Nuclear Proximity Position Sensors

Next Generation Technology for Today's Expanded Sensing Requirements

TOPWORX

EMERSON
Process Management

Next Generation Design Parameters

- Proximity Design that can withstand high temperature, high pressure, high radiation
- Maintain repeatability over its life
- Reduce weight and size of the switch
- Maintenance Free (No user serviceable parts…. reduction in Man/Rad Hours)
- SPDT and DPDT
- Modular Sensor Package with Junction Box
- Minimal dead-band between “make-break” for short stroking applications
- Easily retrofit current mechanical switches in the field
- Overcome Low Current issues
- “See-Through” Applications (Check, Squibb, Steam Valves etc)
- Three levels of Switch certifications Containment, Harsh and Mild

C7/C8 Global Containment Proximity/Limit Position Sensor

- Less dead-band between make and break
- Longer qualified life 60yrs+1
- Proximity… No lever arms to bend, break, or lose set point. No torque on actuator!
- No user serviceable parts.
- 1/10th the weight of Nuclear Rated mechanical switches
- Outstanding for high or low current applications
- SPDT and DPDT

Meets or exceeds:

- AECL 98-30830-TS 008
- AECL 98-60000-TS 005
- AECL 98-60000-TS-006
- IEEE 323-1983
- IEEE 382-1985
- IEEE 572-1985
- IEEE 344 1975/87/2004
- IEEE 382 1985/1996/2006
- IEEE 323 1974/1983/2003
- **RCC-E (K1 Under Review)**
- **KTA (Final Vibration Test Summer 2010)**

Nuclear Proximity Quick Specification Overview

Operating Principle	Magnetically Operated contacts, internal moving part
Operating Targets	Target Magnet with threaded stud, provided with switch
Housing Materials	Switch and Target Magnet housing: 303 stainless steel Target magnet end: Rare earth magnet
Weight	Switch: 0.4 lbs. (0.18 Kg) AMS7A: 0.15lbs. AMS12: 0.29lbs.
Size	Approx. 4” x 1.25” (10.2cm x 3.2cm)
Mounting	Optional standard and custom bracket
External Seals & Gaskets	None, one piece 303 stainless steel enclosures
Electrical Ratings	Qualified: 48VDC 1A Ratings: 120VDC 0.5A / 120VAC 4A

Nuclear Proximity Quick Specification Overview

Sensing (Trip) Range Avg.	AMS7A trips within 0.100” gap between the magnet target and switch AMS12 trips within 0.250” gap between the magnet target and switch
Hysteresis Avg.	AMS7A: 0.023” AMS12: 0.031”
Adjustability	Threaded body switch and Target Magnet provide infinite adjustability
Switch Operating Force & Torque	Force: Switches are Leverless and do not require operating torque.
Cycle Rate	200 cycles per minute
Cycle Life (mechanical)	1 million after exposed to Qualification Testing
Qualified Life	60 years + 1 year post accident

Modular Switch Package With Integral Junction Box

Modular, discrete indication package with an integral junction box for Global Containment.

- Single-point mount, stainless steel modular package with integral junction box
- Fits most quarter-turn actuators
- Two(2) LOCA Rated Proximity Position Sensors For Containment
- Less dead-band between make and break
- Longer qualified life 60+1
- Significant reduction in total installation costs
- Same test parameters as the C7/C8

The DXN meets or exceeds:

- AECL 98-30830-TS 008
- AECL 98-60000-TS 005
- AECL 98-60000-TS-006
- IEEE 323-1983
- IEEE 382-1985
- IEEE 572-1985
- IEEE 344 1975/87/2004
- IEEE 382 1985/1996/2006
- IEEE 323 1974/1983/2003
- RCC-E (K1 Under Review)
- KTA (Final Vibration Test Summer 2010)

C7/C8 Global Containment Qualification Levels

Seismic

- IEEE 382-85/96/2006: RIM 10G
- IEEE 344-75/87/2004: 14G @ 5%, 4.5-16Hz, 12G ZPA

Qualified Mechanical Aging: 25,000 cycles
(Demonstrated 100,000,000 cycles in commercial use)

Environment:

- IEEE 323-74/83: Harsh
- Peak Temp.: 510°F w/o Margin
- Radiation: 2.5E8 RADS TID
- Max. Pressure: 90PSI Peak LOCA w/o Margin / 75 PSIG Cycle Test
- Profile: IEEE 382-85/96/2006- DBA Inside Containment
- Qualified Life: 60 yrs+1
- SPDT or DPDT

H7/H8Harsh Environment Qualification Levels

Seismic

- IEEE 382-85/96/2006: RIM 10G
- IEEE 344-75/87/2004: 14G @ 5%, 4.5-16Hz, 12G ZPA

Qualified Mechanical Aging: 25,000 cycles
(Demonstrated 100,000,000 cycles in commercial use)

Environment:

- IEEE 323-74/83: Harsh
- Peak Temp.: 495°F
- Radiation: 2.5E8 RADS TID
- Max. Pressure: 75 PSIG Cycle Test
- Profile: IEEE 382-85/96/2006- DBA Inside Containment **(Non-Operational)** /Outside Containment **(Operational)**
- Expected Life: 60 yrs.
- SPDT or DPDT

Mild Environment Qualification Levels

Seismic

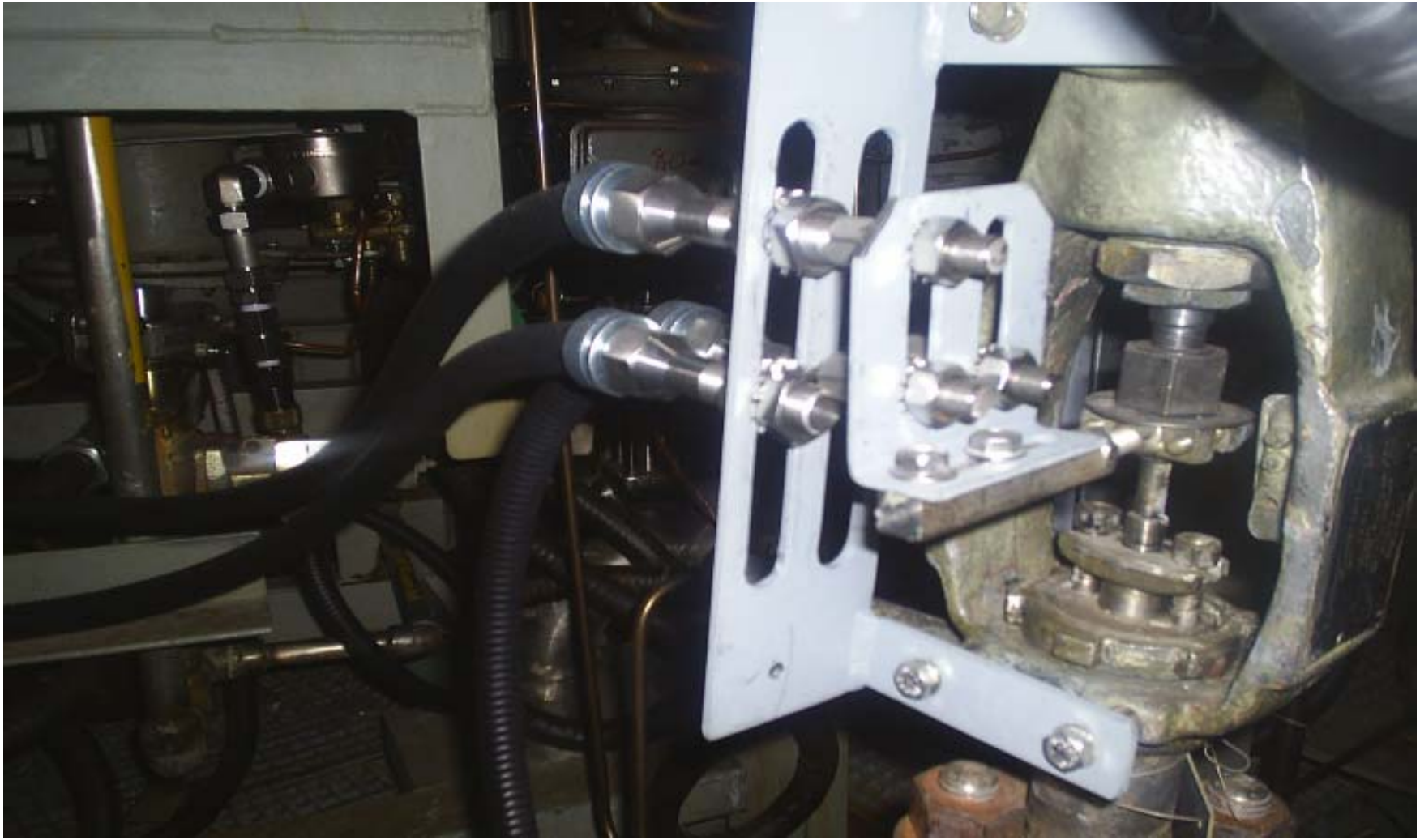
- IEEE 382-85/96/2006: RIM 10G
- IEEE 344-75/87/2004: 14G @ 5%, 4.5-16Hz, 12G ZPA

Qualified Mechanical Aging: 25,000 cycles
(Demonstrated 100,000,000 cycles in commercial use)

Environment:

- IEEE 323-74/83: Mild
- Working Temp.: 250°F Max.
- Radiation: 50E6 RADS TID
- Expected Life:60 yrs.
- SPDT or DPDT

Sampling Valve at Almarez Nuclear



Turbine Switch Monitor System For Harsh Nuclear

Turbine Trip Valve Position Monitor

- Monitors position of turbine valves
- Has the same specifications and certifications as the H7

Direct Drop-In For Westinghouse or GE turbines

- Drop-in replacement eliminates the need for multiple mechanical switches and exposure to excessive vibration and physical contact

Up to 10 switches per Defender

One Defender per valve

- Multiple valves per turbine
- Throttle
- Governor
- Reheat
- Reheat Stop
- Intercept

Before and After Application

Before

After

Non-Valve and Other Applications

- **Fuel Transfer – Generally Requires Underwater Harsh Rated Connector**
- **Cranes/Lifts**
- **Cylinder Extension/Retraction**
- **Direct Damper Position**

  Open/Closed
- **Containment Door Position Open/Closed**

Unusual Product Application

A Nuclear Proximity Switch mounted to a solenoid valve

- First Energy Corporation, Davis-Besse nuclear plant at Oak Harbor, Ohio
- Replace Circle Seal SOV's
- Fourteen valves installed
- Nuclear Proximity Switches were used to indicate main spool position status (open or closed) by directly detecting stem movement

TopWorx Test Specimens

- Implemented 2 separate LOCA profiles
- Westinghouse AP1000 (Named LOCA1) Completed
- C7 Passed submerged ….60+1 post accident
- DXN- Passed ….60+1 post accident
- All Harsh and Mild Switches, Modular Switch Packages and Turbine Monitors Passed …. 60 years expected
- Global Accident Profile to cover increased Westinghouse MSIV curve, non submerged LOCA for C7 and global curves…. (Named LOCA 2) June/July 2010 Start

Testing Parameters

- Receipt & inspection
- Upon receipt, the units-under-test (UUTs) inspected to ensure that the items were in good condition and had not experienced shipping damage. Model numbers and serial numbers were verified to ensure traceability to the original program and compliance with the current program. Any damage was noted and reported via a non-conformance report. A metal tag and/or adhesive tags tag was applied to each UUT. Information on the tag included the unique UUT identification number.
- Baseline Functional Test
- Functional testing was performed throughout the qualification program to document the condition of the UUTs before and after various program elements. Photographs of the UUTs were taken. The photographs contained both close up and overall views to be used for comparison throughout the qualification program.

Testing Parameters

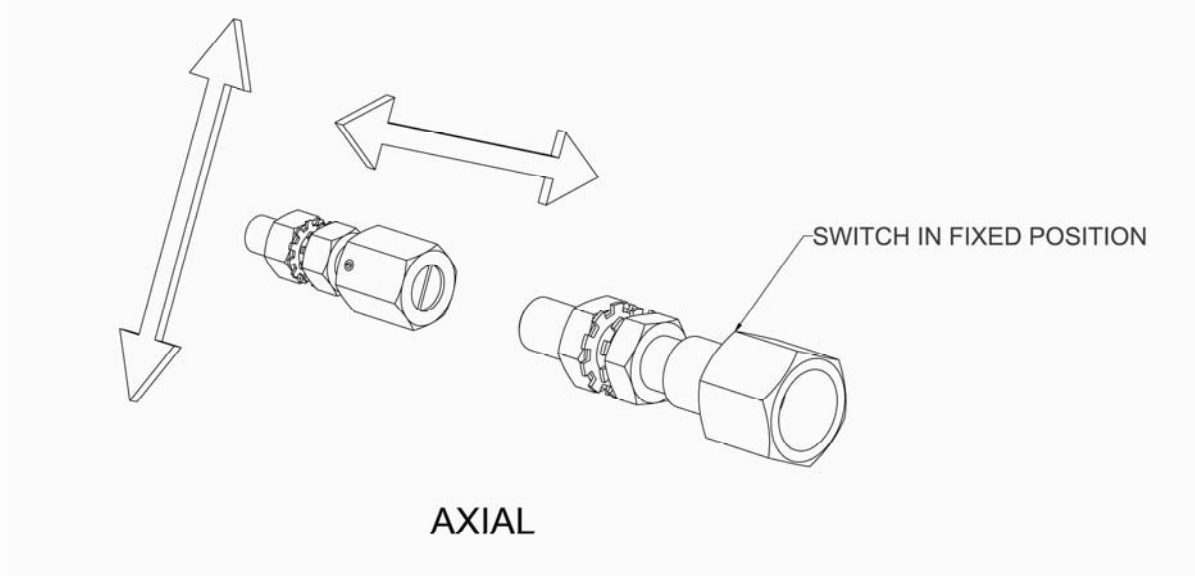
- **Baseline Functional Test**
- **Functional testing was performed with the data recorded for trending of degradation effects. Contact resistance, dielectric strength, sensing and reset distance and contact operation time were verified during functional testing.**
- **Contact resistance measurement:**
- **With the UUT in the non-actuate position, contact resistance was measured between the common lead and the normally closed lead. The expectation was that the resistance shall remain less than 1 ohm throughout the program.**
- **Dielectric Strength Test:**
- **1500 VDC potential was applied between the contact leads together and the UUT housing ground and the leakage current measured. The voltage was maintained for five (5) minutes before recording data. The leakage current was less than 1 mA after the five (5) minute hold period.**

Testing Parameters

- **Sensing and Reset Distance Test:**
- **For reference on axial/coaxial see the figure. Test fixtures were provided by TopWorx to facilitate testing. With the UUT in the non-actuated position (UUT and target magnet in coaxial orientation), the axial distance was slowly decreased between the UUT sensing face and the target magnet face until it actuated as indicated by the contacts changing states. The distance at which actuation occurred was measured. The results of three (3) trials were recorded and the average calculated. The axial distance was decreased the the reset distance measured. This test was repeated in the axial orientation.**
- **Contact Operation Time Test:**
- **With the UUT in the non-actuated position (UUT and target magnet in coaxial orientation) and contacts monitored with a high speed recorder, the axial distance between the sensing face of the switch and the target magnet face was slowly decreased until it actuated. The data was reviewed for discontinuity of the signal across the normally closed and**

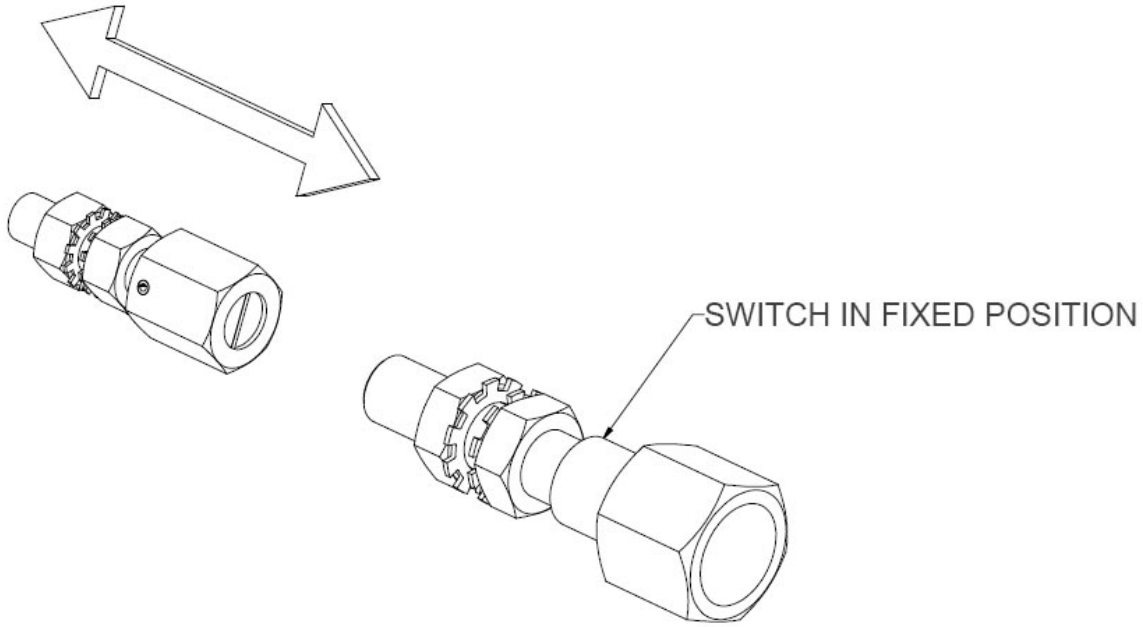
Testing Parameters

- **Sensing and Reset Distance Test Setup**



Testing Parameters

- **Sensing and Reset Distance Test Setup**



COAXIAL

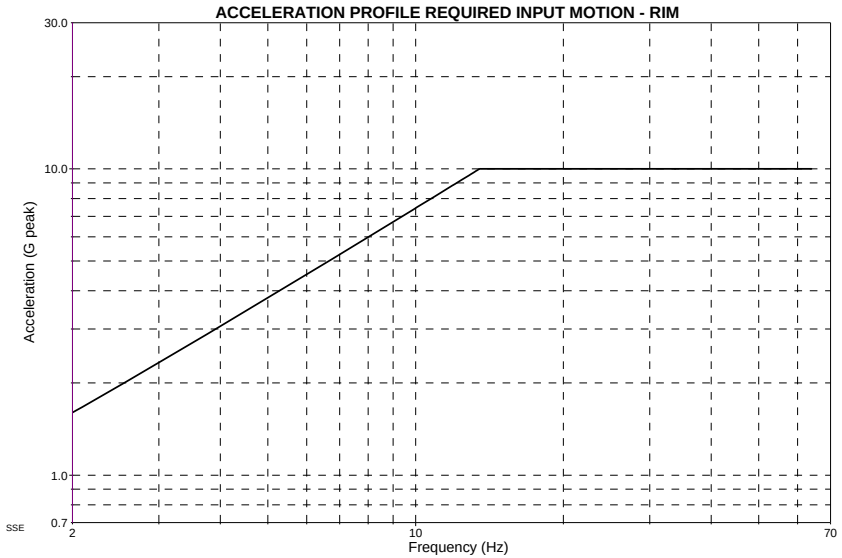
Testing Parameters

- Open contacts during their transitions and any discontinuity was measured and recorded. The test was repeated by slowly increasing axial distance between the sensing face of the UUT and the target magnet until the contacts return to the non actuated position. Again any discontinuity was measured and recorded.
- Thermal Aging
- The UUTs were exposed to greater than 1000 Hours at 266 Deg. F to simulate 40 and 60 year qualified lives. Samples were chosen to have representative designs in each 40 and 60 year tests
- Post Thermal Aging functional test
- Normal Radiation Aging
- Radiation aging performed at a rate not exceeding 1Mrad per hour. The total normal radiation aging total integrated dose was 50Mrads.
- Post-normal radiation aging functional test
- Cycle Aging

Testing Parameters

- Performed to 25,000 cycles with a 48VDC @ 1 Amp load applied to all switch contacts.
- Post-cycle aging functional test
- Vibration Aging
  - IEC60086-2-6
  - Required Input Motion (RIM) test
    - 0.75g for 90 minutes in each axis from 2-100HZ
    - Operational Basis Earthquake (OBE) sweeps performed at 6.6g from 2-64HZ
    - Resonance Search Testing from 1-100HZ
- Post Vibration Aging functional test
- Sine Beat Test
  - Performed at one-third octave spacing from 2-32HZ
  - Performed at one-sixth octave spacing from 32-64HZ and any resonances identified in the search testing
  - Maximum Acceleration 10g

RIM Acceleration Curves

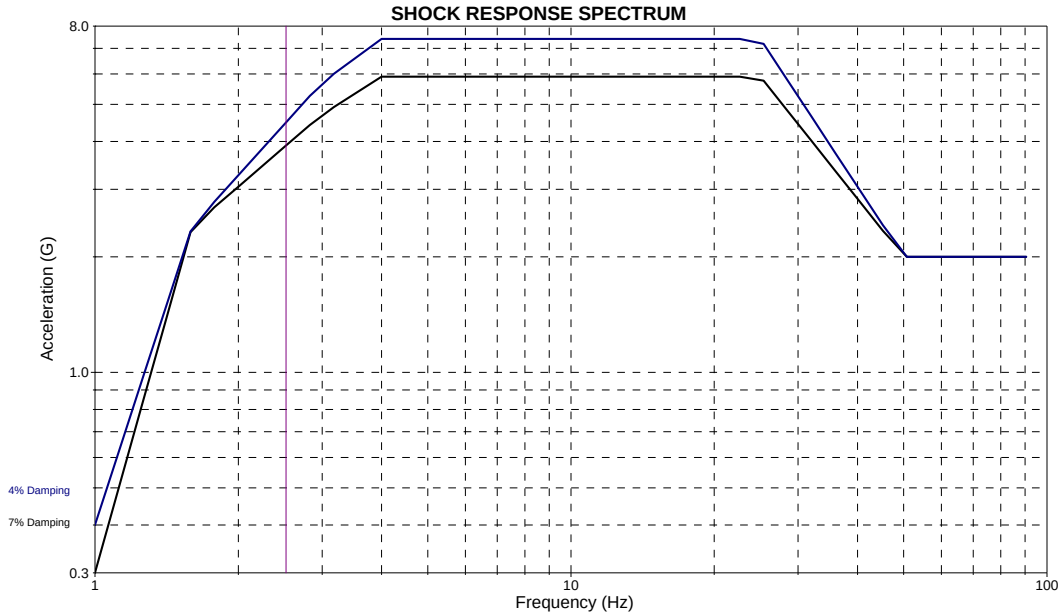


FREQUENCY (HZ)	ACCELERATION (g)
2.00	1.60
2.52	2.61
3.17	3.10
4.00	3.90
5.04	4.50
6.35	5.60
8.00	6.80
10.08	8.00
12.70	10.00
16.00	10.00
20.16	10.00
25.40	10.00
32.00	10.00
35.92	10.00
40.32	10.00
45.25	10.00
50.80	10.00
57.02	10.00
64.00	10.00

Testing Parameters

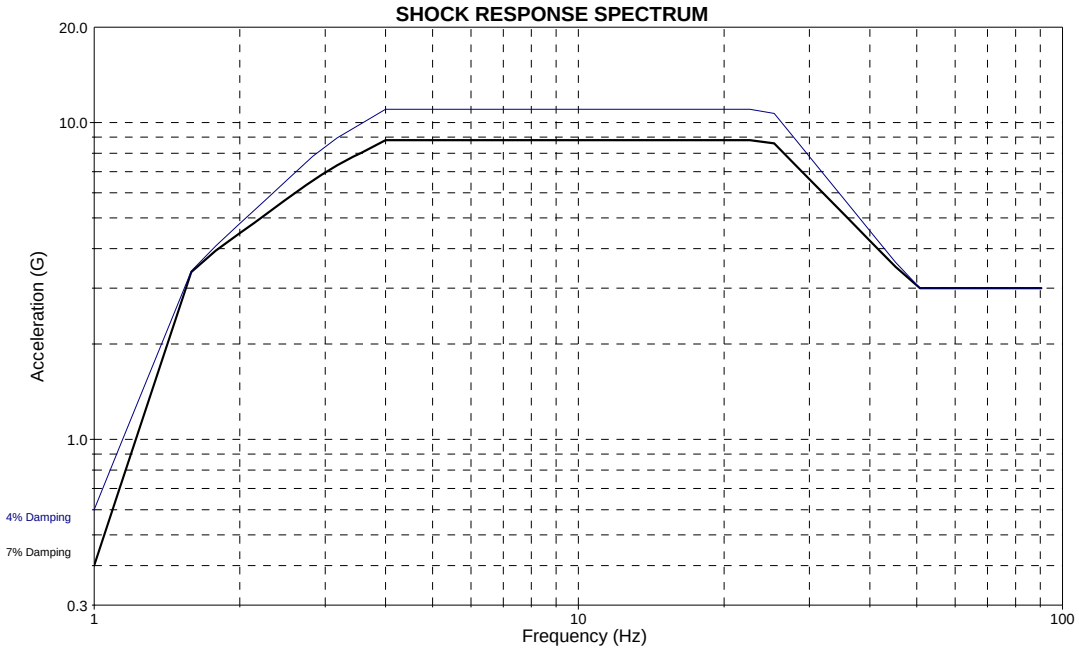
- Post Sine Beat functional tests
- RMF Seismic test
  - One RMF test performed to Westinghouse provided test levels
  - One RMF test performed to table limits of the facility

RMF OBE Shock Response Spectra Curves



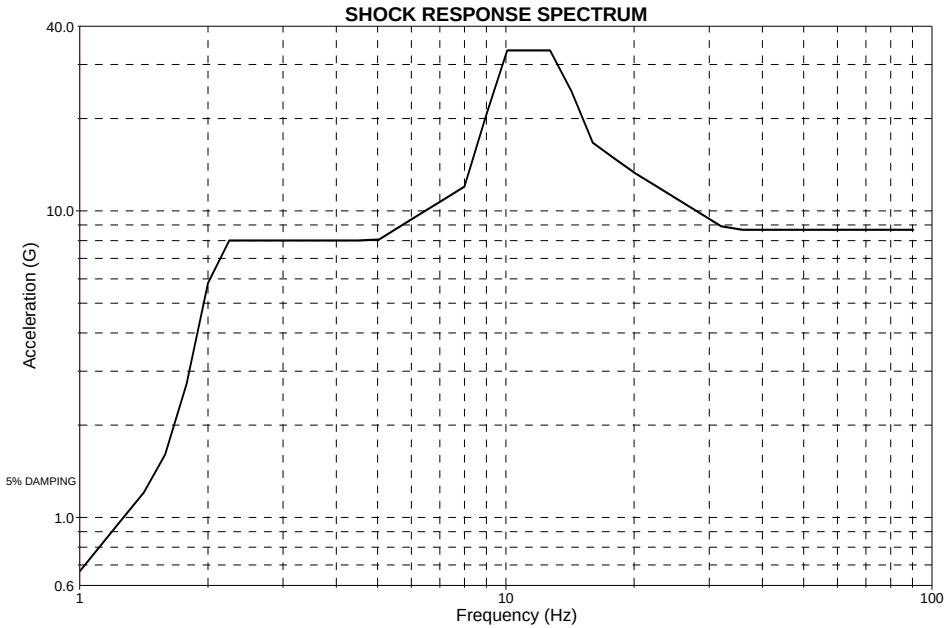
FREQUENCY (HZ)	ACCELERATION (g) @ 4% DAMPING	ACCELERATION (g) @ 7% DAMPING
1.00	0.4	0.3
1.60	2.4	2.4
3.00	5.7	4.7
4.00	7.4	5.9
25.00	7.4	5.9
50.00	2.0	2.0
60.00	2.0	2.0

RMF SSE Shock Response Spectra Curves



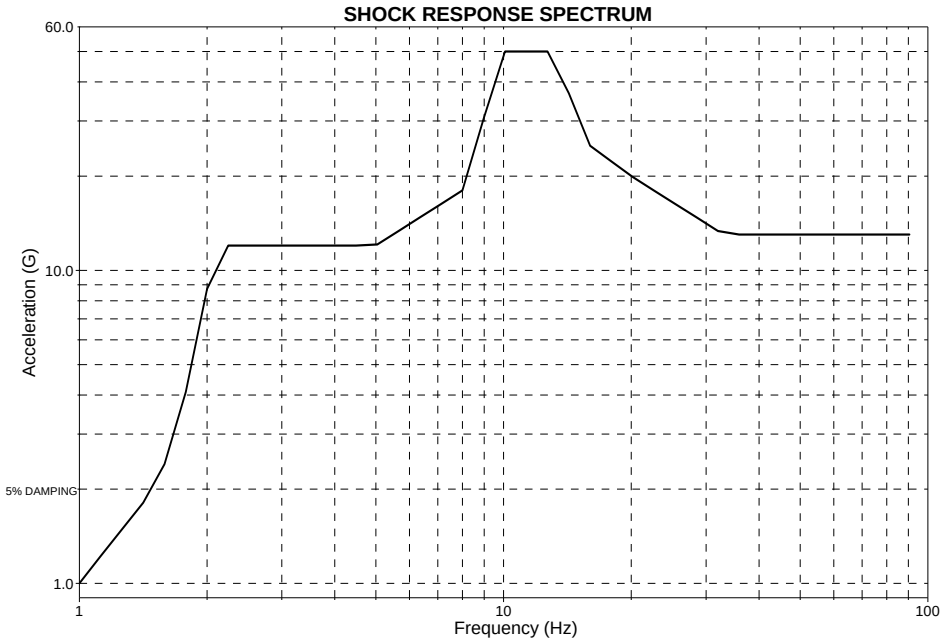
FREQUENCY (HZ)	ACCELERATION (g) @ 4% DAMPING	ACCELERATION (g) @ 7% DAMPING
1.00	0.6	0.4
1.60	3.5	3.5
3.00	8.5	7.0
4.00	11.0	8.8
25.00	11.0	8.8
50.00	3.0	3.0
60.00	3.0	3.0

RMF OBE Shock Response Spectra Curves



FREQUENCY (HZ)	ACCELERATION (g) @ 5% DAMPING
1.00	0.66
1.50	1.32
1.70	1.98
2.10	7.92
5.00	7.92
8.00	11.88
10.00	33.0
13.00	33.0
16.00	16.5
20.00	13.2
33.00	8.58
100.00	8.58

RMF SSE Shock Response Spectra Curves



FREQUENCY (HZ)	ACCELERATION (g) @ 5% DAMPING
1.00	1.0
1.50	2.0
1.70	3.0
2.10	12.0
5.00	12.0
8.00	18.0
10.00	50.0
13.00	50.0
16.00	25.0
20.00	20.0
33.00	13.0
100.00	13.0

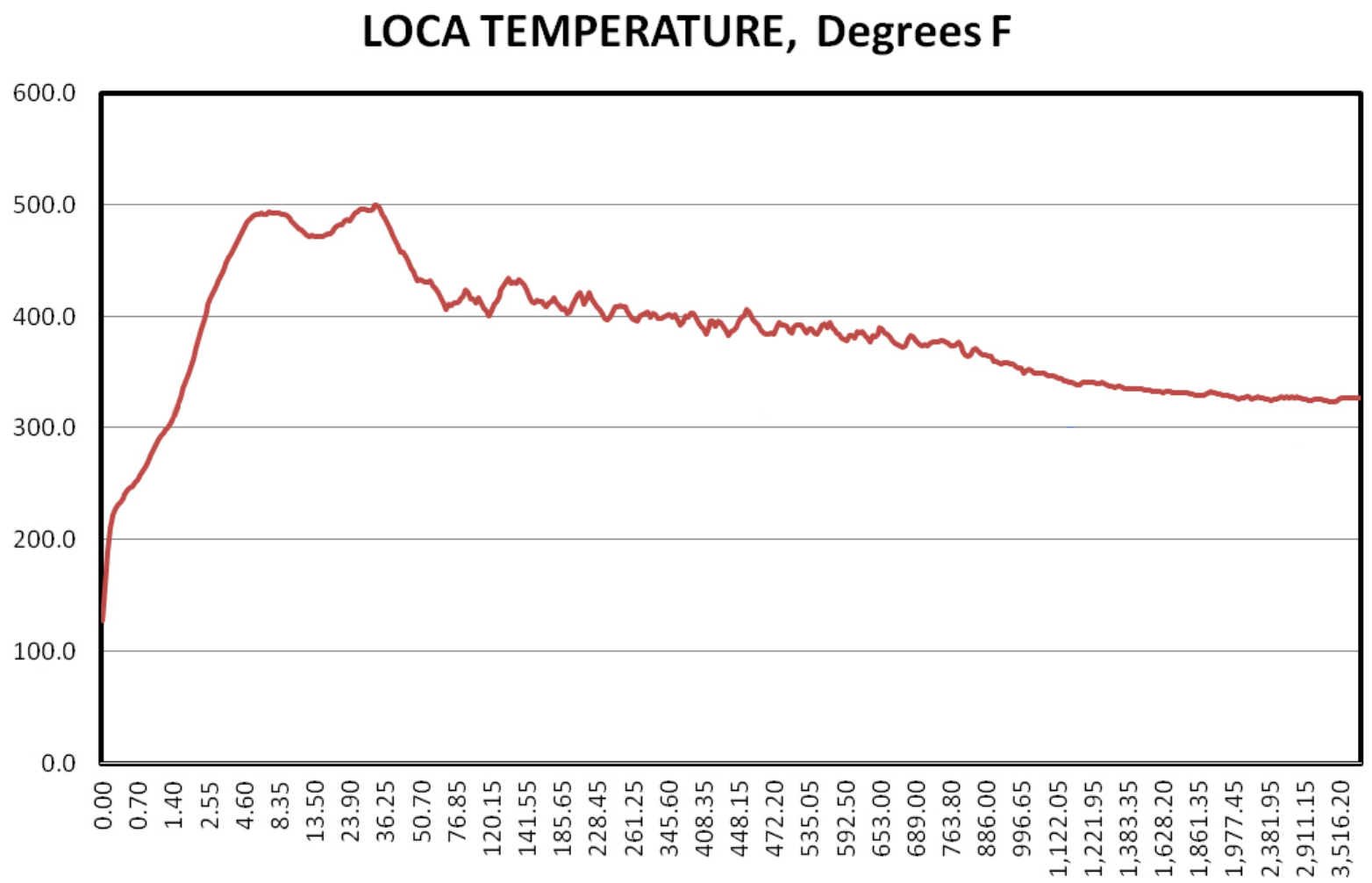
Testing Parameters

- Post RMF Seismic functional tests
- Loss-of-Coolant-Accident (LOCA) Test
- The LOCA#1 test was developed from the AP1000 requirements
- The LOCA 2 was developed utilizing input from various accident scenarios from legacy BWRs and PWRs as well as new generation plants and was developed for AP1000 Non Submersed Additional Accident and Modified MSIV scenarios

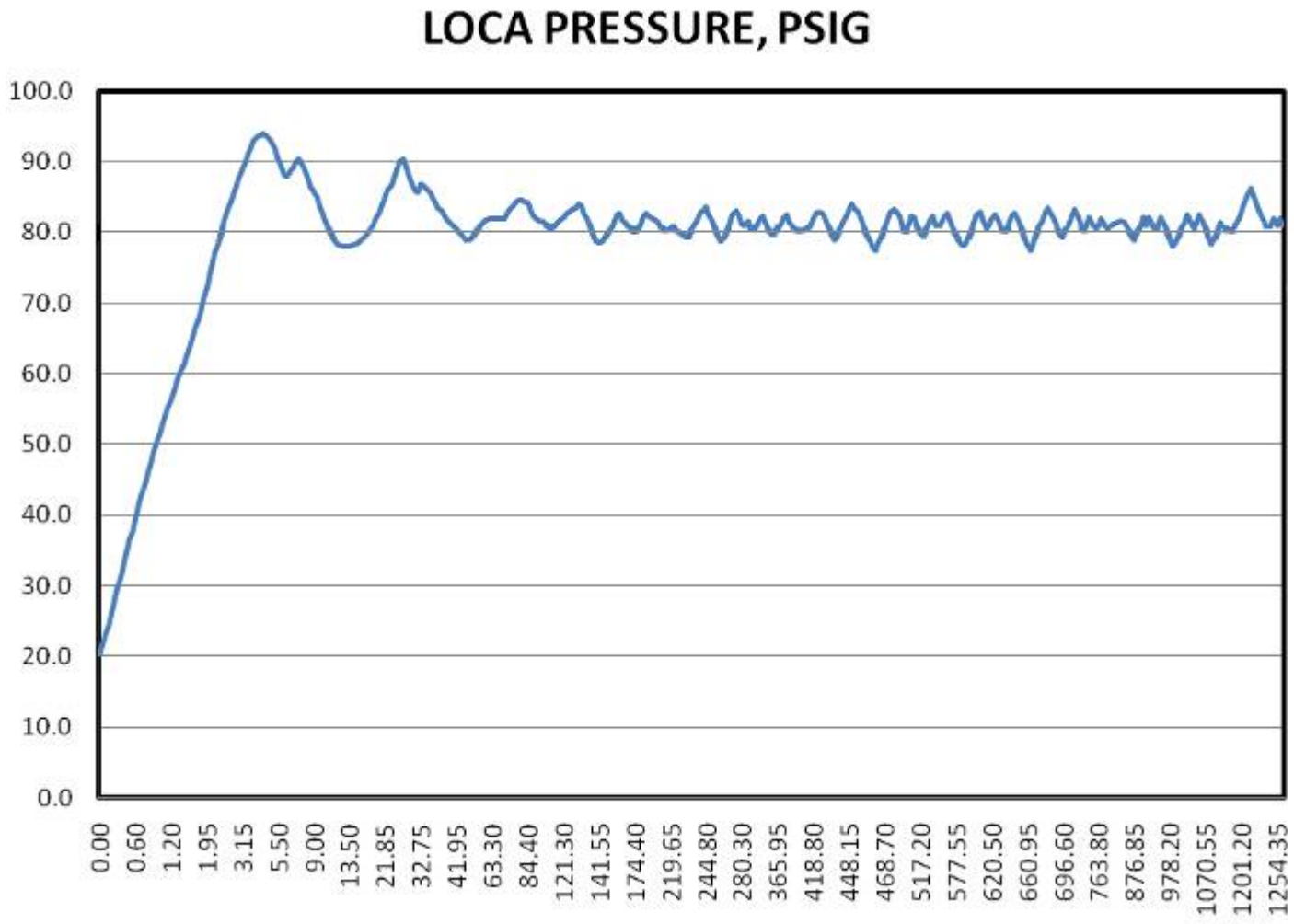
Testing Parameters

- Post Accident Thermal Aging
- The samples were post peak aged to simulate a 1-year post accident mission time.
- Post Accident Thermal Aging functional test
- Final test inspection

Actual LOCA Temperature Curve w/o Margin …. Max at 570F

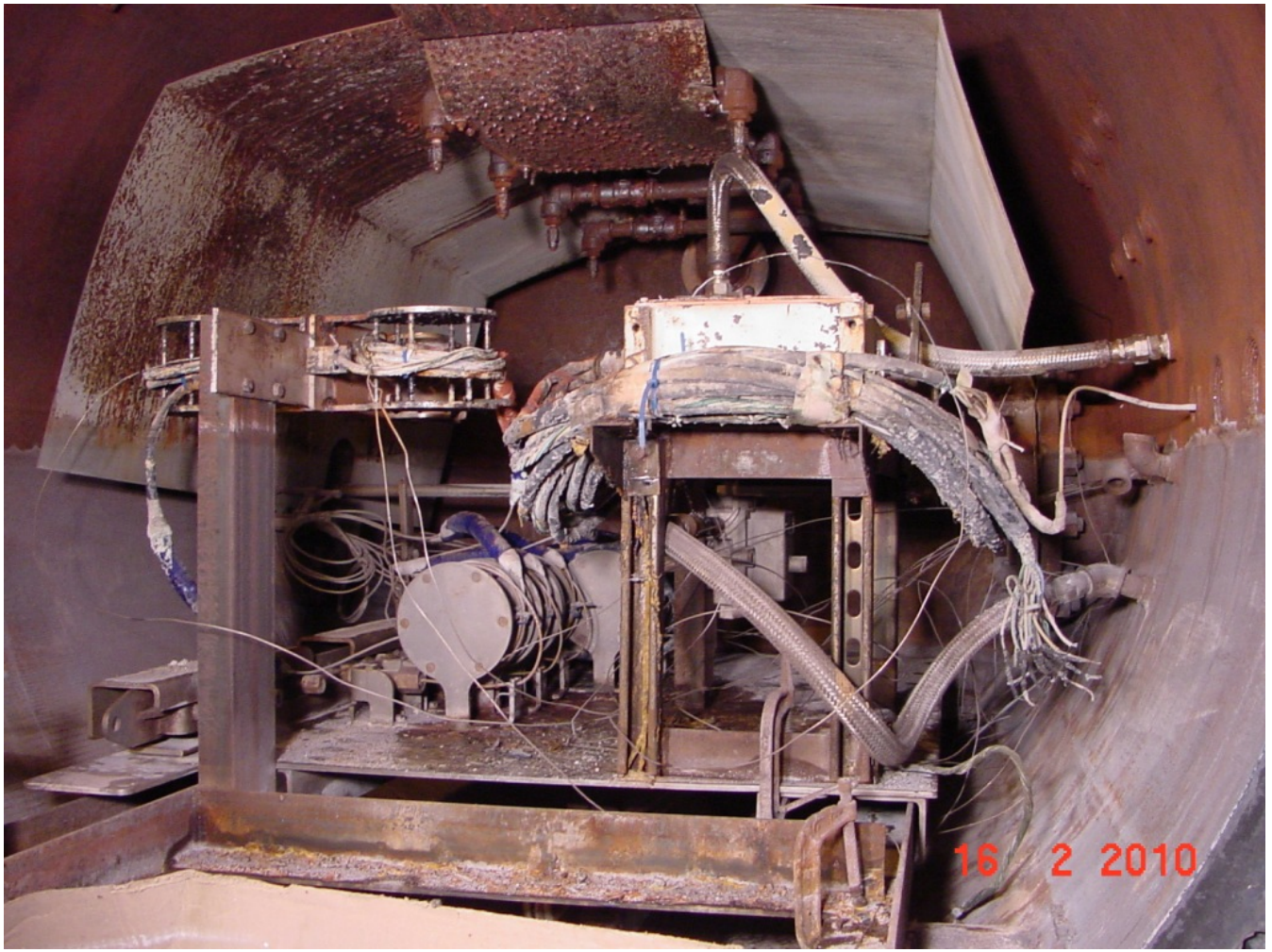


Actual LOCA Pressure Curve w/o Margin…. Max at 104 psi



Before LOCA Test

The Aftermath



Severe Caustics…. Commercial Switches

BOP Commercial Side Of Nuclear Plant

- Standard Discreet On/Off
- 4-20mA Transmitter with optional HART Communication Protocol
- Partial Stroke Testing/Emergency Shutdown (PST/ESD)
- FF, Profibus, Device Net, DN w/HART and ASi Protocols
- Severe or Standard
- Multi-dimensional answer to the complete needs of a Nuclear plant

Nuclear Proximity Position Sensors Benefits In Review

Nuclear Rated Proximity Position Sensors

- Containment
- Harsh Duty
- Mild/Seismic

- 60 year qualified life
- 1/4 the size
  and 1/10 the weight (7.5 ounces vs 4.5 lbs)
- No torque required to operate
- No unreliable lever arms to adjust
- High reliability at <u>low or high current</u>
- Modular Nuclear Valve Monitor w/Switches and Integral Junction
  - No need for a nuclear junction box – one mounting point
- COMPLETE 4-20 / Bus / and Discrete solutions for the BOP

Nuclear Proximity Position Sensors

Next Generation Technology for Today's Expanded Sensing Requirements

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