



JUDGING THE SAFETY OF A REPOSITORY AT YUCCA MOUNTAIN, NEVADA

U.S. Nuclear Regulatory Commission
Requirements

**The U.S. Nuclear Regulatory Commission
must be convinced
by the U.S. Department of Energy
that a proposed repository at
Yucca Mountain, Nevada will:**

- **Protect the public**
- **Protect site workers**
- **Protect the environment**

Introduction

The **U.S. Nuclear Regulatory Commission (NRC)** will only allow construction of a **geologic repository** at Yucca Mountain, Nevada, if the **U.S. Department of Energy (DOE)** is able to convince **NRC** that **DOE** can build and run the repository safely and securely in compliance with **NRC's** rules. That means **DOE** must build and operate the repository to protect the public, site workers, and the environment from the potentially harmful effects of **spent nuclear fuel** and **high-level radioactive waste**.

This brochure answers the following questions:

- What standards and regulations will **NRC** use?
- What do **NRC** regulations require?
- Does **NRC** require more than just a strong **waste package**?
- What makes a **geologic repository** safe?
- What documentation is required of **DOE**?
- After **DOE** closes the repository, can **DOE** just walk away?
- Will **NRC** take **DOE**'s word for it that things are being done right?
- Can **NRC** say no?

This brochure includes a glossary at the end. Words that are explained in the glossary will be in **bold type** throughout the brochure.

What standards and regulations will NRC use?

To demonstrate the safety of a potential repository at Yucca Mountain, DOE will have to comply with regulations set by NRC and with environmental standards set by the **U.S. Environmental Protection Agency (EPA)**. NRC published its rules for the safe construction, operation, and **closure** of a potential **geologic repository** in 2001. These rules are sometimes referred to as *NRC's Part 63 regulations*. By law, these NRC regulations must be consistent with EPA's standards for Yucca Mountain.

In 2005, EPA proposed additional standards that would apply for up to one million years. NRC will modify its regulations to include EPA's additional standards as soon as they are formally issued. NRC's regulations also include many other licensing requirements that DOE must meet before DOE can receive NRC permission to build a **geologic repository** at Yucca Mountain.

What do NRC regulations

Limits

Repository operations include receiving, storing and placing the waste deep underground for disposal. During operations, DOE must comply with safety limits in NRC's regulations, which include the limits on the amount of radiation people could receive, or dose limits, set by EPA. DOE must show that no member of the public would receive a dose greater than 15 millirem each year due to normal repository operations. This amount of radiation is less than 5 percent of the average exposure people across the nation experience from natural sources, such as the sun, every year. DOE must provide a comprehensive safety analysis, called a **preclosure safety analysis**, showing that operational dose limits will be met. DOE must also show that it will protect repository workers using the same standards that apply to workers at all other nuclear facilities licensed by NRC.

Physical Protection and Security

NRC requires that DOE establish detailed security measures for physical protection of **spent nuclear fuel** and **high-level waste** comparable to those required for other large nuclear installations licensed by NRC. DOE must show how it will protect the repository against physical threats, theft of radioactive materials, and potential acts of sabotage.

Emergency Planning

NRC requires that DOE prepare detailed plans for responding to and recovering from radiological emergencies or accidents that might occur during operations and before surface facilities are cleaned up and dismantled. Before NRC would allow waste to be received at a repository, DOE must demonstrate that it will take effective protective measures in the event of an emergency.

require during operations?



Scientists take measurements for an underground experiment at Yucca Mountain.

Retrieval

The repository must be designed so that DOE can retrieve the **waste packages** while they are being put in place, and throughout the completion of a **performance confirmation** program. Also during this period, NRC must be able to review and evaluate any new information obtained. Waste must be retrievable in the event that the **performance confirmation** program shows that the repository is not operating as designed and that retrieval is needed to protect public health and safety.

Protection for Workers Who Raise Safety Concerns

NRC regulations specifically provide protection for “whistleblowers,” or workers who report safety concerns or violations of NRC regulations. Workers cannot be discriminated against or lose their jobs based on providing such information.

Land Ownership and Control

NRC’s regulations require DOE to show that the land used for the Yucca Mountain repository and surface facilities is legally under the jurisdiction and control of DOE. The land must be free from claims such as mineral rights and right-of-way easements. DOE must also show that it has the water rights necessary to operate and close the repository safely.

What do NRC regulations

Limits

After repository **closure**, when DOE is done placing waste for disposal, and all shafts, ramps and boreholes are sealed, DOE must show that projected doses, far in the future, will also meet specific dose limits. DOE must show that for 10,000 years after disposal, a **reasonably maximally exposed individual** who lives near the repository would receive a dose no greater than 15 millirem each year from the repository.

In 2005, EPA proposed additional standards to control potential doses that could occur beyond 10,000 years, up to one million years. NRC will modify its regulations to be consistent with EPA's additional standards as soon as they are formally issued. To show whether the proposed repository would meet these standards far in the future, NRC's regulations require DOE to conduct a comprehensive **performance assessment** of how the repository will function after it is closed.

Performance Assessment

Performance assessment is a systematic method for understanding how well a **geologic repository** retains **high-level radioactive waste** and **spent nuclear fuel**. Many factors affect how well a repository will work to retain waste and to prevent harm to people. Among these are climate, water flow, rock chemistry, design and construction of the repository, strength of the **waste packages** and how well they resist corrosion, the nature of the waste, and natural events such as earthquakes and volcanic eruptions. These many natural features and man-made systems interact and change over time.

NRC must understand these systems and their complex interactions to assess the safety of a repository over many thousands of years. **Performance assessment** is a powerful tool for organizing and analyzing large amounts of information about how a repository works. NRC's regulations include detailed requirements for the **performance assessment** that DOE must use to demonstrate that the proposed repository is safe.

require after closure?

Groundwater Protection Limits

DOE must also show that releases from the repository system do not cause radioactivity in groundwater to exceed EPA limits that have been incorporated in NRC's licensing regulations. Separate standards for groundwater are designed to protect the groundwater resources near Yucca Mountain. To show that the proposed repository would meet these limits, DOE must estimate the concentrations of radioactive elements in groundwater using an analysis similar to the **performance assessment**.



Scientists test groundwater in Amargosa Valley, Nevada.

Monitoring and Testing

If NRC authorizes construction and later authorizes placement of waste, DOE must continue to monitor the site, make observations, and conduct studies as part of a required **performance confirmation** program. DOE must show how the ongoing results of this monitoring program are consistent with assumptions made in the license application about the repository system performance. Should any significant differences arise, DOE must analyze them to find out how the safety of the repository might be affected.

Does NRC require more than just a strong waste package?

Yes. NRC requires that the repository rely on multiple barriers to ensure that safety does not depend solely on any one barrier. A barrier is any material, structure or feature that prevents or slows movement of radioactive waste from the repository to the environment.

A barrier may be:

- A geologic feature, such as an absorbent rock layer in the mountain
- An engineered or man-made structure, such as a concrete slab
- A **canister**, the container in which the waste is stored
- A **waste form** with physical or chemical characteristics that significantly slow the movement of water or **radionuclides**
- Some material placed over and around the waste that delays movement of water or **radionuclides**

Barriers work to isolate waste in various ways. They can limit contact of water with the **waste packages** by blocking or slowing down water as it seeps from the surface to the depth of the repository. Barriers can prolong lifetimes of other barriers such as the **waste package**. Barriers, including the **waste form** itself, can limit the amount of waste that is able to dissolve in water. If the waste reaches the natural system, some portion will stick to rock and mineral surfaces, thereby restricting the waste's ability to travel away from the repository.



The main tunnel under Yucca Mountain, showing ventilation pipes and train tracks.

NRC requires DOE to demonstrate the capabilities of repository barriers for several reasons:

- Such a demonstration should provide NRC additional confidence that public health and safety are protected.
- It helps NRC focus its technical review of DOE's license application on repository attributes that are essential for safety.
- Showing the full capabilities of multiple barriers illustrates how the repository could respond to unexpected events.

By requiring a repository system of multiple barriers, NRC expects that DOE will show that its repository design provides successive levels or layers of protection.

What makes a repository safe?

Multiple Barriers

A safe repository provides both man-made and natural barriers.

- DOE must design its repository system so that **engineered barriers** will work with the surrounding natural barriers to keep projected releases and radiological exposures within rigorous safety limits.
- DOE must identify which man-made features and which natural features in the geologic setting will prevent or slow the movement of the various components of radioactive waste.
- DOE must describe the capability of these barriers in great detail, taking into account the uncertainty in what is known about their properties and behavior over long periods of time.
- DOE must show that NRC's rigorous requirements are met by using a comprehensive set of calculations called a **performance assessment**.

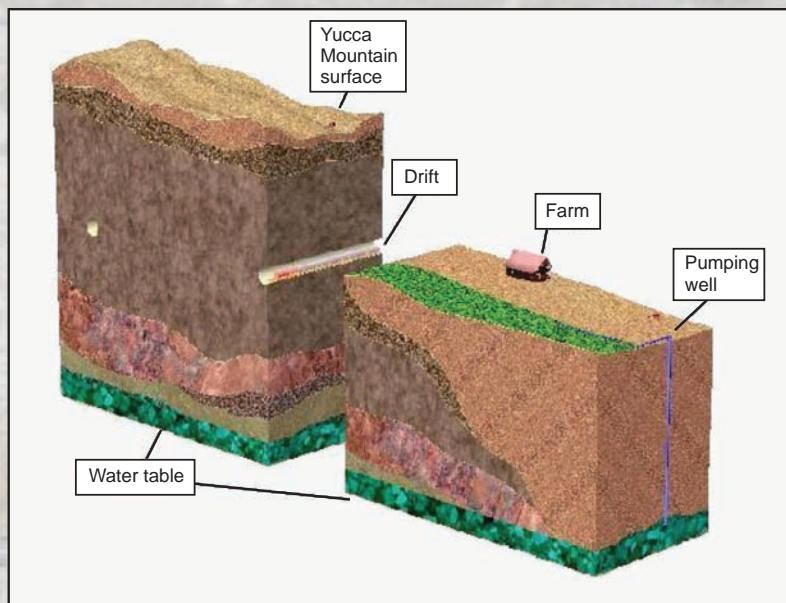


Diagram of underground layers of Yucca Mountain which may serve as barriers.

Is DOE required to document and retain records of what it puts in the repository?

Yes. DOE must keep complete and comprehensive records of its repository activities and findings. These include:

- Site characterization
- Construction activities
- Repository design
- Laboratory tests
- Scientific studies
- Quality assurance
- Personnel training
- Operational procedures
- Inventories of waste
- Others

These documents must be accessible for NRC review. DOE also has to make the repository area, documents and facilities available for NRC inspections and reviews.

After DOE closes the repository, can DOE just walk away?

No. DOE remains responsible for the safety and security of the repository after **closure**. By law, DOE must provide continued oversight and monitor the repository to prevent any activity at the site that could interfere with repository barriers or that could cause radiation doses to the public to exceed allowable limits.

Before NRC would allow DOE to close the repository, DOE must show that it has:

- Established a permanent oversight and monitoring program.
- Put suitable land use controls in place.
- Erected durable markers and monuments.
- Taken measures to preserve knowledge about the location and contents of the repository.

Will NRC take DOE's word that

No. NRC has a rigorous inspection program to confirm independently that things are being done right. NRC also has the legal authority to enforce compliance with safety regulations through notices of violation, monetary civil penalties, or orders.

Resident Inspectors

If NRC authorizes DOE to build a repository, NRC will assign resident inspectors to provide direct oversight at Yucca Mountain. These inspectors would live nearby and would oversee DOE operations on a daily basis. In addition to these routine daily inspections, teams of NRC experts would perform targeted inspections of construction and operational activities. As part of its safety mission, NRC has the authority to conduct announced and unannounced inspections of all licensed facilities at any time.



NRC staff make inspections at Yucca Mountain and nuclear facilities to ensure that safety practices are being followed correctly.

things are being done right?

Quality Assurance

Further, **NRC** regulations require that **DOE** have an acceptable “quality assurance” program in place. Quality assurance (QA) is a system of specific policies and procedures that must be followed and documented to provide confidence that construction and operation of a repository are completed correctly.

QA policies apply to every aspect of the repository that might affect safety. Some examples include checking the quality of materials used in construction, having proper administrative procedures, tracking and controlling documents, testing and calibrating equipment, confirming the accuracy of calculations and computer models, and verifying that materials and data are traceable. QA also means ensuring that the workers building and operating the repository are qualified and properly trained to do the job.

Auditing

Auditing is another important part of quality assurance. Regular review of **DOE** documents, field activities, and laboratory activities by both **DOE** staff and external parties is important to ensure that **DOE** follows its procedures to assure quality.

NRC's On-Site Representatives

To prepare for a licensing decision, **NRC** maintains a local, on-site representatives' office in Las Vegas, Nevada. A small staff of senior **NRC** professionals interact with **DOE** project staff at Yucca Mountain, in accordance with a public agreement. This agreement helps **NRC** prepare to review and judge, independently, the soundness of a potential license application. Reports of **NRC**'s on-site representatives' activities are available to the public on **NRC**'s web site at <http://www.nrc.gov/waste/hlw-disposal/public-involvement/on-site-rep/reports.html>

Continuous Review

DOE also must regularly review the status and adequacy of its QA program and cannot change the program without **NRC** approval.



NRC's On-site Representatives' Office in Las Vegas, Nevada.

Can NRC say no?

Absolutely. NRC has three options once DOE submits an application to construct a repository:

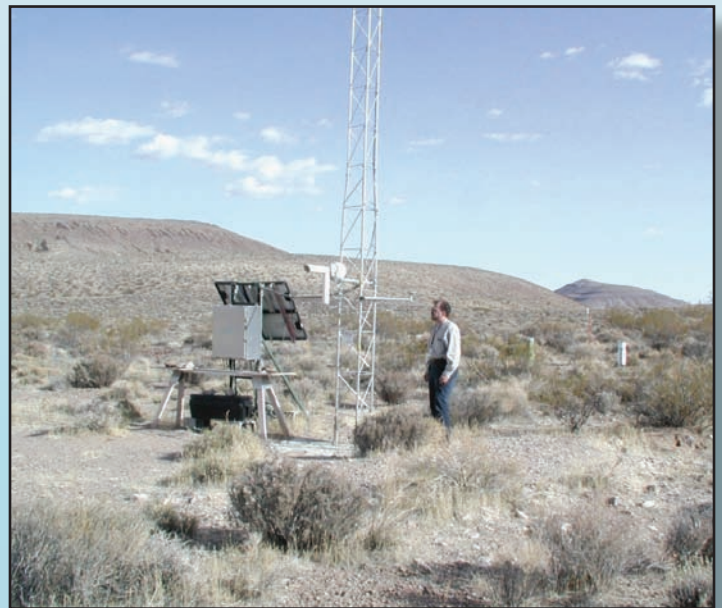
1. NRC could deny the application.
2. NRC could authorize DOE to construct a repository as described in DOE's application.
3. NRC could allow DOE to build a repository subject to specific, enforceable conditions which NRC believes are necessary to ensure safety, security and environmental protection.

NRC will only allow DOE to build a repository at Yucca Mountain if it finds that DOE can build and operate the repository safely and securely, and in a way that meets NRC's regulations. NRC will base its decision on a comprehensive safety evaluation of DOE's application and on the results of a full and fair public hearing. Interested state, local and tribal governments can choose to participate in this hearing, whether or not they elect to contest the contents of DOE's application.

If NRC approves construction of a repository at Yucca Mountain and if DOE builds one, DOE will again need to ask

NRC for permission to receive radioactive waste for disposal.

NRC would make this second decision after inspecting the repository to ensure it was built in accordance with the conditions of NRC's authorization. In addition, DOE would have to demonstrate that it can manage and dispose of waste safely at the repository, in compliance with NRC's licensing regulations. Similar to the decision in granting permission to build the repository, NRC would base the decision of whether to allow DOE to operate the repository on a comprehensive, updated safety evaluation. NRC will also provide the opportunity to request a second full and fair public hearing.



NRC staff observe a field test near Yucca Mountain.

Glossary

Canister. A cylindrical metal container used to handle, transport, store or dispose of high-level nuclear waste. Some types can be used for more than one of these tasks. When used for disposal, a canister may also be referred to as a waste package.

Closure. The sealing of shafts, ramps and boreholes, and final backfilling of the underground repository.

DOE. The U.S. Department of Energy; the agency responsible for designing, constructing and operating a repository.

Engineered barriers. The waste packages, other engineered (man-made) components such as drip shields, and the mined, underground facility consisting of tunnels and drifts.

EPA. The U.S. Environmental Protection Agency; the agency responsible for setting environmental regulations related to Yucca Mountain.

Geologic repository. A system intended for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes the engineered barrier system and the surrounding rock.

High-level waste. Highly radioactive material resulting from the reprocessing of spent nuclear fuel; frequently abbreviated as HLW.

NRC. The U.S. Nuclear Regulatory Commission; the agency responsible for enforcing Yucca Mountain regulations and for granting or denying a license to DOE.

Performance assessment. A systematic analysis that examines what can happen at a repository, how likely it is to happen, and what can result.

Performance confirmation. The program of tests, experiments and studies that DOE must conduct to verify the soundness of the information used to demonstrate that the repository meets NRC's regulations.

Preclosure safety analysis. A systematic examination of the site, the repository design, and potential hazards that could result in the exposure of workers or the public to radiation while waste is received, handled and placed in the repository.

Radionuclide. A radioactive type of atom with an unstable nucleus that decays and emits ionizing radiation.

Reasonably maximally exposed individual. A hypothetical person living in the Amargosa Valley area used for estimating possible radiation exposure to people in the distant future.

Spent nuclear fuel. Fuel that has been irradiated and withdrawn from a nuclear reactor because it is no longer an efficient contributor to producing nuclear energy. Spent fuel is still highly radioactive.

Waste form. The radioactive waste materials and any encapsulating or stabilizing matrix. Spent nuclear fuel and reprocessed, radioactive waste glass logs are the two waste forms that DOE plans to put in a repository.

Waste package. The waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container.

To learn more about NRC's high-level waste repository program, please visit our website at <http://www.nrc.gov/waste/hlw-disposal.html>

NRC is committed to openness in the performance of its regulatory duties. To that end, we hope this brochure has been informative and clear. Please help us improve the quality of our materials by answering a few questions.

- 1. Did you find this brochure helpful?**
- 2. Was there a topic we could have explained better?**
- 3. Are there other questions about NRC's Yucca Mountain regulations that we should address in future revisions of this brochure?**
- 4. Are there other aspects of NRC's program that you would like us to explain?**

Please fill in your responses, detach along perforation and mail this card, or send your replies by e-mail to JPK@nrc.gov. Thank you for your interest.



DIVISION OF HIGH-LEVEL WASTE REPOSITORY SAFETY

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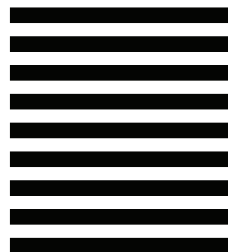


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