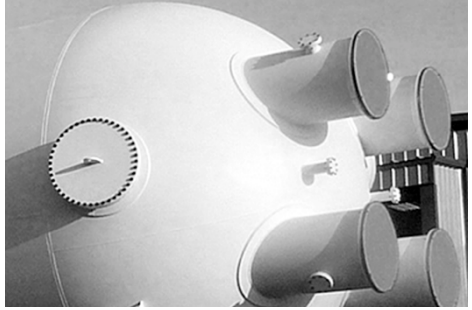
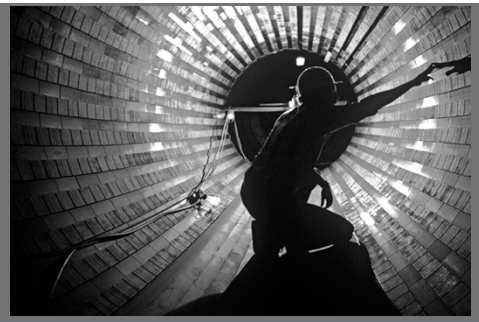
CURTISS-WRIGHT

Nuclear Division





Qualification Program of Curtiss-Wright Nuclear MSIV Electro-Hydraulic Operator

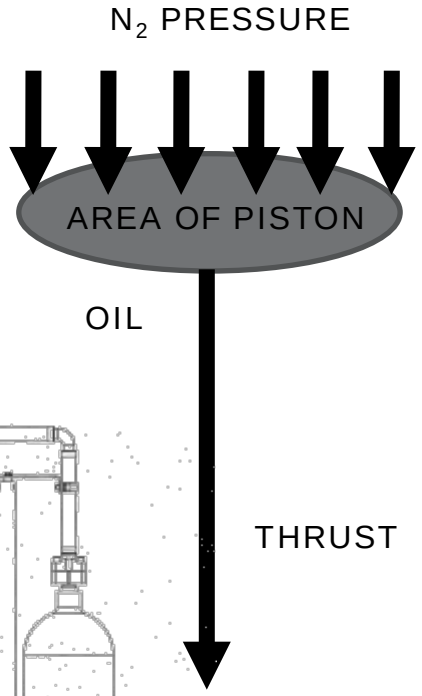
In accordance with IEEE382 and RCC-E

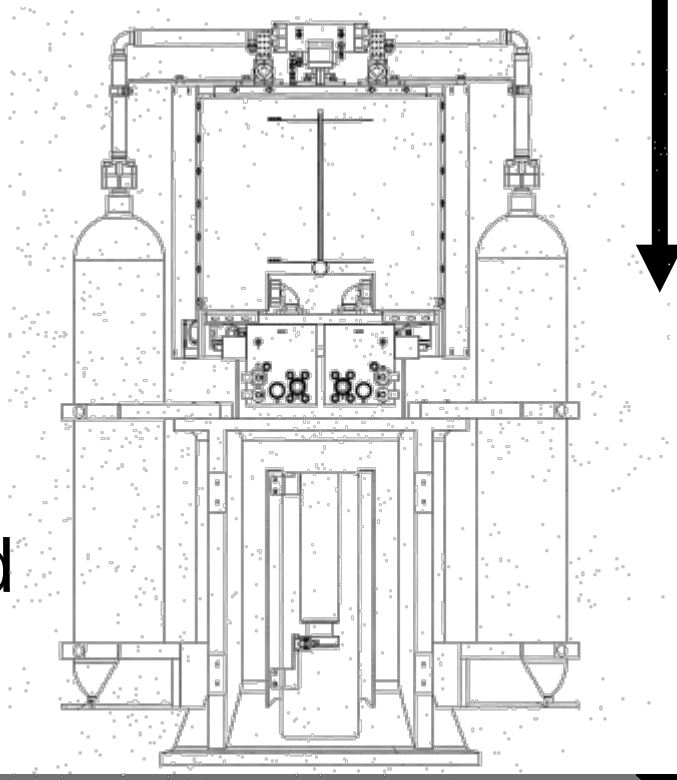
Introduction

- Curtiss Wright Nuclear – MSIV Electro Hydraulic Actuator
- Environmental and Seismic Qualification for US, EU and Chinese power plant designs
- Qualification Standards and Requirements
- Qualification Program
- Technical Challenges and Solutions

Design and Principle of Operation

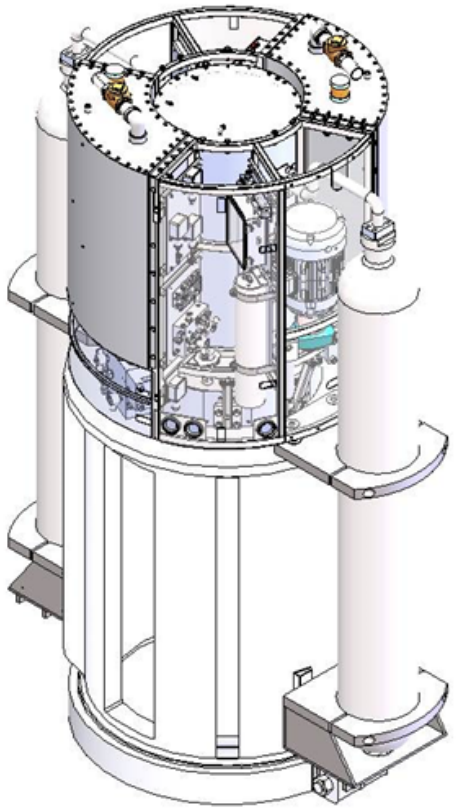
- Gas over oil design
- Independent dump manifolds
- Thrust – up to 500,000 lb
- On/off and modulating applications
- Modular and skid-mounted configurations





Common EHO Applications

- Main Steam Atmospheric Dump Valve (MSADV)
- Main Steam Isolation Valve (MSIV)
- Main Feedwater Isolation Valve (MFIV)
- Containment Isolation Valve
- Recirculating Feedwater Control (RFC)
- Control Room Air Damper

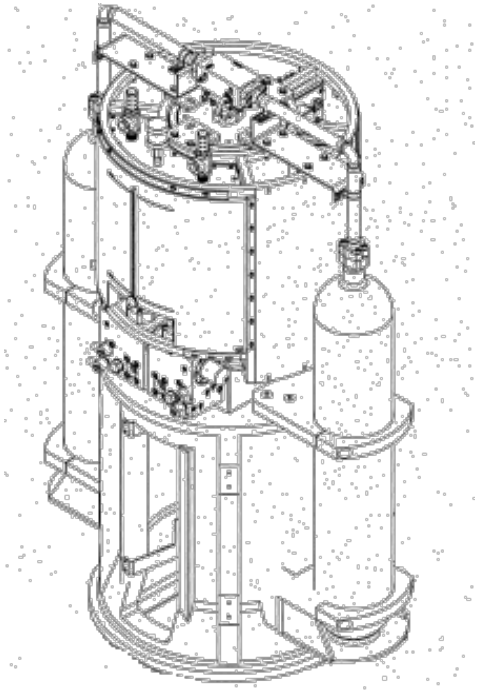


Qualification Requirements

- IEEE 382 – 1996
- RCC-E – 2005
- IEEE 323 – 1974/2003
- Customer Qualification Specifications

Qualification Program Outline

	Parameter Selected for Qualification
Baseline Functional	Selected performance parameters envelop the operating conditions specified (Section 5.1)
Thermal Aging and EMC	13.2 years at 131°F (55°C) (Section 5.2 and 5.7)
Radiation Aging	1.1×10^5 Gy (TID) (Section 5.3)
Cycle Aging	3300 cycles (Section 5.4)
Pressure Cycle	Atmospheric (Section 5.5)
Vibration Aging	0.75g (5-200-5 Hz) (Section 5.6)
DBE Radiation Exposure	γ-rad: 543 Gy β-rad: 2783 Gy (Section 5.8)
Seismic Simulation	6.6g (Section 5.9)
DBE Environment Test	Temperature Profile (See Figure 3 in Section 5.10)



Curtiss-Wright Nuclear MSIV Electro-Hydraulic Operator

Baseline Functional Test – Enertech, Brea

- Proper switch action
- Solenoid Valve action
- Opening/closing speed
- Output thrust based on the reduced pressure (reduced motive power)

Thermal Aging – NTS Labs, Santa Clarita CA

- Thermal Aging (Completed)
  - 131°F for 12 years
  - 10% margin included → 13.2 years
  - Arrhenius Equation

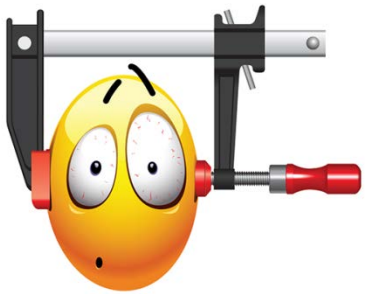
External Pressure & Radiation

Radiation Aging

- TID 192 Mrad (previous EHO qualifications)
- 192 Mrad >> customer requirements

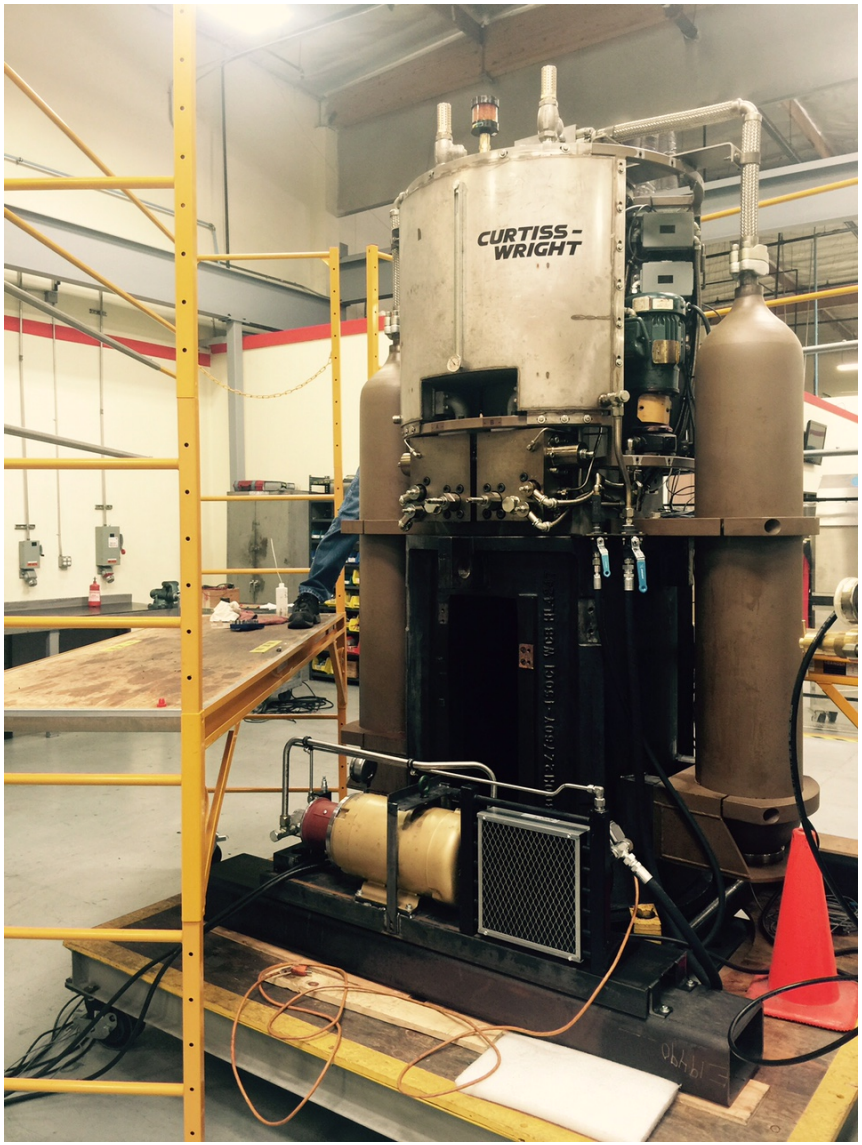
External Pressurization Cycles (Not Applicable)

- Previous EHO Qualifications for Inside Containment

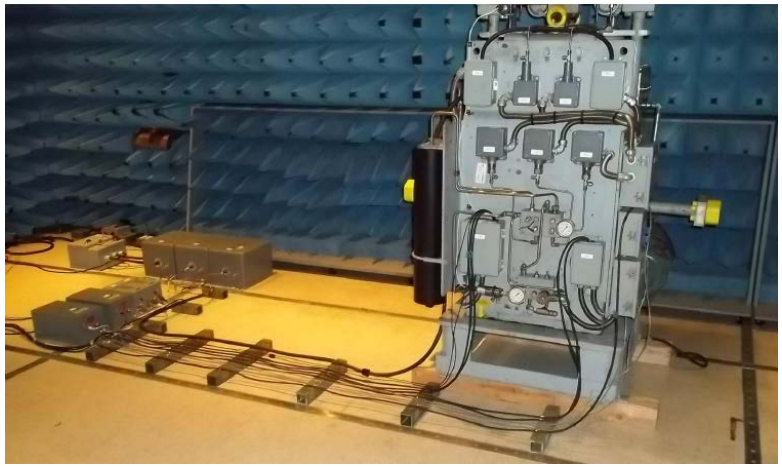


Wear Aging – Enertech, Brea CA

- Wear Aging
  - IEEE382 suggests minimum of 2000 cycles
  - Total number of cycles 3300 (3000+10% margin)
  - Full pre-charge – more conservative



EMC TUV Labs, San Diego CA



MIL-STD-461E

Emission Testing

- CE101: 25 Hz-10 kHz
- CE102: 10 kHz-2 MHz
- RE101: 25 Hz-100 kHz
- RE102: 2 MHz-10GHz

Susceptibility Testing

- CS101: 25Hz-150kHz
- CS114: 10kHz-30MHz
- RS101: 25Hz-100kHz
- RS103: 30 MHz-10GHz
- CS115: 2A
- CS116: 5A，10kHz-100MHz

IEC 61000-4

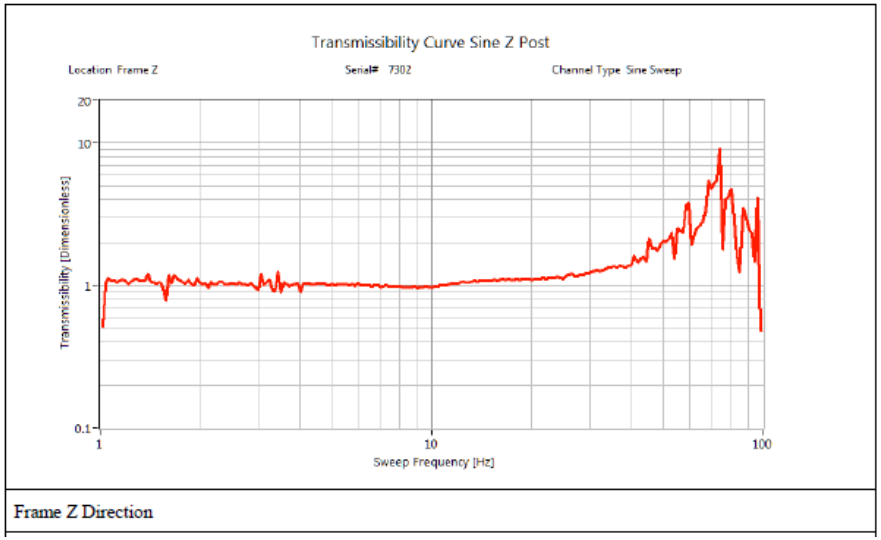
- 4-2: E.S.D., Level 4: 8kV contact discharge, 15kV air discharge
- 4-4: E.F.T., Power: level 4 (4kV), Signal: level 4 (2kV)
- 4-5: Surge, Combination Wave, Power: level 4 (4kV), Signal: level 3 (2kV)
- 4-12: Surge, 100kHz Ring Wave, Power: level 4 (4kV), Signal: level 3 (2kV)

Seismic Tests – Areva US Technical Center, Lynchburg VA

- Requirements
  - Resonance Search
  - Vibration Aging - 5-200-5 Hz at 0.75g
  - OBE – 4.4g
  - SSE – 6.6g

Seismic – Vibration Aging

- 90 minutes in each axis
- 0.75 g
- Max peak to peak disp. 0.025”
- 5-200-5 Hz at 2 oct/min
  - Test table limitation – 100 Hz
  - Test duration extended to 150 minutes in each axis from 5-100-5 Hz per
- Actuator cycled every 15 mins



Seismic – Yoke Welded to the Test Fixture

Seismic – Actuator Mounted on the Vibration Table

Seismic – RIM Curve

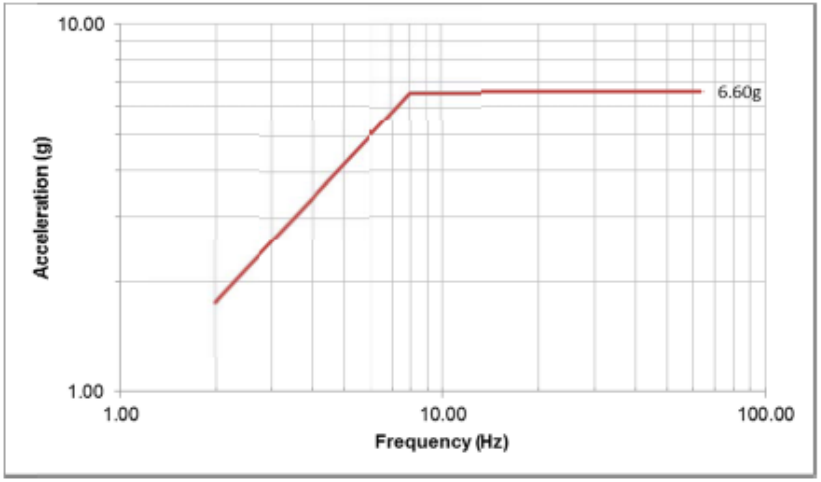


Figure 3-1: Seismic qualification required input motion (RIM)

Frequency (Hz)	Acceleration (g)
2.00	1.76
2.52	2.20
3.17	2.73
4.00	3.40
5.04	4.24
6.35	5.28
7.99	6.60
8.00	6.60
10.08	6.60
12.70	6.60
16.00	6.60
20.16	6.60
25.40	6.60
32.00	6.60
35.92	6.60
40.32	6.60
45.25	6.60
50.80	6.60
57.02	6.60
64.00	6.60

Seismic – OBE

- 2 Sweeps in each axis 2-64-2 Hz at 2/3 RIM at 1 oct/min
  - 1 sweep with actuator open
  - 1 sweep with actuator closed
  - Periodic verification/inspection of the structure/components

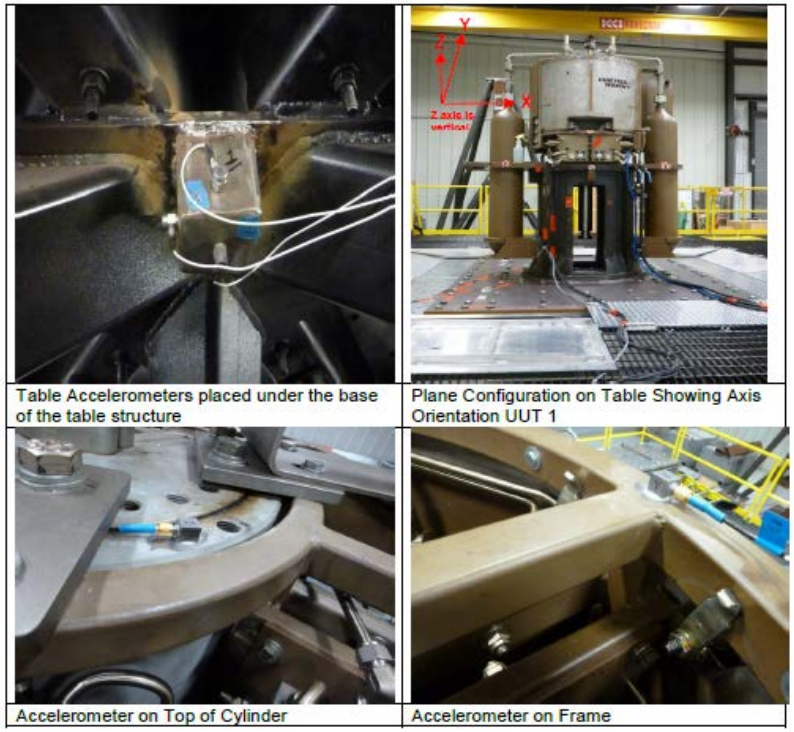
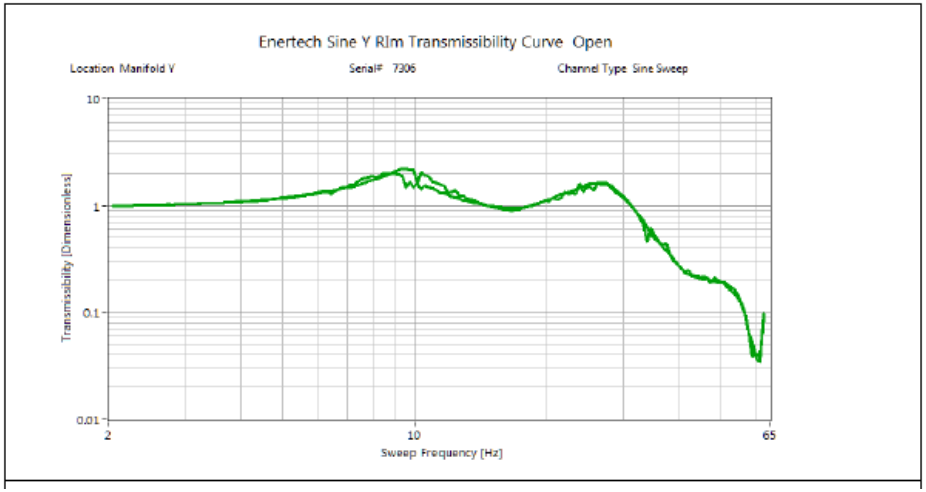


Table Accelerometers placed under the base of the table structure

Plane Configuration on Table Showing Axis Orientation UUT 1

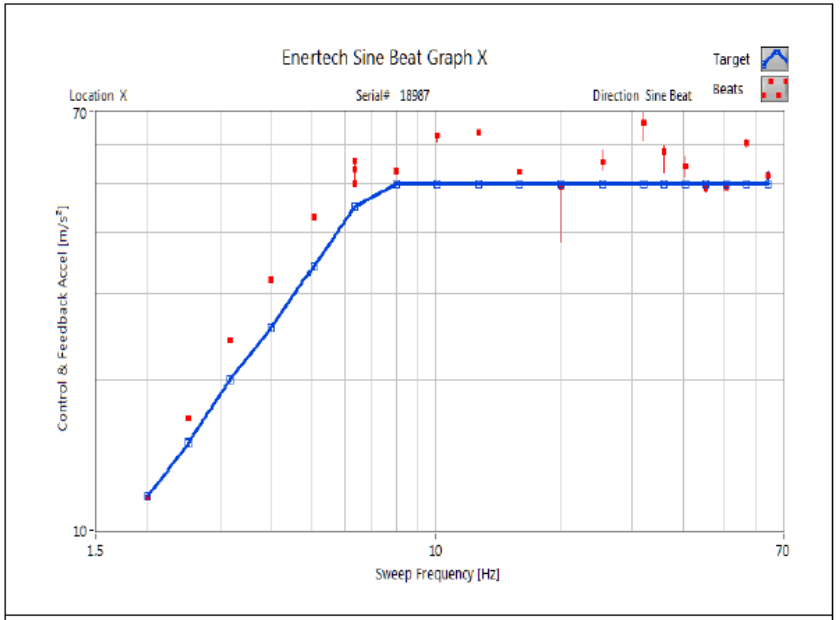
Accelerometer on Top of Cylinder

Accelerometer on Frame



Seismic SSE (Line Mounted)

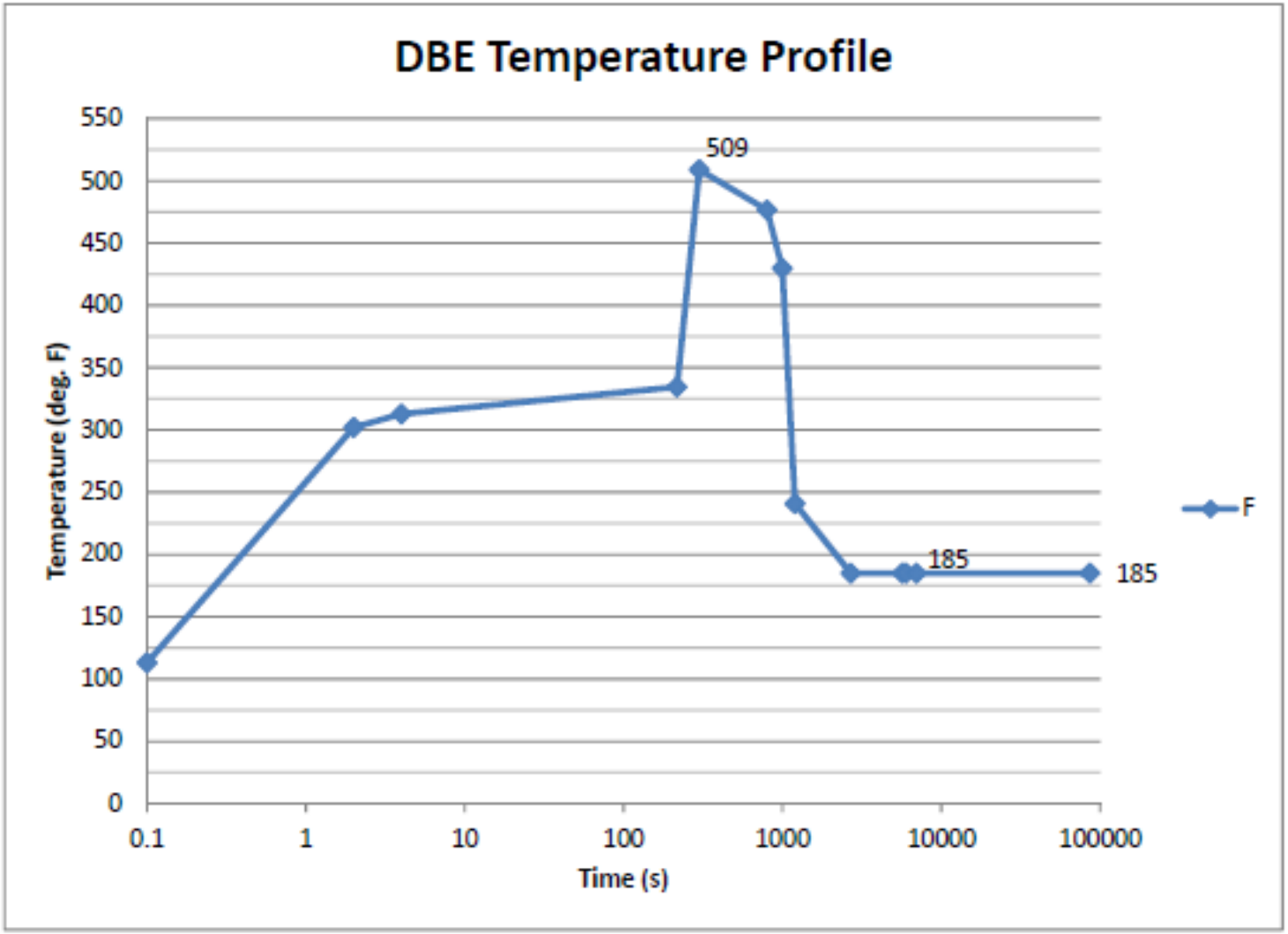
- Single Frequency Sine Beats
  - 2-32 Hz at every 1/3 octave
  - 32-64 Hz at every 1/6 octave
- 12-15 oscillations per beat
- Peak acceleration (RIM curve)
- Gas – low pre-charge to simulate operation under load



SSE Sine Beat X Direction (Table Limits)

DBE Environmental Test Setup

DBE – Thermal



DBE Environmental Test Setup

Qualification Challenges

- Seismic Test
  - Frequency change from 2-32 Hz (IEEE382) to 2-64 Hz
  - Cast iron motor casing failure
  - Test table limitations
  - Maximum achieved SSE acceleration is 5g
  - Vibration aging – table limit was 100 Hz at 10,000 lbm payload
- DBE Environmental
  - 300°F in 2 seconds, 510°F in 5 mins

Solutions to the Challenges

- Seismic
  - Structural Components/Supports – FEA
  - Electromechanical Components – additional seismic test to 6.6g
  - IEC60068-2-6 to justify longer time and lower frequency
  - Dead weights to continue testing
  - Environmental DBE
  - Subject actuator to higher temperature for longer duration

Haykaz Mkrtchyan, PE