**Materials Surveillance Programme for the RA10 Research Reactor**

R. Versaci1,2, G. Bertolino3, A. Yawny3, G. Arias4, H. Blaumann4

1) Subprograma de Gestion y Extensión de Vida de Centrales Nucleares de Potencia. Gerencia de Area Energía Nuclear (GAEN), Comisión Nacional de Energia Atómica (CNEA), Avda. Del Libertador 8250, (1429) Buenos Aires, Argentina.

2) Gerencia Materiales, GAEN-CNEA

3) División Física de Metales, Gerencia de Física CAB, Gerencia de Área Investigaciones y Aplicaciones No Nucleares, GAIyANN-CNEA

4) Gerencia Proyecto RA10, GAEN, CNEA.

Corresponding author: versaci@cnea.gov.ar

**Abstract**. The RA-10 is a new multipurpose research reactor which has been decided to be built in Argentina in order to satisfy the increasing national and regional demands for radioisotopes. The RA-10 is a 30 MW thermal power open pool facility with MTR (Material Testing Reactor) type fuel assemblies.

A Surveillance Program is part of a more general Ageing Management Program and its objective is the assessment of the structural integrity of critical core materials components in order to ensure a safe and reliable long term operation. Neutron irradiation affects ductility, tensile and toughness properties of materials in general and might result in irradiation induced growth in Zirconium base structural materials. Corrosion and IASCC (Irradiation Assisted Stress Corrosion Cracking) effects should also be considered. It is worthwhile to remark here that even when there is a standard practice for the design of surveillance programs for light water moderated nuclear power reactor vessels (ASTM E185), there is a lack of general guidance in the case of research reactors. Therefore, ad-hoc surveillance programs have to be developed for research reactors considering the peculiarities of each design. In the present case, the most exposed critical components were firstly identified. Thereafter, the critical components were categorized in those that are replaceable or no replaceable along the expected life of the reactor. The materials of interest are Zircaloy-4, Zr-2.5 wt.%Nb. The evaluation of the effects of irradiation is followed by periodically removing (5, 10, 20, 30 and 40 years) capsules containing tensile, fracture toughness CT and small punch testing specimens representative of the different materials and thermo mechanical conditions (plates, forgings, welds and HAZ material). Dosimeters are placed within the surveillance capsule and evaluated to determine the associated neutron fluence at the specific location within the vessel and time of extraction. Specimens will undergo post-irradiation testing in a hot cell facility to determine their mechanical properties (and dimensions). The obtained values will be compared with the original values and the predefined design limits to evaluate the operational margin of safety. In summary, the present paper describes the methodology of the implemented surveillance program, the test specimens, their locations and the tests to which they will be subjected.

**1. Introduction**

Whereas the RA10 reactor is postulated that the same should reach at the following design objectives: safe operation, high availability, nominal operating cycle 29.5 days and 2.5 days outage.

Developing a Life Management Program is critical to meet these principles in Safe, High Availability and Long Term Operation [1]. These programs should start with the design; continue during construction, installation, commissioning, operation and decommissioning. Management of Aging, obsolescence and economics are part of these programs. [2] [3] [4][5].

Associate an Aging Management Program must define a Surveillance Programme (SP). The goal of SP is to monitor changes in material properties of the essential components for safe operation of the reactor due to the effects of intense neutron radiation to which they are subjected.

These changes include: tensile properties, radiation induced growth and fracture toughness of the materials from which the critical components exposed to radiation. [6] [7][8].

The implementation of a SP requires the provision within the reactor of specimens of materials that are desired characterized in zones where the neutron flux is higher than the component they represent (with leader factor between 1 and 3). These samples will then be extracted and characterized periodically over the 40 year life contemplated in the design.

The components will be considered not replaced during the life of the reactor are: the Reflector Vessel Tank (RVT) and the Could Neutron Source Vacuum Container (CNSVC).Figure 1.



Could neutron source

Surveillance position for the could neutron source

 *FIG.1 Reflector tank.*

**2. Components and materials**

According to the information presently available, materials that will be included in the SP are "Zircaloy-4", in order to monitor the RVT, and "Zr-2.5% Nb" to monitor the CNSVC. For these alloys there is little information available on the effect of radiation at low temperature.

The specimens chosen for the tensile tests are miniature specimens, with a minimum dimension of 30 x 8 x 2 mm, of the "dog bonne" type because they are the simplest and can be made small without seriously affecting the validity of the results. Such samples provide information on variations in the ductility and the yield stress of the material (hardening).

For the analysis of the fracture properties of the material CT (Compact Tension) dimensions to ensure the validity of results, respecting the existing rules at the time (ASTM standards). These specimens will be with pretension to analyze the effect of the incorporation of hydrogen and radiation a low temperature for the Zircaloy-4.

To evaluate the hardening and loss of ductility Small Punching Disks were used, with a minimum dimension of 10 mm diameter and 0.5 mm thick.

In conclusion materials and samples must be taken into account in the design of the coupon books and also the necessary conditions, monitoring and cooling: Zircaloy-4 Base Material, welded material and heat affected zone, depending on the welding process. Zr-2.5%Nb Base Material, welded material and heat affected zone, depending on the welding process.

**2.1. Location samples**

According to the distribution of fast neutron flux calculated, see Figure 2, and due to the variation thereof with the radius and angle is required to determine more precisely that the faces of the box containers with the samples were placed surveillance in positions A, B and C of Figure 2 a priori determined position in the inner faces, these are de positions for the Zircaloy-4 samples.

To monitor the zirconium alloy Zr-2.5 Nb, corresponding to the CNSVC, we will determine what position to will be placing the samples. It is proposed as an alternative to analyse, during the development of Basic Engineering, place the samples in a position available inside the Reflector Tank near the CNSVC.

There are 3 boxes available, so there will be 6 coupon books in total. The lifetime of Reactor used six boxes (at 2, 5, 10, 20, 30, and 40). If necessary you can add to get the coupon books 2 and 5 years.

 **

**B**

**A**

**C**

*FIG. 2. Neutron flux distribution.*

Each coupon have the ability to accommodate the whole package of specimens that requires each instance of SP that is, not specimens with different coupon books for the same stage of tests will be taken.

For program development is of fundamental importance to have material removed during the manufacturing process of the components.

**2.2. Additional information**

The reactor design life of RA-10 is 40 years, however, it is estimated that a number of components will be replaced before this time. In some cases it is possible to include these components in the SP and the use of materials for the manufacture of test samples. The main components of Zircaloy-4 in this group are the control rods and the control plate structure, to be replaced after 8-10 years of operation, together with the absorber plates. From these materials we can make Charpy and CT samples and obtain additional information.

In addition we designed an experience to place samples in the area of ​​high fast flux to analyze the effect on Zircaloy-4 at low temperature.

**3. Final Remarks**

For safe operation, high availability and long term operation is essential to have an ageing management plan of reactor critical System, Structures and Components.

**4. References**

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Research reactors, IAEA Safety standards series N° SSG-10, (2010), 97.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear power plant life management processes: guidelines and practices for heavy water reactors, IAEA-TECDOC-1503, (2006), 215.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safe long term operation on nuclear power plants, Safety reports series N°57, (2008), 194.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing management for nuclear power plants, Safety Guide, N° NS-G-2.12 (2009), 93.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Proactive management of ageing for nuclear power plant, Safety reports series N°62, (2010), 254.

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, periodic testing and inspection of research reactors, IAEA Safety standards series N° NS-G-4.2, (2006),143.

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Optimization of research reactor availability and reliability: recommended practices, IAEA Nuclear energy series N° NP-T-5.4, (2008), 98.

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the utilization and modification of research reactors, IAEA Safety standards series N° SSG-24, (2012), 167.