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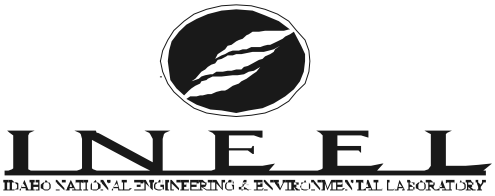

Waste In-Situ Stabilization/Entombment Research and Development Project

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Waste In-Situ Stabilization/Entombment Research and Development Project[1]

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Abstract

The technical basis and stakeholder acceptance of entombment technology is necessary before entombment becomes a decontamination and decommissioning (D&D) option for nuclear reactors. The authors present a research and development (R&D) approach addressing technical basis and stakeholder acceptance of entombment technology. The approach includes a consortium and the conceptual R&D program.

Introduction

R&D is needed to establish entombment as an acceptable D&D option. The technical basis and stakeholder acceptance of entombment technology is necessary before entombment becomes a D&D option for nuclear reactors. Key questions for entombment acceptability to stakeholders are discussed. Entombment R&D objectives are described. The Idaho National Engineering and Environmental Laboratory (INEEL) approach for entombment R&D is summarized. The initial steps to begin entombment R&D at INEEL are described. Five business components to accomplish entombment R&D are identified. The conceptual R&D program is described. This paper is organized into the following sections—entombment R&D need, entombment key questions, entombment R&D objectives, INEEL approach, initial steps and components and conceptual R&D program.

Entombment Research and Development Need

The technical basis and stakeholder acceptance of entombment technology is necessary before entombment becomes a D&D option for nuclear reactors. One of the keys for stakeholder acceptance of entombment will be to demonstrate the containment of radioactivity within the entombed structure. Additional data and information are needed before entombment becomes an effective, safe, and cost conscious solution for the D&D of nuclear reactors[1]. U.S. Nuclear Regulatory Commission[2] (NRC) has identified a path forward that includes several R&D needs including:

- Acceptable entombment designs and intruder scenarios need to first be defined and agreed upon. An isolation assessment needs to be conducted that specifically incorporates the residual source term and site characteristics relevant to nuclear power reactors.
- NRC should establish the bases and methodologies acceptable for the performance assessments needed to determine whether a given reactor/site is suitable for decommissioning via the entombment alternative, similar to the information contained in NUREG-1573. Appropriate regulatory guides must be developed and issued, including

[1] Work supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management, under DOE Idaho Operations Office Contract DE-AC07-99ID13727.

appropriate databases containing the families of parameters and required level of conservativeness to be used in the isolation assessment analyses.
- Eliminating the need for full-time onsite security and surveillance staff will greatly reduce the ongoing costs associated with an extended safe storage period. An appropriate regulatory guide should be developed that defines the minimum acceptable monitoring and surveillance system and methods for a shutdown entombed reactor.

U.S. Department of Energy (DOE), Office of Long-Term Stewardship is responding to the need for improved science and technology and will encourage the development and use of improved technologies for more sustainable long-term stewardship. The immediate science and technology needs for the long-term stewardship program include:

- Information about the durability of materials and more durable materials
- Knowledge of fate and transport mechanisms and predictive capabilities
- Cost-effective monitoring and surveillance methods
- Information management
- Systems engineering and design

Entombment Key Questions

After reviewing the status of entombment technology development, how could the issues effecting entombment be grouped into several essential statements. INEEL identified three essential questions for answering before entombment becomes an accepted D&D option. The three essential questions are:

1. How can entombment ensure long-term containment of waste?
2. How much worker safety improvement and cost savings does entombment provide?
3. What needs to be done to gain public acceptance?

To protect human health and environment, contaminates must remain within the entombed structure and not be migrate outside of the structure. Associated with that issue is duration, which must be defined by policy and rulemaking. When compared to the other D&D options, a technology that is as good as the other options would have minimal application. Therefore, worker safety and cost savings are the essential drivers for utilization of entombment as a D&D option. Equally important to technical issues and questions is whether the public will accept entombment as a viable D&D option.

Entombment Research and Development Objectives

To address the essential questions, what R&D objectives must be accomplished for DOE and NRC licensed facilities to use entombment technology. The objectives that we have identified include:

- Develop a standardized, transferable, engineering and construction methodology
- Develop entombment as a viable D&D option
- Support NRC's rulemaking activities

- Support DOE long-term stewardship efforts
- Complete an INEEL cleanup commitment to D&D a site reactor
- Provide future capability for entombment R&D

These objectives are based upon existing DOE and NRC licensed reactor entombment D&D needs. During evaluation of the entombment R&D needs and essential questions, a correlation establishing whereby one or more than one objective satisfies either the need or question. Each need and its associated desired outcome(s) is addressed in the R&D program via an R&D approach where the results improve the present situation and benefit the nuclear reactor D&D process. The INEEL reactor entombment research and demonstration project includes leveraging information, performing supporting analyses, and conducting small-scale tests and demonstrations to develop a standardized and transferable entombment process for the DOE, commercial utility industry, and the international community. The large-scale INEEL reactor entombment demonstration will assess and improve the entombment process.

INEEL Approach

The proposed INEEL approach includes the research and development necessary to meet the needs described above with entombment of an INEEL reactor that is scheduled for D&D to demonstrate and enhance the viability of entombment. Consortium members will work with the INEEL team to develop a detailed approach for entombment R&D that meets the needs of individual consortium members. A technical steering committee composed of D&D experts will provide independent evaluation of entombment research approach and direction. The project has five components; stakeholder interaction; research, engineering, and model development; pilot scale research; large-scale entombment demonstration; and long-term entombment research capabilities and facilities. The consortium guides all of the component parts.

Fig. 1 identifies several potential consortium members and these members include:

- INEEL
- DOE-EM
- NRC
- Nuclear Energy Institute (NEI)
- Electric Power Research Institute (EPRI)
- Utilities
- Other DOE Laboratories
- D&D Contractors
- Universities
- International Atomic Energy Agency (IAEA)
- Public and Stakeholders

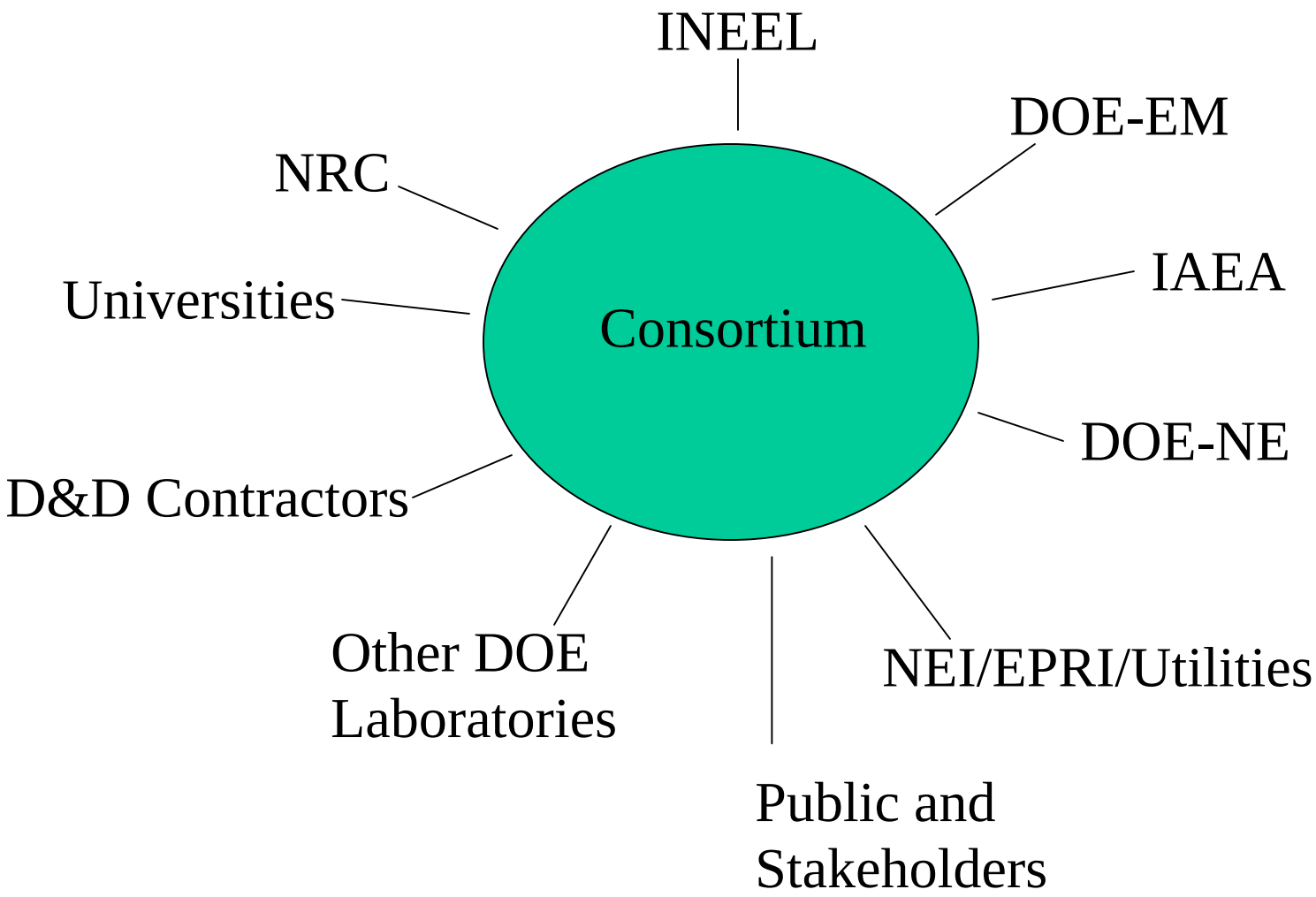

Fig. 1 Potential Consortium Members

The reasons for selecting a consortium approach are:

- A consortium pools limited resources to address entombment R&D needs and issues.
- A consortium undertakes entombment R&D as a group because the resource requirements are beyond any one particular member.

Entombment benefits the potential members in differing manners. The R&D needs are broader than an individual member's interests are. A broad-based partnership ensures a "big-picture planning" viewpoint. A broad-based support leverages limited funding. The consortium funding would be used to fund R&D activities. The ongoing INEEL cleanup program will fund the actual D&D activities of the INEEL reactor. The consortium funding will be used to fund entombment technology R&D--stakeholder interaction; research, engineering, and model development; pilot scale research; large-scale entombment demonstration; and long-term entombment research capabilities and facilities.

Initial Steps and Components

The initial steps to initiate entombment R&D at the INEEL have included:

- Obtained INEEL support
- Implemented R&D and Operations integration
- Define R&D business components
- Initiated consortium membership
- Prepared laboratory directed research and development proposals

The entombment project team initiated a series of meetings with DOE Idaho Operations and Bechtel BWXT Idaho, LLC to obtain support for entombment R&D at INEEL. INEEL management support for entombment R&D was obtained. The entombment project team works in Research and Development while Environmental Management Programs is responsible to D&D INEEL facilities and Site Operations manages INEEL facilities. The R&D planning in conjunction with Operations coupled with routine communications is the initial steps for integration of R&D and Operations.

INEEL's experience decommissioning over 100 nuclear facilities and performing nuclear engineering work combined with an advisory consortium drawing from the nuclear industry, governmental agencies, DOE laboratories, universities and international partners will establish entombment as an accepted, safe, and cost-effective D&D option. Five business components to accomplish entombment R&D were identified. The five components include stakeholder interaction; research, engineering, and model development; pilot scale research; large-scale entombment demonstration, and long-term entombment research capabilities and facilities. Stakeholder interaction component would address the process of deciding whether to select entombment as a decommissioning end while considering the perceptions and concerns of stakeholders**.** This component also includes the information needs valuable to this process. Some of the information needs valuable to the stakeholder process includes neighboring land values, site appearance after D&D activities, public perception of the hazards from the entombed facility, and regulatory and safeguard aspects influencing the D&D process. The Research,

Engineering, and Model Development component will address the model development needs and information needed to complete model development. Some parts of this component include models to evaluate the integrity of an entombed structure and candidacy of an existing nuclear facility for entombment. In addition, tools to predict transport and fate of contaminants out of the entombed structure, and cost-estimating tools based upon predicted and actual entombment costs will be included. Further, this component includes the necessary engineering analyses and studies for entombment R&D. The Pilot Scale Research component will use existing test bed facilities and hot cells to test approaches at a pilot-scale before entombing the reactor facility. Example pilot-scale experiments using the test beds and hot cells include:

- Detection of inadvertent slow leakage of contaminates,
- Development of detection instrumentation,
- Monitoring and surveillance methods that can be encased in the entombed structure, and
- Separate effects testing for proof of concept and GTCC testing.

Large-scale Entombment Demonstration component will use a large-scale INEEL reactor. The entombment demonstration will provide opportunities to obtain actual data where engineering alternatives will be evaluated for various concepts for entombing the reactor facility. The last component is Long-term Entombment Research Capabilities and Facilities where the entombed INEEL reactor, test bed facilities, and developed capabilities will provide a resource for future research and development on entombment.

INEEL has initiated consortium membership by presenting the consortium approach for entombment R&D to many of the potential consortium members. DOE, members of the NEI, the Nuclear Regulatory Commission, and Bechtel Corporation have expressed early interest in the project and may consider membership on the consortium. In addition, countries such as United Kingdom, Japan, Lithuania, Russia, and Taiwan may have strong interest in the concept of entombment for some of their reactors. Florida International University and Pacific Northwest National Laboratories have joined the consortium. An NEI-INEEL co-sponsored workshop on entombment R&D scheduled for 2001 is in the planning stage.

Several laboratory directed research and development proposals were prepared. These proposals included innovative approaches pertaining to entombment on socio-technical decision framework, material testing, model development, performance prediction and structural integrity methodology.

Conceptual Research and Development Program

To initiate the process of defining entombment R&D projects that would become the R&D program, the entombment project team identified the conceptual R&D program. There are two efforts in the preliminary planning stages where consortium members and invited parties will meet in working sessions to develop and define the R&D projects. One of these sessions may be in the fall of 2000 and second one may be part of the NEI-INEEL co-sponsored workshop on entombment R&D.

The conceptual R&D program objectives are:

- Utilize and base R&D projects on historical work
- Address entombment technology needs
- Address INEEL reactor entombment issues
- Demonstrate the viability of entombment
- Transfer the entombment technology
- Create the Waste In-Situ Stabilization/Entombment R&D Facility

Based upon these objectives, twelve subject/discipline areas were identified for entombment R&D. The subject/discipline areas are:

1. Subsurface Soils, Geology and Hydrogeology Science and Instrumentation
2. Material Investigations
3. Civil Engineering
4. Nuclear Engineering
5. Public Decision Making Tools and Stakeholder Acceptance
6. Model Development and Enhancement
7. Engineering Tools
8. Regulatory Policy and Rulemaking
9. Demonstrations and Deployment
10. Expert Systems
11. Performance Evaluations
12. Worker Safety and Environmental Analysis and Evaluations

Subsurface Soils, Geology and Hydrogeology Science and Instrumentation focus upon site characteristics and suitability, the basis for monitoring and surveillance, the need for caps and covers, and instrumentation development for monitoring surveillance. Material Investigations identify the entombing material based upon water infiltration and transport resistance, reduction in component corrosion, and waste form stability. Civil Engineering investigates how to place wastes within an entombed facility, facility re-engineering and layout, waste isolation and containment, and structural integrity of the entombed facility. Nuclear Engineering focuses upon re-utilization of biological shields, enhanced characterization, intruder scenarios, and conceptual entombment designs including greater-than-Class C wastes. Public Decision-Making Tools and Stakeholder Acceptance investigates socio-technical decision analysis tools, stakeholder information needs and acceptance of the technology, stakeholder perceptions and concerns about entombment technology, and utilization of the technology in nuclear reactors. Model Development and Enhancement address isolation assessment, performance assessment, contain contaminates within the entombed structure, and predicting structural behavior and degradation.

Engineering Tools focus upon developing entombment applicable tools for cost estimating, institutional controls, and necessary comparative and feasibility studies for the entombment D&D option. Regulatory Policy and Rulemaking support agency policy development and rulemaking, assist with resolving public issues and preparing guidance documents. Demonstrations and Deployment assists with deploying entombment technology at DOE, Commercial, International and University facilities and conducting the pilot and full-scale demonstrations at INEEL. Once the INEEL reactor is entombed that facility is converted to the

Waste In-situ Stabilization/Entombment R&D facility for future entombment enhancements. Expert Systems develop an evaluation tool for screening reactor sites applicability for entombment that would include site and waste characteristics with associated evaluation tool development and validation. Performance Evaluations address cost-effective monitoring and surveillance and associated instrumentation, methodology and guidance. Worker Safety and Environmental Analysis and Evaluations analyze worker exposure, environmental risk, transportation, and waste disposal issues.

Conclusions

To establish entombment as an acceptable D&D option, additional R&D is needed. The technical basis and stakeholder acceptance of entombment technology is necessary before entombment becomes a D&D option for nuclear reactors.

The three essential questions for acceptance are:

1. How can entombment ensure long-term containment of waste?
2. How much worker safety improvement and cost savings does entombment provide?
3. What needs to be done to gain public acceptance?

Entombment R&D objectives are as follows:

- Develop a standardized, transferable, engineering and construction methodology
- Develop entombment as a viable D&D option
- Support NRC's rulemaking activities
- Support DOE long-term stewardship efforts
- Complete an INEEL cleanup commitment to D&D a site reactor
- Provide future capability for entombment R&D

A consortium for entombment R&D is developing. Several steps to initiate entombment R&D at the INEEL are complete. The conceptual R&D program based upon subject/discipline areas is developing.

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1. D. Vernon, S. Birk, R. Hanson, "Entombment: It is Time to Reconsider this Technology," SPECTRUM 2000, September 24-28, 2000.

2. U.S. Nuclear Regulatory Commission, *Information Paper on the Viability of Entombment as a Decommissioning Option for Power Reactors*, SECY-99-187, July 19, 1999.