

AN OVERVIEW OF ACTIONS CONCERNING LIFE MANAGEMENT OF NUCLEAR POWER PLANTS IN ARGENTINA

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1. REORGANIZATION OF NUCLEAR ACTIVITIES IN ARGENTINA

Since September 1994, the organization of the Argentine nuclear activities has been changed, being at present in charge of:

- "Nucleoeléctrica Argentina Sociedad Anónima" (NASA), which operates the two NPP (Atucha 1 and Embalse), being also responsible of the construction of Atucha 2 Nuclear Power Station.
- "Ente Nacional de Regulación de la Energía Nuclear" (ENREN-National Regulatory Board for Nuclear Energy).
- "Comisión Nacional de Energía Atómica" (CNEA- National Atomic Energy Commission), in charge of Research, Development and Technological activities.

Within this scheme, one of the main activities to be undertaken by CNEA shall be to provide technological assistance to NASA in problems concerning NPP operation. Works on life extensions of NPP are included among these activities.

2. LIFE EXTENSION ACTIONS

Life management requires joint activities between R&D and NPP operation groups to define actions related to the strategy and the execution of a plant life extension program. They include:

- The definition of maintenance programs and their optimization. This action includes:
 - * The diagnosis of the state of components and equipments which conform a plant.
 - * The control of eventual modifications or repairs of components and equipments, original and spares, in order to detect and to characterize discontinuities.
- R&D programs in order to improve inspections and monitoring of critical components. Among these activities:
 - * On line monitoring condition of critical components.
 - * Monitoring conditions of all non-replaceable components.
 - * Fatigue monitoring conditions for critical components.
- Environmental impact studies.

Specific R&D actions for supporting life management of NPP are performed by CNEA. They consist of:

* Three projects which are associated to the study of fundamental problems of Argentine NPP (since 1985):

- RPV Integrity Assessment (CNA-1, CNA-2).
- Reactor Internal Components (CNE, CNA-1, CNA-2).
- Heat Exchangers (CNA-1, CNE).

* R&D associated to these projects and to life management problems.

3. MAIN SPECIFIC R&D ACTIONS

3.1. PROJECTS

The three above mentioned Projects include lines of work developed at the Stations and laboratories at CNEA. The main activities are:

- Reactor Pressure Vessel Integrity Assessment Project:

- * RPV Surveillance Programme.
- * Advanced flux specimens toughness measurement.
- * Non destructive inspections at the reactor RPV.
- * Primary and secondary circuit piping integrity.
- * Thermohydraulic simulation of reactor performance under accident conditions.
- * Reevaluation of critical transients.
- * Ex-vessel dosimetry.

- Reactor Internal Components Project:

At CANDU 600 Embalse NPP:

- * In-service inspection of fuel channels
- * Slaring of Pressure-Calandria garter springs
- * Equipment and training of personnel for Single Tube replacement.
- * In-Lab metallographic measurements of pressure tubes off-cuts.
- * R&D on Hydrogen pick-up, water chemistry, Zr alloys creep and growth studies, leak-before-break.

At CNA-1 NPP:

- * Supervision of Fuel Channels Replacement (including elimination of Co-based Stellite parts).
- * Fuel channels non destructive on side measurements
- * R&D on Hydrogen pick-up, water chemistry, Zr alloys creep and growth studies, leak-before-break.

- Heat Exchangers Project:

At CNA-1 and CNE

- * Chemistry monitoring of the cooling system.
- * Surveillance of equipment performance.
- * Cleaning of equipments feasibility during programmed outages.
- * Activities of the project also include the study and resolution of problems concerning steam generators and moderator circuit heat exchangers.

3.2. OTHER R&D ACTIONS

An important quantity of R&D activities being developed for NPP life management are performed by CNEA. Some of these activities are included in the above Projects.

NDT DEVELOPMENTS

ULTRASONIC TECHNIQUES

- * Development of techniques, methods and devices for automatic ultrasonic inspection of pressure tubes.
- * Application of UT to detect and to evaluate discontinuities in pressure tubes and analysis of the detectability limits. Compatibility of the latter with the requirements for the estimation of remanent life of the pressure tubes.
- * UT with rotating probes to evaluate the integrity of the pressure tubes.
- * Ultrasonic Testing Special techniques: Diffraction and Time of Flight Diffraction for the characterization and sizing of internal discontinuities.
- * High frequency UT on materials. In the present state, a system that allows materials characterization by determining the attenuation and velocity of the elastic wave is being developed at the laboratory.

EDDY CURRENT TECHNIQUES (ECT)

- * Development of rotating probes to be used in multifrequency ECT for nuclear components.
- * Extension of ECT for their use in ferromagnetic materials.
- * Dispositives and automatic testing methods to measure oxides by means of ECT.

ACOUSTIC EMISSION (AE) APPLICATIONS

- * AE for the monitoring of vessels and tubes subject to pressure. Studies on the emission generated by the crack growth in tubes.
- * Early detection of leaks in valves by AE.
- * Development of detection systems of stray parts and characteristic noises by AE technique.

MATERIALS

ZIRCONIUM BASE ALLOYS

- * Stress corrosion cracking in Zircaloy-4. Influence of fission product in the Zircaloy-4 resistance to stress corrosion cracking.
- * Pressure tubes (CNE): surveillance of the aqueous corrosion and deuterium pick-up of the pressure tubes behavior.
- * Irradiation growth of Zirconium alloy. Kinetic of deformations near the reactor temperatures and neutronic flux transients (under contract with Candu Owners Group-COG).
- * Precipitates formation prediction under irradiation. Analysis of formation and stability of precipitates (Zr-2,5% Nb alloy).

- * Formation of hydride blisters by thermic gradient application.
- * Delayed cracking, induced by H in Zirconium base alloys. Crack propagation produced by thermal cycling, in hydride blisters.
- * Modelling of residual stresses originated by thermal and mechanical treatments (under contract with COG).
- * Evaluation of pressure tubes deformation. Evaluation of the operative parameters (temperature, neutronic flux) and the deformation of the CNE in-service fuel channels.

IRON AND NICKEL BASE ALLOYS

- * Localized corrosion phenomena (pitting, stress corrosion cracking) of the Incoloy alloys used in the steam generator tubes.
- * Erosion-corrosion of steels used in the steam pipings of the secondary circuit.
- * Corrosion evaluation risk of the pressure tubes end-fitting stainless steel.
- * Reactor structure: General corrosion monitoring.
- * Fractomechanical data of irradiated samples with different acceleration factors. Applicability of the damage functions under different spectra and fluxes and the influence of the irradiation temperature.
- * Ingress of hydrogen in the end-fittings of the pressure tubes.
- * Hydrogen permeation in ferritic stainless steels.
- * Fracture and fatigue behavior of structural components.
- * Residual stresses effects on life extension management.

WELDING OF SPECIAL ALLOYS

Development of welding technology of special alloys for nuclear use in reparations or replacements of components.

VIBRATIONS AND FRETTING WEAR

- * Vibrations and fretting-wear of heat exchanger tubing.
- * Fuel bundle vibrations and fretting wear. Tests of the fuel bundle-channel are performed using the high pressure testing loop (Ezeiza Atomic Center).
- * Monitoring systems. Tubing monitoring assembling and surveillance systems to evaluate wear and/or fatigue.
- * Monitoring of deformations and temperatures in order to evaluate fatigue.
- * Monitoring systems addressed to predictive maintenance (especially in valves and steam generators).
- * Diagnostic systems by vibrations analysis.

REACTOR CHEMISTRY

HEAT TRANSPORT SYSTEMS:

- * Study of the main components performance.

HEAT EXCHANGERS.

- * Chemistry monitoring of the cooling system.
- * Surveillance of the equipment performance.
- * Feasibility of the cleaning of the equipments during programmed outages.

STEAM GENERATORS

- * Continuous monitoring of the corrosion products transport: chemistry of the secondary circuit, evaluation of the different morpholine concentrations in order to reduce the corrosion

products, to stabilize the transport values and to analyze its influence on the heat exchangers.

- * Removal of hard sludge on the tube-plates and the supporting plates by water lancing. Feasibility of the lancing system development.
- * Study on the feasibility of chemical cleaning of the secondary steam generators in programmed outages.
- * Study on the feasibility of the cleaning of the primary circuit.
- * Analysis of the integrity parameters of the tubes, after cleaning and surface passivation.

CONTROL AND INSTRUMENTATION

Objectives of the C&I studies:

- * To evaluate the residual useful lifetime, taking into account the technology employed and the disponibility of spares in the plant and in the market.
- * To determine which instrumentation and control systems can be obsolete according to the requirements determined by the safety regulations.

ELECTRICAL CABLES

- * Verification of the state of the cables, especially those subjected to radiation dosis and/or harsh environment.
- * Periodical monitoring of the cables that allows an early determination of changes of some cables.

COMPUTER SYSTEMS:

- * Evaluation of the residual useful life taking into account the technology employed and the availability of spare components in the plant and in the market.
- * Evaluation of the necessity of new equipments which shall provide new functions (for example, a more accurate operator/machine interface) which shall respond to new requirements, not foreseen during the design of the plant.

PROBABILISTIC SAFETY ASSESSMENT

Preventive application to the study of the most probable failures in the following cases (works developed in association with personnel of NPP):

- * Steam generators
- * Heat transport systems
- * Electric components
- * Fuelling machines
- * Fuel transfer systems components
- * Leak-before-break