SIEMENS

# SITRANS F

## Coriolis flowmeters

### Functional Safety for SITRANS FC430

Product information

Edition 12/2013

Answers for industry.

SIEMENS

SITRANS F

# Coriolis Flowmeters Functional Safety for SITRANS FC430

Product Information


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## Legal information

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**⚠ DANGER**

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**⚠ WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

**⚠ CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

**NOTICE**

indicates that property damage can result if proper precautions are not taken.

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# Introduction

# 1

These instructions contain information necessary to configure, operate and maintain an FC430 compact device in a safety related system.

The instructions are aimed at integrators responsible for those actions.

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**Note**

**Installation of the FC430**

For information about installation and commissioning of the FC430, refer to the Operating Instructions.

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**Note**

**Hardware and Software versions**

These instructions comply with the latest hardware and software versions as stated in the History log below.

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The contents of this manual shall not become part of or modify any prior or existing agreement, commitment or legal relationship. The sales contract contains all obligations on the part of Siemens as well as the complete and solely applicable warranty conditions. Any statements regarding device versions described in the manual do not create new warranties or modify the existing warranty.

The content reflects the technical status at the time of publishing. Siemens reserves the right to make technical changes in the course of further development.

# 1.1 History

The following table shows major changes in the documentation compared to the previous edition.

| Edition | Remarks | SW version | FW revision | HW revision |
|---|---|---|---|---|
| 03/2012 | First edition | • SIMATIC PDM HART driver 1.00.00-14 | • System: 03.00.00<br>• Transmitter: 02.00.09<br>• LUI: 01.02.15<br>• Sensor: 03.00.00 | • Electronic 01<br>• Sensor mechanic ES: 01 |
| 12/2013 | • Description of general SIL concept removed<br>• Description of specific FC430 SIL concept enhanced<br>• General update | • SIMATIC PDM HART driver 2.00.00-08 | • FW bunddle: 03.02.00-03 | • Electronic 02<br>• Sensor mechanic 02 |

# 1.2 Further information

### Product information on the Internet

The Operating Instructions are available on the CD-ROM shipped with the device, and on the Internet on the Siemens homepage, where further information on the range of SITRANS F flowmeters may also be found:

Product information on the internet (http://www.siemens.com/flowdocumentation)

### Reference documents

- SITRANS FC430 with HART, Operating Instructions
- SITRANS FCS400 sensor, Quick start
- SITRANS FCT030 transmitter, Quick Start

### Additional support

Please contact your local Siemens representative and offices if you have additional questions about the device.

You can find contact information for your local contact person on the Internet:

Local contact person (http://www.automation.siemens.com/partner)

# FC430 Functional safety concept 2

## 2.1 Overview of safety concept

The FC430 is developed in accordance with the Safety Integrity Level (SIL) concept which is defined as a relative level of risk-reduction provided by a safety function. A single FC430 device has a hardware fault tolerance of 0 (HFT=0) and a systematic capability of 3.

- The element complies with SIL 2 in single-channel Safety Instrumented Systems.
- The element complies with SIL 3 in dual-channel Safety Instrumented Systems implementing a compare function to validate the output of the two units that constitute a redundant system.

### Random and systematic faults

- Random faults may occur occasionally at any time, for example an electronic circuit will be faulty immediately.
- Systematic faults occur at specific conditions and will occur reproducible if the same conditions apply again, for example a software failure that occurs under specific conditions.

Hardware has random faults and systematic faults, software has only systematic faults.

| NOTICE |
| --- |
| **Limitations in redundant systems**<br>Redundancy will dramatically reduce the probability of random faults, but will **not** reduce the probability of systematic faults correspondingly. |

### 2.1.1 SIL compliant product variant

The FC430 compact version meets the requirements of the Functional Safety Standard IEC/EN 61508 as a type B device.

The following compact versions of the FC430 are SIL compliant:

- Standard: 7ME4613-XXXXX-XDX3 - Zaaa B11 eee fff
- Hygienic: 7ME4623-XXXXX-XDX3 - Zaaa B11 eee fff
- NAMUR: 7ME4713-XXXXX-XDX3 - Zaaa B11 eee fff

**Valid values for wildcards:**

- X = all configuration options
- aaa = all configuration options
- eee = E04, E05
- fff = all configuration options

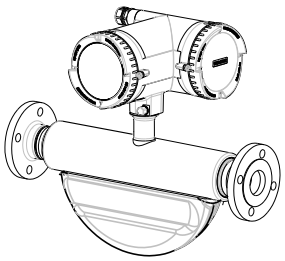


Figure 2-1 FC430 compact version

**Note**

**Device identification**

For detailed information about the device: product identification, product specifications, certificates and approvals refer to the Operating Instructions.

## 2.1.2 Safety function

### Safety function for flowmeters

Measuring flow is the safety function of the SITRANS FC430. The 4 to 20 mA analog output on channel 1 may be used as part of a safety instrumented function (SIF). In addition to the application specific measurement error under standard reference conditions, an additional safety accuracy of ±5% of the maximum measuring range must be added.

Flow transmitter safety allowance: The diagnostics function will respond within 20 seconds if an uncritical individual error of the measured value lies outside pre-determined values.

**Note**

If used outside of standard reference conditions, contact Siemens for definition of the additional safety accuracy.

### Device states

When the device is in Safe Operation mode, see Device modes (Page 9), the states of the device are defined as shown in this table:

Table 2- 1 Possible states when device is operating in Safe Operation mode

| Device state | Description | Failure rate |
|---|---|---|
| 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 below 4 mA (defined as a failure signal). | ($\lambda_{DD}$) 1746 FIT |
| 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 20 seconds. | ($\lambda_{DU}$) 74 FIT |

| NOTICE |
|---|
| **Duration of stated failure rates**<br>The stated failure rates are valid within a 10 year period from the production date of the device. |

## 2.2 Device operation

In order to ensure safe measurement of current output on channel 1, it is necessary to go through the safety validation process as described below.

### 2.2.1 Device modes

The device can operate in various modes:

- Non-Safe Operation mode is for use in non-safety related applications
- All other modes are for use in safety related applications.

Switching between the modes is done via the LUI, menu item 2.7 "Safe Operation".

This diagram illustrates how to navigate between the different modes.

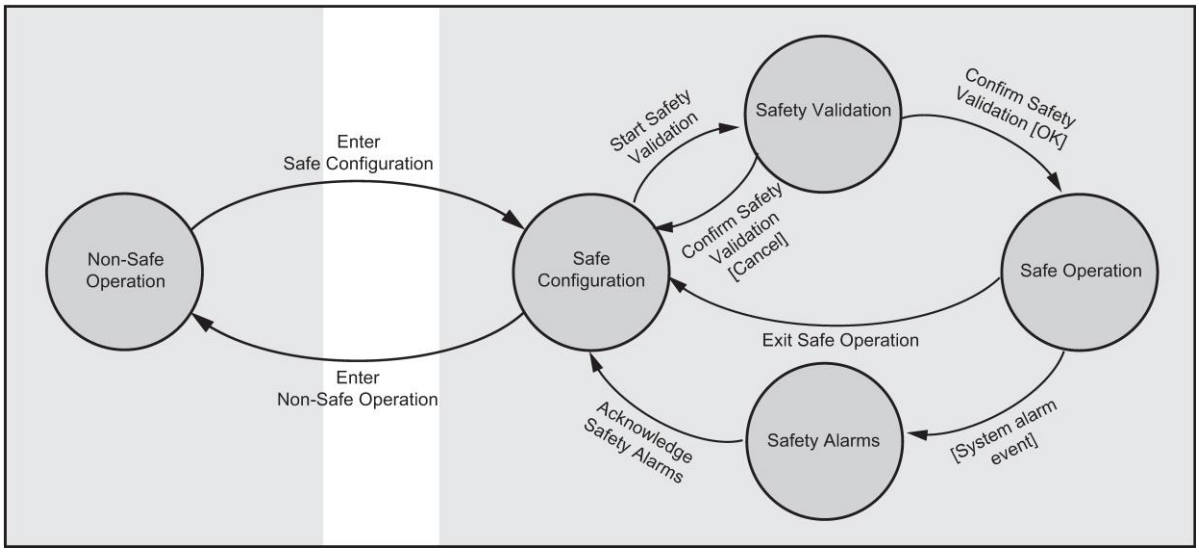


Figure 2-2 Possible device operation modes

**WARNING**

**Operation in safety instrumented system**

The device must be in one of the four safe modes (Safe Operation, Safety Alarms, Safe Configuration or Safety Validation) to operate in a safety instrumented system.

The following table describes the possible modes of SIL Operation. To check current mode of operation see LUI menu item 2.7.1 "SIL Operation Mode".

Table 2- 2 Possible modes of SIL operation (parameter 2.7.1 "SIL Operation Mode")

| Mode | Description | Current output value | Safe current output |
|---|---|---|---|
| Non-Safe Operation | Non-safety operation mode is for use in non-safety related applications. The device should always be in Non-Safe Operation mode if used in non-safety related application. | Operation signal (4 to 20 mA) | No |
| Safety Configuration | Configuration of the safety related parameters of the device is carried out using the LUI or an external interface, for example HART. | Failure signal (3.5 mA) | Yes |
| Safety Validation | Validation of the safety related parameters of the device is performed in the Validation wizard of LUI.<br>Make sure all safety related parameters correpsond to the user application settings and are within the limits described in Safety parameterization (Page 14) | Failure signal (3.5 mA) | Yes |

| Mode | Description | Current output value | Safe current output |
|---|---|---|---|
| Safe Operation | The mode Safe Operation for safety related applications secures safe measurement output on the current output channel 1. | Operation signal (4 to 20 mA) | Yes |
| Safety Alarms | The device enters this mode if the system detects a safety related alarm in Safe Operation mode.<br>The alarms are listed in the alarms list of the device, see Operating Instructions.<br>Once alarms are cleared, the unit can only be returned to Safe Operation mode via the safety validation process.<br>For information on how to return to Safe Operation mode, see Safety Alarms (Page 21) | Failure signal (3.5 mA) | Yes |

### 2.2.2 Device power-up

At power-up the sensor needs approximately 20 seconds to stabilize the measurements. During this time the device will wait in a startup mode signaling a failure signal on the safe current output.

After startup, the device enters the latest active operation mode, unless the device has detected an alarm during startup, in which case the device will start up in Safety Alarms mode.

# Operating FC430 in safety related application 3

## 3.1 Installation

**Note**

The precondition for a correct safety parameterization of the system is a standard commissioning including zero point adjustment. For information on installation and commissioning, see the FC430 Operating Instructions.

## 3.2 Safety parameterization

From factory the flowmeter is set to Non-Safe Operation mode. Parameter configuration can be done only in the Non-Safe Operation mode or Safe Configuration mode. In these modes all parameters may be configured using the LUI menu or an external communication interface, for example HART.

**Note**

**Time constant parameters**

The time constant of the 4 to 20 mA current output depends upon both the Process Noise Damping and Filter Time Constant (current output filter settings).

The Filter Time Constant can be set within the range of 0 to 100 seconds.

For a step change input the current output has settled after 5 * Filter Time Constant plus Process Noise Damping value as described below:

Settling time = Process Noise Damping + (Filter Time Constant × 5)

Example 1:

- Process Noise Damping is set to Centrifugal pump (minimum damping) and
- Filter Time Constant is set to 1 s

Settling time = 0.1 s + (1 × 5) s = 5.1

Example 2:

- Process Noise Damping is set to Cam pump (maximum damping) and
- Filter Time Constant is set to 1 s
- Settling time = 1 s + (1 × 5) s = 6.0 s

**Note**

**Restriction on custom unit Volumeflow**

The usage of the Custom unit (menu item 2.8.10 ) is not allowed on channel 1 in Safe Operation.

## 3.2.1 Setting the device to Safe Operation mode from Non-Safe Operation mode

Setting the device to Safe Operation mode can only be done via the Local User Interface (LUI) as described below. This is done via menu item 2.7. "Safe Operation". Men item 2.7.1 "Safety Mode" shows the current operation mode of the device. See also Device modes (Page 9).

**Note**

**LUI**

Navigation in the LUI is described in the Operating Instructions.

**⚠ CAUTION**

**Close the current output loop before setting the device to Safety mode**

The current output loop must be closed before the device is set to Safe Operation mode. Otherwise the device restarts and enters into Safety Alarms mode.

To restore Safe Operation mode, see Safety Alarms (Page 21).

1. Navigate to menu item 2.7 "Safe Operation" and select menu item 2.7.2 "Enter Safe Configuration".
2. Press ▷, select OK and press ▷ to go to Safe Configuration mode.
   In this mode all parameters can be configured while current output value is 3.5 mA. Safety related parameters should be considered when parameterizing the device, see tables Safety validation of parameters (Page 15).

   **Note**

   In Safe Configuration mode, parameter configuration can be carried out either via LUI or from external communication interface, for example HART.

3. Select menu item 2.7.3 "Start Safety Validation". Press ▷, select OK and press ▷ to go to Safety Validation mode.

   **Note**

   The following two steps are mandatory and must be carried out with great caution.

4. Select menu item 2.7.4 "Safety Validation" and press ▷ to start Safety Validation wizard for validating the safety related parameters. Step through the validation of the parameter settings using ▷ to go to next parameter. Make sure all parameters are valid according to the description in one of the validation wizards for massflow, volumeflow or density below.

**Note**

In case a parameter is not within the value range stated in the Safety validation wizards below , press ◁ to exit the wizard. Correct the invalid parameter and repeat from step 3.

5. The device is now the in Safe Operation mode, and safe measurement output on the current output channel 1 is secured.

## 3.2.2 Safety validation of parameters

Validate the parameters according to the description in one of the three following tables.

1. Select the table that corresponds to the selected process value for the safe current output channel 1 (Massflow, Volumeflow or Density). The selection must correspond to the process value that has been set in menu item 2.4.1.1 "Process value".
2. Check that the value shown in the display corresponds to the expected parameter setting.

**Note**

Appendix A provides a checklist which you can fill out and keep for later reference with the actual validated values from the validation wizard.

### Validation wizards

Table 3- 1 Validation wizard: Massflow

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ① | Process value | 0 = Massflow | Menu item 2.4.1.1 "Process Value": Process value for current output |
| ② | Low Flow Cut-Off | Minimum value for all sensors:<br>• 0 kg/s<br>Maximum values depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | Menu item 2.2.1.2 "Low Flow Cut-Off": Massflow limit for low flow cut-off. Below limit massflow output is forced to zero. |

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ③ | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | Menu item 2.4.1.7 "Filter Time Constant": Defines the damping of the current output signal. |
| ④ | Upper Scaling | Minimum value depending on sensor dimension:<br>• DN15: -8.84 kg/s<br>• DN25: -24.5 kg/s<br>• DN50: -98.2 kg/s<br>• DN80: -251 kg/s<br>Maximum value depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | Menu item 2.4.1.5 "Upper Scaling": Process value assigned to upper output current (20 mA). |
| ⑤ | Lower Scaling | Minimum value depending on the sensor dimension:<br>• DN15: -8.84 kg/s<br>• DN25: -24.5 kg/s<br>• DN50: -98.2 kg/s<br>• DN80: -251 kg/s<br>Maximum value depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | Menu item 2.4.1.6 "Lower Scaling": Process value assigned to lower output current (4 mA). |
| ⑥ | Direction | Check that the number shown in the display corresponds to the expected direction<br>• 0 = Positive Direction<br>• 1 = Negative Direction<br>• 2 = Positive and Negative Directions<br>• 3 = Positive and Negative Directions (symmetrical mode) | Menu item 2.4.1.3 "Direction": Measured flow direction on current output. The flowmeter will output measured value on current output only for selected direction. For example if Positive Direction is selected, the current output for negative flow will be at the lower limit of measurement range, for example 3.8 mA, and the flow value is forced to zero. |
| ⑦ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positive flow direction | Menu item 2.1.1 "Flow Direction": Selected flow direction in the tube, positive or negative (default positive). Positive flow is indicated by an arrow on the sensor. |

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ⑧ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | Menu item 2.2.4.1 "Adjustment Factor": Factor used to adjust displayed flow in percentage. Eliminates inaccuracies caused by process conditions. Default value is 1.00. |
| ⑨ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | Menu item 2.2.5.10.1 "Adjustment Factor": Factor used for compensation density calculation. Default value is 1.00. |
| ⑩ | Density Adjust. Offset | • Minimum value: -14 000 kg/m$^3$<br>• Maximum value: 14 000 kg/m$^3$ | Menu item 2.2.5.10.2 "Adjustment Offset": Offset used for compensation density calculation. Default value is 0.00. |
| ⑪ | Process Noise Damping | • 0 = Centrifugal pump (1: low)<br>• 1 = Triplex pump (2)<br>• 2 = Duplex pump (3)<br>• 3 = Simplex pump (4)<br>• 4 = Cam pump (5: high) | Menu item 2.1.2 "Process Noise Damping": Selected process noise damping value. Check that the number shown in the display corresponds to the expected setting for Process Noise Damping. |

Valid parameter settings when Massflow is selected as process value for safe current output

## Validation wizards

Table 3- 2 Validation wizard: Volumeflow

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ① | Process value | 1 = Volumeflow | Menu item 2.4.1.1 "Process Value": Process value for current output |
| ② | Low Flow Cut-Off | Minimum value for all sensors:<br>• 0 m$^3$/s<br>Maximum values depending on sensor dimension:<br>• DN15: 0.005 m$^3$/s<br>• DN25: 0.015 m$^3$/s<br>• DN50: 0.059 m$^3$/s<br>• DN80: 0.249 m$^3$/s | Menu item 2.2.1.2 "Low Flow Cut-Off": Volumeflow limit for low flow cut-off. Below limit volumeflow output is forced to zero. |
| ③ | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | Menu item 2.4.1.7 "Filter Time Constant": Defines the damping of the current output signal. |

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ④ | Upper Scaling | Minimum value depending on sensor dimension:<br>• DN15: -0.005 $m^3/s$<br>• DN25: -0.015 $m^3/s$<br>• DN50: -0.059 $m^3/s$<br>• DN80: -0.249 $m^3/s$<br>Maximum value depending on sensor dimension:<br>• DN15: 0.005 $m^3/s$<br>• DN25: 0.015 $m^3/s$<br>• DN50: 0.059 $m^3/s$<br>• DN80: 0.249 $m^3/s$ | Menu item 2.4.1.5 "Upper Scaling": Process value assigned to upper output current (20 mA). |
| ⑤ | Lower Scaling | Minimum value depending on sensor dimension:<br>• DN15: -0.005 $m^3/s$<br>• DN25: -0.015 $m^3/s$<br>• DN50: -0.059 $m^3/s$<br>• DN80: -0.249 $m^3/s$<br>Maximum value depending on sensor dimension:<br>• DN15: 0.005 $m^3/s$<br>• DN25: 0.015 $m^3/s$<br>• DN50: 0.059 $m^3/s$<br>• DN80: 0.249 $m^3/s$ | Menu item 2.4.1.6 "Lower Scaling": Process value assigned to lower output current (4 mA). |
| ⑥ | Direction | Check that the number shown in the display corresponds to the expected direction<br>0 = Positive Direction<br>1 = Negative Direction<br>2 = Positive and Negative Directions<br>3 = Positive and Negative Directions (symmetrical mode) | Menu item 2.4.1.3 "Direction": Measured flow direction on current output. The flowmeter will output measured value on current output only for selected direction. For example if Positive Direction is selected, the current output for negative flow will be at the lower limit of measurement range, for example 3.8 mA, and the flow value is forced to zero. |
| ⑦ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positve flow direction | Menu item 2.1.1 "Flow Direction": Selected flow direction in the tube, positive or negative (default positive). Positive flow is indicated by an arrow on the sensor. |
| ⑧ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | Menu item 2.2.4.1 "Adjustment Factor": Factor used to adjust displayed flow in percentage. Eliminates inaccuracies caused by process conditions. Default value is 1.00. |

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ⑨ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | Menu item 2.2.5.10.1 "Adjustment Factor": Factor used for compensation density calculation. Default value is 1.00. |
| ⑩ | Density Adjust. Offset | • Minimum value: -14 000 kg/m³<br>• Maximum value: 14 000 kg/m³ | Menu item 2.2.5.10.2 "Adjustment Offset": Offset used for compensation density calculation. Default value is 0.00. |
| ⑪ | Process Noise Damping | • 0 = Centrifugal pump (1: low)<br>• 1 = Triplex pump (2)<br>• 2 = Duplex pump (3)<br>• 3 = Simplex pump (4)<br>• 4 = Cam pump (5: high) | Menu item 2.1.2 "Process Noise Damping": Selected process noise damping value. Check that the number shown in the display corresponds to the expected setting for Process Noise Damping. |

Valid parameter settings when Volumeflow is selected as process value for safe current output

Table 3- 3 Validation wizard: Density

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ① | Process value | 2 = Density | Menu item 2.4.1.1 "Process Value": Process value for current output |
| ② | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | Menu item 2.4.1.7 "Filter Time Constant": Defines the damping of the current output signal. |
| ③ | Upper Scaling | • Minimum value: 1 kg/m³<br>• Maximum value: 5000 kg/m³ | Menu item 2.4.1.5 "Upper Scaling": Process value assigned to upper output current (20 mA). |
| ④ | Lower Scaling | • Minimum value: 0 kg/m³<br>• Minimum value: 5000 kg/m³ | Menu item 2.4.1.6 "Lower Scaling": Process value assigned to lower output current (4 mA). |
| ⑤ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positve flow direction | Menu item 2.1.1 "Flow Direction": Selected flow direction in the tube, positive or negative (default positive). Positive flow is indicated by an arrow on the sensor. |
| ⑥ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | Menu item 2.2.4.1 "Adjustment Factor": Factor used to adjust displayed flow in percentage. Eliminates inaccuracies caused by process conditions. Default value is 1.00. |
| ⑦ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | Menu item 2.2.5.10.1 "Adjustment Factor": Factor used for compensation density calculation. Default value is 1.00. |

| Safety Validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Description** |
| ⑧ | Density Adjust. Offset | • Minimum value: -14 000 kg/m³<br>• Maximum value: 14 000 kg/m³ | Menu item 2.2.5.10.2 "Adjustment Offset": Offset used for compensation density calculation. Default value is 0.00. |
| ⑨ | Process Noise Damping | • 0 = Centrifugal pump (1: low)<br>• 1 = Triplex pump (2)<br>• 2 = Duplex pump (3)<br>• 3 = Simplex pump (4)<br>• 4 = Cam pump (5: high) | Menu item 2.1.2 "Process Noise Damping": Selected process noise damping value. Check that the number shown in the display corresponds to the expected setting for Process Noise Damping. |

Valid parameter settings when Density is selected as process value for safe current output

The device stays in Safe Operation mode for as long as no safety related alarm is detected and the device is not manually brought out of Safe Operation mode.

## Parameter protection

All parameters are protected against changes for as long as the device is in Safety Operation mode. To change the configuration, the device must be set to Non-Safe Operation or Safe Configuration mode.

# Diagnostics and maintenance 4

## 4.1 Behavior in case of faults

### Repairs

Defective devices should be sent in to the repair department with details of the fault and the cause. When ordering replacement devices, please specify the serial number of the original device. You will find the serial number on the nameplate.

The address of the responsible SIEMENS repair center, contacts, spare parts lists, etc. can be found on the Internet.

### See also

Service and support (http://www.siemens.com/automation/service&support)

Local contact person (http://www.automation.siemens.com/partner)

Technical support (http://support.automation.siemens.com/WW/view/en/16604318)

## 4.2 Safety Alarms mode

The device enters Safety Alarms mode if a safety related alarm is detected when the device is in Safe Operation mode. The safe current output is in fail-safe state, and current output fail safe value is 3.5 mA. The device stays in Safety Alarms mode until all alarms are acknowledged.

### 4.2.1 Safety Alarms

If the system detects a safety related alarm while operating in Safe Operation mode, alarm no. 157 "Safety Alarms" appears and safe current output channel 1 triggers a failure signal (3.5 mA).

When alarm 157 is activated, the device enters Safety Alarms mode. The safety alarm reason can be looked up in menu item 2.7.10 "Safety error reasons" as described in the following table.

Table 4- 1 Safety alarms

| Safety alarm | Description | Action |
|---|---|---|
| 1 | Read-back current failure | Ensure that current control loop is closed, see Safety Alarms (Page 21) |
| 2 | RAM check failure | Contact Siemens customer support (http://www.siemens.com/automation/csi/service) |
| 3 | ROM check failure | |
| 4 | Inconsistent safety critical parameters | |
| 5 | Background diagnosis not executed on time | |
| 6 | Time based check failure | |
| 7 | Thread stack violation | |
| 8 | Invalid device mode | |
| 9 | Not allowed device mode transition | |
| 10 | Shut-down page not erased | |
| 11 | Program flow control failure | |
| 12 | Safety alarm received from sensor electronic in Safe Operation mode | |
| 13 | Safety alarm not reset in Safety Validation mode | |
| 14 | Spurious restart (shut down page invalid ) | |

## Returning the device to Safe Operation

**Note**

Do not break the current loop in Safe Operation mode as the device will enter Safety Alarms mode.

Follow this procedure to return the device from Safety Alarms to Safe Operation mode:

1. Make sure the current loop is closed.
2. Identify alarms and perform corrections until all system alarms, except alarm no. 157 "Safety alarm", are cleared from the alarms list. The alarms are listed in menu item 3.2.3 "Alarm".
3. Select menu item 3.3.4 "Restart Device" press ▷, select OK and press ▷.The device will restart.
4. Select menu item 2.7.7 "Acknowledge Safety Alarms", press ▷, select OK and press ▷ to enter Safe Configuration mode. Alarm 157 "Safety Alarm will be cleared.
5. Select menu item 2.7.3 "Start Safety Validation" to bring the device back to Safe Operation mode, see step 3 in Setting the device to Safe Operation mode from Non-Safe Operation mode (Page 14).

### 4.2.2 Safety transition errors

If an attempt of a valid transition from one mode to another has failed, the error number can be looked up in menu item 2.7.9 "Safety transition errors". In the following table the reasons that has may have caused the error are described.

Table 4- 2 Safety transition errors

| Safety transition errors | Description | Action |
|---|---|---|
| 0-14 | Inconsistent parameter configuration | Contact Siemens customer support (http://www.siemens.com/automation/csi/service) |
| 16 | Process value simulation is active | Disable simulated process value |
| 17 | Illegal configuration of aerated flow filter | Set parameter menu item 3.9.3 “Alarm Limit” to zero |
| 18 | Aerated flow filter is active | Disable menu item 3.9.1“Aerated Flow Filter” |

After replacement of a transmitter electronic or sensor, it is strongly recommended that you revalidate the parameterization of the device. The revalidation must include a check that the serial number registered by the transmitter matches the serial number on the sensor nameplate. You can read out the serial number using LUI or PDM. See the FC430 Operating Instructions.

## 4.3 Proof test

Proof testing makes it possible to detect errors within the FC430 Coriolis flowmeter that are not detected by the normal diagnostics of the transmitter. Proof tests performed at regular intervals will intercept undetected errors that could otherwise prevent the Safety Instrumented Functions from working as intended.

**Note**

Proof test must be carried out from Safety mode (SIL), Setting the device to Safe Operation mode from Non-Safe Operation mode (Page 14)

### 4.3.1 Requirements for proof-test performers

It is required that all persons carrying out proof tests of the FC430 Coriolis flowmeter are trained in Safety Instrumented Systems (SIS) operations. This includes bypass procedures, flowmeter maintenance and company management of change procedures.

## 4.3.2 Proof-test intervals and rules

To ensure reliable operation of the safety function, proof tests must be performed within the recommended proof test intervals of five years. It is the responsibility of the system operator to ensure reliable operation and to observe the stated test intervals.

Proof tests must be carried out in a way that they prove that the safety function works in interaction with all components of the system. Proof test coverage of at least 80% can be obtained by carrying out a proof test on site, see the table Proof test procedure A below. If you want to obtain coverage of at least 90%, the device must be uninstalled and brought to a calibration test area, see the table Proof test procedure B.

Table 4- 3 Proof test procedure A: 80% coverage

| Step | Action |
|---|---|
| ① | Bypass the safety PLC or take other appropriate action to avoid a false trip. |
| ② | Perform and validate a three-point safe current output channel 1:<br>1. Create a defined flow which must lead to 4 mA current output. Validate that 4 mA is generated on the safe current output.<br>2. Create a defined flow which must lead to 12 mA current output. Validate that 12 mA is generated on the safe current output.<br>3. Create a defined flow which must lead to 20 mA current output. Validate that 20 mA is generated on the safe current output.<br>The current generated must not deviate by more than 1% of the reading, for example for a 12 mA output the acceptable range is 11.88 to 12.12 mA. |
| ③ | Validate the safe current output channel 1 fault reaction of the device:<br>1. Open the loop on the safe current output (unplug the cable).<br>2. Wait during the fault tolerance time (20 seconds).<br>3. Close the loop on the safe current output (plug the cable).<br>4. Restart the device and validate that 3.5 mA are generated on the safe current output.[1)]<br>5. Restart the device.<br>The current generated in step 3 must not deviate by more than 1% of the reading, for example for a 12 mA output the acceptable range is 11.88 to 12.12 mA. |
| ④ | Perform a safety validation of the system to set the flowmeter to Safe Operation mode, see Safety validation of parameters in chapter Setting the device to Safe Operation mode from Non-Safe Operation mode (Page 14) |
| ⑤ | Restore the bypass from the safety PLC or otherwise restore Safe Operation mode. |

[1)] The generated current must not deviate more than 1% of the reading; for 3.5 mA output the acceptable range is 3.47 to 3.53 mA.

Table 4- 4 Proof test procedure B: 90% coverage

| Step | Action |
|---|---|
| ① | Uninstall the device and take it to a calibration test site. |
| ② | Perform and validate a three-point safe current output channel 1:<br>1. Create a defined flow which must lead to 4 mA current output. Validate that 4 mA is generated on the safe current output.<br>2. Create a defined flow which must lead to 12 mA current output. Validate that 12 mA is generated on the safe current output.<br>3. Create a defined flow which must lead to 20 mA current output. Validate that 20 mA is generated on the safe current output.<br>The current generated must not deviate by more than 1% of the reading, for example for a 12 mA output the acceptable range is 11.88 to 12.12 mA. |
| ③ | Validate the safe current output channel 1 fault reaction of the device:<br>1. Open the loop on the safe current output (unplug the cable).<br>2. Wait during the fault tolerance time (20 seconds).<br>3. Close the loop on the safe current output (plug the cable).<br>4. Validate that 3.5 mA are generated on the safe current output.<br>5. Restart the device.<br>The current generated in step 3 must not deviate by more than 1% of the reading, for example for a 12 mA output the acceptable range is 11.92 to 12.08 mA. |
| ④ | Validate the flowmeter calibration as follows:<br>Use one of the built in totalizers to validate the calibration of the flowmeter. Make sure the totalizer is set to balanced flow and calibrate the flowmeter by comparing the totalizer value shown on the flowmeter with the totalized flow from reference device, for example a weighing system. The difference must have a tolerance of no more than 1%. |
| ⑤ | Reinstall the device into the system and restore Safe Operation mode. |

### 4.3.3 Documentation of proof test

The documentation of the proof test results must be part of the plant safety management system. Failures that are critical to functional safety should be reported to Siemens Technical Support.

Information about our technical support is available on the Internet at
Technical support (http://support.automation.siemens.com/WW/view/en/16604318)

# Safety validation checklists

# A

## A.1 Validation checklist - massflow

### Validation checklist - current output channel 1 configured to measure massflow

Table A- 1 In this checklist you may enter the validated values from validation wizard

| Safety validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| Step | Parameter name | Value for validation | Enter validated value |
| ① | Process value | 0 = Massflow | |
| ② | Low Flow Cut-Off | Minimum value for all sensors:<br>• 0 kg/s<br>Maximum values depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | |
| ③ | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | |
| ④ | Upper Scaling | Minimum value depending on sensor dimension:<br>• DN15: -8.84 kg/s<br>• DN25: -24.5 kg/s<br>• DN50: -98.2 kg/s<br>• DN80: -251 kg/s<br>Maximum value depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | |

| Safety validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Enter validated value** |
| ⑤ | Lower Scaling | Minimum value depending on the sensor dimension:<br>• DN15: -8.84 kg/s<br>• DN25: -24.5 kg/s<br>• DN50: -98.2 kg/s<br>• DN80: -251 kg/s<br>Maximum value depending on sensor dimension:<br>• DN15: 8.84 kg/s<br>• DN25: 24.5 kg/s<br>• DN50: 98.2 kg/s<br>• DN80: 251 kg/s | |
| ⑥ | Direction | Check that the number shown in the display corresponds to the expected direction<br>• 0 = Positive Direction<br>• 1 = Negative Direction<br>• 2 = Positive and Negative Directions<br>• 3 = Positive and Negative Directions (symmetrical mode) | |
| ⑦ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positive flow direction | |
| ⑧ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | |
| ⑨ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | |
| ⑩ | Density Adjust. Offset | • Minimum value: -14 000 kg/m$^3$<br>• Maximum value: 14 000 kg/m$^3$ | |
| ⑪ | Process Noise Damping | • 0 = Centrifugal pump (1: low)<br>• 1 = Triplex pump (2)<br>• 2 = Duplex pump (3)<br>• 3 = Simplex pump (4)<br>• 4 = Cam pump (5: low) | |

*Date of validation* *Signature*

# A.2 Validation checklist - volumeflow

## Validation checklist - current output channel 1 configured to measure volumeflow

Table A- 2 In this checklist you may enter the validated values from validation wizard

| Safety validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Enter validated value** |
| ① | Process value | 1 = Volumeflow | |
| ② | Low Flow Cut-Off | Minimum value for all sensors:<br>• 0 $m^3/s$<br>Maximum values depending on sensor dimension:<br>• DN15: 0.005 $m^3/s$<br>• DN25: 0.015 $m^3/s$<br>• DN50: 0.059 $m^3/s$<br>• DN80: 0.249 $m^3/s$ | |
| ③ | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | |
| ④ | Upper Scaling | Minimum value depending on sensor dimension:<br>• DN15: -0.005 $m^3/s$<br>• DN25: -0.015 $m^3/s$<br>• DN50: -0.059 $m^3/s$<br>• DN80: -0.249 $m^3/s$<br>Maximum value depending on sensor dimension:<br>• DN15: 0.005 $m^3/s$<br>• DN25: 0.015 $m^3/s$<br>• DN50: 0.059 $m^3/s$<br>• DN80: 0.249 $m^3/s$ | |

| Safety validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Enter validated value** |
| ⑤ | Lower Scaling | Minimum value depending on sensor dimension:<br>• DN15: -0.005 $m^3/s$<br>• DN25: -0.015 $m^3/s$<br>• DN50: -0.059 $m^3/s$<br>• DN80: -0.249 $m^3/s$<br>Maximum value depending on sensor dimension:<br>• DN15: 0.005 $m^3/s$<br>• DN25: 0.015 $m^3/s$<br>• DN50: 0.059 $m^3/s$<br>• DN80: .0249 $m^3/s$ | |
| ⑥ | Direction | Check that the number shown in the display corresponds to the expected direction<br>0 = Positive Direction<br>1 = Negative Direction<br>2 = Positive and Negative Directions<br>3 = Positive and Negative Directions (symmetrical mode) | |
| ⑦ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positve flow direction | |
| ⑧ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | |
| ⑨ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | |
| ⑩ | Density Adjust. Offset | • Minimum value: -14 000 $kg/m^3$<br>• Maximum value: 14 000 $kg/m^3$ | |
| ⑪ | Process Noise Damping | • 0 = Centrifugal pump (1: low)<br>• 1 = Triplex pump (2)<br>• 2 = Duplex pump (3)<br>• 3 = Simplex pump (4)<br>• 4 = Cam pump (5: high) | |

*Date of validation* *Signature*

# A.3 Validation checklist - density

## Validation checklist - current output channel 1 configured to measure density

Table A- 3 In this checklist you may enter the validated values from validation wizard

| Safety validation wizard | | | Parameters configured in Setup menu |
|---|---|---|---|
| **Step** | **Parameter name** | **Value for validation** | **Enter validated value** |
| ① | Process value | 2 = Density | |
| ② | Filter Time Constant | • Minimum value: 0 s<br>• Maximum value: 100 s | |
| ③ | Upper Scaling | • Minimum value: 2 kg/m$^3$<br>• Maximum value: 5000 kg/m$^3$ | |
| ④ | Lower Scaling | • Minimum value: 0 kg/m$^3$<br>• Maximum value: 5000 kg/m$^3$ | |
| ⑤ | Flow Direction | Check that the number shown in the display corresponds to the expected flow direction.<br>• 0 = Negative flow direction<br>• 1 = Positve flow direction | |
| ⑥ | Massflow Adjust.Factor | • Minimum value: -1.999<br>• Maximum value: 1.999 | |
| ⑦ | Density Adjust. Factor | • Minimum value: 0.500<br>• Maximum value: 1.999 | |
| ⑧ | Density Adjust. Offset | • Minimum value: -14 000 kg/m3<br>• Maximum value: 14 000 kg/m3 | |
| ⑨ | Process Noise Damping | • 0 = Centrifugal pump (minimum damping)<br>• 1 = Triplex pump<br>• 2 = Duplex pump<br>• 3 = Simplex pump<br>• 4 = Cam pump (maximum damping) | |

| *Date of validation* | *Signature* |
|---|---|
| | |

# Glossary

### Fail-safe

The capability of a control to maintain the safe state of the controlled device, e.g. machine, process, or to bring the device to a safe state even when faults/failures occur.

### Failure/Fault

Failure:
A resource is no longer capable of executing a required function.

Fault:
Undesired state of a resource indicated by the incapability of executing a required function.

### Fault

→ Failure/Fault

### Fault tolerance

Fault tolerance N means that a device can execute the intended task even when N faults exist. The device fails to execute the intended function in case of N+1 faults.

### Final controlling element

Converter that converts electrical signals into mechanical or other non-electrical variables.

### Local User Interface (LUI)

Operator or human-machine interfaces which offer a user of the device the following options:

- Operate the device, machine or system
- Observe status
- Intervene in ongoing processes

The local user interface contains a digital display and buttons.

### Risk

The combination of probability of a damage occurring and its magnitude.

### Safety function

Defined function executed by a safety-instrumented system with the objective of achieving or maintaining a safe system status taking into account a defined dangerous occurrence.

Example:
Limit pressure monitoring

### Safety Instrumented Function

→ SIF

### Safety Integrated System (SIS)

A Safety Instrumented System (SIS) consists of an engineered set of hardware and software controls which are especially used on critical process systems. A critical process system can be identified as one which, once running and an operational problem occurs, the system may need to be put into a "Safe State" to avoid adverse Safety, Health and Environmental (SH&E) consequences.

### Safety Integrity Level

→ SIL

### Safety-instrumented system

A safety-instrumented system executes the safety functions that are required to achieve or maintain a safe status in a system. It consists of a sensor, logic unit/control system and final controlling element.

Example:
A safety-instrumented system is made up of a pressure transmitter, a limit signal sensor and a control valve.

### Sensor

Converter that converts mechanical or other non-electrical variables into electrical signals.

### SIF

A part/function of a safety-instrumented system that reduces the risk of a dangerous failure occurring.

### SIL

The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL) from SIL 1 to SIL 4. Each level corresponds to the probability range for the failure of a safety function. The higher the SIL of the safety-instrumented system, the higher probability that the required safety function will work.

The achievable SIL is determined by the following safety characteristics:

- Average probability of dangerous failure of a safety function in case of demand (PFDAVG)
- Hardware fault tolerance (HFT)
- Safe failure fractions (SFF)

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