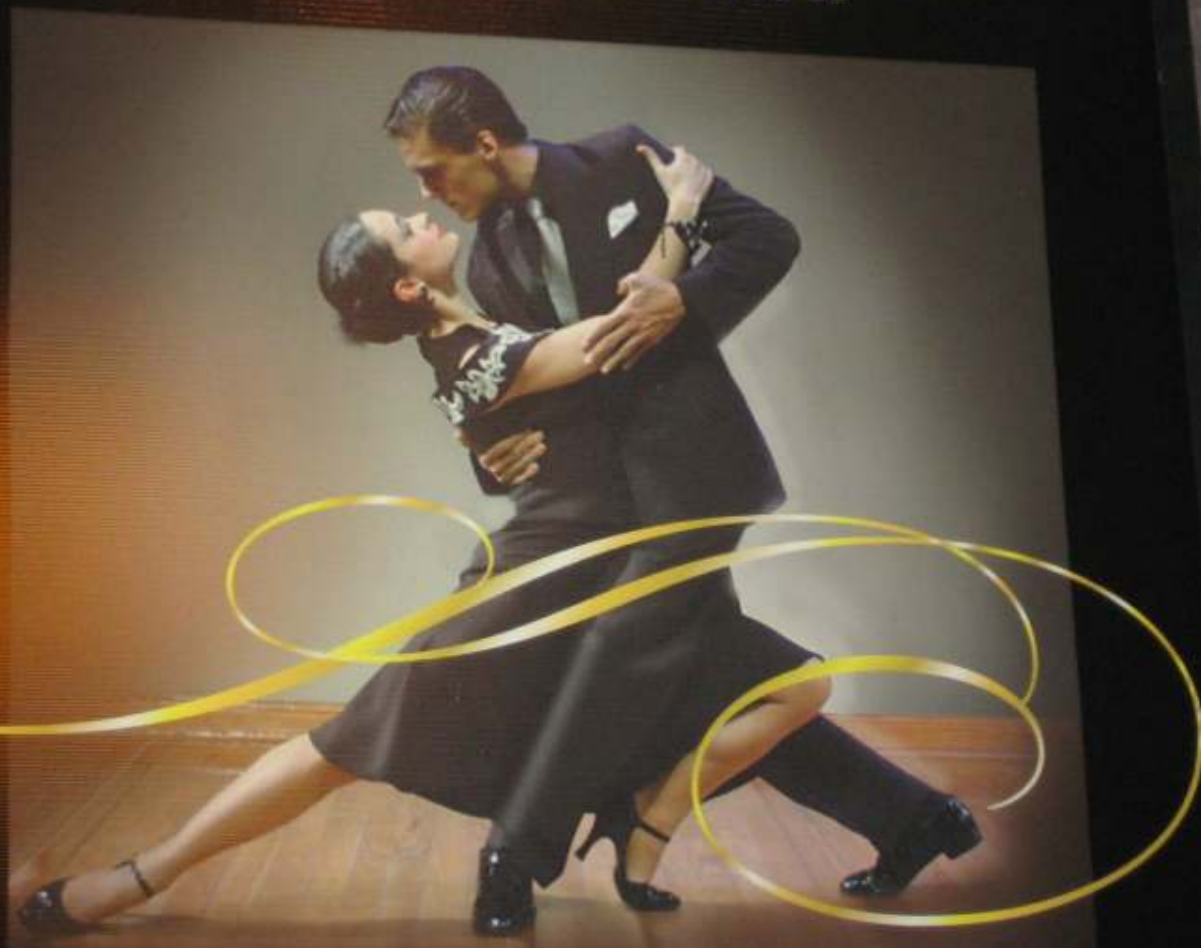


**RLA 4021 TC Project
9 ~ 12 Dec 2008
CNEA, Argentina**

Regional Workshop on
the Detection, Research,
Management and
Monitoring of Ageing
Factors in Nuclear
Power Plants



COMPLEJO
Tango
CENA-TANGO-SHOW



2608

Workshop Team Members

- **Participants : 38~ 40 people**
 - **Argentina : CNEA & Embalse NPP**
 - **Brazil : 7 from CDTN & Elecronuclear**
 - **Mexico : 6 from ININ**
- **Invited Experts**
 - **B. Leonard (PNNL, USA)**
 - **J. H. Lee (PNU, KOR)**
 - **H. Nopper (AREVA, GER)**
 - **K. Streit (AREVA, GER)**
- **Technical Director**
 - **Argentina CNEA; Burkart, Arturo Lorenzo**
- **IAEA Officer**



IAEA
Division)

KA SIG KANG (*Technical Head for PLiM/ LTO, Nuclear Power*

| Time | Tuesday (9 Dec) | Wednesday (10. Dec) | Thursday (11. Dec) | Friday (12. Dec) |
|---------------|--|---|--|--|
| | Basic Knowledge on equipment degradation and ageing focusing on Erosion and Corrosion | R&D activities on equipment degradation and ageing | Application tool or approaches for diagnostics / prognostics on equipment degradation (1) | Application tool or approaches for diagnostics / prognostics on equipment degradation (2) |
| 9:00 – 09:15 | Course Introduction, Opening, Introduction on participants | PLiM and AMP K. Kang (IAEA) | Diagnostics and prognostics: technical challenges B. Leonard (PNNL, USA) | Current in-service inspection and leak monitoring B. Leonard (PNNL, USA) |
| 09:15- 10:00 | IAEA Contributions for PLiM/ EC, K. Kang (IAEA) | | | |
| 10:00-11:00 | Introduction to equipment ageing and degradation: erosion and corrosion B. Leonard (PNNL, USA) | Diagnostics and prognostics: state of the art and programs B. Leonard (PNNL, USA) | Proactive Management of Materials Degradation: an information tool based on NRC 6923 B. Leonard (PNNL, USA) | Condition based maintenance H. Nopper (AREVA, GER) |
| 11:00-11:15 | Coffee Break | Coffee Break | Coffee Break | Coffee Break |
| 11:15-12:15 | Overview of world material degradation issues of NPPs, focusing on pipe wall thinning and rupture; H. Nopper (AREVA, GER) | Main Degradation Mechanisms on Erosion and corrosion, FAC, EAC, Fatigue, SCC H. Nopper (AREVA, GER) | Behaviour and mechanism of pipe wall thinning and rupture H. Nopper (AREVA, GER) | Closing session Summary of WS |
| 12:15 – 13:30 | Lunch | Lunch | Lunch | Lunch |
| 13:30 – 14:30 | R&D on Flow accelerated corrosion, EAC, Fatigue, SCC in Korea. J. H. Lee (PNU, KOR) | Inspection and monitoring of pipe wall thinning and rupture J. H. Lee (PNU, KOR) | PWR secondary side chemistry / corrosion control / steam generator performance(2) K. STREIT(AREVA, GER) | Say Good Bye |
| 14:30- 15:30 | Water Chemistry Diagnosis System K. STREIT(AREVA, GER) | PWR Primary Side Chem. Corrosion Control and Dose Reduction Issues(1) K. STREIT (AREVA, GER) | Application of NDE tool for diagnostics on ageing degradation. J. H. Lee (PNU, KOR) | |
| 15:30 – 15:45 | Coffee Break | Coffee Break | Coffee Break | |
| 15:45 – 16:45 | Participants presentation (1) - Argentina (1) - Mexico | Participants presentation (2) - Argentina(2) - Brazil | Panel Discussion on Advanced Diagnostics/Prognostics– Technical Challenges | |
| 16:45 – 17:00 | Daily Summary | Daily Summary | Daily Summary | |

9 Dec. Summary

- Ki Sig :
 - Introduction of PSR. LRA for life extension and IAEA activities
- Bond : R&D aspect
 - List of R&D topics
 - Proactive Management of Materials Degradation
- Helmut : Utilities' point of view
 - FAC history
 - Basis of philosophy, Introduction of Comsys
- Joon Hyun : Academia aspect
 - Proactive Management of Materials Degradation
 - Ageing Management Programs and SGMP in Korean NPPs (39 AMP)
- Klaus : DIWA system
 - Diagnosis system using expert system, Fuzzy logic
- Three presentations from
 - Argentina



10 Dec. Summary

- **Ki Sig : IAEA EC-FAC activities**
 - Basic calculation of wall thinning
 - Recent material and related managerial issues on nuclear power plants, 15 - 18 February. 2005 at VIC,
- **Bond : Diagnostics and prognostics: state of the art and programs**
 - Research programme summary
 - Non-destructive Evaluation
 - Structural Health Monitoring
 - Condition Monitoring
 - Health and Usage Monitoring Systems
 - Proactive management of material degradation (PMMD)
- **Helmut:**
 - Main Degradation Mechanisms on Erosion and corrosion,
 - General corrosion
 - Microbiological corrosion
 - Localized corrosion



SCC EA
IAEA Fatigue- FAMOS, FAC

10 Dec. Summary

- **Joon Hyun : Inspection and monitoring of pipe wall thinning and rupture**
 - Thinned Pipe Management Program
 - Development of Mechanical Analysis and Crack Management Technology for DMW
 - Inspection & Monitoring Technology of Pipe Wall Thinning
- **Streit : Primary Coolant Chemistry: Fundamental Aspects & Improvements/Optimizations**
 - Requirements to coolant chemistry
 - Fundamental Aspects of Coolant Chemistry / Alkalinity
 - Primary coolant chemistry Improvements and Optimizations
- **Participants presentation (2)**
 - Argentina – Atucha 2 AGM, ENPP PLiM programme
 - Brazil – Fatigue analysis developed by Electro-Nuclear



11 Dec. Summary

B. Leonard:

- **Diagnostics and prognostics: technical challenges**
 - General areas for investigation
 - Components with highest degradation susceptibility
 - LWR – Issue Management Tables
 - Design for inspectability?
- **Proactive Management of Materials Degradation: an information tool based on NUREG 6923**

11 Dec. Summary

H. Nopper : Flow-induced material degradation Basics, Effects and Countermeasures

- Flow-induced material degradation mechanism
- Flow-accelerated corrosion (Introduction, Corrosion process, Influence parameter)
- Cavitation erosion (Introduction, Mechanism, Risk determination)
- Droplet impingement erosion (Introduction, Mechanism, Sensibility)
- Prediction of risk
- Countermeasures (FAC program, Optimized water chemistry, Material concept, Repair technologies)

11 Dec. Summary

J.H. Lee :

- 1. Current and Future Status for Inspection and Monitoring Technologies in NPPs**
 - Performance Demonstration Initiative in Korea
 - Present NDE Techniques for Nuclear Power Plants
 - Flow Accelerated Corrosion
 - Application of NDE in Nuclear Power Plants
 - Condition Monitoring in Nuclear Power
- 2. Development of Advanced Nondestructive Diagnosis Technology for NPP Piping System**

11 Dec. Summary

K. Streit : PWR secondary side chemistry / corrosion control / steam generator performance

- **Steam Generator as Key component**
- **Steam Generator Design Measures and Tube Material Selection to Avoid Corrosion**
- **Water Chemistry Measures to Avoid FAC**
- **Corrosion Control in Steam Generators:**
 - **Impurity Control**
 - **Oxygen Control**
 - **Techniques to Clean Steam Generators**

Panel Discussion

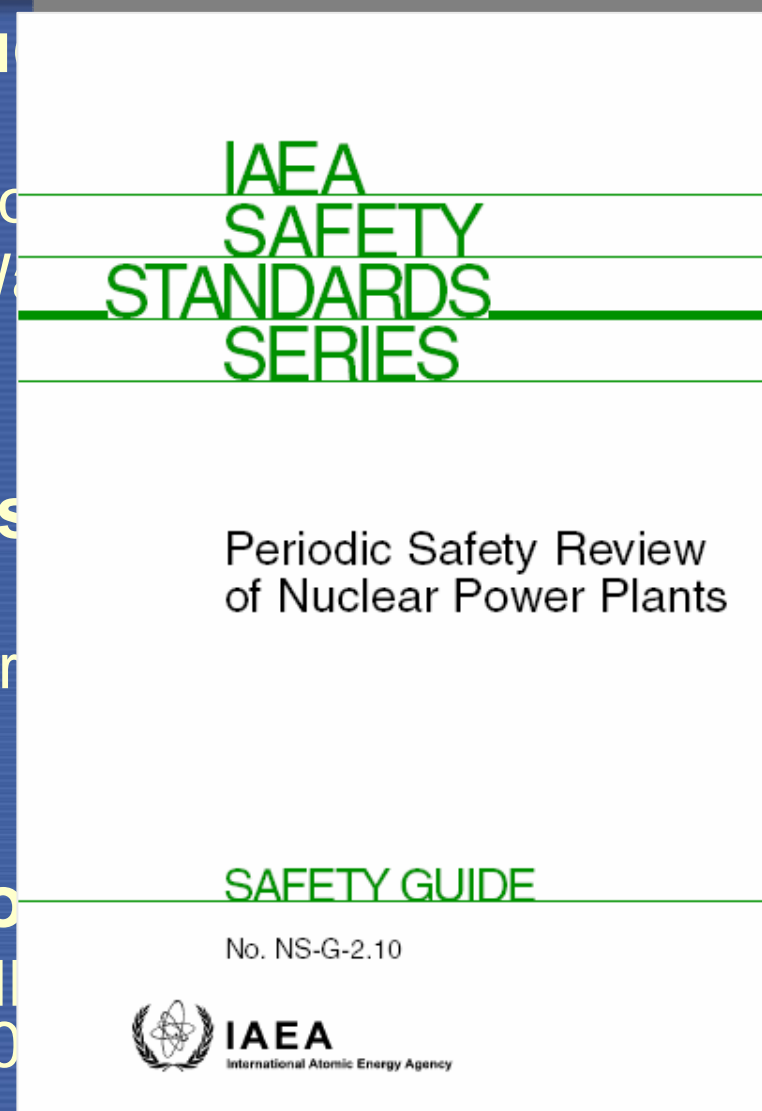
- Chair : B. Leonard
- Panellist : Christina (A), Ferrari (B), Miguel(M)
- Topics : each panel : 5 Min explanation to below topics
 - Approach to manage EC-FAC
 - Proactive management of material degradation programme
 - Water Chemical Control
 - Direction of Life extension/life management
- Advisors : Helmut, JoonHyn and Klaus
- Reporter : Ki Sig





Discussions - Miguel from Mexico

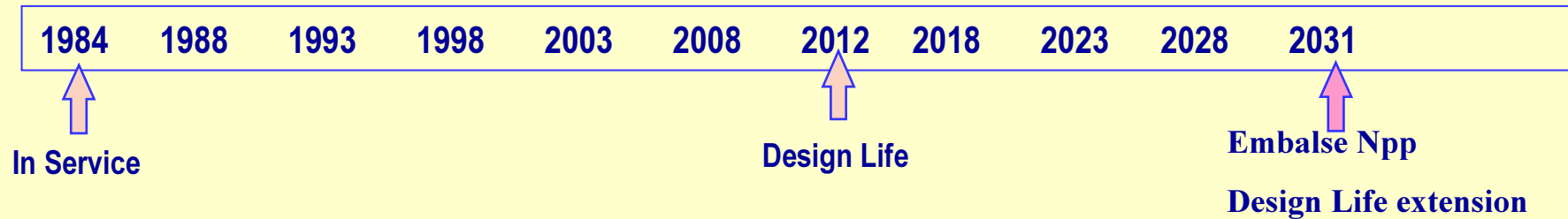
- **Until today Laguna Verde Nuclear (LVNPP)**
 - Contributes with 3.5 % of the electricity
 - LVNPP consists of two Boiling Water Reactors (BWR) (GE design).
- **Due to the lack of regulations in Mexico,**
 - US regulatory rules and procedures are used for operational safety
- **However, for safety evaluation**
 - PSR will be applied for unit 2 ONI using IAEA PSR guidelines (NS-G-2.10)



Discussions - Miguel from Mexico

- Applying PLiM programme
 - **10 programme in progress on Material degradation**
 - **LVNPP has identified SSCs with a level of risk I, II, III and IV.**
 - **Ageing Management Programme : Risk Based Inspection : under review to implement**
 - **Inspection method for Secondary side in radiation field : remote inspection**

Discussions – Cristina from Argentina



- Embalse is a CANDU[®] 600 NPP, Córdoba
- Designed and built by AECL and operated by NA-SA (Nucleoeléctrica Argentina S.A.)
- Started commercial operation in 1984
- **CNSC Regulatory Document RD-360, “*Life Extension of Nuclear Power Plants*”, February 2008.**

Discussions – Cristina from Argentina

- **EC and FAC : Inspection programme since starting operation, decrease problems**
- **Pressure Tube, Feeder Pipes and Replacement of SG before 2012 for life extension**
 - **Expect about 2 years outage time**
- **Independent Group for life management programme**
 - **Ageing management programme reports**
 - **Phase 1 : Condition assessment and Life assessment**
 - **Phase 2 : Generally provide the specification of replacement, topics and projects**



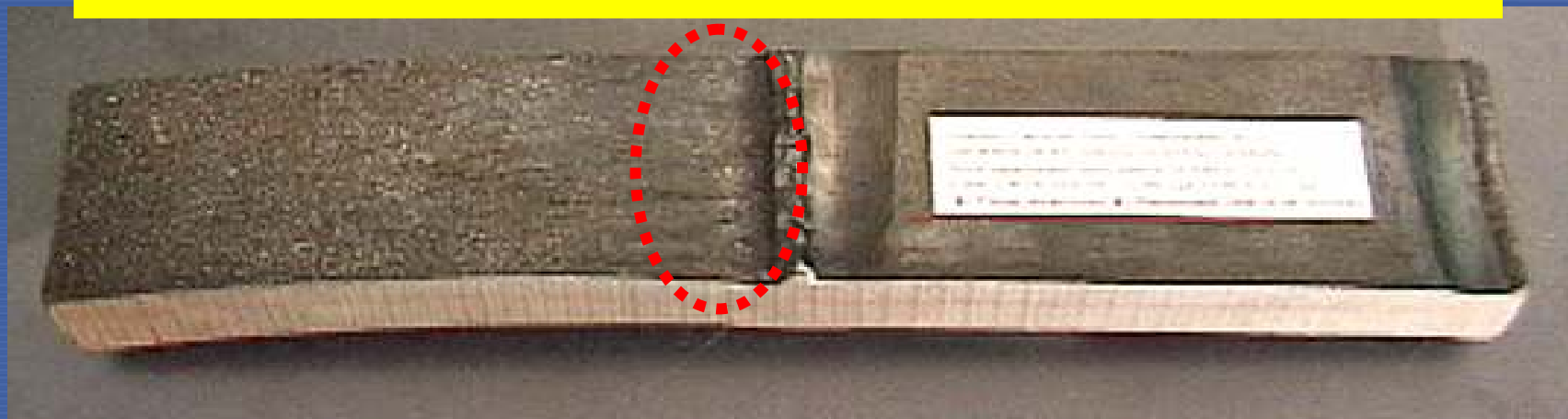
IAEA

Discussions – Ferrari from Brazil

- FAC-EC : Utilized US NPP's experiences and watch the international information

**Low Chrome
Carbon Steel**

**High Chrome
Carbon Steel**



points



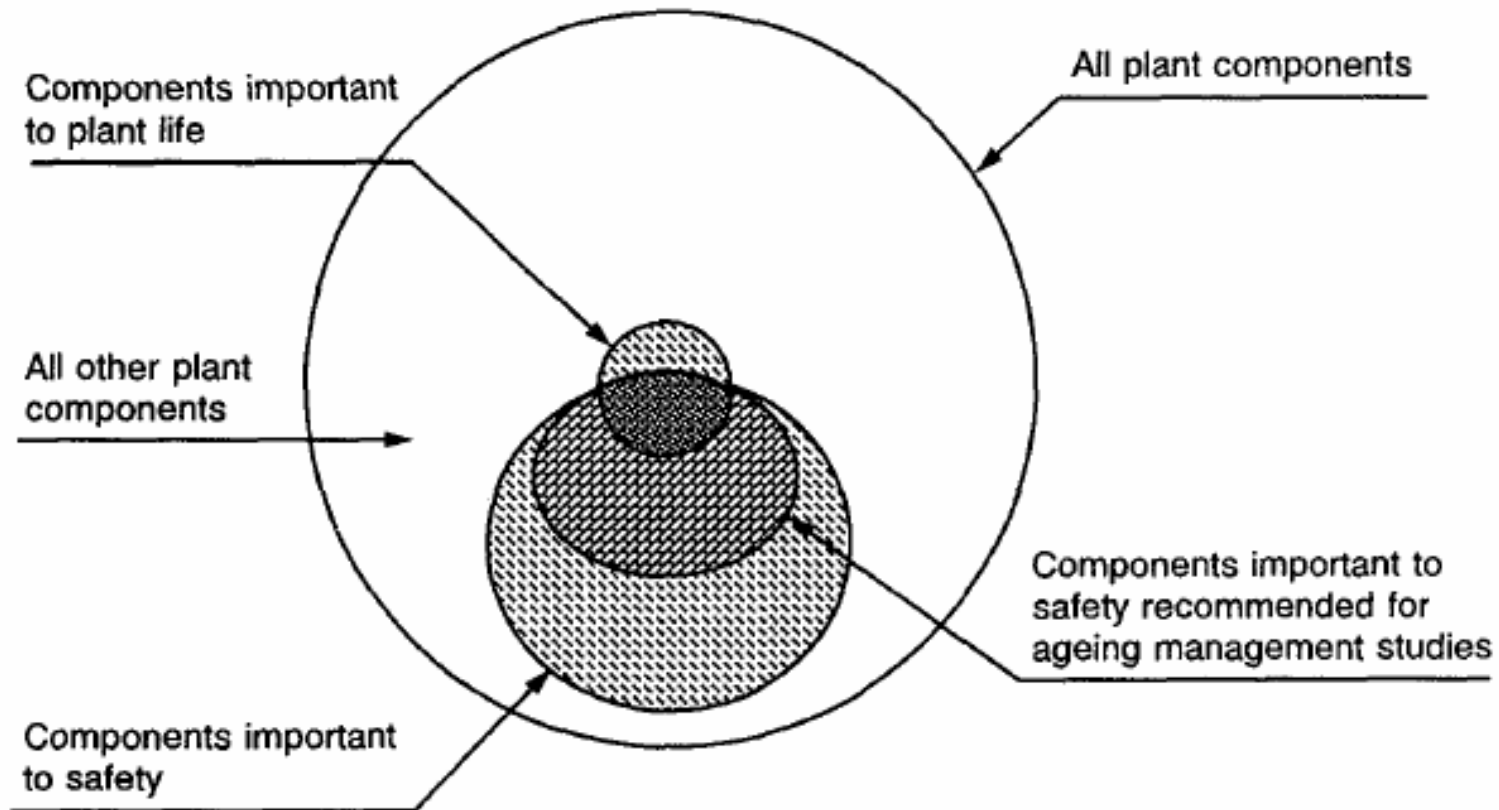
Flow direction

- Fatigue monitoring
- Dissimilar Metal Welding (DMW)

Discussions – Ferrari from Brazil

- WC according to EPRI guidelines
- RVH : No defect, but replace in 2009(** M USD)
- PLiM for life extension programme
 - Only **Safety related SSC for AGM**
 - Improvement of material and prefer to replacement than repair
- Difficult to apply PMMD due to too broad and wide range

Grouping of NPP components for AM



Step 1 screening: at the system and structure level

Question 1.1: *Does the plant system or structure contribute to plant safety?*

- Review a list of all NPP systems and structures
- Use existing safety classification system and/or PSA of an NPP

Output of Step 1 – *a shorter list of systems and structures to be evaluated at component level*

Step 2 screening: at component level

Question 2.1: *Would component failure result in a loss of system safety function?*

Question 2.2: *Does ageing degradation have the potential to cause component failure?*

Question 2.3: *Are current operational and maintenance arrangements adequate for timely detection of significant ageing degradation?*

Step 2 screening: at component level (Cont'd)

Output of Step 2

– list of components for AM studies arranged in generic groups

| Categorizing Criteria | | | Name (Number) | Specification (Capacity × Pump Head) | Selecting Criteria | | | | Selection | Cause |
|---|------------------------------|-----------------|---|--|------------------------------|------------------------------|---------------------------|-----------------------------|-----------|-------------------------|
| (1)Type | (2)Fluid | (3)Material | | | Importance | Condition | | | | |
| | | | | | | Operation | Maximum Pressure (MPa) | Maximum Temperature (°C) | | |
| Vertical Shaft Type Mixed Flow Pump | Sea Water | Stainless Steel | Auxiliary Sea Water Pump (3) | 1420 m ³ /h × 45.7 m | MS-1 | Continuously | approx. 0.5 | 38 | ◎ | Importance Operation |
| | | | Containment Cooling Service Water Pump (4) | 456 m ³ /h × 167 m | MS-1 | Occasionally | approx. 1.9 | 52 | | |
| | | | Circulating Water Pump (2) | 44200 m ³ /h × 13 m | ※ | Continuously | approx. 0.5 | 38 | | |
| | Pure Water | Cast Steel | Condensate Pump (3) | 1360.8 m ³ /h × 220 m | ※ | Continuously | approx. 3.1 | 149 | ◎ | |
| Horizontal Shaft Type Centrifugal Pump | Pure Water | Stainless Steel | Clean Up Auxiliary Pump (1) | 181.8 m ³ /h × 115.8m | PS-2 | Continuously (short time) | approx. 8.3 | 302 | ◎ | Importance |
| | | | Clean Up Recirculation Pump (2) | 91.2 m ³ /h × 802 m | ※ | Continuously | approx. 8.3 | 302 | | |
| | | Carbon Steel | High Pressure Coolant Injection Pump (1) | 681.6 m ³ /h × 853.4m | MS-1 | Occasionally | approx. 13.8 | 204 | ◎ | Importance Pressure |
| | | | Reactor Feed Water Pump (3) | 1360.8 t/h × 811 m | ※ | Continuously | approx. 13.8 | 205 | | |
| | Control Rod Drive Pump (2) | | 14.28 m ³ /h × 1159m | ※ | Continuously | approx. 12.1 | 93 | | | |
| | Condensate Transfer Pump (2) | | 56.8 t/h × 54.9m | MS-2 | Continuously (short time) | approx. 1.6 | 66 | | | |
| | Cooling Water | Cast Steel | Reactor Building Closed Cooling Water Pump(3) | 442.8 m ³ /h × 45.7 m | MS-1 | Continuously | approx. 0.7 | 66 | ◎ | Importance |
| | | | Turbine Building Closed Cooling Water Pump(3) | 770 t/h × 45.7m | ※ | Continuously | approx. 0.7 | 52 | | |
| Vertical Shaft Type Centrifugal Pump | Pure Water | Carbon Steel | Shut Down Cooling Pump (2) | 465 m ³ /h × 45.7 m | MS-1 | Continuously (short time) | approx. 8.3 | 302 | ◎ | Operation |
| | | Carbon Steel | Core Spray Pump (4) | 283.2 m ³ /h × 200 m | MS-1 | Occasionally | approx. 3.5 | 172 | | |
| | | | Containment Cooling Service Water Pump (4) | 363.3 m ³ /h × 100.2 m | MS-1 | Occasionally | approx. 1.7 | 80 | | |



12 Dec. Summary

- **Bond : Current In-Service Inspection & Leak Monitoring**
 - ISI Assessment effectiveness.
 - Time for degradation growth vs. inspection interval
 - Leak detection system effectiveness (including acoustic)
 - Advanced leak detection technology

12 Dec. summary

- **Helmut : Condition based maintenance**
 - **General aspects of condition based maintenance**
 - **Condition based maintenance strategies for Active components - ADAM**
 - **Valves (Safety V/V : 300/ 2000~ 3000), Rotating equipment – monitoring rotating, Vibration monitoring**
 - **Condition based maintenance for Static mechanical components**
 - **Known degradation mechanism : Corrosion, Fatigue**
 - **Comsys, Famos,**
 - **Snubber – in starting period**



Thank You
for Your Attention !!

항상 행복하세요.~



Pusan National University

Quality Engineering & Failure Prevention Lab

Complejo Tango



Planned Activities

- **2007**
 - **WS on Optimization of service life of operating NPPs, May, 14-17 2007, Electronuclear, Angra Brazil**
- **2008**
 - **TM on Metallurgical analysis on IGSCC and IASCC of reactor pressure vessel internal, May 5-8, 2008, ININ, Veracruz, Mexico**
 - **WS on Detection, research, management and monitoring of ageing factors, Dec 9-13 2008 , CNEA, Buenos Aires Argentina**
- **2009**
 - **WS on System structure and components integrity including RPV**
 - **June 22 - 26 2009, CDTN, Belo Horizonte, Brazil**
 - **Potential experts to be invited : Master Curve application for Embrittlement, LBB concept, DMW, Integrity assessment from Europe, USA and Canada or Korea**
 - **WS on Development and implement/perform of the operational safety upgrading program**
 - ****** 2009 , ININ+LVNPP, Veracruz Mexico**



