

2600T Series Pressure Transmitters

Safety Manual for 266 Pressure Transmitters Certified according to IEC61508

Measurement Made Easy

Engineered solutions for all applications



Additional instructions for IEC61508 certified device (ONLY for instruments having digits 8 or T under “output” option within the main product code)

This document replaces the existing Safety Manual chapter into ABB Pressure Transmitter documentation.

This document has to be read in conjunction with 266 operating manuals.

The Company

We are an established world force in the design and manufacture of measurement products for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

Index

| | | | |
|--|----------|---|-----------|
| 1. Scope and purpose of the safety manual | 4 | 11 Faults outside the functional safety..... | 7 |
| 2 Safety philosophy | 4 | 11.1 Other considerations | 7 |
| 2.1 Application..... | 4 | 12 Operation | 7 |
| 2.2 Safety Function | 4 | 12.1 System Operating Discipline | 7 |
| 2.3 Identification of 266 transmitter IEC61508 certified | 4 | 12.2 Preventive and Routine Maintenance..... | 7 |
| 2.4 Physical environment..... | 4 | 12.3 Function-unit Replacement | 7 |
| 2.5 Role and responsibilities | 4 | 12.4 Modification Request | 7 |
| 2.6 Skill level requirement | 4 | 12.5 Change Management | 7 |
| 3 Management of functional safety | 5 | 12.6 Change Management for Process Components and Roles | 7 |
| 3.1 Safety Planning | 5 | 12.7 Change Management for Documentation and Training Requirements | 7 |
| 4 Information requirements (to be made available by the plant owner)..... | 5 | 13 Architecture description and principle of operation | 8 |
| 4.1 Overall Safety Life-cycle Information..... | 5 | 13.1 Principle of operation..... | 8 |
| 4.2 Applicable LAWS and Standards | 5 | 14 Commissioning and configuration issues | 8 |
| 4.3 System Safety Requirement Assignment I/O System Response Time | 5 | 14.1 Operating mode enabling and disabling..... | 8 |
| 4.4 System Structure..... | 5 | 15 Proof tests | 8 |
| 4.5 Safety Requirement Allocation | 5 | 16 Error messages | 9 |
| 4.6 Safety Routines | 5 | 16.1 LCD Display | 9 |
| 5 Design verification | 5 | 16.2 Error states and alarms..... | 9 |
| 6 Installation | 6 | 17 Safety-related parameters | 12 |
| 6.1 Environmental limits..... | 6 | 17.1 Systematic integrity | 14 |
| 6.2 Mechanical installation and System completion | 6 | 17.2 Random integrity | 14 |
| 6.3 Application limits | 6 | 17.3 ROM check time | 14 |
| 6.4 System Wiring | 6 | 17.4 Useful lifetime..... | 14 |
| 7 Commissioning | 6 | 17.5 Connection to SIS logic solver | 14 |
| 7.1 Overall System Functionality | 6 | 18 Release history of 266 hardware and software components..... | 15 |
| 8 Write protection | 6 | 19 Authorized manufacturing locations | 18 |
| 8.1 Write protection activation via external push button | 6 | | |
| 9 Factory settings | 7 | | |
| 10 Output current limits (NAMUR 43 Standard)..... | 7 | | |
| 10.1 Overload condition | 7 | | |
| 10.2 Alarm current | 7 | | |

2.4 Physical environment

266 pressure transmitters are designed for use in industrial field environments and must be operated within the specified environmental limits as indicated in the Transmitter Data Sheet.

2.5 Role and responsibilities

All the people, departments and organizations involved in the life-cycle phases, which are responsible for carrying out and reviewing the applicable overall, E/E/PES (Electrical/Electronic/Programmable Electronic System) or software safety lifecycle phases of a Safety Instrumented System shall be identified. All those specified as responsible for management of functional safety activities shall be informed of the responsibilities assigned to them. All persons involved in any overall, E/E/PES or software safety lifecycle activity, including management activities, should have the appropriate training, technical knowledge, experience and qualifications relevant to the specific duties they have to perform.

2.6 Skill level requirement

System design, installation and commissioning shall be carried out by qualified personnel. Repair and Maintenance activities may only be performed by authorized qualified customer service personnel.

3 Management of functional safety

For each application, the installer or the owner of a safety system must prepare a Safety Planning which must be updated throughout the Safety Life-cycle of the Safety Instrumented System. The safety planning shall include the Safety instrumentation management. The requirements for the management of functional safety shall run in parallel with the overall safety lifecycle phases.

3.1 Safety Planning

The Safety Planning shall consider:

- policies and strategies for achieving safety;
- safety life-cycle activities to be applied, including names of responsible persons and departments;
- procedures relevant to the various life-cycle phases;
- audits and procedures for follow up.

4 Information requirements (to be made available by the plant owner)

The information shall comprehensively describe the system installation and its use in order that all phases of the overall safety lifecycles, the management of functional safety, verification and the functional safety assessment can be effectively performed.

4.1 Overall Safety Life-cycle Information

The overall safety lifecycle shall be used as the basis for claiming conformance to the standard IEC61508. The lifecycle phases consider all the activities related to the Safety Instrumented System (SIS) from the initial concept through design, implementation, operation and maintenance to decommissioning.

4.2 Applicable LAWS and Standards

All applicable general Laws and Standards related to the allowed operations of the equipment, as EU-Directives shall be collected. The plant owner shall produce a Regulatory Requirements List document.

4.3 System Safety Requirement Assignment I/O System Response Time

The total system response time is determined by the following elements:

- Sensor detection time,
- Logic solver time;
- Actuator response time;

The total system response time must be less than the process safety time. To ensure a safe operation of the system, the scan rate of each section of the logic solver multiplied by the number of channels shall be taken into account together with the safety time of actuator and sensor response time.

4.4 System Structure

System configuration drawings shall be available to describe equipment and interfaces required for a complete operational system. The system must be fully operational before start-up.

4.5 Safety Requirement Allocation

Each safety function, with its associated safety integrity requirement, shall be allocated to the designated safety related systems taking into account the risk reductions achieved by the other technology safety-related systems and external risk reduction facilities, so the necessary risk reduction for that safety function is achieved. The allocation indicated shall be done in such a way that all safety functions are allocated and the safety integrity requirements are met for each safety function.

4.6 Safety Routines

Safety additional requirements may be defined in order to ensure the correct functionality of sequences in the Safety Instrumented System.

5 Design verification

Copy of the inspection report for 266 pressure transmitters certified in compliance with IEC61508:2010 issued by the certification body can be requested to local ABB references which will get in touch with ABB marketing department at factory.

A detailed Failure Modes, Effects and Diagnostic Analysis (FMEDA) developed using Exida SILCAL tool and considering the SN29500 failure database is available only at ABB R&D department under management authorization due to its confidentiality

By referring to the safety parameters listed inside this safety manual, the Safety Instrumented Function designer (hereinafter referred to as "SIF" designer) shall verify the Safety Integrity Level (SIL) achieved using the PDFavg considering the architecture, proof test interval, proof test coverage, automatic internal diagnostic, repair time and failure rates of the entire equipment included in the SIF.

The Hardware Fault Tolerance (HFT) must be checked and taken into consideration by the SIF designer to ensure that each subsystem within the SIF are in compliance with the minimum HFT requirements.

6 Installation

6.1 Environmental limits

266 pressure transmitters have been designed to operate in a wide range of environmental conditions typical of industrial field and in hazardous environments. The environmental conditions under which the measuring equipment is designed to operate within its specified accuracy limits and without impairment of its operating characteristics are specified in the "Specification Sheet" document.

SIF designer must check that 266 Pressure Transmitters certified according to IEC61508:2010 are used within the expected environmental limits as reported in data sheet of each transmitters in the chapters "temperature limits", "operative limits" and "environmental limits".

6.2 Mechanical installation and System completion

In order to assure operator and plant safety, it is necessary to read "installation" chapter of the present manual carefully.

6.3 Application limits

It is very important that SIF designer check whether the model meets the measurement and safety requirements of the measuring point with regard to materials, pressure rating, temperature, explosion protection, operating voltage.

The transmitter should not be installed where it may be subjected to mechanical and thermal stresses or where it may be attached by existing or foreseeable aggressive substances. ABB cannot guarantee that a construction material is suited to a particular process fluid under all possible process conditions.

SIF designer must check for material compatibility by considering the process flow and the on-site chemical contaminants. Fill fluid and wet parts materials selections is under SIF's designer full responsibility. If 266 pressure transmitters certified according to IEC61508:2010 are used outside their application limits, environmental limits or with incompatible materials the reliability data and the safety parameter predicted for SIL capability becomes invalid.

The materials for 266 pressure transmitter are specified in the ordering information inside product data sheet for each transmitter.

6.4 System Wiring

The procedures to safely make device electrical connections are described in the section "electrical connections" and "wiring" of the present manual. For installation in hazardous areas, compliance with safety information on the safety marking plate shall be ensured.

SIF designer must check that wiring and electrical connections of 266 pressure transmitters meet the requirements declared in this manual.

Important. According to IEC61326-3-1 in case of surge noise with intensity >1kV and using terminal block without surge protector (code: S2) the acceptable criteria is FS; this means that the instrument could be damaged but the current output is more than 22mA (safe condition). For this reason in case of environment with surge noise above or equal to 1kV it is necessary and recommended the use of the terminal block with surge protector (code: S2).

7 Commissioning

7.1 Overall System Functionality

The activities to validate the required safety functionality of the system together with the pressure transmitter according to the Safety Requirement Specification are the following:

1. Put the Write Protect Mode switch in operative position (see chapter write protection write protection activated)
2. Power-on the transmitter: the transmitter performs automatically a self-test that consists in the operations below:
 - ROM test
 - RAM test
 - Test of the analog output stage and of the feedback A/D converter
 - Test of the power supply voltage
 - Non volatile memory test

8 Write protection

Write protection prevents the configuration data from being overwritten by unauthorized users.

If write protection is enabled, the "Z" and "S" buttons are disabled. However, it is still possible to read out the configuration data using the graphical user interface (DTM) or another, similar communication tool. The control unit may be leaded if request.

8.1 Write protection activation via external push button

When the instrument features the external non-intrusive push buttons (digit R1 within instrument code), the write protection function can be performed as follows:

- Remove the nameplate by releasing the holding screw lying on the bottom left corner
- Use a suitable screwdriver to press the switch down fully
- Then turn the switch clockwise by 90°

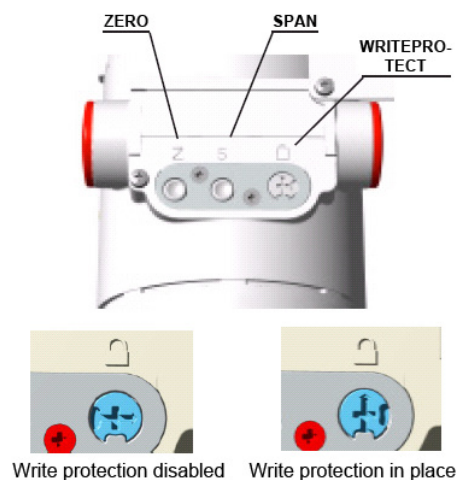


Figure 3: Write-protection pushbutton

Important. To deactivate the switch, push it down slightly and then turn counterclockwise by 90°.

9 Factory settings

Transmitters are calibrated at the factory to the customer's specified measuring range. The calibrated range and tag number are provided on the small plate on the neck of transmitter housing. If this has not been specified, the transmitter will be delivered with the following configuration:

| Parameter | Factory setting |
|---------------------------------|--------------------------------------|
| Lower Range Value (LRV) (4 mA) | Zero |
| Upper Range Value (URV) (20 mA) | Upper Range Limit (URL) |
| Output transfer function | Linear |
| Damping | 1 second |
| Transmitter failure (alarm) | Upscale (21.8 mA) |
| Optional LCD HMI scale | 1 line PV and output signal bargraph |
| Temperature warning (see Add01) | Disabled |

10 Output current limits (NAMUR 43 Standard)

10.1 Overload condition

- Lower limit: 3.8 mA (configurable from 3.8 to 4mA)
- Upper limit: 20.5 mA (configurable from 20 to 21 mA)

10.2 Alarm current

- Lower limit: 3.6 mA (configurable from 3.6 to 4mA)
- Upper limit: 21 mA (configurable from 20 to 22 mA)

Only if "Status temp warning" (see Add01) is enabled:

- Lower limit: ≤ 3.5 mA
- Upper limit: ≥ 21.1 mA

In case that the power supply of the transmitter is not sufficient to drive the current output to high alarm value a switching to low alarm is forced by transmitter.

11 Faults outside the functional safety

The redundant algorithms (only for 266Dxx, 266Vxx, Hxx, Nxx) and the electronics are designed to detect all the internal hardware faults therefore the transmitter diagnostic is not able to detect faults related to the process and to the installation configuration. In the following table the known weaknesses resulting from the transducer FMEA (Failure Mode and Effect Analysis) are listed.

1. Assembled material at the pipes of the transmitter, blockage of pipe.
2. Application outside specified temperature range. (only if "Status temp warning" is disabled)
3. Excess of temperature (only if "Status temp warning" is disabled)
4. Assembled gas at the transmitter, if the transmitter is mounted above the process line
5. Overload pressure, high peak pressure pulses in process lines
6. Penetration of hydrogen, diaphragm crack in applications with hydrogen process medium.
7. Thin walled diaphragm, leaky diaphragm in applications with abrasive medium.
8. Thin walled diaphragm, leaky diaphragm in applications with corrosive medium.
9. Higher diaphragm stiffness, crack in application with contamination of metal ions
10. Mechanical damage through cleaning, damage of the coating, corrosion.

11.1 Other considerations

The alarm levels of the transmitter (down-scale or up-scale) can be selected by the user. As default all the 266 devices are configured with up-scale alarm. For some faults (e.g. crystal breakdown), the output will latch at 3.6 mA even if the up scale alarm level is selected.

11.1.a Consideration in case of current output failure:

1. alarm state period is hold in one state for 4 s in case of alarm oscillation
2. alarm state is automatically driven to high alarm (21mA) or low alarm (3.6mA) by transmitter after comparing current output value and readback value. In case of readback value is higher than expected low alarm value the alarm state will be set high. In case of readback value is lower than expected high alarm value, the alarm will be set low.

12 Operation

12.1 System Operating Discipline

A Plant policy guideline document containing the specific plant policy guideline for the daily safe operation has to be produced and periodically reviewed by representatives of the Process Control Service. It is responsibility of user create the plant policy guideline.

12.2 Preventive and Routine Maintenance

Preventive and routine maintenance activities are defined in the maintenance section of the present manual. The routine activities, like the proof tests, are carried out to detect unrevealed faults

12.3 Function-unit Replacement

In case of hardware failure, corrective actions may be carried out from ABB authorized personnel. In case of transmitter replacement all the operations described in „Electrical Connection“, „Calibration“ and „Commission“ shall be conducted. All maintenance activities shall be documented in the system documentation. Possible safety critical failures shall be reported by the user using the his Incident Report document and process.

12.4 Modification Request

Request of modification due to possible safety critical failures and performance deviations shall be reported to the factory. Modifications shall follow the company modification procedures.

12.5 Change Management

All process changes or SIL category change shall follow the procedures defined in the safety lifecycle of the system and shall be reviewed and validated by the external competent body for a new functional safety assessment.

12.6 Change Management for Process Components and Roles

Each process component needs to be defined in details according to the requirements and the relevant documentation. Each process component change shall follow the activities defined in the overall safety lifecycle.

12.7 Change Management for Documentation and Training Requirements

The Change Management process shall follow documentation and training requirements defined in the system implementation.

13 Architecture description and principle of operation

The instrument consists of three main functional units:

- Primary unit (called Front End Board - FE)
- Secondary unit (called Communication Board - CB)

The pressure transducer unit includes the process interface, the sensor and the front-end electronics; the Secondary Unit includes the electronics, the terminal block and the housing. The two units are mechanically coupled by a threaded joint.

13.1 Principle of operation

The principle of operation is as follows. In the primary unit the process fluid (liquid, gas or vapour) exerts pressure on to the sensor via flexible, corrosion-resistant isolating diaphragms and capillary tubing containing the fill fluid.

As the sensor detects the pressure changes, it simultaneously produces variations of the primary physical value depending on the sensor technology (capacitive, inductive or piezoresistive). The signal is then converted in the front-end electronics in a digital form and the raw values are computed by a microcontroller to a precise primary output linearization, compensating for the combined effects of sensor non linearity, of static pressure and temperature changes on the basis of the „mapped“ parameters calculate in the manufacturing process and stored in the memory of the Front End electronics. Calculations follow independent flows and they are compared in the microcontroller in order to validate the output pressure signal. If a difference between the two measurements is detected the analog output is driven to a safety condition. The measured values and the sensor parameters are transferred via a standard serial digital communication to the secondary unit where the communication board is fitted. The output data value is converted into a pulse-width signal that is filtered and that activates the 4-20 mA transmitter. The bi-directional, digital communication using the standard “HART” protocol is implemented as part of this unit. Internal diagnostics algorithms are implemented to check correctness and validity of all processing variables and the correct working of memories. The output stage is also checked by reading back the analog output signal and by reading the power supply voltage. The feedback loop is obtained by an additional A/D converter put at the end of the output stage, which translates the 4-20 mA signal into a digital form suitable to be compared by the microcontroller.

14 Commissioning and configuration issues

The transmitter is considered in safety condition (normal operating mode) when the write protect switch placed outside the transmitter housing below the metallic nameplate is in Write Protect. In that condition all kind of configurations of the device are disabled and all safety measures are activated.

14.1 Operating mode enabling and disabling

Operating mode can be enabled/disabled depending on the switch position(write protection switch). It is also possible to put the device in write protect condition by a dedicated HART command. In any case the switch position has the priority on the software command.

Warning. After any configuration operation, the transmitter must be put in operating mode (Write Protection activated).

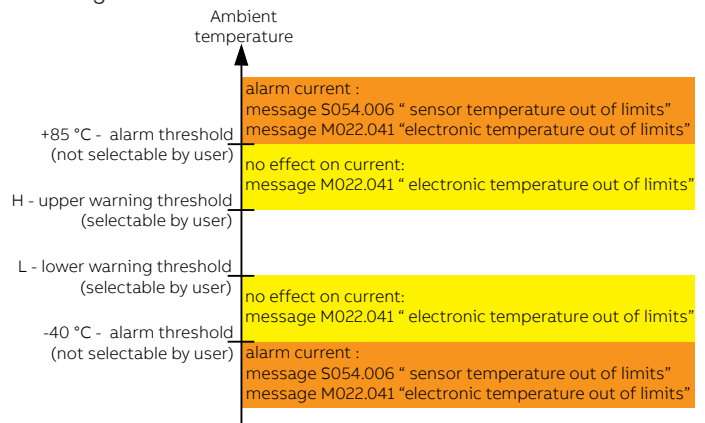
14.2 Temperature alarm functionality

Exceeding the temperature thresholds (-40°C or $+85^{\circ}\text{C}$) cause a warning message via LCD (HMI) and/or via HART (S054.006 „Sensor Temperature Out of Limits“).

User can drive the output current in alarm state (3.5mA or 21.1mA) when one of Front End or Communication Board temperature exceeds the acceptable limit (-40°C or $+85^{\circ}\text{C}$) by activating „Temperature warning“ through HMI (see Add01).

When this functionality is activated, it is possible to set the warning threshold values, via HMI and/or by factory upon request, where a warning message will appear (M022.041 „Electronic Temperature Out of Limits“) in case the threshold fixed by user is exceeded.

With “Temperature warning” activated, the transmitter has the following behavior:



Warning. Message M022.041 appears when one of FE or CB temperature exceeds the limit L or H. Alarm message S054.006 appears when one of FE or CB temperature exceeds the limit of -40°C or $+85^{\circ}$ (different values could be set only in factory on request). For additional details and settings see Add01.

15 Proof tests

Safe undetected faults could occur during the operation of the transmitters. These failures do not affect the transmitter operations. To maintain the claimed Safety Integrity Level (SIL2) a proof test procedure is requested every 10 years.

The proof tests consists in the following operations:



1. Switch off the device.
2. Assure that the Write Protect Mode switch is in Write Protect condition.
3. Power-on the transmitter: it performs automatically a self-test that consists in the operations below:
 - ROM test
 - RAM test
 - Test of the analog output stage and of the feedback A/D converter
 - Test of the power supply voltage
 - Non volatile memory test
4. Apply pressure up to 50% of the calibrated range and check the output value. It shall be within the stated safety accuracy (2% of sensor range)



In case the tests would fail the transmitter will drive the output to the alarm values. In this case a correction action consists in the re-calibration of the A/D converter. In case the normal functionality will be not re-established, the transmitter shall be considered failed and not possible to use.

16 Error messages

16.1 LCD Display

The LCD HMI in case of transmitter errors or malfunctioning is capable of displaying specific error/fault messages to help the user in identifying the problem and resolve it. In case of an alarm, a message consisting of an icon and text appears at the bottom of the process display. Use the (1) key to call up the information level. Use the “Diagnostics” menu to call up the error description with a help text. In the error description, the error number is displayed in the second line (M028.018). Two further lines are used to describe the error. The device status is divided into four groups. The message text beside this icon in the display provides information about where to look for the error. There are the following areas: Electronic, Sensor, Configuration, Operating and Process.

| Icon | Description |
|---|--|
|  | Error / Failure |
|  | Functional check (e.g. during simulation) |

| Icon | Description |
|---|--|
|  | Out of Spec (e.g. operating with empty meter pipe) |
|  | Maintenance required |

16.2 Error states and alarms

– Communication Board / Electronic related error messages.

| Error message | Tx LCD message | Possible cause | Suggested action | Tx response |
|---------------|---------------------------------|--|---|------------------------|
| F116.023 | Electronic Memory Failure | Electronic memory corrupted | The electronic must be replaced | Analog Signal to Alarm |
| F108.040 | Output ReadBack Failure | The output circuit could be broken or not correctly calibrated | A DAC (digital to output converter) trimming should be performed and if the error persists the communication board must be replaced | Analog Signal to Alarm |
| M030.020 | Electronic Interface Error | Data exchange between the sensor and the electronic is incorrect | Power off and on the transmitter and check if the error persists. If yes replace the communication board as soon as possible. | no effect |
| M026.024 | NV Electronic Memory Burn Error | Writings to the electronic non-Volatile Memory has not been successful | The communication board should be replaced as soon as possible | no effect |
| F106.035 | Unreliable Output Current | The D to A converter is not properly Calibrated/Trimmed | Perform an Output Trimming and if the error persists the communication board must be replaced | Analog Signal to Alarm |
| F106.035 | Unreliable Output Current | The Device is not properly configured | Check the device configuration | Analog Signal to Alarm |

–Sensor related error messages

| Error message | Tx LCD message | Possible cause | Suggested action | Tx response |
|---------------|-----------------------------|--|--|------------------------|
| F120.016 | Sensor Invalid | The sensor signal is not being updated correctly as a result of an electronics failure, sensor error or a poorly connected sensor cable. | Check cable connection, check sensor and if problem persists, the sensor must be replaced. | Analog Signal to Alarm |
| F120.016 | Sensor Invalid | The sensor model/version is no longer compatible with the connected electronic version | The sensor must be replaced | Analog Signal to Alarm |
| F118.017 | Sensor Memory Fail | Sensor memory corrupted | The sensor must be replaced | Analog Signal to Alarm |
| F114.000 | P-dP Sensor Fail | Mechanical damage to the sensor. Loss of fill fluid from the cell, ruptured diaphragm, broken sensor. | The sensor must be replaced | Analog Signal to Alarm |
| F112.001 | Static Pressure Sensor Fail | The circuitry for the sampling of the static pressure has failed. | The sensor must be replaced | Analog Signal to Alarm |
| F110.002 | Sensor Temperature Fail | The circuitry for the sampling of the temperature has failed. | The sensor must be replaced | Analog Signal to Alarm |
| M028.018 | NV Sensor Memory Burn Error | Writings to the sensor non-Volatile Memory was not successful | The sensor should be replaced as soon as possible. | no effect |

— Configuration related error messages.

| Error message | Tx LCD message | Possible cause | Suggested action | Tx response |
|---------------|-------------------------|---|---|-------------|
| C088.030 | Input Simulation Active | The P-dP Value produced in output is derived by the value simulated in input | Use a HART configurator (DTM - Hand held) to place device back in to normal operating mode (Remove the input simulation) | no effect |
| C088.030 | Input Simulation Active | The Static Pressure Value produced in output is derived by the value simulated in input | Use a HART configurator (DTM - Hand held) to place device back in to normal operating mode (Remove the input simulation) | no effect |
| C088.030 | Input Simulation Active | The Sensor Temperature Value produced in output is derived by the value simulated in input | Use a HART configurator (DTM - Hand held) to place device back in to normal operating mode (Remove the input simulation) | no effect |
| M014.037 | Configuration Error | Refer to the Instruction manual to understand the possible cause of this error | Use a HART configurator (DTM - Hand held) to correct the configuration | no effect |
| M020.042 | Replace Info | The Electronics or the Sensor have been changed but the replacement operation has not been executed | The replacement operation must be executed: Move the SW 1 of the electronics in position 1 = Enable replace mode -Select the SW 2 the element that has been changed between new Sensor or new electronics -Power Cycle the device -Move the SW 1 of the electronics in position 0 | no effect |
| M020.042 | Replace Info | The Electronics or the Sensor have been changed and a replacement operation for a new sensor has to be executed. | The replacement operation must be executed: Only the data of the electronics can be copied into the sensor-Move the SW 1 to Enable replace mode (1)-Select with the SW 2 to New Sensor (1)-Power Cycle the device-Move the SW 1 to Disable replace mode (0) | no effect |
| M020.042 | Replace Info | The Electronics or the Sensor have been changed, The replacement has been enabled but with a wrong direction (SW 2 = 0). | Change the replacement direction (if possible)-The SW 1 is already set to Enable replace mode (1)-Select with the SW 2 to New Sensor (1)-Power Cycle the device-Move the SW 1 to Disable replace mode (0) | no effect |

— Operation related error messages

| Error message | Tx LCD message | Possible cause | Suggested action | Tx response |
|---------------|--------------------------------------|--|---|---|
| M024.036 | Power Supply Warning | the Device Power Supply is close to the lowest acceptable limit | Check the Voltage at the terminal block and if it is not within the valid range check the external power supply | no effect/alarm switching is possible |
| M024.036 | Power Supply Warning | the Device Power Supply is close to the highest acceptable limit | Check the Voltage at the terminal block and if it is not within the valid range check the external power supply | no effect/alarm switching is possible |
| M022.041 | Electronic Temperature Out of Limits | Default: The electronics temperature is out of its lower acceptable limit. The circuitry for the sampling of the Electronics Temperature has failed. If Status temp warning = enabled The electronic or sensor temperature is out of its lower warning limits (L) settable by user via HMI | Default: The proof test must be executed on pressure instrument once the temperature goes back within specified limits If Temperature warning = enabled No action | Default: No effect If Temperature warning = enabled: No effect |
| M022.041 | Electronic Temperature Out of Limits | The Electronics temperature is out for its higher acceptable limit. The circuitry for the sampling of the Electronics Temperature has failed. If Status temp warning = enabled The electronic or sensor temperature is out of its higher warning limits (H) settable by user via HMI | Default: The proof test must be executed on pressure instrument once the temperature goes back within specified limits If Temperature warning = enabled No action | Default: No effect If Temperature warning = enabled: No effect |

– Process related error messages.

| Error message | Tx LCD message | Possible cause | Suggested action | Tx response |
|---------------|----------------------------------|---|--|---|
| F104.032 | Pressure Overrange | This effect could be produced by other equipment on the process, (valves.....). Exceeding the pressure range can cause reduced accuracy or mechanical damage to the diaphragm material and may require calibration/replacement. | The compatibility of pressure transmitter model and process conditions has to be checked. A different transmitter type could be required | no effect |
| F102.004 | P-dP Out Of Limits | The measurement range has not been correctly calculated OR an incorrect transducer model has been selected. | The compatibility of pressure transmitter model and process conditions has to be checked. Probably a different transmitter type is required. | no effect |
| F100.005 | Static Pressure Out of Limits | The static pressure of the process exceeds the limit of the sensor. Exceeding the Static Pressure can reduce accuracy, mechanically damage the diaphragm and may require calibration/replacement. An incorrect transducer model could have been selected. | The compatibility of pressure transmitter model and process conditions has to be checked. Probably a different transmitter type is required. | no effect |
| S054.006 | Sensor Temperature Out of Limits | Default: the temperature of the process environment affects the pressure transmitter; Excess temperature can reduce accuracy, degrade device components and may require calibration/replacement. If Status temp warning = enabled The electronic temperature or/and sensor temperature is out of its lower (-40°C) or higher (+85°C) acceptable limits. The circuitry for the sampling of the electronic and/or Front end temperature has failed. | The compatibility of pressure transmitter model and process conditions has to be checked. A different installation type could be required e.g. use of remote seals. If Temperature warning = enabled The proof test must be executed on pressure instrument once the temperature goes back within specified limits (-40 °C ... +85 °C) | Default: No effect If Temperature warning = enabled: Alarm |
| S052.031 | Max Working Pressure Exceeded | The static pressure of the process exceeds the max working Pressure supported by the transmitter. Exceeding the Max Working Pressure can mechanically damage the process connections (flanges, pipes....) and/or be dangerous | The compatibility of pressure transmitter model and process conditions has to be checked. | no effect |
| F098.034 | Analog Output Saturated | The analog output for the Primary Variable is beyond its Low scaling limit and no longer represents the true applied process. The Analog Output (4-20 mA) is saturated to the configured Saturation Limit Low. | Adjust the Saturation Limit or the working range if possible. | no effect |
| F098.034 | Analog Output Saturated | The analog output for the Primary Variable is beyond its High scaling limit and no longer represents the true applied process. The Analog Output (4-20 mA) is saturated to the configured Saturation Limit High. | Adjust the Saturation Limit or the working range if possible. | no effect |
| M018.038 | PILD Output | One (HIGH or LOW) or both connections between the pressure sensor and the process is blocked either by plugging or closed valves. | Check valves and impulse line. Clean impulse line if necessary and initiate PILD training | no effect |
| M016.039 | PILD-Changed Op. Conditions | Process conditions have changed to an extent that new settings for the PILD algorithm are needed. | A new Training is necessary for this new process condition. | no effect |

17 Safety-related parameters

Safety 266 pressure transmitters meet SIL2 requirements according to IEC 61508:2010 in low as well as high demand mode of operation. The total PFD in low demand mode for 10 years proof test interval in the worst case is less than the 35% of the range defined in IEC 61508-1. The relevant numbers are stated in the table below:

– HART Pressure transmitters with Standard Terminal Block

| | 266DXX, 266VXX, 266HXX (except ranges W, Z), 266NXX | 266MXX, 266RXX | 266MXX, 266RXX (only range R) | 266GXX, 266AXX | 266HXX (only range W) | 266HXX, 266GSH (only range Z) |
|--|---|-------------------|----------------------------------|-------------------|--------------------------|----------------------------------|
| λ_{dd} [h ⁻¹] | 7.74E-07 | 9.11E-07 | 9.17E-07 | 9.07E-07 | 7.82E-07 | 8.19E-07 |
| λ_{du} [h ⁻¹] | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| λ_{sd} [h ⁻¹] | 2.80E-07 | 2.37E-07 | 2.37E-07 | 2.37E-07 | 2.81E-07 | 2.42E-07 |
| λ_{su} [h ⁻¹] | 1.25E-07 | 1.26E-07 | 1.26E-07 | 1.26E-07 | 1.25E-07 | 1.26E-07 |
| $\lambda_{tot\ sf}$ [h ⁻¹] | 1.29E-06 | 1.35E-06 | 1.35E-06 | 1.34E-06 | 1.298E-06 | 1.26E-06 |
| HFT | 0 | | | | | |
| Architecture | 1oo1 | | | | | |
| T mission | 10 years (87600h) | | | | | |
| PTC [%] | 90 | | | | | |
| SFF [%] | 91.63 | 94.58 | 94.49 | 94.57 | 91.57 | 94.08 |
| MTBF [years] | 89 | 85 | 84 | 85 | 88 | 90 |
| MTTR | 8 hours | | | | | |
| DC | D: 87.79 | D: 92.59 | D: 92.48 | D: 92.56 | D: 87.73 | D: 91.64 |
| | S: 69.13 | S: 65.31 | S: 65.33 | S: 65.31 | S: 69.22 | S: 65.85 |
| PFDavg (PTI=1 year) | 9.03E-04 | 6.14E-04 | 6.28E-04 | 6.13E-04 | 9.17E-04 | 6.28E-04 |
| PFDavg (PTI=10 years) | 4.72E-03 | 3.20E-03 | 3.27E-03 | 3.20E-03 | 4.80E-03 | 3.28E-03 |
| PFH | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| Testing time | <20s | <20s | <20s | <5s | <20s | <5s |
| ROM check time | See paragraph "ROM CHECK TIME" | | | | | |

– HART Pressure transmitters with Terminal Block featuring Surge protector (additional code: S2)

| | 266DXX, 266VXX, 266HXX (except range Z), 266NXX | 266MXX, 266RXX | 266MXX, 266RXX (only range R) | 266GXX, 266AXX | 266HXX (only range W) | 266HXX, 266GSH (only range Z) |
|--|---|-------------------|----------------------------------|-------------------|--------------------------|----------------------------------|
| λ_{dd} [h ⁻¹] | 7.74E-07 | 9.11E-07 | 9.17E-07 | 9.07E-07 | 7.82E-07 | 8.19E-07 |
| λ_{du} [h ⁻¹] | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| λ_{sd} [h ⁻¹] | 2.67E-07 | 2.24E-07 | 2.24E-07 | 2.23E-07 | 2.68E-07 | 2.29E-07 |
| λ_{su} [h ⁻¹] | 1.39E-07 | 1.40E-07 | 1.40E-07 | 1.40E-07 | 1.39E-07 | 1.40E-07 |
| $\lambda_{tot\ sf}$ [h ⁻¹] | 1.300E-06 | 1.35E-06 | 1.35E-06 | 1.34E-06 | 1.299E-06 | 1.26E-06 |
| HFT | 0 | | | | | |
| Architecture | 1oo1 | | | | | |
| T mission | 10 years (87600 h) | | | | | |
| PTC [%] | 90 | | | | | |
| SFF [%] | 91.63 | 94.59 | 94.50 | 94.57 | 91.57 | 94.08 |
| MTBF [years] | 89 | 85 | 84 | 85 | 88 | 90 |
| MTTR | 8 hours | | | | | |
| DC | D: 87.79 | D: 92.59 | D: 92.48 | D: 92.56 | D: 87.73 | D: 91.64 |
| | S: 65.78 | S: 61.56 | S: 61.58 | S: 61.55 | S: 65.88 | S: 62.16 |
| PFDavg (PTI=1 year) | 9.03E-04 | 6.14E-04 | 6.28E-04 | 6.13E-04 | 9.17E-04 | 6.28E-04 |
| PFDavg (PTI=10 years) | 4.72E-03 | 3.20E-03 | 3.27E-03 | 3.20E-03 | 4.80E-03 | 3.28E-03 |
| PFH | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| Testing time | <20s | <20s | <20s | <5s | <20s | <5s |
| ROM check time | See paragraph "ROM CHECK TIME" | | | | | |

— HART Pressure transmitters with Terminal Block featuring Extended EMC (additional code on request: YE)

| | 266DXX, 266VXX, 266HXX (except range Z), 266NXX | 266MXX, 266RXX | 266MXX, 266RXX (only range R) | 266GXX, 266AXX | 266HXX (only range W) | 266HXX, 266GSH (only range Z) |
|---------------------------------------|---|-------------------|----------------------------------|-------------------|--------------------------|----------------------------------|
| λ_{dd} [h ⁻¹] | 7.74E-07 | 9.11E-07 | 9.17E-07 | 9.07E-07 | 7.82E-07 | 8.19E-07 |
| λ_{du} [h ⁻¹] | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| λ_{sd} [h ⁻¹] | 2.69E-07 | 2.25E-07 | 2.26E-07 | 2.25E-07 | 2.70E-07 | 2.31E-07 |
| λ_{su} [h ⁻¹] | 1.46E-07 | 1.47E-07 | 1.47E-07 | 1.47E-07 | 1.46E-07 | 1.47E-07 |
| $\lambda_{tot sf}$ [h ⁻¹] | 1.300E-06 | 1.36E-06 | 1.36E-06 | 1.35E-06 | 1.308E-06 | 1.27E-06 |
| HFT | 0 | | | | | |
| Architecture | 1001 | | | | | |
| T mission | 10 years (87600) | | | | | |
| PTC [%] | 90 | | | | | |
| SFF [%] | 91.69 | 94.62 | 94.54 | 94.61 | 91.63 | 94.12 |
| MTBF [years] | 88 | 84 | 84 | 84 | 87 | 90 |
| MTTR | 8 hours | | | | | |
| DC | D: 87.79 | D: 92.59 | D: 92.48 | D: 92.56 | D: 87.73 | D: 91.64 |
| | S: 64.76 | S: 60.55 | S: 60.56 | S: 60.54 | S: 64.87 | S: 61.17 |
| PFDavg (PTI=1 year) | 9.03E-04 | 6.14E-04 | 6.28E-04 | 6.13E-04 | 9.17E-04 | 6.28E-04 |
| PFDavg (PTI=10 years) | 4.72E-03 | 3.20E-03 | 3.27E-03 | 3.20E-03 | 4.80E-03 | 3.28E-03 |
| PFH | 1.08E-07 | 7.29E-08 | 7.45E-08 | 7.28E-08 | 1.09E-07 | 7.47E-08 |
| Testing time | <20s | <20s | <20s | <5s | <20s | <5s |
| ROM check time | See paragraph "ROM CHECK TIME" | | | | | |

The failure rate is valid only for useful lifetime of the instrument. Failure rate increases after expected lifetime has expired. To perform PFDavg calculation, 10-year mission time has been considered. Mission time exceeding instrument lifetime cannot be used for this calculation since the final result could be too optimistic.

All safety related parameters are calculated using SN29500 failure database and considering a temperature of 40°C according to SN29500. Parameters change if considering a temperature above 40°C. In this case re-calculation is necessary.

Important. A diaphragm-seal-equipped pressure transmitter features different safety parameters if compared to the abovementioned ones. The intrinsic safety failure rates of diaphragm seal should be added to the ones of the pressure transmitter (as per above table). The values represent the worst case and may be slightly different (nearly negligible) depending on the type of diaphragm seal. As a reference, you may want to consider the below value:

| | One diaphragm seal configuration | Two diaphragm seal configuration |
|----------------|----------------------------------|----------------------------------|
| λ_{dd} | 0.46E-08 | 0.92E-08 |
| λ_{du} | 1.38E-08 | 2.75E-08 |
| λ_s | 0 | 0 |

Note. The above failure rates have to be added to the transmitter ones in case you selected a transmitter equipped with one or two diaphragm seals. The above table shows the dangerous failures only because the diaphragm seal system does not generate any safe failure. In order to calculate the Safety Failure Fraction (SFF) and Diagnostic Coverage (DC) of a diaphragm-seal-equipped pressure transmitter, please use the following formulas:

$$SFF = \frac{\lambda_s + \lambda_{dd}}{\lambda_d + \lambda_s} \quad DC = \frac{\lambda_{dd}}{\lambda_{dd} + \lambda_{du}}$$

Important. Values and instructions listed here are valid only for HART digital communication and 4 ... 20 mA IEC 61508 SIL2 certified pressure transmitters (digits T and 8 under the "Output" option within product codes). Therefore safety instructions cannot be considered as valid in case the transmitter features Standard, Advanced or WirelessHART (digits H, 1, L, 7, W, 9), PROFIBUS PA (digits P, 2) or FOUNDATION Fieldbus (digits F, 3) communication protocols.

17.1 Systematic integrity

266 pressure transmitter firmware has met the requirement for Systematic capability equal 3, SC=3. This allow the usage of 266 Pressure transmitters in SIL 3 safety loops only in redundant configuration architecture 1oo2, in this case a common cause factor of at least $\beta=5\%$ and a common cause detected by diagnostic test factor of at least $\beta D=2.5\%$ should be included in the safety integrity calculation.

17.2 Random integrity

266 pressure transmitter with IEC61508:2010 certification is classified as a type B device according to IEC61508, as reported in the safety parameter table the hardware fault tolerant is 0, HFT=0.

The random integrity for type B device is SIL2 @HFT=0.

17.3 ROM check time

The most critical component about ROM check time is the communication board ROM inside the microcontroller. A block of 1Kbyte is checked in the worst case every 120s, so the whole ROM in the worst case is checked within 8h.

17.4 Useful lifetime

Based on the reliability data given by the manufacturer of the components, on the worst data retention time of the microcontroller FLASH, as well as on the in-field experience as stated by section 7.4.9.5 of IEC61508-2 standard, the useful lifetime to be consider should be 14 years at 40°C ambient temperature. Useful lifetime decreases of two years for every 10 °C temperature increase. Lifetime is extended by two years for each 10 °C decrease in ambient temperature.

If plant experience indicates a shorter useful lifetime than 14 years, the number based on plant experience should be used.

Although a constant failure rate (linear part of bath-tube curve) is assumed by the probabilistic estimation method (see FMEDA results), this rate is applicable only if useful lifetime of component is not exceeded. Beyond their useful lifetime, the result of the probabilistic calculation method is therefore meaningless as the probability of failure significantly increase with time. The useful lifetime is highly dependent on the components that form the instrument itself and its operating conditions (for example temperature in particular).

It is responsibility of the end user to maintain and operate 266 pressure transmitters according to manufacturer instructions, so periodic inspection should demonstrate that all parts of the instrument is free from damage.

266 pressure transmitters shall not be operated beyond the useful lifetime declared without undergoing overhaul or replacement.

17.5 Connection to SIS logic solver

266 pressure transmitters shall be connected to logic solver where trip levels must be compatible with the sensor alarm level given in the paragraph "OUTPUT CURRENT LIMITS (TO NAMUR 43 STANDARD)" of this manual.

The minimum downtime to be consider is 200ms equal to the update time of the current.

The maximum detection time is 5min (excluded ROM parts) as declared in the safety specification.

Attention. The maximum time to have an error is when the last block of ROM is damaged, the internal diagnostic shall check the whole blocks in the ROM and after 8h, and the alarm is in output.

Important. In case of oscillation of the current, when it reaches the alarm value, this is held for 4 s. User must use an adequate logic solver to detect this condition.

18 Release history of 266 hardware and software components

– HART Communication Board software release history

| Revision | | Description | Release data |
|----------|---------------------|--|--------------|
| From | To | | |
| | 7.1.11 | First Release | 09/2009 |
| 7.1.11 | 7.1.12* | Bug fixing: <ul style="list-style-type: none"> — microbar and millitor units added — HART command 35 bug fixed. By HART specification #35 unit should not be set pv unit — if the local indicator was not mounted, only one operation via push buttons was performed — MWP diagnosis classification become Maintenance instead of Off-Specification Improvements: <ul style="list-style-type: none"> — replacement functionality improved — internal improvements to reduce factory configuration — more/stronger checks about process variables goodness — HART response time reduced (30%) | 06/2010 |
| | 7.1.13 | Internal release not published | |
| 7.1.12* | 7.1.14* | Improvements: <ul style="list-style-type: none"> — factory configuration speeded up — service detailed diagnosis implemented | 01/2011 |
| 7.1.14* | 7.1.15* | Bug fixing: <ul style="list-style-type: none"> — sensor trimming via local display was performed only in kPa — diagnosis "Replace Error" no more shown — unit strings on local display (Nm3, bbl, t) were wrong New features: <ul style="list-style-type: none"> — new language (French & Spanish) on local indicator — sensor polarity inversion | 01/2013 |
| 7.1.15* | 7.2.1* | Improvements: <ul style="list-style-type: none"> — introduction of HART revision 7 | 11/2015 |
| 7.1.15* | 7.1.16* (HART 5) | New features: <ul style="list-style-type: none"> — Temperature alarm enabled by user — Oscillation alarm control — Switching of alarm in case of wrong power supply | 04/2018 |
| 7.2.1* | 7.2.2* (HART 7) | New features: <ul style="list-style-type: none"> — Temperature alarm enabled by user — Oscillation alarm control — Switching of alarm in case of wrong power supply | 04/2018 |

* Certified releases

– Release history for Communication Board hardware

| Revision | | Description | Release data |
|----------|--------|---------------------------|--------------|
| From | To | | |
| | 0.0.0 | First Release | 01/2009 |
| 0.0.0 | 0.0.1* | | 04/2009 |
| 0.1.1* | 0.1.2* | Change of microcontroller | 02/2014 |
| 0.1.2* | 0.1.3* | Change IC8 type | 04/2014 |

* Certified releases

— 266Dxx,266Vxx,266Hxx,266Nxx Front end software revision history

| Revision | | Description | Release data |
|----------|--------|---|--------------|
| From | To | | |
| | 0.9.1 | First Release | 07/2009 |
| 0.9.1 | 1.0.0* | <ul style="list-style-type: none"> — Change firmware on FPGA — Added SIL functionality | 02/2010 |
| 1.0.0* | 1.0.1* | <ul style="list-style-type: none"> — Changes of trimming limits computation — Strengthening of the synchronization between FPGA and microcontroller when over-range is present. — Change trimming limits computation of minimum span | 04/2011 |
| 1.0.1* | 1.1.0* | <ul style="list-style-type: none"> — Change double algorithm thresholds — Change in burst variables prioritization — Change for 420bar transducer | 12/2011 |
| 1.1.0* | 1.1.1* | <ul style="list-style-type: none"> — Remove of debugging peripheral reset at start-up | 04/2014 |
| 1.1.1* | 1.1.3* | Updating for introduction of 700bar (range W) | 05/2016 |

* Certified releases

— 266Hxx,266Gxx (only sensor Z) Front end software revision history

| Revision | | Description | Release data |
|----------|--------|---|--------------|
| From | To | | |
| | 1.0.0* | First Released certified with IEC61508:1998 (internal release 0.0.5) | 04/2012 |
| 1.0.0 * | 1.0.5* | <ul style="list-style-type: none"> — Updating for IEC61508:2010 — Remove of debugging peripheral reset at start-up — Improve of SPI communication with ADC | 11/2015 |

* Certified releases

— 266Hxx,266Gxx (only sensor Z) Front End hardware revision history

| Revision | | Description | Release data |
|----------|--------|---------------|--------------|
| From | To | | |
| | 1.0.0* | First Release | 03/2015 |

* Certified releases

— 266Dxx,266Vxx,266Hxx,266Nxx Front End hardware revision history

| Revision | | Description | Release data |
|----------|--------|---|--------------|
| From | To | | |
| | 0.0.0 | First Release | 01.2009 |
| 0.0.0 | 0.1.0 | <ul style="list-style-type: none"> — Change power supply for microcontroller — Improvement of temperature sensor — Connection for external bootloader added | 03.2009 |
| 0.1.0 | 0.1.1 | <ul style="list-style-type: none"> — Change position of capacitor on the PCB to allow automation of soldering | 07.2009 |
| 0.1.1 | 0.1.2* | <ul style="list-style-type: none"> — Change of the FW of FPGA to improve the reading performance of pressure sensor — Changed position of capacitor on the PCB to allow automation of soldering — Improvement of hwd performance | 04.2010 |
| 0.1.2* | 0.1.3* | <ul style="list-style-type: none"> — Improvement for start-up with low temperature (-50°C) | 04.2014 |

* Certified releases

— 266Mxx,266Rxx (only range R), 266Gxx, 266Axx Front End software release history

| Revision | | Description | Release data |
|----------|---------------------|---|--------------|
| From | To | | |
| | 1.0.0* ¹ | First Release | 04.2010 |
| 1.0.0* | 1.1.0* | <ul style="list-style-type: none"> — Change in trimming limits — Priority inversion for non-primary variables | 12.2011 |
| 1.1.0* | 1.2.2* | <ul style="list-style-type: none"> — Start-up sequence modifications — Improvements functional performance | 10.2013 |
| 1.2.2* | 1.2.3* | <ul style="list-style-type: none"> — Improvements start-up sequence modification | 02/2016 |

* Certified releases

¹ software release identified also with 0.10.3

– 266Mxx,266Rxx (only range R), 266Gxx, 266Axx Front End hardware release history

| Revision | | Description | Release data |
|----------|--------|--|--------------|
| From | To | | |
| | 1.0.4 | First Release | 12.2008 |
| 1.0.4 | 1.0.6* | – Improvement for start-up circuit – Supervisory circuit adding | 04.2010 |
| 1.0.6* | 1.0.7* | – Improvement for start-up with low temperature (-50°C) not released | 04.2014 |
| 1.0.7* | 1.0.8* | – Improvement for start-up with low temperature (-50°C) | 03.2015 |

* Certified releases

– 266Mxx,266Rxx Front End software release history

| Revision | | Description | Release data |
|----------|---------------------|---|--------------|
| From | To | | |
| | 1.0.0* ¹ | First SIL Release | 04.2010 |
| 1.0.0* | 1.1.0* | – Change in trimming limits – Priority inversion for non-primary variables | 12.2011 |
| 1.1.0* | 1.2.2* | – Start-up sequence modifications – Improvements functional performance | 10.2013 |
| 1.2.2* | 1.2.3* | – Improvements start-up sequence modification | 02/2016 |

* Certified releases

¹ software release identified also with 0.10.3

– 266Mxx,266Rxx Front End hardware release history

| Revision | | Description | Release data |
|----------|--------|--|--------------|
| From | To | | |
| | 1.0.5 | First Release | 12.2008 |
| 1.0.5 | 1.0.7* | – Improvement for start-up circuit – Supervisory circuit adding | 04.2010 |
| 1.0.7* | 1.0.8* | – Improvement for start-up with low temperature (-50°C) not released | 04.2014 |
| 1.0.8* | 1.0.9* | – Improvement for start-up with low temperature (-50°C) | 03.2015 |

* Certified releases

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- Pressure measurement remote seals
- Pressure measurement accessories
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- Temperature sensors for sanitary applications
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Client Warranty

Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment, in accordance with the Company's published specification. Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:

- A listing evidencing process operation and alarm logs at time of failure.
- Copies of all storage, installation, operating and maintenance records relating to the alleged faulty unit.

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