Benefits of implementation of IEEE CAP for Nuclear Equipment Qualification

Mr. Marek Tengler and Mr. Bohumír Myslín

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“Now, what I want is Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. Plant nothing else, and root out everything else. You can only form the minds of reasoning animals upon Facts; nothing else will ever be of any service to them. This is the principle on which I bring up my own children, and this is the principle on which I bring up these children. Stick to Facts, sir!”
— Charles Dickens, „Hard Times“

... personal addendum to Mr. Dickens quote: „... THOSE FACTS SHALL BE DOCUMENTED, VERIFIABLE, TRACEABLE AND CONTEXTUAL...“
Equipment qualification is one of the essential requirements of nuclear regulations for equipment important to safety of nuclear power plants. Equipment qualification shall handle evidences about the safety reliable equipment performance that shall be sustained during whole lifetime and can be jeopardized by Design Basis Event.

The safety-related functions of equipment are verified by testing, analysis, experiences or by combined method in order to prove the design affecting by ageing mechanisms promoting during service life and extreme conditions of internal or external hazards.

The process of generating evidences, that prove the equipment to be qualified for intended safety function, is highly cost and time demanded. Many cases about fraudulent or substandarding (CFSI) of equipment qualification documentation in operational or constructed nuclear power plant exist. Therefore a systematic procedure and third party review over equipment qualification process is needed.
Counterfeit
– Intentionally manufactured or altered to imitate a legitimate product without the legal right to do so.
– A counterfeit item is one that has been fabricated in imitation of something else with purpose to defraud by passing the false copy for genuine or original or is an items copied without the legal right or authority to do so.

Fraudulent
– Items that are intentionally misrepresented with intent to deceive. Fraudulent items include item provided with incorrect identification or falsified or inadequate certification.

Substandard
– deviating from of a quality lower or scope of qualification than that prescribed by required standard
Suspect items are items that are suspected of being counterfeit, fraudulent or substandard

– It may not always be cost effective to verify if a suspect item is indeed counterfeit, fraudulent or substandard

   NOTE: Legally, it may not be appropriate to call an item counterfeit or fraudulent unless it is verified as such.

– In case of authentication testing, simply obtaining an authentic item or one that complies with the specification may be the prudent course of action.

– Conclusive investigation (electrical testing and used advanced invasive methods) is always time consuming and expensive.
A broad definition of the term “counterfeit” for assessment of suspicious item, a counterfeit is a part that is not genuine because it:

• is an unauthorized copy;
• does not conform to original OCM design, model, and/or performance standards;
• is not produced by the OCM or is produced by unauthorized contractors;
• is an off-specification, defective, or used OCM product sold as "new" or working; or
• has incorrect or false markings and/or documentation.

NOTE: OCM – Original Component Manufacture
Did Bad Memory Chips Down Russia’s Mars Probe?

Moscow blames radiation wreckage on an SRAM chip, but does it add up?

At Spectrum’s request, McClure read a translation of the official Russian report. He immediately recognized the specific component identified in the report as the likely locus of the double-hardware failure—the WS512K32, which is a single-package assembly of SRAM totaling 512 kilobytes. There are probably four chips in this bi-32 device,”....

The WS512K32 is “sold on the aircraft market to a military grade—not the space market,” says McClure. He points out that neither the original fabricators nor the commercial vendors test for radiation, and they would not give radiation specs. If this chip had been proposed for a critical component in a space-probe design at JPL, he assured Spectrum, “it would not likely be approved for use.” McClure says that it would be okay for a space mission of a couple of days or for noncritical applications but not for a years-long mission to Mars and back, which would typically “require a probability of failure of less than 1:10 000 [for the] entire mission.”
The US Senate Armed Services Committee said its researchers had uncovered 1,800 cases in which the Pentagon had been sold electronics that may be counterfeit.

In total, the committee said it had found more than a million fake parts had made their way into warplanes such as the Boeing C-17 transport jet and the Lockheed Martin C-130J "Super Hercules".

"A million parts is surely a huge number. But I want to repeat this: we have only looked at a portion of the defence supply chain. So those 1,800 cases are just the tip of the iceberg," said Senator Carl Levin.
• Since year 2001, RIZZO-CZ (formerly Stevenson and Associates Office in Czech Republic) collaborate with Military Technical Institute of the Landforces (VTÚPV) on equipment qualification programs for components intended to use in commercial nuclear facilities.

• Exceptional capabilities of both parties, specifically experienced and qualified personal, brings to market high quality services combined accredited laboratories for functional testing and environmental simulations.

• Almost 100 unique qualification projects have been performed that handled development of the environmental resistant product design, its verification and conditions for utilization.

• Thanks to RIZZO-CZ presence on development of design and qualification rules for the qualification and licensing equipment supplied for Mochovce NPP, Unit 3 and 4 (WWER 440 / V213) there was successfully ensured the compatibility of whole qualification process for safety-related components, their parts and properly documented where VTÚPV played an irreplaceable role.
RIZZO-CZ Main Areas of Services

EVALUATION OF SEISMIC ADEQUACY

• Safety analysis of nuclear/non-nuclear power plant structures, systems, and components;
• Use of seismic experience data and seismic fragility and seismic margin assessment approach to evaluate seismic capacity, and to verify seismic adequacy of nuclear/nonnuclear power plant structures, systems, and equipment;
• Dynamic calculations and testing by simulated vibration of operational and/or seismic loading
• Evaluation of seismic adequacy of above ground and buried structures, pipelines and related equipment.

COMPONENT QUALIFICATION

• Inspections and in-situ evaluation of safety-related structures and equipment components reliability;
• Environmental qualification for mechanical, electrical and I&C components;
• Electromagnetic compatibility / susceptibility of electrical and I&C components.
**RIZZO-CZ Main Areas of Services**

**DESIGN AND ANALYSIS**
- Probabilistic risk assessment and fragility analysis;
- Failure, fatigue, and high temperature and inelastic analysis;
- Soil-structure interaction analysis;
- Design and analysis of blast resistant structures and equipment;
- Design and analysis of above ground and underground structures and pipeline systems;
- High energy pipeline break analysis;
- Nuclear or other hazardous waste tank design and analysis;
- Nuclear or other hazardous pressure-retain components design and analysis.

**STRUCTURAL AND MECHANICAL ANALYSIS**
- Development of simplified, safe, and cost-effective analytical procedures for structural-mechanical design and analysis of structures, systems, and components;
- Development of simplified, safe, and cost-effective experience-based procedures for seismic structural-mechanical verification of adequacy of structures, systems, and components;
- Investigation and failure analysis of structures and equipment components subjected to extreme loads, dynamic impact, blast loads, impulse and cyclic loading, and other extreme loads.
VTÚPV Main Areas of Labs Services

Testing Laboratory No.1103

- Seismic testing
- Mechanical resistance tests
- Measurement of noise, temperature, vibrations
- EMC tests
- Tests of electrical safety
- Tests of physical quantities
- Tests of personal protective equipment
- Tests of marine equipment
- Tests of vehicles
- Tribotechnical diagnostics
General Schema of EQ Process for NPP

- Equipment performance requirements
- Service conditions
- Qualification requirements
- Design requirements

- Qualification specification
- Design specification

- Existing data and experience
- Qualification plan

- Analysis
- Test procedure
- Test execution

- Technical specification for supply
- Procurement
- Storage
- Installation

- Qualification status
- Verification of qualification adequacy

- Basic Design

- Verification of qualification adequacy

- Verification of qualification adequacy

- Verification of qualification adequacy
CFSI ... is Regular WAR...

CFSI = Counterfeit, Fradulant, Substandard Items
CFSI Case Studies – Urgent Need for IEEE Conformity Assessment Program

• „Hard times“ ... for purchasing of nuclear grade equipment.
• In general, only commercial grade design (CGD) equipment is available on common market.
• Those equipment are either try to tested or simply installed in nuclear facility in safety related systems – quite a few of them are reported!
• Even the equipment have been properly qualified, different products or violation of qualification conditions have been reported(!)
• Urgent need to introduce Conformity Assessment Program for serviced commercial nuclear facilities.

CFSI CASES FROM OPERATING NPPs
I. Pressure Switch applied on the pressurizer relive system
II. Two-Stage Pressure Regulator for emergency diesel generator unit air-pressure starter unit
III. Asynchronous motor for high-pressure emergency injection pumps
Situation / Conditions

• Pressure switches are a part of the safety systems (installed inside the hermetic zone), but they do not perform any emergency safety function. This system, along with pressure solenoids only ensures limit of leakage of working media during normal operating conditions. The equipment shall be verified according to IEC 60780 Group 3, but performance of active function during LOCA is not required in terms of qualification.

• Recommended solution: applied qualified equipment (i.e. Rosemeount transmitter) but rejected by the end user due to price, design configuration changes and qualification results transfer to existing installed items.

• Equipment to be qualified:
  Manufacturer: Aerospace Controls Neo-Dyn® Industrial Switches
  Equipment types: 100P52C5 MSD and 100P57C5A MSD
CFSI Case Study –
I. Pressure Switch
Description of pressure switch

Neo-Dyn pressure switches type series 100P are universal pressure switches with the diaphragm spring. These pressure switches are applicable at pressures up to 3000 psig (206.8 bar) and that also for pneumatic and low impulse hydraulic applications. With the choice of different "wetted" materials (materials in direct contact with the medium), these pressure switches are suitable for a wide range of applications. Electrical connection of terminal and the grounding screw is realized through a ¾ NPT female inlet. The pressure connector is in the case of "wetted" material No. 1 equipped with ¼ NPT female inlet and in the case of "wetted" materials No. 4, 5, 7 and 9 ½ NPT female inlet. Equipment weight is about 1.4 kg. Adjustment is carried out within the pressure switch using a wrench. Distribution of Neo-Dyn pressure switches type series 100P according to adjustable ranges.
**EC Declaration of Conformity**


**Standards to Which Conformity is Declared:**
- EN 60079-0:2012
- EN 60079-1:2007
- IEC 60079-1:2007-04
- IEC 60079-31:2008

**Manufacturer’s Name:**
ITT Aerospace Controls, a unit of ITT Corporation

**Manufacturer’s Location:**
28160 Industry Drive
Valencia, CA 91355
United States
661 295-4000

**Equipment Description:**
Neo-Dyn® Pressure and Temperature Switches for use in Explosive Atmospheres

**Equipment Class:**
IIGM - Class A

**Neo-Dyn® Model Numbers:**

**With any of these Snap-Switch Assemblies:**
- 05-7-076L, 05-7-076T, 05-7-076L, 05-7-076T, 05-7-076T, 05-7-076T, 05-7-076T, 05-7-076T, 05-7-076T, 05-7-076T, 05-7-076T

**With any of these variations:**
- Single pole or double pole
- Standard Current or M-Option for Low Currents
- Pressure-Sensing Options as Described in Manufacturer’s Catalog

**EC-Type Examination Certificate**
SIRA 10ATEX101X and IECEx SIR 10.0009X

**QS Certificate of Assessment – EC**
72828-2010-CE-HCU-DNV

**Conformity Assessment Procedure:**
97/23/EC Module H
DEU NORSK VERITAS (0575),
Veritasveien 1, N-1322 Hovik, Norway

**Conformity Assessment Procedure:**
94/9/EC
SIRA (0518), Rayn Lane, Eccleston
Chester, CH4, 9JN, England

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards; with the following limitation:

**Electrical Assembly Endurance Life:**
2,000,000 mechanical actuation cycles for single-pole switches,
4,000,000 mechanical actuation cycles for double-pole switches.

**Place and Date:**
Valencia, CA
12/11/13

**Signature:**
[Signature]
Director of Quality

083-0078 Rev N (ECO 88402)
CFSI Case Study – I. Pressure Switch

Pressure Switch

- Conduit Connection
- Mounting Holes

- Pressure Port
- Wetted Material
- Wetted Materials
- Tlaková připojka

- 2X .50
- 3.50

- 2.85 Max
- 3.7 Max
- 6.48

- 1.40

- .87
- .82
- .11

- Range 1 Only
- Pouze rozsah 1

- 1.12

- 3.50

- 2X Ø .265

- 1/4 NPT
- 1/2 NPT

- 1/4 NPT Materiály ve styku s médium 1
- 1/2 NPT Materiály ve styku s médium 4, 5, 7 a 9
## CFSI Case Study – Pressure Switch

<table>
<thead>
<tr>
<th>Number of adjustable range</th>
<th>Adjustable range of switching points</th>
<th>Deadband [psig] (bar)</th>
<th>Maximum system pressure [psig] (bar)</th>
<th>Test pressure [psig] (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increasing pressure [psig] (bar)</td>
<td>Decreasing pressure [psig] (bar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5 ÷ 75  (0.35 ÷ 5.17)</td>
<td>2.3 ÷ 72.3  (0.16 ÷ 4.99)</td>
<td>2.7  (0.17)</td>
<td>600  (41.37)</td>
</tr>
<tr>
<td>2</td>
<td>15 ÷ 150  (1.03 ÷ 10.34)</td>
<td>9 ÷ 144  (0.62 ÷ 9.93)</td>
<td>6  (0.41)</td>
<td>3000  (206.84)</td>
</tr>
<tr>
<td>4</td>
<td>50 ÷ 300  (3.45 ÷ 20.68)</td>
<td>36 ÷ 286  (2.48 ÷ 19.72)</td>
<td>14  (0.97)</td>
<td>3000  (206.84)</td>
</tr>
<tr>
<td>5</td>
<td>125 ÷ 600  (8.62 ÷ 41.37)</td>
<td>100 ÷ 575  (6.90 ÷ 39.65)</td>
<td>25  (1.72)</td>
<td>3000  (206.84)</td>
</tr>
<tr>
<td>7</td>
<td>500 ÷ 1500  (34.47 ÷ 103.42)</td>
<td>440 ÷ 1440  (30.34 ÷ 99.29)</td>
<td>60  (4.14)</td>
<td>3000  (206.84)</td>
</tr>
<tr>
<td>8</td>
<td>800 ÷ 2800  (55.16 ÷ 193.05)</td>
<td>675 ÷ 2675  (46.54 ÷ 184.44)</td>
<td>125  (8.62)</td>
<td>3000  (206.84)</td>
</tr>
</tbody>
</table>
## CFSI Case Study – Pressure Switch

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Sample number</th>
<th>Test</th>
<th>Simulation of environmental conditions</th>
<th>Verification of adequacy - function</th>
<th>Verification of configuration and mechanical properties</th>
<th>Test conditions</th>
<th>Note:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1, 2, 3</td>
<td>Connection installation and equipment setting</td>
<td>---</td>
<td>☑</td>
<td>☑</td>
<td>installation instructions, see Appendix D04</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2, 3</td>
<td>Test of degree of protection</td>
<td>☑</td>
<td>---</td>
<td>---</td>
<td>see Sec. 3.2</td>
<td>(1)</td>
</tr>
<tr>
<td>2</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1, 2, 3</td>
<td>Accelerated thermal aging test</td>
<td>☑</td>
<td>---</td>
<td>---</td>
<td>see Sec. 3.4</td>
<td>(3)</td>
</tr>
<tr>
<td>4</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1, 2, 3</td>
<td>Aging test of wear by mechanical cycles</td>
<td>☑</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.5</td>
<td>(3)</td>
</tr>
<tr>
<td>6</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1, 2, 3</td>
<td>Radiation aging test (NOC and AC)</td>
<td>☑</td>
<td>---</td>
<td>---</td>
<td>see Sec. 3.6</td>
<td>(3)</td>
</tr>
<tr>
<td>8</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1, 2, 3</td>
<td>Vibration aging and seismic test</td>
<td>☑</td>
<td>---</td>
<td>---</td>
<td>see Sec. 3.7 and Sec. 3.8</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>---</td>
<td>☑</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Test in conditions of postulated accident - LOCA</td>
<td>☑</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.9 and Sec. 3.10</td>
<td>(2)</td>
</tr>
<tr>
<td>12</td>
<td>2, 3</td>
<td>2. test in conditions of postulated accident - LOCA</td>
<td>☑</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.9 and Sec. 3.10</td>
<td>(2)</td>
</tr>
<tr>
<td>13</td>
<td>1, 2, 3</td>
<td>Verification test of basic function</td>
<td>---</td>
<td>☑</td>
<td>---</td>
<td>see Sec. 3.3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1, 2, 3</td>
<td>Post-test inspection</td>
<td>---</td>
<td>---</td>
<td>☑</td>
<td></td>
<td>(4)</td>
</tr>
</tbody>
</table>

**Annotation:**

a) Simulations of environmental conditions include tests:
- Simulated operating environment at NOC,
- During ambient conditions at NOC and AC,
- During conditions of postulated earthquake.
CFSI Case Study –
1. Pressure Switch

Overview of program of functionality tests of pressure switch

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Type of test</th>
<th>Normative Prescription</th>
<th>Acceptance Criteria</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inspection equipment incl. check of connection and electrical function test (conformity with the technical documentation)</td>
<td>---</td>
<td>No tolerances are allowed</td>
<td>(5)</td>
</tr>
<tr>
<td>2.</td>
<td>Insulation resistance measurement</td>
<td>ČSN EN 60204-1, art. 18.3, CSN EN 61439-1</td>
<td>ČSN EN 60204-1, art. 18.3, CSN EN 61439-1</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Measuring of switching pressure value at increase and decrease of inlet pressure</td>
<td>Internal regulation of testing laboratory</td>
<td>$p_{nc} = 6.4 \text{ MPa}_{\text{ig}} (928 \text{ psig})$</td>
<td>(1), (2), (3)</td>
</tr>
<tr>
<td>4.</td>
<td>Pressure test</td>
<td>Internal regulation of testing laboratory</td>
<td>$p_{t} = 34.5 \text{ MPa}_{\text{ig}} (5000 \text{ psig})$</td>
<td>(4)</td>
</tr>
</tbody>
</table>

Notes:
1) Acceptance criteria correspond to the design values of switching pressures.
2) All three test samples are set to the switching pressure of 900 psig roughly inside the body of the pressure switch. The recommended procedure defined in the Installation and operation manual No. 610-0008 [33] where the setting comes with the verification by the calibrated meter was not followed. This does not affect the validity of the qualification. During the qualification process, any changes to these values will be evaluated.
3) The measurements are performed within the functional cycle. Functional cycle starts with increasing the medium pressure fed to the inlet of the pressure switch until switching of the micro-switch in the pressure switch from the end position NO1 to the end position NC1 and after a short delay, there is subsequent reduction of pressure medium supplied to the inlet of the pressure switch until switching of the micro-switch in the pressure switch from end position NO1 to the end position NC1.
4) Acceptance criterion corresponds to the value of the test pressure for given type of pressure switch (Neo-Dyn type 100P57C5 MSD) in the Data sheet AER0935_27/13 [32].
5) This test is not needed to be documented.
CFSI Case Study – Pressure Switch

Overview of the test program of accelerated thermal aging of pressure switches

<table>
<thead>
<tr>
<th>Test sample no.</th>
<th>Test temperature [°C]</th>
<th>Min. test duration [h / days]</th>
<th>Operating temperature [°C]</th>
<th>Service life [years]</th>
<th>Normative prescription</th>
<th>Acceptance criteria</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>110</td>
<td>484 / 20</td>
<td>45</td>
<td>5</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>484 / 20</td>
<td>45</td>
<td>5</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>484 / 20</td>
<td>45</td>
<td>5</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td></td>
</tr>
<tr>
<td>Stage 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(2)</td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>484 / 20</td>
<td>45</td>
<td>10</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td>(3)</td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>484 / 20</td>
<td>45</td>
<td>10</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td>(3)</td>
</tr>
<tr>
<td>Stage 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(2)</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(2)</td>
</tr>
<tr>
<td>3</td>
<td>130</td>
<td>726 / 30</td>
<td>45</td>
<td>40</td>
<td>ČSN EN 60212</td>
<td>CSN EN 60216-4-1</td>
<td>(3)</td>
</tr>
</tbody>
</table>

Notes:
1) After each stage, the function of the equipment according to rep 133-15.kpr [17] was validated.
2) The test sample was not subjected to accelerated thermal aging at this stage.
3) The test samples remain located in one test chamber, so the equivalent time counts.
4) Minimum aging time. Conversion to the days is orientation.
## CFSI Case Study – I. Pressure Switch

### Summary of number of cycles for test samples

<table>
<thead>
<tr>
<th>Test sample label number</th>
<th>Number of suitable qualified service life [years]</th>
<th>Number of cycles (repetitions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>1250</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2500</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>10000</td>
</tr>
</tbody>
</table>
## Summary of required radiation doses for given test sample

<table>
<thead>
<tr>
<th>Test sample label number</th>
<th>Required service life [years]</th>
<th>Required radiation dose corresponding to normal operating conditions [kGy]</th>
<th>Required radiation dose corresponding to accidental conditions [kGy]</th>
<th>Total required radiation dose [kGy]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>
# CFSI Case Study – Pressure Switch

## Scope of tests of vibration resistance simulation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excitation signal</td>
<td>Continuous sine-sweep wave</td>
</tr>
<tr>
<td>Sweep rate [oct.·min(^{-1})]</td>
<td>1</td>
</tr>
<tr>
<td>Frequency of change in sweep mode [Hz]</td>
<td>9</td>
</tr>
<tr>
<td>Number of excitation directions</td>
<td>3</td>
</tr>
<tr>
<td>Number of sweep cycles</td>
<td>10</td>
</tr>
<tr>
<td>Mode 1 frequency range [Hz]</td>
<td>1 to 9</td>
</tr>
<tr>
<td>Mode 1 maximum displacement [mm]</td>
<td>3.5</td>
</tr>
<tr>
<td>Mode 2 frequency range [Hz]</td>
<td>9 to 150</td>
</tr>
<tr>
<td>Mode 2 maximum acceleration [g]</td>
<td>1</td>
</tr>
</tbody>
</table>
# CFSI Case Study – Pressure Switch

## Scope of tests of seismic resistance simulation

<table>
<thead>
<tr>
<th>Order No.</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Examination of natural frequencies</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Excitation signal</td>
<td>Continuous sine-sweep wave</td>
</tr>
<tr>
<td></td>
<td>Frequency change [Oct. min⁻¹]</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Frequency range [Hz]</td>
<td>1 – 100 – 1</td>
</tr>
<tr>
<td></td>
<td>Level of excitation [g]</td>
<td>0.2 (amplitude)</td>
</tr>
<tr>
<td></td>
<td><strong>Seismic type tests</strong></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Excitation character</td>
<td>Single frequency excitation - RIM</td>
</tr>
<tr>
<td></td>
<td>Excitation in directions</td>
<td>1 Axial tests</td>
</tr>
<tr>
<td></td>
<td>Number of tests of excitation level</td>
<td>5x DE - ½ RRS in each direction (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x MCE of RIM in each direction (2)</td>
</tr>
<tr>
<td></td>
<td><strong>Functionality check tests during tests of seismic resistance simulation</strong></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Functionality check tests conditions</td>
<td>basic properties of electrical connection:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Voltage measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Open circuit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>basic properties of pressure connection:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- pressure measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>functional cycles at least once for each direction (X, Y, Z) and each excitation level (5x DE and 1x MCE)</td>
</tr>
<tr>
<td>4.</td>
<td><strong>Comprehensive functionality tests after performance of qualification tests</strong></td>
<td>According to Sec. 3.3</td>
</tr>
</tbody>
</table>

Notes:

1) For tests at the level of design earthquake DE (SL-1, OBE) the test was performed by five (5) sine sweep tests (sweep sine wave) with equivalent excitation equal to one half (1/2) of the RIM curve acceleration (see Fig. 6, Tab. 14) for each orthogonal direction. Each sweep went through the interval of 2 Hz - 32 Hz - 2 Hz at 1 octave per minute.

2) For tests at the maximum calculated earthquake level MCE (SL-2, SSE), it is recommended to perform a single-frequency test by a series of single-frequency sine pulses separated by an interval of 1/3 octave at required frequency range of 2 - 32 Hz for each orthogonal direction. Excitation at each frequency had the form of a continuing series of sine pulses, with each pulse having 12 to 15 oscillations. Acceleration and persistency at each frequency was in accordance with the values given by the RIM curve (see Fig. 6, Tab. 14).
CFSI Case Study – I. Pressure Switch
CFSI Case Study –
1. Pressure Switch

Figures 3, 4: Y axis tests

Figures 5, 6: Z axis tests
Click to edit Master title style

Baseline functional capability tests

Vibration Simulation Tests

Visual inspection (structural integrity)

Sesmic Tests (DBE)

Functional checks

Baseline functional capability tests

Table of testing rig

Supporting frame

Pressure connection (air / water)

Test samples

Lug

Table of testing rig

Reduction valve

Solenoid

Pressure gauge

Solenoid

Pressure source (compressor / bottle)

Pressure switch Neo-Dyn Type 10057C5A MSD

24 VDC
Comparison of test and required pressure profile of LOCA accident

Comparison of test and the required temperature profile of the LOCA accident
Imersion test (IPx8 check) - FAIL

- The test was performed in accordance with EN 60529 with parameters of immersion to the depth of 4500 mm, immersion time of 90 hours.
- Test sample No. 2 was equipped on the side of the electrical connection only with Wiska cable gland type NMSKV NPT ¾ which has according to the technical documentation IP 68 up to 5 bar for 30 min.
- The second test sample, the sample No. 3 was prepared in the same configuration as the first one and subsequently isolated by water and pressure blocking tape and thermo-shrink tube 45/16 (200 mm) (cable splice).
- After the trial period the test samples were removed and dried. The test of insulation resistance measurement was performed.
Imersion test (IPx8 check) - FAIL

- After removing the cover of the test samples, it was found that the test sample No. 2 is 80% flooded with test fluid. Test sample No. 2 therefore failed the test conditions. Test sample No. 3 was dry and complied.
LOCA Test - FAIL

- Two separated LOCA tests have been performed. One for Test Sample No. 1. Second for Test Sample No. 2 and 3.
- Test Sample No. 1 passed. During the first 5 hours of simulation, the check functional cycles and functionality measurements were performed. Within the post-LOCA test phase, the insulation resistance for demonstration that the test fluid did not enter the equipment was measured. At 48.5 h and 68.1 h, the insulation resistance was always greater than the required and the equipment and thus met all the test conditions.
- In the second simulation, only Test Sample No. 2 passed.
Position A shows the location of the top cover sealing, and position B shows the sealing on the side of the electrical connection.
### Overall result of qualification tests of equipment - manufactured by ITT Aerospace Controls

**Neo-Dyn® Industrial Switches type Neo-Dyn type 100P52C5 MSD and type 100P57C5 MSD**

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Type</th>
<th>Qualified lifetime</th>
<th>Qualification result</th>
</tr>
</thead>
<tbody>
<tr>
<td>pressure switch</td>
<td>100P52C5 MSD</td>
<td>10 years (1)(2)(3)(4)</td>
<td>OK (5)</td>
</tr>
<tr>
<td>pressure switch</td>
<td>100P57C5 MSD</td>
<td>10 years (1)(2)(3)(4)</td>
<td>OK (5)</td>
</tr>
</tbody>
</table>

**Notes:**

1) Qualified lifetime is determined for the environmental conditions specified in Sec. 3.1.
2) The body of the pressure switch must be every 5 years resealed using a sealing from material specified in Appendix D or using other qualified sealing.
3) Electrical connection of the pressure switches must be additionally sealed with water and pressure blocking tape and shrink tube 45/16 (200 mm) or by other qualified manner.
4) Connection of the pressure switch on the inlet pressure side must be additionally sealed with glue LOCTITE 577 or by other qualified manner.
5) The equipment (pressure switch) must be properly secured and established and operated, inspected and maintained according to the requirements [32] and [33] of technical documentation and ATD.
Qualification Life Conditions

- The equipment (pressure switches) with cable glands Wiska type NMSKV NPT 3/4 must be additionally insulated by cable splices as specified or by other qualified manner ensuring the hermeticity of cable restraint for conditions for harsh environment (LOCA and post-LOCA).
- The equipment (pressure switches) must be on the side of the pressure inlet subsequently isolated with LOCTITE 577 (according the procedure) or by other qualified manner.
- The equipment (pressure switches) after a qualified service life (5 years) must be resealed by using a sealing from material specified in the procedure, respectively or by other qualified sealings.
- Devices (pressure switches) after a qualified service life (10 years) must be replaced by a new one in accordance with the installation and operating instructions.
Qualification Life Conditions

- The equipment (pressure switches) must be properly operated, inspected and maintained as required by PN 610-0008.
CFSI Case Study – Pressure Switch

REAL LIFE ...

- Vendor wasn't able to provide an original spare part sealing as originally have been tested.
- Only fake „in-garage-made-product“ was available in official supply chain.
REAL LIFE ...

Installation configuration doesn't respond to qualified conditions:

• no cable splices,
• no qualified terminal box
• any program of spare parts changing intervals
Situation / Conditions

- Two-stage pressure reducing valve (PRV) during the end-user nuclear approve program need to be additionally qualified for an active function under seismic conditions.
- PRVs are applied in safety systems relating with primary loop systems for handling nitrogen and oxygen medium.
- PRVs are also applied in system of the diesel-generator air-pressure starting system.
- Two types of structural material of PRV have been chosen with respect to service medium:
  - nitrogen: Stainless Steel ASME
  - oxygen: Brass CW721R
Description of PRV

- PRV is of a 2 stage design. Each stage incorporates an identical valve capsule assembly which can easily be removed and replaced should failure occur. The capsule includes a filter disc for gas applications, Gauge ports are provided for registering inlet, intermediate, and outlet pressures. Each gauge port is fitted with a pressure gauge and isolating valve.
- Both intermediate and outlet pressure can be adjusted. Adjustment of intermediate pressure can be achieved by turning the adjusting screw clockwise to increase pressure and anti-clockwise to decrease pressure. This action increases or decreases load on the main spring. Once set, lock using nut.
Description of pressure switch

- Adjustment of outlet pressure can be achieved by turning the adjusting handwheel clockwise to increase pressure and anti-clockwise to decrease pressure. This action increases or decreases load on the main spring. There is no locking device on this stage.
- The valve pressure sensing -1st stage is by a piston and 2"d stage by a stainless steel diaphragm.
## Test Sample

- Test Sample for vibration resistance and seismic active function prove
- Manufacturer: Thompson Valves Ltd.
- Type Number: J20YPR1A1A18300

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Material</th>
<th>DN</th>
<th>Input Pressure max [bar]</th>
<th>Flow min/norm/max [m³ h⁻¹]</th>
<th>Weight [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>J20YPR1A1A18300</td>
<td>RV59</td>
<td>Brass CW721R</td>
<td>6</td>
<td>230</td>
<td>1 / 2 / 3</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Note:
These data are valid for the service medium - nitrogen. Operating temperature 30 °C.
CFSI Case Study –
II. Two-Stage Pressure Regulator
Functional Failures During Vibration Simulation

- During the first séance of vibrational testing the excessive resonances appear above 100 Hz and pressure flow stack within functional checks (Group Tests B).
- Design change of the console length.
- During the first séance of vibrational testing the excessive resonances appear above 100 Hz and pressure flow stack within functional checks (Group Tests B).
- Redesign of internal part of RPV.
CFSI Case Study –
II. Two-Stage Pressure Regulator
CFSI Case Study – II. Two-Stage Pressure Regulator

First Testing Séance:
Test Sample Configuration

Second Testing Séance:
Test Sample Configuration
CFSI Case Study –
II. Two-Stage Pressure Regulator

First Testing Séance:
Resonance above 100 Hz (X)

Second Testing Séance:
Resonance above 100 Hz (X)
2. **MANUFACTURER'S LIABILITY**

Always ensure that the valve is used for the service for which it was purchased and that it is operated and maintained in accordance with these instructions. The manufacturer accepts no liability for the consequences of improper use.

In case of doubt, consult the Thompson Valves, Poole, Engineering Manager or, in his absence, the Quality Assurance Manager.
II. Two-Stage Pressure Regulator

Definition of Vibration Environment in Industrial Facilities

- Products shall be approved for technical utilization in service accordingly with product’s standards or general requirements for electrical-safety/pressure-safety/fire-safety/... equipment to be sell in „common“ market (CE,PED, ...)
- Nuclear facilities shall comply those basics + extras


# CFSI Case Study – II. Two-Stage Pressure Regulator

<table>
<thead>
<tr>
<th>Environment designation</th>
<th>Vibration environment parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH1⁽¹⁾</td>
<td>Character of vibration movement</td>
<td>Periodic sinusoidal vibrations</td>
</tr>
<tr>
<td></td>
<td>Maximum amplitude</td>
<td>Frequency range 2 – 9 [Hz] 1,5 [mm]</td>
</tr>
<tr>
<td></td>
<td>Maximum acceleration</td>
<td>Frequency range 9 – 200 [Hz] 5 [m.s⁻²]</td>
</tr>
<tr>
<td>AH2</td>
<td>Character of vibration movement</td>
<td>Regular sinusoidal vibrations</td>
</tr>
<tr>
<td></td>
<td>Maximum amplitude</td>
<td>Frequency range 2 – 9 [Hz] 3 [mm]</td>
</tr>
<tr>
<td></td>
<td>Maximum acceleration</td>
<td>Frequency range 9 – 200 [Hz] 10 [m.s⁻²]</td>
</tr>
</tbody>
</table>

**Note:**
(1) Only the maximum parameter values of the vibration environment are given here.
Recommended tests for equipment classified for the environmental class 3M4 and 3M5 in accordance with the standard IEC 60721-3-3 (places with significant vibrations and impacts)

<table>
<thead>
<tr>
<th>Environmental Parameter</th>
<th>Unit</th>
<th>Class 3M4/3M5 (AH2, AG2)</th>
<th>IEC 60721-3 Dynamic Conditions</th>
<th>IEC 60068-2 Dynamic tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>mm</td>
<td>3</td>
<td></td>
<td>like the recommended test</td>
</tr>
<tr>
<td>Acceleration</td>
<td>m.s(^2)</td>
<td>10</td>
<td></td>
<td>60068-2-6</td>
</tr>
<tr>
<td>Frequency range</td>
<td>Hz</td>
<td>2 to 9</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Number of axes</td>
<td></td>
<td>9 to 200</td>
<td></td>
<td>1 to 150</td>
</tr>
<tr>
<td>Number of sweep cycles</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Note No. 1)
CFSI Case Study – II. Two-Stage Pressure Regulator

Environmental testing
Vibration test in values classes AH2 according to STN 33 2000-3
sinusoidal sweep testing according to STN EN 60068-2-6

- Vibration test amplitude
- Cross-over frequency
CFSI Case Study –
II. Two-Stage Pressure Regulator

REAL LIFE ...

- Manufacturer in leaflets/design specs presents under same design marking the „original“ product. Any recognitions of differences in the design of internal part(s).
- Any responses of manufacturer about design change of internal part(s) of RPV in version made from stainless steel type.
CFSI Case Study – II. Two-Stage Pressure Regulator

REAL LIFE ...

- Potentially „passive-mechanical-components“ are sensitive for vibration ageing.
- Arbitrary stipulated parameters for vibrational ageing testing forms high uncertainties in equipment item exploitation in industrial environment – let's standardized procedure and follow existing standards!
III. Asynchronous Motor

Situation / Conditions

- Past seismically qualified asynchronous motor have been ordered for new project by manufacturer of pumps to be installed as an assembly for one of the emergency safety system in nuclear power plant.
- Performed seismic qualification type program did not required verification against vibration testing because asynchronous design shall comply design requirements set-up under provisions of the IEC 60034
- Original qualification functional capability tests comply with requirements of IEC 60034.
- Original qualification documentation fully comply with requirements of Plant’s Qualification Specification. Manufacturer declared the compliance with originally qualified test sample type.
CFSI Case Study – III. Asynchronous Motor
CFSI Case Study –

III. Asynchronous Motor
REAL LIFE...

- During the check of operational loading (longer as to be tested) in-situ, asynchronous motor showed excessive internally generated vibrations.
- Manufacturer didn‘t want communicate about quality and referred to original qualification tests and FAT.
- Forensic analysis had shown serious deviances in the design(!)

idt IEC 60034-14:2003

Rotating electrical machines –
Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher –
Measurement, evaluation and limits of vibration severity

Machines électriques tournantes –
Partie 14: Vibrations mécaniques de certaines machines de hauteur d'axe supérieure ou égale à 56 mm –
Mesurage, évaluation et limites de l'intensité vibratoire

Drehende elektrische Maschinen –
Teil 14: Mechanische Schwingungen von bestimmten Maschinen mit einer Achshöhe von 56 mm und höher –
Messung, Bewertung und Grenzwerte der Schwingstärke
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(IEEE Conformity Assessment Program)

• Rizzo-CZ / VTÚPV intends to work with IEEE to become accredited laboratory.
• How will this benefit our clients?
  • Provide assurance and confidence a product or service met IEEE requirements
  • Empowers the user to make better purchasing decisions
  • Benefits the supplier as products may gain market acceptance
• Conformity Assessment Activities will Include:
  • Conformance to IEEE Standards,
  • Lab audits to maintain accreditation
  • IEEE Certified components following IEEE ICAP process.
• Rizzo-CZ / VTÚPV will begin accreditation process in 2018.
THE END...

QUESTIONS ???