TÜV
SÜDDEUTSCHLAND

Technical Report

on testing

Reliability

Field Device

2600T PRESSURE TRANSMITTERS MODELS 262/264

Manufacturer:

ABB SACE S.p.A.
Via Statale 113
I – 22016 Lenno (Co)

Report No.: AL63031T
Revision 2.1 dated 2003-09-18
Order No.: 70019908

Testing Body:

TÜV Automotive GmbH
TÜV Süddeutschland Group
Automation, Software and Electronics - IQSE
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Revision Log

Revision	Name	Date	Changes/History
1.0	W. Henke	2003-08-18	Initial
2.0	W. Henke	2003-09-12	EMC test report CESI test certificate 2600T Series Test Specification Diagnostic coverage calculation TRP.012.02
2.1	W. Henke	2003-09-18	Document number AN 0915/2 corrected

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Content Page

1 Subject of Testing

The present technical report presents the statement of reliability testing for the **non-safety related** pressure transmitter 2600T.

ABB SACE S.p.A. commissioned TÜV Automotive GmbH with reliability testing of the 2600T on 19/11/2002.

2 Scope of Testing

2.1 Test specimen

The 2600T pressure transmitter is a modular range of field mounted, microprocessor based electronic transmitters, using a unique inductive gauge sensing element for differential pressure, gauge and absolute pressure, flow and liquid level measurement in industrial environments. The output signal is a direct current loop from 4 to 20mA.

2.2 Scope of test specimen

The test specimen consists of the following hardware assemblies and software components:

The 2600T is a 1oo1 transmitter without safety shutdown.

2.3 Testing

The product was examined with regard to the following testing operations:

Analysis of the hardware

Analysis of the architectural constrains on hardware

Reliability testing

Carry out a COMPONENT - FMEA , classification of each component failure in absence of diagnostic tests, calculation of the fractions of the failure probability of each component, determination of those failure modes that are detected by the diagnostic tests, calculation of the probability of the detected dangerous failures, calculation of the diagnostic coverage / safe failure fraction

Electrical safety

Test in accordance with EC-type-examination, Directive 94/9/EC

Analysis of the software

Test of the error prevention measures, error simulations, software tests and functional tests are **not** executed by TÜV Automotive GmbH / Automation, Software and Electronics - IQSE

Susceptibility to environmental errors

Climate and temperature

IP degree of protection

Mechanical effects

Electromagnetic compatibility

Safety information in the product documentation (safety manual, operating instructions)

Facility inspection

Test period: The product was tested during the period from 19/11/2002 to 11/03/2003.

3 Testing principles

Based on product application testing was performed in accordance with the following guideline:

3.1 Basis of computation

Testing standard	Type of test	Severity of test
IEC 61508-2: 2000	Functional safety of electrical / electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical / electronic / programmable electronic safety-related systems	To the extend to which they may be applicable (Annex C, Diagnostic coverage and safe failure fraction) SIL 1...4 isn't applicable
MIL-HDBK-217: F 1991, 1992, 1995	Military Handbook; Reliability Prediction of Electronic Equipment	-

Table 1: Standards Functional Safety

3.2 Environmental testing

3.2.1 Damp test

Basic of verification: IEC 68-2-3
IEC 68-2-30

Test result:

The individual tests demonstrated that the test requirements according the specifications of the transmitter data sheet [14] were satisfied and are recorded in the table at page 6 of document [1].

The transmitter passed the tests successfully.

3.2.2 Shock test

Basic of verification: DIN EN 60068-2-27
DIN EN 60068-2-29

Test result:

The individual tests, performed to the test protocol according document [15] chapter 9.2, demonstrated that the test requirements made were satisfied and are recorded in document [2].

The transmitter passed the tests successfully.

3.2.3 Vibration test

Basic of verification: DIN EN 60068-2-6

Test result:

The individual tests, performed to the test protocol according document [15] chapter 9.1, demonstrated that the test requirements made were satisfied and are recorded in document [3].

The transmitter passed the tests successfully.

3.3 Electromagnetic compatibility

The Electromagnetic Compatibility Tests on "2600T pressure transmitter series" (recorded in document [17], results are in this report) have been performed, referring to the requirements specified in the EN 50081-1 (Generic emission standard for light industry application) and in the EN 50082-2 (Generic immunity standard for industry application) Standards.

3.3.1 Electrostatic discharge test

Basic of verification: DIN EN 61000-4-2 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria A.

3.3.2 Radiated immunity test

Basic of verification: DIN EN 61000-4-3 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria A.

3.3.3 Electrical fast transient / burst immunity test

Basic of verification: DIN EN 61000-4-4 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria A.

3.3.4 Surge test

Basic of verification: DIN EN 61000-4-5 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria B.

3.3.5 Conducted radio-frequency immunity test

Basic of verification: DIN EN 61000-4-6 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria A.

3.3.6 Magnetic field immunity test

Basic of verification: DIN EN 61000-4-8 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria A up to 1000 A/m.

3.3.7 Oscillatory waves test

Basic of verification: DIN EN 61000-4-12 Standard

Test result:

The transmitter passed the tests successfully with the functional condition of criteria B.

3.3.8 Conducted emission measurements

Basic of verification: DIN EN 55011

Test result:

The transmitter passed the tests successfully.

3.3.9 Radiated field emission test

Basic of verification: DIN EN 55022

Test result:

The transmitter passed the tests successfully.

3.4 Quality management at testing

QSH IQSE (Version: 1.4)	Quality Manual of TÜV Automotive / Automation, Software and Electronics – IQSE
EN ISO / IEC 17025: 2000	General requirements for the competence of testing and calibration laboratories

Table 2: Standards Quality Management

4 Inspection and test documents

Testing was based on the following documents and test specimens:

4.1 Test documentation

4.1.1 Manufacturer documentation

The following documentation includes individual test results and was provided by the manufacturer:

No.:	Title	No. / Version	Date
[1]	Feuchteprüfung (damp test)	IAE-A04	08.05.2002

[2]	Schockprüfung (shock test)	IAE-A17	11.03.2002
[3]	Schwingungsprüfung (vibration test)	IAE-A15	11.03.2002
[4]	Hardware Architecture Design 2600T Pressure Transmitters	ADE.001.00	18.02.2003
[5]	Software (DSP and Compensation) Architecture Design 2600T Pressure Transmitters	ADE.002.00	26.06.2003
[6]	Diagnostic Coverage Calculation 2600T Pressure Transmitters Models 262-264 (inductive sensors)	TRP.012.02	28.08.2003
[7]	Component Failure Mode, Effects and Diagnostic Analysis 2600T Pressure Transmitters (inductive sensors)	TRP.013.01	05.08.2003
[8]	Circuit Diagram: µP Board	DH 0003	10.01.2002
[9]	Component List: µP Board	AU 0002/0	10.01.2002
[10]	Circuit Diagram: Inductive Sensor	DH 0005	10.01.2002
[11]	Component List: Inductive Sensor	AN 0915/2	16.04.2003
[12]	Circuit Diagram: PS Board	DH 0001	10.01.2002
[13]	Component List: PS Board	AU 0001/1	06.06.2003
[14]	2600T Pressure Transmitters Datasheet	SS/264XS_1	26.05.2003
[15]	Type test 2600T Series – Test Specification	December 2002	03.07.2003
[16]	CESI test certification of conformity	96/032320	10.10.1996
[17]	2600T series EMC Test Report	TRT.046.00	14.01.2003

Table 3: Manufacturer Documentation

4.1.2 Testing agency documentation

The following documentation includes individual test results and was compiled by the testing agency:

[A]	EC-type-examination Certificate	ZELM 02 ATEX 0081	25.04.2002
[B]	Confidential Report	ZELM Ex 0360117114	25.04.2002
[C]	Component FMEA Review	1.0	04.08.2003

Table 4: Testing agency documentation

5 Performance and result of tests

5.1 Analysis of system concept

Test result:

The architectural constrains of the system don't cover functional safety requirements. One fault could cause a loss of the function.

5.1.1 Analysis of the hardware version 3A515010002

5.1.1.1 Analysis of the hardware

Fault assumptions on component level are based on the fault models specified in annex A of IEC 61508 part 2 and the quality manual of TÜV Automotive / Automation, Software and Electronics - IQSE[2].

Proceeding from the stipulations indicated a FMEA component was performed to determine the effect of each failure mode of each component on the behavior of the system in the absence of diagnostic tests.

Test result:

The failure mode and effect analysis showed that the occurrence of a single fault could cause the loss of the function. The individual architectural constrains are not sufficient and their corresponding degree of fault detection don't provide the required degree of effectiveness. The result is recorded in the document [C].

5.1.1.2 Quantitative analysis of the probability of hardware failure

Abbreviation	Explanation
λ_{DU}	Dangerous undetected failure
λ_{DD}	Dangerous detected failure
λ_{S}	Safe failure
λ_{D}	Dangerous failure
$\lambda_{Don't\ care}$	A special safe state
DC	Diagnostic coverage, %
FIT (λ)	10^{-9}, h^{-1}
MTBF	Mean Time Between Failure

[2] QM-Handbook of TÜV Automotive GMBH / Work instruction / Component Failure Assumptions FMEA / ASE_W_09.12e, Rev.: 0 of June 26, 1998

MTTR	Mean time to restoration, *h*
T1	Proof test interval, *h*
t_{CE}	Channel equivalent mean down time (hour) for 1oo1, 1oo2, 2oo2 and 2oo3 architectures. (This is the combined down time for all the components in the channel of the subsystem
PFD	Probability of failure on Demand
PFH_{SYS}	Probability of failure per hour of a safety function for the E/E/PE safety related system.
PFH_S	Probability of failure per hour of the sensor subsystem
PFH_L	Probability of failure per hour for the logic subsystem
PFH_{FE}	Probability of failure per hour for the final element subsystem
P_{dd}	Probability that the system can be found in the dangerous detected state after T1
P_{du}	Probability that the system can be found in the dangerous undetected state after T1
Rate	Probability that the system can be found in a dangerous state per hour, h^{-1}
SFF	Safe Failure Fraction

Table 5: Abbreviations

The calculus of reliability of electronics is based on an error analysis by Component-FMEA. The Diagnostic Coverage and Safe Failure Fraction evaluation has been elaborated following the requirements of IEC 61508 parts 2 and 6. For the failure rate (λ) calculation the Standard MIL-HDBK-217 F has been used. The analysis gives a predict about the number of safe and dangerous hardware-faults as well as over the diagnostic degrees for dangerous faults. The total results are listed in table 6 and recorded in document [C].

During safety operation a local change of parameter or by HART-communication is illegal. The interlock takes place by means of combination and keyboard interlock.

λ_S, Safe failure	144,517 FIT
λ_D, Dangerous failure	344,703 FIT
λ_{DD}, Dangerous detected failure	260,203 FIT
λ_{DU}, Dangerous undetected failure	83,500 FIT
$\lambda_{Don't\ care}$	134,683 FIT

Table 6: FMEA, Result

With the calculated values in the table 6 the relation of all safe failures + dangerous detected failures to the total of all failures knows (SFF) as well the failure probability during request to be calculated.

Safe Failure Fraction of the electronics:

SFF = (• λ_S + • λ_{DD}) / (• λ_S + • λ_D)

SFF = 82,728 %

5.1.1.3 Result of the PFH calculation

The PFH_{SYS} - value is defined as follows.

$PFH_{SYS} = PFH_S + PFH_L + PFH_{FE}$

$PFH_S = \lambda_{DU}$ = 83,500 FIT

Architectures for low demand mode of operation: 1 oo 1

(Procedure for calculation see IEC 61508-6, annex B)

default values:

with $MTTR = 8h$ and $T_1 = 8760h$

$$PFD_{AVG} = (\lambda_{DU} + \lambda_{DD})t_{CE}$$
$$PFD_{AVG} = 3{,}674 * 10^{-4}$$

$$PFD = 1 - e^{-\lambda_D t_{CE}} \approx \lambda_D t_{CE} = 3{,}685 * 10^{-4} \quad \text{since } \lambda_D t_{CE} << 1$$

5.1.2 Analysis of the Firmware

5.1.2.1 Analysis of the Firmware including self-tests

The individual test operations are **not** proofed by TÜV Automotive GmbH / Automation, Software and Electronics - IQSE.

Test result:

No results.

5.1.2.2 Testing of fault prevention measures

Testing of individual fault prevention measures are **not** proofed by TÜV Automotive GmbH / Automation, Software and Electronics - IQSE.

Test result:

No results.

5.1.2.3 Fault simulation and software tests

Representative hardware and software fault simulations are **not** proofed by TÜV Automotive GmbH / Automation, Software and Electronics - IQSE.

Test result:

No results.

5.1.2.4 Functional testing

Functional testing tests were **not** proofed by TÜV Automotive GmbH / Automation, Software and Electronics - IQSE.

Test result:

No results.

5.2 Electrical safety and environmental testing

5.2.1.1 Electrical safety

The results are covered by the EC-type-examination Certificate ZELM 02 ATEX 0081.

Test result:

The individual tests demonstrated that the test requirements made were satisfied and are recorded in document [B].

5.2.1.2 Environmental testing

The tests are performed by ABB Automation Products GmbH in Minden (Germany).

Test result:

The individual tests demonstrated that the test requirements made were satisfied.

5.2.1.3 Degrees of protection provided by the enclosure

CESI (Centro Elettrotecnico Sperimentale Italiano Giacinto Motta) attested that the product conforms to all requirements of the IEC 529 (1989) Standard recorded in document [16].

Test result:

The transmitter fulfills the IP 67 protection.

5.3 Electromagnetic compatibility

ABB SACE S.p.A. performed the test operations for verification of electrical interference immunity and emitted interference.

Test result:

The individual tests demonstrated that the test requirements made were satisfied.

Munich, 2003-09-18

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