NUREG–1373

Technical Position on Postclosure Seals, Barriers, and Drainage System in an Unsaturated Medium

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

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ABSTRACT

The purpose of this technical position is to provide guidance with respect to the current Department of Energy sealing and drainage concepts for a geologic repository in an unsaturated medium. Section 2.0 of the technical position provides a listing of the 10 CFR 60 regulations which are applicable to the design, testing, selection of materials and placement of the postclosure seals, barriers and drainage system. Staff position statements and the corresponding discussions are presented in Sections 3.0 and 4.0 respectively. Technical positions are organized according to the following topics: (1) design consideration, (2) site characterization considerations, (3) performance confirmation considerations, and (4) performance analysis considerations.

CONTENTS

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission's (NRC's) "Generic Technical Position on Borehole and Shaft Sealing of High-Level Nuclear Waste Repositories" (NRC, 1986) focuses mainly on issues related to repositories in saturated media. However, the Department of Energy (DOE) is currently investigating the unsaturated Yucca Mountain site for detailed characterization. Although the guidance in the existing generic technical position (GTP) is also applicable to repositories in unsaturated media, DOE's current design concepts include a combination of sealing and drainage, and, therefore, additional guidance is needed to clarify the NRC staff position on sealing and drainage for a repository in an unsaturated medium. The purpose of this technical position is to provide guidance with respect to sealing concepts for water inflow and gaseous outflow as described in recent DOE publications (Case and Kelsall, 1987; Fernandez, 1985; Fernandez and Freshley, 1984; Fernandez et al., 1987).

The principal design goals for seals in an unsaturated medium should be to (1) prevent significant amounts of surface or ground water from reaching emplaced waste, and, (2) prevent significant amounts of gaseous radionuclides from escaping through shafts, ramps, and boreholes to the accessible environment. Reliance on the seals for meeting the performance objectives of Part 60 of Title 10 of the Code of Federal Regulations (10 CFR Part 60) can be reduced in part by: (1) limiting the amount of surface water that may enter boreholes, shafts, and ramps; (2) selecting borehole, shaft, and ramp locations and orientations that provide long flow paths from the emplaced waste to the accessible environment above the repository; and (3) maintaining a sufficient rate of drainage below the repository horizon level so that water can percolate down through the rock mass, thereby reducing the potential for water to contact the waste packages. Seals for shafts and boreholes must be designed so that they do not become pathways that compromise the geologic repository's ability to meet the performance objectives.

Provisions for rapid drainage of uncontaminated water through the repository horizon can reduce the risk of water contacting waste packages. However, such a drainage scheme can also provide pathways for rapid flow of contaminated water to the accessible environment. The seals and drainage design should ensure that the flow of contaminated water to the accessible environment will not be enhanced.

A goal for a successful design should be to determine what mechanism, or combination of mechanisms, of sealing and drainage would demonstrate compliance with long-term performance requirements with respect to both anticipated and unanticipated processes and events. The role and contribution of factors affecting the performance of the seal system should be assessed. The assessment should consider (1) the potential for water contacting the waste packages and the consequent release of radionuclides to the accessible environment, and (2) the escape of gaseous radionuclides through the shafts and boreholes to the accessible environment. If drainage is to be incorporated as a basic strategy to control water inflow to the emplaced waste, then the uncertainties in predicting and extrapolating the long-term behavior of the contributing factors (e.g., infiltration and effectiveness of drainage) should be considered in evaluating the postclosure performance of seals and the drainage system.

In establishing the NRC staff positions presented in this document, the staff has recognized that large uncertainties are likely to persist in evaluating the longevity and long-term effectiveness of seals and drainage for the postclosure period. In view of these uncertainties, the staff considers it prudent to minimize the need for seals wherever feasible. These considerations suggest that the number of surface openings be limited, and their locations be selected to discourage infiltration of surface water, consistent with the data requirements for site characterization.

This technical position provides guidance regarding design considerations for seals of shafts, ramps, boreholes, and the underground facility. It should be noted that the design criteria for seals given in 10 CFR Part 60 do not specifically mention seals in ramps and the underground facility. However, because the seals and drainage design in ramps and the underground facility could also affect the overall system performance of the geologic repository, it is reasonable to apply the same guidance to these seals and drainage designs.

This technical position takes into account site characterization and performance confirmation testing, including the need for starting in situ seal testing during site characterization and for confirming the adequacy of seal and drainage concepts, emplacement methods, and material compatibility. In addition, this technical position emphasizes the need for considering the effects of seals and/or drainage design on meeting the overall system performance requirements.

This technical position does not explicitly address the implications of potential changes in water level during the postclosure period or gaseous outflow through faults and fractures. However, it is expected that system performance analyses and requirements will include adequate consideration of faults and fractures, credible future tectonic, geologic, geomorphological, and geochemical processes and events that could affect seal performance. In addition, the seal performance analyses should consider the thermal effects of emplaced waste.

Technical positions describe and make available to the public criteria for methods acceptable to the NRC staff

for implementing specific parts of the Commission's regulations or otherwise provide guidance to the DOE. Technical positions are not substitutes for regulations, and compliance with them is not required. Methods and solutions not in accordance with criteria set out in the position will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

2.0 REGULATORY FRAMEWORK

The applicable regulations in 10 CFR Part 60 are stated below, and the text of these regulations is provided in Appendix B of this document.

10 CFR 60.112 addresses the requirements for the selection of the geologic setting and design of the engineered barrier system and the shafts, boreholes, and their seals to meet the overall system performance objectives for the geologic repository after permanent closure with respect to both anticipated and unanticipated processes and events.

10 CFR 60.21(c)(1)(ii)(D) requires the DOE to assess the effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation.

10 CFR 60.152 requires the DOE to implement a quality assurance program based on the criteria of Appendix B to 10 CFR Part 50 as applicable. If seals are determined to be important to waste isolation, then the seals and the activities which affect their performance should be covered by the quality assurance program.

10 CFR 60.134(a) provides the general criterion for design of seals for shafts and boreholes, and 10 CFR 60.134(b) addresses the selection of materials and placement methods for seals.

10 CFR 60.15 addresses the site characterization requirements.

10 CFR 60.140, 60.141, and 60.142 address the general requirements, confirmation of geotechnical and design parameters and design testing, respectively, pertaining to the performance confirmation program.

3.0 TECHNICAL POSITIONS

3.1 Design Considerations

(1) Measures should be established to document that the applicable NRC regulatory requirements relevant to seal design, materials selection, and placement methods have been adequately translated into design bases, specifications, drawings, procedures, and instructions.

(2) The shaft and ramp designs should specify appropriate construction controls to limit the lateral extent and degree of damage to the rock mass as required to achieve the performance allocated to the seals in the overall system performance. The damage around the shafts and ramps caused by construction should be assessed.

(3) The seals and drainage system for water potentially entering into and around the shafts and/or ramps should be designed to reduce the potential for water to contact the waste.

(4) The design of shaft and/or ramp liners should consider the effects of those liners on postclosure seal performance. If part or all of a liner is to be removed when the geologic repository is closed permanently, the possibility that such removal might create water and gaseous pathways should be examined and the effect on postclosure seal performance should be evaluated. If the liner is to be left in place, the effects of the potential degradation and disintegration of the liner during the postclosure period should be factored into the design.

(5) Seal materials should be designed to be geochemically compatible with the host rock and its environment. In addition, backfill and seal materials should be sorptive to radionuclides to reduce migration. Seals should be analyzed (e.g., through modeling and accelerated testing) for long-term compatibility that is consistent with overall system performance requirements.

(6) Exploratory boreholes drilled within the controlled area boundary for site characterization should be sealed. Other exploratory boreholes, drilled outside the controlled area boundary, should be sealed unless it can be demonstrated that they will not potentially compromise meeting the performance objectives of the repository.

(7) The seals for exploratory boreholes and test holes drilled from shafts, ramps, the underground facility and test areas should be planned, designed, and analyzed to assure compliance with the overall performance objective of 10 CFR 60.112.

(8) The design of seals for the underground facility should consider the consequences of their partial and/or complete failure during the postclosure period. It should be demonstrated that the performance objectives for the geologic repository will be met through consideration of the performance of all

of its systems and components, including seals, taken in combination.

(9) Engineering analysis of seals (including backfill and settlement plugs) should be performed with respect to the potential for both water inflow and gaseous outflow. The analysis should account for possible long-term settlement of shaft backfill and piping (channel flow) along the boundary between the liner and backfill and other potential flow paths such as the damaged zone around the openings.

3.2 Site Characterization Considerations

(1) The shafts and/or ramps (should they become part of ESF) should be located so as to limit the potential infiltration of surface water through and around the shaft and ramp openings.

(2) The number of exploratory boreholes should be limited to the extent practicable to meet site characterization and waste isolation needs. The proximity to the planned waste emplacement areas should be considered in determining the locations of boreholes. Planning of borehole depths should take into consideration the potential adverse effects of inflow of water to waste emplacement areas, of gaseous releases, and of outflow of contaminated water to the accessible environment.

(3) All site characterization activities, including those related to borehole and shaft seals, should be planned and implemented so as not to compromise the isolation capability of the site.

(4) The effects of intrinsic anisotropy in rock mass hydraulic conductivity should be considered in the evaluations of drainage pathways.

(5) Data on the performance of seals for boreholes, shafts, ramps, and the underground facility should be collected using tests, experiments, and analytical methods before the license application is submitted.

3.3 Performance Confirmation Considerations

(1) The program for testing the adequacy of the seals and drainage should include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to demonstrate the adequacy of the design, materials, and placement methods.

(2) If, on the basis of the measurements and observations made during the performance confirmation program (including data obtained during the site characterization program), it is not possible to ensure the effectiveness of the seals and drainage, the need for modification of the seal design should be determined and design changes should be implemented, as needed.

3.4 Performance Analysis Considerations

(1) A methodology should be developed for predicting the long-term behavior of the seals and drainage as designed, including the environmental, thermal, and geochemical effects at seal locations. The methodology should be incorporated into the evaluation of the overall system performance during the postclosure period with respect to both anticipated and unanticipated processes and events including long term changes in seismicity, geology, hydrology and climate. Uncertainties in predicting and extrapolating the long-term behavior of the components affecting seal performance should be considered.

(2) The potential adverse effects of the deteriorated liner and/or grout materials on drainage should be considered in evaluating the effectiveness of drainage and the consequent effect on seal performance during the postclosure period.

(3) The analysis of overall system performance should consider the possible consequences of partial or complete failure of seals and/or drainage over 10,000 years. Alternatively, it should be demonstrated by tests, experimental results, and/or analyses that seals will remain effective during the postclosure period. The analyses should explicity consider the potential for fracture and/or matrix flow.

4.0 DISCUSSION

The following discussion parallels the list of technical positions given in Section 3.0.

4.1 Design Considerations

(1) The NRC staff position on an acceptable method for determining Q-list items is given in NUREG–1318, "Technical Position on Items and Activities in the High-Level Geologic Repository Program Subject to Quality Assurance Requirements" (NRC, 1988). If DOE determines that the seals for shafts, ramps, and boreholes are not important to waste isolation, then seals can be removed from the Q-list. If seals are included on the Q-list, then DOE should ensure that all activities associated with the seals are covered by an adequate quality assurance plan.

The overall systematic design and approval process for the seals should consider the 10 CFR Part 60 requirements that deal with site characterization and

long-term isolation. The process should establish a link between the NRC regulatory requirements and seal design. As a part of the process, the applicable 10 CFR Part 60 requirements dealing with seal design, materials selection, and placement methods should be identified. There should be clear and systematic documentation of how each relevant 10 CFR Part 60 requirement is translated into design bases, specifications, drawings, procedures, and instructions. Those aspects of seal design that may affect waste isolation should be translated into requirements that consider the need to meet the performance objectives for the geologic repository over 10,000 years. In addition, a verification process should ensure that the 10 CFR 60 requirements are incorporated into the various stages of design.

(2) The method of constructing the openings and the care taken while implementing the selected construction procedures may influence the need for sealing. Therefore, to the extent necessary to meet the design objectives, the selected method of construction should be specified so that the lateral extent and degree of damage to the rock mass surrounding the shaft and ramp openings are limited. If the selected construction methods can cause excessive damage to the rock surrounding the openings, the sealing of these damaged zones should be considered and their long-term effects should be analyzed to demonstrate compliance with the performance objectives.

(3) The seals and drainage system should be designed so that water entering the shafts and ramps and the damaged zone around the openings would have a limited adverse effect on the isolation of the waste in the repository. To assess the long-term design criteria, the drainage performance over an extended period should be evaluated. Experimental as well as analytical methods should be used to assess the long-term effectiveness of the drainage system in meeting the design criteria.

(4) The shaft and ramp liners can significantly affect the overall effectiveness of the seal system. This potential must be sufficiently evaluated and accounted for in assessing the long-term performance of the seal system. If part or all of a liner is to be removed at permanent closure, then the effect of such removal should be assessed. The liner-removal process can result in damage of the rock around the shaft and ramp wall. Also, liner removal could change stresses in the shaft and ramp walls and could increase the shaft and ramp closure. The effects of liner removal should be considered in the determination of the rate of drainage with time and the potential for creating water and gaseous pathways.

If the liners are to be left in place at permanent closure, the compatibility of liner material with any water with which it might come in contact should be evaluated because of the potential for dissolution of the material and redeposition in rock pores during the postclosure period. Consideration should be given to the possibility that the liners could: (a) degrade and disintegrate with time; (b) cause minerals to redeposit in rock pores with time and contribute to the clogging of the drainage through the rock mass and fractures; and (c) deteriorate and cause additional closure of shaft and ramp walls, thereby creating rock movements that could cause the creation of additional flow paths for water inflow and gaseous outflow. Such recurrence should be considered when evaluating the role of liners in regard to seal performance. It is desirable that the selection of any emplaced materials, such as cement, aggregates, and rock reinforcement components be based, in part, on chemical compatibility during the postclosure period.

(5) Selection of the seal materials and placement methods is an integral part of the seal design. For the seals to be effective, it is essential that seal materials are geochemically compatible with the host rock environment and that placement methods are specifically selected for the conditions encountered in the seal placement environment. The compatibility of the seal material with the host rock should be analyzed over the long period of time for which the repository performance has to be evaluated. 10 CFR 60.134(b) requires that the materials and placement methods for seals be selected to reduce, to the extent practicable (a) the potential for creating a preferential pathway for groundwater to contact the waste packages or (b) radionuclide migration through existing pathways. Accordingly, the selected seal materials and placement methods should contribute to the overall performance of the seals in reducing the potential for water contacting waste, radionuclide migration and for gaseous outflow. The analysis should consider uncertainties with respect to the behavior and compatibility of seal and host rock materials.

(6) In view of the potential significance of the boreholes because of their large number, proximity to waste emplacement areas, and depths, all boreholes should be sealed as an additional conservatism to effect reductions in any uncertainties about accomplishment of performance objectives. If any of the planned or existing boreholes will not be sealed, the effect of these boreholes on the long-term waste isolation capability of the site should be evaluated. The analysis should consider the possibility that the unsealed boreholes could become pathways for water inflow and/or for gaseous outflow. The analysis

should consider the uncertainties regarding potential future natural processes and events and should demonstrate that the design objectives can be met if the identified boreholes are not sealed.

(7) The exploratory shafts and underground test areas may become part of the final repository. As part of the exploration and testing process, a large number of vertical and horizontal holes may be drilled from within the shafts and test areas. Since most of the exploratory holes and test holes are likely to be in areas that may become a part of the repository, they could affect the waste isolation capability of the site. Therefore, these holes should also be sealed. If it is considered desirable that some of the boreholes not be sealed to facilitate drainage of the uncontaminated water, it should be demonstrated that these holes cannot compromise the waste isolation capability of the site by facilitating outflow of contaminated water. The staff believes that in view of the potential significance of these holes if they should be located in a part of the future repository, their seal design should be planned and analyzed to the same standards as the exploratory surface boreholes.

(8) Seals in the underground facility should meet standards similar to those specified for borehole and shaft seals. For an underground facility developed in unsaturated media, the design of seals may include methods for plugging the surface and underground openings to prevent water inflow or methods for encouraging the drainage of water through the host rock. The design of seals may incorporate a combination of these two design methods. If seal performance is relied on for an extended period, it should be demonstrated that the longevity of the seal material is adequate to meet the performance requirements.

If percolation through host rock is relied on to drain the water out of the repository, large uncertainties exist regarding the system's ability to remain functional for long time periods. Therefore, the analysis of the overall system performance should consider the possible consequences of a partial and/or total failure of the underground facility seals and drainage during the 10,000 years. Alternatively, it should be demonstrated using experimental results and/or analyses that the seals will perform satisfactorily and contribute in meeting the performance objectives for the geologic repository.

(9) The performance requirements for the seals and drainage system for shafts, ramps, boreholes, and the underground facility are all to be governed by the requirements for meeting the performance objectives of 10 CFR 60.112. These requirements state that the shafts, the boreholes, and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to the Environmental Protection Agency standards with respect to both anticipated and unanticipated processes and events. If performance is allocated to the seals, engineering analyses of the seals with respect to the potential for water inflow and gaseous outflow should be done to show compliance with the environmental standards for radioactivity to be established by the EPA.

At permanent closure, the shafts may be backfilled with crushed tuff or some other suitable material. Settlement plugs also may be used to reduce backfill settlement. The behavior of the shaft backfill as well as the settlement plugs during the postclosure period may be important in regard to the potential for both water inflow and gaseous outflow.

The plugs are likely to deteriorate with time and, therefore, the effect of this disintegration on the performance of seals and the drainage system should be taken into account. The backfill is also likely to settle with time. Channeled flow paths could be created within the shaft backfill and act as preferential pathways for both water inflow and gaseous outflow. Such pathways could also be created at the interface of the shaft wall and the backfill. The effects of such phenomena should be taken into consideration when evaluating the effect of backfill on the performance of seals and the overall postclosure performance of the repository.

4.2 Site Characterization Considerations

(1) The locations of the shafts and ramps can be a key factor in determining the long-term infiltration potential through and around the shaft and ramp openings. Reasonable and conservative estimates of flooding, infiltration, sheet flow, and other potential water intrusions should be made taking into account climatic changes with respect to additional rainfall and the potential for surface erosion. It should be noted that uncertainties will always exist in these estimates. A prudent means of arriving at reasonable locations of shafts and ramps is to consider these uncertainties and, whenever possible, locate the openings where there is little potential for future infiltration into and around the openings.

(2) The number of exploratory boreholes, their proximity to the future waste emplacement areas, and their depths with respect to the repository level as well as the groundwater table are all important considerations in evaluating the seal design for these boreholes. 10 CFR 60.15(d)(2) requires that the number of exploratory boreholes and shafts be limited to the extent practicable consistent with

obtaining the information needed for site characterization. Since openings from the ground surface may, if not properly sealed, affect the isolation capability of the site, only the number of boreholes required for obtaining information needed for site characterization should be planned.

If the boreholes are to be located close to the future emplacement area, they can affect the waste isolation capability of the site. 10 CFR 60.15(d)(3) requires that, to the extent practical, exploratory boreholes in the geologic repository operations area be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned. Accordingly, the locations of boreholes should be considered with regard to their proximity to the planned waste emplacement areas and should be planned and coordinated with the design and construction of the geologic repository operations area.

Boreholes that penetrate below the repository horizon can create flow paths for water from the waste emplacement area to the groundwater table. Similarly, shallow holes, if interconnected through existing faults and fractures, can provide pathways for gaseous releases from waste emplacement areas to the ground surface. Therefore, in planning the depths of boreholes, the potential effects of inflow of water, gaseous releases, and outflow of contaminated water through these pathways should be considered.

(3) Subpart F to 10 CFR Part 60 requires that a program of seal design testing should be started during site characterization and should continue until permanent closure. 10 CFR 60.15(d)(1) requires that the investigations to obtain the required information be conducted in a manner so as to limit adverse effects on the long-term performance of the geologic repository to the extent practicable. Therefore, seal testing activities should be planned and implemented so as not to compromise the isolation capability of the site.

(4) The rate of drainage through the host rock may be significantly impacted by the natural variability of the hydraulic conductivity within the rock mass.

(5) Preliminary results from seal and drainage testing should be available when the license application is submitted. At that time, the performance of seals and drainage system during the postclosure period will have to be extrapolated from the results of testing that has been completed. The test program presented in the SCP should provide the basis for making a reasonable estimate of the effectiveness of the seal design, materials, and placement methods during the period in which the seal is to perform its function and should be initiated as early as practicable.

The data available when the license application is submitted should reduce uncertainties in predicting the performance of seals during the postclosure period. Significant amounts and good quality of test data at that stage can lead to fewer uncertainties and accordingly can help the Commission find that the performance objectives will be met.

Before proceeding with sealing operations on boreholes, shafts, ramps and/or the underground facility, the effectiveness of the proposed seals should be evaluated using test results and/or analytical procedures. This evaluation should demonstrate that the proposed seals will function as designed for the intended period in the anticipated range of seal environments.

4.3 Performance Confirmation Considerations

(1) 10 CFR 60.140(c) requires that the evaluation program to determine the adequacy of seal design, material selection, and placement methods shall include in situ monitoring, laboratory and field testing, and in situ experiments, as appropriate. For the test program to be valid and directly applicable to the assessment of the long-term performance of seals, it is essential that it be conducted for the range of environmental conditions that are anticipated in the repository during the postclosure period. Both laboratory and field testing may be necessary to simulate the range of anticipated repository conditions.

(2) 10 CFR 60.141(d) requires that the measurements and observations made during the construction and operation of the repository be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or construction method should be determined. If the effectiveness of the seals and drainage system cannot be ensured, either the design of the seals and drainage system should be modified, or it should be demonstrated that the overall performance requirements can be met without taking into consideration the long-term effectiveness of seals.

4.4 Performance Analysis Considerations

(1) Tests to determine the adequacy of the seal and drainage design can be conducted only for a limited time. Therefore, a methodology should be developed for predicting the long-term behavior of the seals and drainage as designed including the

environmental, thermal, and geochemical effects with respect to both anticipated and unanticipated processes and events.

Confirmation testing of seal performance should be initiated during site characterization and continue until permanent closure. Therefore, additional data should become available from the time the license application is submitted until permanent closure. These data can be used to verify the applicability of the methodology developed in the license application for predicting the long-term behavior of the seals and drainage system as designed. However, despite the availability of performance confirmation data, considerable uncertainties are likely to exist in extrapolating these data for the postclosure period considering possible long term changes in seismicity, geology, hydrology and climate. It is essential that sufficient conservatism is used in the seal and drainage design for shafts, ramps, boreholes, and the underground facility to allow for these potential uncertainties.

(2) In some areas of the ramps, diversion structures such as dams may be installed to guide the water flow on the floor of the ramps. Also, seals may be installed in the shaft and ramp walls and other faces to plug up the damaged areas to prevent the inflow of water. These seal components are likely to shrink and/or disintegrate with time and should only be relied on for long-term performance to the extent that their long-term properties can be determined. Furthermore, the disintegration of dams and other seal components could have detrimental effects on the performance of the drainage system. The effects of such seal disintegration during the postclosure period should be considered in evaluating the drainage potential of the rock. Finally, these effects should be considered in the overall system performance analysis of the geologic repository after permanent closure.

(3) Uncertainties exist with respect to the seals remaining functional throughout the time specified to meet the repository performance objectives. The uncertainties include fracture vs. matrix flow mechanism, potential shrinkage of the seal material, deterioration and degradation of the material, performance of the seals in a heated environment, and future tectonic events that might affect borehole seal performance. Therefore, seal effectiveness should only be relied on if a comprehensive analysis of the future environment and changes at seal locations demonstrate that the required seal performance can be obtained. With this need for conservatism in the design and analysis, the staff believes that the analysis of the overall system performance should consider the possible consequences if seals became partially or completely ineffective during the period following permanent closure. Alternatively, it should be demonstrated using experimental data and/or analysis results that the seals would remain effective during the postclosure period.

There are bound to be uncertainties associated with the prediction of the long-term performance of the seals and drainage behavior during the postclosure period. These uncertainties should be accounted for in evaluating the postclosure performance of the seals and drainage behavior and their role in meeting the overall system performance requirements for the repository.

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APPENDIX A GLOSSARY*

"Accessible environment" means: (1) The atmosphere, (2) the land surface, (3) surface water, (4) oceans, and (5) the portion of the lithosphere that is outside the controlled area.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides. "Engineered barrier system" means the waste packages and the underground facility.

"Geologic repository" means a system which is intended to be used for, or may be used for, the disposal of radioactive wastes in excavated geologic media. A geologic repository includes: (1) The geologic repository operations area, and (2) the portion of the geologic setting that provides isolation of the radioactive waste. "Isolation" means inhibiting the transport of radioactive material so that the amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

"Performance confirmation" means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after permanent closure will be met.

"Underground facility" means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

For definitions of other relevant terms, see 10 CFR 60.2.

*Source: 10 CFR 60.2, "Definitions"

APPENDIX B APPLICABLE 10 CFR Part 60 REGULATIONS

The technical rule 10 CFR Part 60 requires that the Department of Energy (DOE) design seals to meet the following requirements:

- §60.112 Overall system performance objective for the geologic repository after permanent closure

  The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

- §60.21 Content of [license] application

  §60.21(c)(1)(ii) The assessment [of the site] shall contain:

  (D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

- §60.134 Design of seals for shafts and boreholes

  (a) General design criterion: Seals for shafts and boreholes shall be designed so that following permanent closure they do not become pathways that compromise the geologic repository's ability to meet the performance objectives over the period following permanent closure.

  (b) Selection of materials and placement methods: Materials and placement methods for seals shall be selected to reduce, to the extent practicable, (1) the potential for creating a preferential pathway for groundwater to contact the waste packages or (2) radionuclide migration through existing pathways.

10 CFR 60.15 addresses the site characterization plan requirements. 10 CFR 60.140, 60.141, and 60.142 address the site characterization requirements for the performance confirmation program.

- §60.15 Site Characterization

  (d) The program of site characterization shall be conducted in accordance with the following:

  (1) Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

  (2) The number of exploratory boreholes and shafts shall be limited to the extent practical consistent with obtaining the information needed for site characterization.

  (3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.

  (4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository operations area design and construction.

- §60.140 General requirements

  (b) The [performance confirmation] program shall have been started during site characterization and it will continue until permanent closure.

  (c) The program shall include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

  (d) The program shall be implemented so that:

  (1) It does not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

- §60.141 Confirmation of geotechnical and design parameters

  (d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the

need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.

- §60.142 Design testing

  (a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

  (b) The testing shall be initiated as early as is practicable.

  (c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

  (d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full scale operation proceeds to seal boreholes and shafts.

If seals are included on DOE's Q-list, then 10 CFR 60.152 requires the DOE to design seals to meet the following requirements:

- 10 CFR Part 50, Appendix B, Criterion III, "Design Control"

  Measures shall be established to assure that applicable regulatory requirements and the design basis, as defined in § 50.2 and as specified in the license application, for those structures, systems, and components to which this appendix applies are correctly translated into specifications, drawings, procedures, and instructions. These measures shall include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled. Measures shall also be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the structures, systems and components.

APPENDIX C DISPOSITION OF PUBLIC COMMENTS

U.S. Bureau of Reclamation

1. Section 3.1, Position 2

(2) Construction Controls—The requirement as stated to control the damage due to construction is warranted. In addition, some method to determine or measure the extent of damage may be needed, particularly in areas of obvious surficial damage and/or overbreak.

RESOLUTION

In general, the staff agrees with this comment. The TP will be changed to reflect the content of this comment. The following statement will be added to section 3.1 (2); "The damage around the shafts and ramps caused by construction should be assessed."

2. Section 3.1, Position 7

(7) Drill Holes—Many drill holes from the ramps and shafts will be horizontal, while surface boreholes will be predominately vertical. Although being "analyzed to the same standards" may be sufficient, it is clear that there are technical differences in sealing horizontal versus vertical boreholes, with problems that must be analyzed and examined unique to each situation.

RESOLUTION

The staff recognizes the technical differences inherent in the sealing of vertical vs. horizontal boreholes. To clarify the position, 3.1 (7) will be changed to read as follows:

"The seals for exploratory boreholes and test holes drilled from shafts, ramps, the underground facility and test areas should be planned, designed, and analyzed to assure compliance with the overall performance objectives of 10 CFR 60.112."

3. Section 4.4

4.4 Performance Analysis Considerations - In general, there may be a need to carefully differentiate between backfill, seals, and plugs. Backfill may be placed for structural support to the work faces, while seals may be isolated emplacements utilized explicitly for sealing the flow of fluids through or around the repository openings. Plugs may be used to eliminate settlement, or can also be used to control flow. Obviously, the design, analysis, and care in construction and placement using these three methods should be based on the desired geotechnical results.

RESOLUTION

The staff acknowledges that backfill and settlement plugs may have either a sealing or structural utility or both. However, this TP addresses backfill and settlement plugs as sealant materials for reducing water inflow and gaseous outflow as stated in section 3.4 (2).

U.S. Geological Survey

General Comments

Because deterioration and disintegration of seals over time must be anticipated, consideration should be given to emplacing swelling clays at strategic locations above the seals. Performance of any clay to be emplaced should be evaluated at maximum prevailing temperatures prior to use. The lower portions of boreholes that reach the water table but do not penetrate the repository might be used as part of a drainage system to cope with the problem of diverting water working downward in the unsaturated rock surrounding the facility.

RESOLUTION

The staff believes the intent of this comment is addressed in sections 3.1 (5), 3.1 (8) and 3.4 (4). The intent of this TP is not to provide prescriptive solutions to technical concerns. Therefore, although the placement of swelling clays at strategic locations above the seals may be a valid solution, it would be inappropriate to take a position on such alternative design concepts at this time.

State of Nevada

General Comments

1. The GTP provides little guidance or insight into how the NRC will review the performance assessment and design of the borehole, shaft, ramp and underground facility seals at Yucca Mountain. The entire document could be summarized as follows: "The seals should be designed and analyzed such that the performance objectives of 10 CFR Part 60 will be met, and the portions of 10 CFR Part 60 that the staff considers relevant to the topic of seals are appended." It might be most efficient to announce this

position to the potential applicant in a memo which could include the additional points described below.

RESOLUTION

This technical position is not intended to provide guidance on overall performance assessment. The topic of sealing is not simply one of performance assessment but also one of design, construction, testing and analysis. The contribution of sealing to overall performance should be commensurate with the expectations placed on their long-term behavior. Simply repeating the rule will not serve any useful purpose. Therefore, the staff has attempted to provide guidance on acceptable approaches to this uncertainty.

2. The regulations, 10 CFR Part 60, provide performance objectives for the design of seals, but they do not contemplate the need of additional performance objectives for the design of an effective drainage system. The GTP, and DOE reports on seals for the Yucca Mountain site emphasize incorporation of a drainage system in the repository. In reviewing the GTP, one gets the impression that the NRC staff considers seals and drainage systems to act together as a barrier, protecting against loss of waste isolation. If the belief is that the regulations are deficient, perhaps the GTP should include any additional guidance, in the form of criteria and objectives the staff believes necessary if a drainage system is to be considered part of the engineered barrier.

RESOLUTION

The NRC staff does not believe that there is a need to provide additional performance criteria for design of an effective drainage system, nor does the staff believe that a drainage system is to be considered part of the engineered barrier system.

3. While the GTP is presented as a generic document, it is quite obviously written within the context of a potential license review of the Yucca Mountain site, and is responsive, at this early date, to the potential applicant's apparent interest in incorporating a drainage system in conjunction with postclosure seals. Having gone this far, it would seem reasonable that the GTP recognize the matter of known fault and fracture zones transecting the repository block, serving as potential pathways for waste migration, and attempt to address this situation in relation to postclosure repository sealing.

RESOLUTION

The discussion in Section 1.0, paragraph 8 has been revised to state that the systems performance analysis should include adequate consideration of faults and fractures that could affect seal performance. In addition it has been clarified that the technical position does not address gaseous outflow through natural faults and fractures.

4. The concept of regionally sealing (and draining) the repository as a contribution to waste isolation is disturbing, in the limited context of what is currently known about Yucca Mountain geohydrology. Nevada recommends that seals for shafts, ramps, and the underground facility (and drainage systems) not be relied upon for any contribution to waste isolation, but rather if appropriate, be considered as a factor of safety if they are to be installed in the repository. It should also be emphasized that there is a real possibility that, for a number of reasons, emplacement of postclosure seals (and drainage systems) may create conditions adverse to waste isolation assessment. For this reason, any proposed sealing (or drainage) approach must be fully evaluated during the site characterization period, and addressed as an element affecting system performance in a license application.

RESOLUTION

The staff agrees that any proposed sealing or drainage program should be fully evaluated to determine the impact on total system performance. As stated in Section 4.2(3), the staff believes that the program for sealing and drainage testing should be started during site characterization and continue until permanent closure.

5. All boreholes must be plugged prior to being abandoned, however, borehole sealing for the purpose of meeting waste isolation objectives is essentially an untried technology. It is probably inevitable that, during site characterization, some boreholes will be drilled in locations and to depths that result in the requirement that they be effectively and permanently sealed. The GTP should clearly address this issue and announce the expectation that it be fully resolved by the DOE prior to the time a license application is submitted to the NRC for evaluation.

RESOLUTION

The staff believes that the above comment is adequately addressed in Section 4.1(6) of the GTP.

Specific Comments

6. Page 1, 3rd Paragraph

There is a basic dichotomy between the requirement that the seals and drainage design should ensure that drainage pathways for uncontaminated water would not enhance flow of contaminated water towards the

water table and the last sentence in pg. 1, par. 4 which states uncertainties should be considered. To ensure means to make certain, i.e., without the possibility of failure. Although a change in wording might appear to help this situation there is still the fundamental problem of reasonably demonstrating how any drainage design will function over the entire postclosure period. The problem is compounded when any engineered drainage design is superimposed upon the extensive natural drainage from the active faults that the system already possesses. Likely perturbations in the stress field during the next 10,000 years makes the problem even more complicated. Furthermore, the identification of water that flows through the repository horizon as contaminated and uncontaminated will become more and more speculative through time during the postclosure period.

RESOLUTION

The DOE has the responsibility to demonstrate that the sealing and drainage system will meet the performance objectives of 10 CFR 60. This TP addresses the conceptual design and it does not necessarily follow that the staff accepts nor rejects the design concepts presented.

7. Page 2, 2nd Paragraph

It is stated that "the staff has recognized that large uncertainties are likely to persist in evaluating the longevity and long-term effectiveness of seals and drainage for the postclosure period." This statement again conflicts with the position that the DOE should ensure that drainage pathways for uncontaminated water would not enhance flow of contaminated water toward the water table as stated on pg. 1, par. 3.

RESOLUTION

See response to State of Nevada comment #6.

8. Page 2, 5th Paragraph

Statement: "This technical position does not explicitly address the implications of potential changes in water level during the postclosure period. However, it is expected that sealing performance analyses and requirements will include adequate consideration of credible future tectonic, geologic, geomorphological, and geochemical processes and events that could affect seal performance."

Performance analyses of the thermal effects of HLW on the seals should also be emphasized.

RESOLUTION

The staff will highlight thermal effects by adding the following sentence to the end of the paragraph. "In addition, the seal performance analyses should consider the thermal effects of the emplaced waste."

9. Page 3, Par. 2

Page 5, Sec. 4.1(1)

The GTP should not even speculate as to whether or not site sealing is important to waste isolation. It should assume that to be the case, and shaft, ramp, borehole and underground facility sealing should be included on the DOE Q-List, without questions, from the outset.

RESOLUTION

10 CFR 60 does not require DOE to undertake a sealing program. Instead, 10 CFR 60 requires DOE to meet the performance objectives of 60.112. It is therefore possible, albeit not likely, that DOE could demonstrate compliance with 60.112 without allocating any performance to the seals. Section 4.1(1) of the TP has been revised to indicate that seals should be included on the Q-list until DOE demonstrates that seals are not important to waste isolation.

10. Page 3, Section 3.1(3)

Page 6, Section 4.1(3)

In reading the NRC's technical paper, concern is raised with respect to the proposed "drainage" design at the site. If the paper is referring to surface drainage design, then it can be agreed without question that the mine openings (shafts and ramps) should be designed to prevent or greatly hinder water intrusion via surface flooding or infiltration. But to expect to greatly control or manipulate the groundwater migration pathways is not prudent from an engineering standpoint.

RESOLUTION

The staff agrees that it would be very difficult to manipulate groundwater migration pathways within the rock and therefore sentences 2 and 3 of section 4.1(3) have been removed. See also response to State of Nevada comment number 6.

11. Page 3, Section 3.1(5)

Evaluation of seal materials and placement methods will require the same level of experimentation and testing as required for evaluation of the native rock

material. This should be an extensive program if one is to consider coupled systems whose performance is to be evaluated over a 10,000-year time frame.

RESOLUTION

The staff agrees that the evaluation of seal materials and placement methods may require an extensive testing program. No change to the TP is required in response to this comment.

12. Page 3, Section 3.1(5)

Page 7, Section 4.1(5)

The placement of seals and plugs within the repository proposed at Yucca Mountain can have both positive and negative impacts. In some cases, seals may hinder hydraulic transport where desired (i.e., waste emplacement areas); but due to the extremely fractured heterogeneous environment, water may simply travel through zones around the seals, rendering them virtually useless. Another aspect of seal placement that should be addressed is the blockage of existing water pathways that may, in turn, cause a pressure head to form at the point of blockage. Over time, this head can cause structural damage to the seals or force new pathways of transport around the seals.

RESOLUTION

The staff recognizes that seal performance may be affected by placement methods and locations. The staff believes that the concerns raised in this comment are sufficiently addressed in staff positions 3.3(1), 3.3(2) and 4.1(9).

13. Page 3, Section 3.1(5)

Page 7, Section 4.1(5)

Since it is very difficult, if not impossible, to accurately predict the very long-term behavior of seal materials and because, as previously discussed, it may not be possible to confirm the performance of a seal during the allotted assessment period, it would seem prudent not to rely on seals for any contribution to waste isolation.

RESOLUTION

The DOE is responsible for demonstrating compliance with performance objective 60.112. It is therefore DOE's responsibility to demonstrate that seals will or will not be important for waste isolation. As stated in the State of Nevada comment 11 and the corresponding NRC response, an evaluation of seal materials and placement methods may require an extensive testing program. It would seem imprudent to eliminate any consideration of the use and performance of seals with regard to waste isolation prior to analyzing the results of a testing program.

14. Page 4, Section 3.1(6)

It is implied that an analytical solution without any empirical data can be used to demonstrate that the performance objectives can be met for any unsealed boreholes. Such a means of demonstration should not be acceptable.

RESOLUTION

It is not the staff's intent to exclude any technique which can be used to demonstrate compliance with the regulations, but it should not be inferred that empirical data are unnecessary.

15. Page 4, Section 3.2(1)

It should not be too difficult to place the shaft or ramp and associated structures so that surface runoff is essentially eliminated as a potential source of water into the repository.

RESOLUTION

The intent of the guidance in the TP is to assume that the location of the surface openings is such that the potential for meeting the performance objectives is not unnecessarily compromised. No change to TP is considered necessary.

16. Page 4, Section 3.2(1)

Ramps are not currently considered part of the site characterization process.

RESOLUTION

The staff agrees that ramps are not currently planned for use within the Exploratory Shaft Facility (ESF) at Yucca Mountain site. The TP will be revised to include the phrase "should they become part of ESF."

17. Page 4, Section 3.2(2)

Limitation of boreholes is a two-edged sword. The more boreholes, the higher the potential to compromise the site; however, it will be necessary to have a sufficient number of boreholes to obtain spatial resolution for characterizing the repository block.

RESOLUTION

The staff agrees with the State of Nevada comment. The intent of 10 CFR 60.15(d)(2) and Section 3.2(2) of this TP is to limit the number of boreholes to the optimum number needed to characterize the site. The staff believes the intent of this comment is sufficiently addressed in 3.2(2).

18. Page 4, Section 3.3(1)

The requirement for real data for the minimum seal design is absolutely necessary if any of the overall system performance assessment evaluation is to be seriously considered in the license application. Inherent in the performance assessment is the basic concept that the seals will not provide accelerated pathways to the accessible environment. If DOE is relying on the repository design and characteristics of the tuff to provide long travel times, then it must be able to demonstrate that the seals will function as designed.

RESOLUTION

The statement is noted. No change to TP is necessary. The staff believes that the concerns raised in this comment are addressed in Sections 3.1(3), 3.1(4), 3.1(5), 3.1(9), 3.3(2), and 3.4(2).

19. Page 5, Section 3.4(1)

This paragraph raises the question as to when the methodology for predicting long-term behavior has to be developed. If performance confirmation is required prior to license application, as suggested by the previous paragraph, then the methodology should be required to be in place before initiating any construction of any kind of opening that will require sealing.

RESOLUTION

The performance confirmation program shall be started during site characterization and continue until permanent closure, as stated in 10 CFR 60.140(b). Section 3.3 of the TP points out that the performance confirmation program related to sealing design should begin during site characterization. The staff believes no change to Section 3.4(1) is necessary. The staff has previously required the DOE to develop a preliminary performance analysis methodology including evaluation of seal performance with the SCP.

20. Page 5, Section 3.4(1)

Water has a surprising ability to move through low-permeability rocks, especially at slightly elevated temperatures, above 100°C, at which the viscosity of water is low. Examining accomplished work in published literature would reveal the kinds and intensities of water penetration under shallow crustal conditions.

A reservoir of information is in engineering records, particularly of dams and undersea tunnels. For example, flow takes place at low temperature (20–40°C) and low pressure gradients (deltaP = 1–20 atmosphere) in grouted rocks of the Seikan undersea tunnel situated 100 meters below the sea bottom.

RESOLUTION

The State of Nevada comment is noted. No changes are requested and thus the staff considers no changes are necessary.

21. Page 5, Section 3.4(2)

Consideration should include the disturbed zone around all openings.

RESOLUTION

As a result of DOE Comment 24, Section 3.4(2) is now Section 3.1(9).

The staff agrees with the State of Nevada comment. Although the staff considers the intent of the comment to be addressed in 3.1(9), the following phrase will be added to the end of the paragraph: "... such as the damaged zone around the openings."

22. Page 5, Section 3.4(2)

There is a high probability that seals would be affected by expected physical geologic processes, such as strong seismic shaking, which could pull seals apart from rock surfaces.

The possibility that groundwater will be able to penetrate the repository must be faced in a worst-case scenario. The flow could affect the seals physically (washing out clays at boundaries) or chemically (dissolving seal constituents, reacting with repository components and with released waste elements).

RESOLUTION

The comment is noted. The staff believes the intent of the comment is addressed in Sections 3.4(1) and 3.1(9). The staff does not consider a change to this section necessary.

23. Page 5, Section 3.4(4)

Sealing by backfill, packing, and grouting might work on a short time basis, that is, for one-hundred

years or less (engineering time scale), but should not be relied upon for 1,000 to 100,000 years (geological times).

RESOLUTION

See staff response to DOE comment number 15.

24. Page 6, Section 4.1(2)

Any selected construction method that can cause excessive damage to the surrounding rock should not be used unless there is no alternative and then only if there is acceptable technology available to define the physical extent of the disturbed zone.

RESOLUTION

The staff notes the State of Nevada comment and believes its general intent is consistent with Section 4.1(2). No change to 4.1(2) is deemed necessary.

25. Page 6, Section 4.1(3)

In an active tectonic environment such as Yucca Mountain it will be extremely difficult to develop a long-term drainage system that would always allow the water to drain away from the waste emplacement area.

RESOLUTION

The staff recognizes the difficulty in developing a long-term drainage system. To acknowledge these difficulties, the section has been revised by removing the second and third sentences.

26. Page 6, Section 4.1(3)

Statement "Drainage through the rock mass may initially be sufficient to prevent an adverse effect on waste isolation. To assess if the drainage will remain sufficient to meet the long-term design criteria, the drainage capacity over an extended period should be evaluated. Experimental as well as analytical methods should be used to assess the long-term effectiveness of the drainage system in meeting the design criteria."

The DOE should be compelled to describe the experiments pertaining to the assessment of the drainage system in the SCP. The current version, the CD-SCP, does not mention any experiments that assess the drainage from the repository horizon.

RESOLUTION

The staff has provided DOE with several comments regarding the long-term effectiveness of drainage in the CD-SCP review. The staff will continue to monitor DOE's response in the final SCP review and semi-annual progress reports. Section 4.1(3) has been revised as stated in NRC resolution to State of Nevada comment number 25.

27. Page 8, Section 4.2(2)

The statement is made that only the number of boreholes required for obtaining information needed for site characterization should be planned. How is the determination made? By whom and when? What constitutes too many boreholes or too few?

RESOLUTION

The staff recognizes the flexibility in 10 CFR 60.15(d)(2) regarding the number of boreholes placed for site characterization process. It would not be prudent to specify the exact number of boreholes which can be drilled. As noted in the State of Nevada comment number 17, the "...limitation of boreholes is a two-edged sword." Instead, DOE is required to limit the number of boreholes to those necessary for collecting sufficient site characterization information. Therefore, the number of holes required is dependent on the site characterization information needs.

28. Page 9, Section 4.2(3)

A statement needs to be added to the effect that the program for seal design and testing should be developed and in place prior to shaft sinking or borehole emplacement in the immediate repository vicinity.

RESOLUTION

The staff notes the State of Nevada comment. However, the staff believes Section 4.2(3) adequately reflects the staff's position that a program for seal design testing should be started during site characterization. The staff recognizes the need to have a seal design testing plan outlined prior to shaft sinking. The seal test plan presented in the SCP does provide the basis for making a reasonable estimate of the effectiveness of the seal design, materials, and placement methods during the period in which the seal is to perform its function. The staff believes this test plan should be implemented as early as practicable.

29. Page 9, Section 4.3(1)

There is no basis at this time for the statement that data available when the license application is submitted are likely to reduce uncertainties in

predicting the performance of seals during the postclosure period.

RESOLUTION

The first paragraph of Section 4.3(1) states the staff position that preliminary results from seal and drainage testing should be available when the license application is submitted so that a reasonable estimate of the effectiveness of the seal design during the postclosure period can be made. This statement assumes that in order to obtain a reasonable estimate of seal performance, the uncertainties associated with seal performance must be reduced. In addition, the phrase "are likely to" has been replaced with "should" in the first sentence of paragraph two.

30. Page 9, Section 4.3(1)

Where is the testing to take place relative to the repository? If the evaluation is supposed to provide reasonable assurance of functionality in the anticipated range of seal environments, then a good share of the data must come directly from the repository block.

RESOLUTION

The seal design testing program should be planned and implemented so that a sufficient amount of data is collected such that the isolation capability of the site can be evaluated.

31. Page 9, Section 4.3(3)

The effectiveness of any engineered system cannot be ensured (guaranteed not to fail) particularly if a major part of the system is natural. Therefore, the requirement should be to demonstrate that the performance requirements can be met without taking into consideration the long-term effectiveness of seals.

RESOLUTION

The DOE is responsible for demonstrating compliance with performance objective 60.112. It is therefore DOE's responsibility to demonstrate that seals will or will not be important for waste isolation. As stated in the State of Nevada comment 11 and the corresponding NRC response, an evaluation of seal materials and placement methods may require an extensive testing program. It would seem imprudent to eliminate any consideration of the use and performance of seals with regard to waste isolation prior to analyzing the results of a testing program.

32. Page 10, Section 4.4(1)

Confirmation testing of seal performance needs to be initiated at the earliest possible time after an acceptable site characterization plan has been developed.

RESOLUTION

The staff agrees that performance confirmation testing of the seal and drainage system should be initiated during the site characterization program. The first sentence of paragraph two has been changed to read as follows:

"Confirmation testing of seal performance should be initiated during site characterization and continue until permanent closure."

Department of Energy

General Comments

1. The Technical Position (TP) takes a position that the required performance lifetime of the seals must be the same as the period specified by the Environmental Protection Agency for the overall performance of the repository. However, there are no regulations that require seals, per se, to perform satisfactorily for any specific time period. This position should be revised to indicate that the performance lifetime of the seals must be consistent with the performance allocated to the seals through the performance allocation process.

RESOLUTION

The staff agrees with the above stated general comment. The second paragraph in Section 4.1(8), has been revised as follows:

"Alternatively, it should be demonstrated using experimental results and/or analyses that the seals will perform satisfactorily and contribute in meeting the performance objectives for the geologic repository."

2. The TP contains guidance on a broad spectrum of topics only peripherally related to sealing requirements. These are: overall system performance assessment, the design control process, quality assurance, location of the shafts and boreholes, and shaft and ramp construction. The inclusion of such guidance in the sealing TP incorrectly infers that compliance in these areas is required specifically to meet the seals requirements in Part 60. In fact, to the extent it is required, compliance with guidance on these topics is dictated by other provisions in Part 60, not the sealing requirements.

Given the number of regulations which DOE will need to comply with in implementing the repository, it is important that DOE be able to tell where it should look to find the guidance applicable to a particular topic. For example, in establishing the guidance applicable to overall performance assessments it is not obvious that a TP on seals needs to be consulted. Thus, it will greatly facilitate DOE's efforts at regulatory compliance if the guidance in positions and guides is restricted to the requirements particularly under discussion and does not contain guidance on vaguely related topics.

RESOLUTION

While the staff agrees that the sealing TP is meant to provide guidance on the topic of sealing, the topic of sealing cannot be considered in isolation of the site, the design and performance requirements.

Technical positions describe and make available to the public criteria for methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations or otherwise provide guidance to the DOE. Technical positions are not substitutes for regulations, and compliance with them is not required. Methods and solutions not in accordance with criteria set out in the position will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

3. The TP in a few places goes beyond providing guidance on how to comply with existing regulations. It attempts to impose requirements which have no basis in 10 CFR Part 60. Particular examples are: the requirement that all surface boreholes should be sealed to "provide a margin of safety": the requirement that holes drilled from within the shafts and test areas be sealed; and the requirement that seals in the underground facility meet standards similar to those specified for borehole and shaft seals.

RESOLUTION

The staff does not believe that any new sealing requirements are being imposed on DOE as a result of this technical position. As stated on page 2 of the TP, the staff is providing acceptable methods for implementing specific parts of the Commission's regulations. In each and every staff position, care was taken to emphasize what DOE should do rather than what DOE must do. The borehole and shaft seal requirements are stated in Section 2.0 of the TP.

4. The TP sections on performance confirmation considerations presume that data to be used in the license application will be developed as part of the performance confirmation program. This is not in accord with the 10 CFR Part 60 specification of the purpose, scope, and timing of the performance confirmation program. Data to support the predictions of performance for the seals will be collected before the license application is submitted, but this can be done as part of the site characterization and other programs. 10 CFR Part 60 and its regulatory record are explicit in describing performance confirmation as a program, the results of which are applied after a license has been granted, to confirm the analyses and data which were used to make the licensing findings. Section 60.140(b) does indeed require that, in general, the performance confirmation program be started during site characterization. However, this does not mean that data will be generated to go into the license application. In regard to the specific questions as to the start of in-situ performance confirmation testing on boreholes and shaft seals, the specific requirement on this exact topic in Section 60.142 takes precedence over the general, nonspecific requirement of Section 60.140(b). Section 60.142 specifically states that performance confirmation in-situ testing of borehole and shaft seals shall be initiated as early as practicable during construction. A construction authorization is required prior to commencement of construction. We do not believe this prohibits in-situ data on seals, to support the license application, from being collected under some other program.

RESOLUTION

The staff does not want to imply that only sealing performance data collected in performance confirmation program will be used in the license application. The staff expects that some data supporting seal performance will be collected during site characterization and these data should not be excluded from the license application. No change to TP is required.

5. In a few places the TP uses the term "reasonable assurance " as something which should be determined and provided by DOE as a basis for making interim decisions on how to proceed with its technical design and analysis programs. This is an inappropriate use of this term. The finding on reasonable assurance is one which is made by the licensing board. It is a vague and subjective standard. As the Statements of Consideration to 10 CFR Part 60 states, reasonable assurance is a term of law, not of science. Thus the term is not only inappropriate in the context used, but provides no useful guidance to DOE's technical program. A different approach on this part of the position is needed.

RESOLUTION

The staff has revised the technical position to remove the inconsistent use of "reasonable assurance." "Reasonable assurance" has been replaced by "it should be demonstrated."

6. As we have explained in detail in comments on previous technical positions, DOE would prefer regulatory guides to technical positions. The higher level NRC review given to regulatory guides, and the consequent traditionally greater weight accorded them by licensing boards, makes them more useful to the DOE. We would also prefer that the Technical Position section and Discussion section of technical positions be combined. This would eliminate the possibility of inconsistencies between these sections and the ambiguities resulting from differing interpretations of the difference words on the same topics in these sections. We are aware that this format has become the Division's customary technical position format. We are suggesting this customary format be changed.

RESOLUTION

The staff acknowledges DOE's previous and presently expressed preference for regulatory guides instead of technical positions (TPs). However, as stated previously in a letter from Robert Browning to Jim Knight, dated September 4, 1987, TPs represent the Office of Nuclear Material Safety and Safeguards position on acceptable approaches for meeting the regulations and/or describe how various parts of the regulation apply to the High-Level Waste program. In terms of status, TPs and regulatory guides would have equal standing in an NRC adjudicatory hearing. TPs can be issued by the Office of Nuclear Material Safety and Safeguards more readily than reg. guides can be issued by the Office of Nuclear Regulatory Research, because TPs require fewer administrative steps to issue. In the NRC/DOE conversations subsequent to issuance of that letter, DOE agreed with the approach outlined.

DOE has also expressed its preference that in the TP, the "Technical Position" section be combined with the "Discussion" section. The High-Level Waste Division has policies and procedures for developing technical positions that are central to its internal Quality Assurance (QA) program. Accordingly, in the interest of adhering to its policies, the Division prefers to keep the "Technical Position" section separate from the "Discussion" section. The "Technical Position" section affords the Division an opportunity to be clear and concise about the staff's position(s). It further allows the staff to be general and broad or very detailed in the position while the "Discussion" section provides the rationale and technical basis for the positions given.

Specific Comments

7. (a) Page 1, 2nd Paragraph

"...and (3) maintaining a sufficient rate of drainage below the repository horizon level so that water can percolate down through the rock mass." This statement connotes a position which is more restrictive than 10 CFR 60.134(b) (1) and is not justified.

Modify the phrase to read:"so that water can percolate down through the rock mass, thereby reducing the potential for water to contact the waste."

RESOLUTION

The staff does not see a correspondence between 60.134(b)(i) and item (3) on pg. 1, par. 2.

However, the staff agrees to alter the sentence as suggested.

8. (b) Page 1, 3rd Paragraph

"However, such a drainage scheme can also provide pathways for rapid flow of contaminated water to the accessible environment. The seals and drainage design should ensure that drainage pathways for uncontaminated water would not enhance flow of contaminated water toward the water table."

The statement is inconsistent with drainage concepts presented previously in Fernandez et al. (1987) and is unreasonable given the present hydrologic understanding of the site. In areas where water is deliberately focused, there may exist a reduction in ground-water travel time. Given the predominantly vertical, downward gradients at the site, this flow is likely to be down gradient, toward the water table. However, the amount of water that may contact the waste is reduced with a resultant improvement in overall repository system performance.

Revise the last sentence to read:

"...the flow of contaminated water to the accessible environment will not be enhanced."

RESOLUTION

The staff agrees with the comment as presented by DOE. The third sentence of the third paragraph on pg. 1 has been revised to read:"The seals and drainage design should ensure that the flow of contaminated water to the accessible environment will not be enhanced."

9. (c) Page 1, 3rd Paragraph

"The effects of intrinsic anisotropy in rock mass hydraulic conductivity and thermally driven lateral

water or vapor flow should be considered in the evaluations of drainage pathways."

This statement constitutes a position and should be more appropriately placed in Section 3.2, Site Characterization Considerations. In addition, there is no connection between vapor flow and drainage pathways. Pathways for vapor transport should be dominantly upward; engineered drainage pathways are envisioned to be largely at or below the repository level.

RESOLUTION

The staff has no objection to moving this statement to Section 3.2. Therefore, position number four in Section 3.2 will now read as follows: "The effects of intrinsic anisotropy in rock mass hydraulic conductivity should be considered in the evaluations of drainage pathways."

10. (d) Page 1, 4th Paragraph

"A successful design goal should determine what mechanism,...." (Emphasis added.)

This is not a proper statement, since design goals themselves do not determine outcomes. Revise the statement to read:

"A goal for a successful design should be to determine what mechanisms,...."

RESOLUTION

The staff has no objection to the change recommended by the DOE. As a result, sentence 1, par. 4, pg. 1 has been revised as requested.

11. (e) Page 1, Last Paragraph

"If drainage is to be incorporated as a basic strategy to preclude water inflow to the emplaced waste...." (emphasis added)

- DOE does not believe that it is possible to preclude all water inflow to emplaced waste in an unsaturated medium as is found at the Yucca Mountain Project. As discussed by Fernandez et al. (1987), the primary objective for underground sealing components is to control water flow by diverting water away from waste packages and draining water at discrete locations in the underground facility.

Revise the sentence to read:

"If drainage is to be incorporated as a basic strategy to control water...."

RESOLUTION

The staff finds the changes recommended by DOE to be acceptable. The sentence has been revised as stated above.

12. (f) Page 2, 1st Paragraph

"These considerations suggest that the number of surface openings be limited, and their locations be selected to discourage infiltration of surface water."

This is only one of many factors affecting opening location. Opening location is not primarily a sealing consideration. This statement should be deleted or qualified to recognize that the numbers and locations of surface openings (i.e., boreholes, shafts, and ramps) are also a function of site characterization data needs. If retained, rewrite the sentence as follows:

"These considerations ... locations be selected to discourage infiltration of surface water, consistent with the data requirements for site characterization."

RESOLUTION

The staff finds the revision suggested by DOE to be acceptable, and has changed the sentence accordingly.

13. (g) Page 2, 3rd Paragraph

"This technical position takes into account site characterization and performance confirmation testing, including the need for starting in-situ seal testing during site characterization and for confirming the adequacy of seal and drainage concepts, emplacement methods, and material compatibility." (Emphasis added.)

According to 10 CFR 60.142(a), in-situ testing shall be started during the early or developmental stages of construction. According to 10 CFR 60.2, Definitions, "commencement of construction" refers to repository construction, not site characterization activities (which include ESF construction). Therefore, there is no regulatory requirement for starting in-situ testing during site characterization for confirming seal adequacy.

Delete the words "in-situ" from this sentence.

RESOLUTION

The staff does not agree with the DOE interpretation of the rule as stated above. Section 10 CFR 60.142(a) is a section in Subpart F — Performance Confirmation Program. Under the General Requirements (60.140)

section it states that performance confirmation testing shall have been started during site characterization and continue until permanent closure. In addition, 10 CFR 60.142(a) calls for in-situ testing to begin during the early or developmental stages of construction and not at the "commencement of construction." The staff does not believe a revision is warranted at this time.

14. (h) Page 2, 3rd Paragraph

DOE believes the TP should acknowledge the appropriateness of evaluating the effects of omitting seals, in view of the unique characteristic of unsaturated zones in which there is a tendency for water not to move from small openings (fractures, matrix) into larger openings (drifts, boreholes). (SCP Section 8.4.1.3 contains discussion of the capillary barrier effect).

RESOLUTION

The staff recognizes that seals may not be required to demonstrate compliance with the performance objectives as stated in the last paragraph on page one. However, no information has been presented to date which removes seals from the performance allocation process. The staff believes the intent of the DOE comment has been incorporated in par. 4, pg. 1.

15. Section 2.0

(a) No specific reference to 40 CFR 191 (EPA) is made within the TP. However the TP takes regulatory positions for which the bases must be assumed to be derived from the Environmental Protection Agency's Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes, 40 CFR 191. Accordingly, if this is the case, the requirements of 40 CFR 191 should be addressed in this section and in Appendix B. Of concern is the interpretation within the TP that the EPA 10,000 year criterion should be applied not only to the repository system taken as a whole, but also to individual components within the repository system without consideration of the balance of the system, and specifically to seals. This interpretation is unduly restrictive and is unwarranted.

The TP states that seals must be designed to perform satisfactorily for 10,000 years, taking into account the effects of anticipated and unanticipated processes and events. DOE is unaware of regulations that require seals per se to perform satisfactorily for 10,000 years. It is more appropriate that the effects of anticipated and unanticipated processes should be addressed giving consideration to the entire repository system and not to seals or any other subsystem alone. The TP incorrectly equates seals requirements with requirements for the overall repository system.

40 CFR 191 sets the overall performance requirements for the repository system. Within specified limits, the system must perform satisfactorily for 10,000 years, taking into account all significant processes and events (which the NRC calls anticipated and unanticipated processes and events). The TP imposes these system requirements on seals. More properly, the repository system performance should be evaluated taking into consideration all subsystems and components in combination.

RESOLUTION

The staff agrees with the DOE comment as stated above and will clarify the technical position. The staff did not intend to impose 10,000 year performance requirements on the seals and/or drainage system. The staff recognizes that the overall repository system must remain functional for 10,000 years and not the individual components of the system. Seals should be designed to perform satisfactorily to the extent that their contribution is relied upon to meet the overall system performance objectives.

16. Section 3.1

(a) Page 3, Item (2)

"The shaft and ramp designs should specify appropriate construction controls to limit the lateral extent and degree of damage to the rock mass surrounding the shafts and ramps."

Repository shaft and ramp designs as well as many other aspects of the repository system (including contributions from the sealing system), will ultimately affect overall repository performance. Shaft and ramp construction requirements are not primarily a sealing-related matter. Therefore this statement should be deleted from this sealing TP. If the statement is retained, it should be qualified to say that damage control will be consistent with the need to preserve the intended function of the seals and the overall system performance. If retained, revise as follows:

"The shaft and ramp designs ... damage to the rock mass surrounding the shafts and ramps as appropriate to achieve the intended function of the seals and acceptable overall repository performance. The extent of damage should be evaluated to determine its effect on overall system performance."

RESOLUTION

The staff agrees with the basic premise of the DOE comment. Staff position 3.1(2) has been changed to read as follows:

"The shaft and ramp designs should specify appropriate construction controls to limit the lateral extent and degree of damage to the rock mass as required to achieve the performance allocated to the seals in the overall system performance. The damage around the shafts and ramps caused by construction should be assessed."

17. (b) Page 4, Item (8)

"Alternatively, reasonable assurance should be provided that the seals will perform satisfactorily for the 10,000 years specified for meeting the performance objectives for the geologic repository." (Emphasis added.)

This requirement is in conflict with 10 CFR 60.112, which states:

"... seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated process and events."

Revise Item (8) to read:

"The design of the underground facility should consider the consequences of the partial and/or complete failure of seals during the post-closure period. Reasonable assurance should be provided that the performance objectives for the geologic repository will be met through consideration of the performance of all of its systems and components, including seals, taken in combination."

This revision brings Item (8) into consistency with Section 4.1, Item (8).

RESOLUTION

The staff finds the revisions suggested by the DOE to be acceptable and changes to Section 3.1, Item (8) have been made accordingly.

18. (c) Page 3, Item (3)

"The seals and drainage system for water potentially entering into and around the shafts and/or ramps should be designed so as to limit inflow into the waste emplacement area of the geologic repository and to minimize the chance of water contacting the waste." (Emphasis added.)

To remain consistent with 10 CFR 60.134, revise as follows:

"The seals and drainage system ... to reduce the potential for water to contact the waste."

RESOLUTION

The staff finds the revisions suggested by the DOE to be acceptable. Section 3.1 (3) has been revised to read:

"The seals and drainage system for the water potentially entering into and around the shafts and/or ramps should be designed to reduce the potential for water to contact the waste."

18. (d) Page 3, Item (5)

"Seal materials and placement methods should be designed to be geochemically compatible with the host rock and its environment. Seals should be analyzed (e.g., through modeling and accelerated testing) for long-term compatibility that is consistent with overall system performance requirements." (Emphasis added.)

There is no connection between "placement methods" and "geochemical compatibility." Reference to "placement methods" should be deleted. Also the TP should require that seals be designed to be geochemically compatible with the host rock and its environment only to the extent that compatibility is necessary to ensure the seal meets its intended function and period of performance (i.e., does not degrade). In addition, the accelerated testing may not be a necessary part of the analysis of the performance of sealing components. Other approaches may be sufficient. Revise as follows:

"Seal materials should be designed so that they do not compromise the repository's performance, which may require consideration of geochemical compatibility that is consistent with overall system performance requirements."

RESOLUTION

The staff does not object to removing "placement methods" from the position stated in 3.1 (5) as suggested by the DOE.

The staff acknowledges that accelerated seals testing may not be the only acceptable approach to analyze the performance of sealing components. As stated in par. 5, pg. 2,

compliance with technical positions are only intended to provide acceptable methods for implementing specific parts of the Commission's regulations.

20. (e) Page 4, Item (6)

"All exploratory boreholes drilled for site characterization should be sealed."

Some exploratory boreholes will be located well outside the controlled area boundary and will not affect repository performance. Revise as follows:

"Exploratory boreholes drilled within the controlled area boundary for site characterization should be sealed. Other exploratory boreholes, drilled outside the controlled area boundary, should be sealed if it is determined that they could potentially compromise meeting the performance objectives of the repository."

RESOLUTION

The staff agrees that boreholes drilled within the controlled area boundary should be sealed. In addition, the staff believes that all boreholes located outside the controlled areas should be sealed unless it can be demonstrated that they will not compromise meeting the performance objectives of the repository.

21. (f) Page 4, Item (7)

"The seals for exploratory boreholes and test holes drilled from shafts, ramps, the underground facility, and test areas should be planned, designed, and analyzed to the same standards as the exploratory surface boreholes...."

Many boreholes drilled from ramps and shafts will be angle or horizontal holes, whereas those drilled from the surface will be predominantly vertical. Technical differences exist which affect the sealing of boreholes with these difficult orientations. Also, underground and surface seals will be exposed to different environments and therefore need not be planned, designed and analyzed to the same standards.

The plan, design, analysis, and ultimate effectiveness of seals should be uniquely determined for each borehole, because the problems and situations will be unique. Replace the words: "be planned, designed and analyzed" with "perform." Also make the same revisions on pg. 7, Item (7), last sentence of the paragraph.

RESOLUTION

The staff considers the intent of the DOE comment to be consistent with intent of the NRC position. Thus, the staff has no objection to revising the position.

Section 3.1 (7) will now read as follows:"The seals for exploratory boreholes and test holes drilled from shafts, ramps, the underground facility and test areas should be planned, designed, and analyzed to assure compliance with the overall performance objectives of 10 CFR 60.112."

22. Section 3.2

(a) Items (1) and (2) address requirements for the location of shafts and ramps, and for the number and placement of boreholes. These requirements do not pertain to seals and accordingly they do not belong in this TP. Delete Items (1) and (2) and also Section 4.2, Items (1) and (2).

RESOLUTION

While the staff agrees that the sealing TP is meant to provide guidance on the topic of sealing, the topic of sealing cannot be considered in isolation of the site, the design and performance requirements.

Technical positions describe and make available to the public criteria for methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations or otherwise provide guidance to the DOE. Technical positions are not substitutes for regulations, and compliance with them is not required. Methods and solutions not in accordance with criteria set out in the position will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

23. Section 3.4

(a) Pg. 5, Item (1)

"A methodology should be developed for predicting the long-term behavior of the seals and drainage as designed, including the environmental, thermal, and geochemical effects. The methodology should be used for evaluating the overall system performance during the postclosure period with respect to both anticipated and unanticipated processes and events. Uncertainties in predicting and extrapolating the long-term behavior of the components affecting seal performance should be considered." (Emphasis added.)

This guidance belongs in an overall system performance assessment guide, not a sealing position, and

should be deleted. Further, requiring that the same methodology should be used to evaluate both the behavior of the seal components and the overall system performance is unduly restrictive. The methodology developed for predicting the long-term behavior of the seals and drainage as designed need not be the same methodology used to evaluate overall system performance. If retained, replace underlined text with the following:

"The methodology should be incorporated into the evaluation of overall system performance during the postclosure period...."

Further, Fernandez et al. (1987) have noted that there is an advantage to locating seals outside a zone of the high-temperature environment of the underground repository, and that the seal design should consider environmental, thermal, and geochemical effects at seal locations provided that such components are necessary for meeting the performance objectives of the repository. Therefore, insert the words "at seal locations" at the end of the first sentence.

RESOLUTION

The staff has no objection to the sentence revisions proposed by the DOE and the changes have been made accordingly. As is stated in the introduction, this technical position does not constitute a regulation, but instead provides an acceptable approach for implementing specific parts of 10 CFR 60. Therefore, positions taken in this document should not be misconstrued as requirements, as stated in the DOE comment.

24. (b) Page 5, Item (2)

"Engineering analysis of seals (including backfill and settlement plugs) should be performed with respect to the potential for both water inflow and gaseous outflow. The analysis should account for possible long-term settlement of shaft backfill and piping (channel flow) along the boundary between the liner and backfill and other potential flow paths."

The evaluations of settlement of backfill materials and potential piping of backfill materials are design issues, not performance issues. Move this item to become Item 3.1(9). Also note that corresponding Item 4.4(2) should become 4.1(9). Revise the first sentence as follows:

"... seals (including shaft backfill...."

RESOLUTION

The staff has no objection to moving this item to 3.1(9). In addition, Item 4.4(2) will become Item 4.1(9) of the revised technical position.

25. Section 4.1

(a) Page 6, Item (3)

"To assess if the drainage will remain sufficient to meet the long-term design criteria, the drainage capacity over an extended period should be evaluated. Experimental as well as analytical methods should be used to assess the long-term effectiveness of the drainage system in meeting the design criteria." (Emphasis added.)

Inclusion of the underlined passage limits the DOE's flexibility to address the long-term effectiveness of the sealing systems. Analytical methods alone may be sufficient. Replace the last sentence with the following text:

"To assess if the drainage will remain sufficient to meet the long-term design criteria, the drainage capacity over an extended period should be evaluated, using appropriate analytical or experimental methods."

RESOLUTION

Based on comments by the State of Nevada, the staff is revising Section 4.1(3) by removing the second and third sentences.

26. (b) Page 7, Item (6)

"In view of the potential significance of the boreholes because of their large number, proximity to waste emplacement areas, and depths, all boreholes should be sealed to provide a margin of safety in regard to the postclosure performance of the repository system." (Emphasis added.)

There is no basis in 10 CFR Part 60 for this new requirement; thus it should be deleted. As was noted in the comment addressing Section 3.1(6), some exploratory boreholes will be located well outside the controlled areas boundary and clearly will not affect repository performance. Thus, the requirement that all boreholes be sealed is overly restrictive and should be modified as addressed in 3.1(6). As used in the TP, the term "margin of safety" can be interpreted to mean that compliance with the EPA standard as the repository's performance objective is inadequate for safety and that through the TP, NRC is requiring additional margins. It is DOE's position that through the regulations contained in 10 CFR 60, NRC has endorsed the EPA standard as

an acceptable basis for safety whereby acceptable levels of risk will be achieved. There is no basis for requiring additional margins of safety beyond those levels which have already been established as acceptable.

If retained, revise Item (6) to read:

"In view of the potentially large number of exploratory boreholes required for site characterization and the proximity of many of these to the waste emplacement areas, all boreholes located within the controlled area boundary should be sealed as an additional conservatism to effect reductions in any uncertainties about accomplishment of performance objectives."

RESOLUTION

The staff has no objection to the revision proposed by the DOE and the section has been changed accordingly. The DOE should not substitute positions taken in this document for regulations or requirements. However, the staff has no objections to substituting, "as an additional conservatism to effect reductions in any uncertainties about accomplishment of performance objectives" for the underscored phrase identified by the DOE.

27. Section 4.2

(a) Page 8

Consistent with the comment on Section 3.2, Items (1) and (2) address requirements which do not pertain to seals. Accordingly, delete Items (1) and (2).

RESOLUTION

See staff response to DOE general comment #2.

28. (b) Page 9, Item (3)

"The test program should include verification of the adequacy of the seal design, materials, and placement methods and should be initiated as early as practicable." (Emphasis added.)

Clearly verification of the adequacy of the seal design, materials, and placement methods cannot be obtained for approximately 10,000 years, or as long as the seals are needed in meeting the repository's performance objectives. This is obviously not what is intended by the TP. In Section 4.3(1), the TP suggests "... a reasonable estimate of the effectiveness of the seal design during the postclosure period ...."

Revise as follows:

"The test program presented in the SCP should provide the basis for making a reasonable estimate of the effectiveness of the seal design, materials, and placement methods during the period in which the seal is to perform its function, and should be initiated as early as practicable."

RESOLUTION

The staff does not object to the revisions proposed by the DOE. The above noted discussion is now located in Section 4.2(5).

29. Section 4.4

(a) Page 10, Item (2)

"The environmental standards for radioactivity expected to be established by the Environmental Protection Agency require engineering analysis of seals with respect to the potential for both water inflow and gaseous outflow."

There is not any EPA requirement for engineering analysis of seals as stated here. Neither is DOE aware that such a requirement is expected to be established.

Delete this sentence.

RESOLUTION

The sentence has been rewritten as follows:"If performance is allocated to the seals, engineering analyses of the seals with respect to the potential for water inflow and gaseous outflow should be done to show compliance with the environmental standards for radioactivity to be established by the EPA." In addition, Section 4.4(2) was transferred to Section 4.1(9), as a result of DOE comment number 24.

30. (b) Page 10, Item (2)

"At permanent closure, the shafts may be backfilled with crushed tuff or some other suitable material. Settlement plugs also may be used to reduce backfill settlement. The behavior of the shaft backfill as well as the settlement plugs during the postclosure period may be important in regard to the potential for both water inflow and gaseous outflow."

The TP should differentiate among backfill, seals, and plugs. Backfill may be emplaced for structural support to the work faces; seals may be isolated emplacements utilized explicitly for reducing or preventing flow through openings; and plugs may be used to reduce or eliminate settlement as well as to control flow. The design, analysis, and methods of construction and placement for each of these methods should be based on the desired geotechnical results.

RESOLUTION

The staff agrees that the design, analysis and methods of construction and placement for backfill, seals and plugs should be based on the desired geotechnical results. However, if the DOE relies on these components for post-closure performance of the repository, the guidance provided in the TP would be appropriate.

APPENDIX D DISPOSITION OF ACNW COMMENTS

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 16 1989

MEMORANDUM TO: Dade W. Moeller, Chairman
Advisory Committee on Nuclear Waste

FROM: Victor Stello, Jr.
Executive Director for Operations

SUBJECT: RESPONSE TO ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW) COMMENTS ON POSTCLOSURE SEALS TECHNICAL POSITION (TP)

On April 26, 1989, the U.S. Nuclear Regulatory Commission (NRC) staff met with the Advisory Committee on Nuclear Waste (ACNW) to discuss the Draft Technical Position (TP) on "Postclosure Seals in an Unsaturated Medium." Based on the staff presentation and a subsequent review of the Draft TP, ACNW transmitted several comments to Chairman Zech on May 3,1989 (Enclosure 1).

The NRC staff has reviewed the ACNW comments. In general, the staff agrees with the comments as presented. In an attempt to specifically address each point raised by ACNW, the staff has prepared the following responses and has appropriately modified the Draft TP to address ACNW suggestions.

ACNW COMMENT #1

The Draft TP does not deal adequately with factors such as seismicity, tectonics, and long-term changes in geology, hydrology, and climate that might affect seal or barrier performance. Long-term projections on the geology, seismicity, tectonics, and climate of the Yucca Mountain area contain uncertainties and each of these factors could have impacts on the design, location, and performance of the seals. For these reasons, we believe that the Draft TP needs to be expanded to explicitly address these considerations.

STAFF RESPONSE

The staff agrees that seismicity, tectonics and long-term changes in geology hydrology and climate may affect seal performance. Therefore, Sections 3.4(1) and 4.4(1) have been revised to state that the U.S. Department of Energy (DOE) should consider long-term changes in seismicity, geology, hydrology and climate in evaluating the performance of the seals and drainage system.

ACNW COMMENT #2

Backfill materials for shafts and seal cements for boreholes can be selected to have sorptive properties for radionuclides. Such materials would provide added protection against unanticipated events, even if no containment functions are assigned to the backfills and seals. We recommend that the Draft TP include a statement addressing this additional consideration.

STAFF RESPONSE

If seals are necessary to meet the overall repository performance objectives, 10 CFR Subsection 60.134(b) requires that "materials and placement methods for seals be selected to reduce to the extent practicable the radionuclide migration through existing pathways". To meet this requirement, the staff believes it will be necessary for the backfill and seals to have sorptive properties for radionuclides. The Draft TP has been revised to explicitly address this issue in Sections 3.1(9) and 4.1(9).

ACNW COMMENT #3

The Draft TP indicates that the outflow of radioactive gases from the repository could be significant and needs to be prevented. We believe that a rationale to support this position should be provided, as well as some perspective on the significance of this potential release.

STAFF RESPONSE

Carbon-14 released in gaseous form presents a potential difficulty in meeting the EPA's 40 CFR 191 regulations due to a substantial inventory and a long half life. According to ORNL/TM-9591/VI the ^{14}C inventory for PWR spent fuel is 1.38 Ci/MTHM and 0.46 Ci/MTHM at 1,000 and 10,000 years respectively after discharge. The EPA standard is 0.1 Ci/MTHM cumulative release to accessible environment for a period of 10,000 years. A comparison of the inventory of ^{14}C and the EPA limit indicates that there is a potential for exceeding the release limits specified in 40 CFR 191. Limited research (Mat. Res. Soc. Symp. Proc. Vol. 84, 1987) indicates that only a fraction of the ^{14}C is in an oxide form and therefore available for release through waste package breach thus creating the potential for an outflow of radioactive gases from the repository.

The concern for the gaseous release of radionuclides from the repository was also raised by the DOE in the "Preliminary Performance Assessment (1985)". In addition, SAND85-0598 also addresses and analyzes the potential for radionuclide release by air movement.

Substantial uncertainties exist regarding the ^{14}C inventory, including that portion available for release in oxide form, and transport mechanism for release to the environment. The DOE is planning to investigate these uncertainties as part of the site characterization program.

ACNW COMMENT #4

Whether fracture or matrix flow predominates within the repository is an unresolved issue, and its resolution could have an impact on the method of control of potential releases. Because fracture flow may prove significant, its potential impact on the performance requirements for the barriers needs to be addressed in the Draft TP.

STAFF RESPONSE

The staff agrees that there is considerable uncertainty about whether fracture or matrix flow predominates within the repository. However, regardless of which flow mechanism is primary, the seals must be designed to perform such that the performance objectives of 10 CFR Part 60 are met. Sections 3.4(3) and 4.4(3) have been revised to explicitly address the need for analyzing the effects of fracture vs. matrix flow on seal performance.

ACNW COMMENT #5

It appears that the closures that DOE proposes to install in the Yucca Mountain facility might be better characterized as "barriers" rather than "seals". If appropriate, the title of the Draft TP should be altered to reflect this fact.

STAFF RESPONSE

The staff agrees that the current title of the Draft TP does not adequately cover the concepts of both sealing as well as drainage. To more accurately reflect the contents of the Draft TP, the title of the Draft TP will be changed to "Technical Position on the Postclosure Seals, Barriers and Drainage System for an Unsaturated Medium."

The staff is pleased to receive the views of ACNW on this Draft TP. We hope that the staff responses resolve ACNW's concerns.

Victor Stello, Jr.
Executive Director for Operations

Enclosure: As stated

cc: Chairman Zech
Commissioner Roberts
Commissioner Carr
Commissioner Rogers
Commissioner Curtiss
SECY

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

The purpose of this technical position is to provide guidance with respect to the current DOE sealing and drainage concepts for a geologic repository in an unsaturated medium. Section 2.0 of the technical position provides a listing of the 10 CFR Part 60 regulations which are applicable to the design, testing, selection of materials and placement of the postclosure seals, barriers and drainage system. Staff position statements and the corresponding discussions are presented in Sections3.0 and 4.0 respectively. Technical positions are organized according to the following topics: (1) design consideration, (2) site characterization considerations, (3) performance confirmation considerations, and (4) performance analysis considerations.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Seals, Barriers, Drainage System

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AND DRAINAGE SYSTEM IN AN UNSATURATED MEDIUM