# Evaluation of the aging management system for the Triga research nuclear reactor in Brazil

# Avaliação do sistema de gerenciamento do envelhecimento do reator nuclear de pesquisa Triga no Brasil

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**ABSTRACT**
As most research reactors have over 40 years of operational experience, maintenance, modernization and renovation are increasingly important for safety and operational life extension. This is due to the monitoring and development of techniques to control and mitigate the negative effects of operating conditions on structures, systems and components. Aging management is a strategy of engineering, operation, maintenance and other actions to control, within acceptable limits, the aging degradation of the facility. The first criticality of the IPR-R1 Triga research reactor (Training, Research, Isotopes, Atomics) occurred in 1960 with a maximum thermal power of 30 kW. Therefore, this reactor has been operating for more than 60 years. One of the issues that comes from the long time of the operation is the management of aging. This includes functions and issues related to operation, inspections, design changes, testing, and others. The IPR-R1 reactor is a North American project. So, the requirements of United State Nuclear Regulatory Commission (U.S.NRC) are applicable. This article discusses the International Atomic Energy Agency (IAEA), and U.S.NRC requirements to implement an aging management system for the CDTN IPR-R1 Triga Reactor.

**Keywords:** triga reactor, management of aging, safety, IAEA, U.S.NRC.

**RESUMO**
Como a maioria dos reatores de pesquisa tem mais de 40 anos de experiência operacional, a manutenção, a modernização e a renovação são cada vez mais importantes para segurança e para a extensão de vida operacional. Isto ocorre devido ao acompanhamento e desenvolvimentos de técnicas para controlar e mitigar os efeitos negativos das condições de operação nas estruturas, sistemas e componentes. O gerenciamento do envelhecimento é uma estratégia de engenharia, operação, manutenção e outras ações para controlar, dentro de limites aceitáveis, a degradação de envelhecimento da instalação. A primeira criticidade do reator de pesquisa Triga IPR-R1 (Treinamento, Pesquisa, Isótopos, General Atomics) ocorreu em 1960, com uma potência térmica máxima de 30 kW. Portanto, este reator está operando há mais de 60 anos. Uma das questões que advém do longo tempo da operação é a gestão do envelhecimento. Isso inclui funções e questões relacionadas à operação, inspeções, alterações de projeto, testes e outros. O reator IPR-R1 é um projeto norte-americano. Portanto, os requisitos da United State Nuclear Regulatory Commission (U.S.NRC) são aplicáveis. Este artigo discuti os requisitos da International Atomic Energy Agency (IAEA) e da U.S.NRC para implementar um sistema de gerenciamento de envelhecimento para o reator Triga IPR-R1 do CDTN.

**Palavras-chave:** reator triga, gestão do envelhecimento, segurança, IAEA, U.S.NRC.

## 1 INTRODUCTION

The Triga IPR-R1 research reactor (Training, Research, Isotopes, Atomics), in CDTN, was acquired from General Atomics of San Diego (GA) by the government of the State of Minas Gerais in 1960. Its first criticality occurred in 1960 with a maximum thermal power of 30 kW. In the 1970s, new fuel elements were added to the core increasing the power to 100 kW. In 2004 the core configuration and instrumentation was changed, more fuel elements were added and a power of 250 kW was reached. The new configuration was maintained, but the reactor only operates at a maximum power of 100 kW. One of the issues that comes from the long time of the operation is the aging management. This includes functions and issues related to, operation, inspections, design changes, testing, and others (MESQUITA *et al*., 2011). The aging management must be proactively implemented throughout the life of a research reactor (DESHRAJU and EDWARD, 2013).

Based on international experience, the IAEA (2020) (Periodic Safety Review for Research Reactors. No. 99), recommends that a periodic safety review of research reactors be carried out every ten years, from the beginning of their operation until their decommissioning. For facilities that have been in operation longer and have not been subject to this recommendation, this activity should be started as early as possible. An interval of ten years is considered adequate for such revisions.

The regulatory body in Brazil has not established standards to aging management for research reactors. Taking into account to the Cnen (2012) standard NE 1.04, in the absence of Brazilian standards, the documents of the International Atomic Energy Agency (IAEA) or the country that is the designer must be used. The use of the IAEA standards is beneficial for many reasons, including the global base and years of experience and the variety of documents related to the aging management of nuclear research reactors.

Refurbishment and modernization projects should not limit a simple replacement of equipment, systems or structures. They must also seek security improvements to comply with security updates (MESQUITA, *et al.*, 2011).

The Brazilian regulatory body (Cnen) has not established standards to aging management for research reactors. But in Brazil there are four operational research nuclear reactors: the IEA-R1 reactor of the Energy and Nuclear Research Institute - Ipen (*Instituto de Pesquisas Energéticas e Nucleares*) in São Paulo, which was inaugurated in 1957, the IPR-R1 Triga reactor from the Nuclear Technology Development Center - CDTN (*Centro de Desenvolvimento da Tecnologia Nuclear*) in Belo Horizonte, the Argonauta reactor at the Institute of Nuclear Engineering – IEN (*Instituto de Engenharia Nuclear*) in Rio de Janeiro, all were built in the 60's. These three reactors, from North American projects, and the fourth reactor is the Ipen/MB-01 reactor located at Ipen, that was built in the 80's, already with Brazilian technology, aiming at the autonomous development of technology for nuclear power reactors. To define an aging management is important to understand the national and international regulatory requirements.

This article discusses the aging management requirements of IAEA and of U.S.NRC, because the IPR-R1 Triga research reactor is a North American design. The requirements discussed in this article are also applicable to the others research reactors in Brazil.

## 2 MATERIALS AND METHODS

This work is theoretical. Therefore, it is based on a review of the normative basis regarding the aging management of research reactors in the world.

In Brazil there is the standard Cnen (2012) NE 1.04 (Licensing of Nuclear Facilities). The important requirements of this standard for this article are:

“6.5 Codes and Technical Standards

6.5.1 Items must be designed, manufactured, assembled, constructed, tested, tested and inspected according to technical standards compatible with the importance of the safety function to be performed.

6.5.2 In applying the provisions of item 6.5.1, updated Brazilian codes and standards must be adopted. In the absence of adequate Brazilian standards, Codes, Guides and Recommendations of the International Atomic Energy Agency (IAEA) should preferably be used and, in their absence, international standards or those of technically developed countries, provided that these standards and regulations are accepted by Cnen.

6.5.3 In exceptional cases, requirements contained in codes and standards may not be met, provided that the applicant fully demonstrates that there are design conditions that allow, without prejudice to safety, the adoption of other proposed criteria, and that this demonstration is accepted by Cnen.

8.7.6 - The Permit for Permanent Operation of an installation will be granted for the term requested by the applicant or for a set term. In the case of a nuclear power plant, the term will not exceed the limit of 40 (forty) years from the date of granting of the Permit for Permanent Operation."

## 3 RESULTS AND DISCUSSION

Based on the requirements 6.5 and 8.7.6 of Cnen (2012), NE 1.04, it is possible to develop the following considerations:

(i) Brazil does not have a standard for an aging management program for research reactors, so the options for the normative basis for the IPR-R1 Triga are:

- International Atomic Energy Agency and North American standards considering that IPR-R1 Triga research reactor is a North American design.

(ii) The Brazilian standard does not establish a deadline for Permit for Permanent Operation of research reactors.

### 3.1 NORMATIVE BASIS FOR AGING MANAGEMENT ACCORDING TO THE IAEA

The Safety Guide of IAEA (2010), SSG 10, focuses on managing the physical ageing of systems, structures and components important to safety, and also provides guidance on safety aspects of managing obsolescence.

According to IAEA (2010), SSG 10, the purpose of the aging management system is to ensure that the facility meets the safety requirements derived from:

- Regulatory agency requirements;
- Project requirements and assumptions;
- Security Analysis Report;
- Operational Limit Conditions (OLC);
- Administrative requirements.

The aging mechanisms as defined in IAEA (2010), SSG 10, are:

- Radiation - changing properties;
- Temperature - change of properties;
- Drag due to stress / pressure;
- Mechanical displacement / fatigue / vibration wear and cyclic loads;
- Material deposition (eg, raw material);

- Flow-induced erosion;
- Corrosion;
- Damage due to power excursions and operational events;
- Flood - deposition and chemical contamination;
- Fire - effects of heat, smoke and reactive gases;
- Obsolescence and technology change;
- Change in Acceptable Requirements or Standards;
- Others (time dependent phenomena).

The hierarchy of documents applicable to aging management according to the IAEA, are:

- IAEA SSG-10 – Ageing Management for research reactor (IAEA, 2010),
- IAEA Safety standards, fundamentals safety fundamental Nº SF-1 (IAEA, 2006),
- IAEA Safety standards, specific safety requirements nº SSR-3, Safety for research reactor (IAEA, 2016),
- IAEA Safety standards, Safety requirements Nº NS-R-4, Safety of Research Reactor (IAEA, 2005),
- IAEA Specific Safety Guide No. SSG-24, Safety in the Utilization and Modification of Research Reactors (IAEA, 2012),
- IAEA Tecdoc – 792 – Management of Research Reactor (IAEA, 1995).

## 3.2 NORMATIVE BASIS FOR AGING MANAGEMENT ACCORDING TO NORTH AMERICAN REGULATIONS

According to Part 50 of Title 10 of the U.S.NRC (2021a), U.S. Code of Federal Regulations, the following standards are applicable:

- 10CFR 50.34 “Applications: Technical Information” (U.S.NRC, 2021b).

It is necessary to conduct a preliminary analysis and evaluation of the design and performance of structures, systems and components of the facility in order to assess the risk to public health and safety resulting from the operation of installation and including the determination of safety margins during normal operations and anticipated transient conditions during life of the installation, and the adequacy of structures, systems and components foreseen for the prevention of accidents and the mitigation of the consequences of accidents.

- 10CFR 50.36 “Technical Specifications” (USNRC, 2011c).

Operational Limit Conditions (OLC) are the lowest functional capabilities or performance levels of equipment necessary for the safe operation of the facility.

Inspection requirements relate to tests, calibrations or inspections to ensure that what is necessary for the quality of systems and components is maintained, that the operation of the facility will be within safe limits, and that OLCs are met.

- 10CFR 50.59, “Changes, Tests, and Experiments” (USNRC, 2021d).

Change means a modification, addition or removal of facility or procedures that affect a design function, method of performing or controlling the function, or an assessment that demonstrates that the intended functions will be maintained.

A licensed nuclear facility may make changes as described in the final safety review report, procedures, and conduct tests or experiments without having to obtain a license change.

However, if it is considered a technical change, the installation must request a license change.

USNRC (2021d), 10CFR 50.59, explains which conditions of changes are treated as a technical change and requires that all changes must be recorded and records must be maintained so that they are traceable and auditable.

- USNRC (2021e), 10CFR 50.90, “Application for Amendment of License, Construction Permit, or Early Site Permit”.

Whenever the holder of a license, including a construction license and operating license under this part, wishes to change the license or license, the change request must be submitted to the USNRC, fully describing the desired changes, and following to the extent that it complies. applicable, the prescribed form for original orders.

In addition to these documents, the NRC has released a document that is a guide for managing research reactor aging:

- NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors” (USNRC, 1996):

- This document describes how to present, for the regulatory body, a License Renewal Application for Research reactor.
- The applicant must take into account the various deterioration mechanisms for the components and systems under consideration and note which mechanisms are applicable for those components and systems.
- The candidate must determine and justify acceptable levels of deterioration of the components and systems under consideration.

-The analysis must show that unacceptable levels of deterioration can not be reached during the leave period. If the analysis cannot show this, tests and measures to measure deterioration should be discussed. For components and systems that are to be tested or measured, the applicant must propose technical specifications that indicate the frequency of testing or measurement and provide performance standards for the component or system under consideration.

- The facilities maintenance program must be organized, and systematic approach considering the issue of prior use of components and systems and must be based on analysis, tests, measurements or recommendations of the manufacturer to carry out maintenance.

- The applicant must show that the components significant to the safety of the de-energized reactor will function satisfactorily during the period of the license.

## 3 CONCLUSIONS

Brazil does not have a standard for an aging management program for research reactors, so the options for the normative basis for the IPR-R1 Triga are international standards and documents.

This work describes a review of the normative basis regarding the aging management of research reactors, in Brazil, according to IAEA and North American standards, taking account that the IPR-R1 Triga is a North American design reactor.

This normative basis can be followed by CDTN for implement an aging management for IPR-R1 Triga reactor.

It will be necessary to prepare the License Renewal Application according to the document NUREG-1537. CDTN needs to send this document to the regulatory body.

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