



## Health evaluation of TRIGA reactor IPR-R1 operators according to CNEN NE 6.01 standard

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### 1. Introduction

In operation since the 60's, the TRIGA IPR-R1 reactor is currently operating under research demand, with the largest volume of operations carried out to meet the scientific needs of laboratories of the Nuclear Technology Development Center (CDTN). Reactor provides community support through the Operator Training Course for Research Reactor (Curso de Treinamento de Operadores para Reatores de Pesquisa – CTORP) for students and professionals interested in becoming operators and through nuclear experiments such as neutron activation analysis (NAA).

In 2018, through the Federal Official Gazette (Diário Oficial da União - DOU), the requirements for the TRIGA IPR-R1 reactor to maintain the concession for the Permit for Permanent Operation were published. Among the requirements is the production of the first Periodic Safety Review (PSR), which consists of a review document of technical, administrative, and professional factors that influence the safety of a nuclear facility. This guidance document was created by the International Atomic Energy Agency, and it is suggested to be renewed every 10 years. The PSR of the IPR-R1 reactor is expected to be delivered by the end of 2022. [1] [2]

The PSR document used for the study will be the Periodic Safety Review for Research Reactors, from Safety Reports Series n° 99, published in 2020. The document consists of 14 factors that influence safe operation, and are related to the facility, to safety analysis, to operating experience, to organizational effectiveness and to radiological safety.

The reactor uses three groups of collaborators to carry out its functions, namely the operators, administrative management, and support sectors, such as the radioprotection and nuclear waste management sector. The categorization is justified by the diversity of collaborators involved with the facility, since it belongs to the CDTN. CDTN is a technological development center that has several sectors that work to meet internal needs, scientific development and technical support for nuclear and radiological issues. CDTN service offers all the necessary support for the IPR-R1 reactor to take care of the demands regarding the handling of nuclear materials and with the generated samples. [3]

All employees involved in the work have influence over the quality of safety provided by the IPR-R1 reactor. The human factor affects the entire chain of safety and corrective actions and needs to be included in the safety management of the facility. The factor study will match the abilities, limitations, and reliability of human factors in order to guarantee the safe operation of the reactor.

Health conditions offer a point of attention for the management of the IPR-R1, as three operators retired in 2020 and 40% of current operators are expected to retire in the next 10 years. Thus, it is necessary to start the procedures for the renewal of human capital. The paper will explore safety factor to organizational effectiveness [1], referring to human factors, specifically data on the health conditions of potential operators according to standard CNEN NE 1.06 “Health Requirements for Nuclear Reactor Operators”. [4]

## 2. Methodology

The quality of security depends on the employee’s cognitive and emotional capacity. During the execution of the operation, emotional stability and discipline in technical procedures contribute positively to safety, reducing risks and failures. Aligned with cognitive and emotional capacity is the employee’s health. CNEN NE 1.06 standard stipulates which health conditions prevent the operator from operating individually and which conditions are an impediment to exercising the profession.

The CTORP can be used by the management of the IPR-R1 as an opportunity to seek out competent professionals who already show interest in joining a career as a research reactor operator.

Aiming at the future use of CTORP students for the operation in the IPR-R1, a questionnaire was carried out based on the health prerequisites stipulated in the CNEN NE 1.06 standard, organized in objective questions and anonymously. The Google platform known as Google Forms was used and it was forwarded to CDTN servers interested in CTORP through the CDTN commercial email. The proposal to anonymously assess future operators and provide greater opportunity for them to be honest when answering the form.

Thus, six CDTN servers interested in CTORP were selected to participate in the survey, where five responses were obtained. The questions in the questionnaire were based on the guidelines expressed in the CNEN 1.06 standard and contained disqualifying questions and minimum health conditions. The questionnaire addressed:

- mandatory periodic examinations for operators;
- daltonic;
- diseases that can cause sudden incapacity as mentioned in the standard;
- phobia of being alone in confined dark and elevated areas;
- functional impairment if changing meal times;
- severe asthma, disabling bronchial or pulmonary disease;
- heart failure, arrhythmias, valve prosthesis, pacemaker, peripheral vascular insufficiency or arterial aneurysm;
- conditions that can progress to chronic renal failure;
- liver failure;
- diabetes *mellitus*;
- alcoholism or drug addiction as defined in the standard;
- history of attempted self-extermination and psychological or mental conditions that impair reflexes or alter behavior; and
- use of medications that may result in disability.

The responses were compiled and studied quantitatively in order to obtain an overview of the health issues of those interested in CTORP.

### 3. Results and Discussion

The study of the human factor constantly deals with the issue surrounding the man-work relationship. When it comes to a nuclear operation, it is necessary for the operator to carry out the focused activity, following the safety protocols already established and not exceeding the conditions of licensed operations. The study of the health condition of potential operators allows an organization of the IPR-R1 management in relation to the expectation of human capital renewal.

CDTN servers have a medical follow-up routine guided by the health sector of the CDTN, which is also periodically released by the Occupational Health Certificate (ASO), which allows changes in the health condition to be detected. In the form distributed to potential operators of the IPR-R1, none of the disqualifying conditions for the activity were mentioned by the five participating students. Table 1 shows the unfavorable health conditions pointed out by civil servants during the questionnaire.

Table I: Health conditions.

Number of operators that have the condition	Health condition
1	Arterial hypertension
1	Myopia
1	Suffering when being alone, in confined, dark and/or elevated areas
1	Diabetes Mellitus

Of the conditions mentioned, two can be associated with food, being arterial hypertension and *Diabetes Mellitus*. These conditions are identified by the standard as conditions that pose a risk for safe operation as they can cause sudden incapacity, but they are not disqualifying as the most serious harm can be controlled through medication, food and physical activity. However, to exercise the function of a reactor operator, the person who has the conditions is conditioned not to perform the individual operation, needing to be scheduled with an operator who does not have unfavorable health conditions. This same condition should apply to the server that has myopia. In the TRIGA IPR-R1 reactor, for safety reasons, it is prohibited to carry out individual operation, being mandatory for two operators in the control room during the operations. This IPR-R1 procedure allows students with hypertension, diabetes mellitus controlled with insulin and myopia to have their specificities met and not be disqualified in the management analysis.

Another health condition found in CTORP students was suffering when being alone, in confined, dark or elevated areas. The IPR-R1 reactor building is a closed environment, with air circulation made by devices that control temperature and humidity and has artificial lighting. The circumstances described can bring the feeling of claustrophobia by people who have a more pronounced phobia. Also, in extraordinary situations, this phobia can become detrimental to safety. The CNEN standard does not specify in which condition the phobia becomes an impediment, leaving the judgment to the management of the reactor that hires the operator. [5]

None of the questions that address the impairments of mental conditions had a positive answer. The questionnaire also addressed issues related to mental disorder syndromes, such as obsessive-compulsive, conversion, anxiety, dissociative and depressive disorders. The presence of these conditions in an operator

can lead to operating limitations, as it can make the person potentially unable to perform their tasks with the required safety. [4]

As it is an anonymous questionnaire, it is not possible to identify whether the unfavorable health conditions are from different students or from the same. This is because the Google Forms platform informs the data in a statistical way, without distinction between answers.

#### **4. Conclusions**

Operation in the IPR-R1 reactor is recognized for being stable and not posing any safety hazards over 61 years of operation. The health issues highlighted by the students demonstrate the importance of their assessment from the beginning of the operator training process, in order to disqualify potential operators who do not meet the CNEN requirements. The data also allow the management of the IPR-R1 reactor to predict future actions for hiring new operators by CTORP, following CNEN regulations and standards.

The operator of a nuclear reactor must be a person able to follow technical procedures, have a good diagnosis of potential risk and apply appropriate actions in emergency situations, for this, good health is essential. An operator in good health gives greater reliability to the installation as it reduces the chances of accidents caused by sudden incapacity. This should be prepared for any urgent or emergency situation.

The study of the human factor favors the quality of safety and should be incorporated into safety analyses.

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