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Human performance and safety in nuclear facilities – regulatory frameworks

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ABSTRACT

The relation between human performance and nuclear safety was legitimized after nuclear accidents with important radiological consequences caused by human errors. This article presents, by a bibliographical survey, some publications of international regulation bodies of best practices in programs of human performance. In order to list the main available documents and the events occurred over the decades, the data sample range included the period between the year of 1979, with the landmark of Three Mile Island accident, until today. With the presentation of the results, this article aims to raise the discussion about the importance of a specific regulation guide regarding this subject in Brazil.

Keywords: **human performance analysis , nuclear safety, human factors, nuclear regulatory frameworks, risk perception, human error**

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1. INTRODUCTION

The appearance of studies related to human factors in the nuclear field increased after, mainly, events with radiological consequences over the years. According to the United States Energy Department (DOE-HDBK-1028, 2009) [1], 80% of the adverse events are attributed to human error, while 20% are attributed to equipment failure. The same institute states that human performance programs have two main objectives: reduce errors and strengthen controls. These structured programs include, for example, double and triple-checking techniques, pre-job meetings and task observation. But beyond that, they are also concerned with human behavior and how the cognitive and psychological aspects are intrinsic to the operations, and the importance of specific evaluations. Performance analysis cover preventive aspects with work teams, as training and development actions, participation in technical meetings, and others, building an idea of multidisciplinary action. Important to point that the concern of human performance analysis is, ultimately, the mitigation of human failures, but it also contributes to the motivation of teams and has, in its conception, a global view of the human being, known as the biopsychosocial approach (GEORGE, L. ENGEL, 1980) [2].

Recognizing the continued and progressive expansion on the use of nuclear technology in Brazil, established by the Energy National Plan (2020) [3], and the need of continuous optimization on precise analysis, the objective of this paper is to present the main standard publications related to human performance programs in the nuclear global industry, seeking to ratify its importance for nuclear safety and demonstrate the knowledge development throughout the years and events occurred. After that, compare the results with the current existence of any regulation in the Brazilian regulatory repository regarding the subject.

2. MATERIALS AND METHODS

In order to achieve the above-mentioned objective, the bibliographical research was the chosen method, giving priority to regulation documents of standard organizations, focus of this paper. The search contemplates sources from year 1979, with the historical event of the Three Mile Island nuclear power plant accident, until today's reviews.

3. RESULTS AND DISCUSSION

In 1979, the history of the nuclear industry was marked with the Three Mile Island accident, in the United States. Many reports and attention took place to investigate the causes of the event. Among the reasons, the Kemeny Comission Report identified the presence of human error related. After that, many efforts began to arise to attend the development need of the area. In 1979 the Institute of Nuclear Power Operations was created as one of the recommendations of the Report, and had the mission to promote operational excellence setting industry-wide performance objectives, criteria and guidelines for nuclear power plant operations. One of the marking publications of the Institute is “Excellence in Human Performance”, in 1997, and after that the “Human Performance Reference Manual”, in 2006, and “Human performance improvement handbook. v.1: Concepts and principles” and "v.2: "Human performance tools for individuals, work teams, and management”, in 2009. These publications gathered methods related to human performance assessment and stated as references opening models in the field. The Table 1 presents the results of the research, with the main publications available identified throughout the years.

In 1986, another accident took place in the world nuclear event timeline in Chernobyl, Ucraine. In this accident human error was also present as one of the causes and as a response to this, in 1989 was created the World Association of Nuclear Operators, which was a multi nation effort to enhance the support for operators and safe operations in nuclear facilities. The mission of WANO is to “maximize the safety and reliability of nuclear power plants worldwide by working together to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices.” [16]. Among the available publications of the institute are “Principles for Excellence in Human Performance" and “Guidelines for Effective Nuclear Supervisor Performance”.

From 1997, the IAEA also published many documents regarding the subject. “Human performance improvement in organizations: Potential application for the nuclear industry” (2005) presents a full range of human performance solutions that considers experiences from other industries to attend the improvement of the area. The document “Leadership, Human Performance and Internal Communication in Nuclear Emergencies”, published in 2018, presents a guidance on leadership, human performance and internal communication in severe nuclear emergencies, which was an area identified as lacking of information.

Table 1: Publications and events occurred throughout the years

Year	Description
1979	Three Mile Island (EUA) accident
1979	Creation of the Institute of Nuclear Power Operations (INPO) – US DOE
1986	Chernobyl (Ucraine) accident
1987	Goiania (Brazil) accident
1989	Creation of the World Association of Nuclear Operators(WANO)
1997	"Excellence in Human Performance" - INPO(DOE-USA) [4]
1997	"Organizational factors influencing human performance in nuclear power plants"- IAEA-TECDOC-943[5]
2001	"A systematic approach to human performance improvement in nuclear power plants: Training solutions" - IAEA-TECDOC-1204[6]
2002	"Principles for Excellence in Human Performance" – WANO[7]
2005	"Human performance improvement in organizations: Potential application for the nuclear industry" - IAEA-TECDOC-1479[8]
2006	"Guidelines for Effective Nuclear Supervisor Performance"– WANO[9]
2006	"Human Performance Reference Manual"- INPO(DOE-USA) [10]
2009	"Human performance improvement handbook. v.1: Concepts and principles" [1] and "v.2: "Human performance tools for individuals, work teams, and management" - DOE Standards, DOE-HDBK-1028[11]
2011	Fukushima (Japan) accident
2014	"Managing Human Performance to Improve Nuclear Facility Operation", IAEA Nuclear Energy Series NG-T-2.7[12]
2018	"Leadership, Human Performance and Internal Communication in Nuclear Emergencies", IAEA Nuclear Energy Series NG-T1.5[13]
2020	"Assessing Behavioural Competencies of Employees in Nuclear Facilities", IAEA Nuclear Energy Series NG-T1.5 [14]
2022	"Sustaining Operational Excellence at Nuclear Power Plants", IAEA Nuclear Energy Series NR-G-3.1 [15]

These documents based on scientific data present methods and suggestions of instruments to plan and implement a human performance program in nuclear facilities.

The search of a Brazilian regulation found no specific norm that details how to carry an investigation on human performance and behavioral factors that influences the nuclear facilities safety, similarly to the publications presented in table 1.

The standard CNEN NE-1.06 “Health requirements for nuclear operators”[17], item 4.2.4, indicates aspects for admission of operators, but with no integration for assessment on the daily basis operation, what could generate data for further performance evaluation and risk assessment.

The standard CNEN NE-1.26 “Safety in Operation of Nuclear Power Plants” [18], item “Risk Management”, addresses only the aspect of statistical analysis. The method of causal analysis of human behavior is not specified. That could be met through the implementation of a human performance program.

4. CONCLUSION

Human performance is a field of study well applied in the safety optimization of nuclear facilities for over 45 years, based on the chosen sample range, with the purpose to contribute to the mitigation of human error and used in many countries that benefit from this technology.

We can acknowledge that after adverse events, greater importance was given to the investigation of the relationship between human performance and the safety of nuclear facilities, emphasizing the necessity of having implementation guides for its programs.

It was not found in the Brazilian regulatory repository a document that meet those requirements, that could clearly indicate the importance and the tools for its implementation in Brazilian nuclear facilities. By the presented results, it is suggested that, with the scientific knowledge and references available, the elaboration of a regulation/policy document to enhance nuclear safety in this regard.

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