2009 International Nuclear Atlantic Conference - INAC 2009
Rio de Janeiro,RJ, Brazil, September27 to October 2, 2009
Associação Brasileira de Energia Nuclear - ABEN
ISBN: 978-85-99141-03-8

PROJECT, INSTALLATION AND OPERATIONAL TESTS OF A PNEUMATIC SYSTEM FOR THE IEA-R1 REACTOR MATERIALS

Alberto de Jesus Fernando e Tufic Madi Filho

Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
ajfernan@ipen.br , tmfilho@usp.br

ABSTRACT

Pneumatic Transfer Systems (PTS) are equipment broadly and world widely used for the transport, movement and transfer of diverse types of materials, objects and cargo between two or more environments, near or distant from each other [1]. Due to their flexibility and quickness, the system application is present in several areas, such as medicine (hospitals and clinic analyses laboratories) [2]; industry (automobile, metallurgy, iron-making. chemical, food production) [2]; commerce (gasoline stations, cinemas, supermarkets, banks, tolls, on-line commerce, casinos) [3]; public service (public institutions, courts) [2]. In the nuclear field, the PTS has, also, a vast application, highlighting its use in the radioisotope and radiopharmaceuticals of short half life production, such as ^{67}Ga, ^{201}Tl, 18F and ^{123}I-ultra pure [3]. The development of this work is directed to the application of the Pneumatic Transfer System in transport and transfer of materials that will be irradiated in the IEA-R1 reactor, located in the Institute of Energetic and Nuclear Research, IPEN – CNEN /SP, for application of the Neutron Activation Analysis (NAA).

1. INTRODUCTION

The IEA-R1 Reactor, since its construction in 1957, has offered its customers the materials irradiation activation service.

The original project of the reactor facilities already included a PTS, which along the past more than 50 years of operation, has undergone significant alterations and technical updating, with emphasis to 1971´s and 1978´s, until 2000, when the original system was interdicted for use.

In 2003, a new PTS for the IEA-R1 reactor started to be developed, bringing a totally different conception from those previously applied. New technologies, both mechanic and electro-electronic, aiming to improve and enhance the system performance, as to operational and maintenance and to eliminate the risk of a LOCA (loss of Coolant Accident), were implanted at the IEA-R1 reactor.

The PTS´s are mechanisms used in the forced circulation of a fluid (more commonly, the air) inside tubes, normally of the cylindrical section, to move and transport any type of solid body, inserted in these tubes during the fluid flow.

The PTS´s are amply used in research reactors. Their application is very important in the irradiation of target materials, with the aim of analyzing them by the technical application of the Neutron Activation Analysis (NAA), for short half life isotopes [4].

The NAA method is used, with advantage, in relation to chemical analysis methods, since it eliminates the chemical attack to the samples, taking into account: the absence of analytical white; the independence related to the chemical form of the elements; and the necessity of a small amount of samples, allowing the elements determination in percentage concentrations up to a billion (ppb) of the sample element [5].

2 - HISTORY

2.1 – CHARACTERISTIC OF THE FIRST PTS LAY-OUT IMPLANTED IN THE IEA-R1 REACTORS (1957)

The original PTS project was implanted in 1957 and its scheme is presented in Fig. 1. As its main characteristic, it had a beam of 8 hard and stanching tubes set up, constructed with stainless steel, which entered the pool where the IEA-R1 Reactor core is located.

Inside the pool, the tubes beam was L-shaped, so that it had an itinerary from the pool bottom, at a distance of 1.5m from the core, to the proximity of the lateral core. In this point, 4 irradiation stations were installed, so that each pair of tubes, in a total of 4 pairs, comprised the transfer system of an irradiation station. Each station was connected with a specific laboratory. Due to the configuration (the arrival stations near the core centers were put up in different heights and distances, in relation to the core), different values of the neutron flux for irradiation were obtained.

In this system, samples of the materials to be irradiated were used as a holder, metallic aluminum, cylindrical and impervious wrappings, where the sample was stored inside.

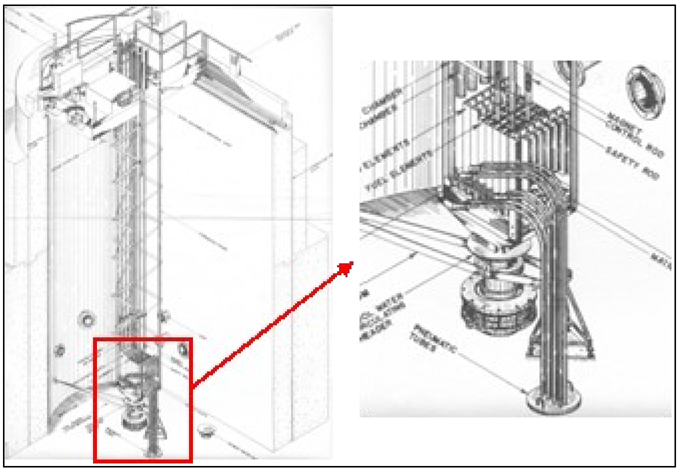

Figure 1. Lay-Out of the original PTS original put up in1957

This array caused some difficulties during its use, mainly as to maintenance, due to its setup location, 9 meters deep, inside the pool. Furthermore, the system was always referred, in the Report of Accidents Analysis of the reactor, as a system that could cause a LOCA (Loss of Coolant Accident). This would occur in case any of the eight tubes ruptured or, even, caused by a defect in the flange fixing the system, what could cause the emptiness of the pool and the core exposition.

2.2 – CHARACTERISTICS OF THE SECOND PTS LAY-OUT, MODIFIED FROM THE ORIGINAL, IN THE IEA-R1 REACTOR (1971)

In 1971, the new lay-out for the IEA-R1 Reactor PTS was implanted, using the same type of tubing of the original project, hard, in stainless steel. The difference was that now it offered only two irradiation stations, i.e., two levels of neutron flux and its setup defined the arrival to the pool by the surface, extending, already in the water, to the lateral proximity of the core center.
The sample holders that operated in this process, remained the same used in the original system, namely, a metallic aluminum cylinder.

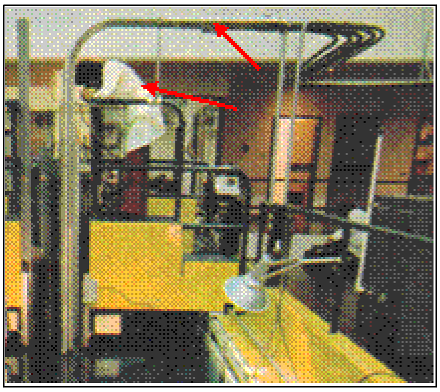

Figure 2. Lay-Out of the PTS put up in 1971

This array operated with limited movement and positioning, around the core, limiting the neutron flux to two levels only. Another limitation of the system, recognized during its operation, was the fact that the activated and radioactive material went along the operation bridge of the reactor core very closely, making it impossible for the operators to be there, when the system was running, in order to avoid the dose from the activated material (Fig. 2).

2.3 – CHARACTERISTICS OF THE THIRD PTS LAY-OUT, FOR THE IEA-R1 REACTOR (1978)

In 1978, a large structural rebuilding was carried out in the pool. On the occasion, it was, also, opted to substitute the original PTS for a new one. The concept of this new project did not differ, significantly, from the original, as it can be seen in Fig. 3. A major alteration was done in the beam itinerary, already inside the pool. The beam of tubes, when entering by the bottom, was divided in 2 pairs, extended to the left lateral proximity of the core center: another set of 2 pairs of tubes was extended to the right lateral proximity of the core. In this case, the condition of 4 different levels of neutrons flux was maintained, to serve 4 laboratories.
Besides the original system adaptation, another significant alteration was performed: the sample holders started to be produced in nylon, with new dimensional and operational

characteristics. The placement and withdraw of the material to be irradiated inside the sample holders became simpler.

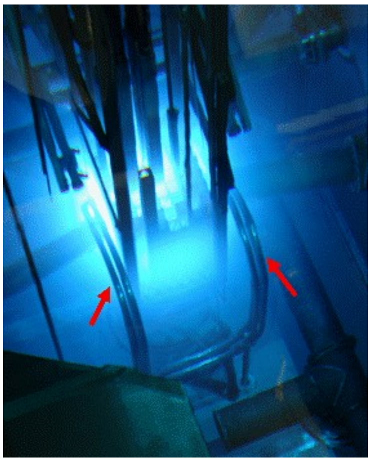

Figure 3. Lay-Out of PTS setup in 1978 (adaptation from the original project)

During its operation, some inconvenience was found out: it did not permit the neutron flux level variation; maintenance was difficult in case of repairs, since all the work should be done inside the 9-meter-deep pool; risk of an accident, due to the rupture of one of the metallic tubes, causing the pool water to be emptied and the core to be totally uncovered (LOCA).
Another problem, during this PTS arrangement operation, was decisive for the interruption of the system in 2000. The sample holders were verified to undergo irradiation damages, with the possibility of contaminating the whole route, mainly, when arriving near the core, what justified its interdiction.
In 2003, the development of a new PTS for the IEA-R1 reactor started, fact that is the target of this paper. The new system was characterized by a completely different concept from those applied previously.

3 – TARGETS

The goals of this work were:
3.1 – To design, build, put up and install a Pneumatic System for the transfer of irradiated samples, used in the application of the Neutron Activation Analysis (NAA) technique.

3.2 – To test the installed system operation.

4 – METHODS

The new PTS project developed in (a) the phases of dimension, details and definitions of the technical specifications of all the mechanic and electro/electronic components of the system;

(b) approach and calculation of the delivery and return velocity of the irradiated samples, within the specified parameters in the standards. A structural evaluation of the supporting metallic plate of the reactor core was performed, using specific software, in order to assess its stability, when submitted to the strain of the new PTS irradiation element set. A study of the IEA-R1 Reactor operation security was done, due to the impact of the new installation, with risk evaluation of accidents that could be caused by it. The development of the PTS electro-electronic and operation automation, plus the preparation of technical instructions to standardize the cold and hot tests were, also, performed, to validate the system operation.
Fig. 4, below, presents the design outline of the PTS, constructed and installed:

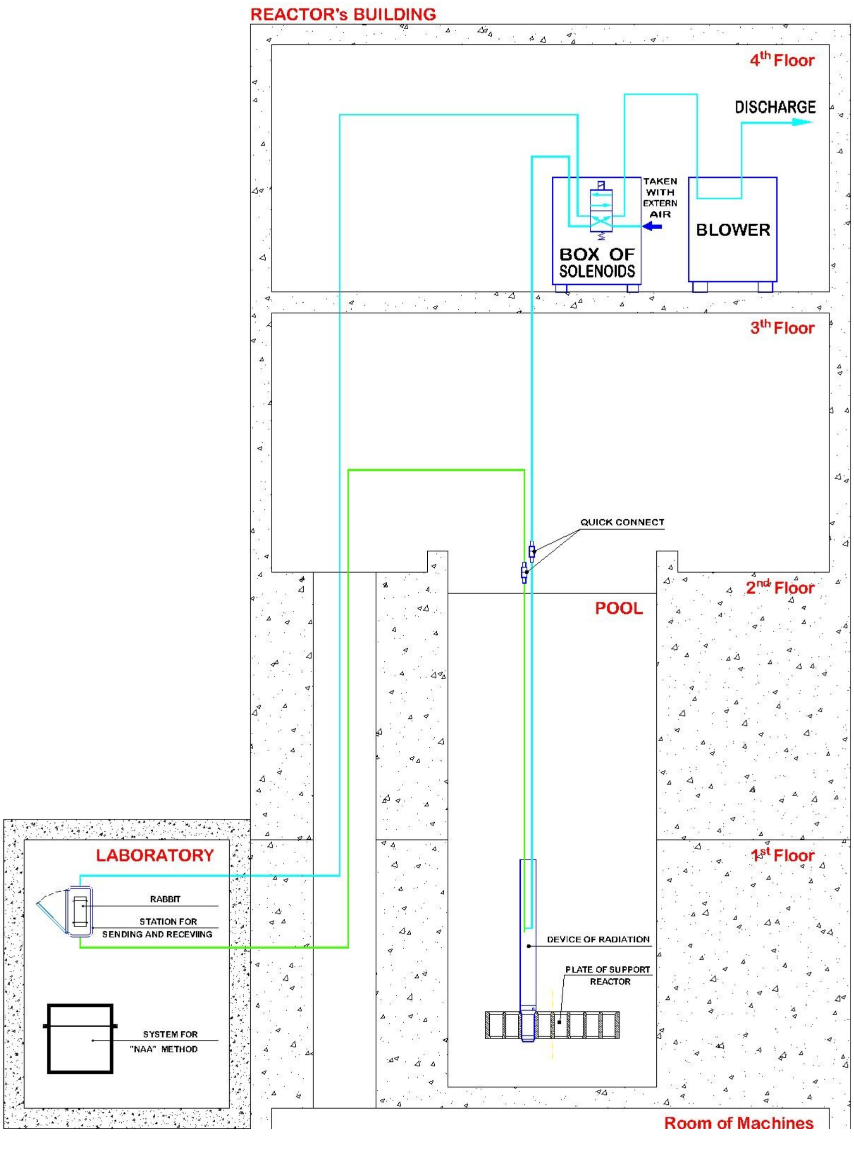

Figure 4. Outline of PTS installed in the IEA-R1 Reactor

5. CONCLUSIONS

The operational tests allow us to conclude that the system is in normal and regular condition of use.
Cold tests were performed, i.e., without radioactive material, for security analysis of the "rabbit" and adjustment of the time system. The time system involves the delivery, irradiation and return time.
Later, materials irradiation tests were carried out and the obtained results showed the feasibility of short half life materials to be analyzed. The operational security conditions were, also, confirmed.

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