Jornada AINE, Energía nuclear en buques y usos marinos civiles

Nuclear Ships: The ABS Experience

Minas Diacakis, Ph.D. | November 18, 2024

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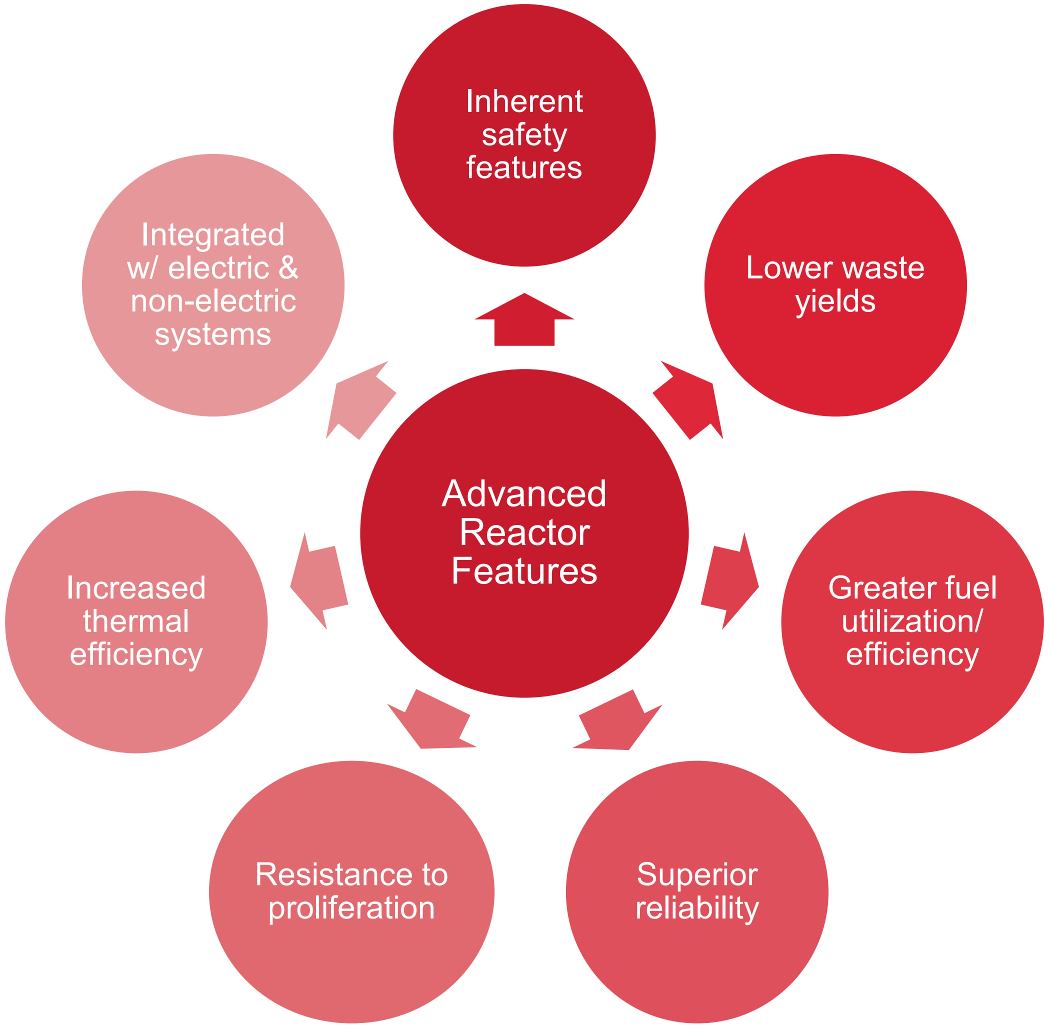
Meet the Speaker

Minas Diacakis, Ph.D.

Senior Engineer II,
Global Ship System Center

Nuclear Technology

Generation IV Reactors - Classification



Advanced Reactor Types

- Advanced Light Water Reactor (LWR)
- High Temperature Gas-Cooled Reactor (HTGR)
- Molten Salt Reactor (MSR)
- Sodium Fast Reactor (SFR)
- Lead Fast Reactor (LFR)
- Fluoride High-Temperature Reactor (FHR)
- Heat Pipe Reactor (HPR)

Liquid Metal Cooled

Design and Classification Tools

Addressing Barriers

Overcome potential barriers or issues to adoption in various ways

Code Standardization / Regulatory Harmonization	Crew Certification & Personnel Training	Successful Land-Based Reactor Demonstration/ Deployment	Establish Fuel Supply
Funding Policy	Investment	Novel Owner/Operator Arrangement	Leverage Government/ Navy Experience
Operational Procedures	Public Education/PR	Robust Design	Robust Testing or Demonstration

Classification Tools — Requirements

- Statutory Requirements
  - IMO International Code for the Safety of Life at Sea (SOLAS) CH. VIII
  - Resolution A.491 (XII) Code of Safety for Nuclear Merchant Ships, 1981
    - Gap Analysis to be proposed at MSC 109
  - Other IMO Codes for nuclear cargo

- National/Industry Standards

  As applicable:
  - ABS Guide (1962 to retired)
  - IAEA Standards
  - ASME Standards

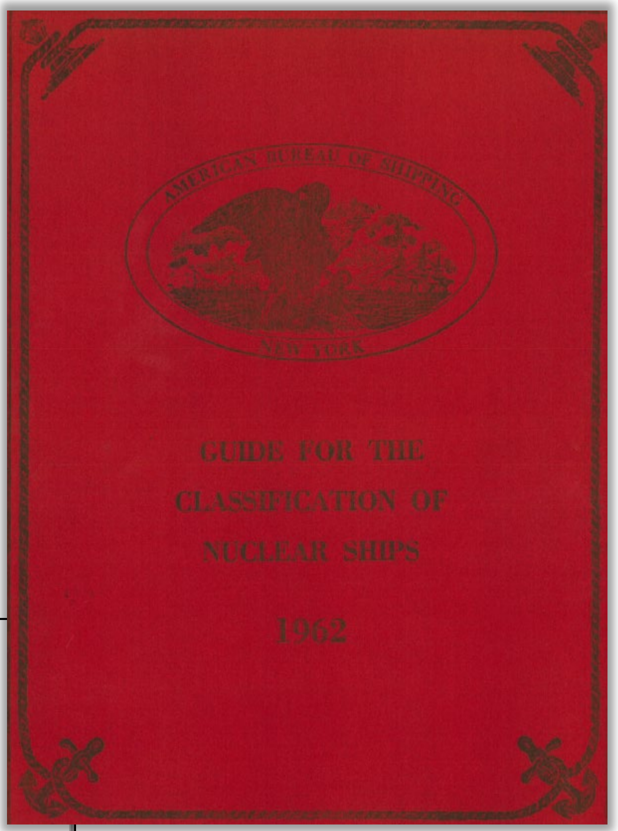
RESOLUTION A.491(XII) adopted on 19 November 1981
CODE OF SAFETY FOR NUCLEAR MERCHANT SHIPS

INTERNATIONAL MARITIME ORGANIZATION

Distr.
GENERAL
A XII/Res.491
18 June 1982
Original: ENGLISH

ASSEMBLY – 12th session
Agenda item 10(b)

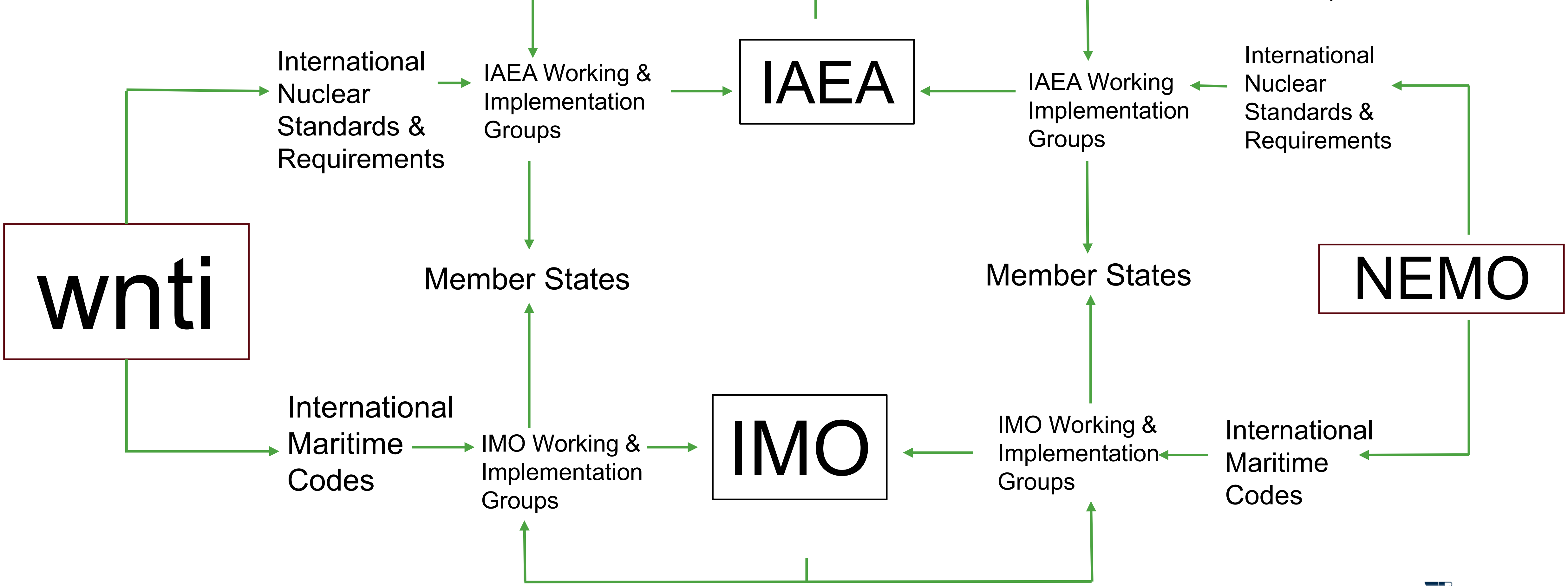
RESOLUTION A.491(XII)
adopted on 19 November 1981
CODE OF SAFETY FOR NUCLEAR MERCHANT SHIPS



Classification Tools — Regulatory Stakeholders

Transport
Safe and secure transport of nuclear materials

Mobility
Nuclear's role in decarbonizing ocean transport



Classification Tools — Industry Engagement

Marine Nuclear Applications Group (MNAG)

Regular collaborative consortium meetings to stay up-to-date and educated on developing topics.

“Research hub and resource center that brings together experts from the maritime and nuclear energy sectors to demonstrate advanced nuclear technologies for a range of marine applications.”

Advanced Nuclear and Production Experts Group (ANPEG)

Technical experts investigate the need for nuclear solutions for the clean energy transition.

“A global consortium dedicated to developing low-carbon energy systems based on a “plug-and-play” nuclear microreactor – or Nuclear Battery.”

World Nuclear Transport Institute (WNTI)

Global non-governmental membership organization headquartered in London. Focus on the transportation of nuclear material and transportation.

“Collaborate with members to influence regulatory change affecting the transport of nuclear materials.”

Nuclear Energy Maritime Organization (NEMO)

Global non-governmental membership organization headquartered in London. Focus on deploying nuclear power for maritime applications.

“…help national and international regulators create appropriate future-oriented standards and rules for the deployment, operation and decommissioning of floating nuclear power…”

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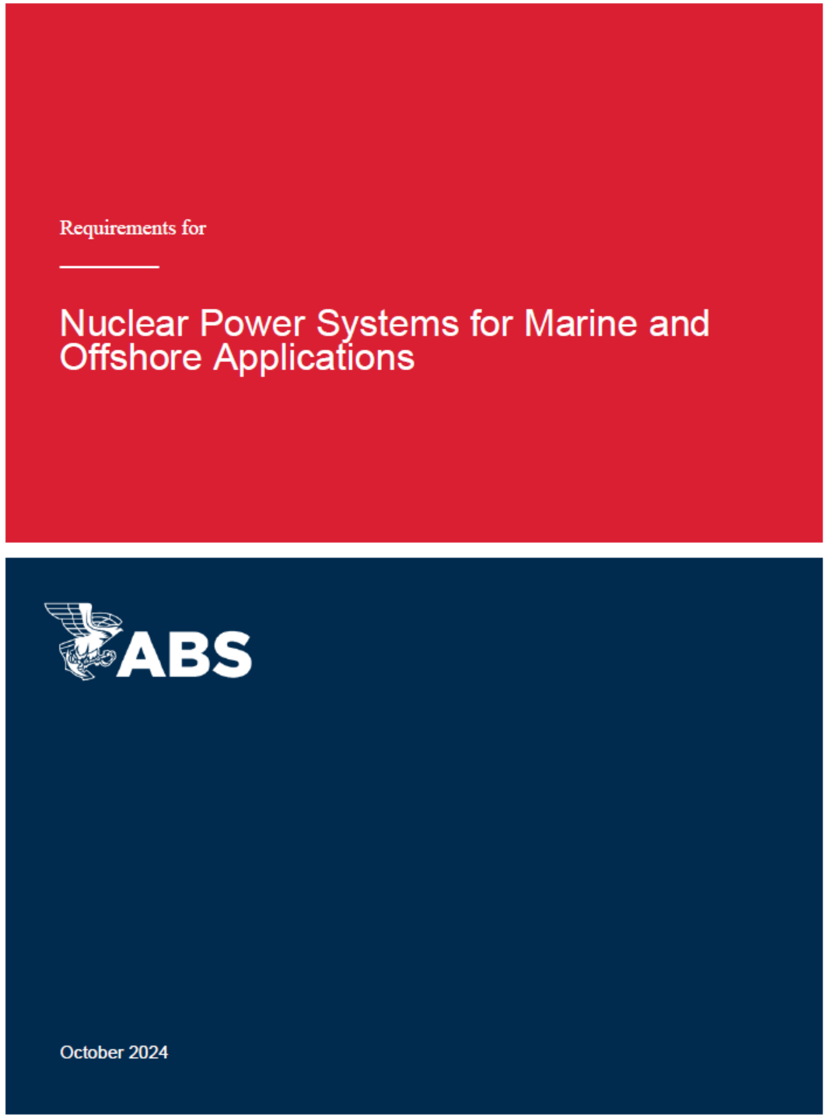
Classification Tools — ABS Requirements for Nuclear Power


Requirements for

Nuclear Power Systems for Marine and Offshore Applications

ABS

October 2024

- Non-nuclear propulsion maritime applications (i.e., FNPPs)
- Mandatory **Power Service (Nuclear)** Notation
- Suitable for any type of nuclear technology
- Designated interface between stakeholders according to marine or nuclear service
- Released 3 October 2024

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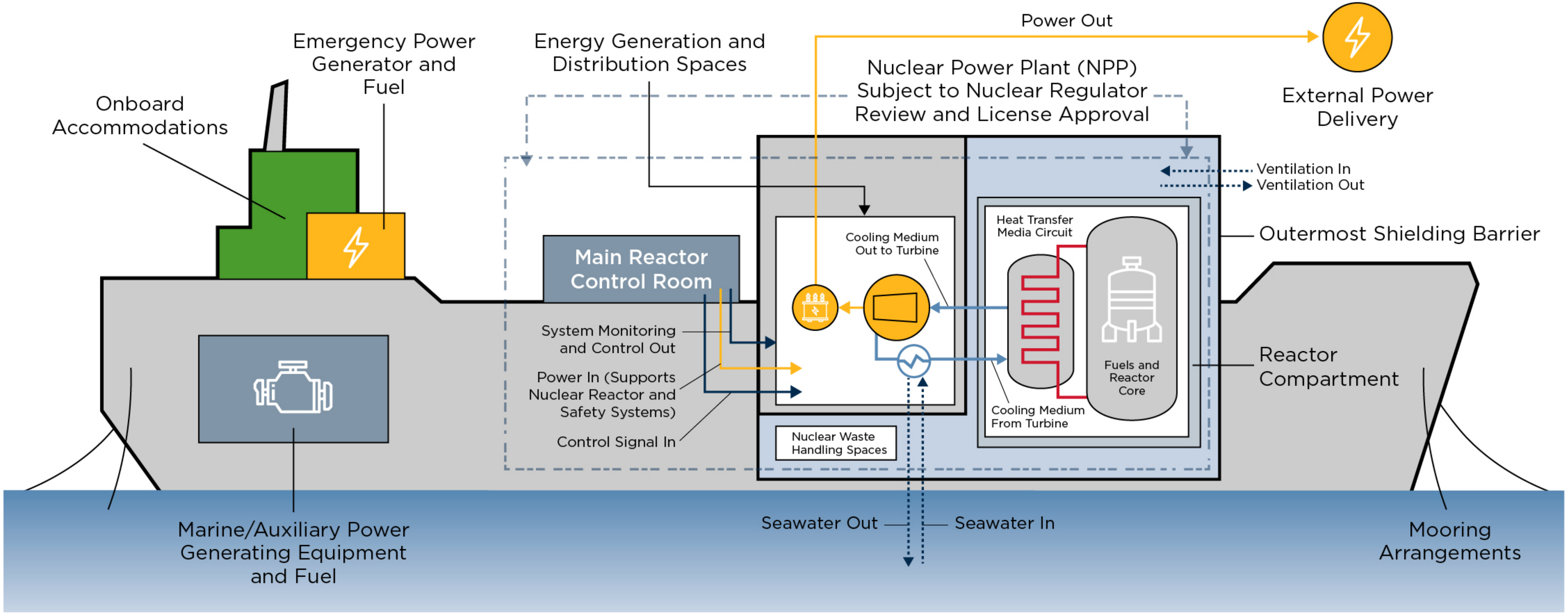
ABS Experience

Classification Tools — Stakeholders Interface

Establish Technical Agreement Among Stakeholders



ABS Experience — MONARC

Maritime and **O**ffshore **N**uclear **A**pplications **R**esearch **C**oalition

- Investigate all maritime applications suitable for nuclear power, including ships and offshore units, to prepare a roadmap for design and demonstration development.
- Focus on technology and regulatory aspects by including stakeholders and original equipment manufacturers to participate in joint development projects (JDPs).

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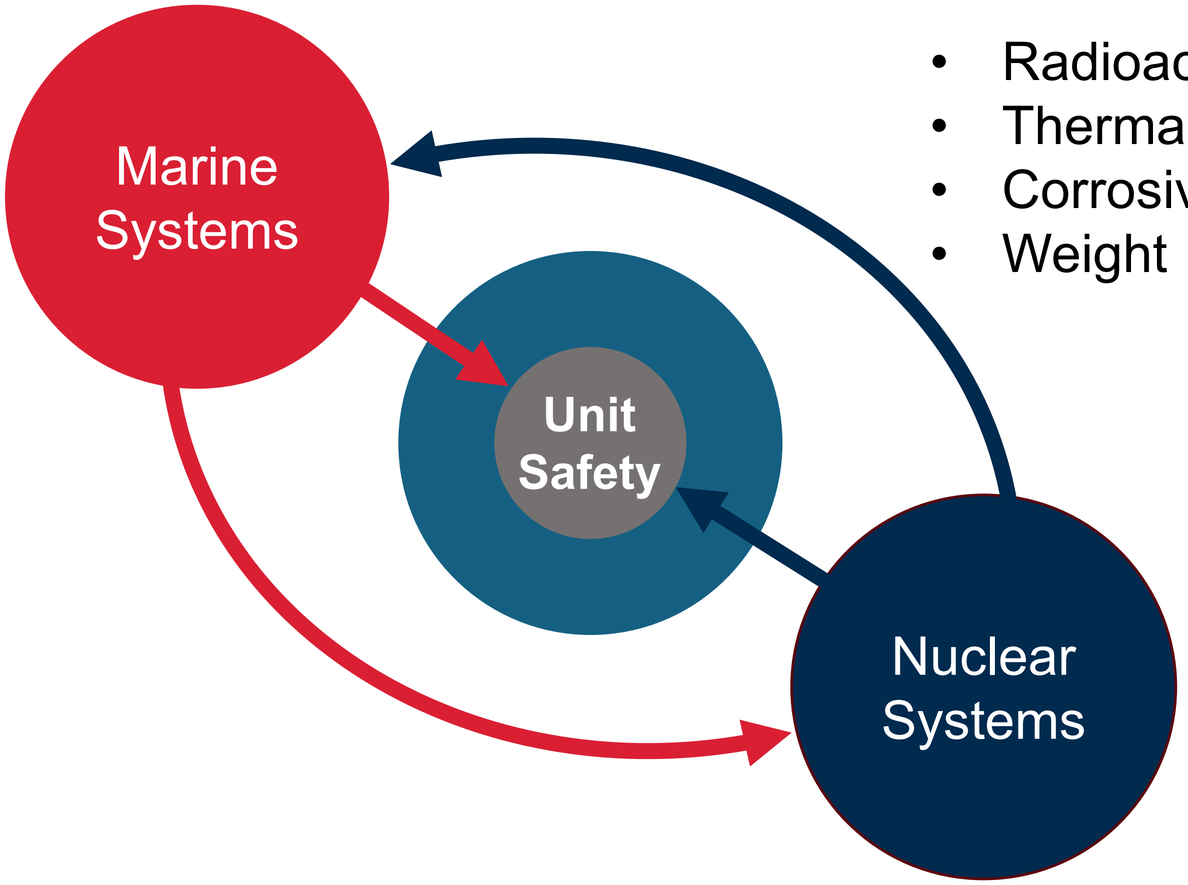
ABS Experience — Risk Assessments

Considerations for Maritime Applications

Nuclear Hazards Imposed on Marine Safety

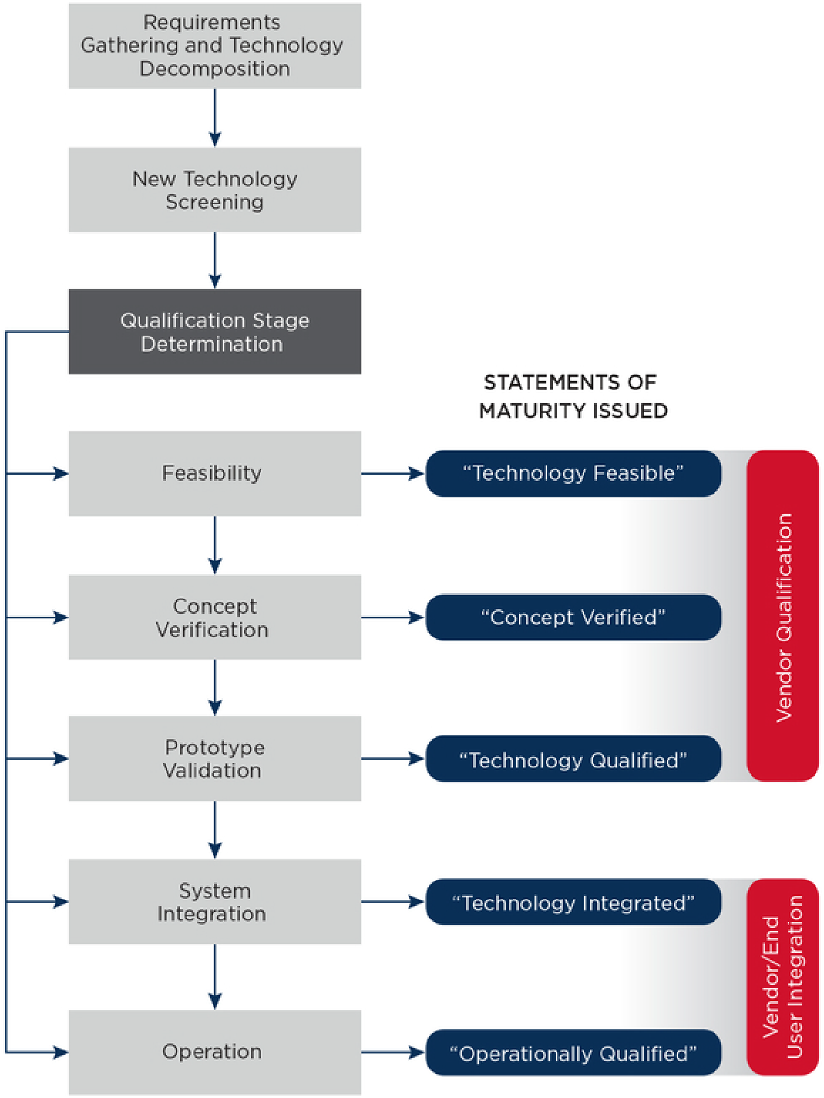
- Radioactivity
- Thermal energy
- Corrosive materials
- Weight



Marine Hazards Imposed on Nuclear Safety

- Structural loads
- Motions
- Onboard fire
- External hazards
- Mooring

ABS Experience — Seaborg Study



"New Technology Qualification Feasibility" statement to Seaborg for a compact molten salt reactor (MSR) to power a commercial power barge.

IN THE SPOTLIGHT: ABS completes feasibility study on Molten Salt Reactor Technology

THU, DEC 17, 2020 15:36 CET

Report this content

ABS Experience — Herbert Study

Scope

Develop two or three designs to cover the range of powerplant sizes.

- 6 MW:
  - Smaller bulkers
  - Chemical tankers
- 16 MW:
  - Feeder containerships
  - Capsize bulkers
  - Suezmax tankers (157K)
- 70 MW: Large container carriers (14K TEUs)

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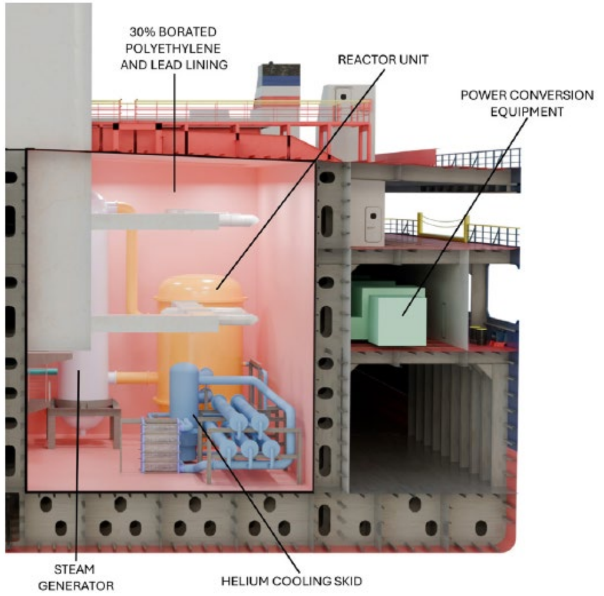
ABS Experience — Herbert Study

ABS Experience — Herbert Study

- 35-70 MWe modular design
- Adapt to the variable load
- Connected to the grid, not forcing the port to adopt special evacuation arrangements.
- Cost-competitive
- No on-site refueling arrangements are included in the design
- Protect the structures from reactor residual heat, collision, grounding and malicious attacks
- Nuclear waste generation, handling, storage and discharge arrangements were not addressed in detail at this stage



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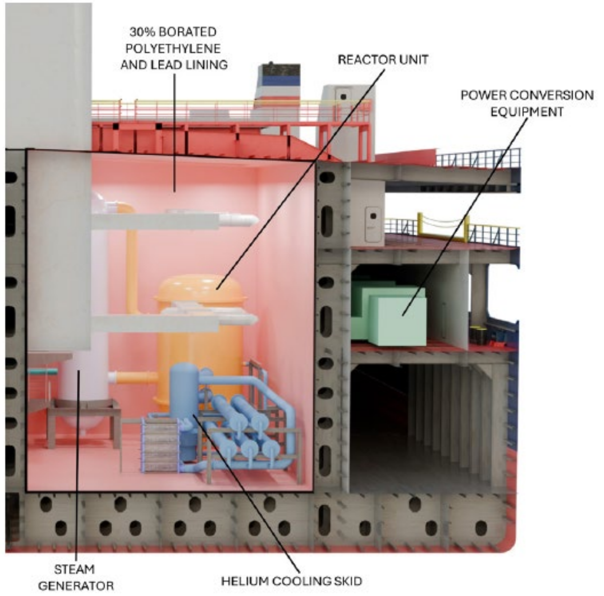
ABS Experience — Herbert Study

- 35 MWe modular design
- The size of the reactors is relatively fixed to be mass-manufactured
- Reactors located aft of accommodation to shield cryogenic cargo
- Supplemented by battery power for load-following and peak-shaving capabilities
- Cannot force visiting ports to adopt special evacuation arrangements
- Acceptable level of safety even in accident scenarios, including grounding and capsizing



ABS Experience — Preliminary Design Considerations

Ship

1. **Nuclear-Electric Plant** is the preferred arrangement
   a. Decouples reactor location from the main propulsion equipment
   b. Most flexible for power management, particularly when associated with batteries
   c. Provides redundancy
2. **The position of the nuclear reactor is likely at mid-ship**
   a. Radiation shielding adding weight and volume at the power plant location
   b. Protection from collision and grounding
   c. Minimized ship accelerations and vibration
   d. Consideration of the cargo areas
   e. Consideration of reactor maintenance and ease of installation/removal
3. **Battery location** needs to account for explosion risk, hazardous area requirements, monitoring, access, weight and replacement concerns
4. **Turbomachinery and electrical generation plant** need to be designed with reactor type (due to operating temperatures)

ABS Experience — Preliminary Design Considerations

Reactor

a. **Reduce size and weight**: As small and as light as possible for a given range and power requirement
b. **Maintainability** during short periods of drydocking
c. **Operate** within a range that allows the ship to transit along the proposed service route
d. **Minimize the need for refueling**
e. **Flexible power** to support variable load requirements typical of time at sea, time in port and time in the yard, as well as faster power variations such as maneuvering or those imposed by the weather

ABS Experience — Concluding Remarks

- Maritime integration of nuclear technology is at an early stage.
- A large number (ci. 75) of companies are developing Generation IV reactors of seven types. It is not clear which technology or which companies will prevail.
- Nuclear technology can provide a drastic and reliable solution to the 2050 IMO zero-emission targets.
- Several technical barriers have been identified. While the technology providers advance with their designs, the maritime industry should treat nuclear reactors as a black box and focus on vessel integration, regulatory, educational/training and public acceptance matters.
- The formation of the regulation framework, focusing on the necessary bilateral agreements, will be critical to integrating the technology, as vessels will be operating between countries.
- Massive investment from the private sector is presently in nuclear energy for maritime propulsion.
- It is reasonable to claim that the first applications will become a reality within a decade.

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