INSPECTION REPORT

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Date:	2023-Nov-24
Report No.:	1435.IM.102439/20TB
Item under inspection:	2600T Series Pressure Transmitters, Model 266 according to IEC 61508:2010
Customer:	**ABB S.p.A.** Via Vaccani, 4 22016 Tremezzina Loc. Ossuccio (CO) Italy
Order No.:	8118017727
Inspection site:	**TÜV NORD Systems GmbH & Co. KG** Functional Safety Inspection Body SEELAB Halderstr. 27 86150 Augsburg / Germany
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Review:	Hermann Kränzle

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Document version history:

Version	Date	Author	Description of change
1.0	2020-12-11	J. Neumann	Re-certification, modification 1000bar and CB Hart firmware 7.2.2 ir4 (see chapter 8.17)
1.1	2021-03-23	J. Neumann	Update of Order No.
1.2	2021-06-17	J. Neumann	Update to CB Hart firmware 7.2.3/7.1.17 (see chapter 8.18)
1.3	2023-11-24	J. Neumann	Update for CB MV hardware revision from 1.0.1 to 1.0.2 (see chapter 8.19)

Tables:

Figures:

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1 Subject of inspection

This report compiles the results of the assessment of the 2600T Series Pressure Transmitters, Model 266 with project name MiLe2 of ABB S.p.A.). The services of TÜV NORD Systems GmbH & Co. KG (thereafter known as TÜV NORD Systems) has been ordered by ABB S.p.A. to certify the 2600T Series Pressure Transmitters, Model 266 because of its use in safety-relevant applications by the process industry (e.g. oil & gas and chemical industry) with the goal of achieving a successful approval of the 2600T Series Pressure Transmitters, Model 266 in the framework of the certification of safety-components.

The 2600T Series Pressure Transmitters, Model 266 is to be certified in accordance with IEC 61508 for single use in Safety Integrity Level 2 (SIL 2) applications. The development and the software process is to be certified in accordance with the Functional Safety Management (FSM) according to SIL 3 requirements allowing the use of dual redundant 2600T Series Pressure Transmitters, Model 266 in SIL 3 applications. TÜV NORD Systems GmbH & Co. KG was ordered in March 2015 for the assessment of the 2600T Series Pressure Transmitters, Model 266 according to IEC 61508:2010 (Ed 2). With P.O. from 08.04.2016 ABB S.p.A. ordered the upgrade to 700bar (see chapter 8.11) and with P.O. from 2015-12-21 the upgrade to Multivariable 266. With P.O. from 2018-03-13, the modification for software 7.1.16/7.2.2 has been ordered. With order from 2020-03-25 the re-certification and modifications for 1000bar sensor and CB HART firmware 7.2.2 ir4 has been ordered.

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2 Definitions

CB	Communication Board
C0	Modification in a module not part of safety related function.
C1	Modification in a module not part of safety related function which interacts with a safety related module.
C2	Modification in a module part of safety related function.
FE	Front End
FIT	Failure In Time (1*10-9 failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
FSM	Functional Safety Management
HART	Highway Addressable Remote Transducer
High demand mode	Mode, where the frequency of demands for operation made on a safety-related system is greater than one per year or greater than twice the proof-check frequency
Low demand mode	Mode, where the frequency of demands for operation made on a safety-related system is no greater than one per year and no greater than twice the proof test frequency
MiLe2	Pressure transmitter model 266
PFD	Probability of Failure on Demand
PFD_{AVG}	Average Probability of Failure on Demand
PFH	Average frequency of dangerous failure [h-1] per Hour
SFF	Safe Failure Fraction
SIL	Safety Integrity Level
SRS	Safety Requirements Specification
Type A component	“Non-Complex” component (using discrete elements); for details see 7.4.3.1.3 of IEC 61508-2
Type B component	“Complex” component (using micro controllers or programmable logic); for details see 7.4.3.1.3 of IEC 61508-2
λ_{du}	Dangerous Undetected (DU) Failure Rate [1/h]

Table 1: Definitions

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3 Overview about the system configuration

The 2600T Series Pressure Transmitters, Model 266 project is the design and development of a new common pressure topwork and involves all the design aspects like hardware, software and mechanics.

3.1 Housing design concept

The housing design is based on the Common BUI Type 2 version. The already existing look and feel is used on the Type 2 for remote application (Temperature) and migrates on the Pressure housing with the modification for the direct mount application. Local keys (2 or 3) are provided in the housing.

Figure 1: Housing Design

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3.2 Electronics design concept

The electronic is based on three boards called respectively Front End Boards (connected directly to the sensors) and Communication Boards (connected to the front end boards) and finally the Terminal block that it is connected to Communication Board.

There are three type of Front End:

- Inductive Front End
- Piezoresistive Front End (dp, dp-HP, p)

There are four type of communication boards, one type uses an analog communication and three types use digital communications:

- Current loop 4 to 20mA plus Hart communication board
- Fieldbus communication board
- Profibus PA communication board
- Modbus communication board

Any front end can be connected to any type of communication board independent of sensor type and communication protocol. This is possible because front end and communication board use a common protocol communication, power supply voltage and signal control.

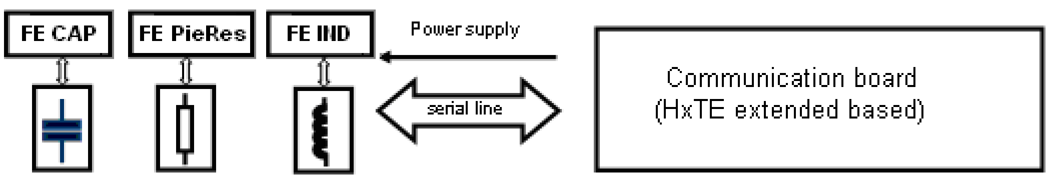

Figure 2: Electronics block design

The common Communication Board (for Hart) and the common Fieldbus Electronics based on common hardware and software framework, include the instrument specific software and provide the interface with the external world (DCS etc.)

3.2.1 Front end boards description

The front-end boards are the same for both the Communication Board and Fieldbus Electronics and carry out the following tasks:

- Primary conversion between the output physical signals by different sensors and one electrical signal;
- Perform A/D conversion of electrical signal;
- Provide diagnostic information;
- Execute the DSP (Digital signal Processing) performing primary signal linearization, compensation and diagnostic (PILD, etc.);
- Carry a non-volatile memory for the storage of the relevant sensor data;
- Provide a standard digital serial communication to the communication board in order to transfer the already characterized signal to the Communication Board;

The Front-End Board is different for different sensors.

Peculiarity of the new structure of the communication between Front End and Communication board is done via a digital serial communication. The communication protocol is common among all BU instruments involved in this project in order to give the possibility to connect to the same communication boards.

3.2.2 Communication boards description

Communication Board is developed for Hart, Fieldbus, Profibus PA and Modbus communication protocol. It is directly derived from the already existing platforms UHTE for Hart and UFTE extended for fieldbus. Main tasks of the communication board are:

- Provide the D/A conversion of the compensated output signal generating the 4 to 20mA output (only for analog version)
- Carry the modem able to transmit the variable coming from the front end to the output in the digital communication protocol (HART, FieldBus and ModBus);
- Provide diagnostic information;

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- Provide the power supply to all the modules;
- Drive the Human Machine Interface (HMI);
- Support the on-board firmware download (there is a particular procedure for this);
- Support the transmitter local adjustment;
- Communicate with the optional external temperature sensor via synchronous serial communication;

3.2.3 Terminal Block

There are three types of terminal boards available:

1 standard Hart terminal block

2 Terminal board with surge protector

3 Terminal board extended EMC

The following figure describes the terminal block architecture.

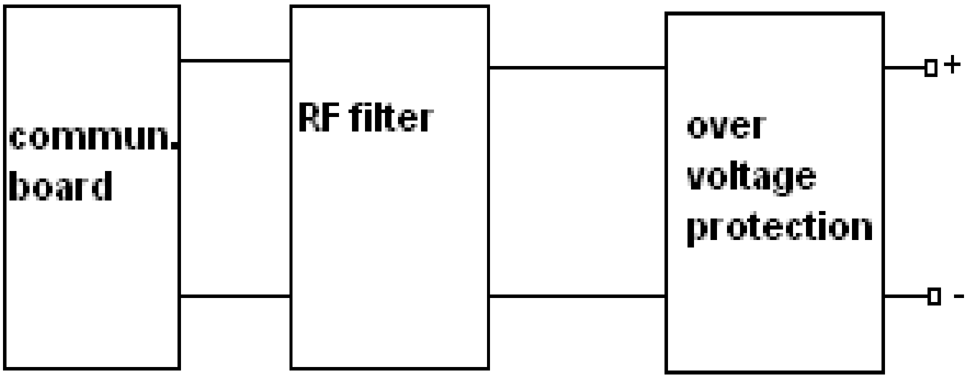

Figure 3: Block diagram communication board with terminal block

Terminal Blocks provides the main power supply, input and output signal. It has a RF filter, for RF immunity. Input is protected from transient overvoltage by clamping action via bidirectional diode (tranzorb).

3.2.4 D. Second Front End (Temperature board) -(optional)

Second Front End main tasks are to convert process temperature signal to electronic signal to calculate a compensated flow, level compensation and enthalpy and to

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generate the isolated digital output signal. Temperature sensor is external of the instrument.

3.2.5 E. Human Machine Interface –(optional)

Display the value of measure and set some parameters.

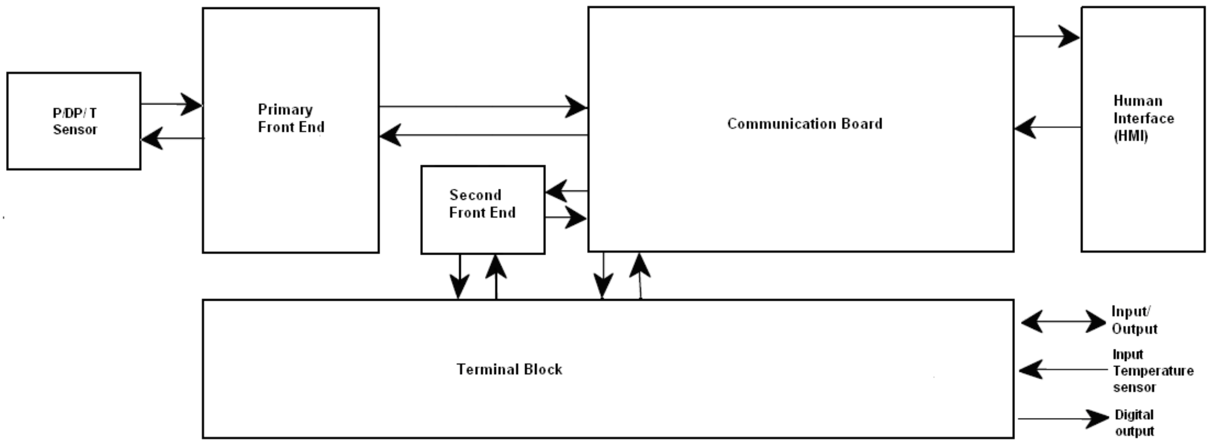

Figure 4: Block diagram MILE 2

3.2.6 Pressure Sensor

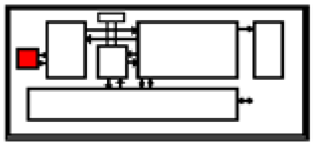

Figure 5: Location of the pressure sensor

The pressure sensor technologies used are:

- Inductive
- Capacitive
- Piezoresistive
- Strain gauge only for 1000bar pressure transmitter

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3.3 SW design concept

Two main software modules are:

- the Communication board software
- the Front-End board software

3.3.1 Communication board

The software architecture is based on the Common Framework and is divided into subsystems.

3.3.2 Front end board

The software embedded in the front-end board is sensor related. Main tasks of it are the Digital Signal Processing, communication handler with the main board, non-volatile memory management and diagnostic (device and process diagnosis).

4 Documentation

The documentation is listed in Chapter 11.

5 Standard

Because of the application area of the 2600T Series Pressure Transmitters, Model 266, the following standard is relevant:

IEC 61508:2010; Ed. 2 SIL 2 capability for single configuration SIL 3 capability for dual configuration Type B	Functional safety of electrical/electronic programmable safety related systems
IEC 61508-1	Functional safety of electrical/electronic programmable safety related systems Section 1: General requirements
IEC 61508-2	Functional safety of electrical/electronic programmable safety related systems Section 2: Requirements for safety related EPSS
IEC 61508-3	Functional safety of electrical/electronic programmable safety related systems Section 3: Software requirements

Table 2: Standard

6 Hardware and software identification

- For hardware and software versions see Appendix A.

7 Assessment activities

For the 2600T Series Pressure Transmitters, Model 266 the following assessment segments have been considered:

1. Functional safety
    1.1 Quality Management und Management of functional safety
    1.2 System and concept
    1.3 Development of hardware (HW)
    1.4 Failure Mode and Effect Analysis (FMEDA) with calculation of λ-values, SFF and PFH/PFD_{avg} value
    1.5 Development of firmware (FW)
    1.6 Test Laboratory
    1.7 Safety related information in the installation and operating manual
2. Environmental influences
    a. Climatic and temperature influence
    b. Mechanical influence
    c. EMC

The documentation of the safety related development of ABB S.p.A. includes documents from the areas QM system, system-level, HW and FW and assessment.

The documents provided by the manufacturer in its valid version are listed in a summarizing document list chapter 4.

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8 Assessment activities and results

8.1 Development Process

General aspects and scope:

In the certification process a safety management audit has been performed to cover the relevant requirements of the IEC 61508, in respect of the fulfilment of the requirements to the safety quality procedures.

The scope of the Functional Safety Management Audit covers the specified Safety Lifecycle Phases of the IEC 61508. The following locations are covered by the assessment:

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Structuring of the development process:

The documents MiLe 2 Quality Plan [D09] and MiLe 2 Project Plan [D01] describes the ABB S.p.A. development processes, procedures and work-instructions for the 2600T Series Pressure Transmitters, Model 266 project. The tool evaluation is shown in [D157] and [D331]. The aim of the assessment was to show that the defined procedures are not only defined but also used and lived in the project. Therefore, interviews to the participants and reviews of documents (e.g., review reports) were performed. This should give the right overview to define whether the project specific management activities are sufficient for the actual assessment. For the Functional Safety Management Audit according to IEC 61508 it was essential that the functional safety management and the software development process are designed for the SIL 3 level to allow setting up a redundant 2600T Series Pressure Transmitters, Model 266 in a SIL 3 environment. The FSM procedures are used to reduce the systematic failure rate.

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The Functional Safety Management Audit covered the following areas:

- Product marketing and safety policy
- Overall safety planning (regarding quality)
- Company FSM procedure
- Feedback control and improvement of safety processes
- Validation test planning
- Change and Configuration management
- Hardware design and development method
- Operation and maintenance method
- Software design and development method
- Requirement specifications
- Operation and modification method

An important part of the audit was to discuss safety aspects of the project with the participants and to ask for the relevant documents and the access to the relevant information. Also, the specific knowledge about safety processes and internal review activities were reviewed. Actual documentation was partly reviewed and the statements of the participants were compared with the relevant parts of the documents.

Result:

The review has shown that the Functional Safety Management System defined in the listed documents complies with the applicable sections of the IEC 61508.

No major findings were detected in the audit.

If changes to the Safety Management Systems are performed than, TÜV NORD Systems must be informed.

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8.2 Review of the System Requirement Specification

The requirements defined for the system are specified in the safety requirement specifications [D15] to [D33]. The specifications have been reviewed according to the standard against the functional requirements and the implemented integrity functions out of the standard.

The requirements are defined in specific sentences with a numbering system (Ident. No.), a short description, a priority and stability statement and a link to the source where requirements come from. The sources are specified to be derived from e.g., Research and Development (R&D) or Marketing (MKT)

Result:

The review shows that the requirements are consistent and cover the necessary integrity requirements according to the defined standard (see section 5).

8.3 System Architecture

The system documents have been reviewed to verify compliance of the system architecture with the standard listed in section 5.

Based on the set of requirements TÜV NORD Systems has evaluated whether the implemented fault detection and fault control measures which are defined for the 2600T Series Pressure Transmitters, Model 266 were sufficient to meet the requirements. The system architecture defined in [D34] was evaluated in regards to completeness and correctness against the Safety Requirements Specifications [D15] – [D33] and the System FMEA [D35]. The system architecture was designed for a Type B subsystem according to the IEC 61508-2 with a Safe Failure Fraction of 90% or higher.

The System FMEA verified the defined safe state of the 2600T Series Pressure Transmitters, Model 266 in the event of possible malfunctions. Probable deviation from the specified function of the unit was also considered to be a malfunction.

Result:

The review from TÜV NORD Systems has shown that the system architecture of the 2600T Series Pressure Transmitters, Model 266 is consistent against the Safety

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Requirements Specification. The specifications in the documentation are consistent and complete and clearly presented. The system concept with the chosen architecture design and the selected measures of fault detection and fault control is able to fulfil the Safety Integrity Level 2 with a Safe Failure Fraction of >90%.

8.4 Review of the System FMEA

The document contains a system level Failure Mode and Effect Analysis (FMEA) for 2600T Series Pressure Transmitters, Model 266. The System FMEA is documented in [D35]. The main considerations are the Communication Board and the Front-End Boards. The System FMEA analysis whether dangerous failures are detected in the subsystem. The analysis was based on the working principle of the boards (sub-systems) and the communication links.

The System FMEA is documented in a more description part and in a detailed table with the failure modes, the effects, detection mechanism and the failure handling.

The System FMEA was reviewed by TÜV NORD Systems against the architecture and the requirements.

Result:

The analysis shows that the System FMEA includes enough details to cover the defined requirements and the architectural aspects of the document [D34]. The failure modes and detection measures are sufficient covered and the diagnostic failure handlings are defined.

8.5 Hardware Design and FMEDA

A Failure Modes and Effects Analysis (FMEA) is a systematic way to identify and evaluate the effects of different component failure modes, to determine what could eliminate or reduce the chance of failure, and to document the system in consideration.

A FMEDA (Failure Mode Effect and Diagnostic Analysis) is an extension of the FMEA. It combines standard FMEA techniques with additional analysis to identify online diagnostic techniques and the failure modes relevant to safety system design. It is a technique recommended to generate failure rates for each important category (dangerous detected, dangerous undetected) in the safety model.

The following sections show the failure rates resulted from the 2600T Series Pressure Transmitters, Model 266 FMEDA.

8.5.1 Assumption / Parameter

From the safety function for SIL 2 follows that the mean PFD of the complete system must be lower than 10^{-2} over the entire life cycle (IEC 61508-1 Chap. 7.6.2.9 Paragraph 3).
The Pressure transmitter is always only a part of the whole safety function. Therefore, the Requirement Specification of MiLe 2 requires a PFD value lower than 35% of the PFD value for SIL 2, in this case **PFD < $3{,}5^{-3}$.**

From SIL 2 and the fact, that the assessed product contains complex devices (Type B according to IEC 61508-2 Chap. 7.4.4.2.2), follows that the SFF for the respective shutdown path must be **SFF > 90%** for the existing 1oo1D architecture (IEC 61508-2 Tab.3).

8.5.2 System limitations

All the components from the circuit diagrams and the component lists built up the base of the FMEDA of the different modules. In a second step the safety related parameters for the complete instruments (subsystems) of sensor modules and transmitter have been calculated.

8.5.3 Calculation results for the complete instruments (subsystems):

Determination of the SFF:

Purpose of the requirements of IEC 61508 is to prevent and control failures in components and to limit the probability of dangerous failures to defined values. For this purpose, the probability of failures on demand PFD required by the standard for a low demand application was determined for SIL 2 with the results of the FMEDA and the combination according to IEC 61508-6. The failure rates of the used components were taken from the Exida FMEDA-Tool which uses the Reliability Standard SN29500.

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Safe Failure Fraction (SFF)	Hardware Fault tolerance **Type B – complex subsystems**		
	N=0 (1oo1D, 2oo2D)	N=1 (1oo2D, 2oo3D)	N=2 (1oo3D)
< 60%	Not allowed	SIL 1	SIL 2
60% ... < 90%	SIL 1	SIL 2	SIL 3
90% ... < 99%	SIL 2	SIL 3	SIL 4
>= 99%	SIL 3	SIL 4	SIL 4
Fault tolerance N means N+1 failure can effect a loss of the safety function.			

Table 3: Required SFF according to IEC 61508 Part 2 Table 2

Based on the FMEDA the part of safe failures was determined for the complete instrument. To perform its designed function according to IEC 61508 (see table 1) the SFF for a Type B – complex subsystem with a Hardware fault tolerance of N=0 has to be > 90%.

For determination of the PFD value the following formula for a 1oo1D subsystem was used.

$$PFD = \lambda_D \cdot \left(\frac{\lambda_{DU}}{\lambda_D} \left(\frac{T_1}{2} + MRT \right) + \frac{\lambda_{DD}}{\lambda_D} MTTR \right)$$

T1 = Proof check Interval = 1 year (8760h) and 10 years (87600h)

MTTR = Mean time to restoration = 8 h

MRT = Mean repair time = 8 h

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	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 S: 69.13	D: 92.59 S: 65.31	D: 92.48 S: 65.33	D: 92.56 S: 65.31	D: 87.73 S: 69.22	D: 91.64 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

Table 4: Safety related parameters for the HART Pressure transmitters with Standard Terminal Block

	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 S: 65.78	D: 92.59 S: 61.56	D: 92.48 S: 61.58	D: 92.56 S: 61.55	D: 87.73 S: 65.88	D: 91.64 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

Table 5: Safety related parameters for the 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]	2.69E-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 S: 64.76	D: 92.59 S: 60.55	D: 92.48 S: 60.56	D: 92.56 S: 60.54	D: 87.73 S: 64.87	D: 91.64 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

Table 6: Safety related parameters for the HART Pressure transmitters with Terminal Block featuring Extended EMC (additional code on request: YE)

	266Cxx, 266Jxx			266Jxx (range R)		
	TB Hart MV	TB Surge MV (code S2)	TB Ext EMC NE21:2004 MV (code YE)	TB Hart MV	TB Surge MV (code S2)	TB Ext EMC NE21:2004 MV (code YE)
λdd [h-1]	9.58E-07	9.58E-07	9.68E-07	9.65E-07	9.65E-07	9.75E-07
λdu [h-1]	7.77E-08	7.77E-08	7.78E-08	7.86E-08	7.86E-08	7.87E-08
λsd [h-1]	2.30E-07	2.29E-07	2.37E-07	2.30E-07	2.29E-07	2.38E-07
λsu [h-1]	1.36E-07	1.33E-07	1.39E-07	1.36E-07	1.33E-07	1.39E-07
HFT	0	0	0	0	0	0
Architecture	1oo1	1oo1	1oo1	1oo1	1oo1	1oo1
Tmission [years]	10	10	10	10	10	10
PTC%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%
SFF [%]	94.46%	94.44%	94.53%	94.42%	94.41%	94.50%
λtot safety [FIT]	1402	1397	1422	1410	1405	1430
MTBF [year]	81	82	80	81	81	80
MTTR [h]	8	8	8	8	8	8
DC_D	92.50%	92.50%	92.56%	92.47%	92.47%	92.53%
DC_S	62.85%	63.26%	63.06%	62.87%	63.27%	63.07%
PFDavg (PTI=1year)	6.54E-04	6.54E-04	6.55E-04	6.62E-04	6.62E-04	6.63E-04
PFDavg (PTI=10 year)	3.41E-03	3.41E-03	3.41E-03	3.45E-03	3.45E-03	3.46E-03
PFH	7.77E-08	7.77E-08	7.78E-08	7.86E-08	7.86E-08	7.87E-08

Table 7: Safety Parameters series 2600T models 266Cxx/266Jxx

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

Table 8: Safety related parameters according to the type of diaphragm seal

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:

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

Result:

The calculated probabilities of failures on demand of the 2600T Series Pressure Transmitters, Model 266 is below the required lower probability limit of ≤ $3,5^{-3}$. It's expected that in addition with the pressure sensor this limit is not exceeded. The demands on the probability are fulfilled for the safety related Safety Integrity Level SIL2 in a single configuration for low and high demand of operation.

8.6 Review of the Software Architecture

The Software Architecture is defined in the documents [D37], [D38] and [D41]. It contains a textual description and diagrams of the Safety Task Architecture Description. The implemented features for internal testing (diagnostics) are considered as safety related as defined in the standard. The various diagrams give a sufficient overview about the principal structure of the software and the defined functions of the software module.

Result:
The review of the Software Architecture has no deviations against the requirements of and the principal requirements out of the standard detected.

8.7 Software Design and Implementation

The software design of the 2600T Series Pressure Transmitters, Model 266 sub-module is described in the documents [D37] to [D63]. The documents define global use cases, context diagrams, entity diagrams, state charts, sequence diagrams and subsystem class diagrams. Software functions and corresponding operation activities are described clearly. The used coding standards are defined in [D31] and are part of the code review performed for the software modules.
Reviews from TÜV NORD Systems have been performed to the overall design documentation and the detailed software descriptions. The basis of the software architecture is defined by the system module specifications.
Through intensive testing the absence of systematic failures could be shown sufficiently. The software modules have been tested extensively by the module and validation testing. All interfaces have been covered and analysed.
The internal test routines and detection of corrupted RAM areas reach a sufficient diagnostic coverage of > 90%.

Result:
The software design and Implementation is compliant to IEC 61508 part 3, SIL 3

8.8 Verification and Validation

The verification and validation activities are defined in the corresponding documentation in specific sections. For the hardware design the reviews are shown in the documents [D214], [D216] and [D09]. The software requirement and design reviews are shown in the specific documents [D217] to [D258] in the review sections.

The reviews of the software design are shown in the corresponding software design documentation [D37] to [D45] and [D48] to [D56]. The software module testing is also defined in this documentation.
After the execution of the validation tests by the manufacturer, the test results have been reviewed by TÜV NORD Systems. The test results are also referenced to the Design Specification.
Additional sample testing of the 2600T Series Pressure Transmitters, Model 266 have been defined by TÜV NORD Systems and a separate list of test items has been generated. The defined fault insertion tests have been executed at the manufacturer by TÜV NORD Systems. The definition and results are documented in the Fault Injection Test Reports [D346] to [D349].

Result:
The review of the Validation Test Specification, the Validation Test Reports from the manufacturer and the performing of the sample tests by TÜV NORD Systems have shown, that the defined tests are consistent to the Design Specification and the tested results can be compared to the tests of the manufacturer. The test definitions are sufficient to prove compliance with the standard.

8.9 Modification for HART7

The HART communication interface of the 2600T Series Pressure Transmitters, Model 266 was updated to comply with HART Revision 7. The safety management plan [D12] has been updated in accordance modification process. An ABB impact analysis [D315] has carried out that the modification about HART7 is not safety relevant. Tests [D191] have been performed to show that the functional behaviour of the transmitter is not changed.

Result:
The update was performed according to the ABB modification process. The requirements of the Functional Safety Standards are fulfilled. The modification regarding HART7 has no impact to the functional safety integrity of the system.

8.10 Modification for 1000bar, piezo software 1.02.03 and MOD4041

The modification for the piezo software 1.02.03 covers the improvement of the SPI CS handling during the ADC initialization because sometimes, during the synchronous communication for the ADC initialization, the CS has been set up before the last bit of last bytes. The modification is documented in [D310].

The modification MOD4041 for the terminal board includes the change of U3 from diode standard to a zener diode (see [D198], [D89], [D110]). This change was already approved for the standard terminal board and was reported in the document change impact analysis TRP138.01 (24/03/2014).

For the 1000bar pressure range functionality a strain gauge sensor has been introduced. A pressure variation causes a deformation of metallic foil pattern. The deformation of foil changes its electrical resistance. This resistance change, measured using a Wheatstone bridge, is related to the strain on sensor by the quantity know as gauge factor. A bit in the transdiode configuration, connected inside the sensor, is used to generate temperature signal for compensation. This strain gauge sensor is connected to the piezo front end. The description is in the hardware architecture design [D34]. Modifications are covered by an impact analysis [D316] and software code review [D282]. The Component FMEDA and diagnostic coverage calculation have been updated [D146]. Test activities are covered by fault insertion tests [D153] and start up test for the front-end software.

Result:

The update was performed according to the ABB modification process. The requirements of the Functional Safety Standards are fulfilled. The modification regarding the 1000bar, piezo software 1.2.3 upgrade and MOD4041 has no impact to the functional safety integrity of the system.

8.11 Modification for 700bar with SW update for FE inductive 1.1.3

A new sensor for 700bar range has been developed. The functionality is the same of the standard inductive sensor but in this new sensor, only one inductor is present to perform the measurement. The inductor is inside a cell filled with nitrogen, a diaphragm divides the part with inductor and nitrogen with the internal oil. The process pressure that pushes on the measuring diaphragm moves the fluid (oil) inside the sensor and transmits the pressure to internal diaphragm.

For the range of 700bar (range W) the checking of double algorithm is not used, but a new safety measurement that checks continually the result of the calculation made by µC, because now one inductor has a fixed value. The new software will be an update of the old software firmware for inductive front end 1.1.0 and 1.1.1 valid for all inductive instruments, when the 700bar sensor is connected the double algorithm is not considered.

The following modifications on C2 level have been defined:

- Change the calculation flow and pressure based on algorithm type.
- Change the physical inductance in case of single cell calculation.

The modification is defined in the impact analysis [D308]. The hardware architecture [D34], the system FMEA [D35] and the sensor interface subsystem FE [D43] have been updated. Test activities are defined in the test procedure [D177] and test results are documented in [D178] and [D197]. Fault insertion tests are provided by [D152] and [D153]. Software modification is covered by the software design review [D252] and code review [D281]. The software has been tested by module tests [D267] which have been reviewed by TÜV NORD Systems. Additional environmental tests have been provided by [D195], [D196], [D199] and [D200].

Result:

The update was performed according to the ABB modification process. The requirements of the Functional Safety Standards are fulfilled. The modification regarding the modified sensor interface according 700bar with FMEDA [D12] and the FE inductive software 1.1.3 upgrade has no impact to the safety integrity level of the system. The safety manual [D328] has been upgraded to cover the updated safety parameters.

8.12 Modification for Model 266 Multivariable and Multisensor (266Jxx / 266Cxx)

Thanks to their multisensor technology, these transmitters are capable of measuring three separate process variables at the same time and offer the option of dynamic calculation of the following values:

— Mass flow for gases, steam, and liquids by means of dynamic compensation

— Standard volume flow for gases by means of dynamic compensation

— Heat flow for water and steam

— Drum water level and level measurement with density compensation of liquids

The differential pressure and absolute pressure are measured by two integrated sensors. The process temperature is measured by an external standard Pt100 resistance thermometer.

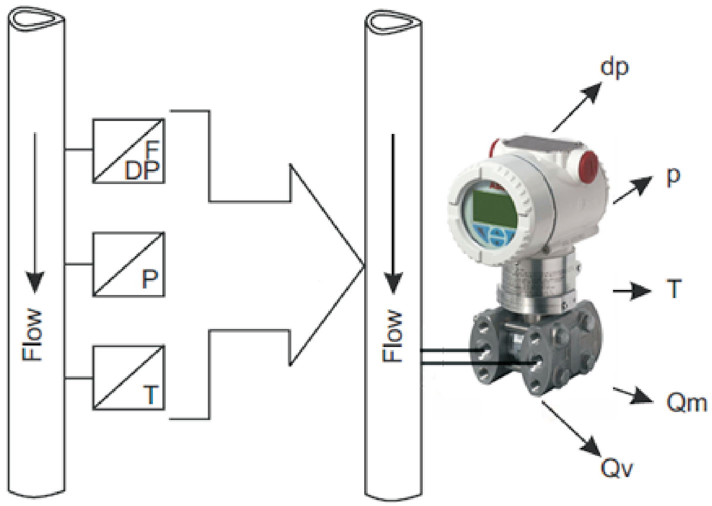

Figure 6: Flow measurement - past and present

The diaphragm seal models covered by this modification are combined with transmitters 266CRX and 266JRX. One or diaphragm seals can be connected to the transmitter via a capillary tube. The following models, which have different order codes, are available:

a) Models 266CRH and 266CRT for compensated mass flow measurement are designed with two diaphragm seals of the same type and size. In the case of compensated level measurement, they are designed with one or two diaphragm seals depending on the application.

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b) Models 266JRH and 266JRT for differential pressure, absolute pressure, and process temperature may be designed with either two remote seals of the same type and size or with one remote seal (on the high pressure (H) or low pressure (L) side) plus a standard process flange with threaded connection. In this case, the threaded connection (1/4-18 NPT or 1/2-14 NPT using adapter) is for the fluid-filled or gas-filled impulse line on the side opposite to the diaphragm seal.

Flow calculation:

The flow calculation carried out by these transmitters includes compensation of pressure and / or temperature as well as more complex variables such as discharge coefficient, thermal expansion, Reynolds number, and compressibility factor. The 266CXX pressure transmitters include flow equations for superheated steam, saturated steam, gases, and liquids – so you only need one device for your system. Multivariable transmitters represent a more economical solution than the designs that have been used for this type of measuring point up to now, in which three different transmitters for differential pressure, absolute pressure, and temperature report their values to a DCS, PLC, or flow computer.

The detailed description is documented in the manuals [D06] and [D07]. The modifications are detailed in the impact analysis [D318] to [D321]. The failure analysis is documented in [D147] and fault insertion tests in [D152]. Type testing is listed in [D163] and Environmental Influences / EMC testing is documented in chapter 8.15.

Result:

The update was performed according to the ABB modification process. The updated and new documents for the Model 266 Multivariable / Multisensor have been reviewed by TÜV NORD Systems. The FMEDA calculation from ABB S.p.A. has been reviewed and accepted by TÜV NORD Systems [D353]. The modifications regarding the Model 266 Multivariable / Multisensor functions have no impact to the safety integrity level of the system. The safety manual [D328] has been upgraded to cover the new functionality.

8.13 Modification for CB firmware 7.1.16 and 7.2.2

As defined in the Change & Impact Analysis for 266 CB Hart7.1.15 and 7.2.1 to 7.1.16 and 7.2.2 [D323] the following modification has been implemented:

a) Changes in Hart Communication Protocol Subsystems

To achieve a new protocol specification, from HART revision 5 to HART revision 7, and to achieve the HART compliance validation.

The updated version with Hart 7 includes a HART5 emulation. The software is defined as 7.2.2 when in HART 7 modus and it is renamed to 7.1.16 via Hart/HMI when the modus is set as HART5 emulation.

b) New HMI Language

- Portuguese

c) Device Temperature Limits Check functionality

A new optional functionality has been added: the Device temperature Limits Check. When it is set enabled, the device changes its normal behavior as following:

- When a warning temperature limit is crossed, a diagnostic message is published on HMI and communication protocol.
- When an alarm temperature limit is crossed, a diagnostic message is published on HMI and communication protocol and the output current is set to the alarm state (accordingly to NAMUR compliance).

When it is set to disabled, the device behavior is the usual mode. The functionality can be or unset by user using HMI.

d) Improved current-out read back

Reason of the modification:

1) When a power supply failure is present, if output current alarm state is high and a failure happens, the device can´t reach the expected high alarm state.
2) When a power supply failure is present, if output current alarm state is low and a failure happens, the device takes 2.5 seconds to go to alarm state, then remains in

alarm state for 300 milliseconds and return back to previous state; if the alarm situation persists, then an alarm bouncing is created.

Solution:

1) The alarm state direction, only in case of current output read-back failure, is now automatically driven by device that, based on the comparison between expected current output value and read-back value, decides to go to lower or upper alarm state. In case of read-back value is lower (or equal) than expected current output value, the lower alarm state is set. In case of higher value, the upper alarm state is set.
2) The alarm state period, only in case of current output read-back failure, has been increased to 4 seconds. The current output read-back retries after the alarm state, only in case of current output read-back failure, has been decreased to 1. The transition period from standard running state to alarm state still takes around 2.5 seconds. The transition from running state, after an alarm state, to an immediately following alarm state now takes 300 milliseconds.

Result:

The update was performed according to the ABB modification process. TÜV NORD Systems have reviewed the updated and new documents for the software 7.1.16/7.2.2, which are marked-up in the safety management plan [D12]. The modifications regarding the software update have no impact to the safety integrity level of the system. The safety manual [D328] has been upgraded to cover the new functionality.

8.14 Update of the Safety Manual

To avoid clarify the and obligate the customer to make a proof test after the temperature of instrument came back to operative range when the temperature has gone below the -40°C.

The action requested is only a change of the Safety Manual [D328] as follows:

“The proof test must be executed on pressure instrument once the temperature goes back within specified limits (-40°C..+85°C)”

The customers can now select an alarm (current in alarm + warning via Hart) or only a warning via Hart.

Result:
The update of the Safety Manual [D328] has no impact to the functional safety integrity.

8.15 Environmental Influences, EMC

The tests related to the environmental influences and EMC have been carried out through ABB and by an certified EMC laboratory to show that the functional safety is not affected [D164] - [D168], [D174]. The test plan and test results for the pressure sensor environmental tests are documented in [D170] - [D173].

Result:
The defined requirements with respect to environmental influences and EMC are met. The tests carried out did not give rise to any safety objections.

8.16 Safety Manual

The safety manuals [D326], [D327], [D328] and [D330] have been reviewed to fulfil the requirements of the considered standard. Specifically, the section about Proof Testing has been checked according to the defined measures to be followed up by the end user to be compliant with the considered standard according to failure detection which are not covered by the diagnostic of the transmitter.

Result:
The review has shown that the safety manual meets the requirement of the considered standard. Detailed descriptions are included for the end user to install, operate and maintain the transmitter in the required safety level.

8.17 Re-certification, modification 1000bar and CB firmware 7.2.2 ir4

8.17.1 Modification for 100bar sensor

To optimize and reduce the production waste on the 1000bar sensor the layout of the sensor has been changed by external sensor producer. New resistors are added in case that the Wheatstone bridge is not balanced and need value correction to sensor.
The modification is defined in the Change & Impact analyses [D324]. The change of the resistors was analysed in a FMEDA [D146]. Additional fault insertion tests [D153] and function tests [D194] were performed by ABB S.p.A. EMC tests according the actual release of the standards was performed by an external accredited Laboratory [D212], [D213].

Result:
The description of the modification and the analysis and test activities has been reviewed by TÜV NORD Systems and are sufficient documented and accepted by TÜV NORD Systems. At system level, the behaviour is the same.

8.17.2 Modification for CB Hart firmware 7.1.16ir4/7.2.2ir4

If a CB board was updated from SW revision 7.1.15 to 7.2.1 or 7.1.15 to 7.1.16/7.2.2 revisions, the instrument activated an alarm. Therefore, the 7.1.16/7.2.2 revision could not be used to update communication boards with a lower software revision number. Firmware 7.1.16//7.2.2 were implemented with a wrong address regarding the replacement of the Front End (FE) NV memory data. When such versions try to activate the FE after the CB replacement, they read from a wrong unused memory location where no actual data are present. The other effect of this problem is, that firmware 7.1.16/7.2.2 store the data to be replaced in a wrong address area. With firmware 7.1.16ir4/7.2.2ir4 this problem was fixed. There is no impact to any other data of FE board and there is no impact on the quality of data. The modification is covered by the Change & Impact analyse [D325]. It was reviewed by TÜV NORD Systems. The described modification was analysed by code review [D305] and module tests [D278]. Finally, function tests [D194] were performed by ABB S.p.A. and reviewed by TÜV NORD Systems.

Result:
The modification is sufficient documented and covered by test activities. The review of TÜV NORD Systems has not revealed safety impacts.

8.18 Modification for CB Hart firmware 7.2.3/7.1.17

In both 7.2.1 and 7.1.16/7.2.2 revisions a malfunction on Replace functionality have been reported, which caused the 7.2.1 and 7.1.16/7.2.2 communication boards couldn't be used to replace communication boards with lower version number. Firmware versions 7.2.1 and 7.1.16//7.2.2 were implemented with a wrong address to the FE NV memory area dedicated to the replace data, so when such versions try to activate the FE top CB Replace functionality, they read from a wrong unused memory location where no actual data is present. The other effect of this problems is that firmware versions 7.2.1 and 7.1.16/7.2.2 store they replace data in such wrong address, but there is no impact in any other data on FE and there is no impact on the quality of data.
The solution is to restore the use of the usual address of replace data in the dedicated FE NV memory area and make this new version capable of loading replace data of any previous version of CB firmware. The modification is documented in [D332]. It is implemented in the non-safety area. A code review has been performed by ABB S.p.A.. The functional test covers the implemented modification. The Safety Manual [D338] has been updated. The documents have been reviewed by TÜV NORD Systems.

Result:
The modification is sufficient documented and covered by test activities. The review of TÜV NORD Systems has not revealed safety impacts.

8.19 Modification for MV hardware from 1.0.1 to 1.0.2

The reason of the modification is the obsolescence of the component IC8 TLV2451, which has been replaced with OPA330. The component is pin to pin compatible with the old component and the failure rate of the component is still valid. The modification is defined in the Impact Analysis [D341] and the affected documents are listed in [D340]. The Requirement Specification [D342] and the Safety Manual [D345] have been updated to the new MV hardware release. The documents have been reviewed by TÜV NORD Systems.

Result:
The modification is sufficient documented. The modification has no impact on the safety functions. The review of TÜV NORD Systems has not revealed safety impacts.

9 Summary

The assessment of the 2600T Series Pressure Transmitters, Model 266 has shown that the system design and the system structure are compliant with the IEC 61508:2010, SIL 2 under consideration of the measures implemented to the transmitter. The defined safety functional management, the development process of the software and the verification and validation activities are in accordance with SIL 3 requirements allowing the use of dual redundant 2600T Series Pressure Transmitters, Model 266 in SIL 3 applications.
The validation and testing activities have shown the compliances between the realised transmitter implementation and the safety requirements specification.
The actual versions of the safety manuals [D326] to [D330] and [D345] must be considered for the use in safety relevant applications. The modifications of the 2600T Series Pressure Transmitters, Model 266 listed in the chapters 8.9 to 8.19 have no impact to the functional safety integrity.

10 Appendix A: Hard- and software revisions

	266Dxx, 266Vxx 266Pxx, 266Hxx 266Nxx (excluded range Z)	266Mxx, 266Rxx	266Mxx 266Rxx (only range R)	266Gxx 266Axx	266Hxx (only range Z), 266GSH (only range Z)	266Hxx (only range W) 266Nxx (only range W)
Sensor technology	**inductive**	**dp piezo**	**dp-hp piezo**	**piezo**	**strain gauge**	**inductive 700bar**
Front end software revision	**1.1.0 u. a. 1.1.1 u. a. 1.1.3**	**1.2.2 u. a. 1.2.3**	**1.2.2 u. a. 1.2.3**	**1.2.2 u. a. 1.2.3**	**1.0.5**	**1.1.3**
Front end hardware revision	**0.1.2 u. a. 0.1.3**	**1.0.7 u. a. 1.0.8 u. a. 1.0.9**	**1.0.6 u. a. 1.0.7 u. a. 1.0.8**	**1.0.6 u. a. 1.0.7 u. a. 1.0.8**	**1.0.0 (internal version 1.0.8 same of piezo)**	**0.1.2 0.1.3**
Communication board software revision	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**	**7.1.14 u. a. 7.1.15/7.2.1 7.1.16/7.2.2 7.1.16 ir4 /7.2.2 ir4 7.1.17/7.2.3**
Communication board hardware revision	**0.1.1 u. a. 0.1.2 u. a. 0.1.3***	**0.1.1 u. a. 0.1.2 u. a. 0.1.3***	**0.1.1 u. a. 0.1.2 u. a. 0.1.3***	**0.1.1 u. a. 0.1.2 u. a. 0.1.3***	**0.1.1 u. a. 0.1.2 u. a. 0.1.3***	**0.1.1 u.a 0.1.2 u.a 0.1.3***

Table 9: Hard- and software revisions (Part 1)

	266Cxx,266Jxx -MV/MS instrument	266Jxx (only range R) -MS instrument
Sensor technology	**dp piezo**	**dp-hp piezo**
Front end software revision	**1.2.2 u.a 1.2.3**	**1.2.2 u.a 1.2.3**
Front end hardware revision	**1.0.7 u.a. 1.0.8 u.a. 1.0.9**	**1.0.6 u.a. 1.0.7 u.a. 1.0.8**
Communication board software revision	**142.1.5**	**142.1.5**
Communication board hardware revision	**1.0.1 1.0.2**	**1.0.1 1.0.2**
SFE hardware revision	**AU3077/2-EC3054/2 u.a AU3077/3-EC3054/3**	**AU3077/2-EC3054/2 u.a AU3077/3-EC3054/3**

Table 10: Hard- and software revisions (Part 2)

u. a. = upon availability; * = only with CB software revision 7.1.16/7.2.2 or 7.1.16ir4 /7.2.2 ir4

11 Appendix B: Documentation

General planning:

[D01] Mile 2 Project Plan; TRP037-01.pdf; 1; 28.11.2006

[D02] Mile 2 (Minden and Lenno 2 jointed project); PDC007-00.pdf; 0; 01.09.2006

[D03] Mile 2 Supplier Control Plan; TRP036-00.pdf; 0; 19.02.2007

[D04] General Requirement Specification; DS_266XSH_1.pdf; 1;

[D05] General Requirement Specification; DS_266HSH_NSH_C.pdf; C; 03/2012

[D06] Model 266CSH/CST Multivariable, Model 266JSH/JST Multisensor ; DS_266_CSx_JSx_EN_B.pdf; DS_266CRX_JRX_EN_B.pdf; B; 02/2017

[D07] Operating manual Multivariable, Multisensor; OI_266Cxx_266Jxx_Hart_EN_A.pdf; A; 02/2017

[D08] Mile 2 Standard Products specification; FSD010-00.pdf; 0; 23.05.2007

[D09] Mile 2 Quality Plan ; TRP057-07.pdf; 6; 17.09.20207

[D10] Change Request process for Common Components; Change request process for common components.pdf; 3; 03.05.2006

[D11] Project development procedures and checklist; GEST0003revisione2.pdf; 2; 29.04.2005

[D12] Functional safety management plan; TSP013-22.pdf; 22; 15.10.2020

[D13] Production object 266 Front end Minden; IIMS-PV01/2010-T; 2.8; 20.02.2016

[D14] MiLe 2 -SIL 2 Factory Enable Specification; FSD019-11.pdf; 11; 09.09.2020

Requirements:

[D15] Safety requirement specification Mile 2 pressure transmitter; RSD022-08.pdf; 8; 09.12.2008

[D16] Mile 2 Requirement Specification; RSD018-04.pdf; 4; 19.09.2008

[D17] Hardware requirement 2 Front end transmitters MILE 2; IIME-P052010-T.pdf; 0.1; 02.07.2010

Software subsystem/module specifications:

[D18] Requirement specification Mile 2 front end board; RSD023-00.pdf; 0; 09.11.2007

[D19] Mile 2 Communication board software requirement specification; RSD020-01.pdf; 1; 25.11.2008

[D20] Mile 2 housing requirement specification; RSD017-00.pdf; 0; 03.10.2006

[D21] Mile 2 communication protocol between front end and communication board software requirement specification; RSD021-09.pdf; 9; 27.01.2010

[D22] Requirement specification P/dP subsystem; RSD024-03.pdf; 3; 29.09.2009

[D23] Requirement specification Electronic services; RSD025-06.pdf; 6; 23.09.2009

[D24] Requirement Specification Common Diagnosis Sub-system ; RS_CD-ETR.pdf; 4; 19.03.2007

[D25] Requirement Specification -Totalizer Subsystem; RSD026-03.pdf; 3; 21.09.2009

[D26] Requirement Specification - Trend Sub-System ; RSD027-03.pdf; 3; 21.09.2009

[D27] Requirement Specification BootLoader Service; RSD028-05.pdf; 5; 21.09.2009

[D28] Mapper Requirements Specification; RSD029-01.pdf; 1; 23.09.2009

[D29] Requirement Specification for service Port; RSD030-03.pdf; 3; 22.09.2009

[D30] A guideline for developing field-device in business unit instrumentation; Software Development Handbook.pdf; ;

[D31] Coding convention for embedded software; SCC7ABA101400.pdf; ;

[D32] Requirement specification Flow Subsystem; RSD055-2.7.pdf; 2.7; 26/02/016

[D33] Requirement specification T subsystem; RSD054-1.4.pdf; 1.4; 26.02.2016

Design and development, Safety concept and design description:

[D34] Hardware architecture design specification Mile 2 pressure transmitter model 266; ADE015-11.pdf; 11; 08.08.2016

[D35] System FMEA Mile 2 pressure transmitter model 266; TRP053-07.pdf; 7; 17.04.2018

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Software design description

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