Perspectives on the Use of Entombment as a Decommissioning Option in the United States

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Decommissioning Mission

The NRC's mission is to ensure safety and protect the public health and the environment, whether the nuclear facility is operating, transitioning from operation to decommissioning, or in the decommissioning process.

The NRC's oversight continues throughout the entire decommissioning process until the facility and site have been radiologically decontaminated, the site is in a condition for radiological release, and the facility license is terminated.

Decommissioning Program Regulatory Framework



Integrated Decommissioning Program

Risk-Informed, Performance Based Regulations (10 CFR 50.82):

- Defined process for various facilities
- Timelines for completion
- Public involvement
- Environmental review
- Financial assurance
- Site characterization
- Site remediation
- Radiological release criteria
- Final site surveys

Regulatory Guidance

Oversight and Inspection

Final Site Configuration is not an NRC Decision

Decommissioning Process



2017 is the 20th Anniversary of the NRC Decommissioning Regulations







Regulatory Guidance Decommissioning Options

- **DECON:** Equipment, structures, etc. are promptly dismantled and removed or decontaminated to a level that permits radiological release.
- SAFSTOR: Facility is placed in a safe, stable condition and maintained in that state until it is subsequently decontaminated to levels that permit radiological release.
- ENTOMB: Facility is encased in a structurally long-lived substance to allow radiological decay until levels permit unrestricted release.

Years to Complete Decommissioning by Option









Decommissioning Regulations

- The ENTOMB decommissioning method was defined in the Supplementary Information to the 1988 Decommissioning Rule (53 Federal Register (FR) 24018), but never codified.
- 10 CFR 50.82(a)(3) requires that decommissioning be completed within 60 years of permanent cessation of operations, and completion of decommissioning beyond 60 years be approved by the NRC only when necessary to protect public health and safety.
- To date, all NRC licensed facilities have sought unrestricted release of the site.





Decommissioning Regulations (continued)

- The 1997 Rule for Radiological Criteria for License Termination (64 FR 39058) established criteria that allow for both restricted and unrestricted release of property.
- In September 2001 the Commission approved a plan for potential development of a rule to allow entombment as a decommissioning option for power reactors.
- The NRC sought stakeholder input on three proposed regulatory options and whether entombment was a viable decommissioning alternative.
- No strong public or industry interest in entombment.



	NUREG-0586, Supplement 1 Volume 1		
	Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities		
280	Supplement 1		
	Regarding the Decommissioning of Nuclear Power Reactors		
-0-	Main Report, Appendices A through M		
All and the second	Final Report		
₽¥J	U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation Washington, DC 20555-0001	NRC	Enton



NRC Entombment Guidance

- NUREG-0586, Supplement 1, "Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," or the Decommissioning GEIS, dated November2002, addresses entombment impacts including:
 - long-term onsite retention of radioactive materials, including those that may be classified as greater than Class C (GTCC)
 - issues related to long-term NRC oversight and monitoring requirements during the entombment phase
 - durability of institutional controls and barriers
 - site-specific requirements

Decommissioning of Facilities



General Safety Requirements Part 6 No. GSR Part 6 IAEA Entombment Guidance

- IAEA Safety Standards Series General Safety Requirements No. (GSR) Part 6, dated 2014:
 - Entombment, in which all or part of the facility is encased in a structurally long lived material, is not considered a decommissioning strategy and is not an option in the case of planned permanent shutdown. It may be considered a solution only under exceptional circumstances (e.g. following a severe accident).
- Reaffirmed at a Waste Safety Standards Committee (WSSC) Meeting in November 2017





Technical Progress

- New facilities are designed to facilitate decommissioning.
- Specialized characterization techniques.
- Simulation tools for estimating source terms, segmentation of reactor pressure vessels and other components and implementing ALARA.
- It is demonstrated that even in the case of immediate dismantling, worker exposures can be kept very low.
- Arrangements for managing large components
- Size reduction and cutting techniques (diamond wire, plasma torches, and the latest is laser cutting).
- Specialized equipment for decommissioning that can be remotely operated, including remotely operated submersibles.
- Mature protocols for final surveys (e.g., MARSSIM).





Entombment Applications

- Worldwide, entombment has been used a limited number of times, mostly in cases that fall into the following categories:
 - Facilities located within large contaminated sites where there are other facilities and where the sites will require long-term institutional control regardless.
 - Locations where the radiological inventories were low, and the institutional control periods required to reach unrestricted release were short (less than 50 years).
 - Entombment is not viewed as a "first choice" decommissioning option by the IAEA.

Future Power Reactor Waste Volumes



Annual Nuclear Plant LLW Disposal



Graphic from "EPRI Low Level Waste and Radiation Management Program Overview", Sean Bushart, December 2006

NRC Decommissioning Rulemaking In Progress



- The decommissioning options available to power reactors were re-examined during an ongoing rulemaking activity related to the permanent shutdown of several plants.
- The NRC staff recommended that, while DECON and SAFSTOR remain viable options, ENTOMB should be removed from the decommissioning guidance.
- Any application of entombment by a power reactor would need to be examined on a case by case basis, making generic regulations difficult and unnecessary.

NRC Decommissioning Rulemaking Milestones



- Regulatory Basis Phase completed November 2017
 - Draft regulatory basis published for public comment
 - Public meeting during comment period
 - Final regulatory basis published recently (ML17215A010)
- Proposed Rule Phase begins in Summer 2018
 - Proposed rule out for 75-day public comment period
 - Public meeting during comment period
 - Draft regulatory guide(s) out for comment with proposed rule
- Final Rule Phase will be complete in late 2019
 - Regulatory guides issued with rule



Conclusions for Entombment

- Entombment is discussed only in NRC guidance as one of the options available for decommissioning, but has not been codified.
- To date, no NRC licensed facilities have chosen entombment as a long term decommissioning option.
- A recent analysis of the decommissioning options for power reactors recommended that entombment should be removed from the guidance since it would only be an option under specific circumstances requiring additional regulatory considerations.
- Additional feedback will be collected regarding the potential for entombment during the ongoing decommissioning rulemaking.





Thank You!





Backup Slides





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Decommissioning Program

- The NRC's statutory authority comes from the Atomic Energy Act of 1954, as amended.
- Performance based, risk-informed reactor decommissioning regulations were implemented in 1997.
- Decommissioning regulations include:
 - Defined decommissioning processes for various facilities
 - 60 year timeframe to complete reactor decommissioning
 - Radiological clean-up criteria
 - Public involvement opportunities
 - Financial assurance requirements



Decommissioning Program (continued)

- Effective decommissioning guidance and use of an independent contractor for confirmatory radiological surveys at all decommissioning nuclear facilities.
- The decommissioning inspection programs for all types of licensees provide oversight throughout decommissioning until the license is terminated.
- Final site restoration decisions reside with the landowner, State government, and other applicable stakeholders.

Shutdown Reactors





Reactors in Decommission Protecting People and the Environment





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Radiological Release Criteria (10 CFR Part 20, Subpart E)

Unrestricted Release

Total Effective Dose Equivalent (TEDE) ≤ 25 mrem/yr (0.25 mSv/a) and As Low As is Reasonably Achievable (ALARA)
Average member of the critical group is used as the representative
All dose pathways ae considered
Period of performance – 1000 years

Restricted Release

 \leq 25 mrem/yr (0.25 mSv/a) TEDE and ALARA, with institutional controls in effect Legally enforceable institutional controls

If institutional controls fail, doses do not exceed 1 mSv/a, or 5 mSv/a, under specific circumstances

Financial assurance via an independent third party

Licensee and NRC public input and outreach requirements







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