# Angra Nuclear Power Station

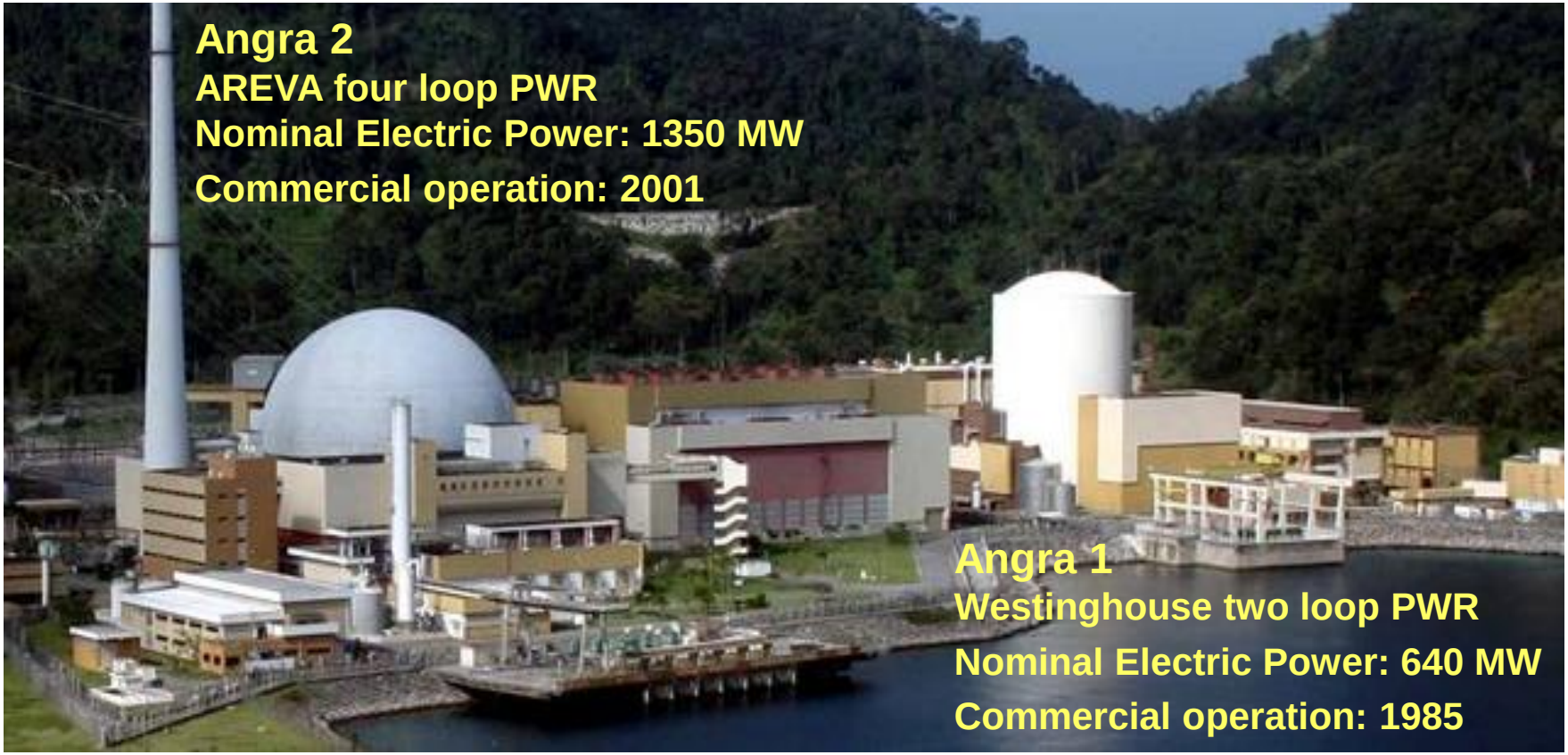
# Initiatives for Long Term Operation

**International Nuclear Atlantic Conference – INAC – 2013**
**Recife - Brazil**

**November 24th to 29th, 2013**

Eletrobras
Eletronuclear

# Central Nuclear Almirante Álvaro Alberto
# Angra Nuclear Power Station



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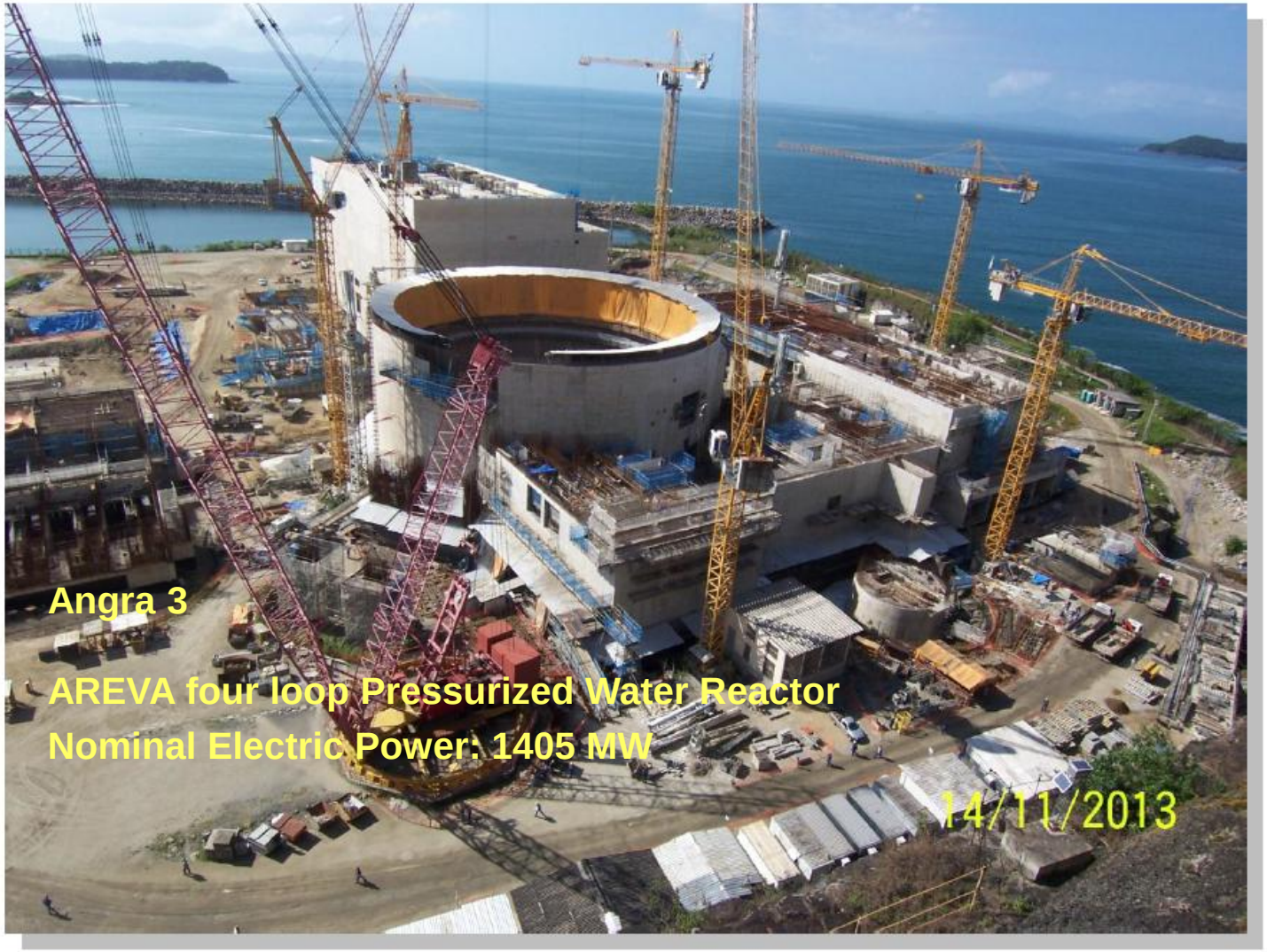
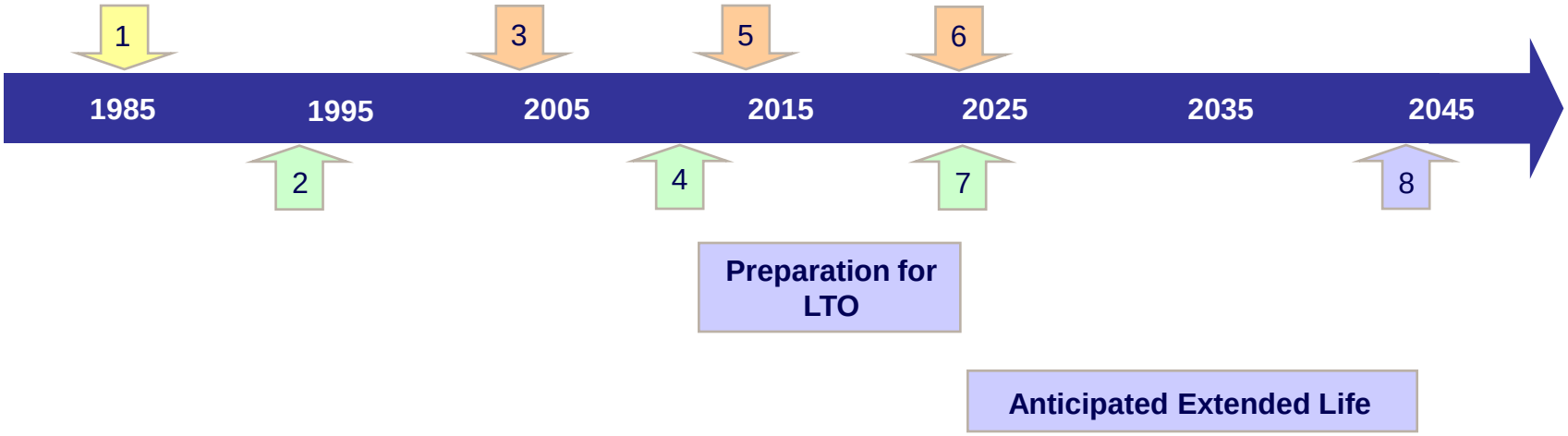


# Angra 1 Licensing Aspects
# Milestones




1- Beginning of commercial operation (1985, design for 40 years)

2- License for 30 years (1994)

3- First PSR (2004)

4- License for 14 years (2010)

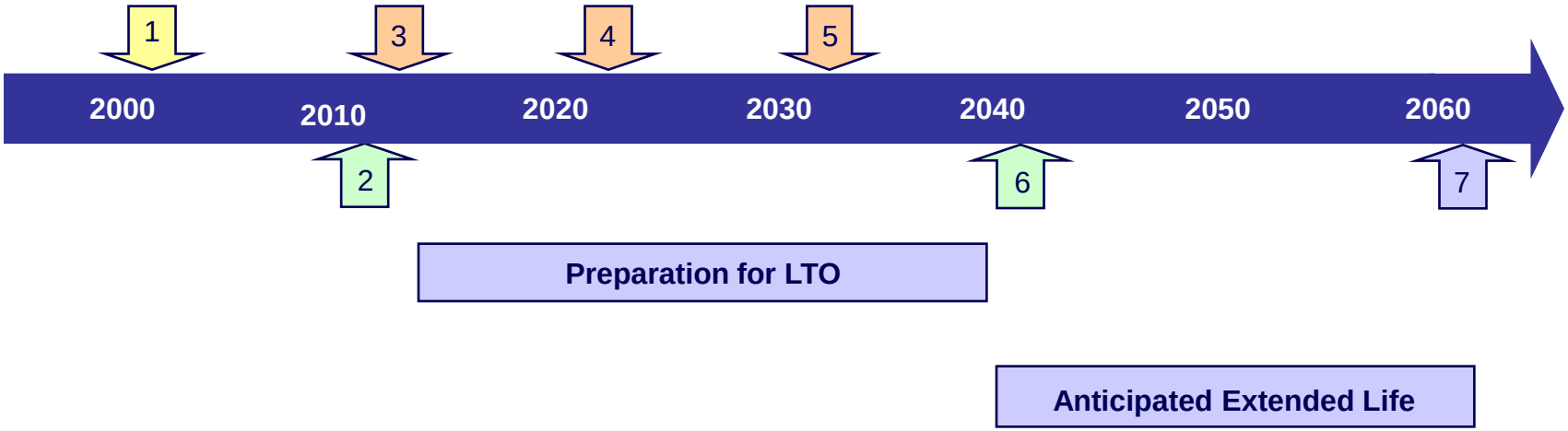
5- Second PSR (2014)

6- Third PSR (2024)

7- Expiration of current license (2024) and beginning of the anticipated extended life - 20 years

8- Anticipated expiration of renewed license (2044)

# Angra 2 Licensing Aspects
# Milestones




1- Beginning of commercial operation (2001, design for 40 years)

2- License for 30 years (2011)

3- First PSR (2012)

4- Second PSR (2022)

5- Third PSR (2032)

6- Expiration of current license (2041) and beginning of the anticipated extended life - 20 years

7- Anticipated expiration of renewed license (2061)

## Brazilian Licensing Process

- Brazilian nuclear power plants are licensed for a period of 40 years in accordance with the rule CNEN NE-1.04, "Licensing of Nuclear Installations", issued by, the Brazilian regulatory board: Comissão Nacional de Energia Nuclear (CNEN)

- Licensing process is based on the following acts:

  a) Site Approval

  b) Construction License

  c) Authorization to Use of Nuclear Materials

  d) Authorization to Initial Operation (AOI)

  e) Authorization to Permanent Operation (AOP)

- License Renewal:

  a) According CNEN NE-1.04, 8.9.1, the current Authorization to Permanent Operation can be extended

  b) This will be based on technical assessments to demonstrate that ageing effects will be satisfactorily managed during the period of the extended operating life.

# Periodic Safety Reviews

- The first Periodic Safety Review (PSR) of Angra 1 was performed in 2004-2005, covering the period from 1994 to 2003

  Angra 1 first PSR was carried out in parallel with the preparation of a procedure for implementing a systematic Ageing Management Programme

- The first Periodic Safety Review of Angra 2 was performed in 2012, covering the period from 2001 to 2011

  Preliminary studies to establish the basis for the implementation of the Ageing Management Programme in Angra 2 have been considered

- The second Periodic Safety Review of Angra 1 will be concluded in 2014

# Ageing Management Approach for Long Term Operation – LTO Summary

## Technical Assessments in the scope of LTO

- Integrated Plant Assessment (IPA)
- Time Limited Ageing Analysis (TLAA) review
- Obsolescence Management

IPA comprises ageing management review of passive long-lived systems, structures and components and the evaluation of plant programmes

Environmental qualification, according to **US NRC 10 CFR 50.49**, is included in the scope of TLAA

Ageing of active SSC should be managed in the scope of the Monitoring of Maintenance Effectiveness Programme (already implemented at Angra units 1 and 2), according to **US NRC 10 CFR 50.65** (the Maintenance Rule)

# Ageing Management Approach for Long Term Operation - LTO SSC Scope

- **Safety-related** systems, structures, and components relied upon to remain functional during and following design-basis events to ensure

  (i) the integrity of the reactor coolant pressure boundary;

  (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition; or

  (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures;

- All **non-safety related** systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified above; and

- All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the regulatory requirements for **fire protection**, **environmental qualification**, **pressurized thermal shock**, **anticipated transients without scram**, and **station blackout**.

# Ageing Management Approach for Long Term Operation - LTO
# Main References

- **IAEA Specific Safety Guide No. SSG-25 –** Periodic Safety Review for Nuclear Power Plants
- **IAEA Safety Guide No. NS-G-2.12 –** Ageing Management for Nuclear Power Plants
- **US NRC 10 CFR Part 54 –** Requirements for Renewal of Operating Licenses for Nuclear Power Plants
- **German Rule KTA 1403 –** Ageing Management in Nuclear Power Plants
- **IAEA Safety Reports Series No.57 –** Safe Long Term Operation of Nuclear Power Plants
- **NUREG-1801 –** Generic Aging Lessons Learned (GALL) Report, US NRC, September 2005
- **IAEA IGALL –** International Generic Ageing Lessons Learned, Final Report (draft)

## Ageing Management Approach for Long Term Operation - LTO
## Main References (cont.)

**Iberoamerican Forum of Radiological and Nuclear Regulatory Bodies**

**Project**

**"Regulatory Practices on Ageing and Life Extension"**

- **TD1** – Guide for Regulatory Criteria on Ageing Management and Long Term Operation of Nuclear Power Plants (Oct, 2011)
- **TD2** – Guide for Assessment of Ageing Management and Long Term Operation of Nuclear Power Plants (May, 2011)
- **TD3** – Guide for Regulatory Inspection of Ageing Management and Long Term Operation of Nuclear Power Plants (Oct, 2011)
- **TD4** – Guide for the Periodic Safety Review of Nuclear Plants Applied to the Ageing Management and Long Term Operation Aspects (Dec, 2011)

## Angra 1 Ageing Management
## Summary of Improvements and Actions

- Replacement of components to eliminate Cu-alloy in the secondary system
- Readiness assessment for the implementation of an AMP (Duke Engineering, 2002-2003)
- Ageing management assessments in the scope of the first PSR (2005)
- Identification of Alloy 600 parts and welds in the Reactor Coolant System and its connections (ETN Report RL-A1-0633, 2007)
- Replacement of RPV Internals split pins (2007)
- Replacement of steam generators (2009)
- Readiness assessment for license renewal (Westinghouse, 2009)
- Weld overlay at the pressurizer surge line, spray line, safety valve lines, and relief valve line nozzles (2010)
- Replacement of the RPV closure head (January, 2013)

## Angra 1 Ageing Management
## Summary of Improvements and Actions
## (cont.)

- Implementation of inspection and maintenance programmes for safety related buildings concrete structures (CONCREMAT, in course)
- Initiatives to contract technical assistance for the implementation of an Environmental Qualification Programme for electrical and I&C equipment (in course)
- Initiatives to contract external technical assistance for the implementation of scoping, screening and ageing management review processes in the scope of an Integrated Plant Assessment – IPA – according to US NRC 10 CFR 54 (in course)
- Time Limited Ageing Analysis – TLAA – reviews, with external technical assistance (Westinghouse, concluded in 2013)
- Studies for the implementation of mechanical stress improvement process – MSIP – for SCC control at RPV nozzles (in course)
- IAEA Pre-SALTO Mission at Angra 1 (November 5$^{th}$ to 13$^{th}$, 2013)

# Angra 2 Ageing Management
# Summary of Improvements and Actions

- Readiness assessment for the implementation of an ageing management programme (AREVA, 2012)
- Ageing management assessments in the scope of the first PSR (2012)
- Initial inspections for the development of periodical inspection plans and maintenance programmes for concrete structures important to safety (in course)

# Angra 1 and 2 Ageing Management
# Summary of Common Improvements and Actions

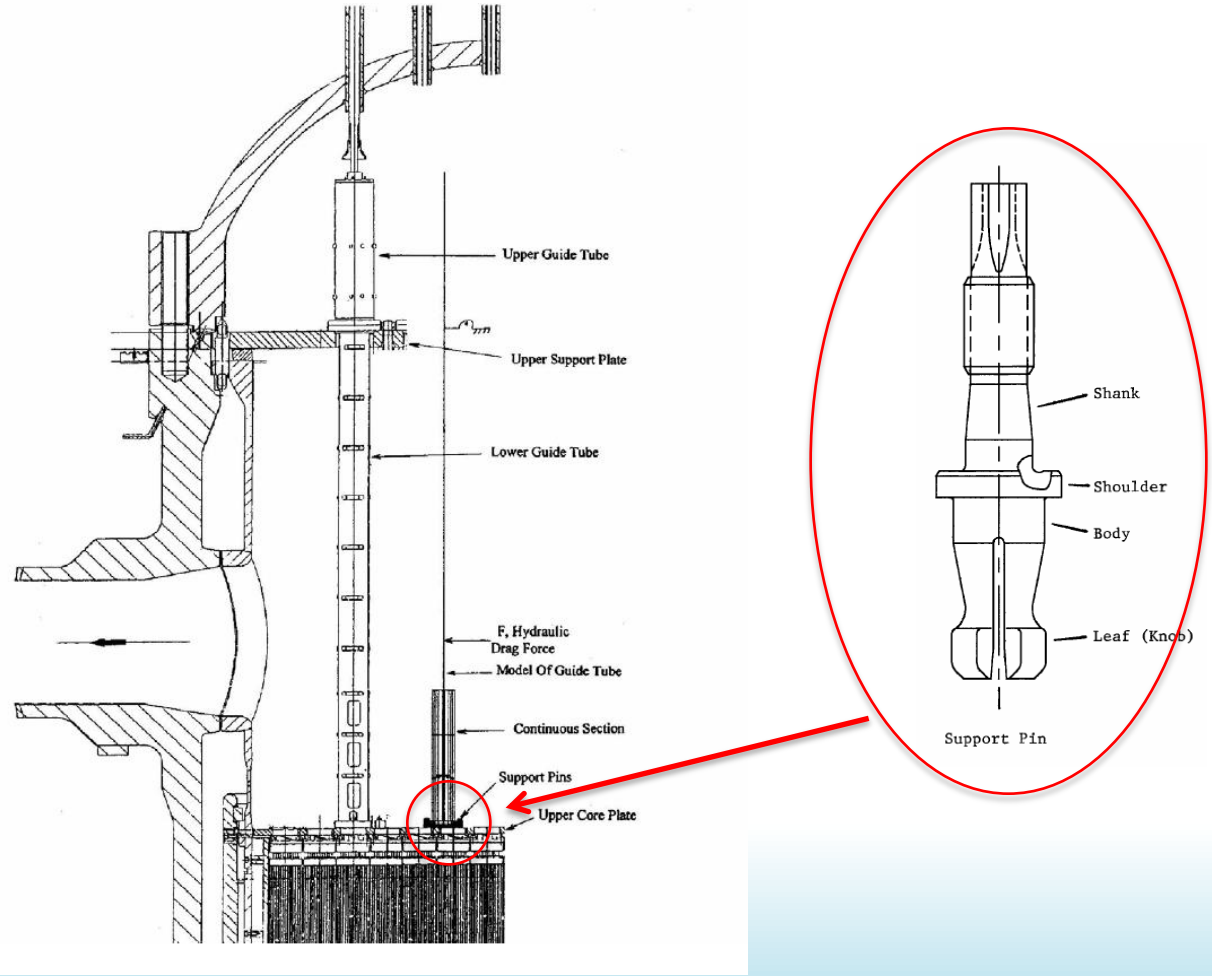
- Extensive use of industry operating experience (WANO, INPO, EPRI, VGB)
- Review of plant programmes according to industry guidelines and internal and external operating experience
- Introduction of new ageing related programmes
- Improvements to obsolescence management practices
- Training – external activities – participation in courses, workshops, technical visits, projects, peer reviews, etc.
- Training – internal activities – lectures, courses, etc.
- Participation in IAEA – IGALL Project

## Examples of Actions to Control Ageing Effects

- Replacement of RPV internals split pins
- Replacement of steam generators
- Pressurizer nozzles weld overlay
- Replacement of RPV closure head
- RPV nozzles Mechanical Stress Improvement Process - MSIP

# Replacement of RPV Internals Split Pins (2007)

## Objective: prevention of stress corrosion

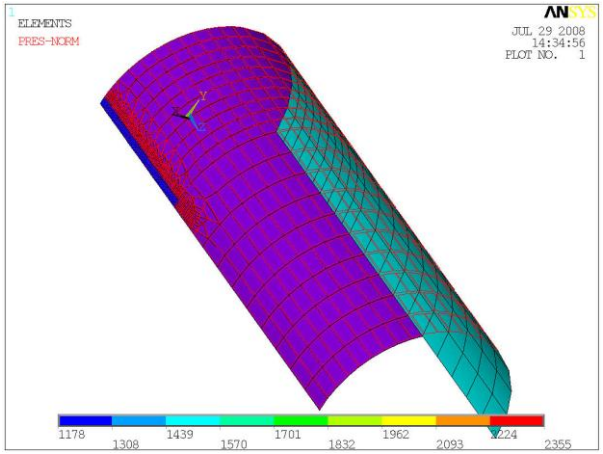



Inconel replaced by stainless steel

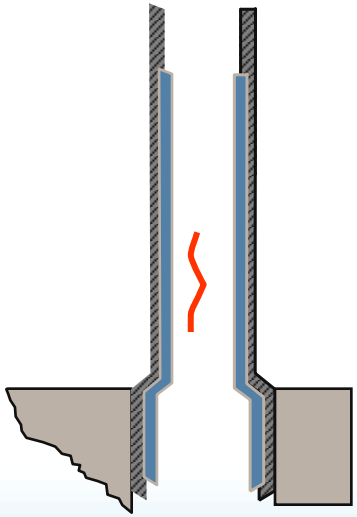
# Replacement of Steam Generators (2009)

## Objective: prevention of stress corrosion of SG tubes

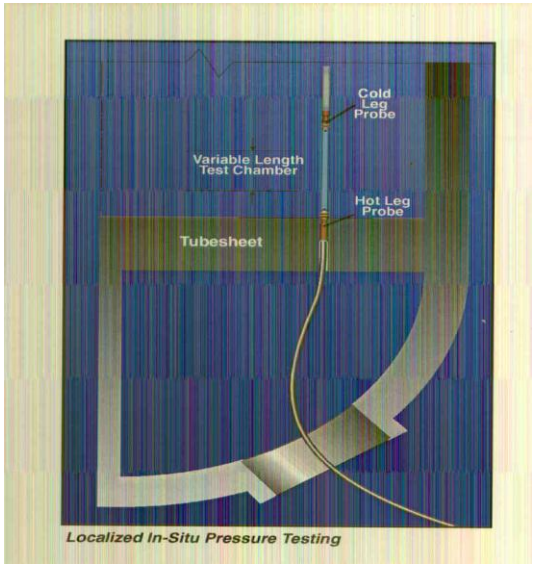
### Inspections and Structural Analysis Programme from 2003 to 2009




Leak analysis



Sleeve installation




Insitu pressure test

Original design: tubes in Alloy 600

New design: tubes in Alloy 690

# Pressurizer Nozzles Weld Overlay (2010)

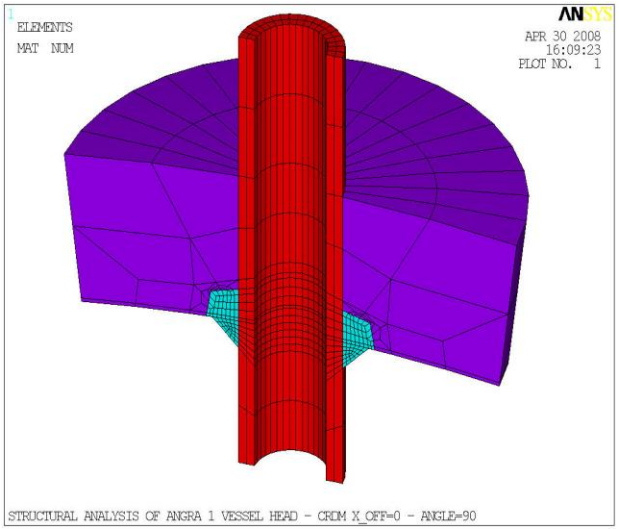
Objective: prevention of stress corrosion at dissimilar welds

Weld overlay induces compressive stresses at nozzle inner surface

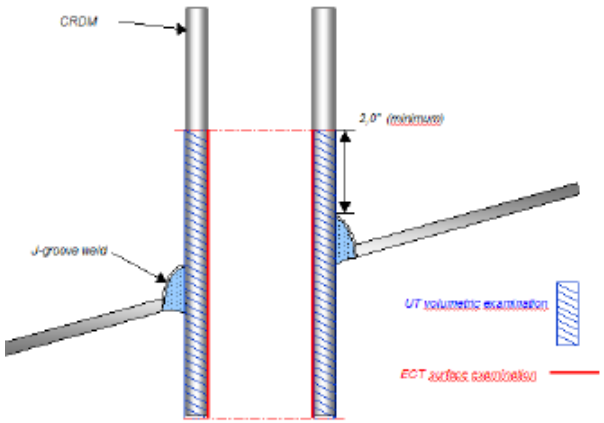
# Replacement of RPV Closure Head (2013)

## Objective: prevention of stress corrosion at penetrations

Inspections and Structural Analysis Programme
for RPV head and penetrations from 2004 to 2013




Flaw Manual




UT Inspections

Temperature measurements

Original design: penetrations and welds in Alloy 600/ 82/182

New design: penetrations and welds in Alloy 690/ 52/152

# Aplication of MSIP to RPV Nozzles

## Objective: Prevention of stress corrosion at RPV nozzles dissimilar welds (2016, planned)

MSIP - *mechanical stress improvement process*

*MSIP® tooling for reactor vessel nozzle*

Hydraulic tool induces compressive stresses at the inner surface of the nozzle

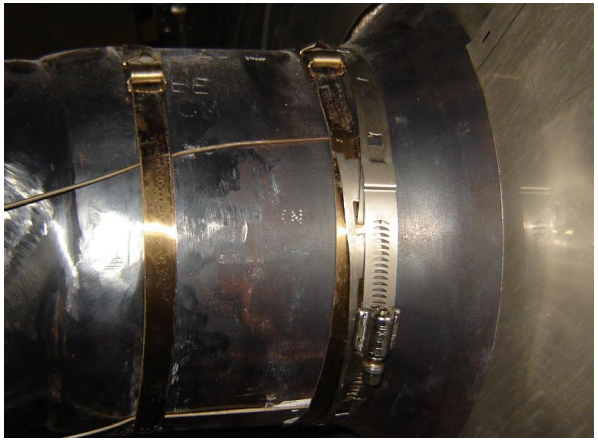
## Examples of Programmes to Control Ageing Effects

- Fatigue Monitoring Programme
- Flow Accelerated Corrosion Programme

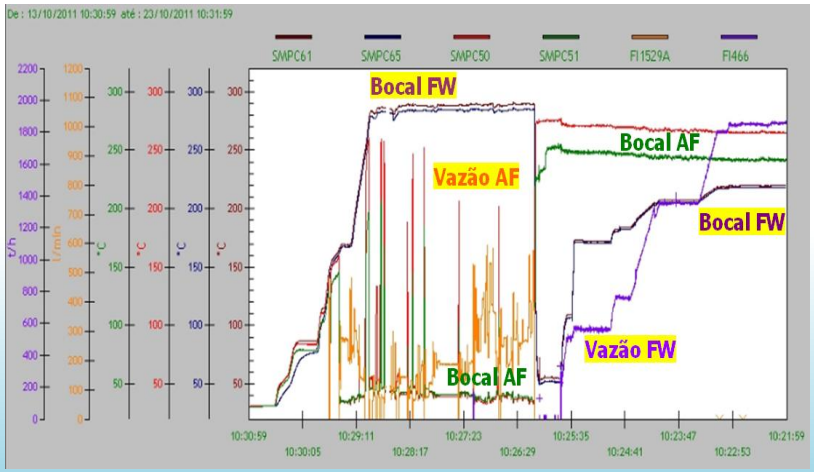
# Fatigue Monitoring

## Continuous monitoring since 2003

## Automatic fatigue control (FatiguePro) and thermal stratification monitoring



Thermocouples at AF nozzle




Measurement results

- [Cycle Summary - Angra_1_Version_2011]

File Edit View Cycles Tools Window Help

Results reflect the period from: 19/09/2011 12:59:59 to: 25/01/2013 23:59:59
Not Filtered: All Event Types displayed

| Event type | Initial | Increment | Ending | flag | Allowable |
|---|---|---|---|---|---|
| ACC. Safety Injection | 0 | 0 | 0 | | 89 |
| Aux. Spray During CD | 0 | 1 | 1 | | 200 |
| Control Rod Drop | 0 | 0 | 0 | | 80 |
| High Head Safety Injection | 13 | 1 | 14 | | 50 |
| Inadv RCS Depress | 0 | 0 | 0 | | 20 |
| Inadv. Safety Injection | 13 | 1 | 14 | | 60 |
| Inadvertent Aux Spray | 0 | 0 | 0 | | 10 |
| Large Step Load Decrease | 7 | 0 | 7 | | 200 |
| Loss of Load w/o RX Trip | 0 | 0 | 0 | | 80 |
| Loss of Off-Site Power | 8 | 0 | 8 | | 40 |
| Operating Basis Earthquake (OBE) | 0 | 0 | 0 | | 400 |
| PZR Cooldown | 66 | 1 | 67 | | 200 |
| Partial Loss of Flow | 0 | 0 | 0 | | 80 |
| Primary Side Hydrostatic test | 1 | 0 | 1 | | 10 |
| Primary Side Leak Test | 4 | 0 | 4 | | 200 |
| RCS Cooldown | 69 | 1 | 70 | | 200 |
| RCS Heatup | 69 | 1 | 70 | | 200 |
| RHR Operation during Cooldown | 69 | 1 | 70 | | 200 |
| Reactor Trip (CD and SI) | 0 | 0 | 0 | | 10 |
| Reactor Trip (CD no SI) | 0 | 0 | 0 | | 160 |
| Reactor Trip (No Cooldown) | 102 | 1 | 103 | | 230 |
| Refueling | 17 | 1 | 18 | | 80 |
| Step Load Decrease of 10% power | 5 | 2 | 7 | | 2000 |
| Step Load Increase of 10% power | 4 | 1 | 5 | | 2000 |
| Turbine Roll Test | 1 | 0 | 1 | | 20 |
| Unit Loading from 0-15% Power | 4 | 2 | 6 | | 500 |
| Unit Unloading from 15-0% Power | 4 | 2 | 6 | | 500 |

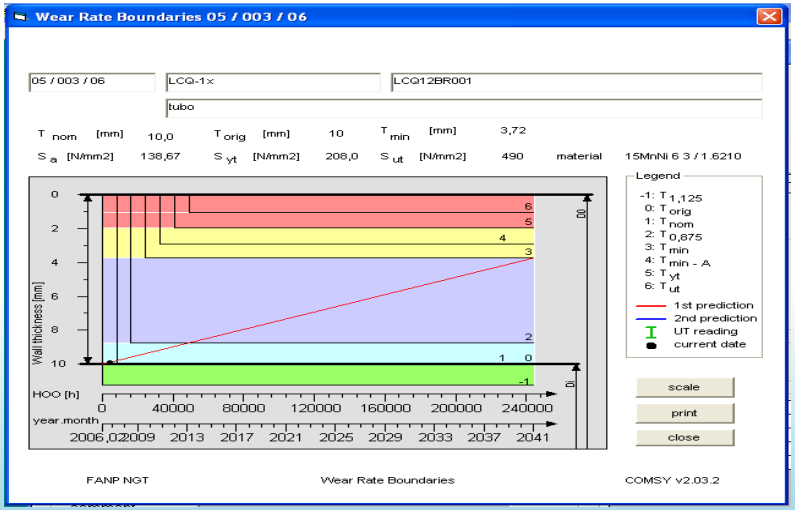
Cycle counting

# Flow Accelerated Corrosion (FAC) Programme

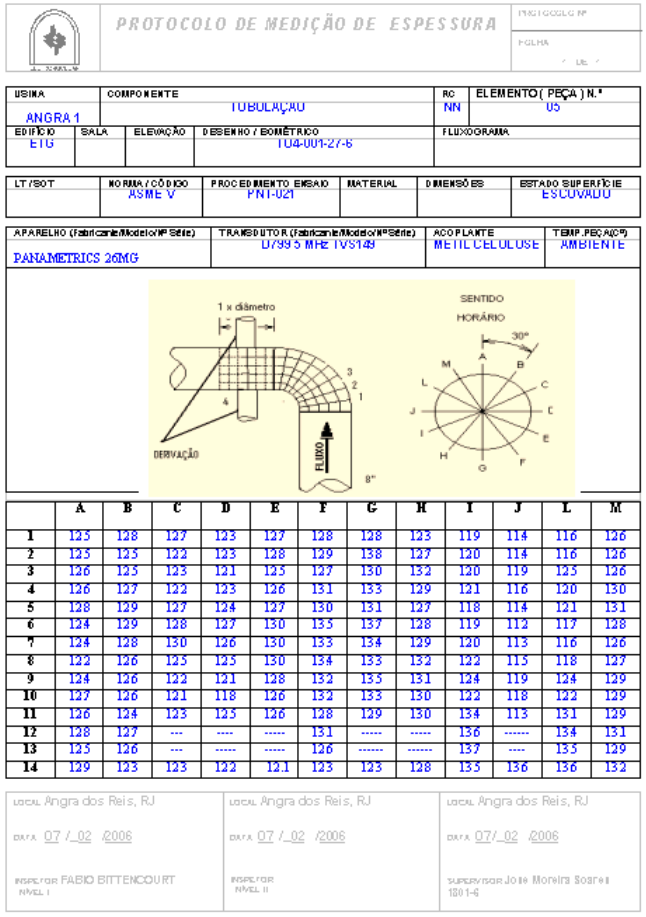
## Continuous monitoring since 2006

## Piping FAC control (Comsy)


Measurement greed




Trending degradation



PROTOCOLO DE MEDIÇÃO DE ESPESSURA

| USINA | COMPONENTE | | RC | ELEMENTO ( PEÇA ) N.º |
|---|---|---|---|---|
| ANGRA 1 | TUBULAÇÃO | | NN | U5 |
| EDIFÍCIO | SALA | ELEVAÇÃO | DESENHO / ISOMÉTRICO | FLUXOGRAMA |
| ETG | | | TU4-001-27-6 | |

| LT/SOT | NORMA / CÓDIGO | PROCEDIMENTO ENSAIO | MATERIAL | DIMENSÕES | ESTADO SUPERFÍCIE |
|---|---|---|---|---|---|
| | ASME V | PNT-021 | | | ESCOVADO |

| APARELHO (Fabricante/Modelo/Nº Série) | TRANSDUTOR (Fabricante/Modelo/Nº Série) | ACOPLANTE | TEMP. PEÇA(ºC) |
|---|---|---|---|
| PANAMETRICS 26MG | D7995 MHz TVS149 | METILCELULOSE | AMBIENTE |



| | A | B | C | D | E | F | G | H | I | J | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 125 | 128 | 127 | 123 | 127 | 128 | 128 | 123 | 119 | 114 | 116 | 126 |
| 2 | 125 | 125 | 122 | 123 | 128 | 129 | 138 | 127 | 120 | 114 | 116 | 126 |
| 3 | 126 | 125 | 123 | 121 | 123 | 127 | 130 | 132 | 120 | 119 | 123 | 126 |
| 4 | 126 | 127 | 122 | 123 | 126 | 131 | 133 | 129 | 121 | 116 | 120 | 130 |
| 5 | 128 | 129 | 127 | 124 | 127 | 130 | 131 | 127 | 118 | 114 | 121 | 131 |
| 6 | 124 | 129 | 128 | 127 | 130 | 135 | 137 | 128 | 119 | 112 | 117 | 128 |
| 7 | 124 | 128 | 130 | 126 | 130 | 133 | 134 | 129 | 120 | 113 | 116 | 126 |
| 8 | 122 | 126 | 125 | 125 | 130 | 134 | 133 | 132 | 122 | 115 | 118 | 127 |
| 9 | 124 | 126 | 122 | 121 | 128 | 132 | 133 | 131 | 124 | 119 | 124 | 129 |
| 10 | 127 | 126 | 121 | 118 | 126 | 132 | 133 | 130 | 122 | 118 | 122 | 129 |
| 11 | 126 | 124 | 123 | 125 | 126 | 128 | 129 | 130 | 134 | 113 | 131 | 129 |
| 12 | 128 | 127 | --- | ---- | ----- | 131 | ----- | ----- | 136 | ------ | 134 | 131 |
| 13 | 125 | 126 | --- | ----- | ----- | 126 | ------ | ------ | 137 | ---- | 133 | 129 |
| 14 | 129 | 123 | 123 | 122 | 121 | 123 | 123 | 128 | 133 | 136 | 136 | 132 |

| local Angra dos Reis, RJ | local Angra dos Reis, RJ | local Angra dos Reis, RJ |
|---|---|---|
| DATA 07 / 02 /2006 | DATA 07 / 02 /2006 | DATA 07 / 02 /2006 |
| INSPETOR FABIO BITTENCOURT NÍVEL I | INSPETOR NÍVEL II | SUPERVISOR José Moreira Soares 1301-6 |

Measurement results

# Angra 1 Planned Investments

- **Keeping of Design Safety and Performance Levels**
  - Mitigation of PWSCC in Dissimilar Metal Welds in RPV Nozzles (MSIP)
  - Service Water System (Equipment and Piping Replacement)
  - Liquid Radioactive Waste System (Replacement of the Evaporator Package)
  - Hydrogen Cathalitic Recombiners
  - Replacement of the Main Transformers
  - I&C Modernization (Advanced Digital Feedwater Level Control System, Digital Turbine Control System, Radiation Monitoring System
  - Assessments and Design Modifications for Severe Accidents
  - Fukushima Response Plan
- **Power Uprating and Reduction in Outage Duration**
  - Modifications in the Secondary Circuit
  - Replacement of Turbine Rotors and Upgrade of the Electrical Generator
  - Improvements in Electrical Equipment
- **Life Extension**
  - License Renewal Process (Implementation of LTO Concepts)
  - I&C modernization
  - Replacement and Refurbishment of Aged Equipment

# Angra 2 Planned Investments

- **Keeping of Design Safety and Performance Levels**
  - RPV Level Instrumentation System
  - Main Control Room Post Accident Filtering System
  - Hydrogen Cathalitic Recombiners
  - Service Water System (equipment and piping refurbishment)
  - I&C Modernization (Reactor Control System, Radiation Monitoring System, Neutron Flux Measurement System, Electrical Generator Voltage Regulator)
  - Monitoring of Civil Structures
  - Assessments and Design Modifications for Severe Accidents
  - Fukushima Response Plan
- **Power Uprating and Reduction in Outage Duration**
  - Modifications in the Turbines and in the Secondary Circuit
  - Improvements in Electrical Equipment
  - Substitution of the Original Reactor Coolant Pumps Seals by Hydrodynamic Seals
- **Life Extension**
  - License Renewal Process
  - I&C modernization
  - Replacement and Refurbishment of Aged Equipment