Argentine´s Experience and Status in Environmental Qualification

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Overview

- Is it EQ needed for Research Reactors?
- Research reactor´s regulatory framework and technical standards
- Non-formal qualifications
- Environmental qualification programme for research reactors
- OPAL, Australian research reactor case
- Research Reactors in the world
- CECAN – Nuclear Environmental Qualification Center
- Environmental Qualification Programme for NPP
- Commercial grade dedication
- Resources, Capabilities and Skills

Is it EQ needed for Research Reactors?

There is not a unique response, as…

Design Requirements over Research Reactor Safety Related Systems typically ask for the compliance with:

- Single failure,
- Redundancy,
- Independence, and
- Fail safe design

and Regulatory requirements, in general, are in accordance with the commensurate risk. As an example, a reference of a paragraph of NUREG 1537 part 1, Chapter 7, Instrumentation and Control Systems states:

> *"…most non-power reactors can be designed and operated to pose acceptably small or insignificant risk to the public without isolating or separating the RPS from other subsystems."*

On the other side, Argentine´s Regulatory Standards fixes more rigorous requirements independently of the potential risk, but,

> in questions of Environmental Qualification, most of the National Regulatory Bodies and IAEA Safety Standards mention almost nothing regarding to EQ requirements over Research Reactor Safety Related Systems.

Nevertheless, during the last years, started a tendency to require more rigorous compliance with the set of safety requirements for Research Reactor Safety Related Systems. These requirements, nowadays, are closer to what is required for NPPs.

In this line, The new update of IAEA Safety of Research Reactors, Safety Standard Series NS-R-4-2005 for the first time will include as a new requirement for the …"*qualification of items important to safety in research reactor facilities*"

So, new projects shall include a Qualification Programme for all safety related systems of the facility.
The same shall be applicable to refurbishment projects.

Non-formal qualifications

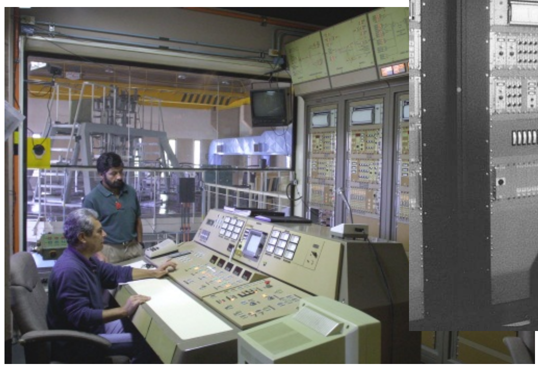
INVAP performed non-formal qualifications during its first research reactor projects,

- RA-6, 1982, Argentina,
- RP-10, 1988, Peru,
- NUR, Argelia 1989,
- RA-8, Argentina, 1997, and
- ETRR-2, Egypt, 1997.

During the implemetation of those projects, qualification was done mainly as seismic and temperature and humidity type tests.

ETRR-2

RA-6



RP-10

NUR

RA-8

Environmental qualification programme for research reactors
OPAL, Australian research reactor case

In 2003 INVAP developed its first Environmental Qualification Programme for Research Reactors.

The EQ programme was developed under the frame of IEEE Class 1E Standards. It was applied during the execution of OPAL project.

More than 110 components were Environmentally Qualified mainly through Type Testing.
Most of the components were located in mild environment.
Only a few of them were located in areas exposed to ionization radiation, mainly gamma flux. In these cases were necessary to apply pre-ageing until obtain the equivalent fluence that simulate the actual case.

OPAL, 2006

Research Reactors in the world

To date, some 768 research reactors have been built, and of these, 246 reactors in 56 countries continue to operate. However, nearly two-thirds of the world's operating research reactors ore now over 40 years old. Many of them received some refurbishment during their service life but is still still pending the modernization of safety related systems that shall comply with the newest requirement in terms of qualification.

Status	Developed Countries	Developing Countries	All Countries
OPERATIONAL	157	89	246
TEMPORARY SHUTDOWN	13	6	19
UNDER CONSTRUCTION	3	3	6
PLANNED	4	8	12
SHUT DOWN	119	21	140
DECOMMISSIONED	318	25	343
CANCELLED	4	4	8
TOTAL	618	156	774

IAEA reference

CECAN – Nuclear Environmental Qualification Center

Based in the previous experience, in early 2014, INVAP took the decision to create the Environmental Qualification Center to support the Argentine Nuclear Program which includes ,among other nuclear projects, to construct three (3) new Nuclear Power Plants during the next 10 years.

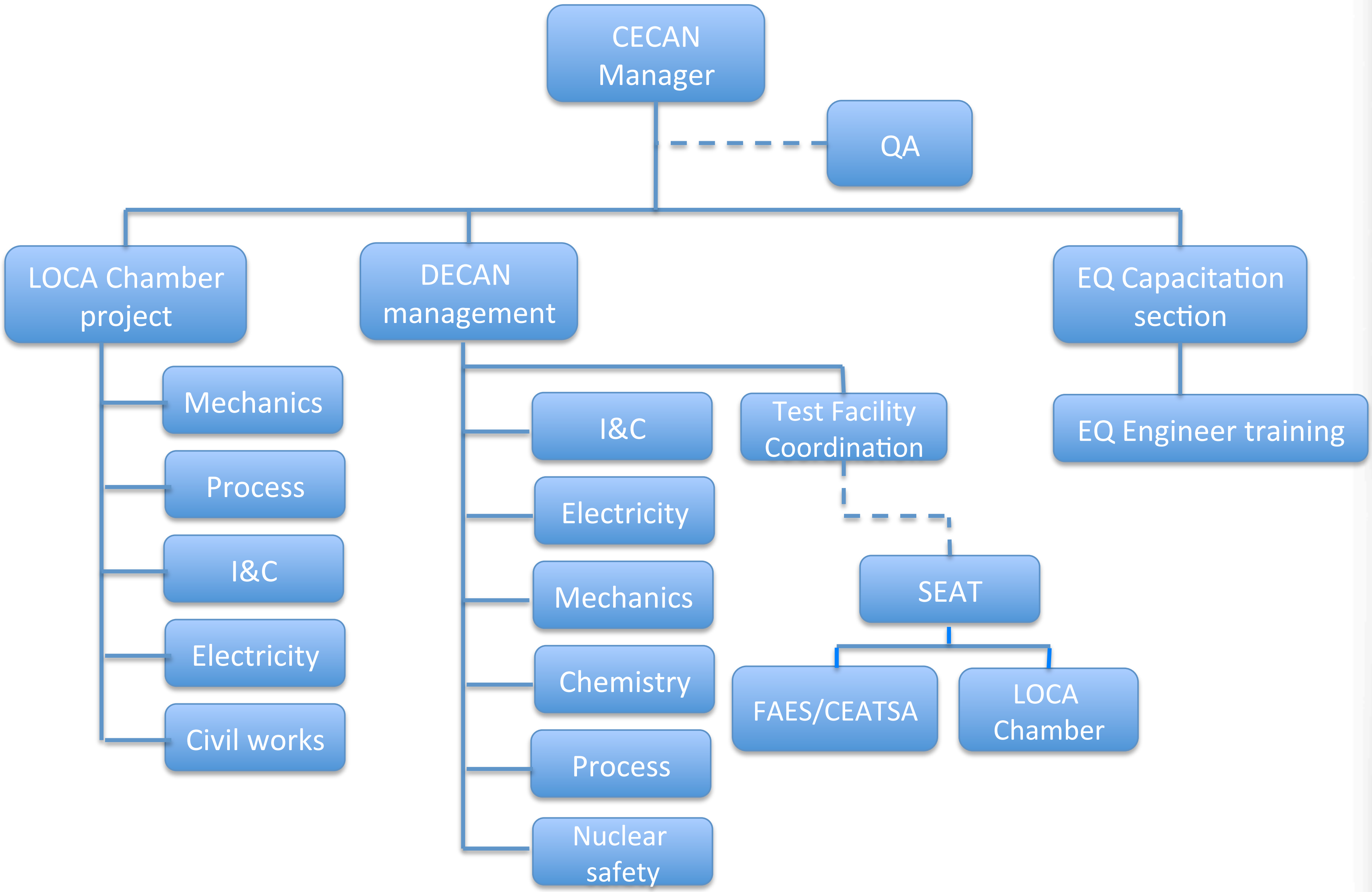
The National Nuclear Program establish that, at least, 70% of the projects will be integrated locally.

Argentine has in operation 3 NPPs, one CANDU and two PHWR designed by KWU.The first one, ATUCHA I, is operating since 1974, the second, ATUCHA II, after a long period of project inactivity, finally was commissioned in August 2014 and started to operate at Full Power in December 2014.

ATUCHA I is close to reach the end of its operating life. On 2017 will start the project to extend the operating live for 15 years more.
As ATUCHA I is unique in its type, and KWU transfer the technical support to AREVA, Environmental Qualification of safety related systems´ components will be a critical issue due to the lack of the original manufacturers.

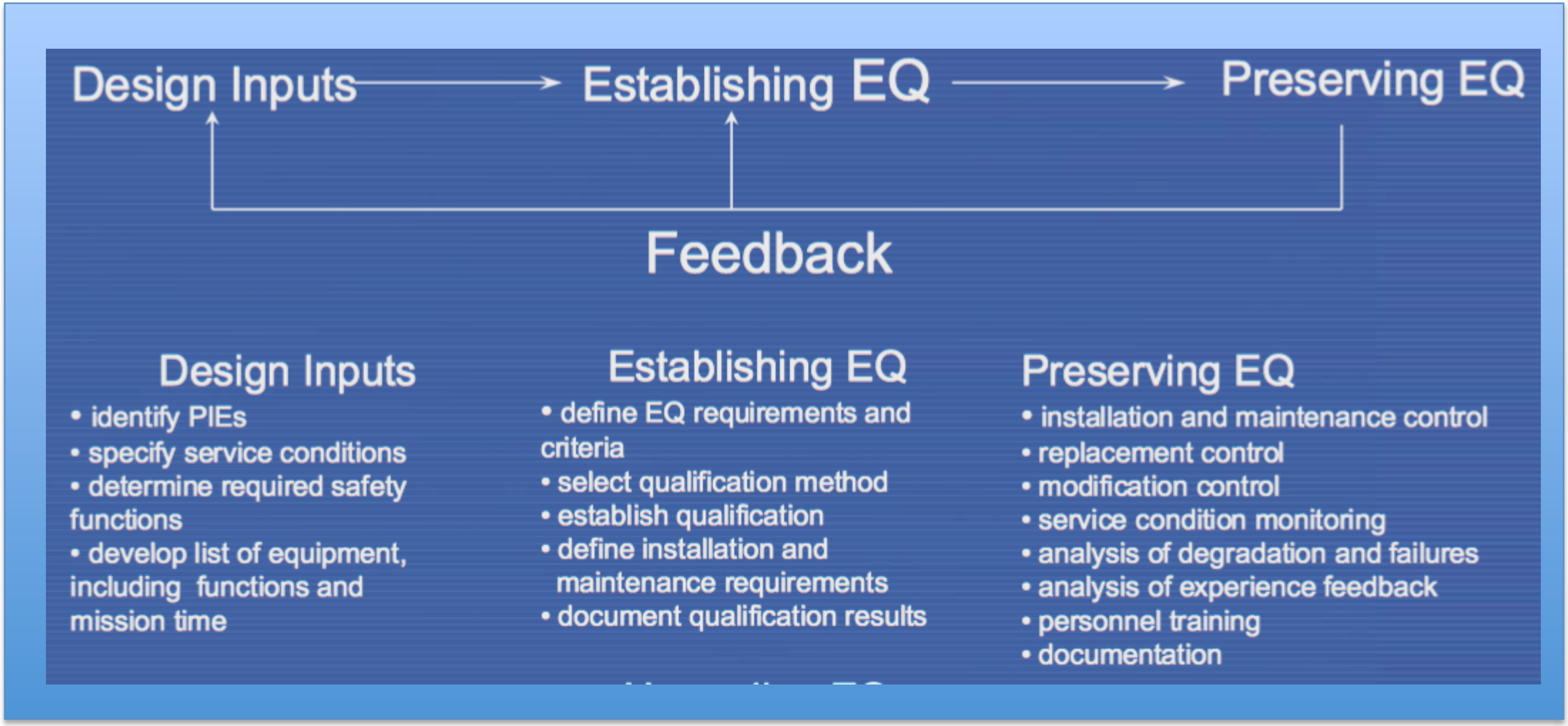
INVAP signed an agreement with NA-SA, the operating organization of the utility, which consists to support NA-SA EQ process during the Life Extension Project of ATUCHA I.

CECAN Organizational Chart



Environmental Qualification Programme for NPP

INVAP Equipment Qualification Programme includes the three phases of EQ



INVAP Environmental Qualification Programme was developed within IEEE frame:

Main and general application standards are:

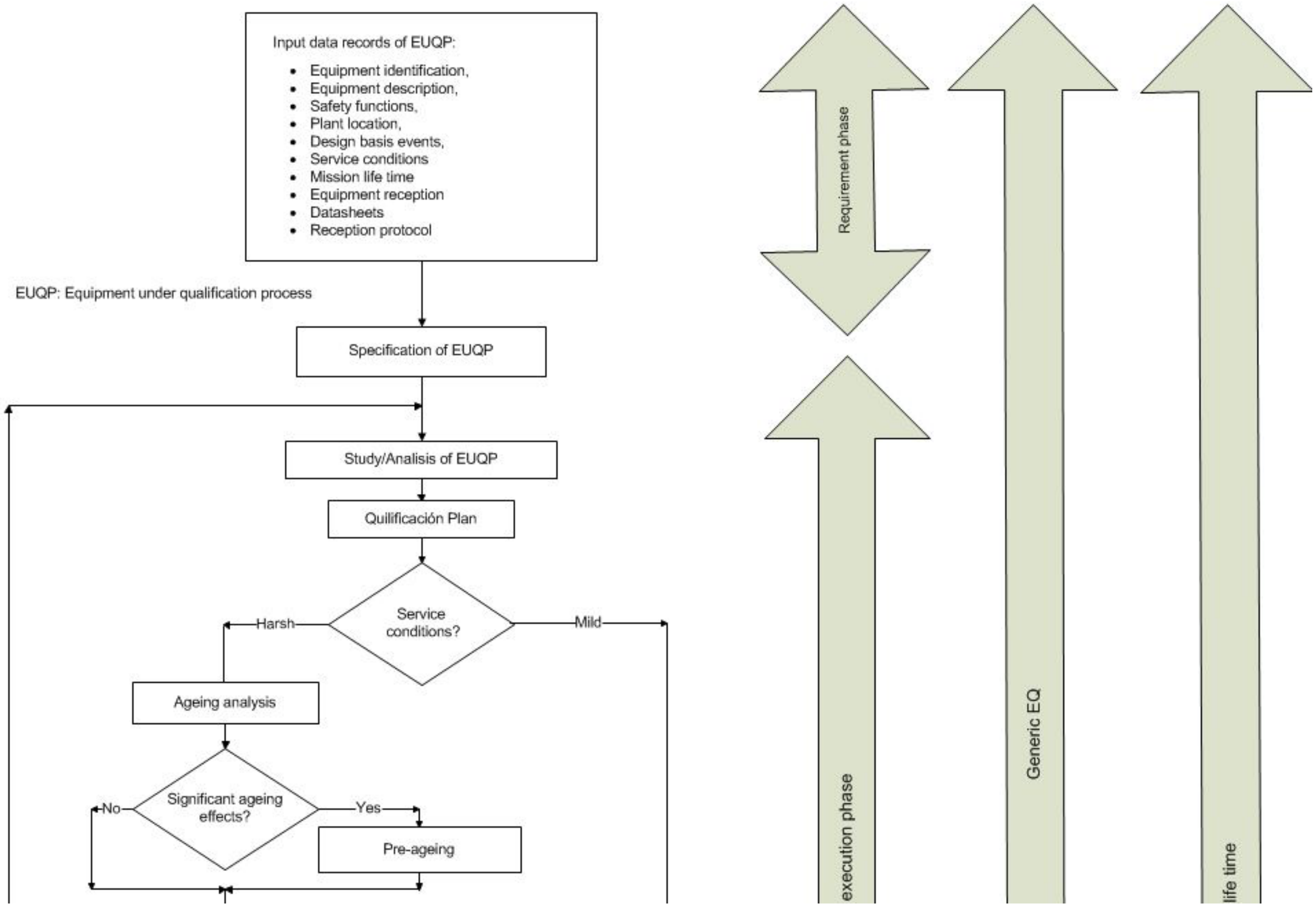
- IEEE Std 627, Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations
- IEEE Std 323, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
- IEEE Std 344, IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations

Specific standards examples:

- IEEE Std 334, Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations
- IEEE Std 382, IEEE Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations
- IEEE Std 383, Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
- IEEE Std C37.105, Standard for Qualifying Class 1E Protective Relays and Auxiliaries for Nuclear Power Generating Stations
- MIL-STD 461, Requirements For The Control Of Electromagnetic Interference Characteristics Of Subsystems And Equipment
- MIL-STD 462 Notice 5, Electromagnetic Interference Characteristics, measurement of

Environmental Qualification Programme for NPP

The programme



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Environmental Qualification Programme for NPP

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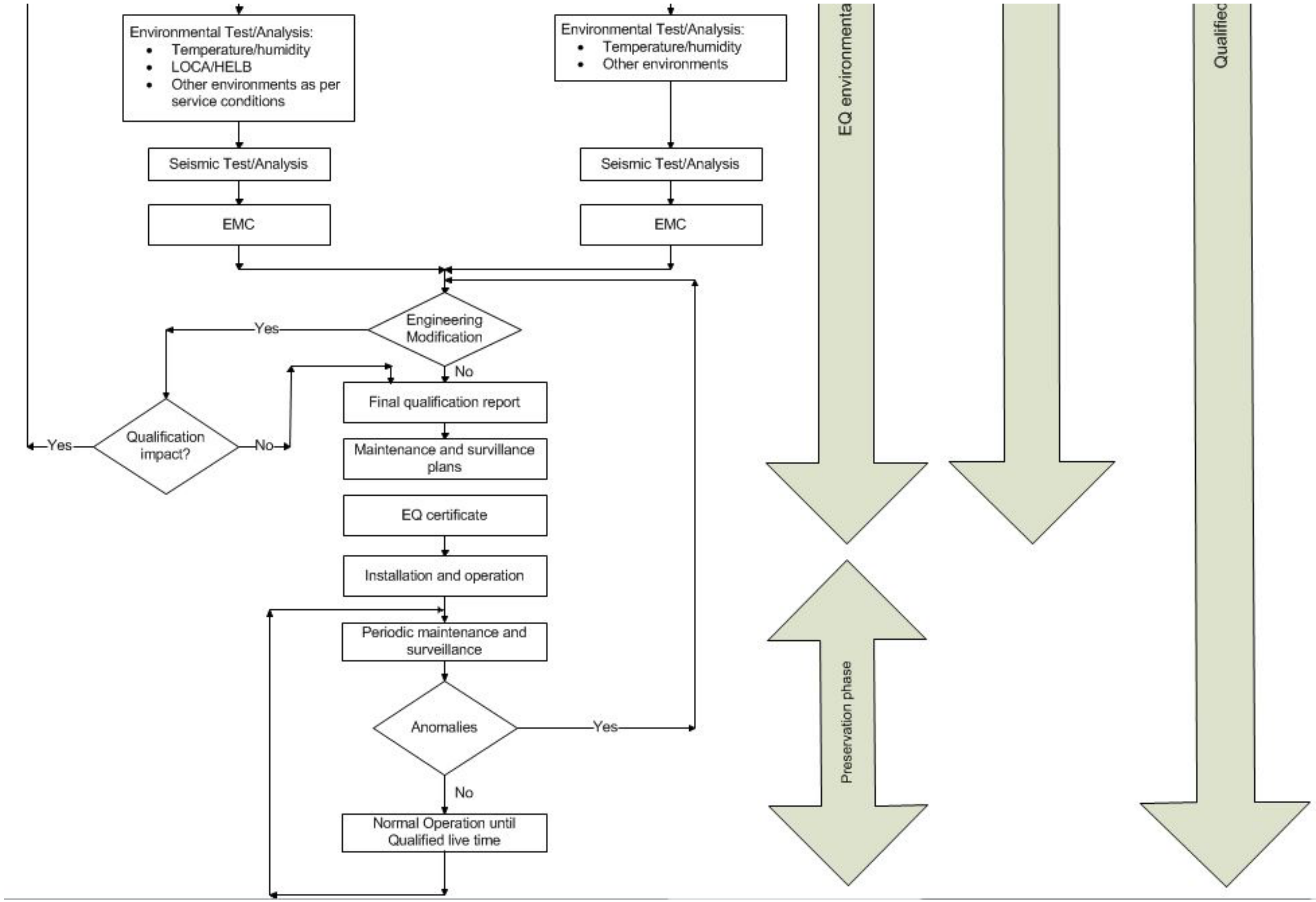


Upgrading EQ

Upgrading EQ is treated as special case of establishing EQ as it applies to existing equipment in operation plants and involves establishing or verifying design input information.

Operation plants could have equipment with some elements of EQ (i.e. Equipment is seismically qualified, but the performance under harsh environmental conditions has not been demonstrated).

On the other hand, there are operation plants (principally the old ones) that could have few or none of the elements of EQ (instead, industrial grade equipment has been installed).

The life extension project of ATUCHA I will necessary needs a partial upgrading EQ process, over some components, together with the replacement of most of the safety related components by, new environmentally qualified or industrial-grade dedication components.

Upgrading EQ (cont.)

The implementation of upgrading EQ necessarily needs an significant participation of the operation organization and this was achieved with NA-SA by the signature of a special agreement.

The compromised main activities will be:

- Identification of the PIEs
- Identification of equipment to be qualified
- Definition of EQ parameters
- Evaluation of the EQ status of the individual equipment
- Definition of corrective actions
- Implementation of interim measures
- Qualification of the selected equipment determining its remaining qualified life time.

Implementation of upgrading EQ (cont.)

The implementation of the developed upgrading EQ programme includes the following activities:

1. Review of existing documentation:
    - safety analysis reports
    - EQ test reports (if they exists)
    - Safety ad functional requirements
    - Equipment specifications/datasheets
    - Detailed equipment parts lists
    - Procurement documents
    - Installation documents, including records and protocols
    - Maintenance history records
    - Peer review and audit reports
    - Calculations and measurements of environmental conditions (for PIEs as well as for normal operation)
2. Equipment Walkdown

Implementation of upgrading EQ (cont.)

3. Corrective action plan with the establishing of priorities. The following EQ upgrade activities are consideredwithin the upgrading EQ programme:
    - Test-Simulate the harsh DBE environment to demostrate that the equipment will function under.
    - Analyss to provide evidence by comparison or by calculation that the equipment can be considered qualified.
    - Proposal of protective changes of the local environment.
    - Proposal to relocate or move the equipment to a less harsh environment.
    - Modify or replace parts which are the cause of the equipment's failure to meet the qualification requirements.
    - Replace a component by a fully qualified one.

Implementation of upgrading EQ (cont.)

4. The implementation of the following interim measures are considered:
    - Sealing components against moisture intrusion
    - Splicing low voltage, low current signal cable termination points in the harsh environment locations
    - Ensuring that other electrical terminations are protected against moisture intrusion
    - Providing drainage points in junction boxes and conduits
    - Replacing components or materials known to fail in a harsh environment
    - Replacing unidentifiable or unqualifiable lubricants with standard lubricants qualified for the required applications.
5. Qualification of selected equipment:
    - Qualify or re-qualifiy the existing equipment
    - Replace by a qualified equipment

Distinctive activities in the commercial/industrial-grade dedication

Even though that the activities for commercial-grade dedication has to comply will the general environmental qualification programme, an additional effort will be applied to define if the commercial/industrial grade equipment is able to perform the assigned safety function as, this equipment was not specially designed to perform safety functions in particular service conditions.

INVAP Dedication Plan includes activities focusing to identify critical characteristics of the proposed equipment which consists in a deep analysis of the equipment identifying materials, components, identification of manufacturer, its QA plan, and tests and technical tasks which can include specs verification, dis-assembly the equipment for internal inspection and functional and performance tests. Each stage of these engineering practices has a set of acceptance criteria.

If the equipment satisfies all the previous mentioned tasks approving the corresponding acceptance criteria it is declared as apt to pass to the next step which is the execution of the EQ programme.

Resources and Capabilities

INVAP has a special Service Department SEAT (High Technology Test Service) specialized in the performance of type test for two relevant technological disciplines, Nuclear and Aero-spatial technology.

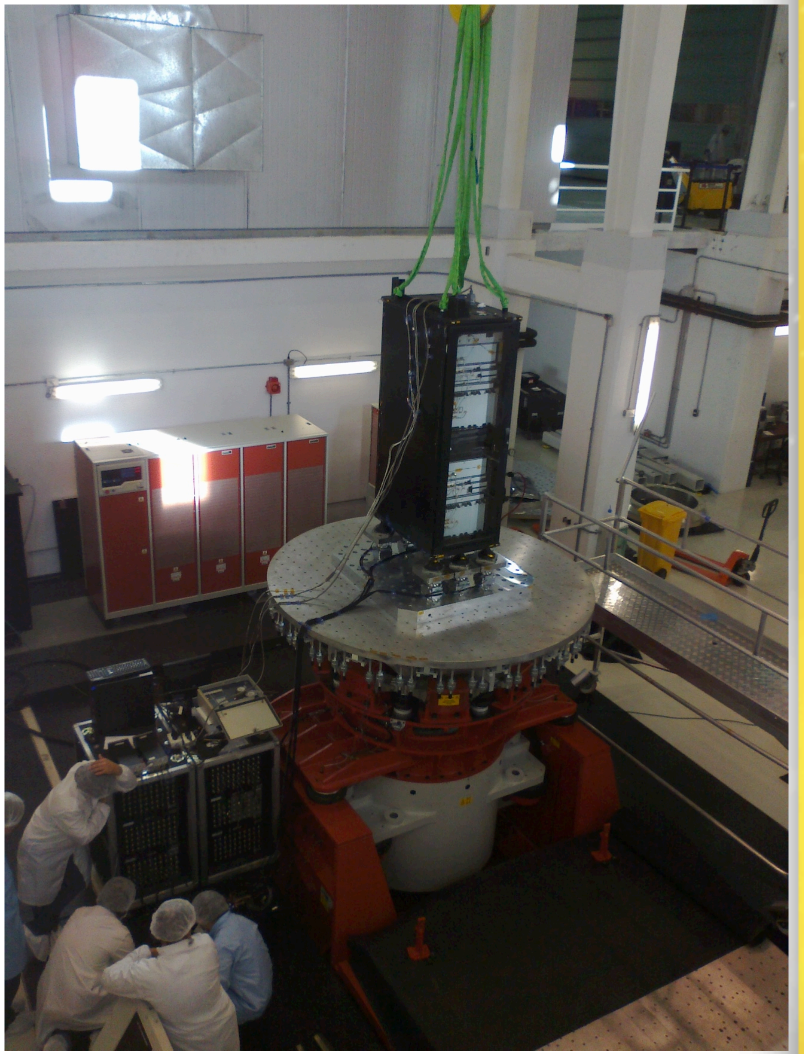
SEAT is responsible to operate CEATSA test facility (the High Technology Test Center) which has different test equipment to perform type tests required to environmentally qualify nuclear and aero-spatial equipment having the capability to test entire satellites.

CEATSA is a test and measurement facility created in 2010 to satisfy the needs of Nuclear a Aero-spatial areas of INVAP to perform environmental tests. It is located in the same place of the main laboratories and workshops of INVAP.

CEATSA test equipment

Shaker V994 – HBT2500 – HBX

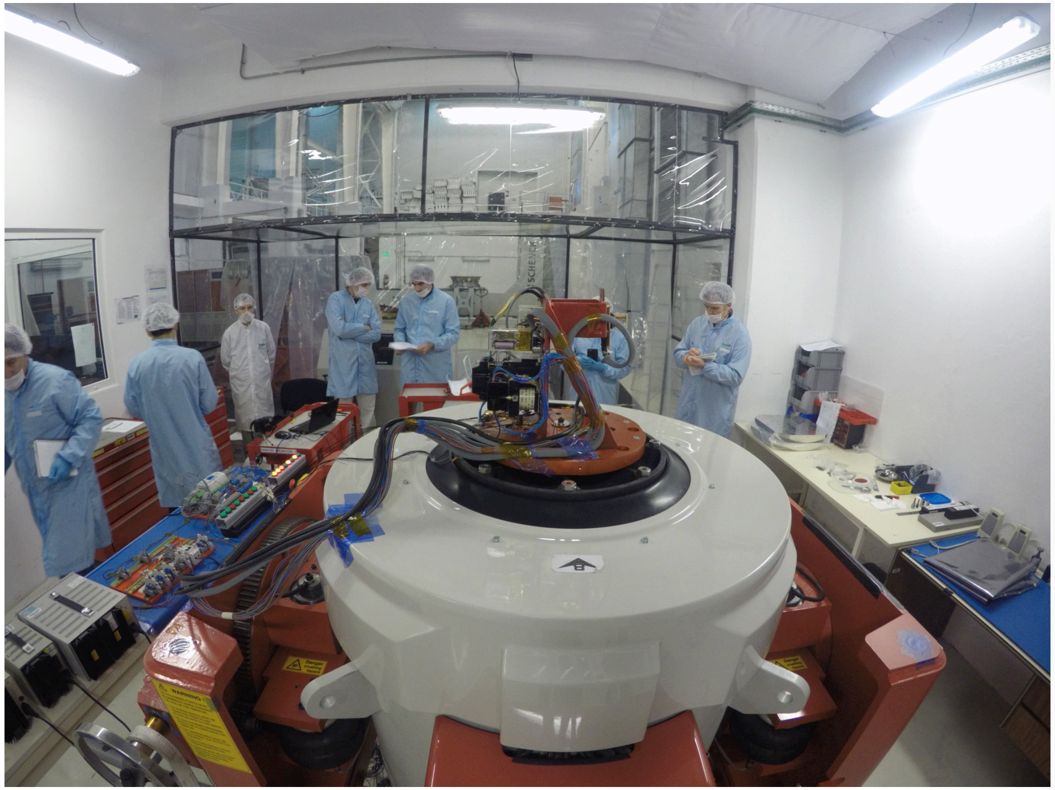
- Sine force: 289 kN
- Random force: 267 kN
- Displacement; 63.5 mm
- Frequency range: 5Hz-2000Hz
- Max. speed: 1.9 m/s
- Slip table: 2.5 m x 3 m
- Maximum load: 20,000 kg

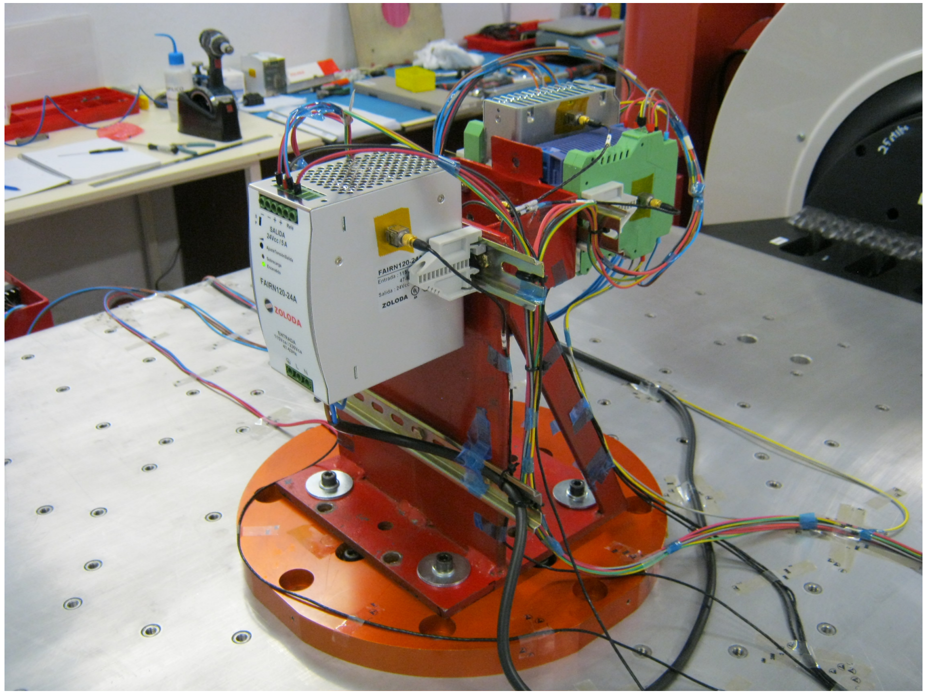


CEATSA test equipment (cont.)

Shaker V988 – HBT1100 – HBX

- Sine force: 57.8 kN
- Random force: 56.6 kN
- Displacement; 63.5 mm
- Frequency range: 5Hz-2000Hz
- Max. speed: 1.8 m/s
- Slip table: 1.1 m x 1 m
- Maximum load: 8,000 kg





CEATSA test equipment (cont.)

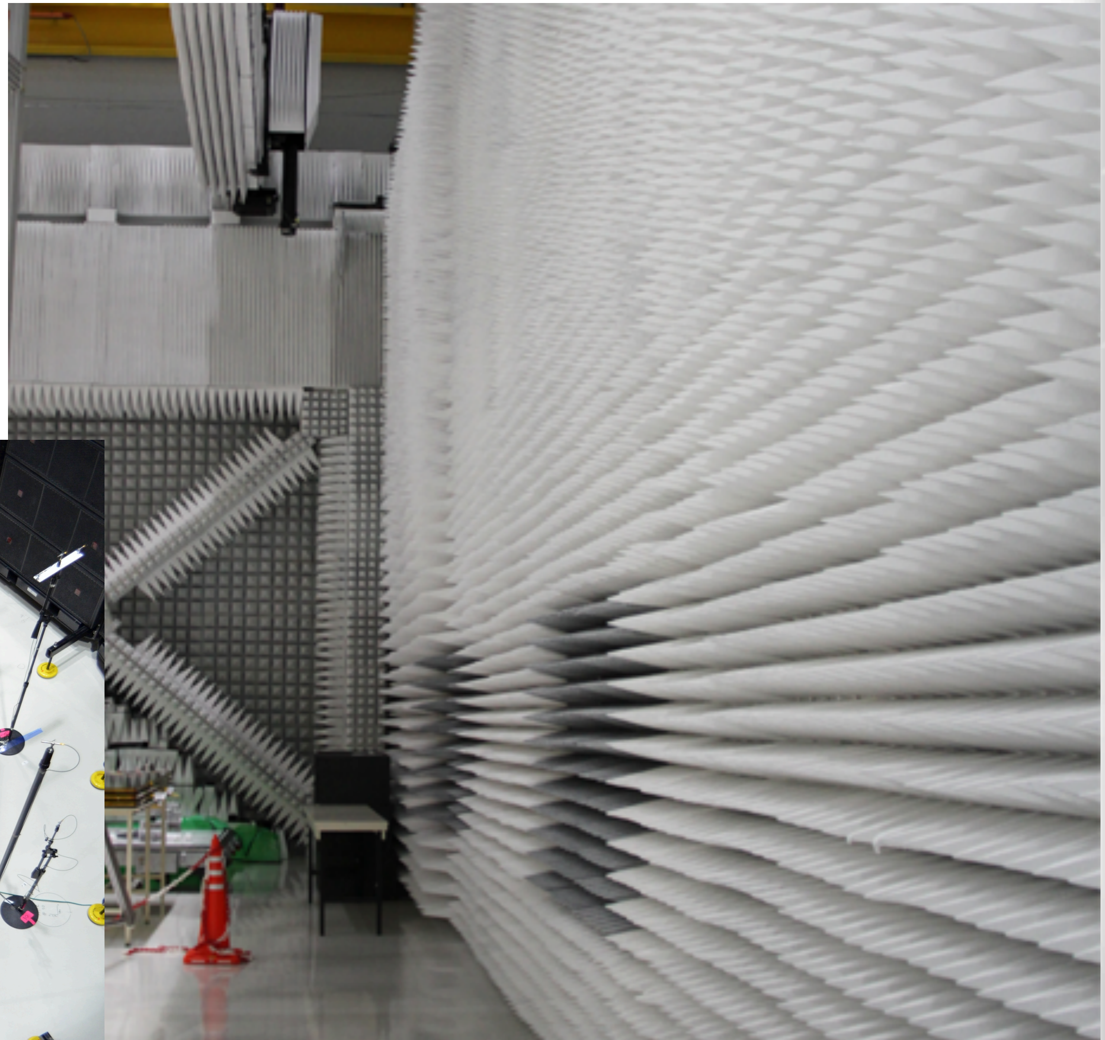
Environmental chambers:

- Four chambers,
- Sizes:
  - 600x500x700 mm
  - 800x700x900 mm
  - 1100x800x900 mm
  - 800x1600x800 mm
- Temperature range: -20ºC-220ºC
- Humidity: 5-98%
- Rise time: 20 min (ambient-to upper limit)
- Ramp programs
- Long term cycler programs

Anechoic Chambers

Emission measurement chamber:
- Type: horizontal flat scanner
- Dimensions: area: 18 x 19 m,
  height: 6 m
- Frequency range: 500 MHz to 40 GHz

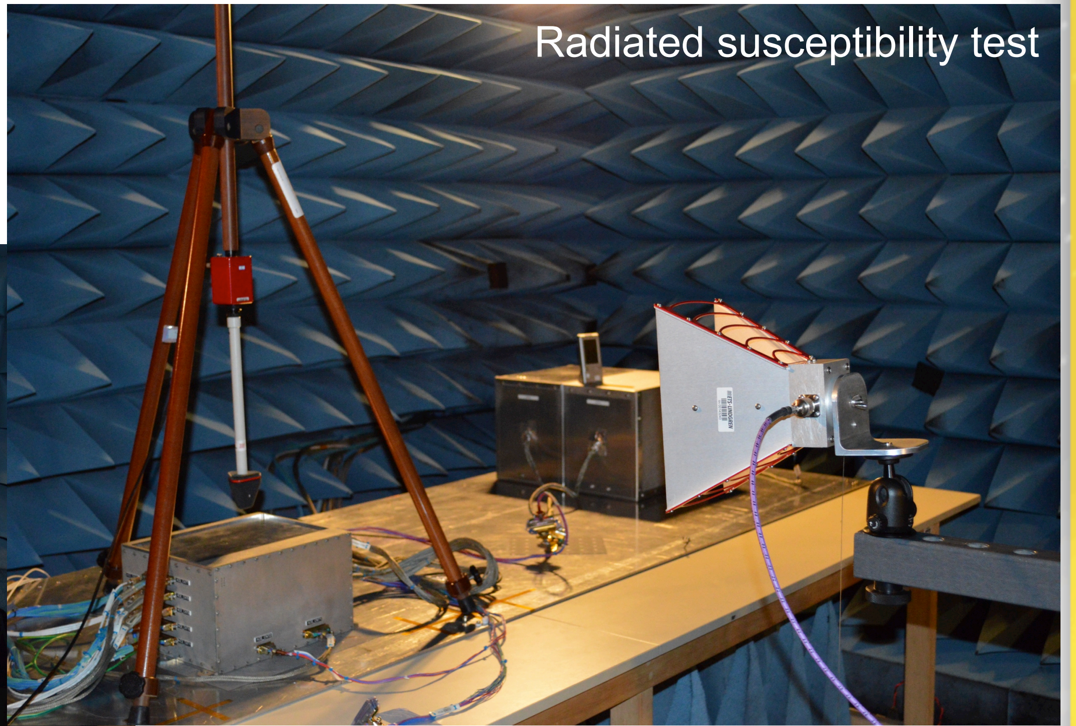
Acoustic test:
- pick power: 3 MW

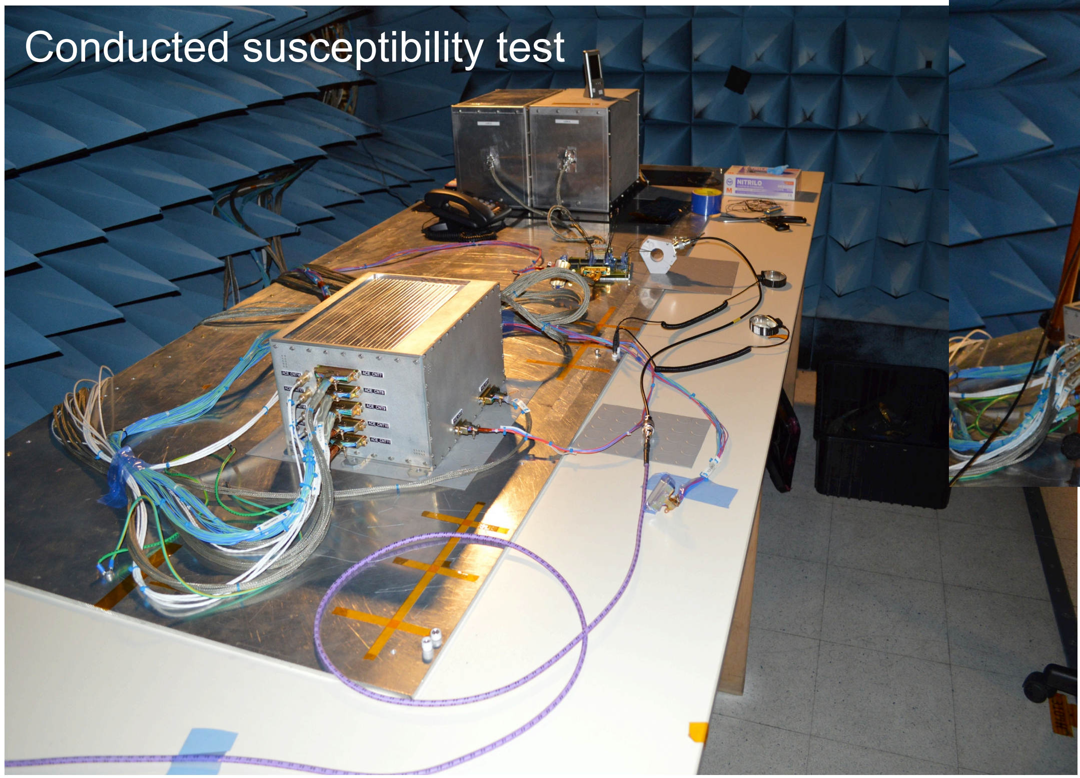


Anechoic Chambers (cont.)

Emission and susceptibility measurements:

- Dimensions: 5 x 3.5 x 2.5 m (free)
- Test as per MILSTD-461/462

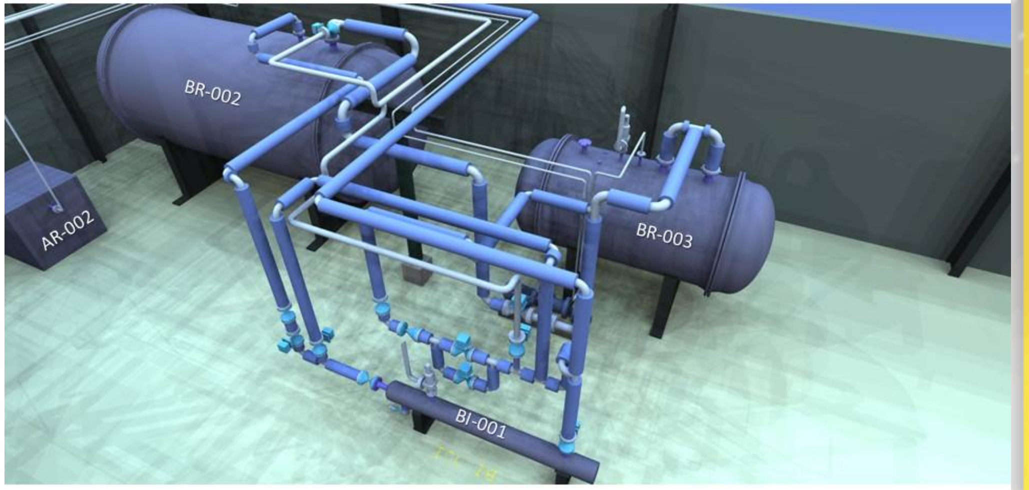

Radiated susceptibility test


Conducted susceptibility test

LOCA Chamber

Nowadays is in progress a project to construct a LOCA Chamber facility to complete the basic type test equipment for harsh environment.

The startup of the LOCA Chamber facility will be in September, 2016 and it will have the following characteristics:



LOCA Chamber:

- Dimensions: Diameter: 1.1 m,
  Length: 1.8 m
  Horizontal position
- Material: AISI 316
- Access door: rapid opening mechanism

Steam boiler:

- Operation pressure: 20 bar,
- Saturated steam: 220 ºC
- Steam rate: 1000Kg/hour (saturated steam, title: 98.5/99 %)

Steam accumulator:

- Volume: 10.3 m^3

Super heater:

- Overheating capacity: 50ºC


Thank you for your attention