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The Graded Safeguards Concept: An Alternative to the Safeguards Approach for Naval Nonreactor Nuclear Facilities (NRNFs)

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ABSTRACT

The Submarine Development Program (PROSUB), under management of the Brazilian Navy, has been developing naval nuclear propulsion technology and, for so, nuclear facilities for maritime activities. The objective of this paper is to present initial thoughts on an integrated approach for implementing the graded safeguards concept in the design of naval Nonreactor Nuclear Facilities (NRNFs) that support the Brazilian Nuclear Propulsion Program. The proposed Alternative is based on the concept of graded safeguards set forth by the United States Department of Energy (DOE). A regulatory framework has been proposed involving regulations from the International Atomic Energy Agency (IAEA), the DOE and the Brazilian National Nuclear Energy Commission (CNEN, Portuguese acronym). This gradual approach has the potential for a more affordable project, and thus the integrated safeguards approach inherent to DOE regulations presents itself as a viable option to complement CNEN NN 2.02 provisions regarding the design and licensing for naval NRNFs in Brazil.

Keywords: Safeguards, Nonreactor Nuclear Facility, Nuclear Licensing.

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INTRODUÇÃO

The Submarine Development Program (PROSUB, Portuguese acronym), under management of the Brazilian Navy, has been developing naval nuclear propulsion technology and, for so, nuclear facilities for maritime activities. The lifecycle of these facilities must go through a nuclear licensing process that encompasses the stages of design, construction, operation, and decommissioning.

The National Nuclear Energy Commission (CNEN, Portuguese acronym) is a federal authority created on October 10, 1956 (Decree nº 40.110) as the Brazilian organization for planning, guiding, supervising, licensing, and controlling the application of nuclear energy. Initially, the CNEN was directly subordinate to the presidency of the Republic (Andrade & Santos, 2013), but currently it is under the Ministry of Science, Technology, and Innovation (MCTI, Portuguese acronym). Furthermore, in order to enhance the national regulators trust and independence, the Law nº 14.222 of October 15, 2021, created the National Nuclear Safety Authority (ANSN, Portuguese acronym) to take over the responsibility of the Safety, Safeguards and Security of ionizing radiation as well asradioactive and nuclear materials — previously under the CNEN's responsibility (ANSN is not regulated and operational at the moment) — and defined as a private competence of the Brazilian Navy Command to regulate, license, inspect and control the nuclear-powered vessels. With that assignment, the Brazilian Navy created the Naval Nuclear Safety and Quality Agency (AgNSNQ) (BARONI et al., 2022).

The CNEN establishes standards and regulations in radiation protection and nuclear safety for peaceful uses. The standard CNEN NE 1.04 *Licensing of Nuclear Installations* (CNEN, 2002) rules the licensing process for nuclear installations in Brazil. This regulation establishes (1) that no nuclear installation shall be constructed or operated without a license (subsection 6.1.1), and (2) the process to be applied to activities related to the location, construction, and operation of nuclear facilities, covering the steps of:

- Site Approval;

- Construction License (total or partial);

- Authorization for the Use of Nuclear Materials;

- Authorization for Initial Operation;

- Authorization for Permanent Operation, and

- Cancellation of Authorization for Operation.

Although this standard is not applied to nuclear installations supporting nuclear propulsion, as stablished in its subsection 1.2.1.1 (quoted at the end of this paragraph), it shall be used as the driving licensing process for those naval nuclear installations: "Activities related to nuclear reactors used as a source of energy in means of transport, both for propulsion and for other purposes, are excluded" (CNEN, 2002).

The exclusion above constitutes a regulatory gap that challenges PROSUB in managing the construction and operation of the Specialized Maintenance Complex (CME, Portuguese acronym), scheduled to be built in the city of Itaguaí, in the state of Rio de Janeiro (RJ). Aiming to overcome this issue, BARONI et al., 2022 assessed the relevance and suitability of the regulatory framework set forth by the United States Nuclear Regulatory Commission (NRC) and Department of Energy (DOE) for a nuclear-powered submarine's land support facility's safety analysis and licensing. DOE regulatory framework was found most adequate to be used as requirements source in the design and licensing process for this type of facility for several reasons, such as that:

- It is applied to the nuclear safety, security, and safeguards of military installations;

- It applies the concept of a graded approach required by the International Atomic Energy Agency (IAEA) publications (IAEA, 2017; 10 CFR Part 830, 2001; US DOE, 2014; US DOE, 2016a; US DOE, 2016b);

- It reflects relevant experience in the design, construction, and operation of NRNFs, experience that supports the U.S Naval Propulsion Program.

It is important to mention that the Brazilian regulator establishes the definitions of nuclear material and radioactive material as quoted below, and that these definitions result in the differentiation of facility types to be licensed:

> Radioactive material - material emitting any electromagnetic or particulate radiation, directly or indirectly ionizing.
> Nuclear Material - nuclear elements or their by-products, defined in Law 4.118/62 (CNEN, 2002).

From the latter definition, the regulator establishes the definition of Nuclear Installation as:

> Nuclear Installation (or simply installation) - installation in which nuclear material is produced, processed, reprocessed, used, handled or stored in relevant quantities, at the discretion of CNEN. The following are included in this definition: a) nuclear reactor; b) plant that uses nuclear fuel to produce thermal or electrical energy for industrial purposes; c) factory or plant for the production or treatment of nuclear materials, part of the nuclear fuel cycle; d) irradiated nuclear fuel reprocessing plant; e) deposit of nuclear materials, not including temporary storage location used during transportation (CNEN, 2002).

The CME is the first national installation for supporting naval nuclear propulsion submarines. According to BARONI et al., 2022, this type of facility is defined as:

> All infrastructure (structures, systems and components) located on land to provide support and necessary resources to nuclear-powered submarines during maintenance activities, repairs, nuclear refueling operations, storage for

> new and irradiated fuel elements and processing and storage of waste (solid, liquid and gaseous) (BARONI et al., 2022)

The definition above meets the definition of Nonreactor Nuclear Facility (NRNF) adopted by the U. S. Department of Energy (DOE) (10 CFR Part 830, 2001) and the International Atomic Energy Agency (IAEA) (IAEA, 2002).

> Nonreactor nuclear facility = Those facilities, activities, or operations that involve, or will involve, radioactive and/or fissionable materials in such form and quantity that a nuclear or a nuclear explosive hazard potentially exists to workers, the public, or the environment, but does not include accelerators and their operations and does not include activities involving only incidental use and generation of radioactive materials or radiation such as check and calibration sources, use of radioactive sources in research and experimental and analytical laboratory activities, electron microscopes, and X-ray machines (10 CFR Part 830, 2001).

These facility definitions allow for the classification of the CME as a naval NRNF (BARONI et al., 2022).

The safeguard requirements established in CNEN NN 2.02 *Nuclear Material Control* (CNEN, 1999) are mandatory in the licensing process for all nuclear installations in Brazil, once compliance with this standard is required in section 7 of (CNEN, 2002) when applying the Authorization for the Use of Nuclear Material Act (AUMAN, Portuguese acronym).

> Authorization for the Use of Nuclear Material will be granted after proof that the facility is ready to receive the nuclear material and after compliance, by the applicant, of the relevant conditions required in the CNEN-NE-2.02 "Control of Nuclear Material (CNEN, 1999, section 7).

The application of AUMAN occurs at the same time as that of the Construction Permit(CNEN, 1999), and, for this reason, this administrative act has great potential to impact the cost and schedule of the project. This circumstance demands that a customized safeguards approach for NRNFs is developed, once their licensing process can differ greatly from that for Nuclear Power Plants (NPPs) and is unprecedented in Brazil. A similar approach was taken by GAMA et al, 2023 in the study of an alternative quality assurance program for naval NRNFs.

Therefore, the objective of this paper is to present initial thoughts on an integrated approach for implementing the graded safeguards concept in the design and licensing of naval NRNFs that support the Brazilian Nuclear Propulsion Program. Furthermore, the approach to be proposed must be compatible with future safeguard arrangements that will be derived from the ongoing negotiations between Brazil, Argentina, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Material (ABACC)and the IAEA about the Special Procedures foreseen in Article 13 of INFCIRC/435. Note: The safeguards agreement reproduced in INFCIRC/435 is that concluded between Argentina, Brazil, the ABACC and the IAEA.

IAEA CONSIDERATIONS REGARDING SAFEGUARD SYSTEM IMPLEMENTATION IN NRNFS

CNEN NE 1.04 regulation requires (in section 6.5.1) the use of technical standards in the design process of items, that is, that any facility's Structure, System or Component (SSC) "items must be designed, manufactured, assembled, constructed, tested and inspected according to technical standards compatible with the importance of the safety function to be performed" (CNEN, 2002).

The order of preference of codes and technical standards to be used to comply with this requirement is stablished in subsection 6.5.2:

> When applying the provisions of item (subsection) 6.5.1, updated Brazilian codes and standards must be adopted. In the absence of adequate Brazilian standardization, Codes, Guides and Recommendations of the International Atomic Energy Agency should

> preferably be used and, in the absence of these, international standards or standards from technical developed countries, provided that these standards and regulations are accepted by CNEN (CNEN, 2002).

Due to the requirement above, IAEA publications were the first source of research on the requirements to be used in the Safeguards approach for naval NRNFs. The most relevant findings are described will be discussed further on.

The first IAEA relevant publication for NRNFs is the IAEA-TECDOC-1221, *Safety of and regulations for nuclear fuel cycle facilities (Report of a Technical Committee meeting held in Vienna, 8 -12 May 2000)* (IAEA, 2000). This publication contains the results of a Technical Committee meeting held in Vienna, on 8-12 May, 2000. The objective of this event

was to compile information on the nature of safety concerns and the status of the regulations concerning nuclear fuel cycle facilities other than NPPs in Member States. Brazil participated with representatives from the national nuclear industry and the CNEN. This TECDOC highlights relevant differences between the safety aspects of nuclear fuel cycle facilities and NPPs. One of these differences is that the nuclear fuel cycle facilities have greater distribution and transfer of material throughout the facility, and thus require greater attention when accounting for the nuclear material throughout installations, not just for safeguard purposes, but also to ensure nuclear safety (IAEA, 2000). This TECDOC is seen as the beginning of an international continued effort aiming to refine integrated requirements for NRNFs.

The second relevant IAEA publication is the IAEA-TECDOC-1267, *Procedures for conducting probabilistic safety assessment for non-reactor nuclear facilities* (IAEA, 2002). This TECDOC is the first IAEA reference to uses the term "non-reactor nuclear facility", and it presents guidance on conducting a Probabilistic Safety Assessment (PSA) study for NRNFs based on the methodology specific to PSA studies for NPPs. Additionally, it references the DOE publications as source of guidance on NRNF safety analysis techniques.

IAEA Safety Standard SSR-4 *Safety of Nuclear Fuel Cycle Facilities* (IAEA, 2017) is the main safety requirement reference for NRNFs. This reference establishes the use of graded approach as a crucial safety principle that must be implemented to ensure the fundamental safety objective of protecting people and the environment from harmful effects of ionizing radiation. In this context, subsection 2.15, SSR-4, states that:

> Nuclear fuel cycle facilities are of diverse natures and types. Their design and operating characteristics may differ significantly and present a variety of different hazards. Where certain hazards are demonstrated to be non-existent or very small, application of some features or procedures required for other higher hazard facilities may be less relevant or important. Because nuclear fuel cycle facilities present a greater range of hazards than do power reactors, a graded approach can be used in the application of certain identified requirements of this publication (IAEA, 2017).

Requirement 11, SSR-4, stablishes that a graded approach shall be used in the application of nuclear requirements for NRNFs, as seen below.

> The use of a graded approach in application of the safety requirements for a nuclear fuel cycle facility shall be commensurate with the potential risk of the facility and shall be based on safety analysis, expert judgement and regulatory requirements (IAEA, 2017).

The DOE safety publications are aligned with this IAEA requirement, as seen in general requirement 7 of 10 by CFR, Part 830, 2001. Accordingly, this rule defines graded approach:

Graded approach means the process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement in this part are commensurate with:

(1) The relative importance to safety, safeguards, and security;

(2) The magnitude of any hazard involved;
(3) The life cycle stage of a facility;
(4) The programmatic mission of a facility;
(5) The particular characteristics of a facility;
(6) The relative importance of radiological and nonradiological hazards; and
(7) Any other relevant factor (10 CFR 830, 2001).

Requirement 75 from the reference (IAEA, 2017) requires an integrated approach in designing and implementing safety, security, and safeguards (3S) requirements in the licensing process for NRNFs, referred to as nuclear fuel cycle facilities in that publication.

> Requirement 75: Interfaces between safety, nuclear security and the State system of accounting for, and control of, nuclear material […].
> 11.1. Safety measures, nuclear security measures and arrangements for the State system of accounting for, and control of, nuclear material shall be designed and implemented in an integrated manner so that they do not compromise one another (IAEA, 2017).

Besides allowing 3S systems to not compromise each other, the integration of 3S measures brings several benefits for the project of NRNFs, such as:

- Avoiding additional costs associated with resolving undetected 3S negative systems interactions;
- Avoiding overlapping or duplicating requirements when using specific safety, security or safeguards regulations in the design process of each system;
- Cost-effective utilization of resources.

The following Security references must be taken into account while designing 3S system:

- IAEA Nuclear Security Series No. 13 Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear

Facilities (INFCIRC/225/Revision 5) (IAEA, 2011a) and IAEA Nuclear Security Series No. 14 Nuclear Security Recommendations on Radioactive Material and Associated Facilities (IAEA, 2011b). The reference (IAEA, 2011a) highlights the need for integration of safety, security, and safeguards in the design process of NRNFs.

> Paragraph 3.17. The recommended physical protection measures in this publication should be additional to, and not a substitute for other measures established for nuclear safety, nuclear material accountancy and control or radiation protection purposes (IAEA, 2011a).

Other important IAEA publications regarding safety and safeguards are listed forward:

- Safety Report Series nª 102 *Safety Analysis and Licensing Documentation for Nuclear Fuel Cycle Facilities* (IAEA, 2020a). This publication adapts the licensing documentation for general nuclear facilities from the reference Specific Safety Guide nº SSG-12, *Licensing Process for Nuclear Installations* (IAEA, 2010), for nuclear fuel cycle facilities other than NPPs and recommends the preparation of plans for accountability for and control of nuclear material as part of the licensing process of NRNFs;

- Specific Safety Guide nº SSG-15 (Rev. 1), *Storage of Spent Nuclear Fuel* (IAEA, 2020b). This Safety Guide provides guidance and recommendations on (1) the design, commissioning, operation, and assessment of safety for different types of spent nuclear fuel storage facility (wet and dry), by considering different types of spent nuclear fuel from nuclear reactors, and (2) on how to meet the requirements established in the reference (IAEA, 2017). This Safety Guide considers physical protection,accountability for and control of nuclear material only to highlight potential implications for safety;

- Nuclear Energy Series No. NF-T-3.1, *International Safeguards in the Design of Facilities for Long Term Spent Fuel Management* (IAEA, 2018a). This publication presents relevant recommendations for safeguards implementation in each of the following stages of a facility's life cycle: Conceptual Design, Basic Design, Final Design, Construction, Commissioning, Operation, and Decommissioning;

- Nuclear Energy Series No. NP-T-2.8, *International Safeguards in*

Nuclear Facility Design and Construction (IAEA, 2013). The focus of this guide is on safeguards by design (SBD), which provides state authorities, designers, equipment providers and prospective purchasers of nuclear facilities with guidance to facilitate the implementation of international safeguards. The IAEA is promoting SBD as an approach whereby international safeguards are fully integrated into the design process of a nuclear facility (IAEA, 2013).

The IAEA Service Series publications, listed forward, are a set of specific safeguards documents whose main objective is to assist the member States in developing and maintaining accounting systems which will support a State's ability to account for its nuclear material in a manner so that the IAEA can exercise its right and meet its obligation to verify a State's declarations (IAEA, 2008). These publications form the IAEA's basis for procedures, methods, measures, and techniques which could be referred to as best practices when used in the state for establishing and maintaining that state's system of accounting for and controlling nuclear material.

- IAEA Services Series No. 15, *Nuclear Material Accounting Handbook*, IAEA-SVS-15 (IAEA, 2008);

- IAEA Services Series No. 21, *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocol*, IAEA-SVS-21 (IAEA, 2016);

- IAEA Services Series No. 31, *Safeguards Implementation Practices Guide on Stablishing and Maintaining State Safeguards Infrastructure,* IAEA-SVS-31 (IAEA, 2018b).

It is observed that some IAEA publications are aimed at Comprehensive Safeguards Agreement (CSA) and Additional Protocol (AP) implementation. However, Brazil is a state with a CSA in force, but no AP in force, and, for this reason, the referred IAEA publications should be used solely with regard to aspects of the CSA.

The DOE has published standards aligned with this set of IAEA requirements, such as those described below. These standards are substantial and establish an acceptable method for complying with the

United States accounting and control laws.

-DOE Order 474.2A, *Nuclear Material Control and Accountability* (US DOE, 2023);

-DOE Order 470.4B, Chg 3 (LtdChg), *Safeguards and Security Program* (US DOE, 2021);

-DOE-STD-1194-2019, *Nuclear Materials Control and Accountability* (US DOE, 2019c);

-DOE-STD-1217-2020, *Safeguards and Security Survey and Self-Assessment Planning, Conduct, and Reporting* (US DOE, 2020).

It is worthy to mention that the abovementioned publications integrate Safeguard and Security measures, and nuclear safety requirements may be found in 10 Code of Federal Regulations (CFR) 830, 10 CFR 835 and Safety related DOE Directives and Standards, such as:

-DOE Order 420.1 C, Chg 3 (LtdChg), *Facility Safety*, 2019 (US DOE, 2019a);

-DOE-STD-1027-2018, *Hazard Categorization of DOE Nuclear Facilities* (US DOE, 2019b);

-DOE-STD-1189-2016, *Integration of Safety into the Design Process* (US DOE, 2016a);

-DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* (US DOE, 2014);

-DOE-STD-3007-2017, *Preparing Criticality Safety Evaluations at Department of Energy Nonreactor Nuclear Facilities* (US DOE, 2017);

-DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents* (US DOE, 2016).

Brazil is not the first state to use DOE Standards and Codes. The hazard categorization process, hazard analysis methodology, and graded approach required in the abovementioned DOE framework was used by KIM et al, 2023 for the development of classification criteria for structures, systems, and components (SSC) for the safety control of NRNFs in Korea, once there is no stand-alone technical standard and regulation for the classification of NRNFs in Korea.

One can observe that safeguards and security issues are addressed in the safety design basis preparation process regulated by (US DOE, 2016a) since early stages of project, as seen in chapter 5 of the Conceptual Safety Design Report (CSDR), titled "Security Hazards and Design Implications", in Appendix B of (US DOE, 2016a) and in item E.12, Appendix E, as below:

> […] Interfaces with safeguards and security that are important to safety basis development include the development of Safeguards Requirements Identification, a Vulnerability Assessment, and participation in the hazard analysis effort (US DOE, 2016a).

This integrated management of safeguards and security set forth by the DOE is aligned with the IAEA's regulation approach, as seen in the reference (IAEA, 2020b).

THE GRADED SAFEGUARDS CONCEPT

The DOE relies on the concept of graded safeguards and on the adoption of measures for the management and verification of safeguards over the entire lifetime of the NRNFs. The directive DOE O 474.2A (US DOE, 2023) establishes requirements for developing, implementing, and maintaining a nuclear material control and accountability (MC&A) program within the DOE and other facilities. The main requirements with direct applicability to naval NRNFs are:

- Physical Protection Requirements; DOE Order 473.1, Physical Protection Program, is indicated for compliance. Although, the requirements from the standard CNEN NN 2.01, Physical Protection of Nuclear material and Installations (CNEN, 2019), seems adequate for naval NRNFs;

- DOE oversight requirements for special nuclear material; The standard DOE-STD-1217-2020 (US DOE, 2020) provides an accepted compliance and performance-based process to conduct and report safeguards & security surveys and self-assessments;

- Attachment 2, Chapter I, recommends that MC&A program must (1) be graded based on the consequence of loss, and (2) Integrate MC&A with Safeguards & Security and other site programs.

The concept of Graded Safeguards, addressed in Attachment 2, Chapter I from (US DOE, 2023) is used to provide the greatest relative amount of control and accountability for the types and quantities of special nuclear material (SNM) that can be most effectively used in a nuclear explosive device. The process consists in determining the attractiveness levels and Categories for each type of SNM. Table 1 and 2 are used in the categorization process.

Table 1 – Special Nuclear materials.

Material Type	Accountable Quantity	Weight Field Used for Element	Weight Field Used for Isotope	Material Type Code
Enriched U-235	1 gram	total U	U-235	20
Uranium-233	1 gram	total U	U-233	70
Plutonium-242 (Pu)	1 gram	total Pu	Pu-242	40
Plutonium-239-241	1 gram	total Pu	Pu-239 + Pu-241	50
Plutonium-238	1/10 of a gram	total Pu	Pu-238	83
Uranium in Cascades	1 gram	total U	U-235	89

Source: adapted from (US DOE, 2023).

Table 2 – Graded Safeguards Table.

	Attractiveness Level	Pu/U-233 Category (kg)				Contained U-235/Separated Np-237/Separated Am-241 and Am-243 Category (kg)			
		I	II	III	IV	I	II	III	IV
WEAPONS Assembled weapons and test devices	A	All	N/A	N/A	N/A	All	N/A	N/A	N/A
PURE PRODUCTS Pits, major components, button ingots, recastable metal, directly convertible materials	B	≥2	≥0.4<2	≥0.2<0.4	<0.2	≥5	≥1<5	≥4<1	<0.4
HIGH-GRADE MATERIALS Carbides, oxides, nitrates, solutions (≥25g/L) etc.; fuel elements and assemblies; alloys and mixtures; UF4 or UF6 (≥50% enriched)	C	≥6	≥2<6	≥0.4<2	<0.4	≥20	≥6<20	≥2<6	<2
LOW-GRADE MATERIALS UF4 or UF6 (≥ 20% < 50% enriched); Solutions (1 to 25 g/L); process residues requiring extensive reprocessing; Pu-238 (except waste)	D	N/A	≥16	≥3<16	<3	N/A	≥50	≥8<50	<8
ALL OTHER MATERIALS Highly irradiated forms, solutions (<1g/L), compounds; uranium containing <20% U-235 or <10% U-233(any form, any quantity)	E	N/A	N/A	N/A	Reportable Quantities	N/A	N/A	N/A	Reportable Quantities

Source: adapted from (US DOE, 2023).

The other requirements for material control in in Attachment 2, Chapter I from (US DOE, 2023) must be applied in accordance with SNM categories determined in the gradation process. In practical terms, the closer the nuclear material is to nuclear weapons, the more restrictive the control and accounting requirements will be. On the other hand, the lower the safeguard category, the greater the resource savings in the installation design. Based in an initial analysis, a naval NRNF similar to the CME would be put into Category I or II and Attractiveness Level C.

It is observed that the DOE methodology for safeguards categorization does not diverge from the significant quantities adopted by the IAEA. A significant quantity (SQ) is the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device can not be excluded. Significant quantity values currently in use are given in Table 3. Timeliness component of the IAEA inspection goal is defined as the periodic activities that are necessary for the IAEA to be able to draw the conclusion that there has been no abrupt diversion of 1 SQ or more at a facility during a calendar year. (IAEA, 2022).

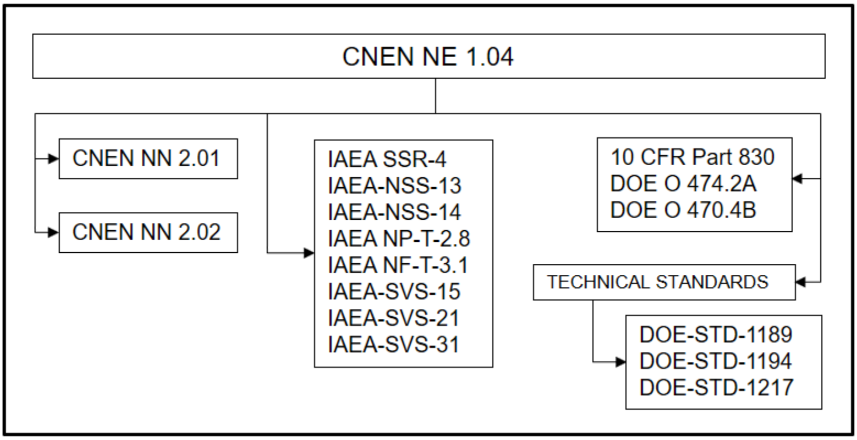
Table 3 – Significant Quantities and detection timeliness goal.

Nuclear Material	Significant Quantities in kg	Timeliness
Plutonium (<80% Pu238)	8 kg total Pu	Irradiated = 3 months Unirradiated = 1 month
Highly Enriched Uranium (≥20% U235)	25 kg U-235	Irradiated = 3 months Unirradiated = 1 month
Low Enriched Uranium (<20% U235) – including natural uranium (NU) and depleted uranium (DU)	75 kg U-235 (or 10 t NU or 20 t DU)	12 months

Source: (IAEA, 2022).

The integrated approach for implementing the graded safeguards concept in the design of naval NRNFs proposed in this paper consists of using laws, directives, standards ang guides from CNEN, DOE and IAEA, focused on the design process of general NRNFs, and requiring little customization for application in Brazilian naval NRNFs. The implementation of the proposed regulatory framework of a Graded MC&A program follows the logical order described further and summarized in Figure 1.

Figure 1 – Regulatory framework proposed for the implementation of a Graded MC&A program for Brazilian naval NRNFs.



Source: Prepared by the author.

- Licensing Driver: CNEN NE 1.04 - This standard governs the licensing steps, associated documentation, and general Safety, Security and Safeguards requirements;

- National Security & Safeguards requirements source:
Security: CNEN NN 2.01;
Safeguards: CNEN NN 2.02;

–International complementary 3S general requirements and recommendations source:
Safety: IAEA SSR-4;
Security: IAEA-NSS-13 and IAEA-NSS-14;
Safeguards: NP-T-2.8, IAEA NF-T-3.1, IAEA-SVS-15, IAEA-SVS-21 and IAEA-SVS-31.

- Graded Safeguards methodology main references:
Safety: 10 CFR Part 830;
Safeguards: DOE O 474.2A;

Security: DOE O 470.4B;
- 3S design requirements source:

DOE-STD-1189, DOE-STD-1194, DOE-STD-1217.

CONCLUSION

The purpose of this article was to present initial thoughts on adopting an alternative safeguards approach, one more suited to a naval and military nonreactor nuclear facility (NRNF). The proposed alternative is based on the US DOE concept of graded safeguards. This gradual approach has the potential for a more affordable project. A regulatory framework was proposed involving regulations from the IAEA, the DOE and the CNEN. In this proposal, the licensing process is governed by CNEN NE 1.04, and the general security and safeguards principles are found in CNEN NN 2.01 and CNEN NN 2.02. The methodology for the graded safeguards program implementation is derived from DOE Order 474.2A. This DOE graded safeguards methodology integrates Safety, Safeguards and Security (3S) and, for this reason, other DOE publications must be used as design, safety and security requirements support (10 Part CFR 830, DOE O 470.4B, DOE-STD-1189, DOE-STD-1194 and DOE-STD-1217). This approach is in line with the IAEA's general principles, requirements, and recommendations.

The use of DOE graded safeguards approach in support of the design and licensing process of NRNFs in Brazil is appropriate since DOE publications are applied to the nuclear safety, security and safeguards of military installations and reflects the relevant experience in the design, construction, and operation of NRNFs that supports the U.S Naval Propulsion Program. Besides that, the DOE regulatory framework applies the concept of a graded approach required by IAEA.

The overall conclusion from this research is that the integrated safeguards approach inherent to DOE regulations presents itself as a viable option to complement CNEN NN 2.02 provisions regarding the implementation of a MC&A program customized for naval NRNFs currently being designed and licensed in Brazil.

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O Conceito de Salvaguardas Graduais: Uma Alternativa para a Abordagem de Salvaguardas para Instalações Navais Nucleares sem Reator

RESUMO

O Programa de Desenvolvimento de Submarinos (PROSUB), sob gestão da Marinha do Brasil, vem desenvolvendo tecnologia de propulsão nuclear naval e, para tanto, instalações nucleares para atividades marítimas. O objetivo deste artigo é apresentar reflexões iniciais sobre uma abordagem integrada para implementação do conceito de salvaguardas graduais no projeto de instalações nucleares sem reator navais (NRNFs) que apoiam o Programa Brasileiro de Propulsão Nuclear. A alternativa proposta baseia-se no conceito do Departamento de Energia dos Estados Unidos (DOE) de salvaguardas graduais. Foi proposto um quadro regulatório envolvendo normas da Agência Internacional de Energia Atômica (AIEA), DOE e Comissão Nacional de Energia Nuclear (CNEN). Esta abordagem gradual tem potencial para um projeto mais acessível e a abordagem integrada de salvaguardas inerente às normas do DOE apresenta-se como uma opção viável para complementar as disposições da norma CNEN NN 2.02 relativas ao projeto e licenciamento de NRNFs no Brasil.

Palavras-chave: Salvaguardas, Instalação Nuclear sem Reator, Licenciamento Nuclear.

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