RadICS System EQ Testing: Results and Lessons Learned

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11th International Workshop on Application of Field Programmable Gate Arrays in Nuclear Power Plants | October 8-11, 2018 | Dallas, USA

Agenda

- Introduction
- Qualification testing of the RadICS Platform
- Conclusions

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Introduction

Introduction (what's new since 2017)

- During 2017-2018 Radiy won 9 tenders to supply I&C systems for Nuclear Power Plants in Ukraine
- As per signed contracts Radiy will deliver to the customers 19 I&C systems including:
  - ESFAS
  - Reactor Power Control and Limitation System
  - Nuclear and Conventional Island Control Systems
- Class 1E systems will be based on RadICS Platform
- Class Non 1E systems will be based on RadICom Platform

Introduction (Modernization experience)

Radiy implemented > 100 digital I&C modernization projects

NPP I&C before upgrade by Radiy

NPP I&C after upgrade by Radiy

Introduction (US NRC Licensing effort)

- Topical Report submitted on Sep 21, 2016
- Acceptance review letter received on Apr 5, 2017
- Topical Report review started in Aug, 2017
- Equipment qualification testing completed in Mar, 2018
- Regulatory audit by US NRC completed in Apr, 2018

U.S. NRC

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United States Nuclear Regulatory Commission
Protecting People and the Environment

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Qualification testing of the RadICS Platform

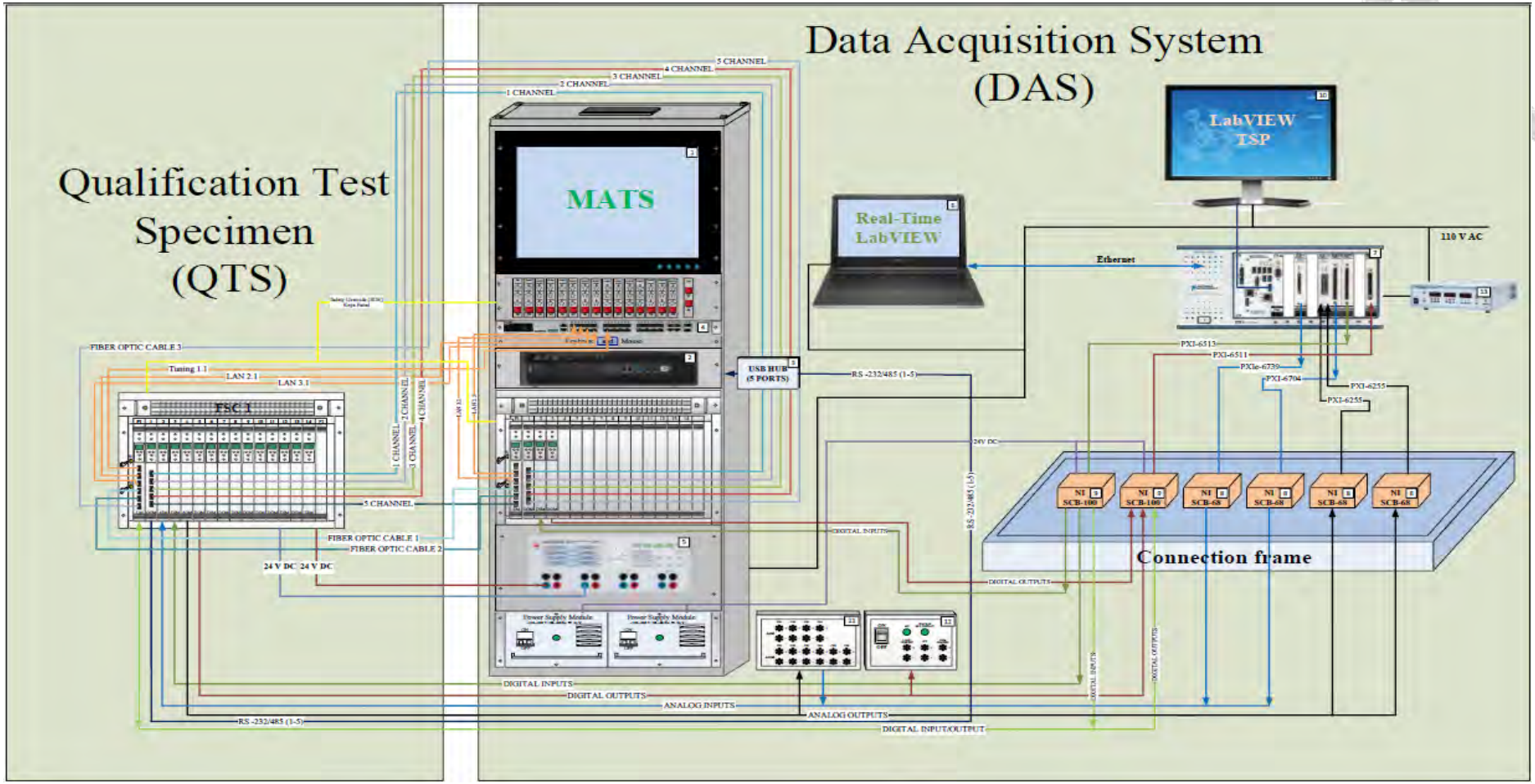
Preparation for EQ (1)

- Design and Manufacturing of Qualification Test Specimen (QTS) and Data Acquisition System (DAS)
- Selection and QA Audit (10 CFR Appendix B) of EQ Laboratory
- EQ Procedures Development
  - Radiation (by analysis, 1000 Rad)
  - Environmental
  - Seismic
  - EMI/RFI

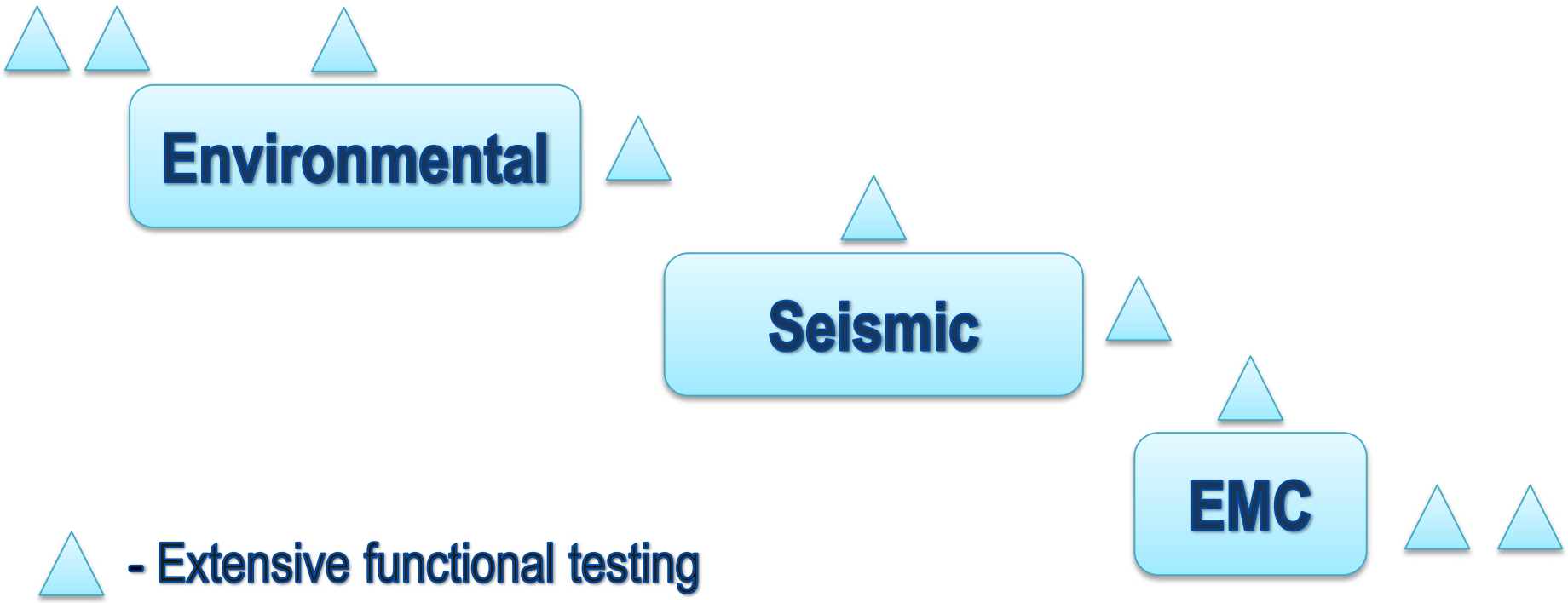
Preparation for EQ (2)

- Functional Test Procedures Development
  - Operability test
  - Prudency
- Running preliminary EQ Tests
  - Environmental (@ Radiy)
  - Seismic (@ Radiy)
  - EMI/RFI (Molniya @ Radiy)

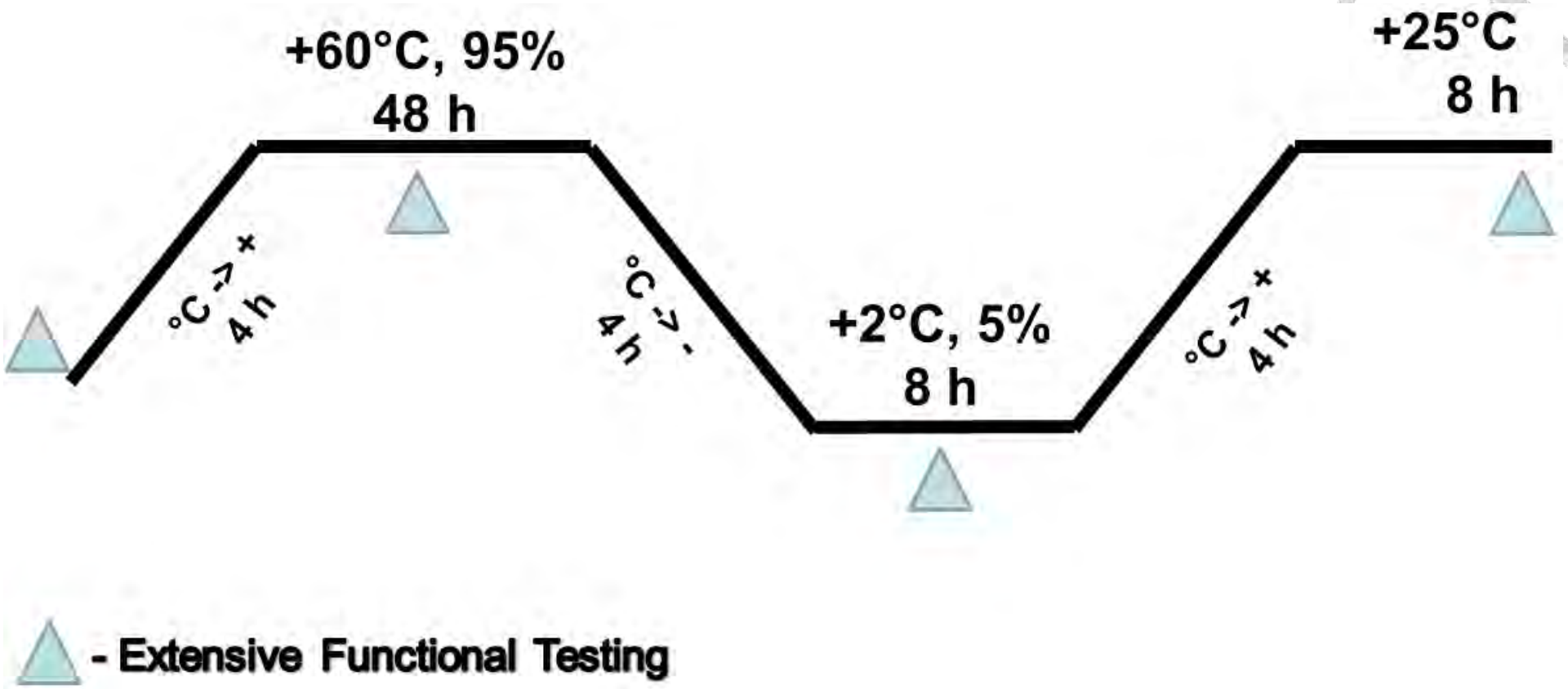
Qualification testing of the RadICS Platform (QTS configuration)



Qualification testing of the RadICS Platform (Qualification Plan was based on EPRI TR-107330)



Qualification testing of the RadICS Platform (Environmental test profile)



Qualification testing of the RadICS Platform (Environmental testing)

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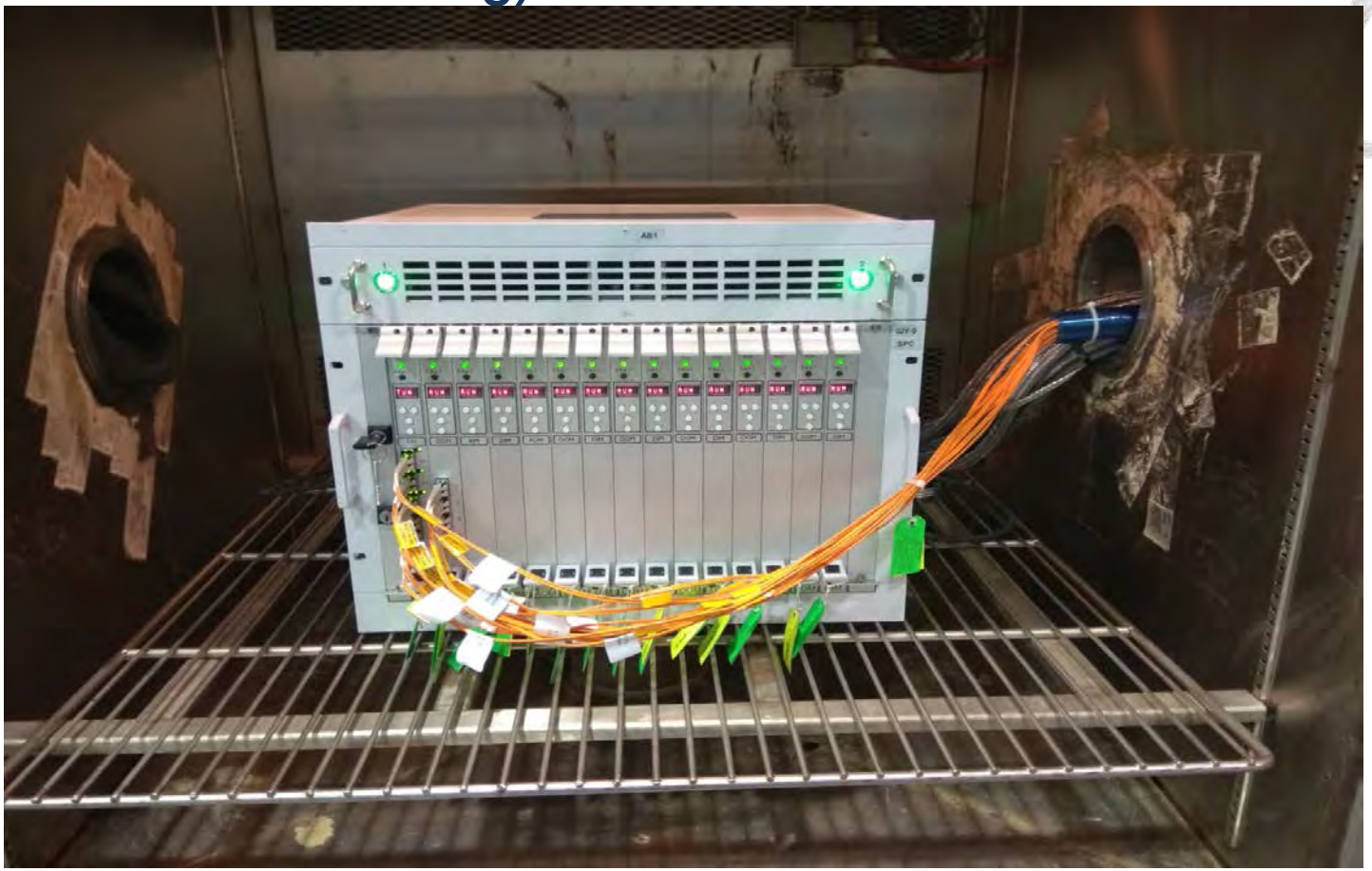
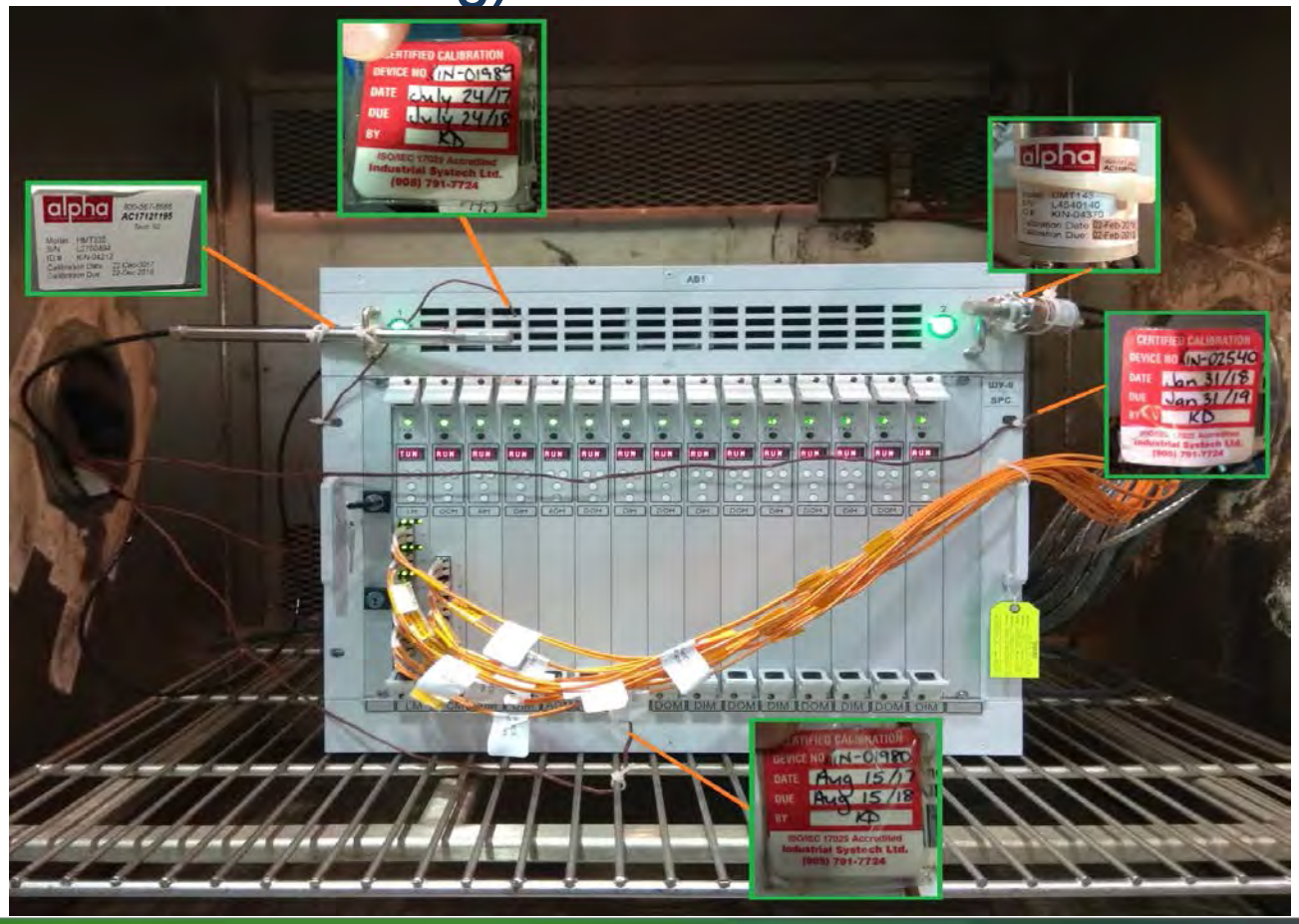
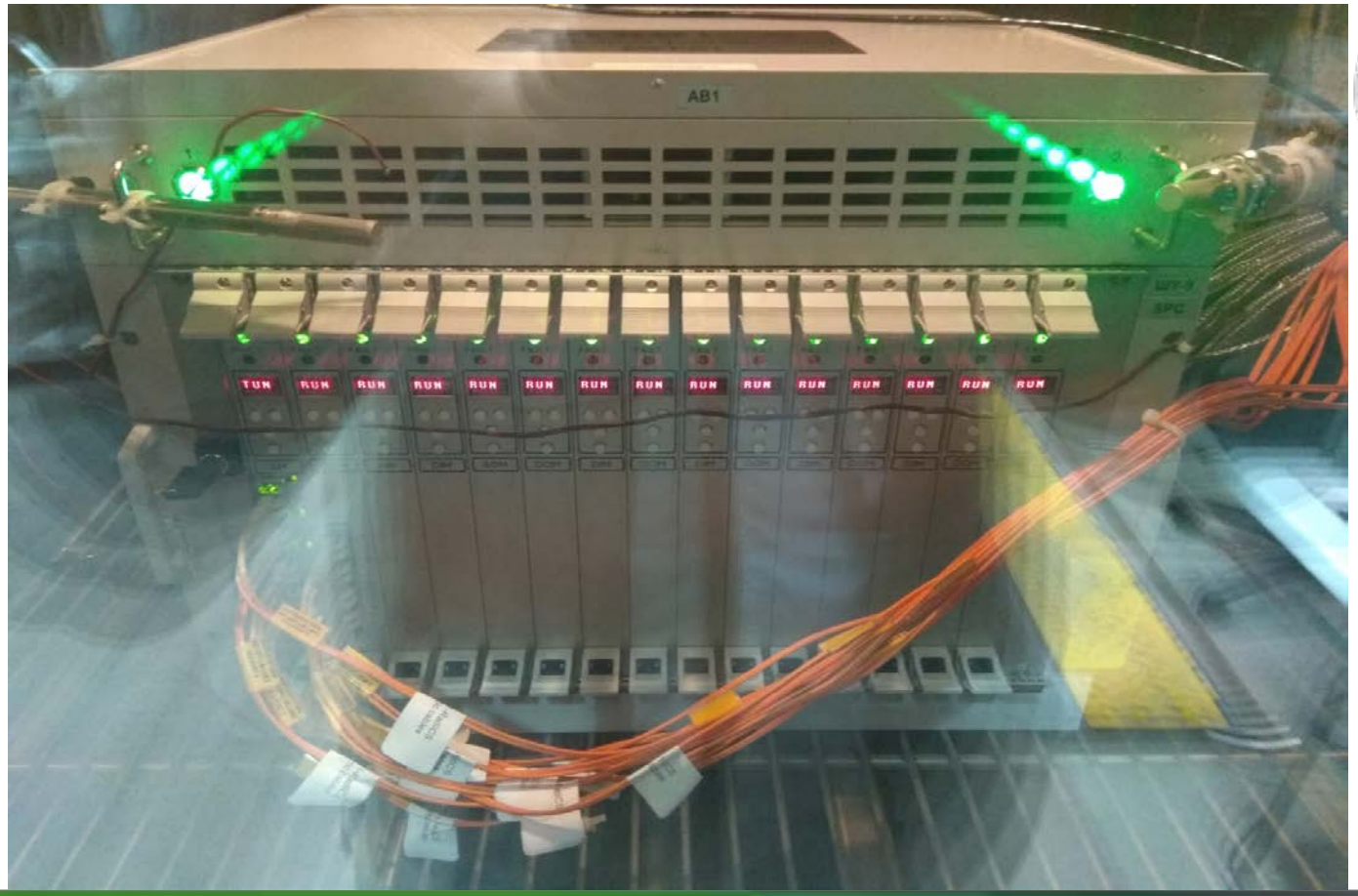


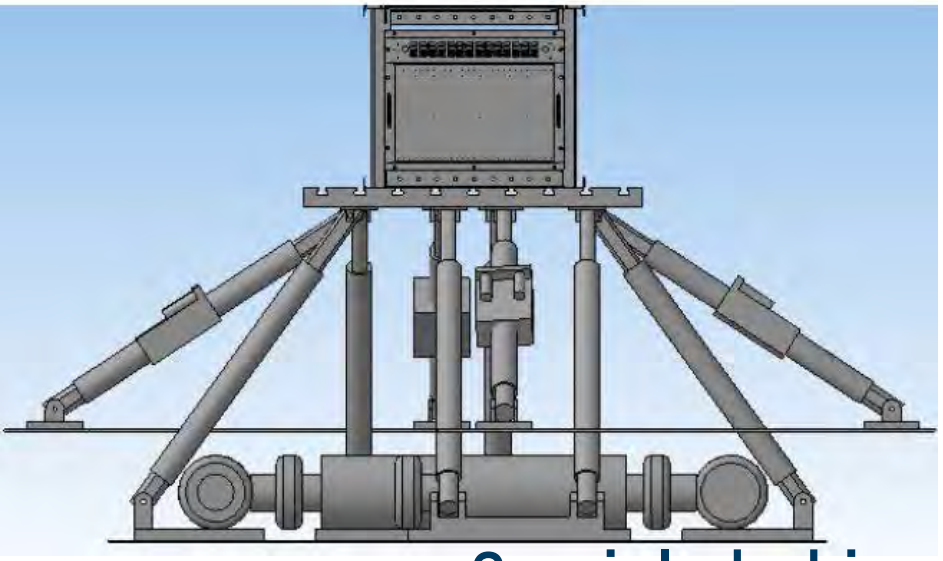
Qualification testing of the RadICS Platform (Environmental testing)

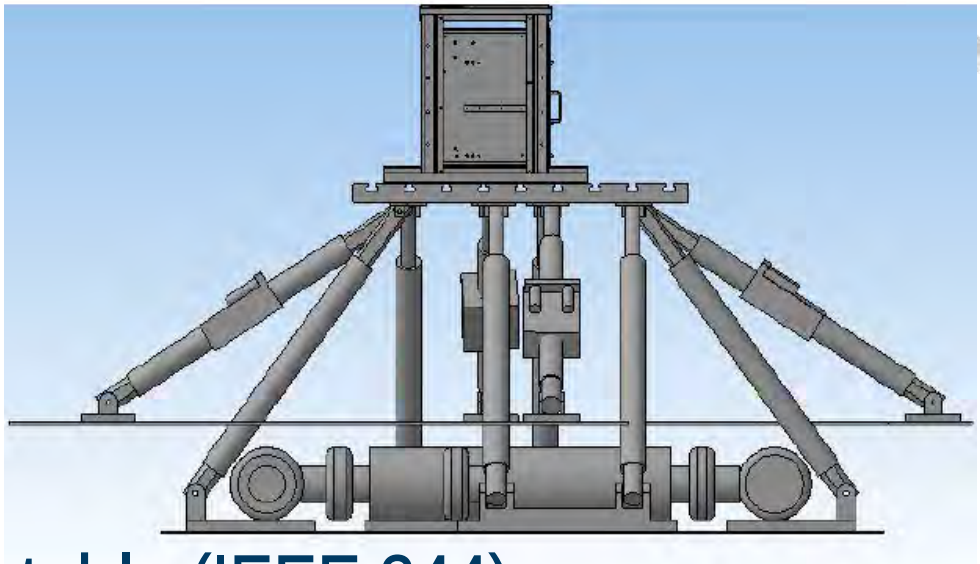


Qualification testing of the RadICS Platform (Environmental testing)



Qualification testing of the RadICS Platform (Seismic testing configuration)



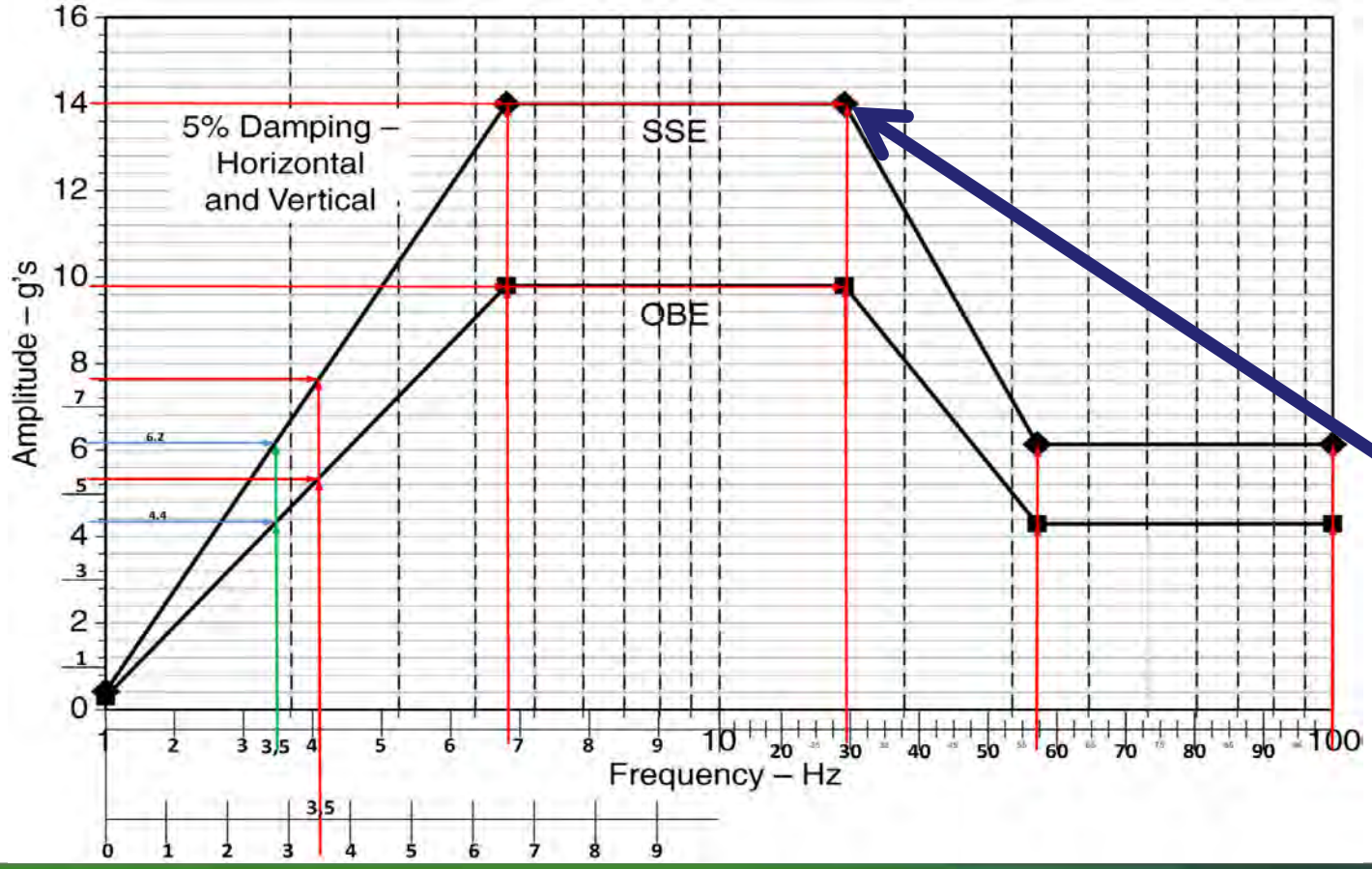


3-axial shaking table (IEEE 344)

5 runs of OBE

1 of SSE

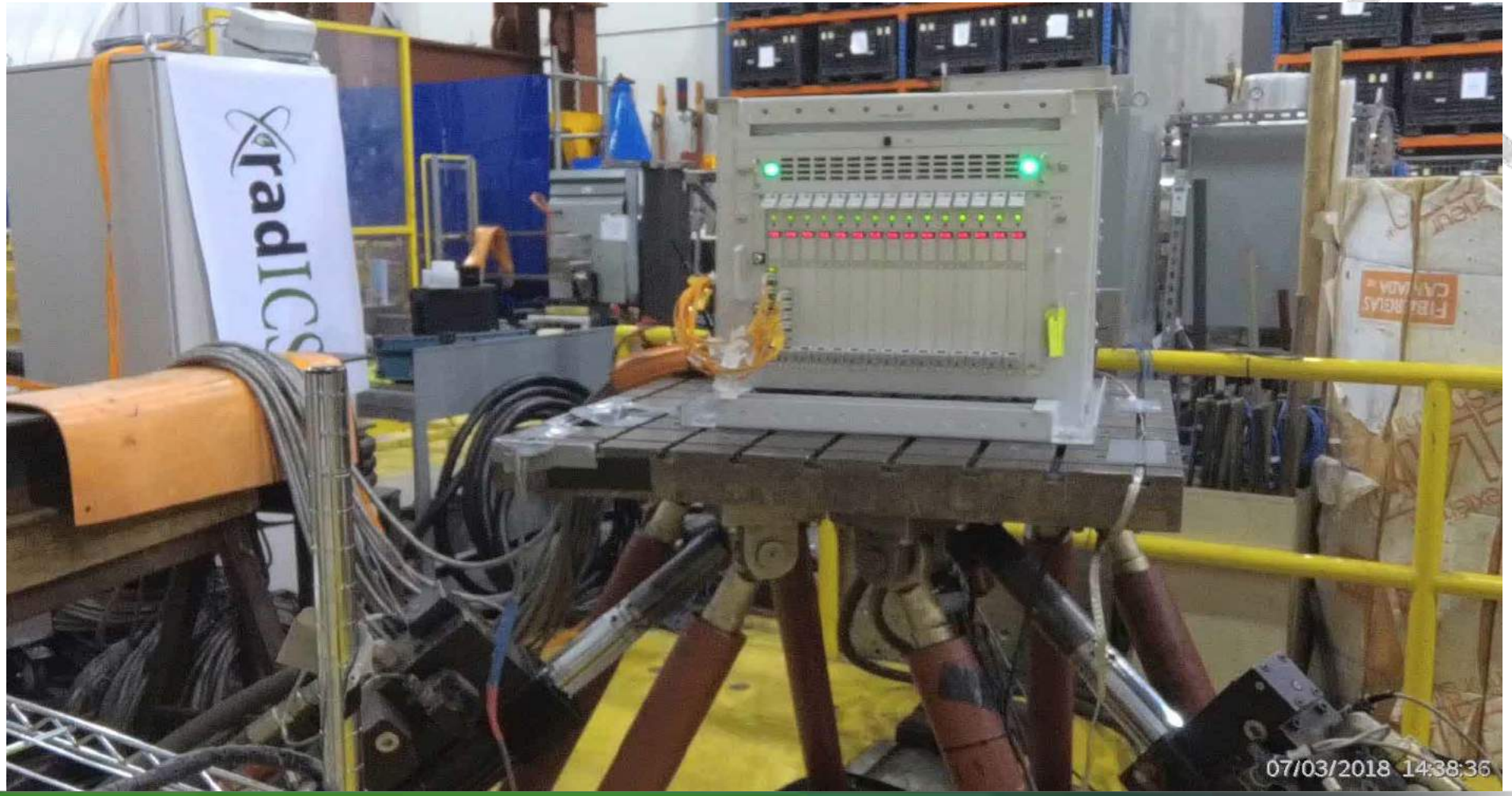
Qualification testing of the RadICS Platform (Seismic testing profile)



Max acceleration = 14 g

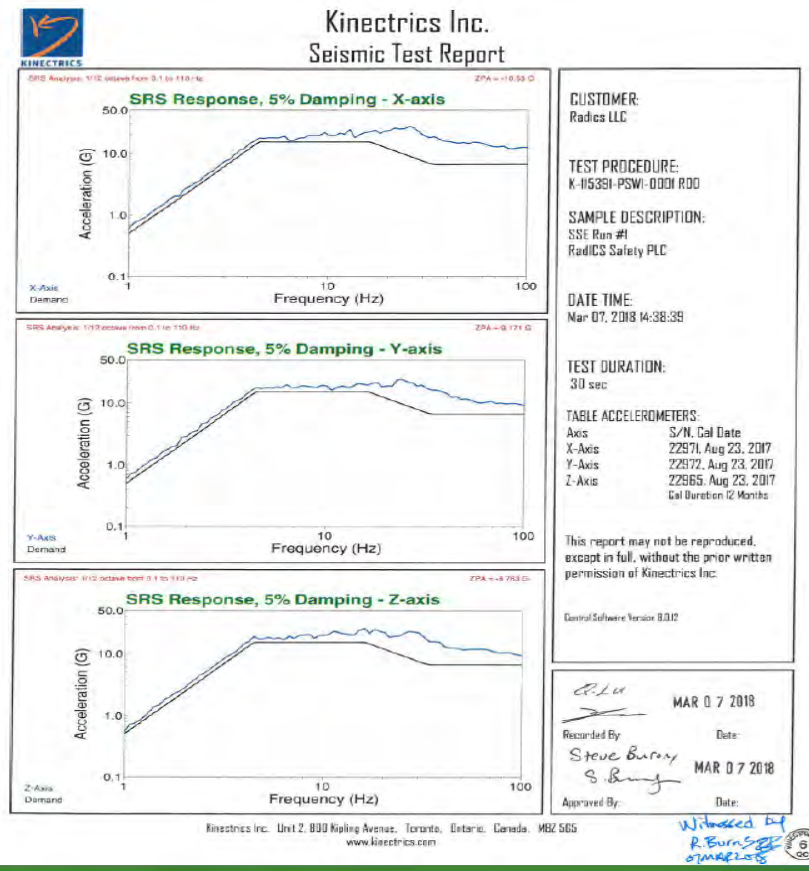
Qualification testing of the RadICS Platform (Seismic testing)

Qualification testing of the RadICS Platform



Qualification testing of the RadICS Platform (Seismic testing results)

SSE Testing Report



Kinectrics Inc.
Seismic Test Report

SRS Response, 5% Damping - X-axis

SRS Response, 5% Damping - Y-axis

SRS Response, 5% Damping - Z-axis

Acceleration (G)
Frequency (Hz)

CUSTOMER:
Radics LLC

TEST PROCEDURE:
K-05391-PSWI-0001 R00

SAMPLE DESCRIPTION:
SSE Run #1
RadICS Safety PLC

DATE TIME:
Mar 07, 2018 14:38:39

TEST DURATION:
30 sec

TABLE ACCELEROMETERS:

Axis	S/N, Cal Date
X-Axis	22971, Aug 23, 2017
Y-Axis	22972, Aug 23, 2017
Z-Axis	22965, Aug 23, 2017

Cal Duration 12 Months

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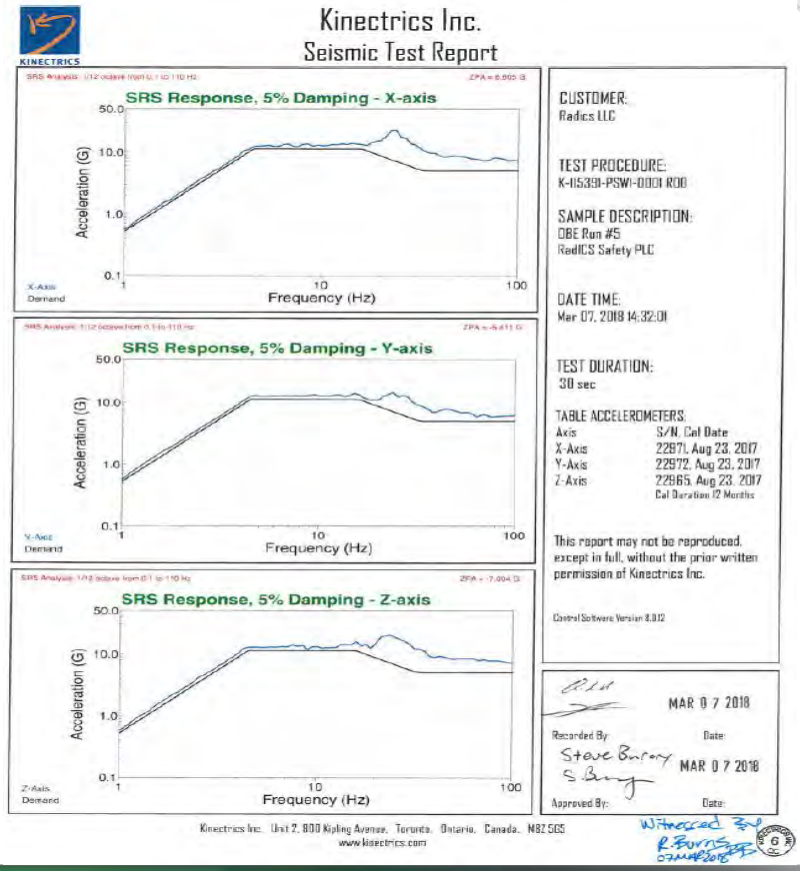
Control Software Version 8.012

MAR 0 7 2018
Recorded By: Steve Burns — Date: MAR 0 7 2018
Approved By: — Date:

Witnessed by R. Burns 07MAR2018

Kinectrics Inc. Unit 2, 800 Kipling Avenue, Toronto, Ontario, Canada, M8Z 5G5
www.kinectrics.com

OBE Testing Report



Kinectrics Inc.
Seismic Test Report

SRS Response, 5% Damping - X-axis

SRS Response, 5% Damping - Y-axis

SRS Response, 5% Damping - Z-axis

Acceleration (G)
Frequency (Hz)

CUSTOMER:
Radics LLC

TEST PROCEDURE:
K-05391-PSWI-0001 R00

SAMPLE DESCRIPTION:
OBE Run #5
RadICS Safety PLC

DATE TIME:
Mar 07, 2018 14:32:01

TEST DURATION:
30 sec

TABLE ACCELEROMETERS:

Axis	S/N, Cal Date
X-Axis	22971, Aug 23, 2017
Y-Axis	22972, Aug 23, 2017
Z-Axis	22965, Aug 23, 2017

Cal Duration 12 Months

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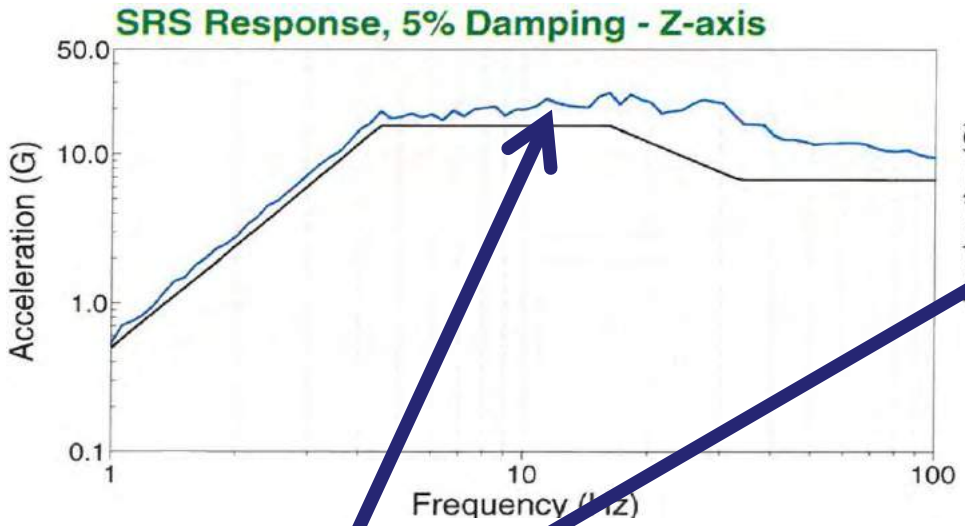
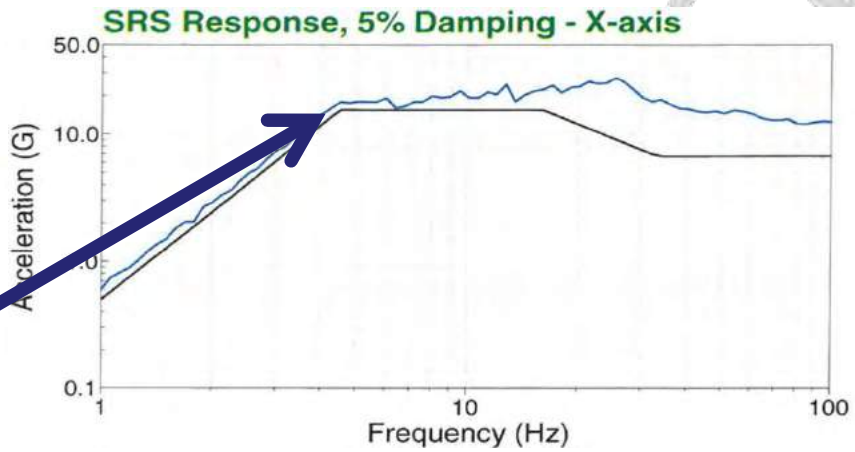
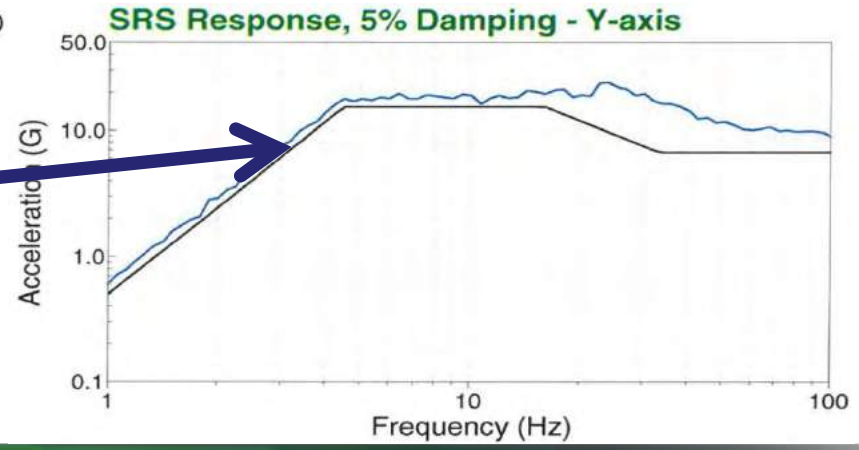
Qualification testing of the RadICS Platform (Seismic testing results)







Safe Shutdown Earthquake
Max acceleration > 14 g

Qualification testing of the RadICS Platform (EMC testing profile 1)

#	Source of Qualification Test Specification	Test Level
1	MIL-461E, CE101 Conducted Emissions, Low Frequency, AC and DC Power Leads	30 Hz to 10 kHz
2	MIL-461E, CE102: Conducted Emissions, High Frequency, AC and DC Power Leads	10 kHz to 2 MHz
3	MIL-461E, RE101: Radiated Emissions, Magnetic Field, QTS Surfaces and Leads	30 Hz to 100 kHz
4	MIL-461E, RE102: Radiated Emissions, Electric Field, Antenna Measurement	2 MHz to 1 GHz
5	IEC 61000-4-6: Conducted Susceptibility, Induced RF Fields, Power/Signal Leads	Level 3
6	IEC 61000-4-16: Conducted Susceptibility, Common Mode Disturbance, Power/Signal Leads	Level 3
7	IEC 61000-4-8: Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure	Continuous pulses, Short duration pulses: Class 4

Qualification testing of the RadICS Platform (EMC testing profile 2)

#	Source of Qualification Test Specification	Test Level
8	IEC 61000-4-9: Radiated Susceptibility, Magnetic Field, Pulsed	Class 4
9	IEC 61000-4-10: Radiated Susceptibility, Magnetic Field, Damped Oscillatory	Class 4
10	IEC 61000-4-3: Radiated Susceptibility, High Frequency, Antenna Exposure	Level 3
11	MIL-STD-461 E – RS103: Radiated Susceptibility, High Frequency, Antenna Exposure	Level 3
12	IEC 61000-4-4	Level 3 :Power Leads, Signal Leads
13	IEC 61000-4-5	Level 2
14	IEC 61000-4-12	Short duration pulses: Class 4
15	IEC 61000-4-2	Contact/Air Discharge Level 1,2,3,4;
16	EPRI TR-107330 Class 1E to Non-1E isolation	250 VAC (± 10 VAC) at 60 Hz or 250 VDC (± 10 VDC)

Qualification testing of the RadICS Platform (EMC testing MIL-STD-461E, CE101)

Qualification testing of the RadICS Platform (EMC testing MIL-STD-461E, RE101)

EQ Challenges

- Working 10000 km away from home. Resources on-site were limited.
- Huge amount of paper work (QA Forms, Check List)
- Some EMI/RFI were not preliminary performed in Ukraine
- EMI/RFI and Seismic/Enviromental were conducted in different locations. Packing\unpacking, transportation of the QTS/DAS

EQ Solutions

- Planning, Planning, Planning ….
- Put the right people to do the job
- Preliminary EQ helped to identify and fix potential problems
- Automation of the Functional Testing

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Conclusions

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- Regulatory audit by US NRC completed in Apr, 2018

Safety Evaluation Report is expected to be issued early 2019

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Thank you for your attention!

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