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DOE/NWTS-33(1)

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NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste

Program Objectives, Functional Requirements, and System Performance Criteria

April, 1981

NWTS Program Office
U.S. Department of Energy

National Waste Terminal Storage Program

PUBLIC DRAFT

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BIBLIOGRAPHIC DATA

U.S. Department of Energy, 1981. *NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Program Objectives, Functional Requirements, and System Performance Criteria*, DOE/NWTS-33(1), Office of NWTS Integration, Battelle Memorial Institute, Columbus, OH, Public Draft.

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Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A03
Microfiche copy: A01

**Department of Energy
Washington, D.C. 20545**

Dear Reviewer:

The United States Department of Energy (DOE) has primary Federal responsibility for developing licensed facilities for the disposal of high-level radioactive wastes consistent with National policy. Among the options for long-term waste isolation is emplacement in a mined geologic disposal system well beneath the earth's surface. Criteria to guide the development of a disposal system are necessary in order to ensure that the disposal system will be provided in a technically defensible, timely, and economical manner.

The final judgment as to what constitutes an acceptable disposal system will ultimately be made by the responsible government agencies, e.g., the Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), and State and local government entities. These organizations are currently working on development of policies, criteria, and regulations to be addressed in characterizing, licensing, and operating a disposal system at a specific site.

At the present time, final repository criteria have not been issued by the responsible agencies. The enclosed document, NWTS Criteria for Mined Geologic Disposal of Nuclear Wastes: Program Objectives, Functional Requirements, and System Performance Criteria, NWTS-33(1) describes general objectives, requirements, and criteria that the DOE intends to apply in the interim to the National Waste Terminal Storage (NWTS) Program.

These objectives, requirements, and criteria have been developed on the basis of DOE's analysis of what is needed to achieve the National objective of safe waste disposal in an environmentally acceptable and economic manner and are expected to be consistent with anticipated regulatory standards. The qualitative statements in this document address the broad issues of public and occupational health and safety, institutional acceptability, engineering feasibility, and economic considerations.

A comprehensive set of criteria, general and project specific, of which these are a part, will constitute a portion of the technical basis for preparation and submittal by the DOE of formal documents to support future license applications for nuclear waste repositories.

The DOE intends to subject the nuclear waste isolation effort to comprehensive peer review and full public scrutiny. As a part of this process, we would like to solicit your review of the enclosed criteria document. Any comments that you may have should be provided to Dr. Colin A. Heath, Director, Office of Waste Isolation, NE-330 (GTN), United States Department of Energy, Washington, D.C. 20545 by July 31, 1981. Such comments will be considered in the further development of these criteria.

JB
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Thank you in advance for your assistance in this matter.

Sincerely,

A handwritten signature in cursive script that reads "Sheldon Meyers". The signature is written in dark ink and is positioned above the printed name and title.

Sheldon Meyers
Acting Deputy Assistant Secretary
for Nuclear Waste Management
and Fuel Cycle Programs

NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste

Program Objectives, Functional Requirements, and System Performance Criteria

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April, 1981

Prepared by the Office of NWTS Integration
Battelle Project Management Division
Columbus, OH 43201
Under Contract DE-AC06-76RLO 1830-ONWI
With the U.S. Department of Energy

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1.0 INTRODUCTION

The Department of Energy (DOE) has primary federal responsibility for the development and implementation of safe and environmentally acceptable nuclear waste disposal methods. Among the options being evaluated for long-term isolation is emplacement of nuclear wastes in mined geologic repositories* well beneath the earth's surface. This option is the most advanced of the various disposal technologies considered^(1,2), and therefore has been selected for near-term development and implementation.^(1,2,3)

The National Waste Terminal Storage (NWTs) program was established under DOE's predecessor, the Energy Research and Development Administration, to provide facilities for the mined geologic disposal of radioactive wastes. The NWTs program directs both the development and the implementation of the technology necessary for designing, constructing, licensing, and operating repositories. The program does not include the management of processing radioactive wastes or of transporting the wastes to repositories.

The NWTs-33 series, of which this document is a part, provides guidance for the NWTs program in the development and implementation of licensed mined geologic disposal systems for solidified high-level** and TRU wastes. This guidance is provided in the form of program objectives, functional requirements, performance criteria, and specifications intended to ensure that the program is consistent with national policy and that it results in the safe and environmentally acceptable disposal of radioactive waste. In this series the term "criterion" is used to mean a standard rule or test by which something can be judged. Functional requirements establish the capabilities that the mined geologic disposal system must provide to achieve the program objectives. Performance criteria designate how the disposal system and its components must perform to ensure that the functional requirements are met. These objectives, requirements, and criteria are applicable to the mined geologic disposal system in general. Specifications that further define the performance criteria and provide a basis for meeting the criteria will be developed for particular design options for the repository and waste package. Site specifications will also be developed as particular areas are identified as potentially suitable. These site specifications will be used to compare and judge potential sites.

The program objectives, functional requirements, and system performance criteria are found in this document, NWTs-33(1). NWTs-33(2) presents the site performance criteria, NWTs-33(3), the repository performance criteria, and NWTs-33(4), the waste package performance criteria. Specifications will be developed as required.

At the present time final criteria have not been issued by the Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA). The criteria in these documents have been developed on the basis of DOE's judgment of what constitutes sufficient protection of the health and safety of the public and the quality of the environment. It is expected that these criteria will be consistent with regulatory standards. The criteria will be re-evaluated on a periodic basis to ensure that they remain consistent with national waste management policy and regulatory requirements. A re-evaluation will be made when final criteria are promulgated by the NRC and EPA.

*A glossary of terms appears at the end of this document.

**It is recognized that operation of a fuel cycle, including reprocessing, may lead to the necessity to dispose of some spent fuel for technical and other reasons. Therefore, methods to handle this waste form in quantities will remain under investigation.

2.0 PROGRAM OBJECTIVES

The program objectives and key requirements that are applied through the NWTS program are presented in this section. These objectives were developed to ensure that the Department of Energy's NWTS program is consistent with the national policy statements and recommendations found in references 1-4. Application of these objectives throughout the NWTS program should ensure consistency among the individual projects.

The NWTS program objectives appear in italics. A discussion follows each objective.

2.1 Effective Waste Isolation

The mined geologic disposal system shall provide reasonable assurance that waste will be adequately isolated from the accessible environment for a period of at least 10,000 years with no prediction of significant decreases in isolation beyond that time. The potential risk to future generations shall be limited to the extent reasonably achievable.

Isolation of nuclear waste from the biosphere is the primary objective of the NWTS program. It is reasonable that current generations assume some risk from the disposal of radioactive wastes in proportion to the benefits gained through nuclear power activities leading to the production of these wastes. Although future generations may receive some benefits because of the resulting conservation of other energy sources and the preservation of the standard of living and economic health in the U.S., such benefits are difficult to evaluate. Consequently, on a risk/benefit basis, future generations should not be required to assume any significant risk from currently generated wastes to the extent reasonably achievable. The 10,000-year time period has been recommended as reasonable⁽⁴⁾ and has been suggested by the EPA for use in its regulations. This value will be evaluated during the regulatory process and revised, if necessary.

2.2 Institutional and Societal Acceptability

The NWTS program shall be conducted in a manner that will promote institutional and societal participation and acceptance of the program plans and activities.

Our ability to develop methods to safely dispose of nuclear waste is a major issue in the United States today. The resolution of this issue will require both the development of technology and the achievement of institutional (governmental) and societal acceptance of that technology. In the NWTS program, institutional and societal participation and acceptance should be sought in program activities through the licensing process, state and local government involvement, technical peer review, public information activities, and open dialogue in appropriate public forums.

Licensing Process

In our system of government, laws, statutes, and regulations provide the framework for protecting the common interest. The primary regulatory body for the commercial nuclear field is the Nuclear Regulatory Commission (NRC), which exerts control through the licensing process. In addition, other federal, state, and local agencies regulate areas not specifically delegated to the NRC by Congress.

The judgment of whether or not a proposed disposal system is licensable for construction, operation, and subsequent decommissioning is the statutory responsibility of the Nuclear Regulatory Commission. The Environmental Protection Agency (EPA) will promulgate generally applicable environmental radiation protection standards for areas outside the boundaries of the repository. The NRC will promulgate regulations to ensure public health and safety and environmental quality, and to ensure that the EPA standards will be met. The NRC has described its role and that of the EPA in Reference 5.

The decision to license the system will be based both on assessments of the safety of the system proposed and on compliance with National Environmental Policy Act (NEPA) provisions. Program activities and data acquisition important to the licensing process should be controlled through quality assurance programs established by the NWTs program and its projects.

This licensing process should ensure that the same mechanisms for determining acceptability as now exist under our system of government for other commercial nuclear developments will be applied to repositories. These mechanisms provide opportunities for societal participation in the decision making.

State and Local Government Involvement

State and local governments in areas being considered for the siting of a repository should be involved in the decision-making process as early as possible. Activities leading to the siting or development of a repository should not be initiated without prior notification of and discussion with the state and local governments in the areas being considered. This interaction is important to the entire decision-making process; it should enable the parties involved to contribute to licensing decisions with a sound understanding of the waste disposal system.

One means of providing for state participation in the NWTs program is through the State Planning Council, a group of state and federal officials appointed by the President to advise the Executive Branch of the federal government and to work with Congress in addressing issues on radioactive waste management.* Individual states should also be involved in the NWTs projects as appropriate.

*The current charter of the State Planning Council expires in August 1981.

Technical Peer Review

Technical peer review provides independent and objective evaluation and comment by the scientific and engineering communities of program plans, activities, and results. Peer review will be used extensively in the NWTS program to enhance technical quality and increase the likelihood that the disposal system will be technically acceptable to the regulatory bodies.

Public Information Activities

To achieve informed public participation in and social acceptance of plans for the disposal of radioactive waste, the public must have access to information on these plans and on the potential impacts of implementing them. The public must also have the opportunity to express its opinions on these plans and know that its comments and concerns are being considered by the decision makers. The NWTS program should be conducted in a manner that is open and accessible to public participation.

2.3 Technical Conservatism

Technical conservation shall be applied throughout the NWTS program. The methods used to design, develop, and demonstrate the disposal system shall be sufficiently conservative to account for residual uncertainties of potential importance to system effectiveness and shall provide reasonable assurance that regulatory standards will be met.

There will always be uncertainties in the technical analysis of the expected performance of the mined geologic disposal system. In response to these uncertainties, the NWTS program has adopted an explicit policy of "technical conservatism". This is consistent with the IRG recommendation that "The existence of residual technical uncertainties . . . be recognized and provided for in the technical program structure." Good engineering practice has always been to design conservatively when uncertainties exist and the potential consequences of failure can be significant. In the NWTS program, a stepwise approach to repository development, a multibarrier system for containment and isolation of the waste, retrievable waste storage for a limited period of time, and conservative design safety limits are used to implement this policy of conservatism.

Stepwise Approach

A high level of confidence in the projected disposal system performance, based on demonstrated understanding of that performance, will be required before a license for final closure of a repository is granted. This means that the characteristics and performance of both the total system and its subsystems must be understood. This understanding will be achieved through "steps" during which the information and experimental data gathered are evaluated. These steps should include testing from the surface during the site selection process, in-situ testing to confirm predictions of system and subsystem performance, demonstrating waste storage during the period of retrievability, and continuous monitoring of the system response to the construction of the repository and the emplacement of waste.

Multibarrier System

The mined geologic disposal system will be composed of three major subsystems: the site, the waste package, and the repository. Together they provide multiple, independent, natural and man-made barriers to radionuclide release. In the multibarrier approach it is recognized that the entire system acts to provide containment and isolation of the waste, and that the system is composed of multiple natural, engineered, and institutional barrier components. Overall technical uncertainties can be reduced by "reinforcing" one or more of the barriers or subsystems, thereby requiring them to provide containment or isolation capability in excess of that which would be required if the entire system performed as expected. Thus, additional confidence in the capability of the disposal system to perform its basic functions is achieved.

Stated another way, the existence of a system of barriers should provide "defense in depth" against the release of hazardous quantities of radioactive materials to the biosphere. The strength of this approach is that reliance placed on any given barrier will not be so great as to jeopardize the successful functioning of the overall system, if a particular barrier ceases to perform in the expected manner. In designing each subsystem to perform its function, however, care must be taken to ensure that interactions between the subsystems are considered and that no component will unacceptably affect the planned performance of another component.

The multiplicity of engineered barriers is most effective and can provide the greatest reduction in isolation uncertainty during the first several hundred years following waste emplacement. This is an important period because it is the time during which the radiotoxicity and the thermal output of the waste decrease most rapidly.

Retrievable Waste Storage

The disposal system will be monitored both during and after waste emplacement to ensure that the system is performing as predicted. If a re-analysis of performance based on data collected during the operational phase indicates that the system is not performing acceptably, retrieval of the waste may be necessary. To ensure this retrieval option, applicable technology and design studies on retrievability will be included in the NWTS program.

Conservative Design Safety Limits

To account for uncertainties in the response of the system to the emplacement of nuclear waste, the repository should be developed and operated in a conservative manner. Design parameters that may be effectively controlled include the age of the waste at emplacement, the temperature of waste package components and the surrounding host rock, the heat loading per unit area, and the rate of waste emplacement.

2.4 Multiple, Regional Repositories

The NWTS program shall provide multiple, regionally sited repositories insofar as technical considerations permit. Features of the repositories shall be standardized to the extent practicable to facilitate safe and economical development and operation.

The IRG has recommended the development of regional repositories as a means of reducing the amount of waste transportation required. The use of regional repositories should distribute the risk and the environmental and political burden across the country rather than concentrating them in one region. In addition, multiple repositories will provide back-up storage in the event that one repository is required to be shut down due to unexpected difficulties. The repositories should be implemented sequentially. The schedule for the first repository should not depend upon any assumed schedule for the development of additional repositories.

As many features of the waste disposal system as are technically and economically practicable should be standardized to facilitate safe and economic operation of the repository and to simplify the licensing of multiple repositories. Standardization should also facilitate the safe handling of waste at different repositories.

2.5 Waste Accommodation

The system of NWTS repositories shall be capable of receiving and disposing of all commercial high-level and transuranic (TRU) wastes and defense high-level wastes in a safe manner, regardless of the amount of nuclear waste produced and of the specific fuel cycle or reactor that produced it.

The United States has been and is continuing to generate radioactive wastes from the nuclear fuel cycle, as well as from the defense program and other activities. Significant quantities of these wastes, because of their long-lived radiotoxicity or long half-lives, require disposal under conditions that ensure their long-term isolation from the biosphere. Mined geologic disposal is the recommended method for providing this isolation. These wastes include defense and commercial high-level wastes (HLW), and transuranic (TRU) wastes from commercial activities. The capability to dispose of all these wastes will be provided within the system of NWTS repositories.

2.6 Effective Resource Utilization

The safe disposal and isolation of radioactive wastes shall be achieved in a manner that provides effective utilization of resources.

The objective of radioactive waste disposal is isolation of nuclear waste from the biosphere in a manner that will protect the health and safety of the public and ensure that the environment is protected. This can be achieved in many ways within the mined geologic disposal system. Alternatives considered in the design of repository components should be evaluated for their beneficial impact on repository performance and for effective use of available economic and natural resources.

2.7 Use of Near-Term Technology

The mined geologic disposal system shall be developed based upon a level of technology that can be implemented within a reasonable period of time. It shall not depend upon

scientific breakthroughs and shall be able to be assessed with current capabilities. Active maintenance or surveillance for unreasonable lengths of time into the future shall not be necessary to ensure adequate isolation.

In order to provide a mined geologic disposal system within this century that can be shown to isolate waste adequately, the technology required for such systems should be available within this decade. Therefore, reliance cannot be placed on scientific breakthroughs. Technology that is "reasonably available" must be applied in a manner that will provide high confidence of successful waste containment and isolation. The prediction of system performance by currently available techniques should increase confidence in the capabilities of the system.

In addition, as emphasized by the Interagency Review Group, the current generation should implement technologies to dispose of nuclear waste without reliance on perpetual surveillance or maintenance activities. The Environmental Protection Agency, in particular, has indicated in its draft criteria for waste management that the Department should not rely on such surveillance or maintenance for a period of more than 100 years after the termination of active disposal operations.⁽⁵⁾

3.0 FUNCTIONAL REQUIREMENTS

In establishing a basis for the development and operation of a mined geologic disposal system, the functions that the system and each subsystem must serve in containing and isolating waste must be defined. The mined geologic disposal system can be viewed as being comprised of three subsystems: the site, the repository and the waste package, each of which has various functions in achieving the system objectives. Requirements for these functions are presented in this section. The requirements fall into two categories for each subsystem: (1) functions relating to operational capabilities of the system and (2) functions relating to long-term containment and isolation of waste.

In the following presentation the requirement is shown in italics. A discussion follows each requirement, presenting the basis for the requirement and conditions for satisfying the requirement.

The functional requirements presented here form the basis for the performance criteria, which appear in Section 4.0 of this document and in NWTs-33(2), (3), and (4). The objectives presented in Section 2.0 are reflected throughout the functional requirements and performance criteria.

3.1 System Functional Requirements

In the mined geologic disposal system, containment and isolation will be achieved by emplacing the waste in a repository hundreds of meters below the ground surface at a site selected for its favorable containment and isolation capabilities. The following system functional requirements provide the basis for the site, repository, and waste package functional requirements presented later.

3.1.1 Operations

The mined geologic disposal system shall provide the facilities and capabilities necessary for waste receipt and emplacement.

The operational capabilities of the system will be provided primarily by the repository subsystem, which is defined as all man-made components of the disposal system except those associated with the waste package. The site and waste package subsystems will also contribute to satisfying this function of the system as described in Sections 3.2.1 and 3.4.1.

3.1.2 Containment and Isolation

The mined geologic disposal system shall provide the capability to adequately contain and isolate radionuclides to ensure that no releases resulting in unacceptable doses to the public occur.

Containment and isolation will be provided primarily by the site. The waste package should increase the confidence in system effectiveness by providing redundant containment and isolation capabilities. The repository will also contribute to this system function as described in Section 3.3.2.

3.2 Site Functional Requirements

The site subsystem is defined as the surface and subsurface portion of the earth's crust that contains the repository and the natural barriers to radionuclide release. The functional requirements for the site are described below.

3.2.1 Operations

The site shall provide a setting compatible with the type and magnitude of operations expected at the waste repository.

The feasibility of constructing a repository must be considered in selecting a site. In particular, the site must provide (1) an adequate volume of host rock for the underground portion of the repository, (2) a host rock in which the underground areas can be excavated safely, (3) features suitable for the construction of the surface facilities, (4) a hydrologic environment compatible with the construction and sealing of shafts, and (5) a location at which environmental and socioeconomic impacts from repository construction and operation would not be unacceptable.

3.2.2 Containment and Isolation

The site shall provide natural barriers that will effectively contain and isolate radionuclides. Thus, the site must provide capabilities to (1) contain the waste, (2) isolate the waste from man, and (3) assist in keeping man away from the waste.

Protection of the public health and safety is the key objective in the selection of candidate sites. The site must therefore provide natural barriers for waste containment and isolation. These barriers should keep radionuclides from reaching man in unacceptable quantities by (1) maintaining the waste in its emplaced location for a given period of time (providing waste containment), (2) limiting radionuclide mobility through the geohydrologic environment to the biosphere (providing isolation), and (3) making human intrusion difficult, principally by locating the repository deep in a host rock (assisting in keeping man away from the waste). The site must contain a host rock suitable for constructing the repository and containing the waste, and surrounding rock formations that can provide adequate isolation. Desirable hydrologic features include low ground-water flow rates, long paths to the biosphere, and long-term stability. The important natural attributes of the host rock include characteristics that determine ground-water movement and chemistry, and the ability to withstand thermal effects of the waste.

3.3 Repository Functional Requirements

The repository is defined as all man-made components of the disposal system except those associated with the waste package. The repository includes the surface facilities and the underground areas excavated for waste emplacement.

3.3.1 Operations

The repository shall provide the capabilities necessary for waste handling operations and waste emplacement. The repository shall also provide design features and equipment to accomplish waste retrieval.

The repository must be capable of such operations as receiving waste canisters, inspecting them, preparing the waste package for emplacement, and emplacing the waste. Capability for waste retrieval must also be an integral part of repository design and operations. For effective operations, the design of repository facilities and equipment used for these operations must consider possible rates of waste receipt and the total quantity of waste to be disposed of.

3.3.2 Containment and Isolation

The repository shall contribute to the containment and isolation capabilities of the mined disposal system by (1) limiting adverse impacts of repository development and operation on waste package and site performance, (2) using engineered barriers that maintain the natural capabilities of the disposal system, (3) monitoring the system performance, and (4) providing measures to protect against human intrusion.

In the design and operation of the repository not only must the capability to emplace waste be considered, but also the contribution of the repository to the long-term containment and isolation of the waste. This involves both using engineered barriers that maintain the capabilities of the system (for example, specially designed sealing materials) and limiting the negative effects of the repository on the surrounding rock mass (such as thermal effects.) Designing and constructing the repository to limit potentially adverse effects are the principal factors that distinguish the repository from a conventional mine. The adverse impacts that must be limited include the thermal and radiation effects of the waste on the host rock and hydrology, the effects of excavation on the surrounding rock, and the impacts of penetrations, such as boreholes, on ground-water flow paths.

The repository can also contribute to long-term containment and isolation by providing for monitoring of system characteristics that are indicative of repository performance. Analysis of the data collected to evaluate repository performance is important in determining if the system is performing as required.

In addition, the use of protective measures to limit the likelihood and, if practicable, the consequences of human intrusion into the repository should be considered. These protective measures may include active controls—such as guards and land use controls—and/or passive controls—such as markers and records.

3.4 Waste Package Functional Requirements

The waste package has been defined to include the waste form, canister, and any other engineered components in the emplacement hole. Requirements relating to the operational functions of the package concern the canistered waste unless otherwise noted. The canistered waste component of the waste package is defined as the canister received at the repository and the waste form and any fillers contained within it. Containment and isolation will be a function of the entire waste package.

3.4.1 Operations

The waste package, in conjunction with the repository waste handling systems, shall provide the means for safe handling of the waste at the repository and for retrieving the waste, if necessary. In addition, the waste package must provide a means of identifying the waste it contains.

The waste package must be capable of being safely received and emplaced at the repository. Following emplacement it must be capable of retrieval, if necessary. These functions are performed by the containerized waste component of the waste package. Before the waste is emplaced, the biosphere could be exposed to the waste if an accident breached the container. To protect the general public and repository work force if such an accident does occur, the waste form should be one that is neither easily dispersed in air nor dissolved in water.

The container must be compatible with transport and handling devices and emplacement and retrieval equipment at the repository. The container also must remain intact during the retrieval period in order to permit removal of the waste with minimum risk to the work force.

For safeguard purposes, each waste package, and thus the contents of each package, must be uniquely identifiable. The identification on the waste package must refer to permanent records that describe the waste in each package.

3.4.2 Containment and Isolation

The waste package shall be designed to provide waste containment for a specified period and provide, beyond that period, a long-term barrier to radionuclide release into the geologic environment.

The barrier capabilities of the package should be determined for the total package subsystem. The components of the package subsystem may include the waste form, container fillers, the container, overpack, sleeve and any coatings. These components together should be required to contain radionuclides within the package boundary for a certain period of time and then control radionuclide release from the package to within specified limits. This function must be maintained for repository conditions expected during normal operations and those resulting from unexpected events. Some of the processes which determine repository conditions are brine migration, gas and pressure generation, radiolysis, stressing due to heat corrosion or lithostatic pressure, devitrification, embrittlement, stored energy

release, interactions with ground water, thermal generation, interactions among package components, and interactions with other disposal system components.

The package characteristics to be evaluated under the conditions imposed by the above processes include corrosion, leach and dissolution resistance; stress resistance; abrasion resistance; combustibility; heat conductivity; geometric stability; potential for interaction with other package and repository components; and the ability of package components to act as a dessicant, radionuclide getter, or radiation attenuator or absorber.

The waste package will be evaluated as a single unit in assessment of its containment and isolation performance. Under certain conditions some components of this subsystem may not survive, and thus could place the burden of their function on other components. These conditions must be evaluated to ensure that the package as a whole will still maintain its ability to act as a barrier to radionuclide transport.

4.0 SYSTEM PERFORMANCE CRITERIA

This section delineates the criteria to be applied to the disposal system in ensuring that the functions described in the preceding section will be performed in a safe and environmentally acceptable manner. Performance criteria specifically for the site, repository, and waste package subsystems can be found in NWTS-33(2), (3), and (4).

4.1 Operational Safety

The safety of the public and the repository work force will have to be ensured during the operation of a repository. Radiological protection is the principal concern in protecting the public health and safety, whereas safety of the repository work force includes protection from mining and other occupational hazards as well as radiological protection.

4.1.1 Public Health and Safety

Applicable federal public health and safety criteria issued by the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) shall be satisfied during the operational phase of the mined geologic disposal system. In particular, the limits specified in 40CFR Part 191 (when adopted) shall be met.

The isolation of nuclear waste from the public is the ultimate goal of the mined geologic disposal system. The public must be protected during repository operations as well as during long-term isolation. Therefore, releases outside the repository boundaries from normal operations or from an operational accident must not exceed established limits, as determined by applicable NRC and EPA regulations.

4.1.2 Occupational Safety

Occupational radiological exposure to the repository personnel shall be maintained to within the limits specified in 10CFR Part 20 and below these limits to as low as reasonably achievable levels. Applicable regulations of the Mining Safety and Health Administration (specifically, 30CFR Part 57) and Occupational Safety and Health Administration shall be used to ensure the protection of repository personnel from mining and other occupational hazards.

In protecting repository personnel consideration must be given to both radiological and other occupational hazards. The repository radiological protection program should be designed following the NCRP guidelines, *Basic Radiation Protection*⁽⁶⁾, for both normal operating and accident conditions.

4.2 Long-Term Safety

The mined geologic disposal system shall meet all applicable standards and shall contain and isolate radioactive wastes to the extent necessary to ensure that releases of radionuclides

to the biosphere do not result in an unacceptable increase in doses to individuals and to the general population. Expected and accidental releases shall meet the limits specified in 40CFR 191 (when adopted).

Until standards are promulgated by the NRC and EPA, the NWTs program will use the following guidelines in evaluating whether or not a proposed disposal system adequately provides for the safe disposal of radioactive waste. The determination of whether or not the doses presented by a mined geologic disposal system are unacceptably high should be based upon a comparison to increments in dose received from fluctuations in natural background radiation and the doses received from exposure to natural bodies of uranium ore. These two comparisons should lend perspective to the hazard imposed by the repository.

The dose received from natural background radiation varies with geographic location and with time. The extent of this variation can be used as a comparison to the dose expected from waste repositories to judge whether or not the dose is acceptable.

The comparison to doses received from exposure to uranium ore bodies is reasonable because uranium is removed from the ore body to create the waste and is then replaced in the ground in a different form and location. Had the uranium not been removed, the ore bodies would have continued to impose a certain dose on the public. Therefore, in evaluating the performance of a repository, the dose imposed by the repository should be compared to that imposed by an ore body that contains the amount of uranium necessary to produce all the waste in the repository.

4.3 Environmental Requirements

Siting, developing, and operating the mined geologic disposal system shall be conducted in a manner that preserves the quality of the environment to the extent reasonably achievable and complies with current environmental legislation. The environmental impacts associated with the mined geologic disposal system shall be mitigated to the extent reasonably achievable.

In selecting a site and in developing and operating the disposal system, environmental impacts and environmental legislation in effect at the start of licensing must be considered. This will involve considering present land use conflicts, resource denial, and construction impacts, including impacts from handling surplus mined material, and complying with NEPA requirements.

5.0 QUALITY ASSURANCE AND STANDARDS

All components of the mined geologic disposal system, including equipment and instrumentation, shall be classified according to their importance to safety and, thus, the level of quality assurance required. A quality assurance program shall be established and implemented in order to provide adequate assurance that these components will satisfactorily perform their required safety functions. This program shall include quality standards for the design, fabrication or construction, and testing of repository components. The quality assurance program shall satisfy 10CFR Part 50, Appendix B—Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants. The standards found in ANSI/ASME NQA-1-1979, Quality Assurance Program Program Requirements for Nuclear Power Plants shall be used as guidance in establishing a QA program which satisfies 10CFR Part 50, Appendix B.

The need for formal quality assurance (QA) programs is well recognized in licensed nuclear facilities. The initial step in developing a QA program for the disposal system is the classification of the components according to their importance to safety. Based upon this classification, different levels of QA should be applied. Comprehensive records must be kept of all phases of the design, fabrication or construction, and testing of repository components.

Where applicable, existing regulations, codes or standards should be incorporated into the QA program. In lieu of specific federal regulations for repository QA, the requirements in 10CFR Part 50, Appendix B—Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants should be met. These standards and the standards found in ANSI/ASME NQA-1-1979 should be adapted and supplemented to ensure their applicability to and sufficiency for system use.

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GLOSSARY OF TERMS

BARRIER—Feature of a waste disposal system that acts either to contain or isolate radioactive waste.

COMMERCIAL WASTE—Radioactive wastes generated in private industrial and other non-government facilities; principally wastes generated in power reactors.

CANISTERED WASTE*—Canister and contents including waste form and any liner, stabilizer, or shielding material.

CONTAINMENT—Confining the radioactive wastes within prescribed boundaries, e.g., within a waste package.

CRITERION—A standard rule or test by which something can be judged.

DEFENSE-IN-DEPTH—A method of providing additional confidence in waste isolation by using relatively independent barriers. (See "multibarrier system".)

DEFENSE WASTES—Radioactive wastes generated in activities related to the national defense program.

DISPOSAL—The permanent placement of radioactive waste, with no intent to retrieve.

ENGINEERED BARRIER—A man-made addition to the geologic environment that minimizes or precludes radionuclide release and transport.

FUNCTIONAL REQUIREMENT—A statement establishing the capabilities required of a system or subsystem.

HIGH-LEVEL RADIOACTIVE WASTE (HLW)—Liquid wastes resulting from the operation of the first-cycle solvent extraction system and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel. Also, solids into which such wastes have been converted. In some cases spent fuel may be considered a waste and would be categorized as HLW.

HOST ROCK—Rock within which radioactive waste is emplaced for disposal.

INSTITUTIONAL BARRIERS—Administrative controls, records, physical constraints, and combinations thereof that direct the activities of human beings to limit intentional or inadvertent access to the waste.

ISOLATION—Segregation of wastes from the accessible environment (biosphere) to the extent required to meet applicable radiological performance objectives.

MINED GEOLOGIC DISPOSAL SYSTEM—A waste management system in which radioactive waste is emplaced in rooms, excavated deep in a stable geologic formation.

MONITORING—Routine measuring of the quantity and type of discharges or migration of radioactive waste from a waste management facility, or measuring changes in physical, chemical, or biological characteristics of the site and the surrounding site area.

MULTIBARRIER SYSTEM—A succession of barriers, operating independently or relatively independently, which acts to contain and/or isolate nuclear waste.

NATURAL BARRIER—The physical, mechanical, chemical, and hydrological characteristics of the geologic environment which, individually or collectively, act to minimize or preclude radionuclide transport.

OVERPACK—Secondary (or additional) external containment for containerized waste.

PERFORMANCE CRITERION—A criterion establishing the required performance of a system or subsystem and qualitative operational, safety, or environmental limits.

RADIOTOXIC—A substance is considered radiotoxic if, when an organism is exposed to it (for example by ingestion or inhalation), biological harm results due to the effects of ionizing radiation.

REPOSITORY—The engineered portion, both above and below ground, of the disposal system, excluding the waste package.

RETRIEVABILITY—Capability to remove waste from its place of isolation using planned engineering procedures.

SITE—The place, both at and below the surface, where the repository and ancillary facilities are constructed. This includes surrounding buffer zones and has a surface area of several square miles.

SPECIFICATION—A performance criterion for a selected design or siting option—often quantitative.

SPENT FUEL—Irradiated reactor fuel that has been utilized to the extent that it can no longer be efficiently used in a nuclear reactor.

STORAGE—Emplacement of packages in a facility with designed provisions for, and the intention of, removal.

SUBSYSTEM—The site repository, or waste package portion of the mined geologic disposal system.

TRANSURANIC (TRU) WASTE—Waste measured or assumed to contain more than a specified concentration of alpha-emitting radionuclides (including U-233 and its daughter products) of long half-life and high specific radiotoxicity that requires isolation.^(3,4) In current usage this concentration is defined as greater than 10 nCi/gm of waste⁽⁷⁾ although a concentration of 100 nCi/gm has been proposed.⁽⁸⁾

WASTE—Material with no currently designated economic value or use.

WASTE FORM—Radioactive waste, in either treated or untreated condition, including any inerts, binder, or stabilizer.

WASTE MANAGEMENT—The range of activities for dealing with radioactive waste including generation, treatment, packaging, storage, transportation, and disposal.

WASTE MANAGEMENT SYSTEM—All elements of the system involved in the management of radioactive wastes.

WASTE PACKAGE*—The waste form and the enclosing envelope that separates the waste from the geologic emplacement medium.

*There have been various applications of the term waste package, either to the package containing waste that is received at the repository for disposal—here called canistered waste—or the package as emplaced in the repository. In this document, the latter usage is applied to the waste package, which includes the waste and all components extending out to the enveloping host rock.

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