Requirements for

Nuclear Power Systems for Marine and Offshore Applications

October 2024

REQUIREMENTS FOR

NUCLEAR POWER SYSTEMS FOR MARINE AND OFFSHORE APPLICATIONS
OCTOBER 2024

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

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Foreword

This ABS *Requirements for Nuclear Power Systems for Marine and Offshore Applications* has been developed to provide requirements for design, construction, and survey for class review and approval of vessels having onboard nuclear power system installations. This document specifies ABS requirements for the mandatory notation **Power Service (Nuclear)** for nuclear power generation for purposes other than self-propulsion. For the purpose of this document, the term "vessel" includes ships, barges, offshore units, and installations.

It is the responsibility of the Nuclear Regulator to license the reactor and applicable nuclear safety structures, systems and components. Therefore, collaboration with other regulators, including those of the intended Port Authority/Port State, Coastal State, Port State Administration of operational site, or Nuclear Regulator as defined in Subsection 1/4, early in the design process is recommended to align the division of responsibilities for each authority regarding the design approval.

These requirements refer to technical requirements found in the *International Convention for the Safety of Life at Sea (SOLAS)* Chapter VIII: Nuclear Ships and Resolution *A.491(XII) Code of Safety for Nuclear Merchant Ships 1981*. It is to be noted that Resolution A.491(XII) is dated, with some content considered obsolete according to advances in nuclear technology applications. Resolution A.491(XII) applies to nuclear-powered vessels implementing pressurized water reactors (PWRs) for propulsion. ABS recognizes that the use of A.491(XII) for the design and construction of nuclear power service vessels is not appropriate. However, since it is the only existing international mechanism available for commercial nuclear technologies applied on floating units, these Requirements refer to certain parts of A.491(XII) that are also applicable to nuclear power service vessels. It is recognized that when Resolution A.491(XII) is updated by the IMO, or other internationally recognized standards are developed by the IMO or the IAEA specific to nuclear power service vessels, these Requirements will also be updated.

It is recognized that terms, systems and definitions used by the nuclear industry may differ from the terms and definitions used and defined in these Requirements. It is recommended to contact ABS for clarification when interpretation is needed.

This document becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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CONTENTS

SECTION 1
Introduction

1 General

The requirements for conditions of classification are contained in the separate, generic ABS Rules for Conditions of Classification (Part 1A) and ABS Rules for Condition of Classification – Offshore Units and Structures (Part 1B).

2 Application

This document applies to barges, ships, site-specific floating offshore installations, fixed offshore installations, and mobile offshore units. Throughout this document, the term 'vessels' is used and should be understood to refer to any of these vessel types. Power service vessels are defined in the ABS *Requirements for Power Service for Marine and Offshore Applications (Power Service Requirements)*.

This document covers new construction or conversion of vessels fitted with nuclear power systems for power service supplied to external or onboard industrial consumers (nuclear power service vessels, as defined in Subsection 2/2). In addition to the requirements provided in the *Power Service Requirements*, the requirements of this document are applicable. The ABS Notation **Power Plant**, as defined in Section 5 of the *Power Service Requirements*, is not applicable to nuclear power service vessels. It is the responsibility of the Nuclear Regulator to license the reactor and applicable nuclear safety structures, systems and components. These Requirements and any use thereof does not replace the review, certification, license, or other approval of Nuclear Power Plant (NPP) technology by a Nuclear Regulator.

This document has been developed for classification requirements specific to design, construction, and survey of vessels fitted with nuclear power systems whose generated power is transferred or distributed to onboard industrial or adjacent facilities. Nuclear power service vessels are intended to operate nuclear power plant systems while temporarily or permanently stationed. This document is not applicable where nuclear power is used for propulsion or auxiliary services on self-propelled vessels.

The following base ABS Rules, as applicable for the unit's base Class notation, apply in full for design, construction, and survey of the unit, except as modified herein:

- The ABS *Requirements for Power Service for Marine and Offshore Applications (Power Service Requirements)*.
- The ABS *Rules for Building and Classing Steel Barges (Barge Rules)* are to be complied with for barges intended for ocean service, as applicable.
- The ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waters (River Rules)* are to be complied with for barges intended for river service, as applicable.
- The ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)* are to be complied with for ships, as applicable.

- The ABS *Rules for Building and Classing Offshore Installations (Offshore Installation Rules)* are to be complied with for fixed offshore installations, as applicable.
- The ABS *Rules for Building and Classing Floating Production Installations (FPI Rules)* are to be complied with for floating offshore installations, as applicable.
- The ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)* are to be complied with for column-stabilized units (CSU), as applicable.

3 Class Notations

3.1 New Construction

Vessels complying with the full requirements of this document are to be classed and distinguished in the *Record* by adding the classification notation **Power Service (Nuclear)**.

The vessel will maintain the base ABS Rule notation such as a ship, barge, floating offshore installation, mobile offshore unit, etc. For example, ✠ **A1 Power Service (Nuclear)** for a self-propelled ship fitted with equipment for power service, ✠ **A1 Barge, Power Service (Nuclear)** for ocean power service barges; ✠ **A1 Barge, River Service, Power Service (Nuclear)** for river power service barges.

3.2 Conversion of Existing Vessels

When an existing vessel is converted to be fitted with nuclear power plant (NPP) systems and it complies with the full Requirements herein, it is to be distinguished in the *Record* by adding the classification notation **Power Service (Nuclear)**. The primary class notation is to reflect the base ABS Rule set notation for the conversion.

For example, if an existing column-stabilized unit is converted into a nuclear power service unit, the base ABS Rule set, the *FPI Rules*, is to be applied for this conversion and it would be assigned with the notation ✠ **Floating Offshore Installation (Column-Stabilized), Power Service (Nuclear)**. If an existing self-propelled ship is converted into a nuclear power service vessel, the base *Marine Vessel Rules* are to be applied for the conversion and it would be assigned with the notation ✠ **A1 Power Service (Nuclear)**.

3.3 Rapid Response Damage Assessment Program (RRDA)

An approved contract is to be implemented with the ABS RRDA program, or with a similar program of another IACS Member Society. The ABS RRDA program provides emergency technical services for owners/operators whose enrolled vessel experiences an incident that may affect the stability or structural strength of the vessel or require the rapid provision of technical analytical services. The ABS RRDA program does not provide assistance for radiation or nuclear safety situations. Arrangements for such services are to be organized with the Flag and Port Administrations along with the Nuclear Regulator, as applicable.

3.4 Stationkeeping and Mooring Arrangements

Where the base ABS Rule set does not mandate stationkeeping or mooring requirements, the ABS *Requirements for Position Mooring Systems* is applicable.

4 Stakeholders

Stakeholders are to be identified in the submittal items according to the development, manufacturing, licensing, and operating plan of the vessel.

Commentary:

While a uniform approach may simplify the arrangement such that stakeholders as identified in 1/4.1 through 1/4.3 are agencies within one nation, a non-uniform approach of stakeholder oversight may be possible where stakeholders are agencies of different nations. It is to be noted that the regulatory oversight regarding a non-uniform approach of the

international use of nuclear energy is not established by international organizations. It is not the intention of ABS to limit or restrict the possible arrangements of regulatory oversight of nuclear power service vessels.

End of Commentary

4.1 Flag Administration

The Flag Administration, or flag state, is the national authority with whom the vessel is registered. Text from IMO instruments use the term *Administration*, understood to have the same meaning as Flag Administration. If the vessel is not registered with a Flag Administration, the term *Flag Administration* is to be understood to refer to the Port State/Coastal State Administration throughout this document. See 1/4.3.

4.2 Nuclear Regulator

The Nuclear Regulator is an independent agency of a national authority that has authority over the approval and licensure of nuclear reactors and related systems. The Nuclear Regulator is to be identified by the technology provider.

The Nuclear Regulator may also be the appropriate authority of the country:

- in which the vessel is constructed (nation of construction);
- where the vessel is serviced or maintained, either in a floating condition or in drydock; or
- where the vessel may be deactivated and decommissioned.

With respect to vessels engaged in services adjacent to the coast over which the State exercises sovereign rights for the purpose of industrial installations or power generation, the Coastal State is the government of that state.

4.3 Port Authorities/Port States, Coastal States, and Port State Administrations

The Port Authority/Port State or Coastal State Administration is the appropriate authority of the country in which the vessel is operating, stationed, or laid up.

Port State Administration may also be the appropriate authority of the country:

- in which the vessel is constructed (nation of construction);
- where the vessel is serviced or maintained, either in a floating condition or in drydock; or
- where the vessel may be deactivated and decommissioned.

With respect to floating platforms engaged in services adjacent to the coast over which the State exercises sovereign rights for the purposes of industrial installations or power generation, the Coastal State is the government of that state.

The Port State Administrations and Coastal States may require additional standards of design, construction, or operation.

5 Certification

ABS design review, survey, testing, and the issuance of reports or certificates constitutes the certification of typical machinery, equipment and systems used on vessels and offshore units; see the base ABS Rule set such as 4-1-1/3 of the *Marine Vessel Rules* or Part 6, Chapter 1 of the *MOU Rules* for requirements for the certification of machinery. The minimum scope of classification is defined in this Requirements document, and the classification boundary is to be stated in the Interface Document (see 2/3.1.1) for each project to clearly demarcate the responsibilities of the Nuclear Regulator and ABS. ABS acceptance of the Interface Document is not a substitute for Nuclear Regulator acceptance of the Interface Document.

6 Format

These requirements refer to technical requirements found in the *International Convention for the Safety of Life at Sea (SOLAS)* Chapter VIII: Nuclear Ships and Resolution *A.491(XII) Code of Safety for Nuclear Merchant Ships 1981*. The text contained in these Requirements that comes from the IMO and IAEA documents is presented in italics.

7 References

Additional requirements from the following ABS Rules, Guides and Requirements are referenced in these Requirements. Users are advised to check online sources periodically to verify the version is the most current.

- ABS *Rules for Conditions of Classification – Ships (Part 1A)*
- ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)*
- ABS *Rules for Conditions of Classification – Alternative Arrangements of Novel Concept and New Technologies (Part 1D)*
- ABS *Requirements for Power Service for Marine and Offshore Applications (Power Service Requirements)*
- ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*
- ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*
- ABS *Rules for Building and Classing Steel Barges (Barge Rules)*
- ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways (River Rules)*
- ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*
- ABS *Rules for Facilities on Offshore Installations (Facilities Rules)*
- ABS *Rules for Building and Classing Floating Production Installation (FPI Rules)*
- ABS *Rules for Building and Classing Offshore Installations (Offshore Installation Rules)*
- ABS *Rules for Survey After Construction (Part 7)*
- ABS *Guide for Building and Classing Accommodation Barges (Accommodation Barge Guide)*
- ABS *Requirements for Autonomous and Remote Control Functions*
- ABS *Guidance Notes on Gas Dispersion Studies of Gas Fueled Vessels*
- ABS *Requirements for use of Lithium-Ion Batteries in the Marine and Offshore Industries*
- ABS *Requirements for Position Mooring Systems*
- ABS *Guide for Nearshore Position Mooring*

The additional requirements of the following codes and standards are referenced in these Requirements:

- International Maritime Organization (IMO)
  - *International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Wastes on Board Ships (INF Code)*
  - *International Maritime Dangerous Goods Code (IMDG Code)*
  - *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)*
  - *International Safety Management Code (ISM Code)*
  - *International Ship and Port Facility Security Code (ISPS Code)*

- American Society of Mechanical Engineers (ASME)
  - Boiler and Pressure Vessel Code
  - Nuclear Quality Assurance (NQA-1) Certification
- International Commission on Radiological Protection (ICRP)
  - ICRP Publication 103 *The 2007 Recommendations of the International Commission on Radiological Protection*
  - ICRP Glossary 2024 http://icrpaedia.org/ICRP_Glossary
- International Atomic Energy Agency (IAEA)
  - GSR Part 5 *Predisposal of Radioactive Waste*
  - SSR-2/1 (Rev. 1) *Safety of Nuclear Power Plants: Design*
  - SSR-6 *Safe Transport of Radioactive Material*
  - SSG-62 *Design of Auxiliary Systems and Supporting Systems for Nuclear Power Plants*
  - Safety Series No. 50-C/SG-Q *Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations: Code and Safety Guides Q1-Q14*
  - *IAEA Nuclear Safety and Security Glossary: Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*, 2022 Interim Edition (IAEA Glossary 2022).
- International Electrotechnical Commission (IEC)
  - IEC 60079-10-1: 2020 Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres

SECTION 2
General

1 Objective

The goals and functional requirements for the topics covered in these Requirements are included in the respective sections.

The goals, functional requirements, and provisions identified in this document are in addition to requirements of the Flag Administration and Nuclear Regulator for nuclear systems, where the prescriptive requirements supporting the goals and functional requirements, and the associated review authorities are to be identified according to the Interface Document defined in 2/3.1. See ABS *Rules for Condition of Classification – Alternative Arrangements of Novel Concepts and New Technologies (Part 1D)* for more information on implementing the Goal-Based Standard approach.

2 Definitions

For the purpose of these Requirements, unless stated otherwise, the terms used possess the meanings defined below. Citations to IAEA and ICRP references are provided in Subsection 1/7; users are advised to refer to the source material for the most up-to-date language. Terms not listed have the same meaning as identified in the base ABS Rule or are provided by other sources as indicated.

- *Auxiliary System: Auxiliary systems and supporting systems can directly or indirectly contribute to the fulfillment of* nuclear *safety functions – for example, ensuring essential* nuclear *services (e.g., electrical, pneumatic or hydraulic power supplies or lubrication) – or can provide a supporting function for a* nuclear *safety system or a* nuclear *safety feature for design extension conditions [IAEA SSG-62].*
- *Containment Structure. Enclosure or boundary consisting of passive and active components designed to contain, within acceptable limits, releases of* radioactive material or as defined by the vendor [A.491(XII)].
- *Controlled Area. A defined area in which specific protection measures and safety provisions are or could be required for controlling* personnel *exposures or preventing the spread of contamination in normal working conditions, and preventing or limiting the extent of potential exposures. A controlled area is often within a supervised area, but need not be [IAEA Glossary 2022].*
- *Decommissioning. Decommissioning […] may be intentional or unintentional, temporary or final. Intentional decommissioning refers to situations where the responsible organization or Administration considers that, for safety or any other reason, the* vessel *should not be kept in service. Unintentional decommissioning occurs when a sea mishap or other cause renders the* vessel *or its* nuclear power plant *unfit for service [A.491(XII)].*
- *Design Basis. The range of conditions and events taken explicitly into account in the design of structures, systems and components and equipment of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits [IAEA Glossary 2022].*

- *Design Basis Accident. A postulated accident leading to accident conditions for which a facility is designed in accordance with established design criteria and conservative methodology, and for which releases of radioactive material are kept within acceptable limits [IAEA Glossary 2022].*
- *Dose. A measure of the energy deposited by radiation in a target [IAEA Glossary 2022].*
- *Dose Limit. The value of absorbed, equivalent, or effective dose that is applied to exposure of individuals in order to prevent the occurrence of radiation-induced tissue reactions or to limit the probability of radiation-related stochastic effects to an acceptable level [ICRP Glossary 2019].*
- *Emergency Shutdown Procedure* (Scram). *A rapid shutdown of a nuclear reactor in an emergency [IAEA Glossary 2022].*
- *Emergency Source of Electrical Power*. A source of electrical power intended to supply the emergency switchboard in the event of a failure of the supply from the main source of electrical power.
- *Essential Marine Services*. For definition of *essential marine services*, see Subsection 2/4.
- *Normal Operating Condition*. A normal operating condition is a condition wherein a unit is on location to perform its functions, and combined environmental and operational loading are within the appropriate design limits established for such operations. See *design basis*.
- *Nuclear Power Plant (NPP).* The main thermal power station comprises a nuclear reactor, coolant and heat transfer circuit(s), and residual heat removal systems. Note that this definition is differentiated from power plant systems, which are defined as industrial equipment outside of the NPP provided onboard for generation and distribution of power to either external or onboard consumers. In these Requirements, '*power*' refers to any form of energy produced and transmitted by an NPP; is generally provided as thermal energy or electrical energy.
- *Nuclear Power Service Vessel*. Nuclear power service vessel may be a power barge, power ship, power offshore unit, power offshore installation, or power mobile offshore unit primarily intended to mount single or multiple nuclear power plants (NPPs) whose generated power is transferred or distributed to adjacent facilities. Refer to Subsection 1/9 of the *Power Service Requirements.*
- *Nuclear Reactor. The central part of the nuclear power plant in which the nuclear core is located and the fission reaction takes place [IAEA Glossary 2022].*
- *Passive Component. A component whose functioning does not depend on an external input such as actuation, mechanical movement or supply of power. Any component that is not a passive component is an active component [IAEA Glossary 2022].*
- *Radioactive Waste. For legal and regulatory purposes, waste that contains, or is contaminated with, radionuclides at activity concentrations greater than clearance levels as established by the regulatory body. In effect, radioactive material in gaseous, liquid or solid form for which no further use is foreseen [IAEA Glossary 2022].*
- *Reactor Compartment. The* onboard space *containing the nuclear* reactor that is *bounded by the hull, the bulkhead deck and fore and aft by athwartship cofferdams or bulkheads [A.491(XII)].*
- *Residual Heat. The sum of the heat originating from decay (radioactive decay and shutdown fission) and the heat stored in reactor related structures and in heat transport media* after shutdown *[A.491(XII)].*
- *Safe state. Plant state, following an anticipated operational occurrence or accident conditions, in which the reactor is subcritical and the fundamental safety functions can be ensured and maintained stable for a* specified amount of *time [IAEA Glossary 2022].*
- *Safety Functions. A specific purpose that must be accomplished for safety for a facility or activity to prevent or to mitigate radiological consequences of normal operation, anticipated operational occurrences and accident conditions. [IAEA Glossary 2022].*
- *Severe Storm Condition*. A severe storm condition is a condition wherein a unit may be subjected to the most severe environmental loadings for which it is designed. Operations are assumed to have been discontinued due to the severity of the environmental loadings.

- *Shielding. Means of reducing radiation exposure below specified levels by interposing a barrier of attenuating material [A.491(XII)].*
- *Single Failure. A failure which results in the loss of capability of a single system or component to perform its intended safety function(s), and any consequential failure(s) which result from it [IAEA Glossary 2022].* The single failure criterion is a criterion (or requirement) applied to a system such that it must be capable of performing its task in the presence of any single failure.
- *Structures, systems and components. A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors. A component is one of the parts that make up a system [IAEA Glossary 2022].*
- *Supervised Area. A defined area not designated as a controlled area but for which occupational exposure conditions are kept under review, even though specific protection measures or safety provisions are not normally needed [IAEA Glossary 2022].*
- *Transitional Source of Emergency Electrical Power.* A battery suitably located for use in an emergency which can operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and so arranged as to supply power automatically for a specified period of time in the event of failure of either the main or emergency source of electrical power.
- *Unreasonable Radiation.* Radiation resulting in exposure exceeding the individual limits established by the competent authorities.
- *Volume penetration.* Any penetration or opening into or through radiation barriers providing biological shielding whose purpose is to limit radiation exposure.

3 Plans and Data to be Submitted

The submittal documents identified below for Classification are in addition to the items required for submittal per the base ABS Rule notation.

The following plans or information are to be submitted:

R: Documents to be reviewed

I: Documentation for information and verification for consistency with related review.

OB: Documentation which needs to be kept onboard

The below listing also includes plans and data to be submitted solely for reference, as indicated by (I) so that, as part of the ABS review, the presence of various information is verified to be consistent with the design information and limitations considered in the vessel's classification. ABS is not responsible for the operation of the vessel.

Note that some *information* may be classified or controlled. In this case, this information is to *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3].* Plans, data and specifications are to be submitted as follows:

- Interface Document, see 2/3.1.1. **(R, OB)**
- Onboard System Integration Test Plan, see 2/3.1.2. **(R, OB)**
- In-Service Inspection Program (ISIP), see 2/3.1.3. **(R, OB)**
- Risk Assessment, see Subsection 3/2. **(R, I, OB)**
- If required by the Flag Administration or Port State Administration, documentation of compliance with the *ISM Code* may be required onboard. **(OB)**
- Documentation verifying a contract with the ABS Rapid Response Damage Assessment (RRDA) Program, or with a similar program of another IACS Member Society. **(I, OB)**

- Details of stability and damaged stability (with assumptions of damage extent), including the stability analysis and parameters. **(R, OB)**
- NPP description and design parameters. **(I, OB)**
- The defined minimum durations for which the reactor can be maintained in a safe state, and the duration of emergency and transitional power that is to be available to services listed in 2/4 Table 3. **(I)**
- Details of reactor containment and enclosure structures and radiation shielding arrangements, including details and calculations of hull interface scantlings to evaluate interface structure. Note that *the information provided for this purpose* may *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3]*. See 4/3.3. **(I)**
- Collision protective structure specific to protecting the NPP. **(I)**
- Operating and maintenance instruction manuals, including training and certification requirements as well as the quality assurance program to be used during construction, and operation. **(I, OB)**
- Plans or procedures for accurately locating the vessel in the event of sinking or unintentional decommissioning. See 3/2 ii). **(I)**
- Radiation dose-equivalent limits in all spaces onboard and on all decks. **(I, OB)**
- Radiation and contamination levels related to division of the vessel into areas and the related access restrictions, including anticipated normal radiation levels for spaces in which personnel monitoring is required. **(I, OB)**
- Details and documentation of nuclear power plant equipment functionality under static and dynamic inclinations. See Subsection 5/3. **(I)**
- Conditions of operation relative to nuclear safety [A.491(XII) Appendix 3/10]. See 6/2.3.3. Note that *the information provided for this purpose* is to *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3]*. These items include **(I, OB)**:
  - *Safety limits*.
  - *Alarm limits*.
  - *Safety trip settings*.
  - Upper and lower limits of process variables that are important to maintain nuclear safety of reactor, including thermodynamic and fission parameters or other technical, administrative or procedural requirements.
  - *Limiting conditions for emergency operation of the* vessel *(see 5.1.4 of* A.491(XII) *Appendix 3)*.
  - *Surveys and inspections:*
    - *Frequency and scope* of tests and records.
    - *Calibrations and inspections*.
  - *Administrative control:*
    - *Procedures for changing and approving operating instructions and orders*.
    - *Procedures and instructions governing normal operation (NO), anticipated operational occurrences (AOO), Design Basis Accident (DBA), and Design Extension Condition (DEC).*
  - *Maintenance and surveillance requirements.*
- Description of the *provisions made for protection […] against unauthorized intrusion, sabotage and theft of nuclear material [A.491(XII) Appendix 3/11.1], including* arrangement and access to controlled and supervised areas, defined in Subsection 2/1. Note that *the information provided for this purpose* is to *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3]*. **(I)**

- Radiation shielding structures, systems, and components, **(I)** including [A.491(XII) Appendix 3/8.2]:
  - *The identification of the source to be shielded.*
  - *Location and purpose of the shield.*
  - *Dimensions and materials of the shield.*
  - *Verification of design by calculation and tests as appropriate, as applicable.*
  - Radiation monitoring arrangements, including the location, type, sensitivity, range of measurement and methods of display and alarm applicable to the detectors used, and their ability to remain operable during design basis conditions.
  - Design attributes of electrical and mechanical shielded volume penetrations and associated radiation shielding design.
- Arrangements for radioactive material release into the environment, including instrumentation and monitoring of gaseous or liquid discharges, and the automatic and manual initiation of release-limiting systems [A.491(XII) Appendix 3/8.5]. **(I, OB)**
- Nuclear fuel and radioactive waste onboard storage and handling. **(I, OB)**
- Description and location of *laboratories, changing rooms, spaces and facilities used for decontamination of contaminated persons or objects, if fitted [A.491(XII) Appendix 3/8.6]*. **(I, OB)**

3.1 Interface Document

The Interface Document is required by ABS to establish the means through which these Requirements are verified by Classification, and describe the means through which requirements and regulations of other Stakeholders, as defined in Subsection 1/4, may be satisfied. The Interface Document describes the marine and nuclear systems of the vessel; the Stakeholders whose approvals are necessary; and the responsibilities assigned to the Stakeholders, for Stakeholder review and approval of the approach.

Commentary:

An agreement between stakeholders identified in the Interface Document is to be established to confirm that all parties involved understand and accept the distribution of responsibilities.

The Interface Document is to reflect the safety expectations for the vessel as integrated between Stakeholders. Approval of the Interface Document by ABS signifies ABS verification that sufficient execution of the planned content will satisfy the Goals and Functional requirements of these Requirements. ABS approval is not intended to replace the approval of other Stakeholders.

The Interface Document, through ABS and Nuclear Regulator approval, may be used to align the Requirements and nuclear design and safety analysis with Nuclear Regulator requirements. It is not intended that the content of these Requirements replace the Nuclear Regulator's requirements, rather that these Requirements supplement existing applicable Classification requirements.

End of Commentary

Structures, systems, and components are to be systematically categorized with respect to their designation as primary essential marine service, secondary essential marine service, services to provide emergency power and to be powered by emergency sources, or other. Refer to 2/3.1.1.

It is the responsibility of the Nuclear Regulator to review and approve the reactor and applicable nuclear safety structures, systems and components on behalf of the nuclear licensing process.

Equipment designated in the Interface Document as primary essential marine service, secondary essential marine service, or emergency source of power provided to the equipment listed in 2/Table 3 are to be subject to Classification review unless indicated otherwise by the Interface Document. Equipment

categorized outside of these designations need not be subject to Classification review and approval. Base ABS notations are applicable in addition to the below references:

i) See 5/3.1 of the *Power Service Requirements* for electrical systems and components submittal items.

ii) See 5/3.3 of the *Power Service Requirements* for piping systems submittal items.

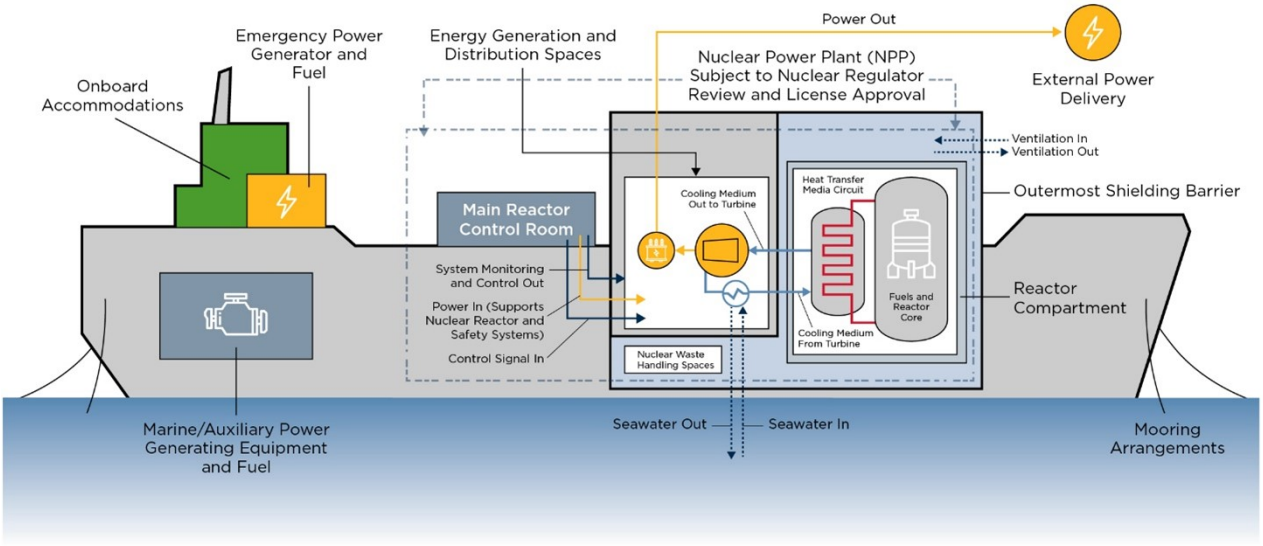
iii) See 4-2-4/1.5 of the *Marine Vessel Rules* for steam turbine systems submittal items.

iv) See 5/3.7 of the *Power Service Requirements* for general equipment submittal item details.

v) Nuclear features, including associated programs and procedures, that are considered important to nuclear safety that maintain the habitability of the vessel.

2/3.1 FIGURE 1 shows a simplified example arrangement of a nuclear power service vessel arrangement with the NPP indicated, and systems in/out that may be subject to both the Nuclear Regulator and ABS Classification approval. This Figure is illustrative and other arrangements may be acceptable according to these Requirements, for example, the arrangement of energy generation and distribution spaces outside of the outermost shielding barrier, or the arrangement of multiple NPP units on one vessel. Verification authority responsibilities are to be included in the Interface Document.

FIGURE 1
Simplified Example Arrangement of Nuclear Power Service Vessel



3.1.1 Interface Document and Defining Stakeholder Responsibilities

The Interface Document is to establish and define the Stakeholder's scope or area of responsibility for structures, systems and components allocated as essential marine services, secondary essential marine services, and services to provide emergency power and be powered by emergency sources as defined in Subsection 2/4. The Interface Document is subject to Flag Administration and Nuclear Regulator's approval.

The Interface Document is to be submitted to ABS prior to the start of design approval.

The Interface Document is to consist of the following components:

i) System Interface and Integration Requirements, as defined in 1D-A2-6/3.1.1 and 2/3.1.2 for the Onboard System Integration Test Plan.

ii) Interface Analysis, as defined in 1D-A2-6/3.1.2.

iii) The list of structures, systems or components provided for essential marine services, secondary essential marine services, and services to provide emergency power and be powered by emergency sources as defined in Subsection 2/4, including their safety systems, control, instrumentation, and monitoring arrangements.

iv) The identified or chosen industry standards, rules, requirements and criteria for equipment and materials design, manufacture, construction and operations during all possible design or operational conditions. See Section 2, Appendix 1 for a representative list of references.

Commentary:

It is noted that nuclear industry standards may define design or operational conditions differently from those of marine industry standards. For example, the IAEA defines typical nuclear design or operating conditions as normal operations (NO), anticipated operational occurrences (AOO), design basis accidents (DBA, as defined in Subsection 2/2), and design extension conditions (DEC). Marine design or operational conditions may include normal operating conditions (defined in Subsection 2/2), upset conditions, emergency conditions, survival conditions and accidental conditions. Throughout this document, the term ‘all possible design or operational conditions’ is used and should be understood to refer to the above listed conditions or other defined nuclear design or operating conditions or marine design or operating conditions. It is the NPP designer’s responsibility to include credible marine conditions in association with appropriate nuclear design or operational conditions for the NPP design.

End of Commentary

v) The verification and validation authority for each aspect of material, construction, welding, transport, testing, maintenance, and operational performance and material conditions. Each listed item or activity is to have at least one identified verification authority. Where the division of responsibility of verification of structures, systems or components according to rules or standards are not clear, the Interface Document is to provide the extent of each organization’s involvement, including the time or stage at which ABS Class involvement is expected to take place, subject to the Flag Administration’s approval. Refer to Section 2, Appendix 2 for an example of Interface Document Contents.

vi) The associated design or engineering review authority and the associated auditing, inspection, or survey validation authority for each structure, system, or component identified in 2/3.1.1 iii).

vii) The associated design or engineering review authority and the associated auditing, inspection, or survey validation authority for each Goal and Functional Requirement listed in this document.

Commentary:

In each Section where goals and functional requirements are used to outline the high-level functional and safety performance objectives of the systems they describe, the prescriptive requirements provided in the Sections clarify the approach to meet the functional requirements and provide instruction on the methods of verification and validation. However, where some functional requirements are not associated with any prescriptive requirements within each Section, distinguished in the Table notes, the review authority responsible to verify conformity is to be provided in the Interface Document.

For example, the Security Functional Requirement listed in Section 6/1.2, associated with the Goal SEC 6, is related to the general design principles to minimize the risk of unauthorized proliferation of nuclear material. As

noted in Subsection 5/6, security arrangements are to be in accordance with the Nuclear Regulator. Therefore, where functional requirements and prescriptive requirements are listed in this Document related to nuclear security, it is the responsibility of the Nuclear Regulator to verify conformity.

In other areas, ABS may list some prescriptive requirements, for example, for radiological protection, which may be verified by ABS. However, if more comprehensive or more stringent requirements are established by the Nuclear Regulator, and will be verified by the Nuclear Regulator, those should be used in addition to or instead of the requirements listed herein, as applicable.

End of Commentary

3.1.2 Onboard System Integration Test Plan

To prepare for ABS Survey attendance of onboard system integration tests, a system integration test plan that details test techniques, test limits, expected test data, and quality assurance requirements is to be developed for use once systems are installed onboard. 1D-A2-6/3.1.3, 1D-A2-6/3.1.4 and submittal items identified in 1D-A2-6/5.1 are applicable. This is to include all necessary documents that describe the scope and responsibilities of ABS Surveyor attendance and the requirements for system-of-systems functionality and interfaces.

The system integration test plan is to be submitted to ABS for review before the system integration testing. The system integration test plan, consisting of system integration test procedures and test results, is to be subsequently summarized in a report and submitted to ABS for review.

In the case that nuclear reactors are replaced or additional units added to the vessel after initial construction and commissioning, the system integration test plan is to be resubmitted to ABS for review prior to system integration testing and resubmitted with test results subsequently following system integration testing.

3.1.3 In-Service Inspection Program (ISIP)

In addition to the surveys during construction as provided in the base ABS Rules, and the surveys after construction according to Part 7 of the *Marine Vessel Rules* or *MOU Rules*, the below requirements for an in-service inspection program (ISIP) plan are applicable.

Where structures, systems and components are identified by the Interface Document as being subject to Classification review, an ISIP is to address in-service ABS survey, inspection, monitoring, sampling and testing (as applicable) during operations.

A draft ISIP is to be submitted with the system integration test plan. In the case that the ISIP is modified according to the results of system integration testing or modifications to the vessel, the ISIP is to be resubmitted for ABS review prior to issuance of the final engineering approval letter.

The ISIP is to consist of the following, as applicable:

i) Verification and validation authority for every applicable inspection or survey activity in accordance with the Interface Document. Each listed item or activity is to have at least one identified verification authority. Where the division of responsibility of verification is not clear, the ISIP is to provide the extent of each organization's involvement, including the time or stage at which ABS Class involvement is expected to take place, subject to the Flag Administration's approval. See 2/3.1.3 iv).

ii) Industry standards and criteria for equipment and materials design, testing, manufacturing, non-destructive testing, quality assurance/quality control testing, or other applicable standard methodologies, calculations, procedures, and criteria.

iii) Identified biological shielding, personal protective equipment (PPE), special test procedures, and decontamination methods for systems and equipment where necessary for radiation detection, monitoring, or containment safety *[A.491(XII) 8.1.8]*. This may

include equipment that indicates and records radiation levels of radioactive wastes, or the spare monitoring instruments and supporting facilities and equipment for the maintenance and calibration of monitoring equipment, as applicable.

iv) In-service inspection and survey period intervals. See the base ABS Rules for periodic survey or inspection activity according to system or component type.

v) Scope or depth of required inspection by the approval authorities, if more than one authority is required to be involved, subject to Flag Administration approval *[A.491(XII) 8.1.7.4]*.

vi) Procedures for corrective/preventive action and communication/reporting upon findings *[A.491(XII) 8.1.7.5]*.

vii) Most recent system integration test plans, test data, and test results are to be included in the ISIP.

4 Essential Marine Services

Examples of primary essential services and secondary essential services are listed in 4-8-1/Table 1 and 4-8-1/Table 2 of the *Marine Vessel Rules*, respectively and 4-1-1/7 Table 3 and 4-1-1/Table 4 of the *MOU Rules*, respectively.

A NPP typically has the following main (or primary) systems: the reactor core, the reactor coolant systems, and the containment structure and containment systems, as well as their associated safety systems and safety features (see Requirements 43-58 of IAEA SSR-2/1 (Rev. 1)). The remaining systems are considered auxiliary systems, as defined in Subsection 2/2 (see Requirements 59-82 of IAEA SSR-2/1 (Rev. 1)), to the main systems and their associated features. Nuclear auxiliary systems are to be included in the scope of marine Classification depending on their function related to safety and as categorized as primary or secondary essential marine services according to this section and as provided in the Interface Document. Note that some information may be classified or controlled. In this case, this information is to *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3]*.

2/Table 1 and 2/Table 2 below provide some examples of primary essential marine and secondary essential marine services for consideration. Final categorization will be defined by system importance to nuclear safety per the Nuclear Regulator's requirements. Based on those categorizations, the interface and integration with supporting nuclear systems or marine systems will be determined and its independence will be categorized.

Primary essential marine services are those considered necessary for:

- Continuous operation to maintain (non-nuclear) propulsion and steering in self-propelled units.
- Continuous operation to maintain station keeping, including dynamic positioning, anchoring or mooring equipment, for non-self-propelled units.
- Systems of the unit that are essential to maintain whose loss or failure (other than the nuclear reactor or reactors) would create an immediate danger to the unit.

TABLE 1
Power Service (Nuclear) Example Primary Essential Marine Services

i)	Services considered necessary to maintain hazardous spaces in a safe condition, including but not limited to (as identified in the Interface Document): *a)* Control, monitoring and safety systems for nuclear power plant. *b)* Control, monitoring and safety systems for nuclear waste handling and storage systems.
ii)	Ventilation and filtration systems necessary to continuously maintain a safe atmosphere that controls the dose-equivalent limits in all normally manned areas.
iii)	Heating, ventilation and air conditioning systems in NPP-related areas.
iv)	Heat transport systems.
v)	Lighting and emergency lighting systems.
vi)	Process and post-accident sampling systems.
vii)	Systems for treatment and control of radioactive waste and radioactive effluents.
viii)	Compressed and instrument air systems, as applicable.
ix)	Demineralized water reserve and associated systems, as applicable.
x)	Containment cooling systems.
xi)	Chemical and volume control systems, as applicable.
xii)	Other services considered necessary to maintain radiation areas in a condition within dose-equivalent limits.
xiii)	Supporting system for emergency power supply and alternate power source.

Secondary essential marine services are those considered necessary for:

- Non-continuous operation to maintain propulsion and steering in self-propelled units or station keeping, anchoring or mooring equipment in non-self-propelled units.
- Non-continuous operation to maintain a minimum level of safety for the vessel's navigation and systems including safety for dangerous cargoes to be carried, nuclear material and radioactive waste.
- Other special characteristics (e.g., special services) of the unit whose loss or failure would create a potential danger to the unit.

TABLE 2
Power Service (Nuclear) Example Secondary Essential Marine Services

i)	Radiation detection and alarm systems.
ii)	Plant gas system (e.g., hydrogen, carbon dioxide, nitrogen) as required.
iii)	Auxiliary and radioactive waste area ventilation systems.
iv)	Demineralized water treatment, transfer and storage system.
v)	Turbine space close cooling systems, if applicable.
vi)	Waste water systems, including equipment and floor drainage systems.
vii)	Controlled area ventilation systems.
viii)	Radioactive waste space HVAC systems.
ix)	Primary and secondary sampling systems.

x)	Electric equipment for security monitoring, security doors and other security closing appliances.
xi)	Security monitoring and security doors.
xii)	Overhead lifting equipment as required.

Essential marine services that are considered either primary or secondary depending on their nature are:

- Each emergency service as described in 4-8-2/5.5 of the *Marine Vessel Rules* or 4-3-2/5.3 of the *MOU Rules,* as applicable. Emergency power supply equipment is considered a primary essential marine service when supporting those items listed in 2/Table 3.

TABLE 3
Services to be Powered by an Emergency Source

i)	Systems essential for reactor shutdown and holding in safe state, as defined in Subsection 2/2 [A.491(XII) 5.10.3.1].[1]
ii)	All reactor protection and safety systems [A.491(XII) 5.10.3.3], and related safety loads, including: ***a)*** Controls and monitoring equipment of reactor safety systems [A.491(XII) 5.11.4.1]. ***b)*** Radiation protection monitoring systems [A.491(XII) 5.11.4.2]. ***c)*** Any other reactor controls and monitoring equipment [A.491(XII) 5.11.4.3].
iii)	Emergency lighting in all reactor control spaces or emergency control areas.
iv)	Emergency lighting for all storage and outfitting positions for radiation protection gear and decontamination stations, including systems and components for the purpose of decontamination, if fitted.
v)	Primary and secondary HVAC systems, as necessary.
vi)	Communication systems throughout the nuclear power plant areas including the reactor control spaces and emergency control areas.
vii)	Process radiation monitoring systems.
viii)	Fire protection systems for NPP and nuclear power service vessel.
ix)	Containment cooling systems.
x)	NPP security systems.
xi)	Survival craft protection systems, including external drenching systems for decontamination, if fitted [A.491(XII) 3.8.2].
xii)	Systems and components provided for security measures, including security doors and monitoring arrangements, including emergency lighting for security control spaces, if fitted.

Note:

1 Assuming a single failure in the electrical system in addition to the initiating event [A.491(XII) 5.8.2].

The duration of time necessary for emergency power and the transitional source of emergency electrical power, as defined in Subsection 2/2, for the equipment listed in 2/Table 3 are to be provided by the equipment designers according to the NPP characteristics. These durations are also to be included in the risk assessment(s). See Subsection 3/2 xix).

SECTION 2

Appendix 1 - Example Nuclear Standards

Some recognized references or documents are listed below for information. The interface document is to refer to industry standards and identify associated responsibilities for the verification and validation of compliance of the identified structures, systems, or components with the identified standard.

This is a representative list and not intended to be inclusive of all industry standards or engineering practices. Users are advised to check online sources periodically to verify the version is the most current.

IAEA Resources

SF-1 Fundamental Safety Principles

GSR Part 2 *Leadership and Safety (2016)*

GS-G-3.1 *Application of the Management System for Facilities and Activities (2006)*

GS-G-3.5 *The Management System for Nuclear Installations (2009)*

SSG-3 (Rev.1) Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants (2024)

SSG-34 *Design of Electrical Power Systems for Nuclear Power Plants*

SSG-4 *Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants* (2010)

Safety Series No. 50-P-12 *Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 3): Off-Site Consequences and Estimation of Risks to the Public: A Safety Practice*

SSG-64 *Protection against Internal Hazards in the Design of Nuclear Power Plants*

Safety Series No. 61 *Control of Radioactive Waste Disposal Into the Marine Environment* (IAEA labeled it as obsolete but its included for information)

SSG-90 *Radiation Protection Aspects of the Design for Nuclear Power Plants*

SSG-3 *Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants* and SSG-4 *Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants*

SSG-40 Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors and SSG-41 Predisposal Management of Radioactive Waste from Nuclear Fuel Cycle Facilities

SF-1 *Fundamental Safety Principles*

GSG-1 *Classification of Radioactive Waste (2009)*

SF-1 *Fundamental Safety Principles (*2006)

SSG-78 *Compliance Assurance for the Safe Transport of Radioactive Material*

TS-G 1.4 *The Management System for the Safe Transport of Radioactive Material* (2008)

GSR Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

SSG-15 (Rev.1) *Storage of Spent Nuclear Fuel* (2020)

Safety Series No. 117 *Operation of Spent Fuel Storage Facilities*

SSG 15 (Rev.1) *Storage of Spent Nuclear Fuel* (2020) and GSG-3 *The Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste* (2013)

SF-1 Fundamental Safety Principles GSR Part 5 *Predisposal of Radioactive Waste*

SSR-2/1 *Safety of Nuclear Power Plants: Design*

SSR-6 *Safe Transport of Radioactive Material*,

Specific Safety Guide No. SSG-62 *Design of Auxiliary Systems and Supporting Systems for Nuclear Power Plants*

IMO Resources

International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Wastes on Board Ships (INF Code)

International Maritime Dangerous Goods Code (IMDG Code)

International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)

ASME Resources

ASME Boiler and Pressure Vessel Code

ANSI/ASME/ANS RA-S-1.4-2021 *Probabilistic Risk Assessment for Advanced Non-Light Water Reactor Nuclear Power Plants Publication*

ANSI/ASME/ANS RA-S-1.1-2024 *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment For Nuclear Power Plant Applications*

ASME Nuclear Quality Assurance (NQA-1) Certification

SECTION 2

Appendix 2 - Example Interface Document Contents

The Interface Document is recommended to contain information and items included in, but not limited to, this Appendix. Content of this Appendix is derived from A.491(XII) Appendix 3: Safety Assessment Recommended List of Contents.

Structures, systems, and components included in the interface document are to be described with the following details provided:

1. *Function Definition*
2. *Description*
3. *Design* Conditions
   - *3.1.* *Normal and limiting operating parameters* defined by design basis, including situations or conditions resulting in actuation of safety systems including automatic shutdown. For example, limiting inclinations or accelerations due to motion that results in the need for safety system startup.
   - *3.2.* *Material selection and qualification*
   - 3.3. *Mechanical design* and structural layout
   - *3.4.* *Thermal and hydraulic considerations*, as applicable
   - 3.5. *Nuclear physics considerations*, including operation in expected and emergency radiation environments
   - 3.6. Potential interactions of nuclear systems with marine environment or marine systems, including sinking/water intrusion, reactivity insertion, and thermal responses
   - 3.7. *Inspection and tests* during construction, commissioning, and operations, including intervals of each and the responsible authority to perform, witness and verify or validate
   - *3.8.* *Maintenance*, including intervals and the responsible authority to perform, witness and verify or validate
4. *Quality assurance requirements*
5. *Design Evaluation* information and criteria
   - *5.1.* *Structural analysis*
   - *5.2.* *Thermal and hydraulic calculations*
   - *5.3.* *Operational Response*

5.4. Impacts on marine structures, systems or components of failures attributable to nuclear systems.

5.5. Impacts on nuclear structure, systems or components of failures attributable to marine systems.

The description and information required by the above are applicable to the various structures, systems, and components listed as follows that may function for marine and nuclear service:

1. Vessel General Information and Systems
   - *1.1.* *Arrangements*
   - *1.2.* *Characteristics*
   - *1.3.* *Stability and subdivision*
   - *1.4.* *Survivability*
   - *1.5.* *Hull structure and strength*
   - *1.6.* *Collision protection*
   - *1.7.* *Communications*
   - *1.8.* *Life-saving appliances* and arrangements
     - *1.8.1.* Escape routes and evacuation arrangements
   - 1.9. Vessel *machinery systems*
     - *1.9.1.* *Fire* and gas *protection and detection*
     - *1.9.2.* Fire fighting equipment and systems
     - *1.9.3.* *Heating, ventilation and air conditioning systems*
     - *1.9.4.* *Bilge and ballast systems*
     - *1.9.5.* Damage control plan
     - *1.9.6.* *Other systems*, as applicable
2. Nuclear Power Plant (NPP) Systems
   - *2.1.* Containment, radiation shielding, or pressure boundaries
     - *2.1.1.* Pressure vessels, as applicable
     - *2.1.2.* Coolant pump or circulation arrangement, as applicable
     - *2.1.3.* *Safety, relief and isolation valves*
     - *2.1.4.* Coolant piping arrangement, as applicable
     - *2.1.5.* Coolant supply and maintenance systems, including steam generators or equivalent
     - *2.1.6.* *Details of anticipated cycling loading induced by pressure and temperature variations [A.491.(XII) 4.6.1.1]*, as applicable.
     - *2.1.7.* *Expected inertial loads imposed by vessel motion and vessel and reactor accidents [A.491(XII) 4.6.1.2]*, as applicable.
     - *2.1.8.* *Vibration loads induced by sources internal or external to the system [A.491(XII) 4.6.1.3]*, as applicable.
   - *2.2.* *Auxiliary systems*
   - *2.3.* *Reactor core*

2.3.1. *Fuel elements* or forms *including enrichment* or other physical properties, such as liquid fuel chemistry, characteristics and composition, as applicable.

2.3.2. Reactor control mechanisms, as applicable.

2.3.3. *Core physics*, as applicable

2.3.4. *Other reactor internal structures*, as applicable

2.4. Instrumentation and control

2.4.1. Reactor instrumentation and control.

2.4.2. Normal operation instrumentation and control.

2.4.3. Safety related instrumentation and control.

2.5. Engineered safeguards

2.5.1. Reactivity control systems.

2.5.2. *Reactor* emergency shutdown.

2.5.3. Reactor protection system.

2.5.4. Emergency core cooling.

2.5.5. Residual heat removal.

2.5.6. Reactor poisons integral to core design, utilized in coolant chemistry, or if required for shutdown margins, as applicable.

2.5.7. Containment structure and containment structure isolation, as applicable.

2.5.8. Leakage detection system.

2.5.9. Arrangements for providing means to the ultimate heat sink/cooling, as applicable.

2.5.10. Drain tanks or equivalent for liquid-fueled reactor types, as applicable.

2.6. Main and emergency reactor control locations

2.6.1. Instrumentation

2.6.2. Location and description

2.6.3. Fire protection

2.6.4. Habitability and access

2.7. Other systems

2.7.1. *Radioactive waste* and radioactive material arrangements, as applicable.

2.7.2. Reactor *poison control*, as applicable.

2.7.3. *Containment atmospheric control and clean-up*, including all ventilation and air filtration monitoring and conditioning.

2.7.4. Process auxiliary systems

2.7.5. *Water* or other materials *chemistry control*, as applicable

2.7.6. *Off-gas and excessive primary* coolant *drainage*, makeup or control systems, as applicable.

3. Radiation protection functions and shielding

3.1. Main criteria for radiation protection, *including radiation dose* expected normal levels and *limits*.

3.2. *Radiation activity and isotope release limits.*

3.3. *Radiation and contamination levels related to division of the vessel into areas and the* corresponding *access restrictions*.

3.4. Radiation monitoring systems, including design principles and the location, type, sensitivity, range of measurement, methods of display and alarms applicable to the detectors used, and their ability to cope with identified accident or emergency conditions.

3.5. *Rules and procedures for managing radioactive materials and access to controlled areas*, including *rules and procedures* for design basis conditions.

3.6. Information on radiation shielding, including:

3.6.1. *Identification of the source to be shielded.*

3.6.2. *Location and purpose of the shield.*

3.6.3. *Dimensions and* materials of construction.

3.6.4. *Verification of design by calculation and tests as appropriate.*

3.7. *Information related to radioactive release to the environment*, including

3.7.1. *Instrumentation and monitoring of plant* discharge, as applicable.

3.7.2. *Automatic and manual initiation of release-limiting systems*, as applicable.

3.8. *Laboratories, changing rooms, spaces and facilities used for handling contaminated persons or objects*, including locations and the number of equipment, instruments, stores, or other items as applicable to the purpose of the space, as applicable.

SECTION 3
Risk Assessment

1 General

The risk assessment(s) are to be conducted for the identification of hazards and the assessment of the associated risk. The purpose of risk assessment(s) is to provide information to aid in decision making regarding the need to introduce risk-reduction measures, and also to verify that design, construction, operation and decommissioning of the nuclear power plant vessel will meet national/international nuclear regulations and marine regulations. This is also to demonstrate that the risks involved with NPPs have been evaluated to either eliminate or to adequately mitigate any adverse effect to the security of life, property, and the natural environment.

It is expected that designer/owner are to develop detailed risk assessment(s) plan(s) and submit for ABS review prior to conduction of any risk assessment(s). A detailed risk management plan needs to be developed for management of risk for the life of the nuclear power plant vessel.

Commentary:

It is recommended that ABS participates in risk assessment workshops and activity before documentation is submitted to ABS for information. It should be noted that, while not all items to be considered and documented in the risk assessment are subject to classification review and approval, risk assessment documentation is to be submitted for information to ABS to share key aspects of design decisions according to risk mitigation and safety.

End Commentary

2 Risk Assessment Methodology

A risk assessment is to be conducted for the nuclear power service vessel design, construction, operation and decommissioning to address the risks arising by virtue of a nuclear power plant and its systems affecting persons on board and the environment.

Risks are to be analyzed using acceptable and recognized risk analysis techniques to determine that the NPP for the nuclear power service vessel does not pose unacceptable risks to the asset, people or the environment. Details of risk assessment plan(s) are required to be submitted for review prior to conducting the risk assessment for the design. The results of each risk assessment and risk management plan are to be submitted with sufficient information for ABS to review. Refer to the ABS *Guidance Notes on Risk Assessment for Marine and Offshore Industries.*

A comprehensive set of postulated initiating events is to be identified and used in the risk assessment *such that all foreseeable events with the potential for serious consequences and all foreseeable events with a significant frequency of occurrence are anticipated and are considered in the design* basis *[IAEA SSR-2.1 Req. 16].*

In addition, *all foreseeable internal and external hazards, including the potential for human induced events directly or indirectly to affect the safety of the* NPP*,* are to *be identified and their effects […] evaluated. Hazards* are to *be considered in designing the layout of the plant and in determining the postulated initiating events and generated loadings for use in the design of relevant items important to safety for the plant [IAEA SSR-2.1 Req. 17].*

The need for updates to any previously submitted risk assessment analysis is to be evaluated and addressed as appropriate. Updated risk assessment reports or engineering analyses are to be submitted to ABS.

The risk assessment is to consider, but is not limited to, the items referenced by these requirements listed below. In general, items annotated by **(R)** are to be submitted for review and items annotated by **(I)** are to be submitted for information. The determination if an item listed below is required to be submitted for review **(R)** or for information **(I)** may be subject to change based on the results of the interface document.

i) *The possible radiological consequences of the ship's sinking*, depending *on the power* history (level and duration) *at which the NPP was operating beforehand, the various transients* that could occur *during the sinking process,* up to and including inverted attitudes, *and the final position,* orientation and depth *of the wreck.* Other systems possibly affected from sinking may include *the continued supply of power and coolant, etc., to the* NPP*; and the possibility* of loss of operational *control and safety equipment [A.491(XII) 1.9.1].* Other effects of sinking may include the increase of structural loads due to increasing temperatures or pressures of water ingress and external water. **(I)**

ii) *The feasibility of recovering the wreck or part of it should be reflected in the design where this proves technically possible [A.491(XII) 1.9.2].* In the event of sinking or unintentional decommissioning, plans or procedures for accurately locating the unit are to be provided. **(I)**

iii) Ambient, transient, and long-term environmental conditions at operating locations and planned routes of transit, even without the nuclear systems in operation. Environmental conditions are to be considered for all possible design or operating conditions and the impact on structures, systems and components. These conditions or effects include *extraordinary seaways, tornadoes* or waterspouts*, tsunamis, hurricanes, winds, snow and ice, applicable to the* vessel's *service [A.491(XII) 2.3.2].* Refer to Subsection 5/3 for inclination requirements. **(R)**

iv) *The inertial forces acting on the* vessel due to marine environmental conditions and their effect on reactor systems, safety systems and operations. Limiting motions due to conditions or environmental limits that initiate reactor shutdown or other procedures are to be clearly defined *[A.491(XII) 2.3.8].* Refer to 4/2.1 for inertial force calculations and Subsection 5/3 for inclinations depending on vessel type. **(R)**

v) *Shock loads on reactor plant components from accidents such as* wave slamming, *collision, grounding or explosion should be considered, and reflected in the design [A.491(XII) 2.3.7].* Damage extent conditions below and around the outermost shielding barrier are to be reviewed for suitability according to credible accident conditions. See 4/3.1. **(R)**

vi) The sufficient safety margins of containment structures such that *materials behave in a non-brittle manner; and the probability of a rapidly propagating fracture is minimized [A.491(XII) 4.11.1.8].* **(R)**

vii) Proximity to land, including *local meteorological conditions as well as a population density and land usage factors, should be included when analysing the effect of a nuclear* unit *on ports being used* or in the proximity of the location of installation *[A.491(XII) 2.3.1].* **(I)**

viii) Location of reactor control rooms in the case of accidents such as fire or flooding and habitability. **(R)**

ix) *The* hazardous *effects of oil vapors from machinery, […] smoke in the event of fire and /*or *toxic gases originating from the cargo*, materials of construction, *or the environment [A.491(XII) 2.3.13].* **(R)**

x) *The effects of propeller and machinery induced vibrations* as well as other normal onboard vibrations *and, where necessary, reflected in the design and testing of monitoring devices and control systems and components [A.491(XII) 2.3.14].* **(R)**

xi) *Location of areas and equipment essential to* asset *and reactor safety, taking account of machinery having a potential for missile generation [A.491(XII) 3.1.13.3].* The potential for unintentional missile effects to the asset or reactor safety equipment are to be minimized. **(R)**

xii) The need for additional quantitative analyses, such as a gas dispersion study, hazard identification (HAZID) analysis, hazard and operability analysis (HAZOP), failure modes and effects analysis (FMEA), failure modes, effects and criticality analysis (FMECA), or quantitative risk assessment (QRA) to support the design approval and the items concerning these requirements. Refer to A.491(XII) Appendix 3 Section 9 for a recommended list of contents to be included in the accident and failure analysis. **(R)**

xiii) Potential *risk of explosion or fire originating from* the NPP, the unit's stores, *or external sources. Where required by analysis, suitable fire protection arrangements, or other special considerations acceptable to the Administration,* are to *be provided [A.491(XII) 3.9.9].* **(R)**

xiv) Ill-intended actions or unauthorized admission to access or remove fissile material. Note that this *information* may be classified or controlled. In this case, this information is to *be presented in a separate document classified in accordance with the requirements of the appropriate authorities [A.491(XII) Appendix 3/11.3].* **(I)**

xv) The need for automatically initiating safety systems for events or incidents *which require fast safety system action […] to prevent unacceptable consequences [A.491(XII) 4.1.4].* **(R)**

xvi) *Coolant flow distribution […] and uncertainties associated therewith* are to *be taken into account. Particular attention* is to be given to *the redistribution of coolant flow and effects on heat transfer and coolant properties under the influence of* inclinations or attitudes. *For abnormal conditions of coolant flow […], adequate safety margins* are to *be demonstrated. Analyses and/or tests* are to *demonstrate the absence or* acceptable levels of any *flow-induced vibration in the core, its supports or appurtenances, to* verify *that no vibration-induced hazards exist which would prejudice safe reactor operation [A.491(XII) 4.2.2].* **(I)**

xvii) The risk assessment is to define the margin of time for which the means of *reactivity control is to be capable of rendering* and maintaining *the core* in a safe state *[A.491(XII) 4.3.2.5].* See Section 5 SAFE-FR2(AUTO). This duration is to consider the range of plant conditions consistent with reactor protection analysis *during and after the service life of the core, including periods of maintenance, refueling, reactor accident conditions and ship accident conditions including capsizing and sinking [A.491(XII) 4.3.2.5].* **(I)**

xviii) *Additional fire protection structure, equipment and systems* as *required to ensure that the integrity of the* radiation *shielding* and sequential barriers of protection for the NPP *and essential reactor safety systems is maintained, such that an onboard fire of single origin will not prevent the shutdown of the reactor nor the maintenance of it in that state [A.491(XII) 3.9.2].* **(R)**

xix) The period of time necessary following an incident that residual heat removal systems and related safety systems are to continuously operate, for example, in the case of *sinking to a depth where it can be proven that flooding of the* NPP *will remove residual heat for as long as is necessary [A.491(XII) 4.8.1.2].* **(I)**

xx) The number of *fixed radiation checkpoints* is to *be established so that it is possible to compare radiation levels or contours within the* vessel *periodically during the life of the ship with the original surveys made when the* vessel *was commissioned.* The *number of fixed points* is to be selected, both within the vessel and on its exterior *[A.491(XII) 6.4.5].* **(I)**

xxi) *Design and operation of* radioactive waste material *treatment and storage facilities, considering the potential* volume and radioactivity content of radioactive waste, radiation *shielding and cooling requirements, possible corrosive effects of certain radioactive liquids or gases, the detection of leaks, the presence and detection of combustible gasses, and provisions to prevent the*

explosion of combustible gases or liquids and to mitigate its effect should it occur [A.491(XII) 6.5.4]. See Subsection 6/3. **(I)**

xxii) *The minimum capacity of liquid, solid and gaseous waste storage facilities for the* vessel's *service,* with an *allowance for contingencies. The capacity* is to *recognize a range of probable […] conditions as well as the period between discharging the waste [A.491(XII) 6.5.5].* See Subsection 6/3. **(R)**

xxiii) *The design, manufacture, operation and testing of the radioactive waste treatment facilities (if any) and of the storage facilities, including the possible need for segregation of wastes on account of their chemical properties and their radioactive characteristics, such as specific activity or radioisotope content [A.491(XII) 6.5.8].* See Subsection 6/3. **(I)**

xxiv) Failure incidents of radioactive wastes, including *gases and their storage under pressure*, including storage structures, systems and components, as applicable. *The possible hazard arising from stored or compressed combustible gases must also be taken into account [A.491(XII) 6.9.4].* **(R)**

xxv) *The likelihood of unintentional decommissioning, due to mishaps at sea, incidents of internal or external origin, acts of sabotage or any other unintended cause. Where appropriate, measures should be provided to prevent their occurrence or limit their consequences [A.491(XII) 1.8.4]. Where it is no longer possible to assure the overall safety of the ship, nuclear safety, which hitherto constituted one aspect of overall safety, should become the principal objective in both the short and long term [A.491(XII) 1.8.5].* **(I)**

xxvi) Hazards associated with physical arrangements and related operational and service provisions for radioactive waste discharge to port, radioactive material transfers, reactor refueling or reactor replacement, as applicable. Where nuclear reactor systems are removed or installed after construction and initial vessel commissioning, additional risk assessment is to be conducted and resubmitted to ABS prior to the start of the removal or installation activity. **(I)**

xxvii) Interfaces between the NPP and the connected systems (system-of-systems). Follow-on qualification activities may be determined from the results of the risk assessment such as engineering evaluation, testing, design improvements or procedure changes. Risk control measures are to be implemented and any outstanding items from the risk assessment closed before proceeding with system integration testing and commissioning. **(R)**

xxviii) Hazards associated with the physical layout, operation and maintenance following any reasonably foreseeable failure. This may include personnel or cargo transfer operations, helideck and helicopter facilities as well as the potential of helicopter crash in the vicinity of nuclear systems or the NPP. **(R)**

xxix) *Those risks arising from concentrated energy sources, such as high pressure and high temperature fluids,* are to be reduced *by appropriate means to minimize the occurrence of accidents and the severity of their effects. [A.491(XII) 1.3.3]* **(R)**

xxx) Hazards associated with adjacent industrial facilities, either onboard or stationed nearby, associated with either NPP safety and security or marine safety. See Subsection 7/2. **(I)**

xxxi) Potential hazards associated with the impacts of nuclear system failures attributable to nuclear systems on marine structures, systems or components. **(I)**

xxxii) Conversely, from Subsection 3/2 xxxi), other potential impacts of marine system failure on nuclear structure, systems or components. **(I)**

2.1 Single Failure

Documentation submitted related to risk assessment activity is to indicate that the following systems related to the reactor are designed to be tolerant to single failure events as defined in Subsection 2/2 *[A.491(XII) 4.1.5]:*

i) NPP safety systems;

ii) *reactor shutdown system;*

iii) *reactor protection system* (including nuclear instruments for radiation monitoring)*;*

iv) *residual heat removal system;*

v) *emergency core cooling system,* if provided;

vi) *containment isolation system,* if provided;

vii) *containment heat removal system,* if provided; and

viii) *containment atmospheric clean-up system,* if provided, and

ix) pressure relief systems, if provided.

It is the responsibility of the Nuclear Regulator to license the reactor and related systems. Items and responsible authorities are to be identified in the Interface Document as appropriate.

Commentary:

As a means of satisfying the single failure criterion in particular and of reducing the probability of failure of essential systems in general, four important concepts may *be incorporated in the design of systems for* nuclear power service vessels*. These provisions, which might be applied singly or in combination, are aimed at reducing the probability of system or component failure [A.491(XII) 1.3.11]. They are:*

1 *redundancy – provision of alternative (identical or diverse) structures, systems and components, so that any single structure, system or component can perform the required function regardless of the state of operation or failure of any other [IAEA Glossary 2022];*

2 *independent equipment – equipment that possesses both the following characteristics: (a) The ability to perform its required function is unaffected by the operation or failure of other equipment. (b) The ability to perform its required function is unaffected by the occurrence of the effects resulting from the initiating event for which it is required to function [IAEA Glossary 2022];*

3 *segregation – and the physical separation of structures, systems and components by distance or by means of some form of barrier to reduce the likelihood of common cause failures [IAEA Glossary 2022]; and*

4 *diversity – the presence of two or more independent (redundant) systems or components to perform an identified function, where systems or components have different attributes so as to reduce the possibility of common cause failure, including common mode failure [IAEA Glossary 2022].*

End of Commentary

SECTION 4
Hull Design and Arrangement

1 Objective

1.1 Goals

The hull structure and arrangement are to be designed, constructed, operated and maintained to:

Goal No.	*Goal*
AUTO 3	have an alternative means to enable safe operation in the event of an emergency or failure of remote control[1].
AUTO 7	enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment.
STRU 1	in the intact condition, have sufficient structural strength to withstand the environmental conditions, loading conditions, and operational loads anticipated during the design life.
STRU 2	withstand structural failure associated with accidental conditions.
STRU 3	provide protection to persons onboard, the environment and required safety services.
STRU 3.1	maintain mechanical properties during extreme temperatures.
SAFE 5	eliminate *unreasonable radiation or other nuclear hazards, at sea or in port, to the crew, passengers or public, or to the waterways or food or water resources (SOLAS VIII/Reg 6)*.
SEC 6	minimize the risk of unauthorized proliferation of nuclear material.
MGMT 5.1	facilitate safe access, ease of inspection, survey, and maintenance of the vessel, machinery and electrical systems.

Note:

1 Goal AUTO 3 used in these Requirements, the term '*remote control*' is to have the same meaning as defined in 4-9-1/5.1.7 of the *Marine Vessel Rules*: a device or array of devices connected to a machine by mechanical, electrical, pneumatic, hydraulic or other means and by which the machine can be operated from a remote location on board the vessel, and not necessarily within sight of, the operator. It is not necessarily meant to indicate remote operation of the NPP from a location not onboard the vessel.

Materials are to be suitable for the intended application in accordance with the following Goals and support the Tier 1 goals listed above.

Goal No.	*Goal*
MAT 1	The selected material's physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, installation and maintenance of hull structure and arrangements are to be in accordance with the following functional requirements:

Functional Requirement No.	***Functional Requirements***
SAFETY OF PERSONNEL (SAFE)	
SAFE-FR1 (ENV)	Provide means to prevent penetration, rupture, cracking, leaks or unintentional damage of reactor compartment *in the case of collision, groundings, and hazards arising from cargoes, missiles and other sources specifically identified by the* risk assessment to prevent the uncontrolled release of radioactive materials, as applicable according to the Interface Document, see 2/3.1.1 *[A.491(XII) 3.1.2.1]*.
SAFE-FR2	As far as reasonably practicable, radiation *exposure of those on board, the public and the environment* is to *be* minimized *[A.491(XII) 2.1.1.1 Criterion A]*.
SAFE-FR3	*Bilge, ballast and drainage systems* are to *be arranged to prevent inadvertent release of radioactive material [A.491(XII) 5.4.2]*.
SAFE-FR4	*Parts of the ship in which radioactive materials or contamination may exist should be identified and appropriate design measures taken to ensure that the spread of radioactive material or contamination into other parts will be minimized and that any necessary decontamination procedures can be carried out safely within the relevant dose-equivalent limit [A.491(XII) 6.2.8]*.
SAFE-FR5	*Arrangements should be provided to ensure that servicing, maintenance and in-service inspection can be carried out safely, with neither unacceptable exposure of personnel to radiation nor unacceptable release of radioactive material to the environment [A.491(XII) 6.2.13]*.
SAFE-FR6	*Provision* is to be *made to* protect *crew members within the main* reactor *control rooms, emergency control position, or navigating bridge* from conditions which may lead *to a degradation of the safe operation of the* reactor and therefore a degradation of the safe operation of the marine or offshore application *[A.491(XII) 3.2.3]*.
SAFE-FR7[1]	*The* main *reactor control room* or rooms are *to be constructed to afford its inhabitants radiation and fire protection during all* possible design or operating conditions to *allow it to remain manned [A.491(XII) 4.4.3.2]*.
SECURITY (SEC)	
SEC-FR1[1]	*The reactor compartment design shall facilitate the salvage of the reactor or recovery of its essential parts from the ship in the event of a shipwreck, without prejudicing the safety of the reactor installation in normal service [A.491(XII) 3.1.4]*.
STRUCTURE (STRU)	
STRU-FR1	*The reactor compartment* and reactor control stations are to *be provided protection against external fires or explosions [A.491(XII) 3.1.2.2]*.
STRU-FR2	*Location of areas and equipment essential to ship and reactor safety,* including systems handling and storing radioactive waste *[A.491(XII) 6.5.10],* are to *be chosen, taking into account the disposition of such areas and equipment should ensure in the best way possible their immunity from damage in the event of an internal or external accident [A.491(XII) 3.1.13.1]*.
STRU-FR3	Foundational and protective structures are to provide structural continuity of the hull in normal operating conditions.

Functional Requirement No.	*Functional Requirements*
STRU-FR4	*The* reactor compartmentdesign and material are to withstand design basis conditions and design basis accident conditions, including prevention of *collapse from external pressure due to sinking* or other possible external loads *[A.491(XII) 4.11.1.4]*.
STRU-FR5	*Deformation to hull structures and the* reactor compartment during conditions of the design environment are not to *affect the structural integrity* or result in the release of radioactive material *[A.491(XII) 3.1.11.14]*.
STRU-FR6	Physical damage to the NPP is not to impede the performance of the nuclear safety systems.
AUTOMATION (CONTROL, MONITORING and SAFETY SYSTEMS) (AUTO)	
AUTO-FR1	*Redundant systems and components* essential *to the safe operation of the ship and* the NPP are to be physically separated *[A.419(XII) 3.1.13.2]*.
AUTO-FR2[1]	*Those systems, including their energy supply, designed to ensure essential reactor safety functions in the event of a failure in the principal system,* are to *be functionally independent of and physically separated from the principal system. Wherever practicable, segregation by fire resistant and watertight structures should be adopted [A.491(XII) 3.1.13.5]*.
AUTO-FR3[1]	*Separate and remote from the reactor control room* or rooms*, an emergency control position* is to *be provided. From this position, it* is to *be possible for an operator to bring the reactor to a safe shutdown condition and maintain it in a subcritical state while maintaining residual heat removal [A.491(XII) 3.1.13.6]*.
AUTO-FR4[1]	*Emergency control position*(s) *may be functionally connected […] so that, in case of emergency, an* emergency shutdown procedure *could be performed under the control of* any one emergency control position *[A.491(XII) 3.1.13.7]*.
SAFETY MANAGEMENT (MGMT)	
MGMT-FR1	*Design of* nuclear systems incorporated into ship structures are to *include provisions for periodic inspection*, testing, maintenance and other programs *[A.491(XII) 4.11.1.6]*.
MATERIALS (MAT)	
MAT-FR1	Radiation shielding barriers, containment, piping, pressure vessels and other material components expected to be in contact with or potentially exposed to ionizing radiation or radioactive gases are to be suitable for the intended purpose.

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the Interface Document. Refer to Part 1D, Chapter 2.

2 General

The ABS Rule set, as applicable for the vessel's base Class notation, applies in full for hull construction and equipment except as modified herein. Subsection 2/1 of the *Power Service Requirements* is applicable.

Hull interface structures are to comply with the applicable requirements of the appropriate base ABS Rule set. Where heavy nuclear or other power plant equipment is installed, details of hull interface scantlings are to be submitted for review and calculations are to be submitted.

2.1 Inertial Forces

Empirical formulas are to be used to calculate the motions, accelerations, and resulting forces on structures and foundations due to motions at sea.

Note that the most severe accelerations are expected to be those that occur when the vessel is underway or under tow. However, for structural load assessments, the most severe loading conditions are assumed in the calculations. Reduced motions, accelerations and resulting forces on structures and foundations due to motions can exist where the vessel does not experience such attitudes, for example, when installed or operating on station in protected waters.

Commentary:

Formulas and methodologies to investigate motion are provided to understand the inertial loads experienced by structural elements onboard. In addition to evaluating the foundation structures of the NPP, the Nuclear Regulator is also to consider the typical and extreme inertial loads during the approval of nuclear reactor and nuclear safety systems.

End of Commentary

Equations in the Rule set most appropriate for the hull forms are to be used as follows:

- Vessels > 90m:
  - Full Form Vessels (Block Coefficient > 0.8): 5A-4-3/3 of the *Marine Vessel Rules*.
  - Fine Form Vessels (Block Coefficient < 0.8): 5C-5-3/5.5 of the *Marine Vessel Rules*.
- Vessels ≤ 90 m: 5D-5-3/5.3 of the *Marine Vessel Rules*.
- Barges: 5-3-3/5.7.1 of the *Barge Rules*.
- For column-stabilized units or other offshore surface units, refer to the Section 3-1-3 of the *MOU Rules* for environmental loadings.

Alternatively, accelerations derived from other recognized standards or direct calculations, model tests considering the most severe environmental conditions the vessel is expected to encounter may be considered. Seakeeping analysis or model tests may be accepted subject to ABS review.

See Subsection 5/3 for Design Angles of Inclinations for machinery.

2.2 Materials

These Requirements are intended for marine and offshore units designed and constructed of steel materials having properties as specified in the ABS *Rules for Materials and Welding (Part 2)*.

The use of steel or other materials that have properties different from those specified in the ABS *Rules for Materials and Welding (Part 2)* and the corresponding scantlings are subject to case-by-case review and approval by ABS.

3 Ship Arrangements

The vessel is to *be divided into areas classified on the basis of radiation hazards actually or potentially present [A.491(XII) 3.1.1]. Taking into account the nature of the radiological hazard in controlled and*

supervised areas, access barriers, protective clothing, personnel monitors, washing facilities and changing rooms are to *be located, as needed, between controlled or supervised areas and adjacent uncontrolled areas, to prevent the transfer of contamination from one area to another. Warning signs* are to *be placed at the entrance to a controlled or supervised area to indicate the hazards. Access to a controlled area* is to *be limited to authorized persons and their entrance and exit* is to *be registered [A.491(XII) 6.2.5]*.

Systems containing radioactive material including high-level radioactive waste which require protection of their integrity in case of a collision, are to *be located inboard of the collision protection [A.491(XII) 3.1.13.1]*.

Where explosive gas atmospheres may exist in spaces onboard or on deck, hazardous area zones are to be evaluated and established according to IEC 60079 Series of Explosive Atmosphere Standards, as applicable to the type of gas atmosphere that may exist. Refer specifically to IEC 60079-10-1:2020 Classification of Areas – Explosive gas atmospheres.

3.1 Reactor Compartment and Nuclear Power Plant (NPP) Arrangements

The reactor compartment is to *be bounded fore and aft and longitudinally by cofferdams or bulkheads extending from the* bottom or *double bottom* (as applicable) *to the bulkhead deck [A.491(XII) 3.1.2.2]*.

3.1.1

The use of cofferdams, double bottoms, and double hull arrangements comprising the boundaries of the reactor compartment, as applicable, are to be *restricted to the carriage, if any, of non-potable water [A.491(XII) 3.1.3]*.

3.1.2

The lower extent of the outermost shielding barrier is not to be less than B/15 or 2 meters (6.56 ft) above the bottom, whichever is greater, for ships and barges, or not less than 3 m (9.84 ft) above the bottom for non-ship-shape units *[A.491(XII) 3.6.1]*.

3.1.3

The longitudinal watertight, gastight bulkheads forming the sides of the outermost shielding barrier are to be located outside of the damage extent regions:

- For Ships and Barges, *inboard of the ship's side at least* B/5 or 11.5 m (37.73 ft), whichever is less *[A.491(XII) 3.1.10]*.
- For column stabilized units, 3.0 m (10 ft) inboard of the region between 5.0 m (16.4 ft) above and 3.0 m (10 ft) below the draft under consideration. Refer to 3-3-2/3.5.2 of the *MOU Rules.*
- For tension leg platforms (TLPs) and SPAR installations, 1.5 m (5 ft) inboard of the hull plating region between 5.0 m (16.4 ft) above and 3.0 m (10 ft) below the draft under consideration. Refer to 5B-2-2/1.1 and 5B-3-2/1.5.3 of the *FPI Rules*, respectively.
- The damage extent regions of other types of units are to be specially considered by ABS for review.

The damage extent regions from the side shell need not be considered a double hull limited to carrying ballast or potable water; other functional spaces or rooms may be fitted in those areas.

3.1.4

When collision protective structures specifically designed to limit penetration […] are fitted abreast of the reactor compartment, a lesser extent of side or bottom *damage* may be accepted than those provided in 4/3.1.2 and 4/3.1.3*, subject to an equivalent protection against flooding be provided,* the results of the risk assessment and subject to the approval of the Flag Administration and Nuclear Regulator *[A.491(XII) 3.4.3.4]*.

3.2 Reactor Control Rooms

The main reactor control room or rooms (in the case of multiple NPP units onboard) are to *be in the least vulnerable position (to fires, missiles resulting from explosions, toxic substances, radioactivity, etc.)* as identified in the Risk Assessment 3/2 viii) *[A.491(XII) 3.1.13.4]*.

3.3 Structures

Hull structures and arrangements are to meet the base ABS Rules and be acceptable to the Flag Administration and port state administration(s) unless provided otherwise by these Requirements.

Foundations for the reactor compartment and containment structures are to be designed with consideration given to:

- loads under any inclination *[A.491(XII) 3.3.8]*, see Subsection 5/3;
- thermal stresses *[A.491(XII) 3.3.8]*;
- accessibility for inspection and maintenance activities *[A.491(XII) 3.3.8]*;
- normal deformation of the unit, and deformations under extreme conditions *[A.491(XII) 3.3.10]*;

3.4 Subdivision and Stability

Stability is to meet the base ABS Rules and be acceptable to the Flag Administration and port state administration(s) unless provided otherwise by these Requirements.

The stability analysis demonstrating that the vessel meets the stability criteria is to be submitted for ABS review and approval.

3.4.1 Ship-shapes and barges

The subdivision and damage stability requirements of IMO Resolution A.491(XII) Section 3.4 are applicable.

3.5 Bilge

Bilge pumping installations, serving compartments into which radioactive liquids may leak in normal service, are to *be separate from and independent of the* vessels' *main bilge system [A.491(XII) 5.4.3]*.

SECTION 5
Nuclear System

1 General

It is the responsibility of the Nuclear Regulator to license the reactor and applicable nuclear safety structures, systems and components. Items and responsible authorities are to be identified in the Interface Document as appropriate.

This section is intended to provide operational considerations and criteria for nuclear systems subject to approval by the Nuclear Regulator, unless subject to Classification approval as identified in the Interface Document, with appropriate definitions of the scope of involvement, references to tests and procedures, and inspection/test frequencies provided in the associated onboard system integration test plan (see 2/3.1.2) and ISIP (see 2/3.1.3) plan, as applicable.

1.1 Goals

The nuclear system is to be designed, constructed, operated and maintained to:

Goal No.	*Goal*
STRU 2	withstand structural failure associated with accidental conditions.
SAFE 5	eliminate *unreasonable radiation or other nuclear hazards, at sea or in port, to the crew, passengers or public, or to the waterways or food or water resources (SOLAS VIII/Reg 6)*.
SEC 1	have suitable (physical) security arrangements and plans to reduce the internal and external security risks that vessels may face on voyages.
SEC 6	minimize the risk of unauthorized proliferation of nuclear material.
ENV 7	minimize the negative impact of vessel decommissioning.
ENV 10	have provisions in place for the safe handling, storage, and disposal of radioactive waste.
AUTO 1	perform its functions as intended and in a safe manner.
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance.
AUTO 3	have an alternative means to enable safe operation in the event of an emergency or failure of remote control.
AUTO 4	provide the equivalent degree of safety and operability from a remote emergency location as those provided by the main reactor control rooms.
AUTO 5	be provided with a safety system that automatically leads machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment.

Goal No.	*Goal*
AUTO 6	independently perform different functions, such that a single failure in one system will not render the others inoperative.
AUTO 7	enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment.
MGMT 5.1	facilitate safe access, ease of inspection, survey, and maintenance of the vessel, machinery and electrical systems.

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, maintenance, and decommissioning of nuclear power systems are to be in accordance with the following functional requirements:

Functional Requirement No.	*Functional Requirements*
SAFETY OF PERSONNEL (SAFE)	
SAFE-FR1	As far as reasonably practicable, radiation *exposure of those on board, the public and the environment* is to *be* minimized *[A.491(XII) 2.1.1.1: Criterion A]*.
SAFE-FR2 (AUTO)	*Means* are to *be provided to control and shut down the reactor safely and to maintain it in that state as long as necessary [SOLAS CH VIII A.491(XII) 2.1.1.3 Criterion C]*.
SAFE-FR3	Arrangements are to be provided for ready access to systems for the purpose of inspection, maintenance or repair, as applicable.
SAFE-FR4[1]	Radiation *shielding* is to *be arranged so that manning of essential control positions is possible* without exceeding personnel limits *for a reasonable period following* any incident conditions *[A.491(XII) 3.1.13.8]*.
SECURITY (SEC)	
SEC-FR1[1]	safeguard nuclear material.
SEC-FR2[1]	nuclear fuel is to be sealed from personnel contact and controls in place to verify the seal for the duration of the time in which fuel is handled prior to, during, and after its use on board.
SEC-FR3 (EER)[1]	*No security measure* is to *prevent the immediate egress of a person from any compartment in the ship in the event of a fire or other emergency, nor prevent entry into a compartment as required for the performance of safety functions [A.491(XII) 3.10.2]*.
SEC-FR4[1]	*Security measures against malevolence* are to be arranged *to achieve protection of the* asset *and fissile material on board. Security and safety measures* are to *be consistent and harmonized [A.491(XII) 3.10.1]*.
AUTOMATION (AUTO)	
AUTO-FR1[1]	Systems for reactor controls are to be operable such that the reactor can be placed in a subcritical state *without exceeding any of the specified fuel* or other *design limits [A.491(XII) 2.1.2.3.2]*.
AUTO-FR2	protection and safety systems are to start or operate automatically during the initial period of an emergency situation.
AUTO-FR3	*Reactor safety systems as well as their energy supplies should be designed to operate when the* vessel *is experiencing a static* or dynamic inclination according to design operational conditions *[A.491(XII) 2.3.10]*. See 5/3.

Functional Requirement No.	*Functional Requirements*
AUTO-FR4[1]	*The design* is to be such *that an operator can resume control of safety protection system functions but cannot* override *correct safety system action* except as allowed by specific, approved operating procedures consistent with qualified operating procedures *[A.491(XII) 4.1.4]*.
AUTO-FR5	*Separate and remote from the* main *reactor control rooms, a separate emergency control position* is to *be provided* for each NPP. *From this position, the means of reactivity control* are to *be designed to be operated, with the capability of rendering and maintaining* reactor shutdown *[A.491(XII) 4.3.2.7]*.
AUTO-FR6	*Failure of any control component* shall not *prevent the safe shutdown of the reactor [A.491(XII) 4.4.1]*.
AUTO-FR7	In the case that nuclear plant power output is lost, the power supply to reactor controls, reactor cooling, emergency cooling systems and reactor safety equipment including lighting and ventilation, if arranged, are to remain available independently as long as required to support safe shutdown, cooldown and maintenance of a safe state.
AUTO-FR8	*Reactivity control systems, reactor safety systems as well as their energy supplies* are to be *fully operable within all* possible design or operational conditions *and be capable of functional testing, periodic calibration of instruments* over *the entire range of reactor power, and verification of proper functioning of instrumentation [A.491(XII) 4.3.2.4]*.
SAFETY MANAGEMENT (MGMT)	
MGMT-FR1	*System design* is to *permit periodic in-service inspection and testing without loss of safety protection [A.491(XII) 4.1.1]*.

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the Interface Document. Refer to the Conditions of Classification Part 1D, Chapter 2.

2 Reactor

The NPP is not to be used for propulsion, positioning, or maneuvering of the vessel.

Nuclear reactors are to be licensed by a recognized authority as approved by the Flag Administration. The design, testing, construction, inspection, and maintenance of the NPP, including the core, containment, cooling circuits and supplies, controls systems, safety equipment and quality assurance program are to be approved and certified by a recognized organization as approved by the Flag Administration provided they are designed such that they will function properly under the environmental conditions specified by the Owner.

The structures, systems, and components subject to the Nuclear Regulator approval and the associated verification and validation (V&V) of construction, installation, maintenance and operation are outside the

scope of ABS Classification review. Plans and documents are to be submitted to ABS regarding the nuclear systems, including the Interface Document defined in 2/3.1, for information to verify that the goals and functional requirements of Section 5/1.1 and 5/1.2 are addressed in the design, construction, and verification and validation plans as approved by the nuclear licenser.

Commentary:

Refer to available IAEA Safety Standards, Guidelines, and other publications provided by nuclear licensers. For the quality assurance program, reference is made to IAEA GSR Part 2 Leadership and Safety (2016), GS-G-3.1 *Application of the Management System for Facilities and Activities (2006),* and GS-G-3.5 *the Management System for Nuclear Installations (2009).*

End of Commentary

2.1 Reactor Safety Functions

To provide for the reactivity control system and reactor safety and protection systems, at least two independent sources of power are to *be available [A.491(XII) 4.3.3].*

3 Inclinations

The design of the nuclear reactor is to consider potential angles of inclination during operations. Documentation is to be submitted that define the environmental limits for all possible design or operational conditions, including the limiting inclination conditions for each.

Inclination requirements of 4-1-1/Table 7 of the *Marine Vessel Rules* are applicable to ship or barge-type vessels. 4-1-1/Table 1 of the *MOU Rules* are applicable to column-stabilized units or other offshore surface units.

Commentary:

Formulas, simulations and methodologies to investigate inclinations are provided to evaluate the continued operation of essential marine equipment at extreme dynamic and static angles. However, expected inclinations are also necessary to consider the design of nuclear reactor and nuclear safety systems at these potential conditions.

End Commentary

The equipment manufacturer is to submit:

- Test reports showing operation under maximum angles of inclination, or
- Calculations or simulation, or
- Evidence of satisfactory service experience under inclination.

In addition to the applicable design inclinations specific to installations or components, the inclination requirements under the conditions of 5/Table 1 apply.

TABLE 1
Inclinations

	Angle of inclination, degrees [1]			
	Athwartship		*Fore-and-aft*	
Installations, components	***Static***	***Dynamic***	***Static***	***Dynamic***
Reactor Safety Systems and their Energy Supplies, including emergency energy supplies [A.491(XII) 2.3.10]	30	45	10	15

Note:

1 Athwartship and fore-and-aft inclinations are assumed to occur simultaneously.

3.1 Emergency Shutdown System at Inclinations

Emergency *shutdown system* is to *be designed for, and be capable of shutting down the reactor at angles of up to 90° and be capable of maintaining the reactor in shutdown condition at all angles [A.491(XII) 4.3.1.4]. In addition, the reactor* emergency *shutdown system* is to *operate automatically at smaller inclinations for safety reasons when:*

i) flooding occurs within reactor containment *[A.491(XII) 4.3.1.4.1]; or*

ii) *the* vessel *becomes submerged [A.491(XII) 4.3.1.4.2]; or*

iii) *the* vessel *heels to an angle of 45° or is trimmed to 10° inclination either way in the fore and aft direction or the* vessel *heels to the angle of vanishing intact stability, whichever is less [A.491(XII) 4.3.1.4.3].*

3.2 Inclination Exceptions

Reduced design angles of inclination than those provided in 5/Table 1 and 5/3.1 are subject to special consideration where it is proven that the vessel does not experience such attitudes. The allowed reduction is to be included in the risk assessment per Subsection 3/2 in either the intact or damaged condition.

4 Reactor Control Functions

To control and shut down the reactor safely and to maintain it in that state as long as necessary, the below are applicable:

- Safety systems for reactor controls and management in regular or subcritical states are to be provided.

See Section 9 for requirements for control, monitoring and safety systems related to the NPP.

The design of the NPP is to be such *that human action is not required to start or operate protection and safety systems during the initial period of an emergency situation [A.491(XII) 1.3.5.3].* These protection and safety systems may be necessary *to place the reactor plant in a safe condition* or initiate the normal operation of the residual heat removal systems, as applicable *[A.491(XII) 4.1.4].*

ABS *Requirements for Autonomous and Remote Control Functions* associated with autonomous or remote control functions that are necessary for vessel operation, safety of life at sea or protection of the marine environment are applicable. See Section 9 for additional requirements for Control equipment subject to Classification Review and approval.

4.1

Complete control of the reactor is to *be possible from the main reactor control room* or rooms*, which* are to *be equipped to operate and monitor the reactor(s) and all related safety systems under* the defined *normal and emergency* operating *conditions [A.491(XII) 4.4.3].*

4.2

The emergency control position is to *be equipped with instrumentation and controls for [A.491(XII) 4.4.4]:*

i) *independent initiation of* reactor shutdown processes *[A.491(XII) 4.4.4.1]*

ii) *monitoring the reactor condition and maintaining it in shutdown state [A.491(XII) 4.4.4.3]; and*

iii) *removal of residual heat from the reactor [A.491(XII) 4.4.4.4].*

5 Reactor Cooling Systems

5.1 Primary Heat Transfer System

5.1.1

Supply of coolant *for domestic […] purposes* is not to *directly employ* the coolant material within the primary heat transfer system *[A.491(XII) 3.12]* to minimize the risk of radiation exposure.

5.1.2

Where subject to Classification review according to the interface document, *fluid systems and pressure vessels* are to *[…] include provisions for [A.491(XII) 4.1.2]:*

i) *initial pressure testing;*

ii) *periodic inspection and/or pressure testing;*

iii) *periodic testing […] of penetrations* for radiological leakage*;*

iv) *system isolation;*

v) *surveillance programs;*

vi) purging or *flushing of systems after initial installation, modification or repairs; and*

vii) *overpressure protection, as applicable.*

5.1.3

Systems essential to operation or safety of the primary heat transfer system are to *be capable of being manually controlled, in addition to any automation provided [A.491(XII) 4.1.3].*

5.1.4

In addition to satisfying the requirements of the base ABS Rule set, means are to be provided for detecting reactor coolant leakage for pressure vessels, pressure boundaries, pressure relief systems and penetrations to boundaries that contain or may contain primary coolant, as applicable [A.491(XII) 4.6.1]. See Section 9.

6 Security

Arrangements for security purposes are to be established by the Nuclear Regulator and take into account credible incidents or situations that may lead to security-related risks. The ISPS Code is to be referred to for the vessel.

Commentary:

Note that the ISPS Code is also to be referred to for port facilities.

End of Commentary

Security arrangements, including necessary structures, systems and components, are to be included in the interface document as defined in 2/3.1, including the responsible authority to review, approve, and verify compliance with the identified security code or standard. Additional security requirements or arrangements may be established by the Flag Administration or Port State Administrations.

Security information is to *be in accordance with the requirements of the appropriate authorities* for the management of classified or protected information *[A.491(XII) Appendix 3/11.3].*

SECTION 6

Radiological Protection and Nuclear Material Handling

1 General

It is the responsibility of the Nuclear Regulator to License the reactor and applicable nuclear safety structures, systems and components. Items and responsible authorities are to be identified in the Interface Document as appropriate.

This Section *sets out the basic principles and requirements for radiological protection and radioactive waste management having a bearing on the design, construction and operation of a* nuclear power service vessel *[A.491(XII) 6.1.1]*.

1.1 Goals

The vessel and nuclear system are to be designed, constructed, operated, maintained, and decommissioned to:

Goal No.	*Goal*
ENV 10	have provisions in place for the safe handling, storage, and disposal of radioactive waste.
ENV 13	provide means to monitor and record environmental discharges.
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
SAFE 1	promote the occupational health and safety of personnel onboard.
SAFE 4	provide for health protection and prompt access to medical care onboard vessel and ashore.
SAFE 5	eliminate *unreasonable radiation or other nuclear hazards, at sea or in port, to the crew, passengers or public, or to the waterways or food or water resources (SOLAS VIII/Reg 6)*.
SEC 6	minimize the risk of unauthorized proliferation of nuclear material.
AUTO 1	perform its functions as intended and in a safe manner.
FIR 1	*prevent the occurrence of fire and explosion (SOLAS II-2/Reg 2.1.1)*.

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of nuclear power systems are to be in accordance with the following functional requirements:

Functional Requirement No.	*Functional Requirements*
PROTECTION OF ENVIRONMENT (ENV)	
ENV-FR1 (SAFE)	manage and store radioactive waste streams to prevent unreasonable radiation into the sea or air.
ENV-FR2 (SAFE)	systems, structures or components that may exhibit radioactive characteristics or produce ionizing radiation are to be designed as far as reasonably practicable to facilitate transport and removal during safe disposal or decommissioning, as applicable.
ENV-FR3[1] (SAFE)	*Structural and surface irregularities are to be avoided in systems and equipment containing radioactive materials to minimize the difficulties of decontamination procedures and to permit proper control of the radioactive wastes which arise [A.491(XII) 6.2.9].*
SAFETY OF PERSONNEL (SAFE)	
SAFE-FR1	*Releases of radioactive products, under* all possible design or operational conditions *including decontamination procedures,* are to *be prevented or controlled to the dose limits by the provision of a series of successive physical barriers* or abatement systems *between the nuclear fuel and the environment* and administrative controls *[A.491(XII) 1.3.5.1, 6.2.8].*
SAFE-FR2	As far as reasonably practicable, radiation *exposure of those on board, the public and the environment* is to *be* minimized *[A.491(XII) 2.1.1.1 Criterion A].*
SAFE-FR3 (ENV)	*Design* is to *provide for the safe management*, control and treatment *of radioactive wastes* to keep exposure to *within the* dose limits *[A.491(XII) 6.5.1]*. Provisions for the remote handling of radioactive wastes are to be provided consistent with the waste radioactivity levels.
SAFE-FR4	*Means should be provided to remove residual heat safely from the* nuclear fuel *[A.491(XII) 2.1.1.2]* in all possible design or operational conditions.
SAFE-FR5	*The number of penetrations of the boundaries of the reactor compartment* and any radiological barriers *are to be minimized as much as practicable [A.491(XII) 3.1.12].*
SAFE-FR6	*Storage, onboard processing (if any) and transportation facilities and discharge pipelines for radioactive waste materials are to be arranged in such a way that any uncontrolled release of radioactive substances to the environment or into other compartments of the vessel will be prevented [A.491(XII) 6.5.7].*
SAFE-FR7	Boundaries of the reactor compartment or boundaries within the space of the reactor compartment, including access openings that form watertight, gastight or fire protection divisions are to maintain the integrity of the division in which they are located [A.491(XII) 3.11].
SAFE-FR8	Any containment structure and related systems for the protection of unacceptable release of radioactive material are to be designed *so that the consequences of any such release are within the* established *limits [A.491(XII) 4.11.1.1].*
SAFE-FR9	Measures to contain radioactive materials and attenuate ionizing radiation are to be taken when the ship is being designed, constructed, commissioned, operated and decommissioned [A.491(XII) 1.3.2].
SECURITY (SEC)	
SEC-FR1[1]	physically protect and safeguard nuclear material.
AUTOMATION (AUTO)	
AUTO-FR1	Nuclear waste handling and monitoring arrangements and *their energy supplies,* as applicable, are to be *fully operable within all* possible design or operational conditions *and be capable of functional testing, periodic calibration of instruments […], and verification of proper functioning of instrumentation [A.491(XII) 4.3.2.4].* See Section 5/3.

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the Interface Document. Refer to Part 1D, Chapter 2.

2 Radiation Shielding and Radiological Safety

The dose, as defined in Subsection 2/2, *likely to be received by persons on board or in the vicinity of the ship during normal operation* are not to exceed *the dose limits or, where they exist, the individual limits set by the competent authority [A.491(XII) 1.3.8].* Refer to ICRP Publication 103.

Protection against the effects of radiation is to *be provided by applying, either singly or in combination:*

1) radiation *shielding arrangements;*

2) *controlled areas of the ship,* as defined in Subsection 2/2*;*

3) limited *exposure times; and*

4) limiting the distances from and the prevention of *the unnecessary approach of persons to sources of radiation*

2.1

Sequential radiation shielding barriers are to be arranged to prevent unintentional release and limit the exposure to radiation and the leakage of radioactive material in all possible design or operational conditions.

Sequential radiation shielding barriers are to be sufficient such that the vessel shell is not to be considered as a radiation shielding barrier in any operating condition.

2.1.1

The specific functions of the arrangement of sequential radiation shielding barriers are identified below:

i) *to prevent and control (including monitoring, delaying and processing) the releases of radioactive material to the other parts of the ship and to the environment from other sources of radioactivity it may contain [A.491(XII) 3.1.5.2]; and*

ii) *to ensure, […] that there remains at least one physical barrier between irradiated fuel and the environment with the gastightness and watertightness required for nuclear safety [A.491(XII) 3.1.5.3].*

2.1.2

Compartment bulkhead isolations, shielding and engineered protective measures are to be arranged to *confine for treatment and controlled release to the environment by the off-gas ventilation system: [A.491(XII) 3.1.6]*

i) *radioactive material which may leak from the* reactor*, or from a small line rupture outside the containment structure [A.491(XII) 3.1.6.1]; and*

ii) *radioactive material leaking from an open containment structure, or from high or medium level waste storage containers within the* reactor compartment *[A.491(XII) 3.1.6.2].*

Note: *The off-gas ventilation system, in case of release, filters and cleans gaseous waste* to less than specified release limits *before discharge to the environment.*

2.1.3

Sequential barriers *are to be located entirely within the* NPP boundaries *and within the structural boundaries designed to protect it and its contained equipment from the external hazards of marine application [A.491(XII) 3.1.8].*

2.2 Containment System

2.2.1 Penetrations

i) Penetrations of the boundaries of the reactor containment systems are to be limited to those required for nuclear safety.

ii) *Access openings in boundaries of the reactor compartment or in the boundaries of spaces within the reactor compartment which form watertight, gastight or fire protection divisions,* are to *be fitted with closures which will maintain the integrity of the* watertight, gastight or fire protection *division in which they are located. Where necessary for security or safety purposes, closures* are to *be provided with appropriate arrangements for local and remote operation. Provision* is to *also be made, by airlock arrangements if necessary,* so *that required air pressure differentials, where provided between adjacent compartments, are not rendered ineffective during operation of access closures [A.491(XII) 3.11].*

2.2.2 Overpressure protection

Overpressure protection is to be provided in a redundant arrangement such that no contaminated radioactive material above acceptable exposure limits are released into the environment or into onboard spaces in any operational condition [A.491(XII) 4.6.4].

2.3 Radiological Protection

See Section 9 for requirements related to dosimetry and radiation monitoring.

2.3.1

Onboard areas are to be *designated according to the actual or potential magnitude of the radiological hazard involved. Taking into account the nature of the radiological hazards in controlled and supervised areas, access barriers, protective clothing, personnel monitors, washing facilities and changing rooms* are to *be located, as needed, between controlled and supervised areas and adjacent uncontrolled areas, to prevent the transfer of contamination from one area to another. Warning signs* are *to be placed at the entrance to a controlled or supervised area to indicate the hazards. Access to a controlled area* is to *be limited to authorized persons and their entrance and exit* is to *be registered [A.491(XII) 6.2.5].* Depending on radiological or hazardous conditions, boundaries may be required to be locked or guarded.

2.3.2

The vessel *is to be equipped with […] means of individual protection including filter respirators and air-supplied sets to deal with* all possible design or operational conditions *[A.491(XII) 6.3.4].*

2.3.3

Onboard *procedures* are to *address radiation protection procedures for crew members under all* possible design or operational conditions, including *[A.491(XII) 6.3.5]*:

i) *Systematic and thorough surveying of work areas prior to commencement of work;*

ii) *Planning of work and worker occupancy time in the work area, to provide that individual radiation exposures* are *within* dose *limits;*

iii) *Estimation of individual radiation exposures for the work planned;*

iv) *Selection and number of the necessary personnel dosimeters, protective clothing, respiratory, and communication equipment for each worker;*

v) *Administrative controls, to preclude inadvertent exposure to unexpectedly high radiation levels during maintenance and inspection;*

vi) *Prophylactic measures and decontamination of contaminated workers and* equipment*; and*

vii) *Radiation emergency procedures on board, including interfacing with the* Flag and Port *Administration's port contingency plan, and regular periodic exercise of emergency plans* through training, qualification and drills.

3 Radioactive Waste Handling

Commentary:

Refer to existing standards and regulations for radioactive waste handling, including, but not limited to, the IAEA GSR Part 5 *Predisposal of Radioactive Waste*, IAEA SSR-6 *Safe Transport of Radioactive Material*, IMO INF Code, IMDG Code, and IBC Code.

End of Commentary

3.1

The design, manufacture, operation, and testing of the handling, storage containment, and transfer systems for solid, liquid and gaseous radioactive wastes are to be in accordance with recognized standards approved by the Flag Administration and Port State Administration.

3.2 Solid Radioactive Waste

Commentary:

Solid radioactive wastes containing radioactivity or originating from the NPP may include ion exchange resins, filters, and miscellaneous items such as contaminated clothing, tools and items from the sampling laboratory.

End of Commentary

3.2.1

Solid radioactive waste is to *only be discharged to properly equipped dockside* or floating *facilities and not to the sea [A.491(XII) 6.7.2].*

3.2.2

Prior to storage, solid radioactive wastes are to *be segregated […] according to their activity, types of radiation emitted, chemical activity, combustibility, etc. [A.491(XII) 6.7.3].*

3.3 Liquid Radioactive Waste

Commentary:

Liquid radioactive wastes may derive from *primary coolant resulting from thermal expansion as the reactor is brought to operating temperatures; operational leakages and wastes originating from* […] *circuits, equipment and personal decontamination, laundry, sampling and other miscellaneous sources; and repair and maintenance work [A.491(XII) 6.8.1.1-6.8.1.3].*

End of Commentary

3.3.1

The discharge of large amounts of chemically toxic and radioactive wastes, which may result from major decontamination procedures requiring draining of radioactive circuits, is to *be carried out using special facilities complying with the requirements of the* Flag *Administration* and Port/ Coastal Administration *where the discharge takes place. The facilities* are to *provide for the transfer of liquid radioactive wastes from the* vessel *to the shore, or to special floating facilities, by separate systems, one intended for* high level radioactive *wastes and the other for* low-level radioactive *wastes [A.491(XII) 6.8.2],* as applicable. The Flag Administration is to identify the standard for defining low-level and high-level radioactive wastes.

3.3.2

Radioactive liquids are to *be collected and stored on board* the vessel *in closed containers or tanks, if their discharge would exceed the* dose *limits [A.491(XII) 6.8.3].*

3.3.3

Provisions for the storage of liquid radioactive wastes include:

i) Liquid radioactive wastes are to *be segregated on the basis of their physical and chemical nature and/or their radioactive characteristics, such as specific activity or isotope content [A.491(XII) 6.8.4.1];*

ii) The means to remove *unwanted sludge from systems [A.491(XII) 6.8.4.2];*

iii) *A monitoring system and delay tanks […], with arrangements for determining the volume and radioactivity of their contents as well as the rate at which these contents are released to the environment.* See 10/3.1.2. *Design is to account for further treatment of contents, if required [A.491(XII) 6.8.4.3];*

iv) *Each discharge and transfer line handling radioactive waste is to have automatic isolation capability, to prevent inadvertent or uncontrolled releases [A.491(XII) 6.8.4.4];*

v) *The capacity of liquid radioactive waste storage tanks is to accommodate all bilge liquids produced in the* reactor compartment *and other controlled areas in* design basis or design basis accident *conditions [A.491(XII) 6.8.4.5];*

vi) *Cooling and shielding arrangements are to be provided as applicable for treatment and storage facilities according to the physical and chemical properties of the stored liquid [A.491(XII) 6.8.4.6]*

3.4 Gaseous Radioactive Waste

Commentary:

Gaseous radioactive waste may result from *neutron activation of the primary coolant and its impurities; the escape of gaseous and volatile fission products from defective fuel elements; and direct neutron activation of the air of the containment structure [A.491(XII) 6.9.1].*

Typical discharge sources may include leakage from the primary coolant; venting of the primary circuit; venting of the waste tank gas spaces; and venting of the containment structure volume [A.491(XII) 6.9.2].

End of Commentary

3.4.1

Gaseous radioactive waste *discharge lines* are to *be equipped with isolation capability to prevent inadvertent or uncontrolled releases [A.491(XII) 6.9.5].*

3.4.2

It is to *be possible to monitor the activity or radiation level […] in the storage container area [A.491(XII) 6.9.6].*

4 Residual Heat Removal Arrangements

For the purpose of residual heat removal, as defined in Subsection 2/2, it is necessary to:

i) *transfer residual heat from the* nuclear fuel *to an ultimate heat sink [A.491(XII) 2.1.2.2.1].*

ii) *to maintain sufficient coolant inventory*, as applicable *[A.491(XII) 2.1.2.2.2].*

iii) *to provide services necessary for safety systems* related to heat removal systems and coolant availability *[A.491(XII) 2.1.2.3.3].*

Commentary:

Residual heat removal requirements may take into account post shutdown situation of where at certain conditions, for example flooding or sinking, the residual heat removal systems may be less effective than heat loss to ambient.

End of Commentary

4.1

Residual heat removal arrangements are to be continuously operational during periods of reactor shutdown (cooldown) and dormancy. Redundancy or other system continuity is to be provided to continue operations in the case of any single failure.

4.2

Residual heat removal arrangement safety systems are to be continuously operational during all operational and emergency conditions. Redundancy or other safety system continuity is to be provided.

5 Ventilation

5.1

Ventilation systems serving spaces which contain or may contain radioactive material are to *be segregated from other ventilation systems, […]* and *segregated from spaces outside the controlled area, except where the ducts and stacks are suitably provided with shielding, protected* from incidents as defined in the risk assessment Subsection 3/2*, and […] gastight. [A.491(XII) 3.2.1]*

5.2

Exhaust ventilation systems serving spaces which contain or may contain radioactive material [A.491(XII) 6.10.2] are to *be monitored and controlled for possible radioactivity in accordance with* Section 10 *[A.491(XII) 3.2.2].*

5.3

Redundancy for ventilation and exhaust systems serving spaces which contain or may contain radioactive material *is to be* such that the capacity of the remaining ventilation fan(s) is not less than 100% of the total required after a single failure in any part of the system*. [A.491(XII) 3.2.5]*

5.4

For ventilation air flowing *from one space to another, the flow* is to *be from areas of lower potential airborne contamination to areas of higher potential airborne contamination [A.491(XII) 3.2.6].*

5.5

All ventilation inlets and outlets are to be arranged *to avoid the possibility of re-entry of discharged radioactive gases* or other harmful emissions.

Commentary:

A gas dispersion study may be done to identify potential hazardous areas according to expected harmful emissions. Refer to the ABS *Guidance Notes on Gas Dispersion Studies of Gas Fueled Vessels* or other recognized industry guidance or standard on gas dispersion modeling techniques such as computational fluid dynamics (CFD).

End of Commentary

5.6

Ventilation and filtration arrangements are to *be provided to maintain airborne radioactivity concentration in* all *spaces within* established dose-equivalent *limits*, *permit reactor containment structure purge capability, and prevent uncontrolled spread of airborne contamination [A.491(XII) 6.10.1].*

SECTION 7

Machinery, Electrical, Piping and Equipment

1 General

This Section covers main and auxiliary machinery and electrical systems required for vessel operation and safety but do not directly serve NPP related systems. Except where covered in this Section, conventional machinery and electrical requirements are to comply with the ABS base requirements.

1.1 Goals

The vessel and nuclear system are to be designed, constructed, operated and maintained to:

Goal No.	*Goal*
POW 1	provide safe and reliable storage and supply of fuel/energy/power.
POW 2	provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel.
POW 3	enable *all electrical services necessary for maintaining the vessel in normal operational and habitable conditions* to be available *without recourse to the emergency source of power (SOLAS II-1 Reg 3-7 and SOLAS II-1 Reg 40-1.1).*
POW 4	enable all electrical services required for safety to be available during emergency condition *(SOLAS II-1 Reg 40-1.2).*
POW 5	enable supply/power for essential services to be restored after malfunction.
SAFE 1	promote the occupational health and safety of personnel onboard.
MGMT 5.1	facilitate safe access, ease of inspection, survey, and maintenance of the vessel, machinery and electrical systems.
PROP 6	*be provided with* means *to enable the safe conduct of towing, mooring* and anchoring *operations (SOLAS II-1 Reg 3-8.2).*

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of machinery, electrical and piping systems are to be in accordance with the following functional requirements:

Functional Requirement No.	*Functional Requirements*
POWER GENERATION & DISTRIBUTION (POW)	
POW-FR1	Main and emergency electrical systems are to be capable of shutting down the reactor and maintaining a safe state for a sufficient period.
POW-FR2 (SAFE)[1]	Provisions are to be provided for rapid recovery to habitable conditions following the failure of a single component of the main electrical system generator or auxiliaries *[A.491(XII) 5.9.1.1.3].*
POW-FR3[1]	*The service generating capacity* is to *be sufficient to supply the full electrical power necessary for maintaining the ship in normal operational and habitable conditions [A.491(XII) 5.9.2].*
SAFETY MANAGEMENT (MGMT)	
MGMT-FR1 (SAFE)[1]	*Provisions* are to *be made to facilitate cleaning, inspection and maintenance of* […] *machinery, including arrangements for radioactive contamination, where required [A.491(XII) 5.2.1].*
PROPULSION, MANEUVERING, STATION KEEPING (PROP)	
PROP-FR1	Anchoring and mooring equipment, as applicable, are to have sufficient holding power to maintain the vessel in position based on the environmental conditions.

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the interface document. Refer to Part 1D, Chapter 2.

2 Onboard Facilities

Refer to the *Facilities Rules* for requirements for hydrocarbon production and/or processing facilities located on floating or fixed offshore facilities, as applicable.

Special consideration will be given to vessels fitted with industrial equipment not applicable to the *Facilities Rules* intended to be powered by the NPP, subject to Flag/Port State Administrations and the Nuclear Regulator.

3 Electrical Installations

3.1

The base ABS Rule set and the requirements in this Section apply for electrical installations except as modified herein.

The main electrical system is composed of service generators, standby generators and main distribution system, including energy storage systems such as batteries, *and* may supply *electrical power to both the* vessel *and reactor consumers [A.491(XII) 5.8.4].*

Commentary:

In a non-self-propelled vessel, where electrical power from NPP is stepped down to supply to the vessel consumers, the classification boundary is to be from and includes the main distribution board(s) to the vessel consumers. The NPP, distribution system and step-down transformers do not need to be classed. Refer to the requirements in Subsection 3/7 of the ABS *Power Service Requirements*.

End of Commentary

The emergency electrical system is that system, composed of emergency power sources and their associated distribution system, including energy storage systems such as batteries, *which supplies electrical power to consumers essential to* vessel *and reactor safety [A.491(XII) 5.8.7].*

Shore power supply is acceptable as either main source of power or emergency source of power provided requirements in 7/3.1.1 of this document, Subsections 3/7 and 3/9 of the ABS *Power Service Requirements*, whichever are more stringent, are complied with.

3.1.1

In any operational or accident condition*, the electrical system as a whole, excluding the generating sets dependent on* the NPP*,* are to *be capable of shutting down the reactor and holding it in* a safe *state for* a duration specified in the submittal documents, *assuming a single failure in the electrical system in addition to the initiating event which caused the […] condition [A.491(XII) 5.8.2].* Refer to 2/4 Table 3.

3.1.2 High Voltage Shore Power Connection

Vessels equipped with a high voltage shore power connection designed to power the vessel with the shore power alone, enabling the shipboard generators to be shut down while in port, are to comply with the requirements given in the ABS *Guide for High Voltage Shore Connection.*

3.1.3 Protection from Shore Distribution Faults

If the nuclear power service vessel provides power to shore, which may also augment other shore power generation sources as a parallel power source, the connection from the nuclear power service vessel to the shore distribution system is to be protected from shore power faults, frequency, and voltage variations in accordance with the applicable recognized codes/standards in the country where it is providing power.

4 Mooring Systems

The purpose of the position mooring system in this document is to keep the nuclear power service vessel on station at a specific site. The system includes mooring lines, anchors, mooring accessories, mooring equipment, and thrusters, where applicable.

For nuclear power service vessels, the mooring system design is to comply with the applicable requirements associated with the power service vessel's primary class notation (e.g., Barge, Floating Offshore Installation, Column-Stabilized Unit).

- Mobile Offshore Power Service vessels are to comply with the requirements contained in Section 7-1-9/15 and 7-1-A1 of the *MOU Rules*
- Site Specific Power Service vessels - Ship Type and Other Floating Installations: Section 7-1-3 of the *FPI Rules*.
- Nearshore Power Service vessels are to comply with the requirements contained in ABS *Guidance Notes on Nearshore Position Mooring*.

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SECTION 8
Fire Safety

1 Objective

1.1 Goals

The fire safety system is to be designed, constructed, operated and maintained to:

Goal No.	*Goal*
FIR 1	*prevent the occurrence of fire and explosion (SOLAS II-2/Reg 2.1.1).*
FIR 2	*reduce the risk to life caused by fire (SOLAS II-2/Reg 2.1.2).*
FIR 3	*reduce the risk of damage caused by fire to the ship*[1]*, its cargo and the environment (SOLAS II-2/Reg 2.1.3).*
FIR 4	detect, *contain, control and suppress or swiftly extinguish a fire in the compartment of origin (SOLAS II-2/Reg 2.1.4).*
ENV 10	have provisions in place for the safe handling, storage, and disposal of radioactive waste.
EER 1	*provide means of escape so that persons on board can safely and swiftly escape to* a protected place of refuge, muster station, or embarkation station *(SOLAS II-2/Reg 13.1).*

Note:

1 Here, the term ship is to be understood to have the same meaning as vessels, defined in Subsection 1/1.

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of fire safety systems are to be in accordance with the following functional requirements:

Functional Requirement No.	*Functional Requirements*
PROTECTION OF ENVIRONMENT (ENV)	
ENV-FR1 (FIR)[1]	fire extinguishing agents are to be able to be controlled in the case of radiation exposure and the need to decontaminate [A.491(XII) 3.9.3.1].
FIRE SAFETY (FIR)	

Functional Requirement No.	*Functional Requirements*
FIR-FR1[1]	fire detection, fire alarm and firefighting systems are to be suitable for the characteristics/operational requirements of the protected space with due regard to expected radiation levels, the fire growth potential and smoke generation.
FIR-FR2[1]	provide safeguards to prevent fire and explosion caused by leakage of flammable gas or liquids.
FIR-FR3	the design of structural fire protection *and the use and placement of fire protection equipment* is to *minimize the probability of hazard or damage to the* NPP system, the primary heat transfer system, *and its control systems resulting from a fire in a non-nuclear section of the* vessel *[A.491(XII) 3.9.4]*.
FIR-FR4[1]	*Where safety systems must meet their safety functions in case of a fire, segregation by suitable fire resistant structures* is to *be provided between redundant sections of the system or its subsystems [A.491(XII) 3.9.1]*.
FIR-FR5[1]	*Within spaces such as the reactor compartment and spaces containing equipment essential to the continued safe operation of the* NPP*, the use of combustible substances,* or those that may emit toxic substances in the case of fire, *and systems requiring* either of these *substances* are to *be avoided to the greatest possible extent [A.491(XII) 3.9.6]*.
ESCAPE, EVACUATION, RESCUE (EER)	
EER-FR1	*Escape routes from the main reactor control rooms and from the compartment in which the emergency reactor control position is located are to be provided with effective fire shelter from the compartment to the weatherdeck [A.491(XII) 3.9.5]*.
EER-FR2 (FIR)	*Combustible wastes* are to *be […] protected against fire [A.491(XII) 6.5.9]*.
AUTOMATION (AUTO)	
AUTO-FR4[1]	*The main reactor control rooms* are *to be constructed to afford its inhabitants radiation and fire protection during* conditions during which they must *remain manned [A.491(XII) 4.4.3.2]*.

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the Interface Document. Refer to the Conditions of Classification Part 1D, Chapter 2.

2 Requirements for Fire Safety

Requirements for fire safety (i.e., detection, extinguishing, structural protection) as provided in the base ABS Rule set are to be met, in addition to this Section.

The requirements of the ABS *Power Service Requirements* Subsections 4/5 and 4/7 are applicable.

Additional fire protection measures, including structure, systems and components may be required according to the risk assessment or other safety assessment.

2.1

Where use of combustible substances cannot be avoided, appropriate equipment and management procedures are to be described in the Operating Manual [A.491(XII) 3.9.6].

2.2

Systems within spaces such as the reactor compartment and spaces containing equipment essential to the continued safe operation of the primary heat transfer system […] are to be segregated and physically separated by structural fire protection and be provided with individual fire-extinguishing equipment [A.491(XII) 3.9.7].

2.3

The use of an emergency control position […] is to *enable the reactor to be brought to a cold shutdown condition, and kept in a cold subcritical condition while maintaining residual heat removal functions, in the event of a fire in the main* reactor *control room. Conversely, a fire at the emergency control position* is not to *affect the ability to control the reactor at the main* reactor *control room [A.491(XII) 3.9.8].*

3 Egress

3.1

At least two (2) means of escape are to *be provided from the main reactor control room and the compartment in which the emergency reactor control position is located. Each route* is to *provide* adequate structural fire protection *from the compartment to the weather deck [A.491(XII) 3.9.5].*

SECTION 9
Control, Monitoring & Safety Systems

1 Objective

1.1 Goals

The control, monitoring and safety systems are to be designed, constructed, operated and maintained to:

Goal No.	*Goal*
AUTO 1	perform its functions as intended and in a safe manner.
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance.
AUTO 5	be provided with a safety system that automatically leads machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment.
AUTO 6	independently perform different functions, such that a single failure in one system will not render the others inoperative.
SAFE 5	eliminate *unreasonable radiation or other nuclear hazards, at sea or in port, to the crew, passengers or public, or to the waterways or food or water resources (SOLAS VIII/Reg 6)*.
ENV 13	provide means to monitor and record environmental discharges.
SEC 6	minimize the risk of unauthorized proliferation of nuclear material.
COMM 2	provided with means for internal communications.

The goals covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of vessel systems are to be in accordance with the following functional requirements:

Functional Requirement No.	*Functional Requirements*
AUTOMATION(AUTO)	
AUTO-FR1 (ENV)	As far as reasonably practicable, monitor radiation at all times and in every compartment or area where the possibility exists and under all possible design or operational conditions.

Functional Requirement No.	*Functional Requirements*
AUTO-FR2 (ENV)[1]	The control and instrumentation systems are to provide an effective means for monitoring and controlling reactor status and physical characteristics of operation and other process variables for the safe and continuous operation of the vessel.
SECURITY (SEC)	
SEC-FR1[1]	access or penetration to any nuclear fuel system are to be continuously monitored and recorded.
SAFETY OF PERSONNEL (SAFE)	
SAFE-FR1 (ENV)[1]	Be equipped *with sufficient portable monitors for routine and emergency radiation surveys; this equipment* is to *include beta, gamma, and neutron survey meters, air samplers, and alpha/beta contamination monitors [A.491(XII) 6.4.7].*
SAFE-FR2[1]	*The quantity of personal dosimeters carried onboard* are to *meet the needs of normal service and* are to *be sufficient for all passengers and crew in the event of an accident [A.491(XII) 6.4.8].*
PROTECTION OF ENVIRONMENT (ENV)	
ENV-FR1	*Where provision is made to vent a containment structure to atmosphere after any postulated* condition*, such venting* is to *be capable of being controlled and monitored for radioactive material* and other hazardous gases. Vented material or gases are not to exceed permitted dose or exposure limits, as applicable *[A.491(XII) 3.1.11.10].*

Note:

1 No associated prescriptive requirements within this document. The appropriate review authority responsible for verifying conformity is to be provided in the Interface Document. In these cases, ABS is not to be identified as responsible.

The functional requirements covered in the cross-referenced Rules (Regulations/Guides/Standards, as applicable) and the applicable base ABS Rule sets are also to be met.

1.3 Compliance

In addition to the requirements from the Nuclear Regulator that covers this Section, a vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. The verifying authority is to be identified in the Interface Document. Refer to Part 1D, Chapter 2.

1.4 General

This Section defines criteria for the instrumentation and control systems for nuclear power service vessels.

When subject to Classification review according to the Interface Document in 2/3.1, as a minimum, control systems are to comply with Sections 4-9-3, 4-9-9, 4-9-10, 4-9-13, and 4-9-14 of the *Marine Vessel Rules* for computer-based systems and cyber resilience, regardless of **ACC**, **ACCU**, **ABCU** or **CR** notation.

The design of these systems is to comply with the requirements of the base ABS Rule set or other acceptable standards and the additional criteria contained in this Section.

i) Where control over the electrical power generation and distribution is required for the operation of the marine or offshore application, then the control system is to also be arranged to cover this.

ii) Control and instrumentation systems for NPP systems, including alarm and indicator devices, are to be suitable for the intended application, designed for use in a marine environment, resistant to corrosion, and capable of operating under anticipated environmental conditions.

iii) Control and safety shutdown systems are to be designed for safe operation of the equipment during start-up, shutdown and normal operational conditions.

2 Control Systems, Instrumentation and Automation

See Subsection 5/4 for requirements for reactor control.

2.1 Communications

At least one system of communication, which is to *be available in the event of complete loss of electrical power,* is to *be provided between each of the locations [A.491(XII) 5.3.1]:*

i) *Navigating bridge;*

ii) Main *reactor control rooms;*

iii) *Emergency control position;*

iv) *Machinery space containing main propulsion machinery, main service generating sets, standby generating sets and emergency generating sets;*

v) *The main and emergency machinery control rooms, if any; and*

vi) *Accessible spaces of the reactor compartment.*

3 Radiation Safety

When subject to Classification review according to the Interface Document in 2/3.1, the monitoring/alarm systems requirements provided in 4-9-2/7 of the Marine Vessel Rules are applicable for radiation monitoring and alarm systems.

3.1 Radiation Monitoring and Alarms

In all possible design or operational conditions and locations where radiation exposure pathways exist outside of the NPP, radiation *monitoring facilities, incorporating fixed* and *portable equipment as appropriate*, are to *be provided* throughout the vessel *to indicate and record radiation levels, airborne and surface contamination levels, radioactive concentrations, and flows [A.491(XII) 6.4.1]. The following* are to *be included:*

3.1.1

Measures to provide warning, including audible and visual alarms *[...] if predetermined levels of radiation, contamination, radioactive concentrations or radioactive flows are exceeded [A.491(XII) 6.4.1.1]*

3.2 Laboratory

Unless suitable facilities are available upon request as needed, the vessel is to *be provided with* a laboratory and *[...] laboratory equipment, satisfactory to the Flag Administration, for the analysis of radioactive samples [A.491(XII) 6.4.9].*

4 Monitoring and Safety Functions

When subject to Classification review according to the interface document in 2/3.1, the safety system requirements provided in 3-7/11 of the *FPI Rules* are applicable for radiation safety and nuclear power systems.

4.1

Portable radiation monitoring devices are to *be provided for use in* all *survival craft [A.491(XII) 3.8.1].*

4.2

Indications of radiation levels and of airborne contamination levels in controlled areas are to *be presented at a central control point.* If any significant increase in radiation level is detected within spaces, visual and audible alarms are to be arranged within each space *[A.491(XII) 6.4.3]*.

4.3

Radioactive monitoring and recording systems outside of the NPP are to *include:*

4.3.1

Fixed and portable equipment for assessing the concentrations and amounts of gaseous and airborne particulate radioactive material which may be released to the environment [A.491(XII) 6.4.10.1];

4.3.2

Installed equipment, including an *[...] alarm system, to monitor from the gaseous discharge lines the rate of release of radioactivity and the total activity released [A.491(XII) 6.4.10.3]*, as applicable*;*

4.3.3

Equipment to assess to a specified accuracy the activity concentration and total amount of liquid wastes in the collection, treatment and storage facilities [A.491(XII) 6.4.10.4], as applicable*;*

4.3.4

Equipment to determine the levels of specified radioactivity isotopes in liquid wastes prior to their discharge to the marine environment [A.491(XII) 6.4.10.5], as applicable*;*

4.3.5

Installed equipment, linked to a suitable alarm system and having the capability of automatically isolating the liquid waste discharge lines, to measure and record the activity concentration and the discharge flow rate where liquid waste discharge to the sea is permitted [A.491(XII) 6.4.10.6], as applicable*.*

4.3.6

Equipment for assessing the levels and types of radiation emitted by solid radioactive wastes, prior to segregation and treatment [A.491(XII) 6.4.10.7]; and

4.3.7

Procedures and testing and monitoring equipment to verify the correct operational condition of the waste management equipment [A.491(XII) 6.4.10.8].

5 Shutdown Systems

When subject to Classification review according to the Interface Document in 2/3.1, the shutdown systems requirements provided in 3-7/13.1 and 3-7/13.5 of the *Facilities Rules* are applicable for radiation safety and nuclear power systems.

SECTION 10
Survey & Testing

1 General

The objective of this section is to outline the class requirements for vessels classed for **Power Service (Nuclear)** to confirm that at the time of construction and during the Periodical Surveys (Annual, Intermediate or Special) the condition of the hull structure, equipment and piping systems are being maintained in satisfactory condition for the intended service. Objectives of this Section include:

i) Provide means to effectively evaluate the condition of the hull structure and equipment at Hull Surveys to demonstrate the vessel is maintained in a satisfactory condition.

ii) Examine and verify as far as practicable the vessel's hull and parts including hull plating and its closing appliances, watertight penetrations, weather decks, hatch covers and coamings, tanks and tank openings including gaskets, covers, coamings, venting systems and flame screens and safety systems as applicable are in satisfactory condition.

iii) Verify that all changes, repairs, replacements and upgrades have been approved, tested and found or placed in satisfactory condition.

In addition to the survey requirements identified in the base ABS Rule set and the requirements provided in the ISIP defined in 2/3.1.3, this Section is applicable.

2 Survey During Construction

The Onboard Systems Integration Plan defined in 2/3.1.2 is to include full interface and function test programs performed in the intended (or closely simulated) environment. The impact of the NPP and supporting structures, systems and components on the performance and integrity of other systems as well as the impact of other systems on the NPP itself are to be addressed.

An initial operational test and evaluation are to be performed to assess the operational effectiveness and suitability of the NPP in the intended environment. The operational test is to demonstrate that the operational aspects associated with the application of the NPP in a marine or offshore environment correspond with typical operational practice for these facilities.

Changes to the technology design or operational procedures may be necessary to address any issues encountered during integration and operational testing. The results of the system integration testing shall result in a modification to the ISIP. See 2/3.1.2 and 2/3.1.3 for submittal requirements of the system integration test plan and ISIP plan.

ABS Surveyor will witness the system integration testing and the ISIP Plan according to the Interface Document to verify that proper testing processes are satisfactorily complete, properly documented and meet the quality assurance requirements based on the witness points as agreed between the vendor/operator, Flag/Coastal State and ABS.

2.1 Surveys at Manufacturer's Facility

Construction and testing of nuclear power plant structures, systems and equipment are to be in accordance with the approved Interface Document.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required, the manufactured/assembled system components will be verified to be satisfactorily in compliance with the Interface Document. Surveyor's attendance is required typically for the following purposes:

i) To confirm that the facility to manufacture, fabricate, or repair structure, systems, and equipment has and maintains a quality control program effectively covering design, procurement, manufacturing and testing, as applicable, and meets the requirements of a recognized standard applicable to their product.

ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.

iii) To verify material certificates/documentation, particularly for materials of piping, radiation shielding structures or barriers, main pressure retaining parts of valves. Material testing is to be witnessed where required by the Interface Document and the *Marine Vessel Rules or MOU Rules,* as applicable.

iv) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.

v) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication process.

vi) To witness testing of subassemblies and completed units as called for in the fabrication process.

vii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.

viii) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as identified in the Interface Document and as agreed upon during the prefabrication meeting.

2.2 Surveys during Installation and Trials

This Subsection provides requirements for initial surveys during manufacturing, installation, and start-up (commissioning) of power generation and distribution systems installed on vessels as documented by ABS Engineering.

The requirements in ABS *Requirements for use of Lithium-Ion Batteries in the Marine and Offshore Industries* are to be complied with for Surveys during Construction for lithium-ion battery systems.

During construction, ABS Surveyors are to be provided access to manufacturers or fabricators' facilities to witness construction and/or testing as required by Part 4 of the *Marine Vessel Rules*, and the applicable design codes and/or standards.

The manufacturer/fabricator is to contact the ABS Surveyor to make necessary arrangements to examine systems, subsystem, equipment, and/or components.

The purpose of the initial onboard survey of equipment is to verify that the installation is in compliance with the ABS approved plans, with particular emphasis on examination of the following, as applicable:

i) Location of equipment in relation to any hazardous areas.

ii) Equipment orientation on the vessel, equipment structural arrangements, supporting foundations, securing details, and protective coating.

iii) Visual and/or non-destructive testing (NDT) examination of assembled and installed equipment, attachment on board, including underdeck support.

iv) Hook-up and integrity of equipment piping, electrical, machinery, and ventilation system, including watertight penetrations and integration with associated ship systems.

v) Piping system visual examination, NDT, and pressure test per applicable Rules or codes.

vi) Testing of pressure relief and safety valves for hydraulic/pneumatic systems on board.

vii) Visual examination of electrical equipment, wiring connections, cable routing, earthing, cable penetrations, and distribution panels to include testing of electrical systems and insulation tests.

viii) Lighting systems examination and test.

ix) Ventilation systems examination, ducting arrangements, penetrations, damper arrangements, operational tests.

x) Control systems, safety devices, and shutdowns to be tested to the satisfaction of the attending Surveyor.

xi) Fire/Safety measures such as fire control plan, emergency escape breathing devices (EEBDs), lifesaving appliances, as applicable, crew protection, general alarm/public announcement, fire detection, portable extinguishers, escape arrangements, main and emergency lighting, and any required emergency shutdowns.

xii) Compliance with any special requirements from the flag Administration, local codes, or regulations.

xiii) Commissioning of communication equipment related to nuclear power plant operation.

xiv) Safety functions of the containment structure are to be tested according to the system integration test plan identified in the following:

a) Pressure testing and testing for leaks according to the requirements provided in 5/5.1.5 and 6/2.2.

b) Visual and non-destructive examination for surface defects, flaws or cracks according to methodology and criteria identified in the ISIP plan. *This examination is to form the reference basis for later examinations* [*A.491(XII) 8.2.3.3]*.

c) *Prior to startup for the first time, the* sequential radiation shielding barriers is to *be tested for* ability to shield radiation*. The integral leak rate* is to *be determined by methods approved by the* Flag *Administration and is to be carried out subsequent to the pressure test [A.491(XII) 8.2.3.4]*.

2.2.1 Contents of an ISIP Plan

An In-Service Inspection Program (ISIP) as described in 2/3.1.3 is a long-term, comprehensive program that outlines the procedures to be followed and the inspection frequency of the structures, systems and components of the Nuclear Power System subject to Classification requirements per the Interface Document.

Additional documents such as tables, checklists, and procedural lists may be included as an Appendix to the program. Refer to 7-2-3/3.3 of the *FPI Rules* for the required contents of an ISIP Plan, as applicable to the vessel type.

In addition to the surveys referenced in the ABS *Rules for Survey After Construction (Part 7)*, the following are to be carried out in the presence of an ABS Surveyor on an annual basis, as applicable:

i) Examination of structure and hull connection weld points.

ii) Review of calibration record, operations manual and logbooks, and insulation resistance log.

iii) Examination of all support piping systems outside the NPP as per 2/Figure 1.

iv) Examination and testing of electrical systems and related equipment.

v) Compliance with any special requirements from the flag/coastal state Administration, local codes, or regulations.

vi) Requirements identified in the approved In-Service Inspection Plan (ISIP), as defined in 2/3.1.3, including but not limited to:

a) Satisfactory operational test of all emergency stops and controls.

b) Examination and testing of fire/safety alarms, detectors, and ventilator dampers.

c) Testing of all means of communication.

d) Functional tests of equipment integrated or associated with vessel's systems.

e) Satisfactory operational test of all vessel equipment alarms.

f) Functional test of Primary, Secondary and Emergency Essential Marine Services (see Section 2/4 Tables 1-3).

2.2.2 Surveys of the Mooring System

- Mobile Offshore Power Service Units are to comply with the requirements contained in Section 7-1-9/15 and 7-1-A1 of the *MOU Rules*
- Site Specific Power Service Unit - Ship Type and Other Floating Installations: Section 7-1-3 of the *FPI Rules*.
- Nearshore Power Service vessels/units are to comply with the requirements contained in ABS *Guide for Nearshore Position Mooring*.

3 Survey After Construction

Surveys after construction are to be in accordance with the applicable requirements based on the notation assigned to the vessel as below.

3.1 Annual Surveys

Annual surveys after construction of the vessel's hull, machinery and power generation and distribution systems supporting systems as identified in the Interface Document (see 2/3.1.1), Onboard System Integration Test Plan (see 2/3.1.2), In-Service Inspection Program (ISIP) (see 2/3.1.3), and Risk Assessment (see Subsection 3/2) installed on nuclear power service vessels are mandatory for maintenance of the **Power Service (Nuclear)** notation, are to be in accordance with the applicable requirements based on the notation assigned per the following:

- Marine Vessel: Section 7-3-2 and Section 7-6-2 of the ABS *Rules for Survey after Construction (Part 7)*.
- Mobile Offshore Power Service Units: Section 7-2-4 of the *MOU Rules*.
- Site Specific Power Service Unit - Ship Type and Other Floating Installations: Section 7-2-4 of the *FPI Rules*.

In addition to the surveys referenced above, the following are to be carried out in the presence of an ABS Surveyor on an annual basis, as applicable:

i) Examination of structure and hull connection weld points.

ii) Examination of all piping systems.

iii) Functional tests of equipment integrated or associated with vessel's systems.

iv) In-Service Inspection Program (ISIP) (see 2/3.1.3), including:

a) Satisfactory operational test of all emergency stops, controls, and remote controls.

b) Review of calibration record, operations manual and logbooks, and insulation resistance log.

c) Examination and testing of fire/safety alarms, detectors, and ventilator dampers.

d) Testing of all means of communication.

e) Examination and testing of electrical systems and related equipment.

f) Operational test of all vessel equipment alarms.

v) Compliance with any special requirements from the Flag Administration, local codes, or regulations.

Commentary:

The ISIP is a live document, and should be reviewed annually. Any updates are to be reviewed by ABS.

End of Commentary

3.1.1 Onboard Documentation

In addition to the required onboard documentation available as identified in ABS *Rules for Survey After Construction (Part 7)* or *MOU Rules or FPI Rules*, as applicable, the below are to be verified onboard:

i) *Operating License (if issued by the* Flag *Administration) and details of any operational constraints imposed by the* Flag *Administration [A.491(XII) 7.2.1.2].*

ii) *The* Risk *Assessment and associated drawings* or other documentation *[A.491(XII) 7.2.1.3].*

iii) *The Operating* and Maintenance *Manual [A.491(XII) 7.2.1.4].*

iv) The Interface Document, as defined in 2/3.1.1.

v) Onboard System Integration Test Plan, defined in 2/3.1.2.

vi) The approved In-Service Inspection Program (ISIP), as defined in 2/3.1.3.

vii) *Certificates attesting to the nuclear training of the master and ship's officers, and other relevant crew members holding specialized certification [A.491(XII) 7.2.1.5].*

- Records of onboard training and drills for all relevant parties, including temporary service providers, inspectors/surveyors, passengers and land-based/portside personnel.

viii) *The radiation emergency plan and the radiation muster list [A.491(XII) 7.2.1.6]*, including the radiation dose-equivalent limits in all spaces and the radiation and contamination levels with related access restrictions.

ix) *Records of surveys, functional tests, maintenance and repairs of the* NPP *[A.491(XII) 7.2.1.7].*

x) *Registration logs for radiation control, radioactive waste management, and fissile material inventory [A.491(XII) 7.2.1.8].*

xi) Documentation of compliance with the *ISM Code*, if required by the Flag Administration or Port State Administration.

xii) Documentation of contract with ABS Rapid Response Damage Assessment (RRDA) Program, or with a similar program of another IACS Member Society.

xiii) Details of stability and damaged stability (with assumptions of damage extent), including the stability analysis and parameters.

xiv) NPP description and design parameters.

xv) Nuclear fuel and radioactive waste onboard storage and handling.

xvi) Description and location of *laboratories, changing rooms, spaces and facilities used for* decontamination of *contaminated persons or objects*, as applicable.

3.2 Special Periodic Survey

A Special Periodical Survey of the facilities is to be carried out within five (5) years of the initial Classification Survey and at five-year intervals thereafter.

Periodic surveys after construction of the vessel's hull, machinery and power generation and distribution systems supporting systems as identified in the Interface Document (see 2/3.1.1), Onboard System Integration Test Plan (see 2/3.1.2), In-Service Inspection Program (ISIP) (see 2/3.1.3), and Risk Assessment (see Subsection 3/2) installed on nuclear power service vessels are mandatory for maintenance of the **Power Service (Nuclear)** notation, are to be in accordance with the applicable requirements based on the notation assigned per the following:

- Marine Vessels: Section 7-3-2 and Section 7-6-2 of the ABS *Rules for Survey After Construction (Part 7)*.
- Mobile Offshore Power Service Units: Section 7-2-4 of the *MOU Rules*.
- Site-Specific Power Service Units – Ship Type and other Floating Installations: Section 7-2-4 of the *FPI Rules*.

In addition to the applicable requirements noted in Section 10/3.1 above as applicable for Annual Surveys, the following is to be carried out in the presence and to the satisfaction of the attending ABS Surveyor:

i) Examination of structure and hull connection weld points, supplemented by NDT of the connection welds.

ii) Examination of power plant equipment wiring, wireways, junction boxes, and electrical panels for damage, corrosion, or loose connections.

iii) In-Service Inspection Program (ISIP) (see 2/3.1.3), including:

a) Verification of safety systems per the Onboard System Integration Test Plan (see 3/2.1.2).

b) Examination and testing of insulation resistance of motors and cables related to power systems and equipment.

c) Calibration of essential safety alarms, detectors, and equipment identified in the approved In-Service Inspection Program (ISIP), as defined in 2/3.1.3.