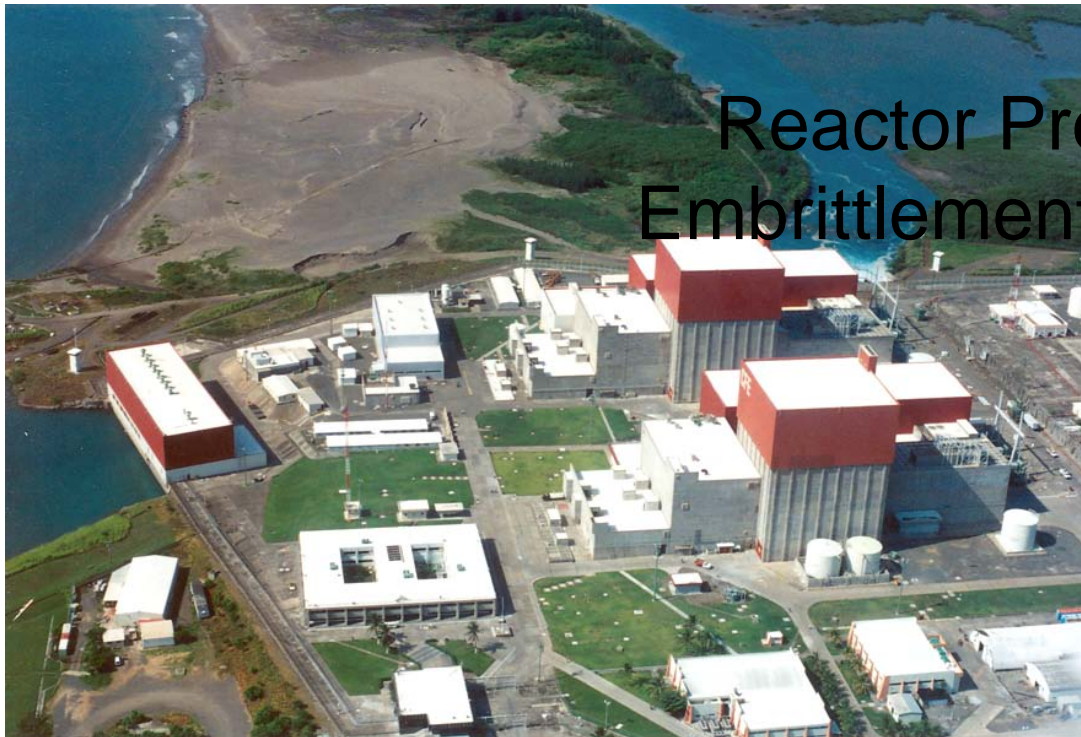




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GERENCIA DE CENTRALES NUCLEOELÉCTRICAS



# Reactor Pressure Vessel Embrittlement & Metal fatigue

Laguna Verde NPP  
Long Term Operation  
expectatives

Materials Degradation Technical Meeting  
Vienna, November 5-8/2013

Ma. Magdalena Gris C  
CNLV Engineering



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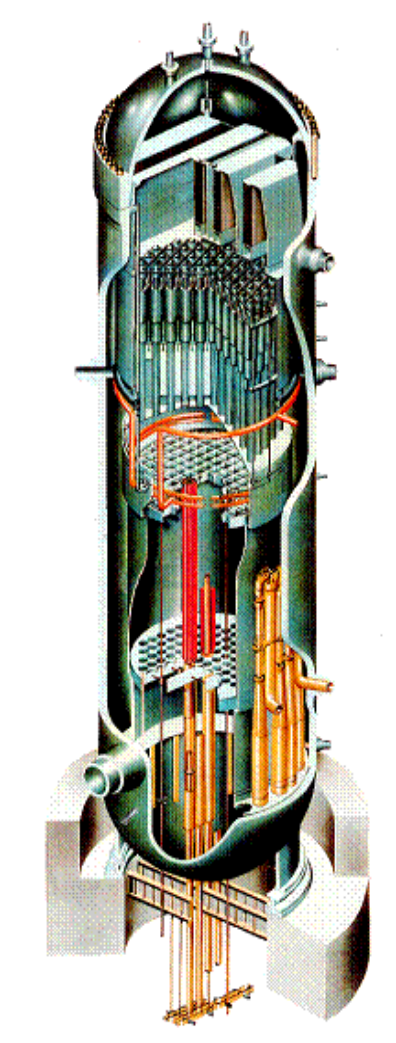


# OUTLINE

- General data of Laguna Verde Units 1 and 2 and service conditions.
- Reactor Vessel and its Internals features (design and materials)
- Aging effects to be addressed.
- RPV materials surveillance Program
  - Original, status and future
- Fatigue issues
- RVI Degradation Experience
- Conclusions

# Laguna Verde General Data

- **BWR 5/201 Reactors Mark II**
- **Commercial operation**
  - **Unit 1 since July 1990, 23 years on operation**
  - **Unit 2 since April 1995, 18 years on operation**
- **Power**
  - **Unit 1: 2027 MWt (105%); EPU 2317 MWt (120%) implemented in May/2010**
  - **Unit 2: 2027 MWt (105%); EPU 2317 MWt (120%) in Nov/2010**
- **Current cycle**
  - **Unit 1: 15<sup>th</sup> -18 month cycle**
  - **Unit 2: 12<sup>th</sup> -18 month cycle**
  - **EPU operation is not yet authorized**



# Laguna Verde General Data (2)

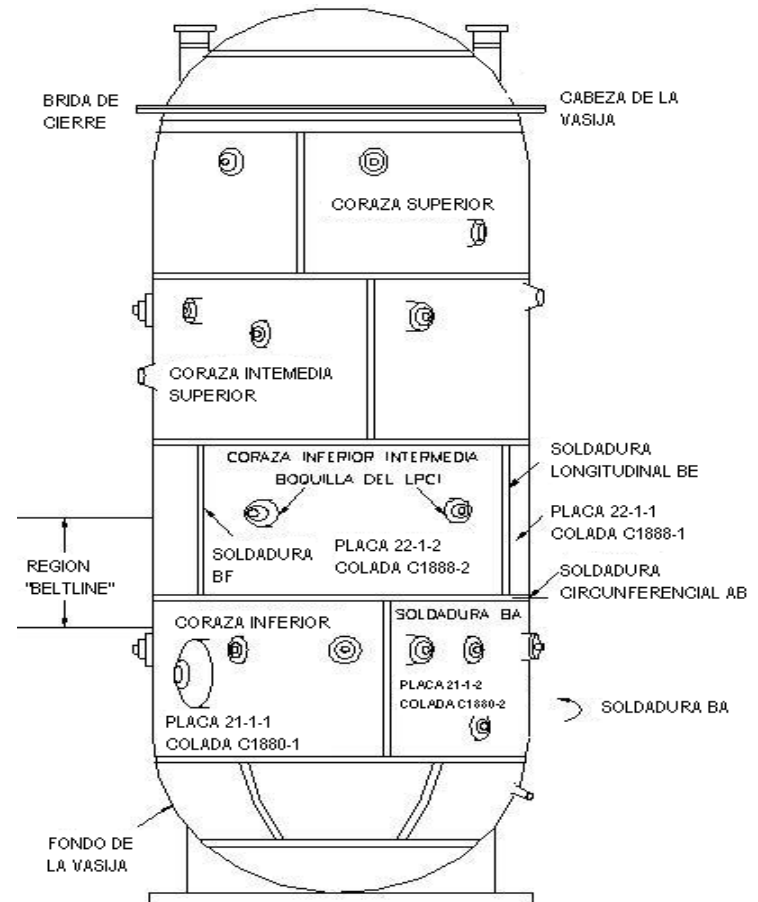
- **Control:** 109 control rods of SS with Boron carbide or Boron plus Hafnio
- **Pressure:** 70.69 Kg/cm<sup>2</sup> nominal.
- **Steam flow:** 3962 Ton/h at 100%/ 4536.36 Ton/h at new 100%
- **Recirculation pumps** 2
- **Recirculation Nominal flow** 9235 Ton/h (at 100%)
- **Feed water flow** 3950 Ton/h/ 4450 Ton/h for EPU
- **Jet pumps** 20
- **Vessel** Made of carbon steel, internally clad with SS, Total height; 20.8 m, diameter 5.30 m and Thickness from 13 to 18 cm.

# RPV and its Internals features

## Design and materials

### VESSEL

- Low alloy, high strength steel plate and forgings.
- Plates of SA 533 grade B, class1 and forgings for nozzles SA 508 class2.
- Welded construction using submerged arc and manual electrode welding processes
- Internally clad with Stainless Steel
- Plates and welds material was tested with drop weight technique





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# RPV and its Internals features

## Design and materials

Component	Material
Core Shroud	SS 304L
Core Spray Piping and Sparger	SS 304L
LPCI Coupling	SS 304
Top Guide	SS 304/304L
Core Plate	SS 304
Orificed Fuel Support	SS CAST CF8
Shroud Support	ALLOY 600
Access Hole Cover	SS 316L/Alloy 600
Control Rod Guide Tubes	SS 304
Incore and Control Rod housings	SS 304/Alloy 600
SLC / $\Delta$ P Core Plate	SS 304
Vessel Attachments	SS 304/304L/SA-533 GB
Jet Pumps	SS 304/X750/CAST CF8
Feed Water Spargers	SS 304
Steam Dryer	SS 304





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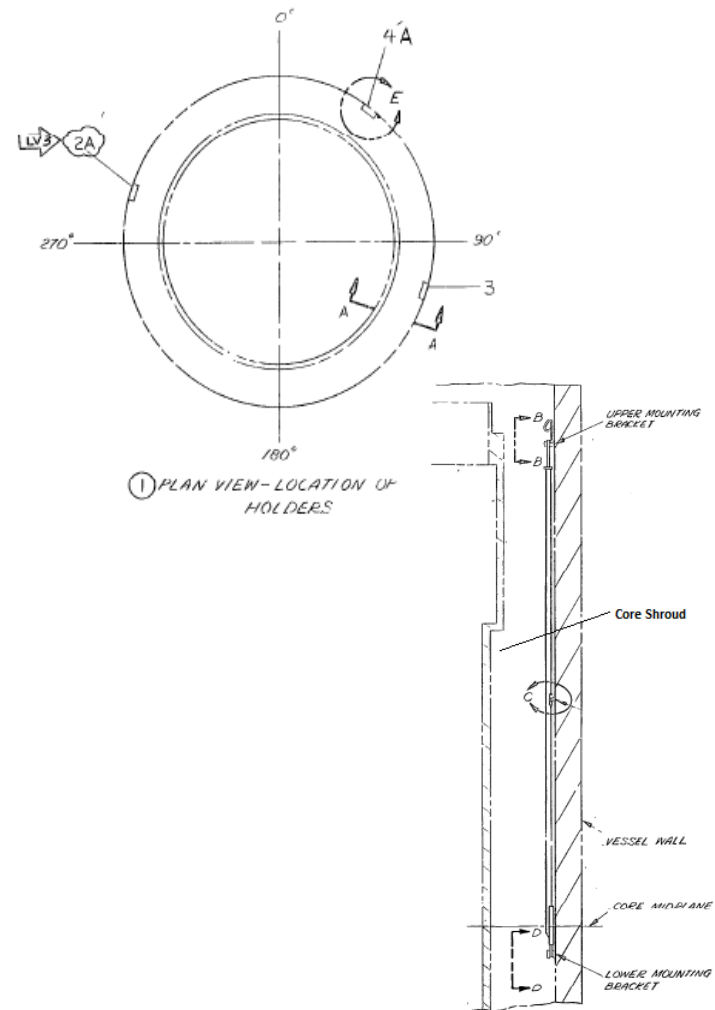


# Ageing effects to be addressed for Long term Operation

- At the beginning of 2012 Laguna Verde NPP started with its License Renewal evaluation, based on the American regulation which main rule is 10 CFR 54.
- At this time has been identified the components in the scope of the evaluation and the aging effects .
- The key elements to be evaluated for Vessel and its internals are:
  - ✓ Neutron embrittlement
  - ✓ Fatigue
  - ✓ SCC (for internals)

# Vessel Materials Surveillance Program.

- The vessel material surveillance program was established under appendix H and G of 10CFR 50
- Three surveillance capsules per unit containing charpy and tension specimens.
- Specimens were prepared from same plates and welds of belt line locations
- Additionally was installed in 30 capsule, dosimeters which were withdrawn during the first outage each unit.







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# Vessel Materials Surveillance Program 2

	First holder Location Azimuth 30°	Second holder Location Azimuth 300°	Third holder Location Azimuth 120°	Fourth holder Location Azimuth 30°	Fifth Holder Location Azimuth 300° (U1)
Charpy impact specimens	36	24	24	24	24
Base metal	12	8	8	12	12
Weld metal	12	8	8	12	12
Weld heat affected zone material	12	8	8		
Tensile specimens	10	6	8	6	6
Base metal	3	2	3	3	3
Weld metal	4	2	3	3	3
Weld heat affected zone material	3	2	2		
<b>Extraction sequence EFPY</b>	<b>6</b>	<b>15</b>	<b>32</b>	<b>Undefined</b>	<b>Undefined</b>

- Were reconstituted specimens of first and second capsule unit 1 and reinstalled during 7<sup>th</sup> and 14<sup>th</sup> outages
- Unit 2 just have the azimuth 30 with specimens reconstituted.
- U1 has a complete set of surveillance material, U2 has two remaining capsules.



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# Vessel Materials Surveillance Program 3

## **32 EFPY ART Calculations for Unit 1 Beltline Materials**

### **Lower-Intermediate Shell Plate & Welds**

Thickness in inches = 5.00	32 EFPY Peak I.D. fluence =	3.90E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		2.89E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		2.89E+18 n/cm <sup>2</sup>

### **Lower Shell Plate & Welds & Lower to Lower-Intermediate Girth Weld**

Thickness in inches= 5.00	32 EFPY Peak I.D. fluence =	3.60E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		2.67E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		2.67E+18 n/cm <sup>2</sup>

### **RHR/LPCI Nozzles**

Thickness in inches= 5.00	32 EFPY Peak I.D. fluence =	1.64E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		1.21E+18 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		1.21E+18 n/cm <sup>2</sup>

### **Recirculation Inlet Nozzles**

Thickness in inches= 5.00	32 EFPY Peak I.D. fluence =	6.73E+17 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		4.99E+17 n/cm <sup>2</sup>
32 EFPY Peak 1/4 T fluence =		4.99E+17 n/cm <sup>2</sup>

**Will be performed an evaluation of fluence considering 120%  
EPU, for 54 EFPY in order to update the program for LTO**



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# Vessel Materials Surveillance Program 4

## ***32 EFPY ART Calculations for Unit 2 Beltline Materials***

### **Lower-Intermediate Shell Plate & Welds**

Thickness in inches = 5.00	32 EFPY Peak I.D. fluence =	4.10E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	3.04E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	3.04E+18 n/cm <sup>2</sup>

### **Lower Shell Plate & Welds & Lower to Lower-Intermediate Girth Weld**

Thickness in inches = 5.00	32 EFPY Peak I.D. fluence =	3.76E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	2.79E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	2.79E+18 n/cm <sup>2</sup>

### **RHR/LPCI Nozzles**

Thickness in inches = 5.00	32 EFPY Peak I.D. fluence =	1.64E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	1.21E+18 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	1.21E+18 n/cm <sup>2</sup>

### **Recirculation Inlet Nozzles**

Thickness in inches = 5.00	32 EFPY Peak I.D. fluence =	7.53E+17 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	5.58E+17 n/cm <sup>2</sup>
	32 EFPY Peak 1/4 T fluence =	5.58E+17 n/cm <sup>2</sup>

**Will be performed an evaluation of fluence considering 120%  
EPU, for 54 EFPY in order to update the program for LTO**



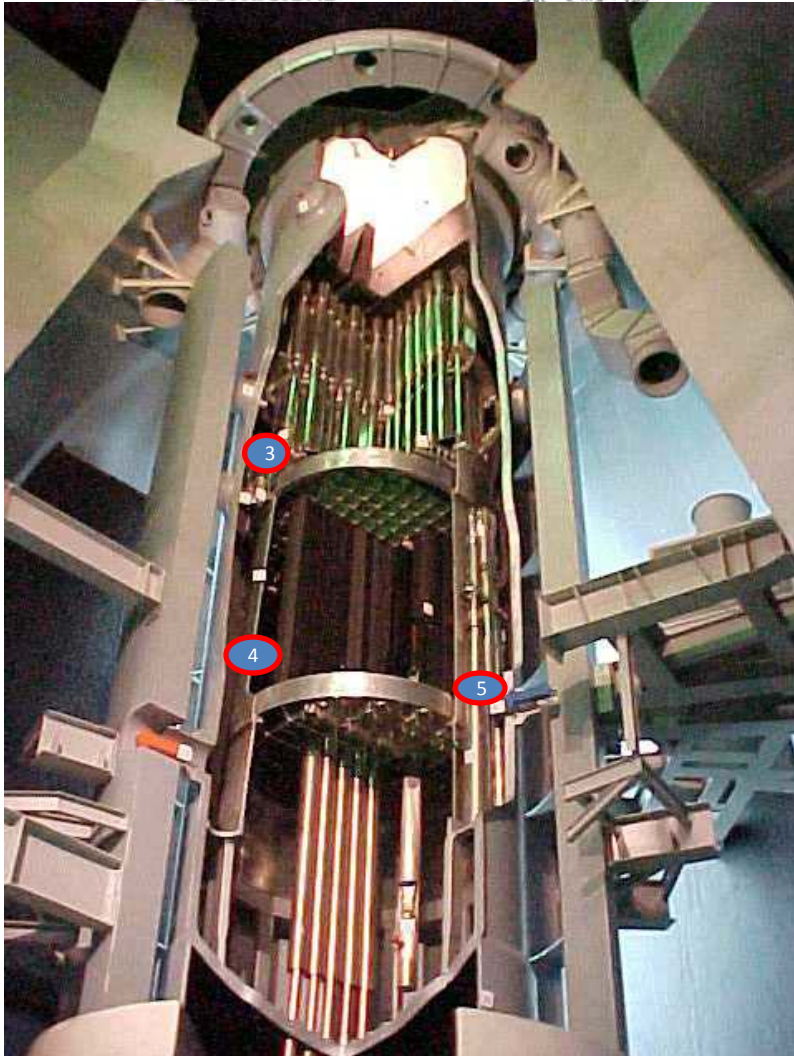
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# Fatigue evaluations for RPV And components class 1

- Metal Fatigue Scoping and Recommendation study:
  - ✓ To establish the structure of a FMP (Fatigue Management program) including the Environmental fatigue monitoring program
- Evaluation of Plant Cycle Counting and Fatigue Monitoring Locations:
  - ✓ It will be performed a comprehensive review of existing plant-specific systems, cycle counting procedures, and requirements at CLV. Cycles will be projected for 60 years of operation for each unit.
- EAF Screening:
  - ✓ Also it will be performed an EAF screening analysis using the rules of NUREG/CR-6909 to determine the sentinel locations for each component, which will include those locations specified by NUREG/CR-6260.

# RPVI degradation experience



Following RVI have experienced flaws:

1. Steam Dryers of U1 & 2.
2. Steam Separators U1/U2
3. End bracket pins at Unit 2
4. Core Shrouds of U1 & 2
5. Jet Pumps of U1 & 2

**Others internals without flaws**



# RPVI degradation experience 2



**Jet Pumps Assembly-Construction**



**Wedge Assembly-construction**



**Cracking of riser pipe JP 9/10 during RF-13**



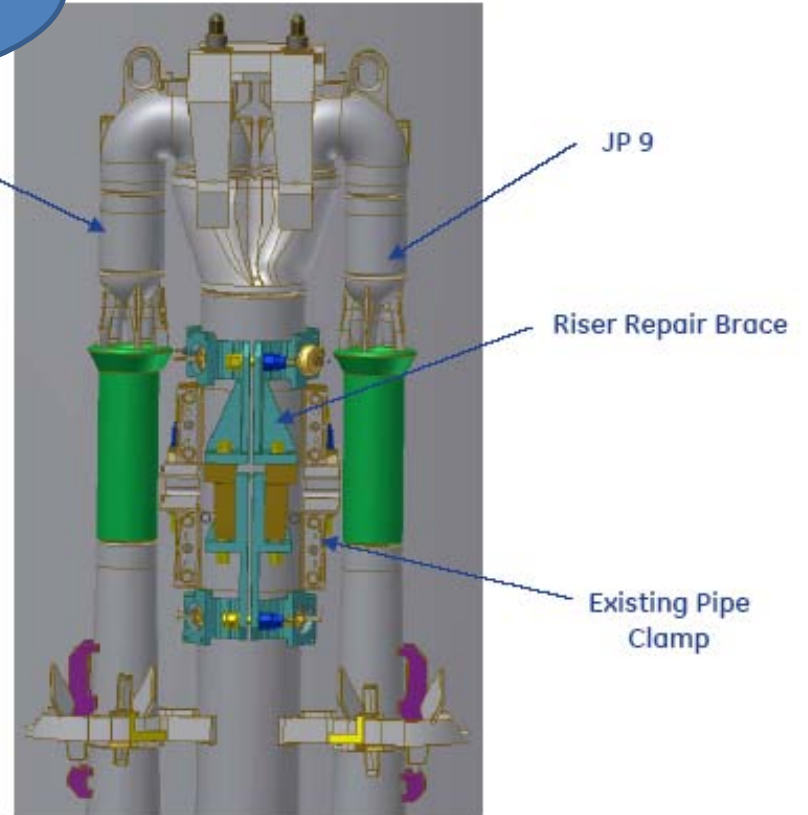
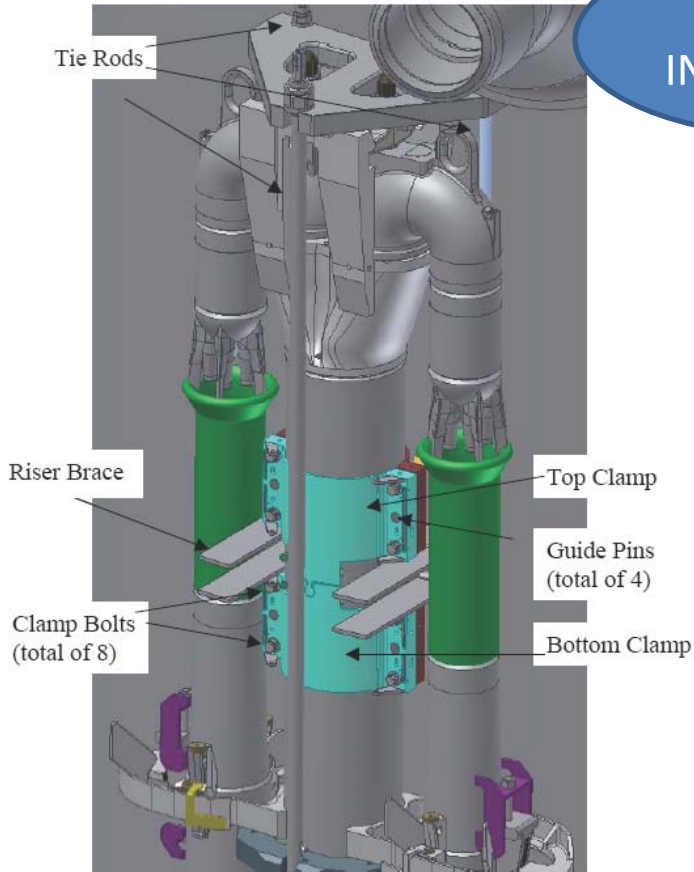
**High movement and wear of wedge of JP10 during RF-13**



**JP 10 AS-1 GAP SS**

# RPVI degradation experience 3

PROPERTY  
INFORMATION



**Clam Shell with Tie-Rods  
Temporary Repair**

**The repair will allow EPU conditions for  
design life**





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# Conclusions

- As was mentioned, Laguna Verde is working preparing the evaluations for Long Term Operation, following the License Renewal rule (10CFR54)
- One of the most important system what is being evaluated is vessel and its internals, specifically addressing the neutron embrittlement and fatigue related with its components.
- Regarding the surveillance program Laguna Verde has the sufficient material for the extended period.
- It is expected that, with the repairs and programs to be implemented the Long Term operation is granted.