Safety Manual SM/266HART-SIL-EN Rev. P

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 conjuction with 266 operating manuals.

Power and productivity
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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 acontinuous program of innovative design and development to incorporate the latest technology.

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1. Scope and purpose of the safety manual

The present safety manual contains information to design, install, verify and maintain a Safety Instrumented Function (SIF) using 266 Pressure Transmitters certified according to IEC61508. This document states all assumptions that shall be made by the application to meet the SIL capability declared for the product. If these requirements are not respected, SIL capability cannot be achieved.

2 Safety philosophy

266 Pressure Transmitters are field devices designed according to the requirements of the standard IEC61508 for the Safety Related Systems. Standard currently used focus on individual parts of all the safe instrumentation used to implement a safety function. The IEC61508 defines requirements related to all the system that normally comprises initiating devices, logic solver and final elements. It also introduces the concept of Safety lifecycle defining the sequence of activities involved in the implementation of the safety-instrumented system from conception through decommissioning. For a single component, it is not correct to define a SIL level. The term SIL (Safety Integrity Level) refers to the complete safety loop therefore the single device shall be designed in order to be suitable to achieve the desired SIL level in the entire Safety Loop.

2.1 Application

266 Pressure Transmitters certified according to IEC61508 are intended to be applied for safety relevant application in the process industry. They are suitable to be used in SIL2 applications when applied as single channel and in SIL3 applications when applied with a double channel with architecture 1oo2. Special attention has to be given to the separation of safety and non-safety relevant use.

2.2 Safety Function

The instrument could be used in safety-critical applications to measure process pressure and drive 4-20mA output current according to the measured values. If the process value is invalid due to an internal failure of instrument, the system is to go into safe/alarm state (in compliance with NAMUR NE43) and the malfunction must be shown as warning message on the LCD (if any) as well as a variation in the output. The only safety function is the current output 4-20mA. It is important that the transmitter is user-configured for the correct application.

2.3 Identification of 266 pressure transmitter IEC61508 certified

Only IEC61508-certified pressure transmitter can be used in safety loops. 266 Pressure transmitter family includes a wide range of different instruments. To identify the safety ones, there are some important detail to consider starting from the product code laser printed on the nameplate:

— The “Output” characteristic as per product datasheet is to be codified with digits 8 or T.
To identify IEC61508:2010 certified instruments by reading the nameplate check if the main product code (mandatory characteristic) ends with 8 or T. Mandatory characteristics to be selected by the user are always composed by one single digit. If a product code ends with T, no additional options are required, whereas if the code ends with digit 8, the user selected some additional options which are differentiated by being composed by two digits and being preceded by a blank space.

Below are two examples of nameplates with code 8 or T:

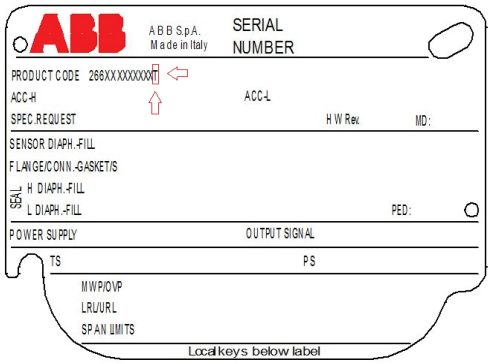


Figure 1: Product Code with digit “T” (no additional options)

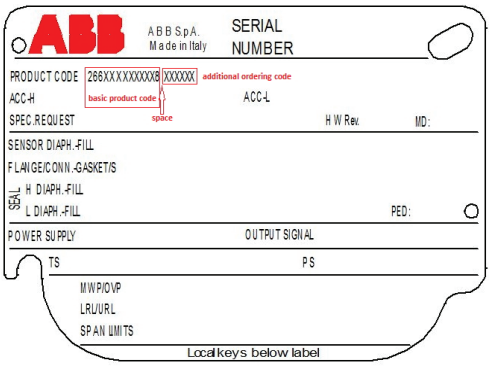


Figure 2: Product Code with digit “8” (additional options required)

The user shall check 266 pressure transmitters compliance for use in safety applications by reading the nameplate (product code). Product codes to be in line with what stated in the previous paragraph.

Important. 266 pressure transmitter certified according to IEC61508 have mounted on the neck an additional label with indicate the TUV mark, this permit to have a tag for SIL instrument. The additional label does not guarantee that the instrument is SIL, the only guarantee is the code printed on the nameplate that must have the fixed part that ends with 8 or T. The user must check the correct product code before the installation of the instrument on the plant.

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 the 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.

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°

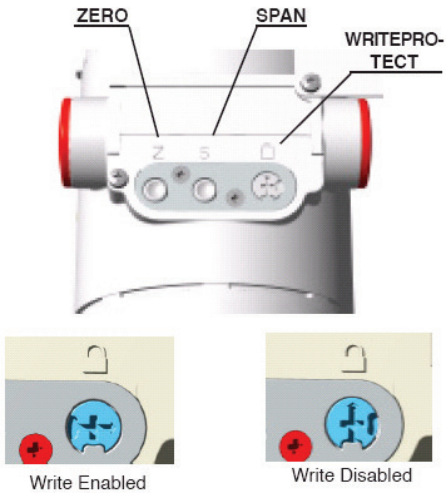


Figure 3: Write-protection pushbutton

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

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)

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.
3. Excess of temperature
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.

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 pronciple of operation

The instrument consists of three main functional units:

— Primary unit (called Front End Board)

— Secondary unit (called Communication Board)

— Electrical interface (called Terminal Block Board)

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.

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:

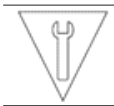
1. Switch off the device.
2. Assure that the Write Protect Mode switch is in Write Protect condition.
3. Power-on the transmitter: the transmitter performs automatically a self-test that consists in the operations below:
   — ROM test
   — RAM test
   — Test of the analog output stage and of the feedback A/D converter
   — Test of the power supply voltage
   — Non volatile memory test
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, Operanting and Process.

Icon	Description
	Error / Failure
	Functional check (e.g. during simulation)
	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 outpt 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
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
M022.041	Electronic Temperature Out of Limits	The Electronics temperature is out of its lower acceptable limit . The circuitry for the sampling of the Electronics Temperature has failed.	The proof test must be executed on pressure instrument once the temperature goes back within specified limits (-40 °C ... +85 °C)	set by customer: no effect or alarm
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.	The proof test must be executed on pressure instrument once the temperature goes back within specified limits (-40 °C ... +85 °C)	set by customer: no effect or alarm

— 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	The temperature of the process environment affects the pressure transmitter; Excess temperature can reduce accuracy, degrade device components and may require calibration/replacement.	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.	no effect
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)
λdd [h^{-1}]	7.74E-07	9.11E-07	9.17E-07	9.07E-07	7.82E-07	8.19E-07
λdu [h^{-1}]	1.08E-07	7.29E-08	7.45E-08	7.28E-08	1.09E-07	7.47E-08
λsd [h^{-1}]	2.80E-07	2.37E-07	2.37E-07	2.37E-07	2.81E-07	2.42E-07
λsu [h^{-1}]	1.25E-07	1.26E-07	1.26E-07	1.26E-07	1.25E-07	1.26E-07
λtot 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)
λdd [h^{-1}]	7.74E-07	9.11E-07	9.17E-07	9.07E-07	7.82E-07	8.19E-07
λdu [h^{-1}]	1.08E-07	7.29E-08	7.45E-08	7.28E-08	1.09E-07	7.47E-08
λsd [h^{-1}]	2.67E-07	2.24E-07	2.24E-07	2.23E-07	2.68E-07	2.29E-07
λsu [h^{-1}]	1.39E-07	1.40E-07	1.40E-07	1.40E-07	1.39E-07	1.40E-07
λtot 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)
λdd [h^{-1}]	7.74E-07	9.11E-07	9.17E-07	9.07E-07	7.82E-07	8.19E-07
λdu [h^{-1}]	1.08E-07	7.29E-08	7.45E-08	7.28E-08	1.09E-07	7.47E-08
λsd [h^{-1}]	2.69E-07	2.25E-07	2.26E-07	2.25E-07	2.70E-07	2.31E-07
λsu [h^{-1}]	1.46E-07	1.47E-07	1.47E-07	1.47E-07	1.46E-07	1.47E-07
λtot sf [h^{-1}]	1.300E-06	1.36E-06	1.36E-06	1.35E-06	1.308E-06	1.27E-06
HFT	0					
Architecture	1oo1					
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 PDFavg 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
λdd	0.46E-08	0.92E-08
λdu	1.38E-08	2.75E-08
λs	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 followiong formulas:

$$SFF = \frac{\lambda s + \lambda dd}{\lambda d + \lambda s} \qquad DC = \frac{\lambda dd}{\lambda dd + \lambda du}$$

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 ß=5% and a common cause detected by diagnostic test factor of at least ßD= 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.

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:** — 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:** — 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: — factory configuration speeded up — service detailed diagnosis implemented	01/2011
7.1.14*	7.1.15*	**Bug fixing:** — 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:** — new language (French & Spanish) on local indicator — sensor polarity inversion	01/2013
7.1.15*	7.2.1*	**Improvements:** — introduction of HART revision 7	11/2015

* 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*	— Change firmware on FPGA — Added SIL functionality	02/2010
1.0.0*	1.0.1*	— 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*	— Change double algorithm thresholds — Change in burst variables prioritization — Change for 420bar transducer	12/2011
1.1.0*	1.1.1*	— 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*	— 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	— Change power supply for microcontroller — Improvement of temperature sensor — Connection for external bootloader added	03.2009
0.1.0	0.1.1	— Change position of capacitor on the PCB to allow automation of soldering	07.2009
0.1.1	0.1.2*	— 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*	— 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*	— 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 (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 hardfware 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

19 Authorized manufacturing locations

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Products and customer support

ABB's portfolio for valve automation:

– Continuous electrical actuators and pneumatic actuators

– Electro-pneumatic, pneumatic, and digital positioners

– I/P signal converters

ABB's pressure measurement:

– Absolute, gauge and differential pressure transmitters

– IEC 61508 SIL2/3 certified pressure transmitters and switches

– Multivariable transmitters

– Interface level/density transmitters

– Pressure measurement remote seals

– Pressure measurement accessories

– Pneumatic pressure transmitters

ABB's temperature measurement:

– Universal temperature sensors

– High-temperature sensors

– Temperature sensors for sanitary applications

– Mineral isolated temperature sensors

– Thermowells

– Temperature transmitters

– IEC 61508 SIL2/3 certified temperature sensors and transmitters

ABB's portfolio of recorders and controllers:

– Process controllers and indicators

– Videographic recorders

– Paper chart recorders

– Field mountable indicators and controllers

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– Magnetostrictive and guided wave radar level transmitters

– Laser and scanner level transmitters

– Ultrasonic, capacitance and vibrating fork level transmitters and switches

– Rotating paddle and thermal dispersion level switches

– IEC 61508 SIL2/3 certified level transmitters

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– Fieldbus and wireless solutions

– Scalable asset & device management

– Asset vision software

– Mobility handhelds

Customer support

We provide a comprehensive after sales service via a Worldwide Service Organization.

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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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