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Study on the Licensing Framework for Land Facilities Supporting Nuclear-powered Submarines in the United Kingdom

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Abstract: This study examines nuclear regulation in the United Kingdom, focusing on licensing processes for land facilities supporting nuclear-powered submarines. It highlights the importance of these submarines for defense and maritime security, along with the need for specialized infrastructure to operate them safely and effectively. The study analyzes the UK's procedures and regulations for nuclear licensing, with emphasis on regulatory bodies such as the Office for Nuclear Regulation (ONR) and the Defence Nuclear Safety Regulator (DNSR). Results discuss the classification of nuclear facilities in the UK, including those dedicated to submarines and nuclear defense, as well as the applicable standards and guidelines for licensing these facilities. It is concluded that nuclear regulation in the UK is robust and transparent, providing a solid foundation for licensing facilities supporting nuclear-powered submarines. The adoption of these standards as a reference in Brazil could significantly contribute to establishing a solid and secure regulatory framework for such facilities.

Keywords: United Kingdom nuclear regulation, nuclear powered submarines, nuclear support facilities, Defence Nuclear Safety Regulator.

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Estudo sobre a Estrutura de Licenciamento para Instalações Terrestres que Suportam Submarinos com Propulsão Nuclear no Reino Unido

Resumo: Este trabalho aborda a regulamentação nuclear no Reino Unido, focando nos processos de licenciamento para instalações terrestres de apoio a submarinos com propulsão nuclear. Destaca a importância desses submarinos para a defesa e segurança marítima, além da necessidade de infraestrutura especializada para operá-los de forma segura e eficaz. O estudo analisa os procedimentos e regulamentos do Reino Unido para licenciamento nuclear, com ênfase nos organismos reguladores, como o Office for Nuclear Regulation (ONR) e o Defence Nuclear Safety Regulator (DNSR). Os resultados discutem a classificação das instalações nucleares no Reino Unido, incluindo as dedicadas a submarinos e defesa nuclear, além das normas e diretrizes aplicáveis ao licenciamento dessas instalações. Conclui-se que a regulamentação nuclear no Reino Unido é robusta e transparente, fornecendo uma base sólida para o licenciamento de instalações de apoio a submarinos nucleares. A adoção dessas normas como referência no Brasil pode contribuir significativamente para o estabelecimento de um quadro regulatório sólido e seguro para tais instalações.

Palavras-chave: Regulação nuclear no Reino Unido, submarinos nucleares, instalações de apoio nuclear, Regulador de Segurança Nuclear de Defesa.

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1. INTRODUCTION

The USS *Nautilus* was the first nuclear-powered submarine, demonstrating that the use of an nuclear reactor for propulsion offers numerous advantages over conventionally used energy sources for this purpose (Diesel generators and batteries). In addition to having significantly superior range and autonomy compared to conventional submarines, one of the main advantages of nuclear propulsion in submarines is that it eliminates the need for the vessel to surface in order to use Diesel generators to recharge the batteries. Thus, they can remain submerged/hidden for indefinite periods, limited only by conditions related to the crew, such as the available food supply.

In addition to mastering nuclear technology, the need to ensure the safe operation of a nuclear reactor, whether embarked or not, encompasses the technological paradigm and, to a large extent, the difficulty in developing nuclear technologies. Consequently, to ensure the safety of individuals and the environment, specific regulations and standards were established for nuclear projects, setting design requirements and criteria, as well as parameters related to radiological protection. As a result, even today, approximately seven decades after the launch of the first nuclear-powered submarine, only six nations possess this type of technology (USA, Russia, United Kingdom, France, China, and India), reflecting the high degree of exclusivity enjoyed by these nations due to their mastery of this technology. Consequently, given the high degree of complexity in its design and construction, acquiring nuclear propulsion technology is notably a technological milestone for any nation.

However, an underexplored aspect concerns the design of naval facilities developed to provide land support for nuclear-powered submarines. These facilities combine maritime, military, and nuclear characteristics, being responsible, for example, for storing new and irradiated fuels, treating and storing waste, and performing nuclear reactor refueling for these

submarines. As a result, the level of complexity and secrecy involved in the design of these onshore support facilities is comparable to that associated with nuclear-powered submarines.

Due to their nuclear aspect, these land support facilities for nuclear-powered submarines are subject to a licensing process, in which a safety analysis of the installation must be conducted to demonstrate, through compliance with normative and regulatory criteria, that the facility is capable of operating safely, without posing undue risk to workers, the general public, and the environment. This safety analysis is conducted based on a series of normative and regulatory criteria established by competent authorities. These criteria cover a wide range of areas, including safety engineering, radiation protection, contamination control, radioactive waste management, and emergency measures.

These aspects present regulatory challenges and highlight the lack of well-established boundaries between the licensing of these facilities and the licensing of the nuclear-powered submarine itself, especially when addressing interface operations, where onshore and submarine systems operate jointly and in a coordinated manner.

This scenario is encontered in the project of the Specialized Maintenance Complex – (CME). The CME is the Brazilian Navy's enterprise to be built in the Southern Area of the Shipyard and Naval Base (EBN), located on Madeira Island/Itaguaí, in the Rio de Janeiro state, aimed at providing all logistical support and onshore support necessary for Brazil's first Conventionally Armed Submarine with Nuclear Propulsion (SCPN).

Given the unprecedented nature of this type of facility within the Brazilian context, the lack of overt information on reference installations, and the absence of a regulatory model to be followed for its safety analysis and licensing, the licensing of the CME constitutes a unique situation for both the Brazilian Navy (applicant), and the nuclear regulatory authority (CNEN) responsible for processing the CME licensing.

Thus, the safety analysis and licensing of such an enterprise, pioneering in Brazil, is the motivation for the development of this proposal, which aims to provide a comprehensive

bibliographic review of the regulations and procedures adopted in the United Kingdom (UK) for the nuclear licensing of land support facilities for nuclear-powered submarines, providing valuable insights which may be adopted as a model in the CME project.

2. MATERIALS AND METHODS

The proposed study was conducted through searches on open-access sources on the internet, primarily on the website of the Office for Nuclear Regulation (ONR) and the Defence Nuclear Safety Regulator (DNSR) under the Ministry of Defence (MOD).

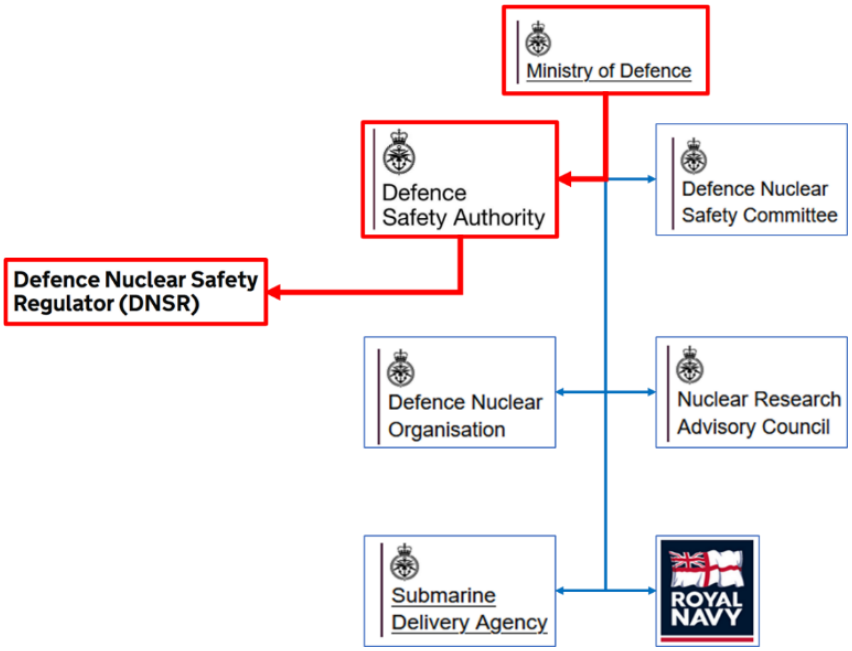
2.1. Office for Nuclear Regulation x Defence Nuclear Safety Regulator

The Defence Nuclear Safety Regulator (DNSR) is the regulatory body within the hierarchical structure of the Ministry of Defence (MOD) responsible for regulating the applications of nuclear energy for defense/military purposes. The DNSR's subordination to the MOD is through the Defence Safety Authority (DSA), which serves as the Defence authority acting as an independent regulator for safety (including health and environmental protection) in terms of aviation, nuclear, maritime, land, ordnance, and explosives.

As shown in Figure 1, besides the Royal Navy, which is responsible for operating the submarines by providing personnel and in-service support, there are several bodies under the United Kingdom's Ministry of Defence related to the nuclear sector and the use of submarines. The Defence Nuclear Safety Committee provides independent advice on defense activities concerning nuclear safety issues related to defense nuclear programs (and physical protection and environmental issues where such matters have the potential to impact nuclear safety). The Defence Nuclear Organisation provides consultancy on nuclear policy, planning, and international cooperation on nuclear issues. It oversees all defense nuclear business (excluding

operations). The Nuclear Research Advisory Council offers independent advice on the capability to design, certify, manufacture, and maintain a stockpile of nuclear weapons, taking into account the context of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The Submarine Delivery Agency manages the acquisition, support, and decommissioning of nuclear submarines, encompassing everything from delivering the necessary nuclear infrastructure to support the submarine fleet to maintenance operations and new constructions.

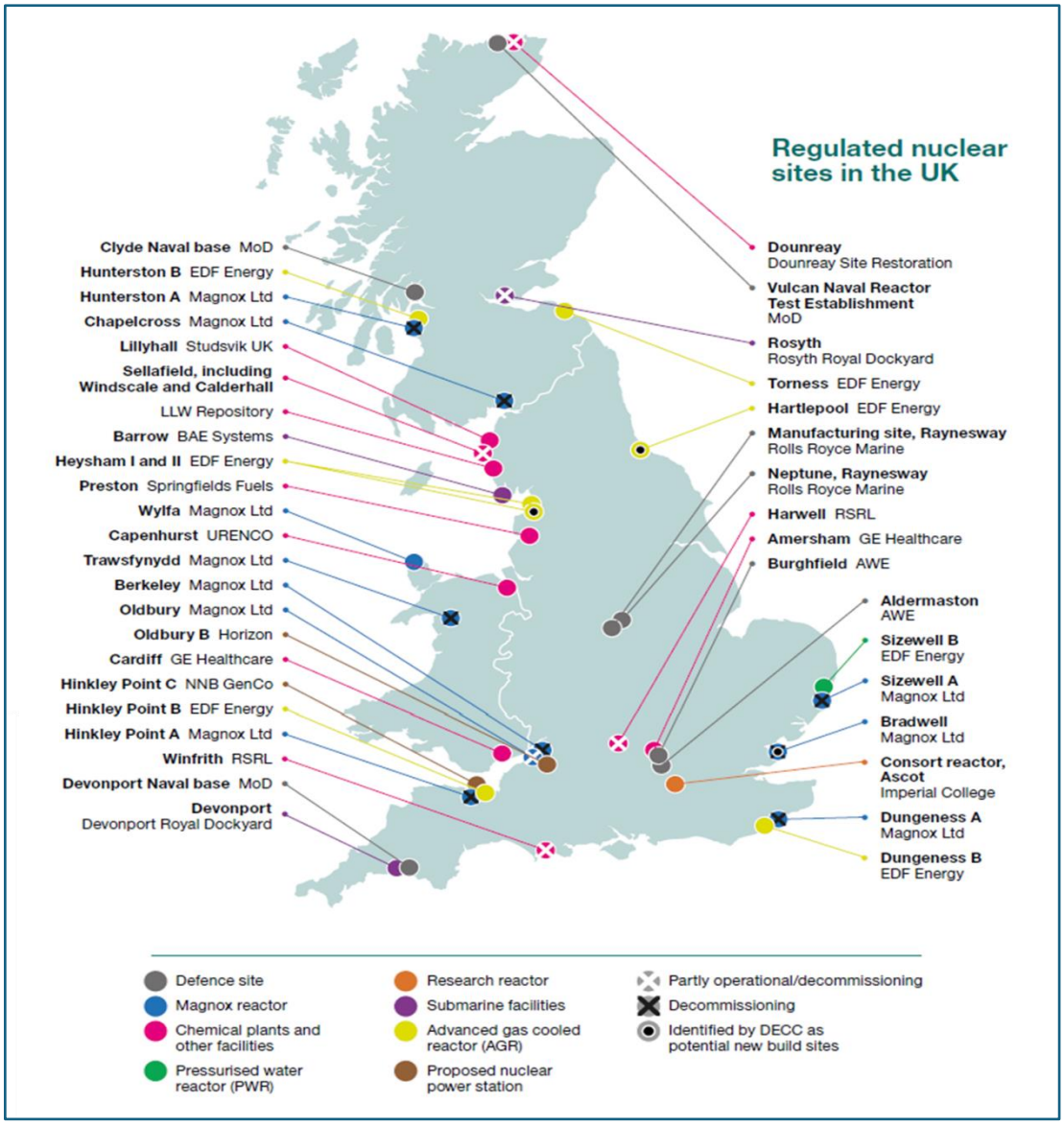
Figure 1: Subordination of DNSR to MOD through DSA



Source: Author.

The Office for Nuclear Regulation (ONR) is the United Kingdom's independent nuclear regulator for nuclear safety, security, and safeguards. The ONR independently regulates safety and security at 37 licensed nuclear sites across the UK (Figure 2) [1]. These sites include operational (commercial) reactors, fuel cycle facilities, waste management and decommissioning sites, as well as defense nuclear facilities (within its areas of competence).

Figure 2: Nuclear sites in the United Kingdom



Source: ONR – A Guide to Nuclear Regulation in UK [1].

2.2. Defence site x Submarine site

As shown in Figure 2, nuclear sites in the United Kingdom are classified into various categories, including "Defence site" and "Submarine facilities" that are pertinent to the objectives of this study.

A "Defence site" is any facility or area utilized by the MOD for military and defence activities. This can encompass a wide range of locations with diverse functions. Therefore,

in Figure 2, the "Defence sites" marked are specifically those related to the use of nuclear materials/activities.

"Submarine facilities" are a specific type of "Defence site" focused on submarines, with installations that support their operation, maintenance, construction, repair, and decommissioning. These facilities are designed with structures directly related to submarines, such as dry docks, shipyards, nuclear fuel storage, etc. In the nuclear domain, "Submarine facilities" are subject to nuclear and environmental safety regulations enforced by the ONR and the DNSR. The "Submarine facilities" are [1]:

- Devonport Royal Dockyard – Submarine maintenance and refueling;
- Barrow Dock Hall – Submarine construction and commissioning;
- Rosyth Dockyard – Submarine decommissioning.

2.3. Licensed site x Non-licensed site

In the nuclear domain, "Defence sites" are regulated by the DNSR, and depending on the specific type of nuclear activities conducted, they may also be subject to regulation by the ONR. Thus, "Defence sites" are categorized into Licensed and Non-Licensed sites. Licensed sites have ONR authorization for specific nuclear activities, while Non-Licensed sites conduct nuclear activities that either do not require specific ONR licensing or are exempted under the Nuclear Installations Act 1965 (NIA 1965)1. There are seven "Defence sites" that are licensed [2]:

- Aldermaston Weapons Manufacturing Site;
- Burghfield Weapons Assembly Site;
- Devonport Royal Dockyard;
- Barrow Dock Hall;

[1] As established in Section "9 – Duty of Crown in respect of certain sites", of the NIA 1965.

- Rolls Royce Nuclear Fuel Production;
- Rolls Royce Neptune Test Reactor;
- Rosyth Dockyard.

It is important to emphasize that even at sites without a specific ONR license – Non-Licensed[2] (as they are under Crown control – MOD), nuclear and radiological safety is jointly regulated by the DNSR and ONR, which enforces conventional safety regulations within these sites. ONR regulates these sites through the Health and Safety at Work etc Act 1974 (HSWA), the Ionising Radiations Regulations 1999 (IRR99), and the Radiation Emergency Preparedness and Public Information Regulations 2019 (REPPIR) [2].

The naval sites that are non licensed (exempt from certain aspects of ONR regulation under the Nuclear Installations Act 1965 – NIA 1965) are:

- HM Naval Base Devonport;
- DRDL Devonport site (adjacent dry docks to HM Naval Base Devonport);
- HM Naval Base Clyde (including Coulport e Faslane);
- Vulcan Naval Reactor Test Establishment;
- Operational submarine piers at nine locations in England and Scotland.

Thus, the ONR's Defence Programme regulates nuclear and conventional safety at various nuclear sites (both licensed and unlicensed), which operate with the aim of maintaining the United Kingdom's nuclear defense capability, under the responsibility of the MOD.

An example is Devonport Naval Base and Dockyard, which is a center for the operation and maintenance of submarines in the United Kingdom, carrying out major

[2] The Ministry of Defence (MOD) is a Crown body, and the sites it operates have certain legal exemptions. Furthermore, the Nuclear Installations Act 1965 excludes any nuclear reactor integrated into a means of transportation, such as a submarine, thereby exempting, for example, parts of Devonport Royal Dockyard Limited from ONR licensing requirements [2].

overhauls and refueling of nuclear-powered submarines. The use of the entire site can be broadly described through two main operational organizations:

- HM Naval Base Devonport (Ministry of Defence - MOD);
- Devonport Royal Dockyard (Babcock International Group).

Thus, HM Naval Base Devonport is authorized to conduct its nuclear activities through the Ministry of Defence's internal regulator – DNSR. However, Devonport Royal Dockyard is licensed by the ONR (Figure 3) and is authorized to operate through the DNSR for defense purposes.

Figure 3: Boundary of the licensed area at Devonport Naval Base and Dockyard marked in red color.

Source: ONR. Regulation of Great Britain's Defence Nuclear Programme [2].

2.4. Naval Nuclear Propulsion Programme: ONR x DNSR

Within the regulatory bodies, with ONR and DNSR overseeing nuclear energy regulation in the UK, several documents have been established to define the coordinated action (and boundaries) between MOD (through DNSR) and ONR regarding the regulation of the Defence Nuclear Enterprise – DNE[3], which includes the Naval Nuclear Propulsion Programme – NNPP:

- "General Agreement Between Ministry of Defence and Office for Nuclear Regulation" (2015) [3] – Agreement made with ONR in 2015 which sets out how ONR's regulatory activities are modified to take account of legal and other constraints related to Defence Nuclear Programme (DNP) international obligations connected to MOD related activity and the nature of the work of the MOD's DNP in relation to Government's defence priorities;
- "Letter of Understanding between the ONR and the DNSR setting out their intentions for coherent, complete and seamless regulation of the Defence Nuclear Programme" (2015) [4] – provides a framework for complete, effective and coordinated regulation of licensed and non-licensed defence-related nuclear sites.
- "Memorandum of Understanding Between the Ministry of Defence and the Office for Nuclear Regulation" (2024) [5] – establishes the strategic intent of the MOD and the ONR to work together to secure and maintain safe and assured delivery of the UK's defence nuclear capability to deter the threat and protect our nation.

These documents describe the legal framework and the relationship between ONR and DNSR in fulfilling their respective roles and responsibilities in regulating the DNP, providing a framework for comprehensive, effective, and coordinated regulation of licensed and unlicensed defense nuclear sites. It should be noted that even at unlicensed sites

[3] The Defence Nuclear Enterprise (DNE) encompasses the Naval Nuclear Propulsion Programme (NNPP) and the Nuclear Weapon Programme (NWP).

(operated by the MOD and therefore not subject to the UK licensing regime defined by ONR), there are still general obligations imposed by the Health & Safety at Work Act 1974 (HASWA) and regulations made under it, or by other relevant health and safety regulations.

2.5. Authorisation Condition

Several sites licensed under the Nuclear Defence Programme (NDP) are not owned by MOD, but conduct activities exclusively for MOD purposes. Some NDP sites are not licensed; however, some or parts of these sites are "authorized" for Defence activities by the DNSR [2]. For instance, the Naval Reactor Plant (NRP) is also "authorized". Authorized sites are subject to Authorization Conditions, which closely resemble those required by ONR for licensed sites and are regulated by the DNSR, as shown in the Figure 4.

Figure 4: a) Authorisation Conditions (DNSR); b) Licence Condition (ONR)

Annex A: Guidance on the Application of the Authorisation Conditions

AC1 Guidance Note	Interpretation
AC2 Guidance Note	Marking of the Site Boundary
AC3 Guidance Note	Restrictions on Dealing with the Site
AC4 Guidance Note	Restrictions on Nuclear Matter on the Site
AC5 Guidance Note	Consignment of Nuclear Matter
AC6 Guidance Note	Documents, Records, Authorities and Certificates
AC7 Guidance Note	Incidents
AC8 Guidance Note	Warning Notices
AC9 Guidance Note	Instructions to Persons on the Site
AC10 Guidance Note	Training and Information of Training
AC11 Guidance Note	Emergency Arrangements
AC12 Guidance Note	Duly Authorised and Other Suitably Qualified and Experienced Persons
AC13 Guidance Note	Nuclear Safety Committee
AC14 Guidance Note	Safety Documentation
AC15 Guidance Note	Periodic Review
AC16 Guidance Note	Site Plans, Designs and Specifications
AC17 Guidance Note	Management Systems
AC18 Guidance Note	Radiological Protection
AC19 Guidance Note	Construction or Installation of New Plant
AC20 Guidance Note	Modification to Design of Plant Under Construction
AC21 Guidance Note	Commissioning
AC22 Guidance Note	Modification or Experiment on Existing Plant, Nuclear Weapon, Naval Reactor Plant, Component or Relevant Support Equipment
AC23 Guidance Note	Operating Rules
AC24 Guidance Note	Operating Instructions
AC25 Guidance Note	Operational Records
AC26 Guidance Note	Control and Supervision of Operations
AC27 Guidance Note	Safety Mechanisms, Devices and Circuits
AC28 Guidance Note	Examination, Inspection, Maintenance and Testing
AC29 Guidance Note	Duty to Carry Out Tests, Inspections and Examinations
AC30 Guidance Note	Periodic Shutdown
AC31 Guidance Note	Shutdown of Specified Operations
AC32 Guidance Note	Accumulation of Radioactive Waste
AC33 Guidance Note	Disposal of Radioactive Waste
AC34 Guidance Note	Leakage and Escape of Radioactive Material and Radioactive Waste
AC35 Guidance Note	Decommissioning
AC36 Guidance Note	Organisational Capability

a)

Licence conditions

1	Interpretation
2	Marking of the site boundary
3	Control of property transactions
4	Restrictions on nuclear matter on the site
5	Consignment of nuclear matter
6	Documents, records, authorities and certificates
7	Incidents on the site
8	Warning notices
9	Instructions to persons on the site
10	Training
11	Emergency arrangements
12	Duly authorised and other suitably qualified and experienced persons
13	Nuclear safety committee
14	Safety documentation
15	Periodic review
16	Site plans, designs and specifications
17	Management systems
18	Radiological protection
19	Construction or installation of new plant
20	Modification to design of plant under construction
21	Commissioning
22	Modification or experiment on existing plant
23	Operating rules
24	Operating instructions
25	Operational records
26	Control and supervision of operations
27	Safety mechanisms, devices and circuits
28	Examination, inspection, maintenance and testing
29	Duty to carry out tests, inspections and examinations
30	Periodic shutdown
31	Shutdown of specified operations
32	Accumulation of radioactive waste
33	Disposal of radioactive waste
34	Leakage and escape of radioactive material and radioactive waste
35	Decommissioning
36	Organisational capability

b)

Source: DSA03-DNSR [6] and Licence condition handbook [7].

These Authorisation Condition – AC, are detailed in Annex A - "Guidance on the Application of the Authorisation Condition" of document DSA03-DNSR: "Defence Nuclear Safety Regulations of the Defence Nuclear Enterprise - Guidance" [6], and the "Licence conditions" outlined in the "Licence condition handbook" document [7] (36 conditions in total across both references). Additionally, DSA03-DNSR [6] introduces Further Authorisation Condition – FAC as shown in Figure 5.

Figure 5: Further Authorisation Condition – FAC (DNSR)

FAC1 Guidance Note	Duty of Co-operation
FAC2 Guidance Note	Operational Berths
FAC3 Guidance Note	Radioactive Discharges
FAC4 Guidance Note	Unused
FAC5 Guidance Note	Design of a Nuclear Weapon or Naval Reactor Plant
FAC6 Guidance Note	Nuclear Weapon Periodic Withdrawal
TC1 Guidance Note	Transport, Packages and Containers

Source: DSA03-DNSR [6].

3. RESULTS AND DISCUSSIONS

The ostensive regulation found in the UK's nuclear licensing framework by the ONR, clearly considers its applicability to defense nuclear installations (under the terms of the Nuclear Installations Act 1965 – NIA 1965), as per the following documents:

- Regulation of Great Britain's Defence Nuclear Programme – Technical Inspection Guide (TIG) NS-INSP-GD-056 [2] – According to the document itself, it outlines the responsibilities of the ONR and aims to provide guidance to the inspectors directly involved in regulating nuclear, radiological, and conventional safety at MOD's defense-related nuclear sites, for both the Nuclear Weapons Program (NWP) and Naval Nuclear Propulsion Program (NNPP), encompassing both licensed and non licensed sites.
- Licensing nuclear installations (ONR) [8] - In its introduction, it states: "*This document describes, how we administer the process to enable nuclear installations in GB to gain*

a nuclear site licence as required by the Nuclear Installations Act 1965 (NIA 1965). Such installations include nuclear power stations, nuclear fuel manufacturing facilities, nuclear defence facilities for weapons manufacturing and fuelling/ maintenance of nuclear submarines…".

- Safety Assessment Principles for nuclear facilities (ONR) [9] - In its introduction, within the regulatory context, sites for the construction, maintenance, and refueling of nuclear submarines are defined as licensed sites for nuclear activities.

Regarding the ostensive regulation by the DNSR, the following standards were found:

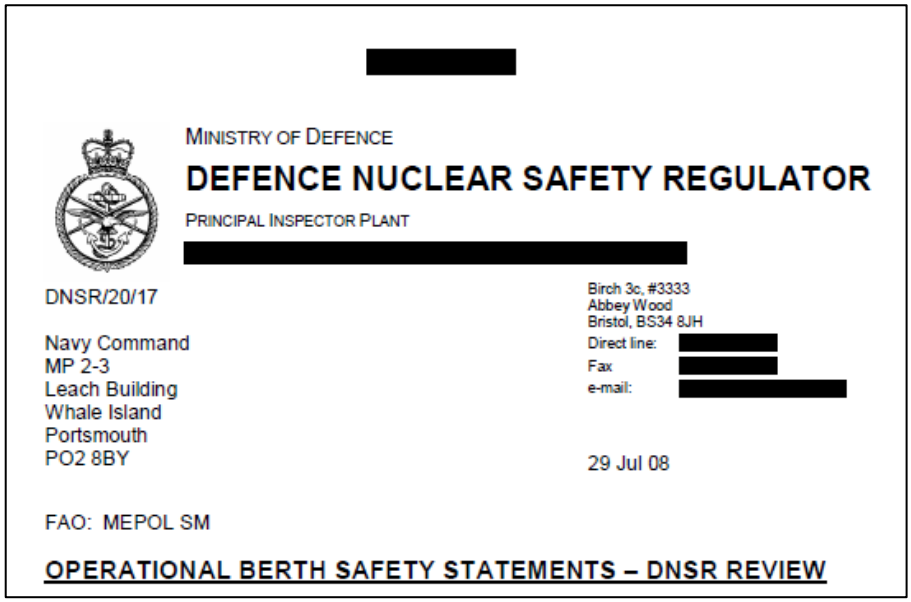
- DSA02-DNSR: Defence Nuclear Safety Regulations of the Defence Nuclear Enterprise [10] – Defines the nuclear regulatory regime of the (DNE);
- DSA03-DNSR: Defence Nuclear Safety Regulations of the Defence Nuclear Enterprise - Guidance [6] – For the purpose of this study, in addition to other considerations regarding the NNPP, it includes Annex I: Interpretation of Safety Assessment Principles for Naval Nuclear Propulsion Application.

The DSA02 and DSA03 are issued by the DNSR and constitute the basis of the MOD's regulatory framework for the Defence Nuclear Sector, encompassing the Naval Nuclear Propulsion Program (NNPP) and the Nuclear Weapons Program (NWP). However, specifically concerning policy and guidance for the management of nuclear safety, radiological safety, and environmental protection in NNPP activities, the DSA02 and DSA03 have superseded the following documents since 2021:

- JSP 518 – Regulation of the Naval Nuclear Propulsion Programme, Part 1: Directive [11];
- JSP 518 – Regulation of the Naval Nuclear Propulsion Programme, Part 2: Guidance [12].

Like the defense nuclear programs of other nations, it is presumed that the United Kingdom's defense nuclear programs (NNPP and NWP) have their own standards and additional guidelines, which are not overt, to provide further direction and regulation of their applications. For example, reference document [13] discusses assessments conducted by DNSR regarding the operational safety of berths, which, despite their confidential nature (Figure 4), were disclosed in response to a request under "The Freedom of Information Act" (Law approved on November 30, 2000) with some information hidden.

Figure 4: "Operational Berth Safety Statements – DNSR Review"



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OPERATIONAL BERTH SAFETY STATEMENTS – DNSR REVIEW

Source: Operational Berth Safety Statements – DNSR Review [13].

However, it is noteworthy that the United Kingdom demonstrates greater clarity and transparency in presenting the regulatory framework of its nuclear defense sector (including some standards) and the interrelationship between its regulatory bodies, compared to previously studied countries.

4. CONCLUSIONS

In this study, it was observed that the nuclear regulation of the United Kingdom stands out for presenting clear considerations and applications of its standards, in publicly accessible sources, as well as the relationships between its regulatory bodies in the nuclear field. This is evidenced by establishing specific criteria and guidelines for the safety analysis of land facilities dedicated to the maintenance and refueling of nuclear-powered submarines. Consequently, the adoption of UK standards as a reference for the licensing processes in Brazil may have significant gain concerning the establishing of a robust regulatory framework in the safety analysis of facilities supporting nuclear-powered submarines.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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