Essays on Nuclear Energy & Radioactive Waste Management

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- 10 -
Design Bases for Automation of a Quality Assurance System in Radioactive Waste Management[13]

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Abstract: The design, construction, operation and decommissioning of a radioactive waste management facility requires compliance with the applicable regulations for nuclear quality assurance. However, although compliance is mandatory, in some countries the requirements are outlined for every type of nuclear facility, therefore they are generic and lack details of the actions necessary to ensure that the more specific quality objectives for a radioactive waste management facility are met. Besides that, the quality assurance system of such enterprise is complex, but ready-to-use, commercially available computer tools to assist managing the processes are still needed. The available quality management software requires either adaptation through the inclusion of specific data sets from the quality control program of a radioactive waste management facility, or the development of a customized tool. Therefore, the objective of this work is to search for a brief historical background of the emergence of Quality Assurance in the nuclear area in the Western world, providing information to form the engineering bases that allow the development of a computerized quality assurance system that may assist the quality manager to assure compliance with the applicable regulation in these countries.

Keywords: radioactive waste management; quality assurance; ASME-NQA-3; DOE/OCRWM-QARD; CNEN-NN-1.16.

Resumo: O projeto, construção, operação e o descomissionamento de uma instalação de gestão de rejeitos radioativos requer conformidade com os regulamentos aplicáveis à garantia da

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qualidade nuclear. No entanto, embora o cumprimento seja obrigatório, em alguns países tais requisitos são descritos para qualquer tipo de instalação nuclear, portanto, são genéricos e não detalham as ações necessárias para garantir que objetivos de qualidade mais específicos para uma instalação de gestão de rejeitos radioativos sejam atendidos. Além disso, o sistema de garantia de qualidade desta instalação é complexo,e ainda não há ferramentas computacionais comercialmente disponíveis já prontas para o uso para auxiliar na gestão de tais processos. O software para gestão de qualidade disponível requer uma adaptação por meio da inclusão de conjuntos de dados específicos do programa de controle de qualidade de uma instalação de gestão de rejeitos radioativos, ou então o desenvolvimento de uma ferramenta customizada. Desta forma, o objetivo deste trabalho é apresentar um breve histórico do surgimento da Garantia da Qualidade na área nuclear no mundo ocidental, fornecendo informações para formar as bases de engenharia que permitam o desenvolvimento de um sistema informatizado de garantia da qualidade que possa melhor auxiliar o gerente de qualidade para garantir o cumprimento da regulamentação aplicável nesses países.

Palavras-Chave: Gestão de Rejeitos Radioativos; Garantia da Qualidade; ASME-NQA-3; DOE / OCRWM-QARD; CNEN-NN-1.16.

1. Introduction

In recent decades, nuclear technology has turned into one of the most controlled and regulated fields of all industries. An ever more stringent set of requirements for design, construction, commissioning, operation and closure of facilities has been imposed to this sector as a means to achieving and maintaining the highest levels of safety. The escalating costs that resulted from this movement toward excellence required keeping the systems optimized and as safe as possible, with Quality Assurance (QA) in all stages of a nuclear project as a key factor for success.

Radioactive waste management, while may seem like a simple activity when compared to the complexity of other enterprises such as constructing or operating a nuclear reactor, also requires a rigorous control of processes. The predisposal facilities and, especially, the final disposal facilities are committed to the assurance of safety, so that the radionuclides present in the waste can be duly isolated from the environment, until their activity decays to levels that pose acceptable risks. To this end, a quality assurance system must ensure that such facility is designed in compliance with the technical requirements; the relevant properties of the natural environment of the site are adequately characterized; the technical data upon which engineering decisions are founded are documented and retained; and the data used in the licensing procedure are valid and accurate [1-3].

The complexity of the QA system of a radioactive waste management installation may also require computerized management tools, and no products have been found commercially in their final form ready for use; there are only programs for Business Process Management (BPM), such as IBM BPM [4] and MasterControl [5], among others, which require the introduction of a specific set of waste management data, so that they can be properly applied to the QA control of a radioactive waste management facility. An analysis must be carried out in each situation regarding the most suitable option: to develop such a data set in order to adapt any of the existing commercial systems, or to develop a customized computerized system. In either case, it will be also necessary to map the processes of the installation to be controlled.

Therefore, the objective of this work is to study the emergence of Quality Assurance in the nuclear area in the Western world, providing information to form the engineering bases that allow the development of a computerized quality assurance system that may assist the quality manager to assure compliance with the applicable regulation of radioactive waste management.

2. Materials and Methods

2.1. History

The policies of QA in radioactive waste management started at the beginning of the 1980s. Before that, there was no real control of the radioactivity dumped in the environment: until 1982, drums with the radioactive waste produced by the 13 most advanced countries in the area were thrown into the deepest places in the ocean; according to the International Atomic Energy Agency, approximately 85.0 x 10^{15} Bq of radioactive waste were discharged into the ocean [6]. And regarding the 520 nuclear tests on Earth's surface, which were halted in 1963 thanks to the Partial Nuclear Test Ban Treaty, it is estimated that an order of magnitude greater than 1.0 x 10^{21} Bq of radioisotopes were dispersed in the air, with the emission of gases and aerosols [7].

The scientific and engineering communities of the radioactive waste management program in the United States of America already had recognized QA as essential for the development of radioactive waste disposal projects [8, 9]. In Europe, besides the regulations developed in each country, the importance of a robust QA approach in the field of nuclear waste management was recognized by the European Commission. Therefore, in 1982 a workgroup was created to review the status of implementation of production standards and QA of radioactive waste management there. In 1992, the European Network of Testing Facilities for the Quality Checking of Radioactive Waste Packages (ENTRAP) was founded, an independent organization that promotes European collaboration in this field, with the objective of examining "the needs, incentives, scopes and ways of implementation of a European network of national QA/QC facilities for radioactive waste products" [10].

The practices that evolved in the construction and licensing of nuclear power plants started to be applied also to waste repositories. In 1989, the American Association of Mechanical Engineers (ASME) issued the ASME-NQA-3 - Quality Assurance Program Requirements for the Collection of Scientific and Technical Information for Site Characterization of High-Level Nuclear Waste Repositories [11]. In 1990, the US Nuclear Regulatory Commission (NRC) published a guidance on the application of QA for characterizing low-level waste disposal sites [12] and, in the next year, issued a more general guidance on QA in low-level radioactive waste disposal facilities [13].

In 1992, the Office of Civilian Radioactive Waste Management of the U.S. Department of Energy issued the first version of the "Quality Assurance Requirements and Description for the Civilian Radioactive Waste Management Program – QARD/OCRWM" [14], to be applied to the Yucca Mountain repository. Finally, other steps of radioactive waste management, such as waste treatment and waste packages were the object of development of QA programs at the same time [15, 16]. The trend reached the International Atomic Energy Agency (IAEA) in 1989, with the development of a technical document on the application of a QA program in the nuclear area in general [17], and another one more specifically designated for waste disposal facilities a few years later [18].

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, organized by the IAEA in 1997, is the first legal instrument to address the issue of spent fuel and radioactive waste management safety on a global scale. In Article 23, it states that "...each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programs concerning the safety of spent fuel and radioactive waste management are established and implemented" [19]. Brazil internalized it in its national legal framework in October 2006 [20].

Getting back to Europe, in 1999 the Western European Nuclear Regulators' Association (WENRA) was established, comprising the Heads of Nuclear Regulatory Authorities of European countries with at least one nuclear power plant in the construction, operation or decommissioning phase, with the objectives of developing a common approach to nuclear safety, providing an independent capability to examine nuclear safety and providing a network for chief nuclear safety regulators in Europe to exchange experience and discuss significant safety issues [21]. One of the working groups established by WENRA is the Working Group of Waste and Decommissioning (WGWD).

2.2. Regulation Framework

The application of quality assurance to a waste management project requires establishing the proper basis of design for the system. "Design basis" mean the set of conditions, needs and requirements taken into account in the design of the facility, as well as the fundamental principles upon which the project is based. Applicable design inputs shall be appropriately specified on a timely basis and correctly translated into design documents [22, 23].

The North American standard NQA-3 was developed in accordance with the structure of Federal Regulation 10 CFR 50, Appendix B [24], presenting the following control items: Organization; Quality Assurance Programs; Design Control; Procurement Document Control; Procedures, Instructions, and Drawings; Document Control; Control of Purchased Material, Equipment and Services; Identification and Control of Materials, Parts and Components; Control of Special Processes; Inspection; Test Control; Control of Measuring and Test Equipment; Handling, Storage and Shipping; Inspection, Test and Operating Status; Nonconforming Material, Parts or

Components; Corrective Actions; Quality Assurance Records; Audits. A number of countries based their own QA nuclear regulations on the NQA-3, such as Brazil [25] and Egypt [26, 27].

In the United States there is not only one regulatory commission; the commercial facilities are regulated by the Nuclear Regulatory Commission (NRC), which only uses parts of the ASME-NQA in its regulatory guides, and are subject to 10 CFR 50, while government facilities such as those of the Department of Energy (DOE) normally follow the 10 CFR 830 (Nuclear Safety Management) Subpart A (Quality Assurance Requirements). The DOE regulates its own facilities based on the use of appropriate national and international standards for the implementation of its quality assurance requirements [28].

As previously mentioned, one of the sites controlled by the DOE is the Yucca Mountain Nuclear Waste Repository Project, in the state of Nevada, which had been underway since 1987 but is still in the licensing phase. In 1982 the Office of Civilian Radioactive Waste Management (OCRWM) was created, a department that was responsible for implementing the national policy for the disposal of radioactive waste. This department elaborated a document with requirements and descriptions of procedures, the DOE/RW-0333P - Quality Assurance Requirements and Descriptions [14], with its chapters being organized in the same structure as the 10 CFR 50.

The DOE/RW-0333P document was progressively revised and updated 21 times in order to reflect the most recent technological and legal changes, until 2010 when the department was shut down due to political issues and lack of funding [29]. This document was also based on the ASME-NQA framework and adapted to the requirements of a high-level radioactive waste repository. Although this document has been designed specifically for quality assurance in the management of high-level waste, the control requirements are similar as those used in a low- and intermediate-level waste management facility.

3. Results and Discussion

As consequence of this research, an analysis of the DOE/OCWRM-QARD was performed, with the identification of the items, services and processes that should be controlled. In order to develop a specific tool that directly assists in the development of a computerized system for recording and controlling the QA system of a radioactive waste management facility, a process mapping was then carried out through the development of a set of logical algorithms in the form of flowcharts, with the procedures for application and compliance with the QA requirements of the regulation in the various activities, items, services and processes. The flowcharts were designed respecting the 3-level requirements for origin, review and approval of procedures, with a set for each of the control items of 10 CFR 50, Appendix B.

The principle of these flowcharts is to graphically represent each action that should be recorded, during the phases of design, operation and decommissioning, together with control points for verification of the data entered, whether each piece of information was correctly provided in accordance with the corresponding regulations.

Each action should be placed within a geometric shape, with arrows to indicate the direction of the flow of information. The resources used and the products that result from the process can also be included in the structure. In this work, the preset rules and standards about flowchart symbols defined by the American National Standards Institute (ANSI) in the 1960s were used. Afterwards, the International Organization for Standardization (ISO) adopted the ANSI symbols in 1970 [30]. The current standard, ISO 5807, was revised in 1985 [31, 32].

As the goal is the computerization for automation of the QA control system, the flowcharts were created in the format of software pages: the first round for data inclusion, as seen in Figure 1:

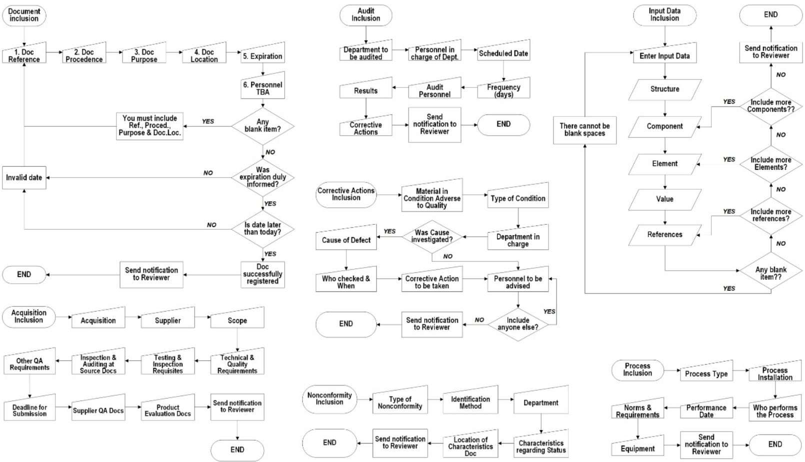

Figure 1 - Example set of flowcharts for including data.

Source: author.

The second round is for searching, consulting and editing previously added data, as presented in Figure 2; and after confirmation of the appropriate data, registration in the corresponding database and notification of the competent parties for reviewing and approval, as seen in Figure 3.

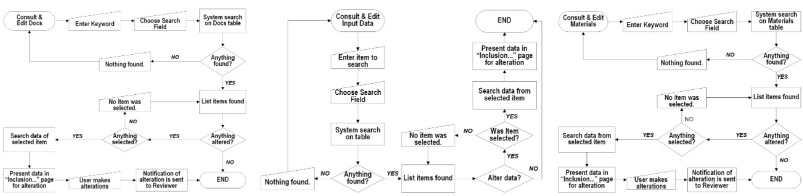

Figure 2 - Example set of flowcharts for consulting and editing data.

Source: author.

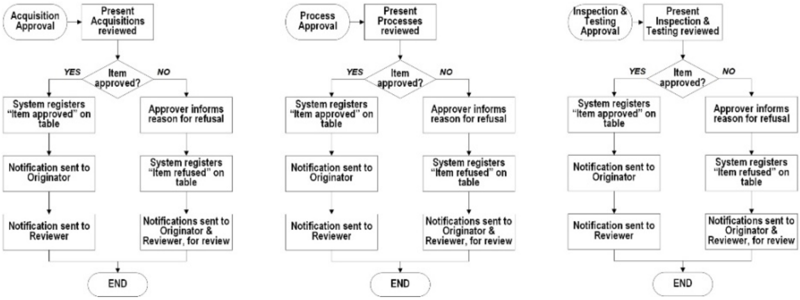

Figure 3 - Example set of flowcharts for reviewing and approval.

Source: author.

The quality control system applied to site performance and safety assessment software for the construction of repositories has already been well established through the best practices already in operation [33, 34]. Such practices can be equally used for software applied to QA in radioactive waste management, with due registration of changes in version and code, as well as verification, validation and approval in order to assure that the impact of any change is carefully assessed before updating the baseline [35].

The processes analyzed by such mapping are at the level of the most elementary operations, so that they can be properly redesigned according to the more specific procedures pertinent to each department or service of the nuclear waste management facility [36, 37]. The objective of working on this level is also to facilitate the comprehension at the time of practical use, which may allow an individual with less knowledge in the nuclear field, including a computer programmer, to understand with effortless ease the important safety procedures to be registered and controlled.

The analysis of the DOE/RW-0333P American regulation demonstrated, because of its more extensive specificity, that the information in this regulation addresses a great variety of situations in a radioactive waste management facility, which can ultimately minimize ambiguous interpretations of rule enforcement.

4. Conclusion

The results of this work with relation to the development of flowcharts and logical procedure sequences in the level of elementary operations, in spite of being primarily focused on the Brazilian regulations, may nevertheless be properly utilized for the process mapping in similar fields elsewhere. The validation of process mappings can be obtained only by considering that the confidence in the process results is increased due to the reduction of their uncertainty. This can be achieved through continuous process improvements, as new data and information become available and incorporated into progressive updates on modeling.

Although some situations need to be verified or further developed in other works, it is considered that the objectives of the present work have been met. Future studies are recommended to verify which methods should be most suitable for error mitigation and validation of the process mapping presented in this work, when applied to a radioactive waste facility. The full paper is available at the University's website [38].

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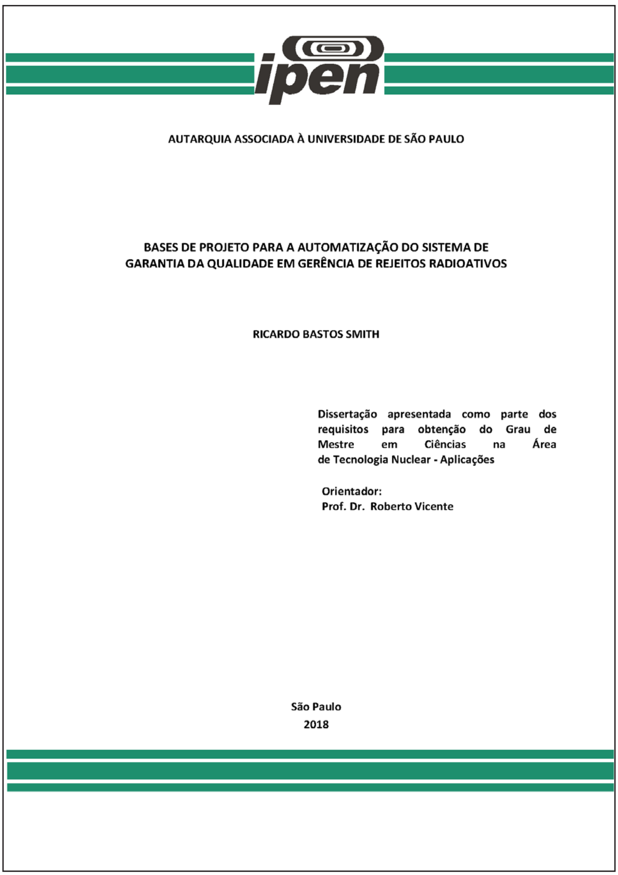

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AUTARQUIA ASSOCIADA À UNIVERSIDADE DE SÃO PAULO

BASES DE PROJETO PARA A AUTOMATIZAÇÃO DO SISTEMA DE GARANTIA DA QUALIDADE EM GERÊNCIA DE REJEITOS RADIOATIVOS

RICARDO BASTOS SMITH

Dissertação apresentada como parte dos requisitos para obtenção do Grau de Mestre em Ciências na Área de Tecnologia Nuclear - Aplicações

Orientador:
Prof. Dr. Roberto Vicente

São Paulo
2018