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Technical note

Study of the boron homogenizing process employing an experimental low-pressure bench simulating the IRIS reactor pressurizer – Part II

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ABSTRACT

The reactivity control of a nuclear reactor to pressurized water is made by means of controlling bars or by boron dilution in the water from the coolant of a primary circuit. The control with boron dilution has great importance, despite inserting small variations in the reactivity in the reactor, as it does not significantly affect the distribution of the neutron flux.

A simplified experimental bench with a test section manufactured in transparent acrylic, was built in reduced scale as to be used in a boron homogenizing process, simulating an IRIS reactor pressurizer (International Reactor Innovative and Secure). The bench was assembled in the Centro Regional de Ciências Nucleares do Nordeste (CRCN-NE), an entity linked to the Comissão Nacional de Energia Nuclear (CNEN), Recife–PE.

1. Introduction

On Part I of this paper, we saw that the pressurizer is an important component in the functioning of a PWR since it controls SRR pressure keeping it under-cooled, performing this control through electric heaters and valves for squirting water. During normal reactor operation, system pressure is controlled by the pressurizer through the aspersion valves and electric heaters, which keep the pressurizer temperature at a reference value.

IRIS is a generation III+ modular reactor, refrigerated by pressurized light water, with an integral configuration (Carelli, 2003).

Boron (B^{10}) is an excellent absorber of thermal neutrons and, in the form of boric acid diluted in the coolant of the PWR, it is used for controlling reactivity. From Beginning of Life (BOL) to End of Life (EOL) of a reactor fuel cycle, the boron concentration in SRR is reduced for compensating the fuel burn. The question of homogenization becomes an important safety factor in operating a reactor, in function of inadequate procedures for boron homogenization.

2. Theory

The accident analysis is crucial in the safety area of the nuclear centrals. From the hypothesis of accidents formulation, the behavior of the central is studied and the criteria, which determine the condition for a safe operation, are established. The plants are licensed for operation with the guarantee that accidents and postulated transients do not surpass the safety limits established by technical specifications.

2.1. Pressurized water reactors (PWRs)

The PWR reactor, the most widely used power reactor in the world, uses light water as cooler, moderator and reflector. The main characteristic of a PWR unit is the pressured cooling water (primary circuit), always keeping a liquid phase once the pressure varies from 14 to 17 MPa. The reactor refrigerator removes the heat generated by the core and, also, works as a moderator, reducing the neutrons energy which will produce the fissions in the fuel elements and generate heat. Besides, it also functions as a neutrons reflector, reducing their escape from the interior of the vase of the reactor and also serving as a solvent means of the boric acid which is used to aid in the control of the generation of the power in the nucleus, once it absorbs neutrons and with this, it can be used as to control the fissions reactions, In the interior of the reactor vase, the combustible elements heat the refrigerator, which

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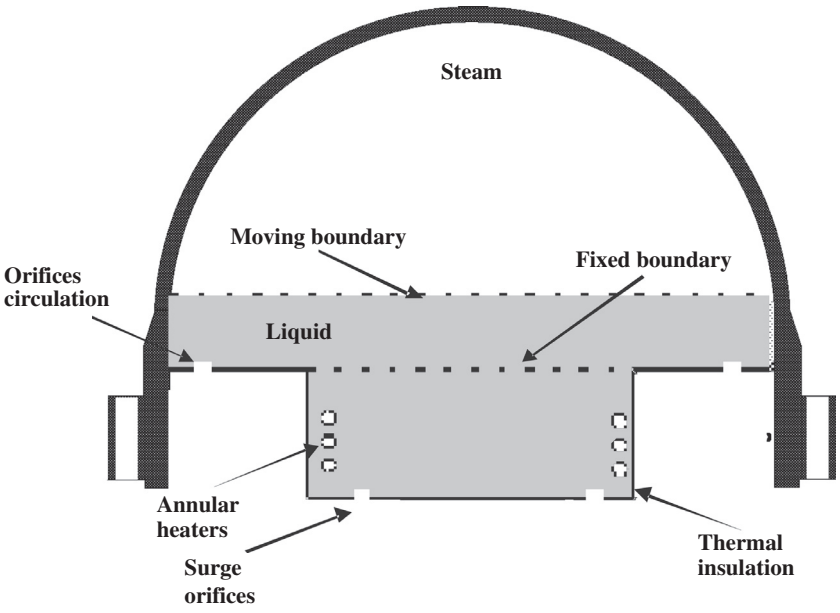

Fig. 1. Transversal cut of the IRIS pressurizer.

Fig. 2. Experimental set.

remains sub-refrigerated (temperature below the saturation point, for the existing pressure), in the sequence, it is taken to the steam generators where it will transfer heat, through tubes for the feeding water which is in the interior of the GVs.

2.2. Pressurizer of PWR

In the pressurizer of a PWR, saturated liquid and vapor coexist in balance and, thus, maintain the RCS under-cooled, since the temperature of the PZR is greater than that of the RCS. The maintenance of the balance between saturated liquid and vapor makes it possible to control RCS pressure. The pressurizer is a vertical, cylindrical container, with the superior and inferior hemispheric lids made in carbon steel, coated with austenitic stainless steel on all surfaces in contact with the reactor coolant. Immersion electric heaters are set up on the base of the container while the junctions of the spray line, relief valves and safety valves are set up on the superior lid of the container.