD Pt 50 – GOST 6651-2009 (α = 0.00391)	-200	850	°C
Pt100GOST-09	RTD Pt 100 – GOST 6651-2009 (α = 0.00391)	-200	850	°C
Cu100GOST-94	RTD Cu 100 – GOST 6651-1994 (α = 0.00426)	-50	200	°C
CuxGOST-94	RTD Cu x – GOST 6651-1994 (α = 0.00426)(1)	-50	200	°C
NixGOST-09	RTD Ni x – GOST 6651-2009 (α = 0.00617)(1)	-60	180	°C
Ni50GOST-09	RTD Ni 50 – GOST 6651-2009 (α = 0.00617)	-60	180	°C
Ni100GOST-09	RTD Ni 100 – GOST 6651-2009 (α = 0.00617)	-60	180	°C
uV±	Micro-Volts bipolar	-800,000	800,000	uV
mV±	Milli-Volts bipolar	-800	800	mV
V±	Volts bipolar	-0.8	0.8	V
TCB-IEC	TC Type B - IEC 584	0	1820	°C
TCW5-ASTM	TC Type W5 - ASTM E 988	0	2300	°C
TCW3-ASTM	TC Type W3 - ASTM E 988	0	2300	°C
TCE-IEC584	TC Type E - IEC 584	-200	1000	°C
TCJ-IEC584	TC Type J - IEC 584	-100	1200	°C
TCK-IEC584	TC Type K - IEC 584	-180	1372	°C
TCN-IEC584	TC Type N - IEC 584	-180	1300	°C
TCR-IEC584	TC Type R - IEC 584	-50	1760	°C
TCS-IEC584	TC Type S - IEC 584	-50	1760	°C
TCT-IEC584	TC Type T - IEC 584	-200	400	°C
TCL-DIN43710	TC Type L - DIN 43710	-200	900	°C

Table 2-2: Parameter Name: Input 1 Input Type, Verification User: 01 Input Type 1 *(continued)*

Description	Input type	Minimum range	Maximum range	Units
TCU-DIN43710	TC Type U - DIN 43710	-200	600	°C
TCLr-GOST	TC Type Lr - GOST 3044-84	-200	800	°C
CuxGOST-09	RTD Cu x – GOST 6651-2009 (α = 0.00428)(1)	-180	200	°C
PtxGOST-09	RTD Pt x – GOST 6691-2009 (α = 0.00391)(1)	-200	850	°C
uV	Micro-volts unipolar	-100,000	1,700,000	uV
mV	Milli-volts unipolar	-100	1700	mV
V	Volts unipolar	-0.1	1.7	V

(1) *Input 1 RTD Factor applies for these Input Types.*

Table 2-3: Parameter Name: Input 1 RTD Factor, Verification User: 02 RTDFactor 1

Description
RTD Factor (R0) value in Ohms for Input 1 Only used if a PtX, NiX or CuX sensor type is selected for Input 1 Input Type Range: 10..10,000 Ohm for Ptx and Nix, 5..1000 for CuX

Table 2-4: Parameter Name: Input 1 Number of Wires, Verification User: 03 NumWires 1

Description
Number of wires used for cable compensation of Input 1 Only used if an RTD, Linear Resistance or Potentiometer is selected for Input 1 Input Type Range is dependent on the selected Input 1 Input Type **If an RTD type or Linear resistance is selected, the range is 2 – 4:** 2 = Measurement is compensated with a fixed cable resistance value: Input 1 Cable Resistance 3 = Measurement is compensated for cable resistance using three wires. (All sensor wires must be equal length and type) 4 = Measurement value is compensated for cable resistance using four wires **If Potentiometer is selected, the range is 3 – 5:** 3 = Measurement is compensated with a fixed cable resistance value: Input 1 Cable Resistance 4 = Measurement is compensated for cable resistance using four wires. (All sensor wires must be equal length and type) 5 = Measurement value is compensated for cable resistance using five wires(1)

(1) *Five-wire compensation is only possible for dual input types.*

Note

If two or three wires (three or four for Potentiometer input) is selected in SIL mode, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

Table 2-5: Parameter Name: Input 1 Cable Resistance, Verification User: 04 CableRes 1

Description
Cable resistance for Input 1: Total cable resistance in the two wires to an RTD or linear resistance sensor element Only used if RTD, Linear Resistance or Potentiometer input type is selected for Input 1 Input Type and if 2 (3 for potentiometer) is selected for Input 1 Number of Wires Range: 0...100 Ohm.

Table 2-6: Parameter Name: Input 1 CJC Type, Verification User: 05 CJCType 1

Description
Cold Junction Compensation type for Input 1. Only used if a thermocouple sensor type is selected for Input 1 Input Type • Int = Internal: internal temperature sensor used for CJC • Ext = External: external connected temperature sensor is used for CJC (see External CJC Type) • Fix = Fixed: fixed temperature, given in Input 1 Fixed CJC Temperature, used for CJC

Table 2-7: Parameter Name: Input 1 Fixed CJC Temperature, Verification User: 06 CJCTemp 1

Description
Value for fixed CJC temperature for Input 1 Only used if a thermocouple sensor type is selected for Input 1 Input Type and if Fixed is selected for Input 1 CJC Type Range: -50 to 135 °C

Table 2-8: Parameter Name: Input 1 Lower Trim Point, Verification User: 07 LoTrimP 1

Description
The process value on Input 1 where the last lower value was trimmed (see Input 1 Trim Offset/Trim gain for details on trimming)

Note

If the trimming is reset, the Input 1 Lower Trim Point value will be forced to 0.0 by the device.

Table 2-9: Parameter Name: Input 1 Upper Trim Point, Verification User: 08 UpTrimP 1

Description
The process value on Input 1 where the last upper value was trimmed (see Input 1 Trim Point Offset/Trim Point gain for details on trimming)

Note
If the trimming is reset, the Input 1 Upper Trim Point value will be forced to 0.0 by the device.

Table 2-10: Parameter Name: Input 1 Trim Offset, Verification User: 09 TrimOffs 1

Description
Input 1 trimmed offset If the Input 1 Trim Offset is different from 0.0, a user trimming has been applied to Input 1 Required accuracy must be verified by user; end user must verify by test that the applied trimming does not introduce failures exceeding the requirements for the safety application

Table 2-11: Parameter Name: Input 1 Trim Gain, Verification User: 10 TrimGain 1

Description
Input 1 trimmed gain If the Input 1 Trim Gain is different from 1.0, a user trimming has been applied to Input 1 End user must verify if the required accuracy is achieved; end user must verify by test that the applied trimming does not introduce failures exceeding the requirements for the safety application

Input 2 parameters

Table 2-12: Parameter Name: Input 2 Input Type, Verification User: 11 InputType 2

As Input 1 Input Type for Input 2. **In addition, the Input Type *None* can be selected to disable Input 2 measurement.** **Only certain combinations are allowed depending on the configuration of Input 1 Input Type:**	
Selected Input 1 Input Type	**Allowed value for Input 2 Input Type**
Ohms or kiloOhms or any RTD type	None, Ohms, kOhms, or any RTD type
Potentiometer	None or Potentiometer
Micro-volts unipolar, Milli-volts unipolar, or Volts unipolar	None, Micro-volts unipolar, Milli-volts unipolar, or Volts unipolar
Micro-volts bipolar, Milli-volts bipolar, or Volts bipolar	None, Micro-volts bipolar, Milli-volts bipolar or Volts bipolar
Any TC type	None, Any TC type, Ohms, kOhms, or any RTD type

Table 2-13: Parameter Name: Input 2 RTD Factor, Verification User: 12 RTDFactor 2

Description
As Input 1 RTD Factor for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-14: Parameter Name: Input 2 Number Of Wires, Verification User: 13 NumWires 2

Description
As Input 1 Number Of Wires for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Note
Five-wire compensation on potentiometer input is not possible for Input 2. Four-wire compensation on potentiometer input is not possible for Input 2 if five-wire is selected for Input 1.

Table 2-15: Parameter Name: Input 2 Cable Resistance, Verification User: 14 CableRes 2

Description
As Input 1 Cable Resistance for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-16: Parameter Name: Input 2 CJC Type, Verification User: 15 CJCType 2

Description
As Input 1 CJC Type for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-17: Parameter Name: Input 2 Fixed CJC Temperature, Verification User: 16 CJCTemp 2

Description
As Input 1 Fixed CJC Temperature for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-18: Parameter Name: Input 2 Lower Trim Point, Verification User: 17 LoTrimP 2

Description
As Input 1 Lower Trim Point for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-19: Parameter Name: Input 2 Upper Trim Point, Verification User: 18 UpTrimP 2

Description
As Input 1 Upper Trim Point for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-20: Parameter Name: Input 2 Trim Offset, Verification User: 19 TrimOffs 2

Description
As Input 1 Trim Offset for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-21: Parameter Name: Input 2 Trim Gain, Verification User: 20 TrimGain 2

Description
As Input 1 Trim Gain for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

External CJC parameters

Table 2-22: Parameter Name: External CJC Type, Verification User: 21 ExtCJC

Description
External CJC sensor Code Only used if either: • a thermocouple sensor type is selected for Input 1 Input Type and External CJC is selected for Input 1 CJC type • a thermocouple sensor type is selected for Input 2 Input Type and External CJC is selected for Input 2 CJC type Pt100 = Pt100 (IEC751) is used as External CJC sensor Ni100 = Ni100 (DIN43760) is used as External CJC sensor

Table 2-23: Parameter Name: External CJC, Number of Wires, Verification User: 22 CJCNumWires

Description
Number of wires used for measuring external CJC sensor: Only used if Input 1 Input Type is a thermocouple sensor type and *External* is selected for Input 1 CJC Type. 2 = two-wire measurement compensated with the External CJC Cable Resistance 3 = three-wire automatic cable resistance compensation 4 = four-wire automatic cable resistance compensation

Note
If *2* or *3* is selected, the end user must ensure the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

Note
Four-wire only applies to dual input transmitters and if Input 2 Input Type is not an RTD-type.

Table 2-24: Parameter Name: Extern CJC Cable Resistance, Verification User: 23 CJCCableRes

Description
Cable resistance for external CJC Temperature Sensor: Total cable resistance in the two wires to the RTD element measuring the External CJC temperature Only used if either: • Input 1 Input Type is a thermocouple sensor type, *External* is selected for Input 1 CJC Type and *2-wire* is selected for External CJC Number of wires • Input 2 Input Type is a thermocouple sensor type, *External* is selected for Input 2 CJC Type and *2-wire* is selected for External CJC Number of wires Range: 0..100 Ohm

PV parameters

Table 2-25: Parameter Name: PV Mapped To, Verification User: 24 PVMap

Variable	Label	Description
Device variable assigned to Primary Variable The DV performing the appropriate measurement function (applicable to the PV and thereby the analog output)		
DV 0	Input1	Input 1
DV 1	Input2	Input 2
DV 2	Input1CJC	Input 1 CJC temperature, only valid if Input 1 is a TC
DV 3	Input2CJC	Input 2 CJC temperature, only valid if Input 2 is a TC
DV 4	AvgI1I2	Average Input 1 and Input 2
DV 5	DiffI1-I2	Difference Input 1 - Input 2
DV 6	DiffI2-I1	Difference Input 2 - Input 1
DV 7	AbsDiffI1-I2	Absolute difference (Input 1 - Input 2)
DV 8	MinIS1I2	Minimum (Input 1, Input 2)
DV 9	MaxI1I2	Maximum (Input 1, Input 2)
DV 10	I1WI2Backup	Input 1 with Input 2 as backup
DV 11	I2WI1Backup	Input 2 with Input 1 as backup
DV 12	AvgI1I2Back	Average with Input 1 or 2 as backup
DV 13	MinI1I2Back	Minimum with Input 1 or 2 as backup
DV 14	MaxI1I2Back	Maximum with Input 1 or 2 as backup

Table 2-25: Parameter Name: PV Mapped To, Verification User: 24 PVMap *(continued)*

Variable	Label	Description
DV 15	ElectrTemp	Electronics temperature

Table 2-26: Parameter Name: PV Lower Range, Verification User: 25 PVLowerRng

Description
PV lower range value (LRV) Lower input value for the linear measurement range (i.e. the input signal value corresponding the Output Range 0% [4.0 mA]) Range is dependent on the selected Input Type for the DV selected as the *PV Mapped To* Value is shown in the units that supports the Input Type for the DV selected as the *PV Mapped To* (e.g. “mV” for mVolts bipolar, “µV” for micro-volts bipolar)

Table 2-27: Parameter Name: PV Upper Range, Verification User: 26 PVUpperRng

Description
PV upper range value (URV) Upper input value for the linear measurement range (i.e. the input signal value corresponding the Output Range 100% [20.0 mA]) Range is dependent on the selected Input Type for the DV selected as the *PV Mapped To* Value is shown in the units that supports the Input Type for the DV selected as the *PV Mapped To* (e.g. “mV” for mVolts bipolar, “µV” for micro-volts bipolar)

Table 2-28: Parameter Name: PV Damping, Verification User: 27 PVDamp

Description
Damping for the DV selected as the PV Mapped To Damping is a first order digital filter applied to the DV value Damping value specifies the time constant (i.e. the time at which 63.2% of a full signal change on the input is reached on the output) Valid range is 0 to 60 seconds

Note

Damping value ≈ 0.434 x Response Time (i.e. the time at which 90% of full signal change is reached, approximately 2.3 times higher than the damping).

Analog output parameters

Table 2-29: Parameter Name: Output Range 0%, Verification User: 28 Out0%

Description
Analog output at PV Lower Range[1] Current in mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For SIL mode the value must be exactly 4.0 mA (conforms to NAMUR NE43).

Table 2-30: Parameter Name: Output Range 100%, Verification User: 29 Out100%

Description
Analog output at PV Upper Range(1) Current in mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For SIL mode the value must be exactly 20.0 mA (conforms to NAMUR NE43).

Table 2-31: Parameter Name: Limit Check Configuration, Verification User: 30 LimitCheck

Description
Limit Check Configuration(1) None = Limit Check disabled(1) Input = Limit Check enabled on Input Range Output = Limit Check enabled on Output Range(1) Input+Output = Limit Check enabled on Input Range and Output Range

(1) See restrictions described in *Analog output**.*

Note
For SIL mode the value must be Limit Check enabled on Input Range or Limit Check enabled on Input and Output Range.

Table 2-32: Parameter Name: Output Limit Error Value, Verification User: 31 OutLimErrVal

Description
Current output in mA indicating Output Limit Check error if the calculated output value is outside the limits configured in ***Output Lower/Upper Limit*** (i.e. when Device Status bit ***Loop Current Saturated*** is set [only if enabled]).(1) Range: 3.5...23.0 mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For SIL mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43) if enabled.

Table 2-33: Parameter Name: Output Lower Limit, Verification User: 32 OutLowLim

Description
Current output lower limit[1]
Current level where the output current will saturate in lower direction
Current in mA

(1) *These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.*

Note
For SIL mode the value must be exactly 3.8 mA (conforms to NAMUR NE43).

Table 2-34: Parameter Name: Output Upper Limit, Verification User: 33 OutUpLim

Description
Current output upper limit[1]
The current level where the output current will saturate in upper direction
Current in mA

Note
For SIL mode the value must be exactly 20.5 mA (conforms to NAMUR NE43).

Table 2-35: Parameter Name: Sensor Error Action, Verification User: 34 SensorError

Description
Sensor error action[1]
None = Sensor error detection disabled
Broken = Sensor error detection of broken sensor enabled
Shorted = Sensor error detection of shorted sensor enabled
Broken+Short = Sensor error detection of both broken and shorted sensor enabled

(1) *These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.*

Note
For SIL mode the value must be Sensor error detection of *Broken* and *Shorted* enabled.

Table 2-36: Parameter Name: Broken Sensor Error Value, Verification User: 35 BrkSensVal

Description
Broken sensor alarm analog output signal[1]
Current in mA indicating broken sensor alarm
Range: 3.5...23.0 mA

(1) *These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.*

Note
For SIL mode the value must be ≤ 3.6mA or ≥ 21.0 mA (conforms to NAMUR NE43).

Table 2-37: Parameter Name: Shorted Sensor Error Value, Verification User: 36 ShortSensVal

Description
Shorted sensor alarm analog output signal(1)
Current in mA indicating shorted sensor alarm.
Range: 3.5...23.0 mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For SIL mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43).

Table 2-38: Parameter Name: Sensor Drift Action, Verification User: 37 SensDrift

Description
Sensor drift action(1)
Disable = No detection of sensor drift
Warning = Warning on HART® device is only issued if drift is detected
Error = Analog output is set to Sensor Drift Current if drift is detected
The process values measured by Input 1 and Input 2 are compared regularly and if the absolute value of the difference |Input 1 - Input 2| exceeds Sensor Drift Limit for longer than Sensor Drift Timeout, a sensor drift is detected.
If the difference is lower than the limit, the detection is cleared and the timer is reset.

(1) Only valid for dual input applications (i.e. Input 2 Input Type < > "None").

Table 2-39: Parameter Name: Sensor Drift Limit, Verification User: 38 SensDriftLim

Description
Sensor drift limit
Measurement limit for drift detection on difference between Input 1 and Input 2. See Sensor Drift Action.

Note
Only valid if Sensor Drift is not set to *Disable*.

Note
No units are used, since the Input 1 Input Type and Input 2 Input Type are expected to have the same measuring unit.

Table 2-40: Parameter Name: Sensor Drift Timeout, Verification User: 39 SensDriftTim

Description
Sensor drift timeout
Timeout value for sensor drift detection in seconds (see Sensor drift configuration).
Range: 0...86,400 seconds (~24 hours)

Note
Only valid if Sensor Drift is not set to *Disable*.

Table 2-41: Parameter Name: Sensor Drift Error Value, Verification User: 40 SDriftErrVal

Description
Sensor drift alarm analog output signal[1] Current in mA indicating sensor drift alarm. Range: 3.5...23.0 mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
Only valid if Sensor Drift is set to *Error*.

Note
For SIL mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43).

Table 2-42: Parameter Name: Input Limits Error Value, Verification User: 41 InLimErrVal

Description
Current output in mA indicating Input Limit Check error if Input 1 or Input 2 is outside the limits configured in Input 1 Lower/Upper Limit and Input 2 Lower/Upper Limit (i.e. when the Device Status bit *Primary Value Out Of Limits* is also set).[1] Range: 3.5 – 23.0 mA

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For SIL mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43).

Table 2-43: Parameter Name: Input 1 Lower Limit, Verification User: 42 LowLim 1

Description
Lower Measurement Limit for Input 1 Depending on the wanted measurement (PV assignment), this value should be set to support the configured PV Range. The range is dependent on the selected input type as shown for Input 1 Input Type. The value is shown in the units that supports the selected Input 1 Input Type (e.g. “mV” for mVolts bipolar, “µV” for micro-volts bipolar).

Table 2-44: Parameter Name: Input 1 Upper Limit, Verification User: 43 UpLim 1

Description
Upper Measurement Limit for Input 1 Depending on the wanted measurement (PV assignment), this value should be set to support the configured PV Upper Range. The range is dependent on the selected input type as shown for Input 1 Input Type. The value is shown in the units that supports the selected Input 1 Input Type (e.g. “mV” for mVolts bipolar, “µV” for micro-volts bipolar). If Input 1 Input Type is set to *Potentiometer*, this value determines the selected potentiometer size.

Table 2-45: Parameter Name: Input 2 Lower Limit, Verification User: 44 LowLim 2

Description
As Input 1 Lower Limit for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-46: Parameter Name: Input 2 Upper Limit, Verification User: 45 UpLim 2

Description
As Input 1 Lower Limit for Input 2

Note
This is only relevant if Input 2 Input Type is different from *None*.

Table 2-47: Parameter Name: Analog Output Calibration Gain, Verification User: 46 OutCalGain

Description
Analog output calibration gain(1) Loop current can be trimmed using measured loop current values with HART commands 45 and 46. This parameter holds the calculated gain.

(1) *These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.*

Note
This value must be 1.0 for SIL mode.

Table 2-48: Parameter Name: Analog Output Calibration Offset, Verification User: 47 OutCalOffset

Description
This parameter holds the calculated offset.(1)

Note
This value must be 0.0 for SIL mode.

HART parameters

Table 2-49: Parameter Name: Polling Address, Verification User: 48 PollAddr

Description
Polling address for HART communication(1) Range HART 7 mode: 0...63

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Table 2-50: Parameter Name: Loop Current Mode, Verification User: 49 LoopCurrent

Description
Loop Current Mode(1) Disable = Constant 4 mA output Enable = Analog Output is proportional to measured Primary Value

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
For HART 7 mode this must be set to *Enable* in SIL mode.

Table 2-51: Parameter Name: Write Protection, Verification User: 50 WriteProtect

Description
Indicates if Write Protection is enabled(1) HW = Configuration is protected by HW jumper PW = Configuration is protected by password No = Configuration is not protected

(1) These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a SIL application.

Note
The configuration must be write protected with password in SIL mode.

Table 2-52: Parameter Name: SIL Mode, Verification User: 51 SILMode

Description
Indicates if SIL mode is active No = Normal operation mode (no SIL restrictions applies) Yes = SIL operation mode (all restrictions described in this manual apply)

Note
Must be *Yes* for a SIL configuration to be valid.

Table 2-53: Parameter Name: SIL Status, Verification User: 52 SILStatus

Description
Indicates the result of configuration check by SIL rated SW(1)
FAIL: No valid configuration has been received
OPEN: Actual configuration is NOT locked (non-SIL)
LOCK: Actual configuration is locked (SIL validated)
INIT: Initial status when load/check is in progress

(1) *The value is not shown until the SIL mode is entered.*

Note
Only the value *LOCK* indicates a successful SIL parametrization.

Option parameters

Table 2-54: Parameter Name: Mains Frequency Filter, Verification User: 53 MainsFilter

Description
Frequency for mains supply damping filter
50 Hz = 50 Hz mains supply noise will be suppressed
60 Hz = 60 Hz mains supply noise will be suppressed

Entering SIL mode

When all relevant parameters has been configured correctly according to the required safety application, the user shall request the SIL mode.

SIL mode is requested by pressing the ***Change SIL mode*** and ***Enter SIL mode*** from the configuration tool and entering the requested password (default "* * * * * * * * *"). Optionally, the password can be changed.

Validating safety related parameters

The user's validation of correct parametrization is mandatory and will be requested automatically by the configuration tool after SIL mode is requested. The tool will reset the device to make sure that the verified configuration parameters are stored non-volatile in the transmitter.

The tool will then request the transmitter to validate the currently stored safety relevant configuration parameters. If the stored configuration parameters are valid for SIL mode, a report showing every relevant parameter listed in Safety-related configuration parameters is requested by the configuration tool and then shown in the "human readable format" (as generated by the transmitter). The parameters may be shown one or more at a time, or as a whole, depending on the tool.

NOTICE

The reported parameters must be carefully verified by the user to be in accordance with the safety application.

If the stored configuration parameters are not valid for SIL mode, an error report showing the invalid parameter is generated by the transmitter, and shown on the configuration tool, instead of the normal report.

NOTICE

If any of the parameters listed in Safety-related configuration parameters are not shown correctly or have an incorrect value, the procedure must be aborted by pressing *Parameters NOT OK* and the device may not be considered as being in correct SIL mode.

If all parameters are correct, the user validates them by pressing *Parameters OK*. The tool will confirm the configuration by sending a CRC calculated over the whole parameter report, and then ask for the resulting SIL mode. Finally, this will be polled by the tool and shown to the user. Only the value *LOCK* shall be accepted by the user. If the result is not shown or if anything else is shown (i.e. OPEN, FAIL, or INIT), the device shall not be considered as being in correct SIL mode. It may take a few seconds before the correct value is shown. Press **Status OK** to confirm the status *LOCK* and end the procedure, or press **Status Wrong** to reject if the value *LOCK* is not shown.

Exiting SIL mode

To exit SIL mode, select **Change SIL mode** → **Exit SIL mode** in the configuration tool, and enter the correct password when prompted.

The configuration tool will request normal operation mode and show the resulting SIL mode.

The value *OPEN* indicates the device is not in SIL mode, and it will then be possible to change the parameters.

Functional test

After entering SIL mode, the user is responsible for making a functional test after verification of the safety parameters (see Periodic proof test procedure).

In addition, if a process calibration is taken into SIL-mode operation (see Periodic proof test procedure), it is mandatory that the accuracy of the device (and sensor, if applicable) is tested.

3 Proof tests

3.1 Periodic proof test procedure

This test will detect approximately 90 percent of possible “du” (dangerous undetected) failures in the device. See FMEDA report issued by exida, chapter 5.9. The proof test is equivalent to the functional test so this procedure shall be followed when a functional test must be carried out, as described in Functional test.

Procedure

1. Bypass the safety PLC or take other appropriate action to avoid a false trip/ measurement.
2. Disconnect the input signal(s) from the input terminals and connect instead a simulator suited for simulating the actual input setup for each active input channel.
3. Apply input value(s) to each active channel, corresponding to 0% and 100% output range.
4. Observe whether the output acts as expected.
5. Restore the input terminals to normal operation (i.e. reconnect the input signal(s)).
6. Measure the process value (temperature) at the connected input(s) and observe that the output current corresponds to the applied input value(s).
7. Remove the bypass from the safety PLC or otherwise restore normal operation.

4 Operating considerations

4.1 Reliability data

4.1.1 Fault reaction and restart condition

When the transmitter detects a fault, the output will go to Safe State.

A suitable configuration tool will be able to show a diagnostic message describing the detected error.

Application specific faults

If the fault is caused by a sensor error or sensor wiring, the LED on the transmitter will flash red and the correct output current will automatically be reestablished when the fault has been corrected.

Device faults

If the fault is in the device itself (detected by internal diagnostic measures), the LED on the transmitter will be solid red.

There are two ways of bringing the device out of Safe State:

1. Power-cycle the device.
2. Reset the device by using a configuration tool that supports a reset of the device (if the error is persistent, the device will enter the Safe State again).

4.2 Failure reporting

If you detect any failures that compromise safety, contact customer service.

See Emerson.com for complete contact information.

4.3 Maintenance

No maintenance required.

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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