Ageing Management Program of Reactor Pressure Vessel Internals components in a BWR Nuclear Power Plant.

Carlos R. Arganis Juarez
National Nuclear Research Institute ININ Mexico.

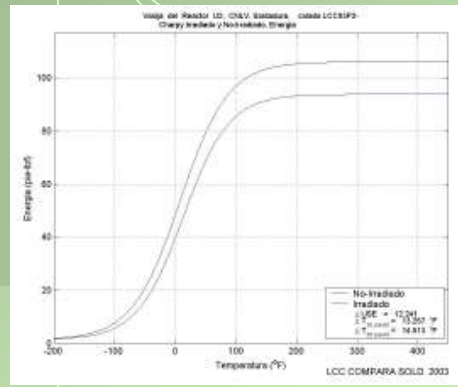
Marco A. Sanchez M.
Comision Federal de Electricidad. Mexico.

Second International Symposium on NPP PLiM, Shanghai China

Introduction.

ININ is a Research Institute to give Scientific support to Laguna Verde NPP.

IAEA Projects



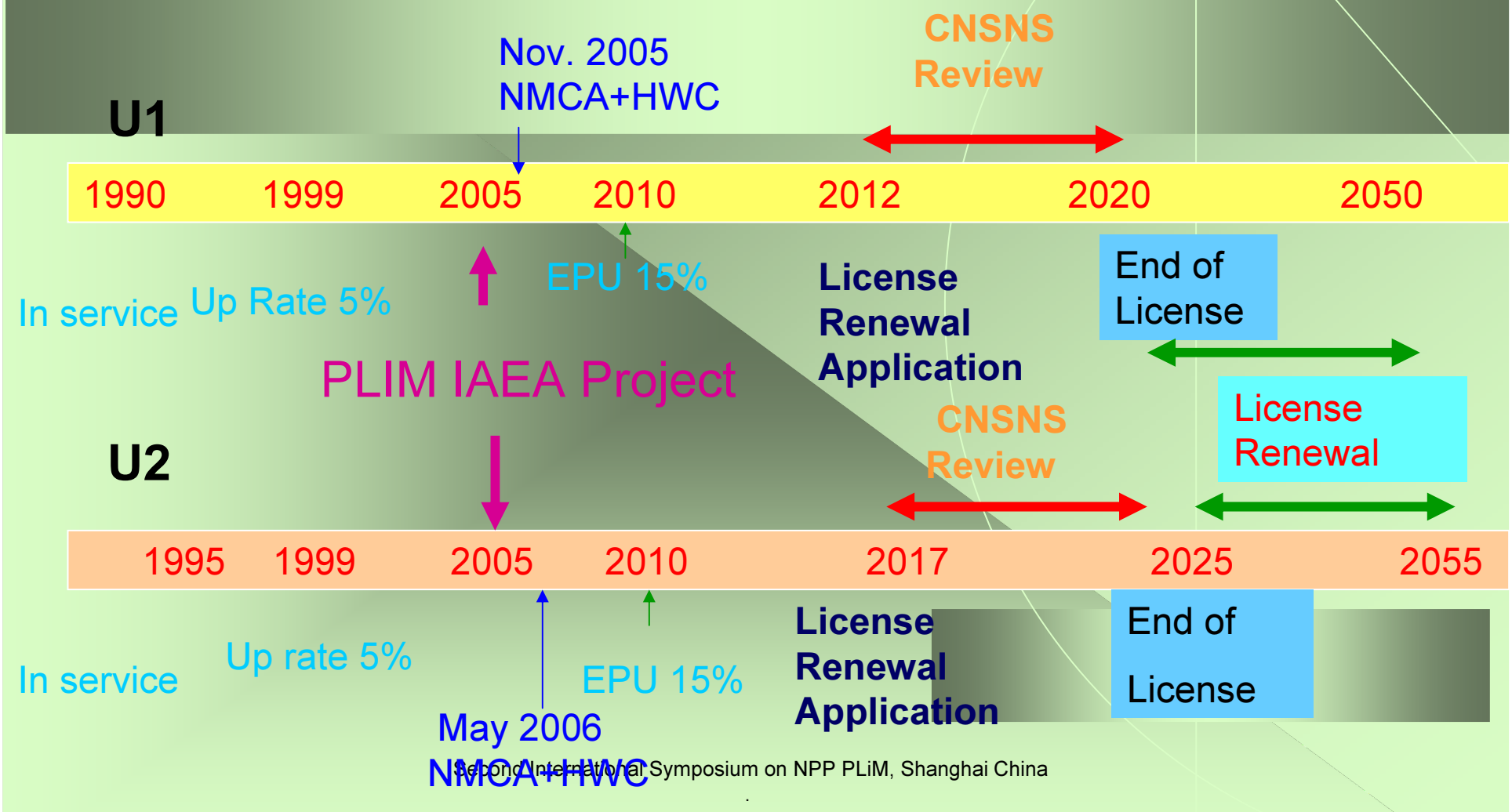
- **IAEA Projects**
- **1993-1996 MEX 4/044 SCC and FM**
- **1997-1998 MEX 4/047 SCC at BWR NPP**
- **1999-2000 MEX 4/047 A1 Core Shroud**
- **(RPVI´s Studies)**

- **Since 2001 IAEA projects are**
- **focus in RPV (MEX 4/051 and MEX 4/053)**

- **2003 Surveillance Program U2 with ININ collaboration**

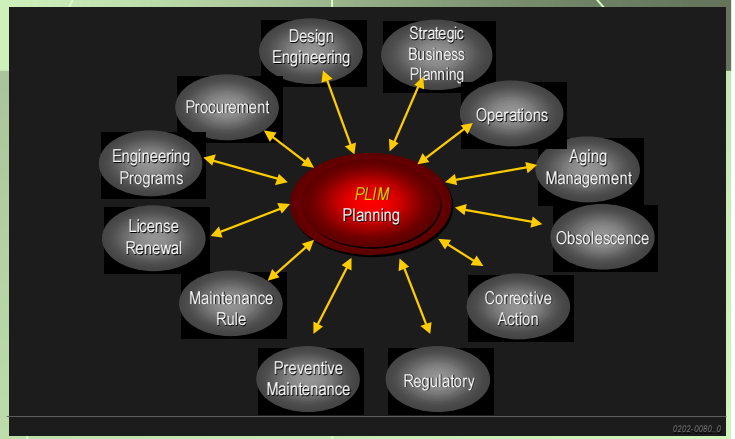
2 General Electric BWR-5 Units, Mark-II Containment.
Commercial operation: U-1 in July 1990; U-2 in April 1995.
License for 30 years.
US regulations have been adopted by the Mexican Authority. CNSNS
Current cycle: U-1, 13th cycle; U-2, 9th cycle.
Original licensed reactor thermal power is 1931 MWth, uprated to 2027 MWth in 1999. 5%
20% Extended Power Uprate Project.

Laguna Verde.



PLiM program integrated other programs.

- **Programs, studies and data based existed in the NPP.**
- **On line monitoring**
- **Surveillance Programs**
- **In Service Inspection Programs (ISI),**
- **In Vessel Visual Inspection Program (IVVI).**
- **Other inspection programs.**

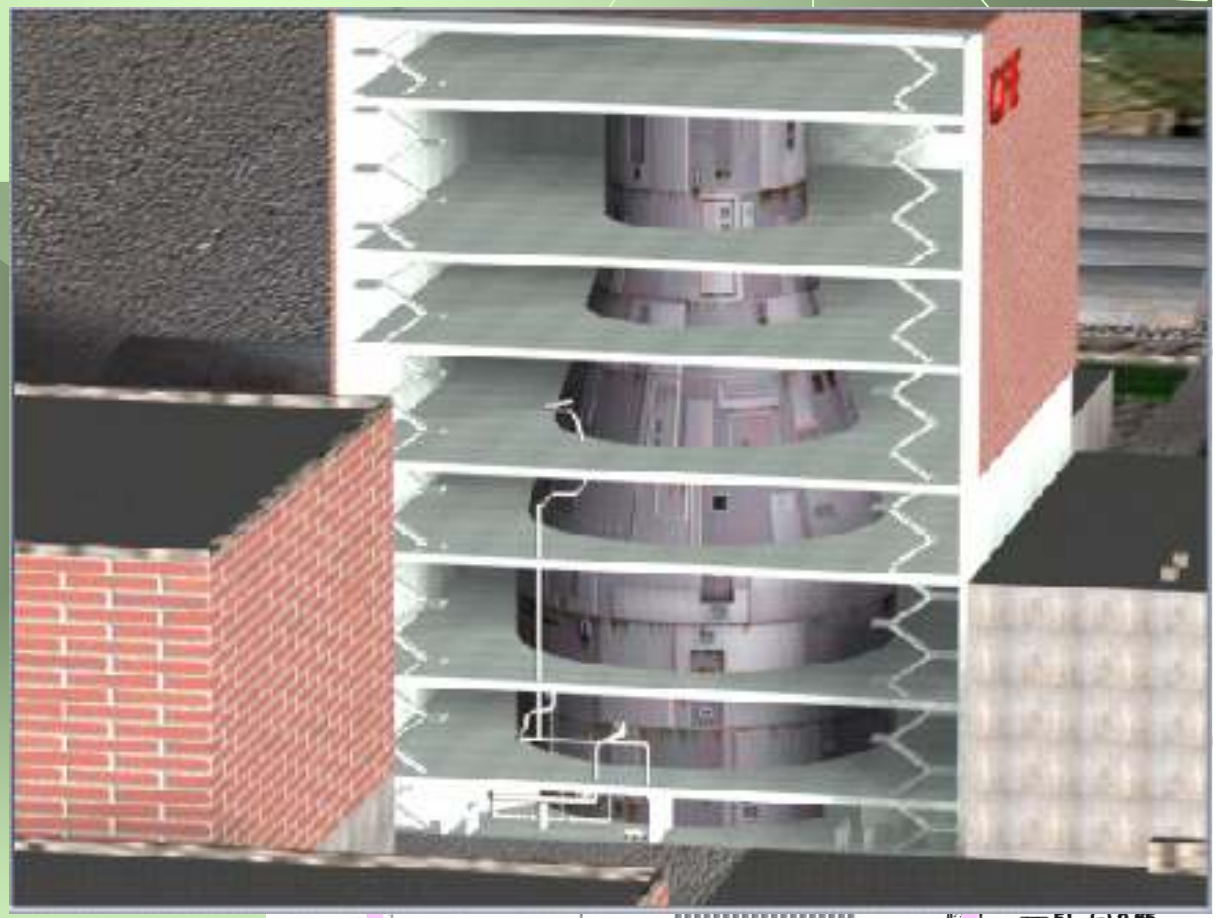


- **Maintenance and operation data bases**
- **Maintenance Rule**
- **Reliability programs** (AP-913 Reliability Process)
- **Ageing Management Programs**

- **Extended Power Uprate Project**
- **EPRI Full Membership**

Ageing Management Pilots programs

Core Shroud
(Extended to RPVIs)
Reactor Pressure Vessel
RFW
Primary Container
Cables



Project MEX 04/53 Status Report

Project Manual and Procedures:

- **Manual is in the review process**
- **Long Term Plan procedure in the review process**
- **SSCs Selection procedure is being prepared.**

Ageing evaluation procedure will be prepared

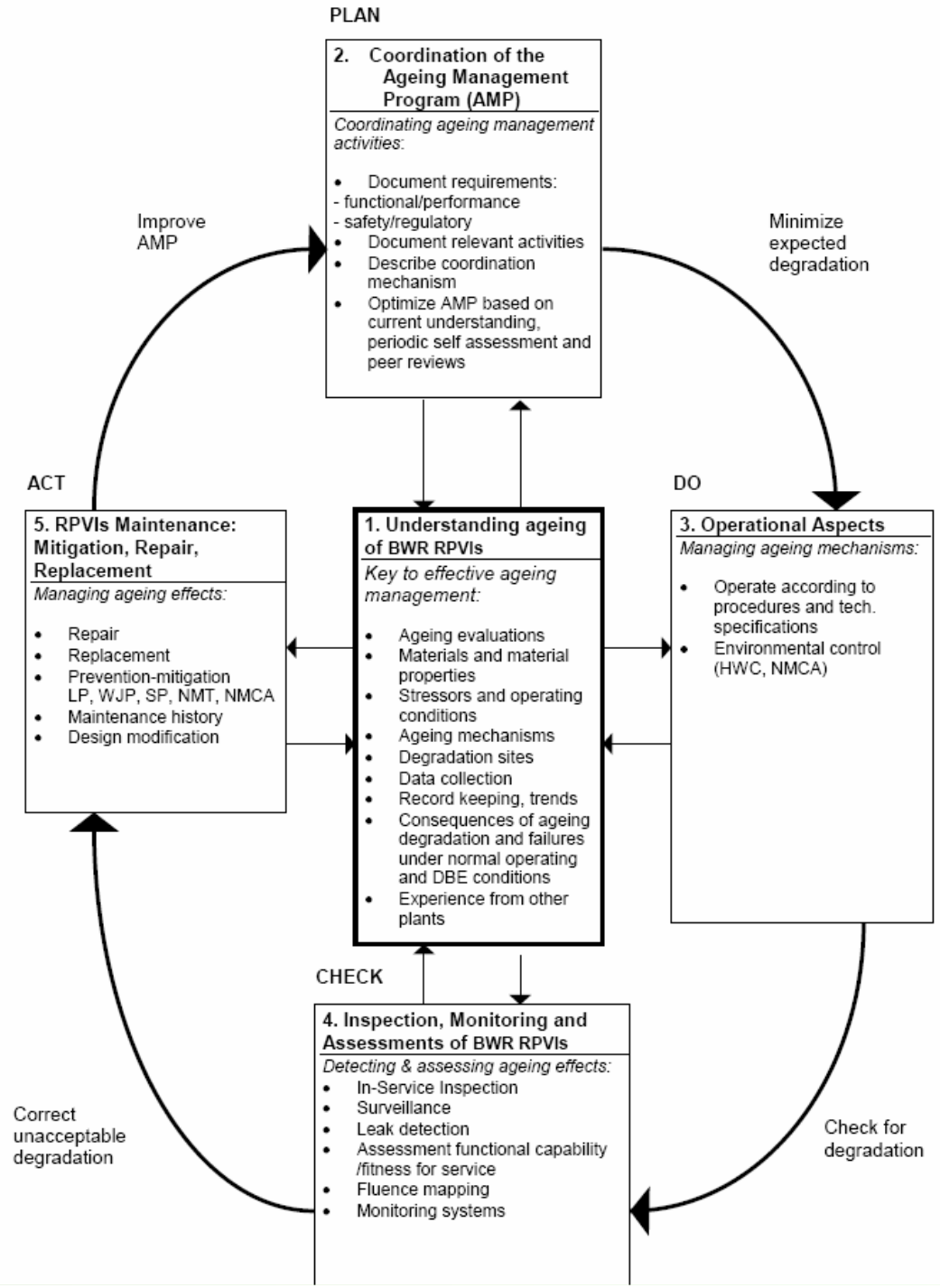
- **ININ is working in Scooping & Screening processes based in CRF 54 and focusing in Renewal License.**

Training:

Identification and Detection of Ageing Issues
Specific training

Databases:

Selection of (software) alternatives is being performed. Access is using now.

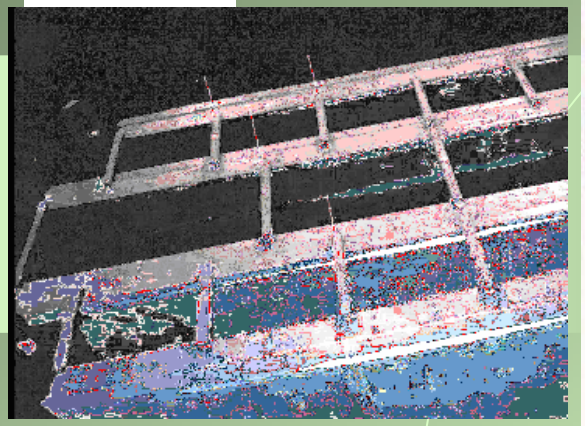

PLAN
2. Coordination of the Ageing Management Program (AMP)
Coordinating ageing management activities:
• Document requirements:
- functional/performance
- safety/regulatory
• Document relevant activities
• Describe coordination mechanism
• Optimize AMP based on current understanding, periodic self assessment and peer reviews
Improve AMP
Minimize expected degradation
ACT
DO
5. RPVIs Maintenance: Mitigation, Repair, Replacement
Managing ageing effects:
• Repair
• Replacement
• Prevention-mitigation LP, WJP, SP, NMT, NMCA
• Maintenance history
• Design modification
1. Understanding ageing of BWR RPVIs
Key to effective ageing management:
• Ageing evaluations
• Materials and material properties
• Stressors and operating conditions
• Ageing mechanisms
• Degradation sites
• Data collection
• Record keeping, trends
• Consequences of ageing degradation and failures under normal operating and DBE conditions
• Experience from other plants
3. Operational Aspects
Managing ageing mechanisms:
• Operate according to procedures and tech. specifications
• Environmental control (HWC, NMCA)
CHECK
4. Inspection, Monitoring and Assessments of BWR RPVIs
Detecting & assessing ageing effects:
• In-Service Inspection
• Surveillance
• Leak detection
• Assessment functional capability /fitness for service
• Fluence mapping
• Monitoring systems
Correct unacceptable degradation
Check for degradation

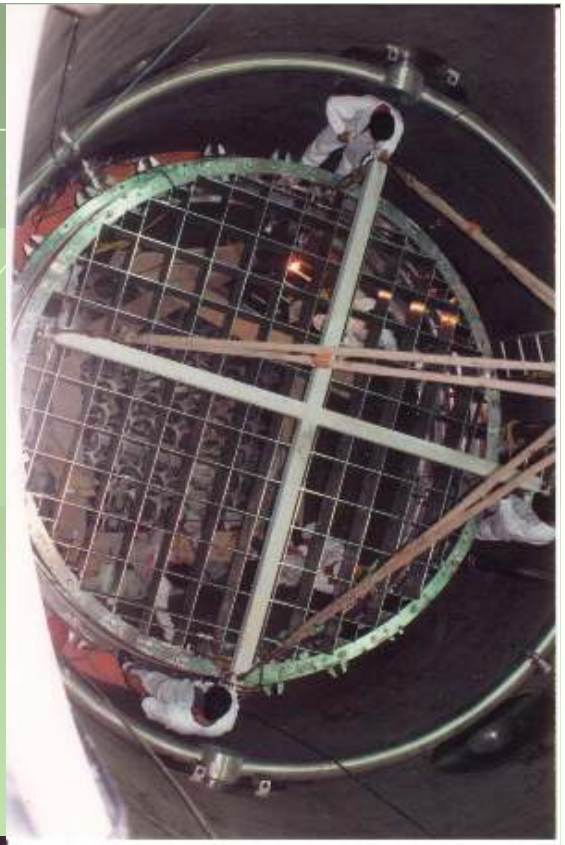
DP y SLC

instrumentation

Penetrations U1, U2

Steam Dryers U1

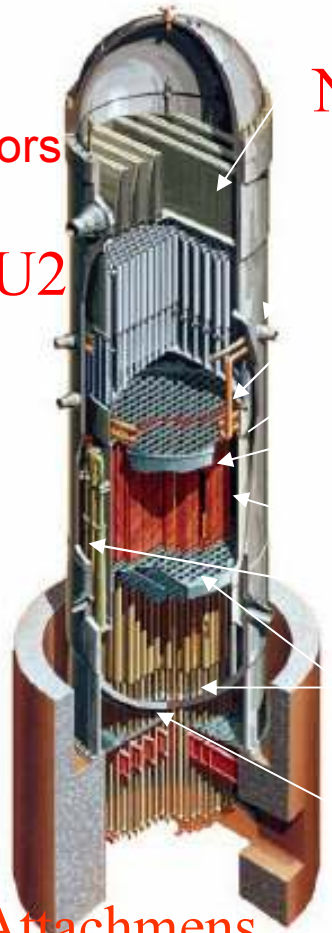




Steam separators U1 U2

N4B

LPCI U2 U1



Core Spray U1, U2

Top Guide U2 U1

Core Sparger U1 y U2

Core Shroud U1 y U2

Jet Pumps U1 y U2

Support Plate U2 U1

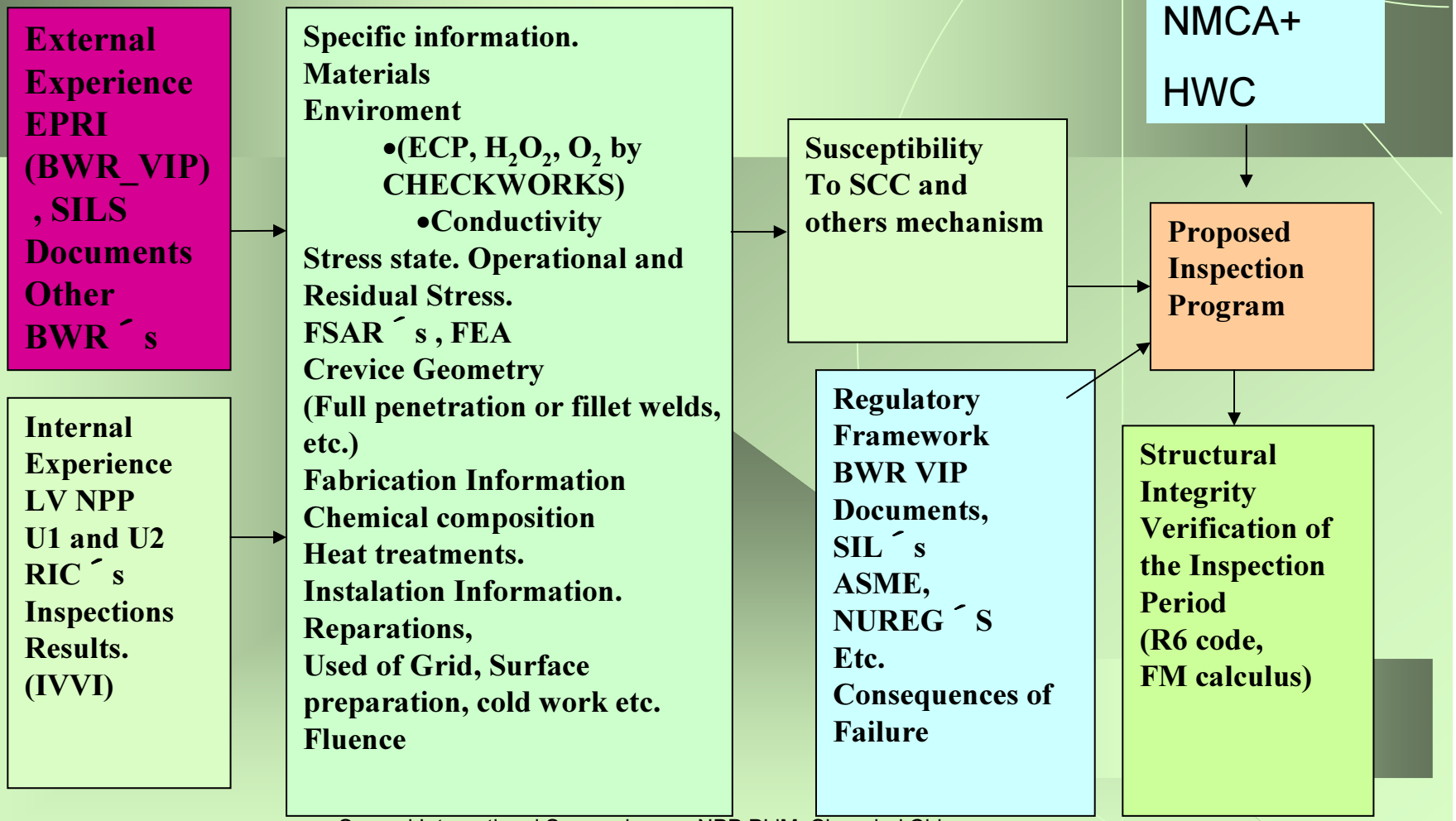
Core Plate U2 U1

CRD U2 U1

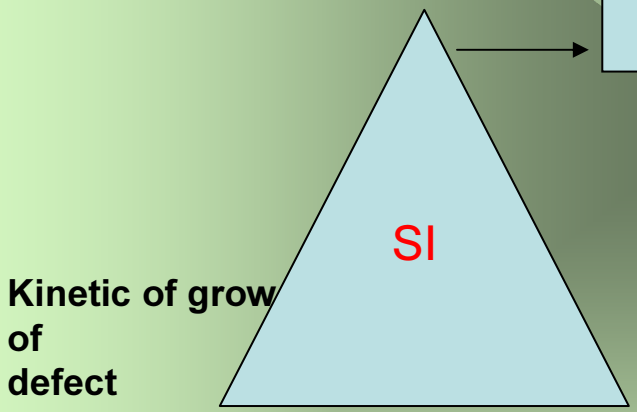
Weld Attachmens U2 U1

Access Hole Cover U2, U1

Methodology used to assessment of Internals components in LVNPP.



Methologies for Structural Integrity used in some components.



Size
Defect "a"
NDT

Operational and
Residual Stress
σ y K (FEA)

Use Failure
Assessment
Diagram
In the
component
or fracture
mechanical
calculus

Extrapolation by the
predictive model for a
Period of time proposed

Inspect in the period of
time proponed is the
FSD shows that is safe

Kinetic of grow
of
defect
da/dt=V, AK^n
Predictive

Mechanical
Properties
UTS, σ y, KIC,

U1 Water Chemistry.

Cicle	Conductivity (□S/cm)	Chlorides (ppb)	Sulfates (ppb)	Oxigen* (ppb)
1	0.240	3.6	---	---
2	0.130	2.56	---	---
3	0.180	2.90	4.62	---
4	0.190	4.06	5.07	91.00
5	0.124	2.10	3.49	80.75
6	0.114	1.39	2.80	82.75
7	0.100	3.32	2.59	78.75
8	0.057	1.40	1.40	79.02
9	0.122	0.70	1.13	67.63
10	0.121	0.86	1.40	35.89
11	0.119	1.21	1.85	65.48
Average	**0.136**	**2.19**	**2.71**	**72.66**

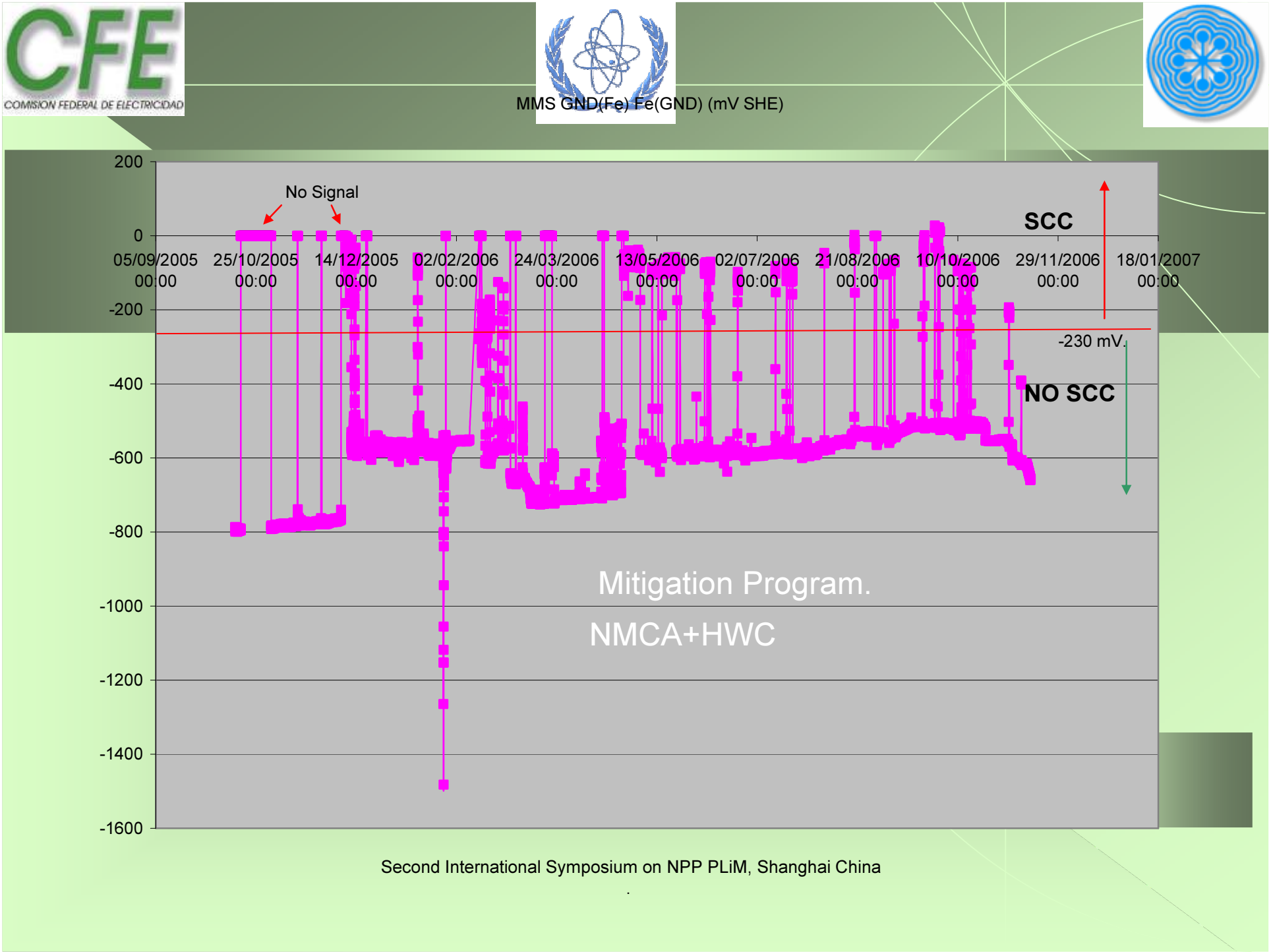
*Feed Water

Example of ECP values by CHECWORKS

	Weld/Region					
Cycle	H3 Inside Channel mV. vs. SHE	H3 Outside Down comer mV. vs. SHE	H4 Inside Channel mV. vs. SHE	H4 Outside Down comer mV. vs. SHE	H5 Inside Channel mV. vs. SHE	H5 Outside Down comer mV. vs. SHE
1	277.07	224.24	262.11	289.99	265.75	230.37
2	302.31	276.31	286.49	276.71	264.41	251.33
3	303.07	275.27	288.67	278.25	265.39	251.58
4	300.16	276.39	288.61	278.38	264.01	258.36
5	299.33	220.83	291.53	242.02	265.75	230.37
6	301.07	275.79	290.03	270.46	262.30	241.66
7	306.83	284.95	288.20	282.24	266.84	259.81
8	300.27	279.81	290.28	274.79	259.90	244.12
9	294.22	268.81	291.67	259.52	258.46	227.53
10	241.39	202.88	247.58	259.32	252.84	283.01
11	256.21	274.18	288.03	271.07	260.96	243.85
Average	**289.26**	**259.88**	**283.01**	**271.15**	**262.41**	**247.45**

Table 1. Main Internals components, safety function, materials and guidelines associated

Internal Components	Safety function	Material	BWR VIP Associated document.
Shroud	Yes	304L welds 308L Support ring alloy 600	76
core spray internal Piping	Yes	304L welds 308L	18
Core Spray Sparger,	Yes	304L welds 308L	18
core plate	Yes	304 welds 308 and 308L	25
top guide	Yes	304, 3304L welds 308L	26
In core Housing-CRD housing-CRD Guide tube-Dry tubes	Yes	Several	47
Jet Pumps	Yes	304, 304L beams X-750 low ring alloy 600 alloy 182 welds	41
LPCI Coupling	Yes	304 welds 308L	42
Weld internals attachments	Some of them	A533, 82/182/600 alloys	6A, 48A, 18A

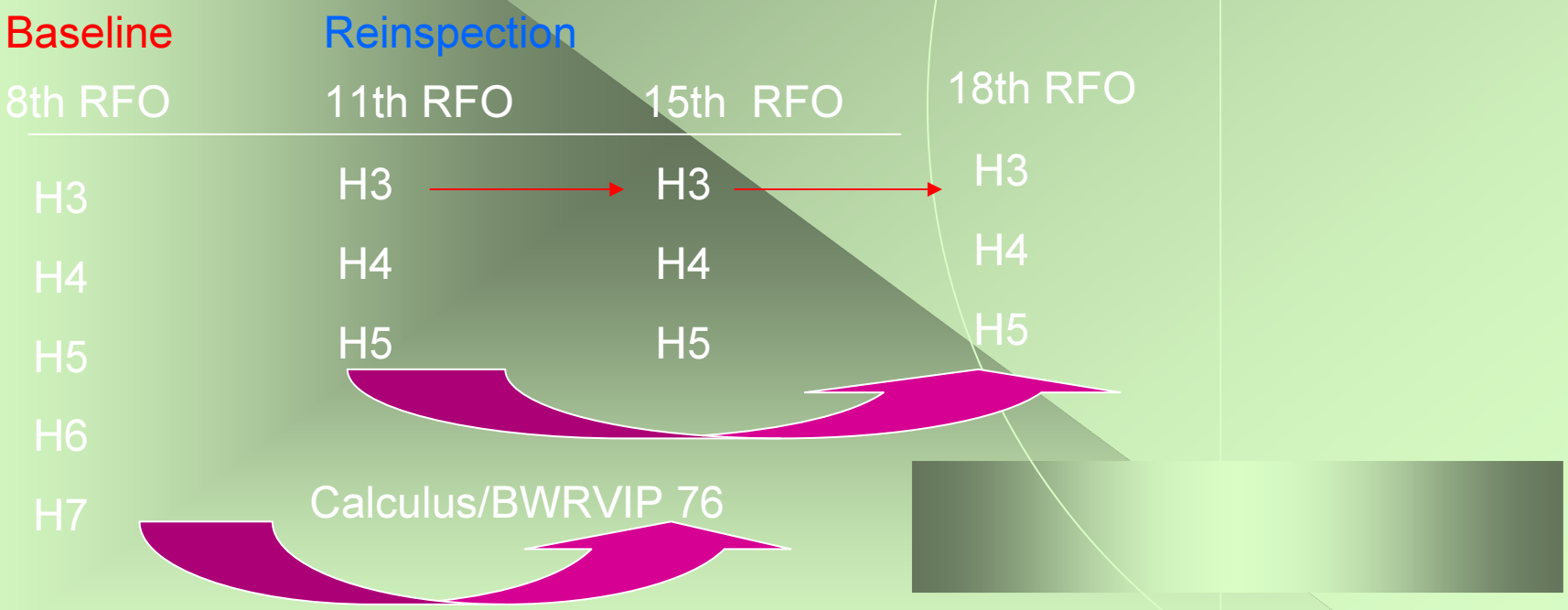

MMS GND(Fe) Fe(GND) (mV SHE)
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
05/09/2005 00:00
25/10/2005 00:00
14/12/2005 00:00
02/02/2006 00:00
24/03/2006 00:00
13/05/2006 00:00
02/07/2006 00:00
21/08/2006 00:00
10/10/2006 00:00
29/11/2006 00:00
18/01/2007 00:00
No Signal
SCC
-230 mV.
NO SCC
Mitigation Program.
NMCA+HWC

Ageing Mechanisms example: Shroud

- Mainly IGSCC & TGSCC is possible
- IASCC on H4/H5 after cycle 14

(CFE has calculated conservative Fluence, ININ refined calculations.)

Structural Integrity.



Programms Inspection IVVI. Shroud

WELD	INSPECTION METHOD	RFO	REMARKS
H3, H4 & H5	UT	8 th 11th 18 th	Baseline inspection (Jun/2001). 1fst Reinspection (Sep/2005). 2nd Reinspection, Feb/2016. H3 will be reevaluated for 10 years.
H1, H2, H6A, H6B & H7	UT	8 th 15 th	Baseline inspection (Jun/2001). 1fst Reinspection (Sept/2011).
V1 through V10	EVT-1 or UT	7th, 9th	V3 through V8 inspected by EVT-1 no indications. Reinspection depends of results of horizontal welds (BWRVIP 76). V3 through V5 will be reevaluated after fluence refined calculations.

Shroud.

- AMP is well advanced.
- Integrity is assure for next 10 years of operation (From 2005).
- Inspection program is regarding to BWRVIP
- Mitigation program is already implemented.
- It is necessary to evaluated the EPU impact in the Ageing Management Programs of all the RPVIs components

CONCLUSIONS

- The methodologies applied to the Internal Reactor Pressure Vessel components, which were designated like a pilot program within the scope of the Ageing Management Programs (AMP) and PLiM Program was discuses.
-
- The state of the art of the AMP´s of the Internal was presented.

- The used of BWR-VIP Guidelines and ININ´s experience in IGSCC and other ageing mechanism obtained in IAEA research projects was very important to the AMP for the RPVI´s in the Mexican BWR units.

Thanks very much

Second International Symposium on NPP PLiM, Shanghai China