INTEGRATED ANALYSIS OF THE ATUCHA-1 REACTOR PRESSURE VESSEL MATERIAL DATA BASE IN VIEW OF PLANT LIFE MANAGEMENT

Background

The surveillance program of the CNA-1 (Central Nuclear Atucha Unit 1) reactor pressure vessel, which was located at a non-representative surveillance position in the reactor pressure vessel, has been shown to have serious limitations in monitoring the material degradation of the vessel beltline region because of an extremely high thermal-to-fast neutron ratio. As such, the installed surveillance program alone can not assure the safe operation of the nuclear power plant. As no alternative vessel beltline position was accessible due to design constraints, complementary accelerated irradiation programs have been conducted over a number of years using fresh samples of the surveillance materials exposed in neutron spectra and irradiation temperatures which were representative of CNA-1 beltline conditions. The irradiation facilities employed were the VAK reactor in Germany, the BR2 reactor in Belgium and the Loviisa reactor in Finland. The irradiations covered a range of neutron fluences up to twice that anticipated at the end-of-life (EOL) design time for CNA-1. Different types of tests were performed on the samples including Charpy impact, tensile and fracture toughness.

Objectives

The work performed in collaboration with experts from US, Argentina, UK and Finland consisted in an integrated analysis of all existing data on the CNA-1 surveillance materials with respect to the integrity assessment of the CNA-1 reactor pressure vessel for EOL conditions and beyond (1.5 EOL).

Principal results

Given the critical Pressurized Thermal Shock (PTS) transient and the Regulatory Guide 1.99 Rev. 2 approach, we have shown that direct initial fracture toughness measurements on unirradiated material combined with the irradiation-induced shifts in fracture toughness or Charpy impact behaviour can provide assurance of reactor pressure vessel integrity up to EOL and 1.5 EOL for the limiting surveillance materials as originally selected.

The high degradation of the original surveillance material in the CNA-1 surveillance position, mainly arising from thermal neutron effects, can be explained by the use of an effective damage parameter for the thermal neutrons within the dpa (displacement per atom) damage function. As such, spectrum effects on material degradation between the surveillance position in CNA-1 and beltline positions may be taken into account satisfactorily. We have also demonstrated that any spectrum differences between the accelerated host reactor irradiations and the vessel beltline position in CNA-1 are minimal.

In support of our evaluation, ample evidence has been presented for the non-occurrence of dose rate effects between the accelerated irradiations and the beltline applications, based on materials similar to the CNA-1 surveillance materials and, more generally, on evidence from other irradiated materials.

The outcome of this work was successfully presented to NA-SA (Argentinean utility managing the CNA-1 plant) and ARN (Argentinean Safety Authority) during several meetings which took place in March 2006, and has lead to the licensing of the Atucha 1 reactor until EOL.

Future developments

A new contract for the setting up and implementation of the surveillance program for Atucha Unit 2, currently under construction, is presently in the negotiation phase between NA-SA and SCK•CEN.

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Main reference

E. Lucon, M. Caro, A.F. Iorio, R. B. Jones, R. Nanstad, M. Scibetta, M. Valo and E. van Walle, *Integrated Analysis of the CNA-1 Reactor Pressure Vessel Material Data Base in View of Plant Life Management*, Final Report – Contract INTEGRITY, SCK•CEN R-4306 Rev.(1), June 2006.