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Licensing Approach for Nuclear-Powered Submarines Land Support Facilities

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1. Introduction

The nuclear licensing process is a fundamental stage for the design and implementation of a nuclear enterprise. Basically, the applicant shall demonstrate to the regulatory agency that its facility is being designed and will be constructed and operated in such a way as to ensure the safety of its workers, the public and the environment against to the risks involving exposure to radiation. In Brazil, the licensing process of Central Nuclear Almirante Álvaro Alberto (CNAAA) nuclear power plants, in Angra dos Reis, was established mainly based on the U.S. Nuclear Regulatory Commission (U.S.NRC) guidelines. However, for each purpose specific requirements are established which promote a standardisation appropriate to the type of installation in question. Thus, not every nuclear installation can be adequately framed in the standards and requirements established for the licensing of a nuclear power plant, especially when considering nuclear facilities for strategic and defense purposes.

For instance, the Specialized Maintenance Complex (CME) project that is being developed by the Brazilian Navy and aims to offer all the structure and systems for support on land to the first Brazilian submarine with nuclear propulsion. Therefore, when considering the interfaces between maritime/naval systems and operations, the purpose and specificity of installations such as CME extrapolate the commonly established nuclear normative framework. Due to the innovation of this type of installation in Brazil, there is no specific regulation for its licensing, constituting a unique situation for both the Brazilian Navy (applicant) and the National Nuclear Energy Commission - CNEN (Brazilian Nuclear Licensing Agency). Even when researching standards and other guides in ostensible sources of nations that holds nuclear reactor technology for naval propulsion (and land support facilities), no normative guidance dealing specifically with the safety analysis and licensing of this type of installation has been identified.

Thus, this paper proposes a first approach and analysis of the standards used by the U.S. Department of Defense (U.S.DOE) comparing them to the standards of the U.S. Nuclear Regulatory Commission (U.S.NRC) aiming to compose a specific normative proposition to carry out the safety analysis and licensing of a nuclear-powered submarines land support facility.

2. Methodology

The CNEN is the regulatory agency that, since its creation, has the licensing of nuclear installations in Brazil. However, Provisional Measure nº 1.049 of May 14, 2021, defines as private competence of the Brazilian Navy Command to regulate, license, inspect and control the nuclear-powered vessels, having been created the Naval Nuclear Safety and Quality Agency (AgNSNQ) with such an assignment. Nevertheless, it is not common

sense that the interpretation of this Provisional Measure also assigns to the Brazilian Navy Command the competence to license the nuclear-powered submarines land support facility. On the other hand, CNEN NE 1.04 [1] standard that regulating the process of licensing nuclear installations by CNEN, defines in its section 1.2.1.1 that: "*activities related to nuclear reactors used as source of energy in means of transport, both for propulsion and for other purposes, are excluded*".

Summarizing, these initial circumstances are intended not only to illustrate the absence of specific framework regulation for the licensing of a nuclear-powered submarines land support facility, but also a possible uncertainty of the regulatory agency responsible for such licensing, when considering its assignments and competences. However, in terms of criteria and requirements to be met, the safety fundamentals and philosophy that guide the establishment of a normative basis should converge to a common understanding, independent of the regulatory agency, representing a commitment to protect public health and safety and the environment against the harmful effects of radiation.

Thus, even if CNEN NE 1.04 [1] is not used as a definitive reference, there are general concepts and propositions associated with the nuclear licensing process that can initially contribute to the establishment of a normative basis aiming at the licensing of a nuclear-powered submarines land support facility. For example, one can make use of the steps foreseen in the general process of licensing a nuclear installation according to its section 4.1.1: Site Approval, Construction Permit, Nuclear Material Use Authorization, Initial Operation Authorization and Permanent Operation Authorization. The issuance of these permits and authorizations is subject to the submission and review/approval of Safety Analysis Reports (PSAR or FSAR, depending on the step in question). Thus, in its item 6.4, CNEN NE 1.04 standard [1] defines the minimum information that must be included in the PSAR, but still without establishing a standard format, acceptance criteria or other guidelines for its elaboration, leading to the application of the provisions in its item 6.5.2: "*In the absence of adequate Brazilian standardization, Codes, Guides and Recommendations of the International Atomic Energy Agency should preferably be used and, in their absence, international standards or standards from technically developed countries, provided that these standards and regulations are accepted by CNEN"*.

Thus, when assessing the IAEA's guides and recommendations, they present general and comprehensive fundamentals and concepts, possibly applicable to a wide variety of installations, in view of its most fundamental purpose regarding the protection of public and the environment against the risks involving exposure to radiation.

Nonetheless, despite being useful and having significant importance in the establishment of nuclear normative bases, they do not have the applicability and the proposal of, for example, to define codes and standards that will establish criteria and normative requirements to be used in the design, licensing and construction of nuclear installations. Consequently, considering the history of nuclear licensing in Brazil, using US standards and codes, it was decided to evaluate the relevance and adequacy of the regulations of the U.S.NRC and the U.S.DOE to carry out the safety analysis and licensing of a nuclear-powered submarines land support facility.

Initially, an analysis of the characteristics and specificities of the nuclear-powered submarines land support facility was performed, grouping their operations into conventional (commonly found in nuclear facilities) and non-conventional (specific to this type of installation and not commonly found in nuclear installations).

Subsequently, the structures, systems, and components (SSC) necessary to perform these operations were evaluated, and an evaluation was made between the possibilities of framing this type of installation in the regulations of the U.S.DOE and the U.S.NRC.

According to [2], [3] and [4], the conventional SSC and operations of these facilities are:

- Spent fuel pool;
- New fuel storage area;
- Nuclear waste processing system;
- Initial nuclear waste storage area; and
- Radiological protection monitoring systems.

The non-conventional aspects of these facilities and the submarines supported by it are [5], [6] and [7]:

- Reduced source term - of the submarine's reactor, if compared to a commercial nuclear power plant;
- Low permanence rate - the submarine (nuclear reactor) will be present only in fraction of the time at the installation, not permanently;
- Operation at low power - in general the submarine reactor operates at 15% of total power;

- Reactor shutdown at quay;
- Intrinsic safety - after the reactor shutdown, the Thermal Rollover[1] is achieved in a few weeks;
- Reaction time - residual heat levels are low, allowing high reaction times;
- Additional systems - submarine and land support systems can operate in coordination;
- Interface naval structures - piers, pontoons and fenders, drydock, drydock gate, keel blocks, etc;
- Nuclear Refueling - needs additional containment structures;
- Mobility/buoyancy - additional margins against accidents, and for emergency actions and mitigation; and
- Extended levels of defense in depth – land support structures may serve as additional barriers against radiological releases.

Due to the nature of its application, the U.S.NRC normative basis (commercial nuclear power plants) does not allow an adequate and proportional consideration of the characteristics mentioned above. Hence, its exclusive use may not be sufficient and/or not take into account in a balanced way the intrinsic characteristics of these types of installations, implying excessively conservative requirements in some cases, and may make the project/licensing impossible. In other cases, these standards may not be comprehensive enough to establish requirements for maritime installations, for example. A non-prescriptive normative would be beneficial, as it would allow for an adequate assessment and consideration of these characteristics, and would allow the application of a "graded approach", by assigning criteria and dimensioning proportionate to the risks offered by these facilities. The safety analysis required for the licensing of these facilities should consider both conservative (deterministic) aspects, such as the concept of defense in depth and the single failure criterion, as well as concepts of "best estimate" in a more realistic (probabilistic) approach [8] e [9].
Thus, the use of the normative set of the U.S.DOE is more appropriate, with a graded approach found in 10 CFR 830[2] [10], which should consider:

- The relative importance to safety, safeguards, and security;
- The magnitude of any hazard involved;
- The life cycle stage of a facility;
- The programmatic mission of a facility;
- The particular characteristics of a facility;
- The relative importance of radiological and non-radiological hazards; and
- Any other relevant factor.

According to DOE O 420.1C – *Facility Safety* [11], the U.S.DOE treat with the safety of nuclear facilities (military use and defense), including the *National Nuclear Security Administration* (NNSA) and the *Naval Nuclear Propulsion Program* (NNPP), in addition to regulating the "*DOE Defense Nuclear Facilities*" according to DOE O 140.1A – *Interface with the Defense Nuclear Facilities Safety Board* [12]. In fact, these agencies (NNSA and NNPP) have purposes that are more compatible with the design and licensing of a nuclear-powered submarines land support facility than the U.S.NRC. The U.S.DOE normative set has consistency and allows the association and the use of standards of *Department of Defense* (U.S.DOD), subordinate to *Naval Facilities Engineering Systems Command* – NAVFAC / *Engineering Criteria and Programs Office* – CIENG, with direct application in the type of installation under study.

3. Results and Discussion

According to the characteristics and operations carried out in a nuclear-powered submarines land support facility, the use of the U.S.DOE regulations would make it possible to classify it as a nonreactor nuclear facility, as defined in 10 CFR 830 [10]:

> *"**Nonreactor nuclear facility** means 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*

[1] Condition from which the decay heat and dissipated heat by the systems equalize and the nuclear plant tends to cool.

[2] 10 CFR 830 regulates the safety related activities of the U.S.DOE nuclear facilities, except for facilities under the Director of Naval Nuclear Propulsion, pursuant to "Executive Order 12344, Public Law 106-65".

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."

This normative approach (*Nonreactor nuclear facility*) presupposes the use of Standard DOE-STD-3009-2014 – *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [13] as a standard format for the preparation of its Safety Analysis Report - in this case entitled *Documented Safety Analysis*, and the DOE-STD-1104-2016 – *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents* [14] as a reference for its review and approval by the nuclear regulatory agency.

4. Conclusions

This paper suggests the U.S.DOE normative set (and other related documents, including those of NNSA, NNPP and U.S.DOD) as the most appropriate to substantiate the licensing of a nuclear-powered submarines land support facility, equivalent to CME to be built by the Brazilian Navy.

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