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Volume 12

A Compilation of
Reports of

The Advisory Committee on Nuclear Waste

July 2001 - June 2002

U. S. Nuclear Regulatory Commission

August 2002

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ABSTRACT

This compilation contains 10 reports issued by the Advisory Committee on Nuclear Waste (ACNW) during the Thirteenth year of its operation. The reports were submitted to the Chairman and Commissioners of the U. S. Nuclear Regulatory Commission (NRC). All reports prepared by the Committee have been made available to the public through the NRC Public Document Room, or from the Publicly Available Records System (PARS) component of NRC's document system (ADAMS) which is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room); the U. S. Library of Congress, and the Committee's Web site at http://www.nrc.gov/reading-rm/doc-collections/.

PREFACE

The enclosed reports are the recommendations and comments of the U. S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste during the period between July 1, 2001 and June 30, 2002. Previously issued Volumes 1 through 11 of NUREG-1423 contain the Committee's recommendations and comments from July 1, 1988 through June 30, 2001.

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (CONT'D)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

August 13, 2001

The Honorable Richard A. Meserve
Chairman
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: REVIEW OF CHEMISTRY ISSUES AND RELATED NRC STAFF CAPABILITY FOR THE PROPOSED HIGH-LEVEL WASTE REPOSITORY AT YUCCA MOUNTAIN

The ACNW conducted a review of chemistry issues associated with the performance of the engineered barrier system (EBS) and the release and transport of radionuclides for the proposed Yucca Mountain high-level waste (HLW) repository. As part of this review, an ACNW Working Group on Chemistry Issues for the HLW repository at Yucca Mountain met on February 21 and 22, 2001, at NRC headquarters in Rockville, Maryland. The chemistry review is part of the ACNW's "vertical slice" approach to evaluating the NRC's process for the identification and resolution of issues related to the proposed Yucca Mountain HLW repository. This letter presents observations and recommendations based on the ACNW's review of the Working Group's report, which is attached.

The Working Group focused on waste package and drip shield corrosion, near-field (i.e., inside the drifts) and in-package chemistry, radionuclide mobilization and transport, and coupled thermal-hydrologic-chemical (THC) processes. The Working Group addressed the adequacy of process-level modeling to address specific chemical issues, the abstractions of process models into the Total System Performance Assessment for the Site Recommendation (TSPA-SR), and the technical bases of the TSPA-SR. The Working Group also commented on the degree to which "conservative" assumptions about chemistry might compromise the credibility of the analyses of the near-field and natural environments, and on how well the NRC is prepared to address contingencies, such as changes in DOE's repository design (e.g., from a "hot" to a "cold" repository) or changes in the DOE safety-case strategy.

Observations and Recommendations

Observation 1

The NRC staff has developed a process for reviewing issues in connection with the proposed Yucca Mountain repository. The process is based on a set of Key Technical Issues (KTIs) and related subissues that are documented in the Issue Resolution Status Reports (IRSRs). This iterative process for reviewing issues in technical exchanges and establishing specific agreements with DOE appears to be appropriate. The staff is addressing the important chemistry issues on engineered barrier lifetimes and radionuclide release and transport through the KTIs. The issue resolution process is neither designed nor intended to serve as a basis for unearthing new, potentially important chemistry issues that DOE has not considered. In general, the NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) staff seem to be well positioned to deal with the impacts of evolutionary repository design changes. Major design changes featuring new components, materials, and approaches could, however, have a significant impact on the staff's ability to complete a thorough review in a timely fashion.

Recommendation 1

The staff should continue exploring the chemical issues associated with major repository design changes such as a "hot" versus a "cold" repository or the use of backfill.

Observation 2

The KTIs dealing with chemistry-related issues are generally comprehensive. There are numerous specific subissues and questions that are intended to address chemistry issues in detail. These are addressed by DOE with uneven quality and thoroughness. DOE tends to use very "conservative" assumptions in some cases but not in others, and does not integrate differing approaches in a consistent way. The inconsistent use of "conservatism" throughout the TSPA-SR models makes it difficult to identify issues important to risk and to ascertain if particular errors or problems are significant to overall performance. In addition, the complexity of the TSPA-SR model and code make it difficult to evaluate.

The NRC staff (including the CNWRA) is employing its own analytical tools (e.g., the Total-System Performance Assessment [TPA] model) and expertise on repository chemistry to reach conclusions on DOE's ability to meet regulatory requirements for licensing.

Recommendation 2

- The NRC staff should continue to be supported and encouraged in their efforts to conduct independent analyses using the NRC's TPA code, process models, and internally developed confirmatory data and information in reviewing the proposed Yucca Mountain repository.
- The staff needs to continue evaluating DOE's TSPA computer code and supporting process models in as much detail as practicable to fully understand how the models are implemented in the codes and the important results.
- The staff needs to have sufficient independent computer capability to evaluate probabilistic codes for TSPA and process models and to defend its conclusions about DOE's ability to meet regulatory limits.

Observation 3

The long-term extrapolation of short-term experimental corrosion data to material performance continues to be a concern to the ACNW. For example, engineered barriers are modeled as primarily corroding in humid air, but the data used is derived from experiments and tests in fully saturated conditions. This assumption may be appropriate, but there are uncertainties about the longevity of the corrosion-resistant oxide layers on the metals. This may lead to a lack of confidence in the validity of the results obtained. An understanding of waste package corrosion mechanisms relevant to the expected repository environment is central to projecting repository performance over long times. Planned upgrades in the NRC's TPA code and ongoing experimental work will be useful for understanding the consequences of these issues.

Recommendation 3

We reiterate previous ACNW recommendations that staff continue developing a better understanding of corrosion mechanisms for Alloy 22 and other engineered barrier materials to judge the validity of extrapolating short-term experimental results on material performance to very long time frames.

Observation 4

We continue to be concerned about the treatment of coupled chemical processes due to the difficulty in incorporating them into the modeling, the complexity of the processes, and the potential for negative impacts on performance. Although considerable effort has been expended both by NRC and DOE on coupled processes, the inherent complexity of phenomena and the paucity of important data have limited the benefit of what has been done. In addition, continuing uncertainty about final repository design introduces uncertainty in the identification of important contributors to coupled processes such as temperature effects and the impacts of material interactions on chemistry, barrier degradation, and possible radionuclide releases and transport. It is likely that such processes can have important influences on repository performance.

Recommendation 4

The staff should continue evaluations of coupled THC processes, especially with respect to the chemical environment on the waste packages and drip shields, to ensure that important phenomena that affect the degradation of barrier performance are not overlooked.

Observation 5

The overall TSPA-SR treatment of in-package chemistry, which controls the release rates of radionuclides, does not address important complexities and the technical bases are not adequately described and justified. In addition, it is not necessarily a "conservative" approach for waste packages that have some liquid water present inside. It is not clear that process model abstractions capture the important uncertainties of in-package and near-field chemical conditions (e.g., pH and oxidation-reduction reactions).

Recommendation 5

The staff needs to more fully address in-package chemistry issues as it develops an integrated chemistry model to be implemented in TPA. Current plans for upgrading the chemistry capabilities of the NRC's TPA code emphasize the chemistry of water on the exterior of the waste packages.

Observation 6

The TSPA-SR employs conflicting physical and chemical processes and conditions to model the radionuclide source term. For example, the in-package chemistry model is based on the assumption that the waste package is full of liquid water. This is not physically realizable for the vast majority of waste packages that are only coated with a thin film of moisture. The source term model, however, employs a "nonmechanistic release scenario" that does not account for varying amounts of moisture inside the waste packages. While this appears to be a very "conservative" approach, it is not clearly discussed and leads to confusion and uncertainty as to its importance to dose. This approach may be a significant contributor to relatively high dose values at long time frames in TSPA-SR, and when waste packages are neutralized in DOE's analyses for its Repository Safety Strategy. This may lead to perceptions that early waste package failures would result in doses greatly exceeding regulatory limits and that only the waste package outer barrier stands between the public and the waste at Yucca Mountain. The NRC and CNWRA have identified a number of concerns with the implementation of the source term model in TSPA-SR, and DOE is likely to put forth a more realistic source term model in the next iteration of TSPA.

Recommendation 6

The staff should continue to develop an appropriate source term model for NRC's TPA code to be prepared to review a more realistic source term model from DOE and should continue identifying important parameters, issues, and concerns.

Observation 7

Transport of radionuclides as both ionic and colloidal species in TSPA-SR is represented by unchanging parameters (e.g., K_ds) that provide little predictive capability or insight into the controlling chemical mechanisms for retardation. DOE has agreed to address numerous staff concerns about colloid formation and movement and the development of appropriate information for radionuclide transport and attenuation.

Recommendation 7

NRC and CNWRA staffs should continue efforts to gain better insights into radionuclide transport and attenuation processes in TSPA.

Concluding Remarks

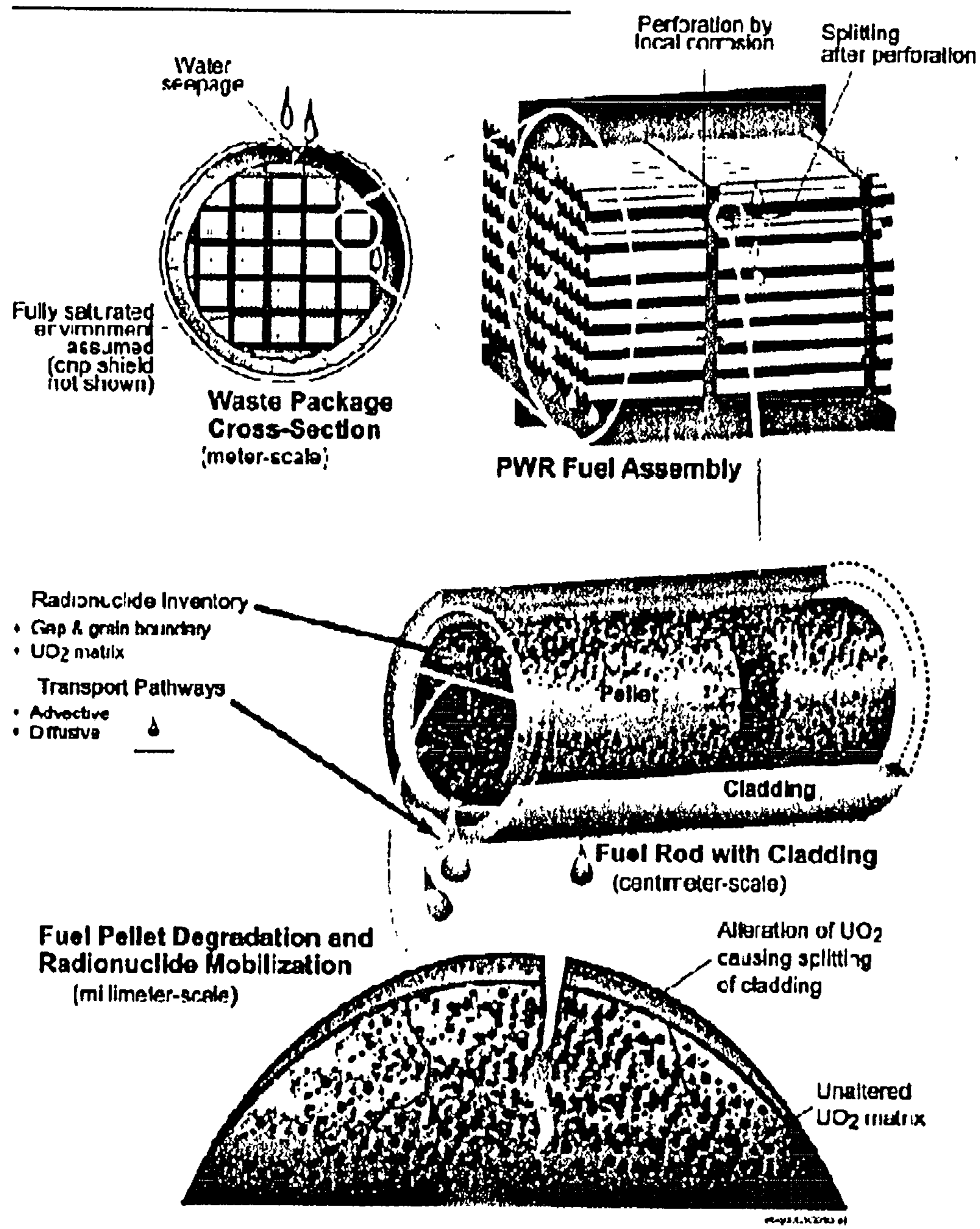
The NRC's prelicensing process for resolving issues, as it pertains to chemical phenomena affecting performance of the proposed Yucca Mountain repository, is well documented in the IRSRs. The staff appears to be addressing the chemistry issues that are likely to be important and the issue resolution agreements with DOE appear appropriate. Currently, limited information exists on the chemical processes that may mobilize radionuclides and transport them through the EBS. In subsequent iterations of TSPA, DOE needs to conduct a thorough reevaluation and documentation of the information bases, modeling approaches, and calculations of in-package chemistry, and to develop more realistic approaches for radionuclide release and transport. We continue to be concerned about the treatment of coupled chemical processes because of the potential for negative impacts on performance in the compliance period. We believe that these issues are solvable in a timely fashion but will require a careful evaluation of models and approaches.

Sincerely,

George M. Hornberger
Chairman

Attachment:
Report of the ACNW Working Group on Chemistry Issues and Related NRC Staff Capability for the Proposed High-Level Waste Repository at Yucca Mountain by Andrew C. Campbell, James H. Clarke, Paul G. Shewmon, Martin J. Steindler, and Raymond G. Wymer, dated August 2001

Figure 1. Waste form degradation model in TSPA-SR.



Report of the ACNW Working Group on Chemistry Issues and Related NRC Staff Capability for the Proposed High-Level Waste Repository at Yucca Mountain

Andrew C. Campbell, James H. Clarke, Paul G. Shewmon,
Martin J. Steindler, and Raymond G. Wymer

August 2001

INTRODUCTION

The Department of Energy's (DOE's) post-closure safety case for the proposed Yucca Mountain High-Level Waste (HLW) repository has shifted from an original focus on the geology of the site to emphasis on the engineered barrier system (EBS). This is reflected in the nominal scenario of the DOE's Total System Performance Assessment for the Site Recommendation (TSPA-SR)[1]. The scenario depends on a system of corrosion-resistant nickel-chromium-molybdenum alloy waste containers and titanium alloy drip shields to delay any potential releases from the EBS beyond the 10,000-year compliance time.[i] The performance of these barriers is based on extrapolating measured or estimated chemical properties and processes, derived from short-term laboratory testing, to very distant times. Chemical mechanisms and processes also play a dominant role in the performance of other engineered and natural barriers (e.g., cladding degradation, waste form dissolution, and mobilization and transport of radionuclides). It is important for the Nuclear Regulatory Commission (NRC) staff to understand the technical bases and performance impacts of chemical processes affecting the EBS and natural system to determine with reasonable expectation that the repository will meet the regulatory requirements. Given the time scales involved, the NRC is faced with the task of making judgments about phenomena and processes that cannot be tested directly and that are outside the framework of scientific endeavors where the outcome of an experiment and the test of a model or of a hypothesis can be directly observed. Thus, it is essential to assess the technical context for the TSPA modeling and the NRC's review approach, which are based on relevant information, data, and analyses. The lines of evidence that support the modeling results and regulatory conclusions need to be clear and traceable to valid scientific data.

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[i] The 10,000 year compliance time is specified in both NRC's proposed high level waste (HLW) regulation, 10 CFR Part 63, and the Environmental Protection Agency's final HLW standard, 40 CFR Part 197.

BACKGROUND

The NRC is charged in the site recommendation process for the proposed Yucca Mountain HLW repository with providing comments on the sufficiency of the subsurface and waste form data for a license application. An important concern to the Commission is ensuring that the staff's review of approaches, methods, expertise, and capability are adequate for the sufficiency comments and for review of a license application. An Advisory Committee on Nuclear Waste (ACNW) Working Group evaluated the chemical issues associated with the engineered barriers and natural system and the adequacy of the related NRC issue resolution activities.[ii] The Working Group, chaired by Raymond G. Wymer, met on February 21 and 22, 2001, at NRC headquarters in Rockville, MD. The Working Group's activities are part of the ACNW's effort to evaluate the NRC's pre-licensing process for identification and resolution of issues related to licensing the proposed Yucca Mountain HLW repository. This report presents the findings and conclusions resulting from the Working Group meeting and from independent studies of NRC and DOE documents by the working group members.

CHEMISTRY REVIEW ISSUES

We conducted an audit review of the following chemistry topics: waste package and drip shield corrosion, near-field chemical environment, in-package chemistry, radionuclide release, and radionuclide transport. Our review builds upon previous ACNW reviews of the near-field environment.[2,3] Many of the chemical processes, particularly those in the EBS, need to be

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[ii] Members of the Working Group were Dr. Andrew C. Campbell (ACNW Senior Staff Scientist), Dr. James H. Clarke (ACNW Consultant), Dr. Paul G. Shewmon (ACNW Consultant), Dr. Martin J. Steindler (ACNW Consultant), and Dr. Raymond G. Wymer (ACNW Member). Representatives from the NRC staff and the Center for Nuclear Waste Regulatory Analyses (CNWRA) attended and participated in the meeting, and a telephone link was open to the CNWRA. The meeting was announced in the *Federal Register* and open to the public. Representatives of DOE and the State of Nevada were also present.

considered in the context of coupled thermal-hydrologic-chemical processes that affect the performance of specific subsystems. We have sought to understand with a reasonable level of detail the underlying science, assumptions, models, and abstractions as provided by DOE, and the corresponding issues and review comments by the NRC staff for this limited set of topics. During the course of our review we considered issues in the context of relevant Key Technical Issues (KTIs), subissues in the NRC's HLW program[4], and relevant system attributes and principal factors of the DOE Yucca Mountain Repository Safety Strategy (RSS).[5] The Working Group addressed the process-level modeling for specific issues, the abstractions of process models into TSPA-SR, and the technical bases for TSPA-SR. In this context, the Working Group evaluated the adequacy of the NRC review capabilities and methods to deal with the DOE safety case for the specific chemistry issues and discussed regulatory issues, such as the multiple-barriers requirement. The Working Group also commented on the degree to which "conservative" assumptions challenge the validity and the utility of the analyses in the near field and in the natural environment. A final point addressed was the flexibility of the NRC to deal with contingencies, such as changes in the repository design.

DISCUSSION

Corrosion of the Waste Packages and Drip Shields

The Alloy 22 waste package outer barrier and titanium drip shields are key engineered elements of the repository system. ACNW has previously reviewed the corrosion of Alloy 22.[6] The predicted long-term performance of the drip shield and waste package barrier system is based upon the slow general corrosion rates and resistance to localized corrosion and stress corrosion cracking (SCC) of the materials within the expected chemical and physical environment of the repository. The Working Group looked at the technical bases for modeling the corrosion of these features, including general and localized corrosion of the Alloy 22 waste package, SCC of Alloy 22, and hydride cracking of the titanium alloy drip shield.

Corrosion of Alloy 22 Waste Package

The calculated life of the waste package is determined in most scenarios by the general corrosion rates of Alloy 22 measured in experiments.[7] The general corrosion rate appears to be extremely slow under a wide range of temperature and chemical conditions.[8] General corrosion rates are derived from measurements in aqueous solutions (liquid water), whereas the majority of waste packages will be covered only with an adsorbed layer of water in equilibrium with humid air. The corrosion process is assumed to proceed at the rate of dissolution measured in the aqueous solutions. For example, in experiments at the Center for Nuclear Waste Regulatory Analyses (CNWRA), the materials are subjected to elevated temperatures, aggressive chemical constituents (e.g., high concentrations of chloride ions and low pH), applied voltages to facilitate corrosion, and stirring to avoid the buildup of corrosion products. Alloy 22 develops a protective Cr-rich oxide layer and the titanium alloy develops a protective oxide film that result in these materials corroding very slowly in experiments, making it difficult to discern variations in corrosion rates for different conditions. The use of aqueous corrosion data appears to conservatively bound waste package degradation. For example, humid air corrosion rates for 316L stainless steel are about 10 times slower than aqueous corrosion rates.[9] Measurement of general corrosion rates for Alloy 22 under humid air conditions has not been done by NRC, but DOE is conducting limited experiments.

Alloy 22 is much more resistant to crevice and pitting corrosion in chloride solutions than are stainless steels. The time frame for initiating such corrosion should be longer than that calculated for failure by general corrosion. The resistance to SCC around and in the Alloy 22 welds is less clear. Some tests indicate somewhat faster corrosion here than away from the welds, and some show little difference. The matter is still under study and NRC is concerned about the effects of welding and post-weld treatments on localized corrosion and SCC. There is evidence that there can be SCC failure in the weld zone after a surface layer of the Alloy 22 (with compressive stress) has been removed by general corrosion. Under extreme laboratory conditions, which are not representative of expected repository conditions, Alloy 22 can undergo SCC failures.[iii] DOE will be evaluating the SCC impacts of trace elements (potential catalysts) on Alloy 22 in accord with issue resolution agreements with the NRC.

According to DOE's sensitivity analyses for TSPA-SR, the SCC lid stress profiles and general corrosion of lid welds in waste packages are more important than any other variable until well beyond 100,000 years. The area of SCC cracks is extremely small relative to the area of general corrosion patches that are assumed to develop on the waste packages (by about 3-4 orders of magnitude). No water is allowed to flow through the SCC cracks and only very small releases of radionuclides occur via diffusion. Thus, SCC only affects the low dose region (well below 15 mrem) of the overall dose distribution and is a negligible contributor to overall risk. The usefulness of these sensitivity measures to inform decision makers about the important

[iii] Experimental data show very slow general corrosion under a wide range of temperature and chemical conditions. Consultants to the State of Nevada conducted experiments that showed Alloy 22 can be induced to undergo SCC for specific conditions of high acidity, temperature, and pressure, and in the presence of lead and mercury ions at about 0.5 wt. percent The ACNW concluded that the range of experimental conditions used by consultants was not relevant to environmental conditions anticipated for the proposed Yucca Mountain high-level waste repository, however, there is a need to conduct confirmatory work to ensure the robustness of the Alloy 22 waste package (Ref 6)

contributors to risk from the repository is not apparent and needs to be clearly explained by DOE.

Corrosion of Titanium Alloy Drip Shield

Hydride cracking of the titanium drip shield is excluded by DOE based on estimates that the hydrogen pickup would not be sufficient ". . . to attain critical hydrogen concentration in Ti drip shields before failure by general corrosion."[10,11] The NRC staff did not accept this exclusion and requested that DOE provide the technical bases for it. The staff was concerned about the effect of fluoride-induced corrosion on hydrogen absorption. The Working Group discussed the critical hydrogen concentration and felt that the geometry of the shield and the mine drift would not allow enough mechanical work to be put into the titanium shield to break it (i.e., it is still robust enough to avoid fracture). An additional safety margin, for which no credit is taken, is provided by the 0.1% palladium that will be alloyed with the titanium. This will reduce the rate of hydrogen pickup by the titanium in the drip shield alloy to an even lower level than assumed in the "conservative" estimate.

Comments on the Adequacy of the NRC Staff Approach and Capability to Address Resolution of Corrosion Chemistry Issues

In reviewing the NRC and CNWRA evaluations and analyses for container and drip shield corrosion, the Working Group has concluded that no important corrosion areas or questions have been neglected. The Staff has considered a number of subissues in the Issue Resolution Status Reports (IRSRs) for the Container Life and Source Term (CLST) and Evolution of the Near-Field Environment[12] (ENFE) KTIs related to drip shield and waste package corrosion.

Within the issue resolution process, the NRC staff has raised a wide range of specific questions to satisfy itself that DOE's approaches, assumptions, and methods are appropriate and supported. These questions are the basis of the interactions with DOE in a series of technical exchanges focusing on each KTI and its subissues. These include questions about the following: general and local corrosion rates and SCC rates that are measured in laboratory experiments, the waste package chemical environment, the influence of trace metals on SCC, thermal treatments to relieve stress, passive oxide film stability, and the use of measured corrosion rates for projecting long-term performance. DOE has made agreements to address specific concerns and to provide more documentation to the NRC.[13] At this time all of the subissues related to waste package and drip shield performance in both CLST and ENFE are closed pending additional information, tests, and documentation from DOE. However, issues that relate to the use of this information in the TSPA-SR model (e.g., the abstraction of information into TSPA-SR) are currently open and will be addressed in the technical exchanges for Total System Performance Assessment and Integration (TSPAI) KTI.[14]

In general, we find the NRC's IRSRs to be well documented in terms of identifying important issues that are the focus of the DOE/NRC technical exchanges and agreements. In particular, we note that the CLST IRSR, Revision 3, provides a comprehensive treatment of the issues and carefully documents the agreements and the context of those agreements with respect to the issue areas most important to performance. The staff also appears to be well positioned in terms of approach and expertise to deal with evolutionary changes in design and their impacts on waste package corrosion.

Near-Field Chemical Environment

The near-field (in-drift) chemical environment is an important element of the TSPA-SR analysis because it determines the chemistry of the water contacting the drip shield and waste package and influences the degradation rates.[15] The in-drift chemistry will be controlled by coupled processes involving thermal-hydrological-chemical (THC) interactions between the water entering the drifts and the emplaced materials.[iv] During the 10,000-year compliance time chemical reactions will be affected significantly by radioactive decay heat, especially in the first few thousand years. Beyond 10,000 years, the decay heat slowly decreases so that at 100,000 years the system is near ambient thermal conditions. At post-10,000-year time frames coupled hydrological-chemical (HC) processes are likely to dominate in-drift chemistry. The THC and HC interactions affecting waste package performance are followed by NRC in the ENFE KTI methods through subissue 2 -- the effects of coupled THC processes on the waste package chemical environment.

In the current DOE modeling approach, corrosion of the drip shield and waste package barriers is assumed to start when the relative humidity exceeds a critical value (between about 60 and 80%), at which point very thin layers of water will coat the surfaces.[16] Salts will precipitate on the drip shield where dripping water occurs and the evaporation rate exceeds the seepage rate.[17] Particulate material (rock dust and aerosol particles) will also coat the drip shield and the waste package. As cooling proceeds, brines will form by redissolution of the salts and reactions with particles.[18] As the temperature drops and the amount of sorbed water increases, these

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[iv] The principal materials placed in the drifts are iron (steel drift supports, invert framework, and waste package inner barrier and internals) and uranium [spent nuclear fuel (SNF)], which constitute about 46% and 20%, respectively, of the material mass (excluding the drift rock and invert-fill material or backfill if it is used). The metals constituting the drip shield and waste package outer barrier make up another 32% of in-drift materials.

brines will become increasingly diluted. The composition and temperature at which brines may form on the barrier surfaces may have an impact on local corrosion or SCC if sufficient stresses are present (e.g., from rock falls). In DOE's approach, coupled THC processes are treated separately and then recombined in the TSPA-SR analysis. The NRC staff has expressed concerns about this approach and DOE has agreed to provide further information.

Concern has been expressed about the use of J-13 well water as a proxy for the water entering the drift. Water dripping on the drip shield and waste package will contain dissolved chemicals derived from reactions with the rock as it passes through the mountain, as well as gases that are absorbed from air in the drift [including oxygen (O_2) and carbon dioxide (CO_2)]. The presence of some of these chemicals, which are not necessarily represented by J-13 well water, could have deleterious effects on the drip shield or waste package. For example, interaction of percolating water with soluble minerals in the high-silica rhyolite may introduce certain trace elements such as fluoride (F^-) and lead (Pb^{2+}) ions to the water. These aqueous solutions will also react with particles deposited on the drip shield and waste package, further complicating the potential chemical mix reacting with the barriers. Chemicals in the water dripping on the drip shield and waste package may also include constituents derived from emplaced materials of construction such as steel corrosion products and leachate from cement grout in the drifts. Currently, the effects of emplaced materials on water chemistry are generally excluded from consideration because DOE believes that most water contacting the drip shields and waste packages will not have interacted significantly with drift components. In addition, design changes may significantly alter the types and amounts of chemicals in the water (e.g., from material used as backfill). The DOE testing program includes evaluation of evaporative effects on chemistry; CNWRA has done some confirmatory work. However, the influence of the chemistry of the incoming water to long term barrier performance is not well constrained at this time. This is an area of concern to the staff in the ENFE subissue 2 and is the focus of a number of agreements with DOE.[19]

Comments on the Adequacy of NRC Staff Approach and Capability to Address Resolution of Near-Field Chemistry Environment Issues

The chemical environments on the drip shield and waste package are a concern to the NRC staff in subissue 2 of the ENFE KTI -- "the effects of coupled thermal-hydrologic-chemical processes on the waste package chemical environment." To a limited extent, in-drift chemistry impacts are also addressed in the CLST KTI through subissue 1 -- "the effects of corrosion processes on the lifetime of the containers." In the ENFE technical exchange NRC and DOE agreed that DOE will provide further documentation of the geochemical environment to help predict corrosion behavior of the drip shield and waste package. This includes DOE providing the technical basis for bounding the impacts of trace metals (e.g., lead) and fluoride and the impacts of engineered materials. Other agreements by DOE with the NRC include issues dealing with the following: the technical bases for certain features, events, and processes (FEPs), model and data uncertainties for the in-drift geochemical environment, local chemistry effects (including cement-water interactions, range of water composition, kinetic effects of chemical processes), and impacts of dust and salts on waste package degradation. DOE has also agreed to provide additional documentation and analyses to support modeling approaches.

In our review we found the staff positions to be comprehensive and thoroughly documented in the relevant IRSRs. At this juncture, we do not believe that the NRC and CNWRA have missed significant issues in this area. Questions about the integrated subissue on the chemistry and quantity of water on the waste package as implemented in the TSPA-SR model are currently open and will be addressed in the technical exchange for the TSPAI KTI.

In Package Chemistry

Another area of concern to the Working Group is the in-package chemistry affecting radionuclide release.[20] The slow corrosion rates of the waste package and drip shields have lead DOE to conclude that the waste package system will meet the compliance requirements in 10,000 years. However, simplifying assumptions used for the source term appear to be extremely "conservative" and result in significant releases once the waste packages become degraded. The degree to which the source term assumptions bias overall performance toward a "conservative" result is not considered. Without the benefit of more realism about waste and material chemistry inside the waste packages, the waste package may be perceived as the only significant barrier protecting public health and safety.

The Working Group evaluated in-package chemical conditions and processes, focusing on water chemistry properties, such as pH, and chemical processes, like reduction and oxidation (redox) reactions, that affect the chemical speciation of radionuclides. The TSPA-SR model for the in-package chemistry is a simplified approach assuming a fully saturated environment at ambient temperatures (see Figure 1). This approach, which DOE maintains is "conservative," is used because of uncertainties about the composition of water that could contact waste forms, and because of the complexities of predicting interactions between water penetrating the waste package and materials within it.[21] However, DOE has not evaluated the effects of reacting more limited amounts of water with a subset of materials within the waste package at elevated temperatures. Because of the complexities and difficulties in calculating meaningful pH values for chemical processes, we conducted an evaluation of approaches and assumptions that affect the pH of water inside the waste package and the resulting impact on waste form degradation and radionuclide solubility.[v]

In-package pH Effects

In DOE's TSPA-SR model, the calculated in-package pH[vi] plays a fundamental role in determining the release of radionuclides from the EBS. The pH is used in calculating radionuclide solubility (e.g., of Np), spent fuel degradation rates, which congruently releases non-solubility-limited radionuclides (e.g., of Tc and I), HLW glass dissolution rates, and the stability of colloidal species (e.g., of Pu). The calculated pH thus serves as a "master variable" controlling the release of the most significant radionuclides in TSPA-SR.

The pH is a complicated function of a number of competing reactions for the dissolution of materials in the waste package that either produce or consume hydrogen ions.[vii] The

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[v] Note that DOE recently issued revised in-package chemistry and in-package chemistry abstraction model reports (references 21 and 22 respectively). The pH results in the revised reports are much more complicated than the previous calculations that were abstracted into TSPA-SR, Rev. 00. Our comments here focus on the more recent reports as a subsequent revision to TSPA-SR will likely show significant differences from the existing set of model results.

[vi] The pH of a solution is a measure of its acid content. The pH is defined as the negative log to the base 10 of the hydrogen ion (or proton) concentration (i.e., $pH = -\log_{10} H^+$). In pure water pH 7 is neutral, a pH less than 7 is acidic and a pH above 7 is basic. Because pH is a log scale, a one unit change in pH represents a 10 fold change in hydrogen ion concentration. Thus a solution with pH equal to 4 has a 1000 fold higher hydrogen ion concentration than a solution of pH 7. At pH values above 7 concentrations of the basic hydroxyl ion (OH^-) become significant.

[vii] The pH is modeled as a function of the amount of water passing through the waste package and the reactions and reaction rates of the materials in the waste package (i.e., Fe and Al alloys, commercial spent nuclear fuel (CSNF), or HLW glass for co-disposal packages). The amounts of CNSF or HLW glass exposed to water were specified in the calculations. The dissolution reactions for Fe-containing materials (e.g., A-516 steel and 316 stainless steel) are acid-producing (i.e., the pH goes down) and the dissolution reactions for Al alloys, CSNF, and HLW glass are acid-consuming reactions (i.e., pH goes up). The balance achieved among these competing reactions determines the pH at any time as water reacts with the waste and package materials. (It is assumed that the waste packages contain 4,500 liters of water.) The change in pH values over time is a consequence of the progressive consumption of different materials in the waste package as water flows through the system. By about 300,000 years all the internal materials will have reacted. At this point the pH is determined by the chemistry of the incoming water, which is assumed to be about the same as J-13 well water.

relationship among the material reaction rates and the overall pH is fundamentally nonlinear, and uncertainties, such as in those in the thermodynamic data bases, may strongly affect the calculated pH, and consequently the calculated chemical effects, in unanticipated ways. Moreover, coupled THC interactions between the water and the degrading materials at temperatures above ambient have been ignored. In addition, no comparisons with laboratory, field, or analog data are made to provide confidence that the approach used by DOE in fact bounds the pH values that could be expected to occur in the waste package. Because of the significant impacts on radionuclide release rates and transport properties, the coupled processes affecting pH need to be more carefully evaluated and the evidence bases supporting the approach need to be thoroughly described and documented.

Finally, abstraction of the pH into the TSPA-SR model relies on a complicated mix of response surfaces for shorter time frames and linear extrapolations for longer time frames.[22] The TSPA-SR abstraction for pH is focused on bounding the variability from the process model calculations. DOE assumes that the variability in the pH results obtained for a limited number of equilibrium chemistry model (EQ3/6) calculations represents the uncertainty of the in-package pH. While the response surface abstraction into TSPA-SR may bound this variability, it is not clear that the abstractions capture the important uncertainties in pH.

In-Package Reduction and Oxidation (Redox) Reactions

DOE makes the assumption that an oxidizing environment exists within the waste packages at all times, and that this is a "conservative" assumption for times when most of the metals are still present and the ingress of water and gases (e.g., O_2 and CO_2) would be limited by the slow development of general corrosion "patches" on the waste packages. In the current modeling approach the chemical state of the water is set to be fully oxidizing by setting the partial pressure of dissolved oxygen in the water to a constant value that is representative of equilibrium with oxygen in air. Most of the important stable radionuclide solid phases under oxidizing conditions have significantly higher solubilities than the stable solid phases under reducing conditions.[viii] Aqueous corrosion of steel in the waste package could have a significant effect on radionuclide solubilities by producing a reducing environment when the ingress of oxygen is limited (e.g., from closure to well beyond the first 100,000 years of repository life). Redox gradients within the waste packages are acknowledged as possible by DOE. Taking credit for consumption of oxygen relative to the ingress of oxygen would require coupling chemical reaction kinetics with water and gas exchange through waste package breaches. At this time, no attempt has been made to evaluate or bound this scenario and so no conclusions can be made about the impact of this "conservatism" on radionuclide release rates.

The DOE assumption of an oxidizing environment, however, is not carried through the analysis in a consistent fashion. For example, it is assumed that the ionic species for I and Tc are in their most mobile forms -- iodide (I^-) and pertechnetate (TcO_4^{2-}). If oxidizing conditions prevail, however, the predominant iodine species may be iodate (IO_3^-), which is capable of reacting with many materials in the EBS and natural environment. The assumption that iodide species prevails is inconsistent with the assumed chemical conditions.

It is not clear that the TSPA-SR models address chemical effects when some chemical species that are likely to be present in irradiated UO_2 react with water at modest temperatures. Such

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[viii] For example, the stable form of Tc in a reducing environment is technetium oxide (TcO_2) which is insoluble in water, whereas the stable form under oxidizing conditions is the pertechnetate (TcO_4^{2-}) ion, which is highly soluble in water. In a reducing environment Np^{4+} will form, which will be less mobile than NpO_2^+, the stable form in an oxidizing environment.

speciation in the fuel could significantly affect the resulting reactions with modified groundwater. For example, if technetium oxide (TcO_2) and/or sulfide (TcS_2) are formed, the rate of release from dissolving fuel could be much slower than currently assumed. However, there seem to be no kinetic data to indicate how soon these would transform to the mobile TcO_4^-. Moreover, leaching experiments of spent fuel under oxidizing conditions provide some limits to the importance of this reaction. Furthermore, there is good evidence that part of the technetium in the spent fuel will be present as finely divided metal.

DOE continues to evaluate Np solubility limits, which are too uncertain for such an important isotope in TSPA-SR.[23] The selection of the most soluble form of crystalline neptunium oxide (Np_2O_5) as the solubility limiting solid phase is "conservative."[24] Less soluble oxide phases of Np may be more appropriate for repository conditions. In addition, the formation of Np solid solutions and the incorporation of Np into secondary uranium oxide phases need to be further evaluated to establish more realistic limits for Np solubility.

Radionuclide Release Models

The in-package chemistry model assumes all the void volume inside the waste package is filled with water (~4,500 liters) and that this water reacts with all available materials in the waste package (i.e., it behaves in a manner analogous to the way the same reactions would take place in a well-stirred bathtub). The approach taken in the model appears to be "conservative" because the radionuclide release model assumes much smaller amounts of water entering waste packages that intercept drips (between 15 and 0.15 liters per year). Moreover, most waste packages in the TSPA-SR model never have liquid water in them. DOE does claim that the approach is "conservative." However, DOE apparently has not quantitatively evaluated the impact of smaller amounts of water with respect to the potential for producing more aggressive chemical conditions. Though less water dripping on the waste packages would imply less waste reacting with it, the possible tradeoffs in terms of enhanced radionuclide mobility (e.g., Np solubility, congruent release of Tc, or the stability of colloidal Pu) have not been addressed. On the other hand, mobilization and release of radionuclides from waste packages that are assumed never to have contained liquid water seem to be "conservative" to the point of absurdity. Given the complexity of the in-package chemistry and the importance in terms of radionuclide mobility, DOE needs to better document and support its approach.[ix]

To mobilize radionuclides from the EBS, the TSPA-SR model uses both diffusive releases (via moisture films in the EBS) and advective releases (via flowing water).[25] The TSPA-SR results show that diffusion dominates the overall radionuclide releases from the repository even in the absence of flowing water. The model of diffusive transport of radionuclides out of the waste packages and through the invert is decoupled from the amount of liquid water available in the waste package. The water chemistry model is developed for a fully saturated waste package and is used to provide concentrations for the diffusion model. A zero-concentration boundary condition is assumed outside the waste package and at the interface between the invert and the unsaturated zone rock. These assumptions imply significant water is present, whereas a diffusion only model implies extremely limited amounts of water are present. Thus, the TSPA-SR employs conflicting physical and chemical processes and conditions to model the source term release. While this appears to be a very "conservative" approach, it is not clearly

[ix]In general, using a "conservative" model or parameter value in a complex nonlinear model system does not necessarily produce "conservative" results. Such an approach requires that the outcome with a reasonable range of values be evaluated to bound the overall impacts. For example DOE uses a "conservative" (i e., high) HLW glass dissolution rate that raises pH in the waste package as the glass dissolves. A more realistic lower dissolution rate produces more acidic conditions, which in turn would affect other aspects of the release model such as radionuclide solubilities, material degradation rates, colloid stability, and so forth. It is not clear that this type of coupled analysis has been done to assure that using "conservative" parameter values or model assumptions is truly "conservative" in terms of overall impacts on the TSPA-SR results.

discussed and leads to confusion and uncertainty. What is more important, the use of this extreme "conservatism" in the model appears to be a significant contributor to relatively high dose values at long time frames and when waste packages are "neutralized"[x] in DOE's RSS analyses. This may lead to perceptions that early waste package failures would result in doses exceeding regulatory limits.

The problems of modeling these processes are surmountable and other nations' repository development programs have dealt with the complexities of modeling advection and diffusion into and out of breached waste packages. For example SKB -- the Swedish Nuclear Fuel and Waste Management Co. -- has conducted an extensive program of engineering development. This program includes experimental, modeling, and design development work focused on the waste package and internal processes that would attenuate radionuclide releases from their proposed repository system.[26]

<u>**Comments on Adequacy of NRC Staff Approach and Capability to Address Resolution of In-Package Chemistry**</u>

The chemical environment in the waste package is a concern to the NRC staff in subissue 3 of the ENFE KTI -- "the effects of coupled thermal-hydrologic-chemical processes on the chemical environment for radionuclide release." The in-package chemistry impacts are also addressed in the CLST KTI through subissue 3 -- "the rate at which radionuclides in SNF are released from the EBS through the oxidation and dissolution of SNF" -- and subissue 4 --"the rate at which radionuclides in HLW glass are leached and released from the EBS." The staff has developed a significant number of specific questions for each of these subissue areas. At this time these

[x] Neutralization of a barrier means that its effect is removed from the model.

issues are closed pending the additional work that DOE has agreed to address. Issues that relate to the use of this information in the TSPA-SR model (e.g., the abstraction of information into TSPA-SR) are currently open and will be addressed in the technical exchange for the TSPAI KTI.

In the CLST KTI subissue 3, the NRC staff reviewed various aspects of the issues discussed here, including issues such as in-package chemistry, radionuclide solubilities, spent fuel dissolution rates, and the assumed oxidizing condition for near-field chemistry. Issues involving the implementation of the in-package chemistry model continue to be evaluated by the NRC and a number of agreements with DOE on the issue resolution process are intended to address these concerns. For example, the NRC staff has pursued the issue of Np solubility limits and the current range of values used by DOE appears to be "conservative." NRC has also concluded that, although a reducing state may occur soon after the waste package is breached, ultimately the waste package environment will be oxidizing. The staff concurs with DOE that the assumption of an oxidizing environment is "conservative." The staff believes that the diffusion release model is very "conservative," but at this time has not identified significant problems with the degree of "conservatism." However, it needs to be noted that the DOE's basis for meeting the dose standard within the regulatory compliance period is based on the performance of the waste package. In the absence of long waste package performance times, the "conservative" approaches to the release and transport of radionuclides would lead to doses exceeding the regulatory limits at much earlier time frames. It is not clear that the NRC staff has fully addressed all of the in-package issues identified above.

Radionuclide Transport in Near- and Far-Field Environment

The TSPA-SR employs a sophisticated mathematical model of flow and radionuclide transport to predict doses as a function of time at a compliance point in the saturated zone that is 20 kilometers down gradient from the proposed repository. This model necessarily requires input assumptions concerning a wide range of chemical information. Given the long time frames involved, a good understanding of those assumptions to which the predictions are most sensitive is essential.

Radionuclides can be transported as "true colloids" or "pseudo colloids." In the TSPA model the latter include both irreversibly bound colloids (IRBC) and reversibly bound colloids (RBC).[xi] In IRBCs, radionuclides are irreversibly associated with colloidal material (e.g., silicate particles from HLW glass degradation). In RBCs, radionuclides are reversibly attached to colloidal material (e.g., natural clays in ground water and iron oxyhydroxide corrosion products). In TSPA, the IRBCs are transported as anionic solutes that can be retarded through filtration processes but are not permitted to diffuse into and sorb onto the rock matrix in units with significant fracture flow. In RBC, the radionuclides partition between colloids (natural or waste form) and the aqueous dissolved phase. The partitioning is defined by a colloid partition coefficient, K_c. Unattached radionuclides are transported as dissolved solutes and can be attenuated through diffusion into and sorption onto the rock matrix in fracture-flow-controlled units. The NRC staff has evaluated many issues and concerns with regard to the approach used by DOE in modeling colloid formation and transport. These concerns and issues are

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[xi] True colloids are those formed by the radionuclide itself (e.g., PuO_2 colloids). The TSPA model considers pseudocolloids, where radionuclides become associated with other colloidal particles such as clays and iron oxyhydroxides

described and discussed in the ENFE IRSR under subissue 3 and are addressed by agreements with DOE from the ENFE technical exchange[19].

Radionuclide transport is driven by water flow through the subsurface, with incorporation of the pertinent retardation processes for each model unit. Some important subsurface processes include sorption of dissolved solutes on alluvial and rock matrix surfaces and filtration of IRBC. Laboratory and field tests have been used both to demonstrate the efficacy of attenuation processes, such as sorption, and to develop the appropriate parameters needed for the model. Laboratory studies with both site-specific materials and field testing (e.g., through the injection of tracers as was done with the C-wells complex) have been done. There are, however, issues that need to be resolved about how well the tracers used in these studies represent radionuclide behavior (e.g., the specific size ranges of polymer microspheres used to represent colloid behavior). Continuing investigations are being performed to address existing NRC concerns and to provide data to determine K_ds and other transport parameters for the alluvium.

Chemistry is included only indirectly in transport modeling through experimentally determined parameters such as Kd, a measure of the distribution of chemical species between liquid and solid phases. Chemistry considerations should also be included to support the appropriateness and degree of "conservatism" associated with the modeling assumptions that are made. For example, iodine may be expected to be present in a more reactive form as the iodate species (IO_3^-); however, it is being modeled as if it were always present as the non-sorbing iodide (I^-) anion, thus potentially overestimating its mobility.

Comments on NRC Staff Approach to Issue Resolution

The NRC staff has documented its approach to issue resolution in the Radionuclide Transport IRSR[27] and has established agreements with DOE in the radionuclide transport technical exchange for three subissue areas: radionuclide transport through porous rock, alluvium, and fractured rock.[28] While the issue resolution process has resolved many technical issues, a few "ongoing issues" appear to be worthy of mention. The length of the flow path in alluvium is important from the standpoint of radionuclide attenuation (sorption). Additional data from the ongoing Nye County work should help here. While the efficacies of the major attenuation processes have been demonstrated (e.g., matrix diffusion in fractured rock), there are concerns about limitations to the attenuation capacity of the system.

Much of the issue resolution process is focused on process model issues, resulting in a concern on our part for potential problems at critical interfaces, e.g., waste package/engineered barrier/unsaturated zone and unsaturated zone/saturated zone. Information which is produced by DOE to resolve an issue may or may not be accompanied by additional information that is necessary to enable deeper understanding of the importance of the issue to the total system performance. Thus there is merit to more comprehensive documents which include the interfaces. To a large degree this is the role of the TSPAI KTI and the integrated subissues in the NRC's framework and the TSPA-SR in the DOE approach.

CONCLUSIONS

1. NRC's Issue Resolution Status Reports in the chemistry area are well documented. No important issues or questions with regards to corrosion appear to have been overlooked by the staff.

2. The NRC staff appears to understand what would be required to deal with possible future repository design changes, but resources may be inadequate to deal with some potential scenarios.

3. Alloy 22 and 316L stainless steel will likely corrode more slowly than predicted by DOE unless an unexpected catalytic effect by trace elements occurs. Studies are underway to investigate this possibility.

4. The effects of SCC and localized corrosion on the degradation of welds are uncertain and staff has required more information on the impacts of weld treatments from DOE.

5. The usefulness of DOE's sensitivity and importance analyses in TSPA-SR to identify and understand the most significant contributors to overall risk is questionable.

6. The central role of the waste packages and the drip shields in meeting the dose limits in the 10,000 year compliance period could lead to the erroneous conclusion that their slow corrosion is all that is protecting the public. Other important protective chemical processes may significantly limit the release and transport of radionuclides, such as secondary-phase formation and retardation.

7. The importance of THC processes during the 10,000-year compliance period is uncertain, but chemical reactions, including corrosion, could be significantly accelerated if liquid water heated by radioactive decay contacts the barriers or waste form materials.

8. In TSPA-SR, J-13 well water has been used as a surrogate for water contacting waste packages, drip shields, and waste forms. However, it probably is unrepresentative of water in the near field and does not provide bounding chemical characteristics. The importance to performance of differing water chemistries and the impacts of coupled interactions of water with emplaced materials are not well understood at this time. DOE has agreed to conduct experiments with a variety of water chemistries to evaluate impacts on material degradation.

9. The in-package chemistry model assumes a fully saturated waste package and does not address potentially important chemistry issues such as radionuclide speciation in the SNF, solubility controlling reactions, or redox reactions. DOE needs to more clearly link the simplifying assumptions used in the model to experimental and analog evidence and also to address varying moisture conditions.

10. The abstractions of process model chemical phenomena into TSPA-SR does not appear to capture important uncertainties in chemistry (e.g., pH), which control the release and transport of the important radionuclides.

11. Diffusive releases of radionuclides in the TSPA-SR model are significant. DOE assumes that diffusion can occur along thin moisture films. However, the release model

actually employed in TSPA-SR is not adequately described. Apparently data and assumptions based on fully saturated conditions are used in situations where no liquid water can exist in the waste package. According to DOE, this "non-mechanistic release scenario" in TSPA-SR will be changed to a more realistic approach.

12. Potentially important colloid chemistry complexities may not be addressed in transport experiments, which are performed using organic polymeric microspheres to represent the behavior of colloidal radionuclides.

13. Chemical processes governing radionuclide transport are represented in a gross sense in the TSPA-SR model by the use of experimentally measured parameters (K_ds) that give little insight into rate controlling chemical mechanisms, thus limiting testing of model predictive capability and understanding.

14. A general area of concern that emerged in our review is that by striving always for conservative assumptions in a chain of events one can obtain unreasonable answers. The cumulative effect of overly conservative assumptions may obscure the most important components of the repository system in terms of performance and risk. Moreover, overly conservative assumptions in a specific process model abstraction may not be conservative with respect to the overall risk.

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

September 18, 2001

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: TOTAL SYSTEM PERFORMANCE ASSESSMENT-SITE RECOMMENDATION (TSPA-SR)

This letter documents the findings of the Advisory Committee on Nuclear Waste's (ACNW's) vertical slice review of the TSPA-SR. The Department of Energy's (DOE's) Supplemental Science and Performance Analysis (SSPA) Report following the TSPA-SR, addressed a number of the issues that the Committee identified in its vertical slice review. Because our vertical slice review of the TSPA-SR preceded the SSPA, this letter addresses only some of the SSPA changes. It should be noted, however, that the Committee has not yet reviewed the SSPA report, although we do currently have access to it.

In conducting its vertical slice review of the TSPA-SR, the Committee adopted an approach to: (1) determine the principal drivers of the assessed repository performance (including the supporting evidence) working from the final results, and (2) examine the extent to which the assessment achieves a risk-informed result.

Review Findings

In developing the TSPA-SR, DOE performed an extensive amount of modeling, and the results and supporting technical bases are reasonably well displayed in the context of the models employed. However, based on the Committee's vertical slice review, the principal findings are that the TSPA-SR does not lead to a realistic risk-informed result, and it does not inspire confidence in the TSPA-SR process. In particular, the TSPA-SR reflects the input and results of models and assumptions that are not founded on a realistic assessment of the evidence. The consequence is that the TSPA-SR does not provide a basis for estimating margins of safety.

Discussion

The Committee's principal concerns with the TSPA-SR are that: (1) modeling is guided by an inconsistent set of assumptions, including a mixture of conservative and nonconservative bounding assumptions, that do not represent realistic conditions; (2) the TSPA-SR relies on many assumption-based computations and analyses that do not support or link the assumptions with the available evidence; and (3) the TSPA-SR does not provide a sequence model of dominant dose contributors, therefore, it is not transparent or well-integrated.

The following paragraphs summarize representative examples of the problems that the Committee's vertical slice review identified in the TSPA-SR, along with the Committee's recommendations.

The TSPA-SR relies on modeling assumptions that mask a realistic assessment of risk. Among such assumptions are those having to do with such phenomena as radionuclide solubilities, in-package chemistry (including the formation of secondary mineral phases), cladding unzipping, decoupling of the drip shield model from the waste package model, and transport of radionuclides through the geosphere. Other assumptions that mask a realistic assessment and reasonableness have to do with mixing conservative and nonconservative bounding analyses and the general treatment of uncertainty. While the TSPA-SR analysts clearly recognize the masking problem and the modeling inconsistencies with respect to realistic assumptions, they fail to convey the expected risk, based on the available evidence.

The Committee believes that the TSPA-SR is driven more by an attempt to demonstrate compliance with the standards than by the need to provide an assessment designed to answer the question: What is the risk? The result is that the assessment does not really risk-inform the safety of the repository even in the spirit of DOE's own words, "... the goal of performance assessment is to provide decisionmakers with a *reasonable* estimate of the *realistic* future performance of the disposal system and a clear display of the extent to which uncertainty in the present understanding of the system affects that estimate." (The italics are added.)

The stated DOE practice is to choose parameter distributions that are "deliberately conservative" where uncertainty distributions "cannot be adequately justified based on available information." To suggest that the distributions are conservative implies some knowledge about the underlying processes, and how the results are affected by parameter values. While this approach may be suitable under some circumstances, when modeling involves linear systems and independent processes, the application of this approach to the high-level waste (HLW) repository at Yucca Mountain may be flawed. This is because the underlying processes in the near field of the repository, for example, are not entirely linear or independent. To the contrary, significant coupling is expected among nonlinear hydrological, chemical, and thermal processes. Determining what is conservative and what is not under these conditions is neither intuitive nor straightforward.

The masking of realism in the TSPA-SR precludes providing a clear basis to estimate the margins of safety, or making an objective regulatory decision that is in the best public interest.

We note that the SSPA report prepared following the TSPA-SR addresses both information and modeling uncertainties, describes how simplified and bounding models in the TSPA-SR, in some cases, were replaced in the SSPA with more detailed and representative models, and compares supplemental model results with those from the TSPA-SR. The Committee has not reviewed the SSPA and cannot comment on the quality of its results at this time. Nonetheless, there are some notable differences between the results of the SSPA and TSPA-SR models. In particular, the calculated doses for late times have significantly decreased in the SSPA models compared to the TSPA-SR models in the nominal case scenario, and increased for the disruptive case scenario. DOE claims that the differences between the supplemental SSPA model and TSPA-SR have essentially no impact on conclusions that might be drawn with respect to comparisons with the dose standard.

Computations and analyses are assumption-based, not evidence-supported. The TSPA-SR seems to rely more on assumption-based computations and analyses than on the available evidence. This has resulted in limitations that concern the Committee, especially as they relate to: (1) coupled processes, (2) waste package failure, and in-package physical and chemical processes leading to mobilization of the waste, (3) uncertainty in amounts and rates of radionuclides released, and (4) uncertainty in the source term for radionuclide transport. A specific example of relying on assumptions without supporting evidence is an attempt in the TSPA-SR to compare "degraded" and "enhanced" scenarios to provide an indication of the impact on results of two different assumption sets. The idea is a good one and greatly facilitates the understanding of the impact of different assumptions. Nonetheless, the analysis lacks the linkage between the assumption sets and the supporting evidence. The real issue is what the evidence supports, not what are the possibilities? Working from 5th and 95th percentiles of bounding parameter uncertainties in the TSPA-SR does not have much to do with "pessimistic" and "optimistic" results. It would have been much more informative if the TSPA-SR provided sensitivity analyses with respect to parameter values that are probabilistic, but also realistic, reasonable, and supported by evidence. The idea is to move in the direction of "evidence-supported" analyses and away from "assumption-based" analyses.

An alternative approach would be to select several performance scenarios for each of the nominal and disruptive cases, and emphasize the evidence supporting each individual scenario. The three peak-dose models (scenarios) considered in the TSPA-SR represent the beginning of such an approach, but fail to discriminate among the scenarios in terms of their likelihood and supporting evidence. Clearly defined scenarios can greatly facilitate the general question of what the evidence may or may not support.

A dominant sequence model has not been developed. There is a need to abstract a simple model for the dominant dose contributors to the critical group that clearly illustrates how the major modules of the TSPA-SR are integrated and assembled from the detailed models that make up the TSPA-SR. The absence of a simple model for the dominant dose contributors greatly handicaps verification and confidence in the performance assessment results. This is particularly true with regard to evaluating the roles of the different components of the repository system.

In the reactor risk assessment field, the industry has had considerable success in developing simplified risk models based on the dominant contributors to risk (sometimes referred to as a dominant sequence model). These models have contributed to better understanding of the real risk and the contributing factors. They lend themselves to repetitive calculations for checking results. They have also greatly facilitated the review process by allowing simple tradeoffs to be made in assumptions and design conditions while building confidence in the results. There does not appear to be a counterpart to these models in the performance assessment models employed in the TSPA-SR.

The complexity of the TSPA-SR model compromises the ability to comprehend and develop confidence in the results. There are few radionuclides (Tc, I, Np, and Pu) that are driving the risk, suggesting a great opportunity to abstract a simple model. One interpretation of a simple model would be to simply trace the radionuclide Tc for early dose results (say up to 40,000 years) and Np dose calculations for late and peak doses (10^5 to 10^6 years). The adoption of "pinch points" by the DOE investigators is a move in the right direction to show continuity in the analysis and to modularize the models for greater transparency. The problem for the TSPA-SR is that the idea was implemented too selectively to facilitate putting all the pieces of the model together.

Recommendations

On the basis of its vertical-slice review of the TSPA-SR, the Committee recommends that the NRC staff take the necessary action to be assured that:

- The performance assessment of the proposed Yucca Mountain repository is, in fact, risk-informed.
- DOE has adopted an evidence-supported approach and realistic modeling assumptions for use in the TSPA-SR while reducing the dependence on parameter bounding and conservatism to overcome uncertainty and increase the reliance on such available evidence as site-specific field and laboratory data, natural analogs, and expert knowledge.
- The NRC staff's review of the TSPA-SR adequately emphasized waste package failure and in-package processes to assure the staff that the waste package can perform as DOE claims and to inspire confidence in the characteristics of the source term for radionuclide transport.

The Advisory Committee on Nuclear Waste is prepared to discuss these issues with the NRC staff.

Sincerely,

George M. Hornberger
Chairman

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

September 28, 2001

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: ACNW COMMENTS ON NRC STAFF'S ISSUE RESOLUTION PROCESS FOR RISK-INFORMING ITS SUFFICIENCY REVIEW OF DOE'S TECHNICAL BASIS DOCUMENTS FOR THE YUCCA MOUNTAIN SITE RECOMMENDATION

The *Nuclear Waste Policy Act* (NWPA) requires the U. S. Department of Energy (DOE) to include in its site recommendation to the President preliminary comments from the NRC as to whether DOE's at-depth site characterization and waste form proposal for the proposed high-level waste (HLW) repository seem to be sufficient for inclusion in a possible license application. In this letter, we provide our observations and recommendations regarding the issue resolution process that the NRC staff used in its sufficiency review of DOE's technical basis documents pertaining to the site recommendation for the proposed Yucca Mountain, Nevada, HLW repository.

In summer of 2000 the Advisory Committee on Nuclear Waste (ACNW) initiated a vertical slice review of the NRC staff's issue resolution process and DOE's technical basis documents for the Yucca Mountain site recommendation. The purpose of our vertical slice review was to evaluate the NRC staff's tools, guidance, and technical capability for evaluating sufficiency and, if needed, an eventual license application. Primary objectives of our review were to evaluate: (1) whether the NRC's sufficiency review comments and issue resolution process are transparent, traceable, and defensible, and (2) whether the NRC's issue resolution agreements and information requested of DOE reflect a risk-informed and performance-based (RIPB) approach and are appropriate and realistic. In planning our vertical slice review, we selected four technical areas that correspond to one or more key technical issues (KTIs). The four areas were: (1) high-level waste chemistry, (2) saturated zone flow and transport, (3) thermal effects on flow, and (4) total system performance assessment and integration. Because we have not yet seen the staff's sufficiency comments, our observations are predicated solely on the issue-resolution process. The staff has informed the Committee that the information gleaned from technical exchange meetings and the agreements that stemmed from them formed the basis for the staff's sufficiency comments.

On the basis of our selected reviews, we make several observations and recommendations:

- The staff appears to be well equipped with analytical tools, technical capability, and guidance for conducting the sufficiency review and an eventual license application (LA) review, particularly in light of the staff's ongoing upgrades to the TPA code for analyzing the waste package and source term. It is not obvious, however, whether or how the staff used information and performance assessment tools to focus its sufficiency review on the most risk-significant issues, and whether or how it used its TPA code to develop risk insights to support the sufficiency review.

- The NRC staff should continue to use its TPA code in conducting sensitivity analyses to explore important contributors to risk at the sub-issue level. We also encourage the staff to continue to enhance its use of the TPA code to allow for greater realism in its analyses and to conduct its own risk-informed assessments to quantify the uncertainties associated with the important risk contributors. We believe this will allow the staff to meet the Commission's intent of having a risk-informed analysis, refine its understanding of the potential risks associated with the proposed Yucca Mountain repository, focus its licensing review, and better justify its request for information and detailed analyses from the DOE.

- Through its issue resolution process, the staff appears to be addressing the issues that are likely to be important for conducting an LA review for the proposed Yucca Mountain repository.

- The technical exchange meetings have proven very valuable in resolving issues and establishing substantial and essential communication between NRC and DOE staffs.

- The NRC staff used the ongoing issue resolution process efficiently and effectively to conduct its review in a timely fashion.

- The staff seems to be doing an excellent job of tracking issue resolution as the emphasis shifts from KTIs to integrated sub-issues (ISIs). The ISI format appears to effectively capture and integrate material from the KTIs.

- In the areas where the Committee focused its vertical slice review, the staff's issue resolution process is logical, defensible, and well documented in the issue resolution status reports (IRSRs).

- DOE's inconsistent use of conservatism throughout the TSPA-SR models makes it difficult to identify issues that are important to risk, and precludes a risk-informed analyses of the proposed repository on the basis of the evidence.

- The NRC staff should clarify and publish in its YMRP how it will tailor its licensing review of the abstractions (ISIs) on the basis of their importance to safety. We are concerned that the staff's technical exchange agreements may be challenged if the staff does not document how it is focusing on the most risk-significant issues. The Committee believes that the staff is on its way toward making the YMRP an RIPB guidance document, but still faces a significant challenge in making its issue resolution process and possible LA review RIPB and documenting how this was achieved.

- The staff should clarify in the YMRP how to use "conservatism" appropriately to treat uncertainty, while providing a risk-informed analysis and understanding of the risks associated with the proposed repository.

- According to the staff, the issue resolution agreements that emerged from the technical exchange meetings formed the basis for the staff's sufficiency comments. However, the existing IRSRs do not reflect the most current information supporting the recent agreements. This discrepancy will make it difficult to trace the bases and criteria that the staff used to develop its sufficiency comments. We understand that the staff intends to update the IRSRs to reflect the most recent information and acceptance criteria in the integrated IRSR, but this document is still under development and may not become publically available for some time. The traceability, clarity, and transparency of the sufficiency comments will not be complete without this integrated IRSR. Therefore, we recommend that the staff release this document to the public as soon as feasible.

The ACNW developed a "template" containing a set of questions to guide its review toward achieving the desired objectives. Our answers to the template questions and additional background information for our review are provided in the attachment to this letter.

Sincerely,

George M. Hornberger
Chairman

Attachment: Advisory Committee on Nuclear Waste's Vertical Slice Review Approach

Attachment

Advisory Committee on Nuclear Waste's Vertical Slice Review Approach

In Summer 2000, the Advisory Committee on Nuclear Waste (ACNW) initiated a vertical slice review of the NRC staff's sufficiency review of the technical basis documents prepared by the U.S. Department of Energy (DOE) for the site recommendation regarding the high-level waste (HLW) repository at Yucca Mountain, Nevada. The ACNW's approach for this review is one element of our larger strategy for evaluating the staff's overall licensing review capability. Other elements of the strategy include ongoing evaluation of the staff's key technical issue KTI resolution program, specific KTIs, the staff's performance assessment (PA) tools and capability, and the staff's overall regulatory framework for HLW. The Committee briefed the Commission on its overall strategy in March 2001.

Background

During its March 2000 meeting, the Committee heard a briefing from the NRC staff on its draft strategy to conduct the Yucca Mountain sufficiency review, and subsequently received a copy of the draft sufficiency review strategy in September 2000.

In a letter to the Commission dated June 29, 2000, the Committee conveyed that the staff's approach appeared to be well thought out, logical, and consistent with the risk-informed and performance-based (RIPB) strategy outlined in the proposed draft 10 CFR Part 63.

In July 2000, at the Commission's request, several Committee members informally provided feedback on the staff's draft proposed Yucca Mountain Review Plan (YMRP), which the staff developed for conducting an RIPB review of an eventual license application (LA). The staff also developed and provided to the ACNW a copy of the draft YMRP implementing guidance for conducting the sufficiency review. The Committee has not yet received a briefing on the draft YMRP or its implementing guidance and has not yet reviewed these documents in detail.

During its August 2001 meeting, the Committee heard a briefing from the NRC staff on its sufficiency review and DOE's supplemental science and performance analysis (SSPA). However, we have not reviewed the SSPA and have not considered it in our evaluation of the staff's sufficiency review. Finally, the Committee members also gained insights into the staff's issue resolution process over the past year by participating in informal interactions with the NRC staff and by attending DOE-NRC technical exchange meetings for resolving technical issues.

NRC Staff's Sufficiency Review

The purpose of the NRC staff's sufficiency review was to evaluate whether the DOE has enough data and conceptual understanding of the Yucca Mountain HLW repository system to develop a safety case for a potential license application. Consequently, the scope of the sufficiency review was narrower than it would be for an LA review. For example, the staff will not make estimated dose comparisons relative to 10 CFR Part 63, and it will not make findings regarding the correctness of the site recommendation in relation to DOE's siting guidelines in 10 CFR Part 963. Rather, the staff will provide preliminary comments on where data and analyses appear to be sufficient or insufficient, what additional data and analyses are needed and within what time frame, whether conceptual models are supported by sufficient data, and the status of DOE's quality assurance (QA) efforts. The staff's sufficiency review will also document the status of the KTI issue resolution process, in addition to reporting on progress in the DOE's program. The staff informed us that the DOE-NRC KTI technical exchange meeting agreements formed the basis for its sufficiency review, and that it used the issue resolution process and IRSRs to risk-inform and document the basis for its sufficiency review.

Similar to the way the ACNW conducted its review of the DOE's viability assessment in its letter dated April 8, 1999, each Committee member informally met with the NRC staff one or more times to exchange ideas and information related to their technical area. The Committee used the staff's IRSRs and agreements from the ongoing NRC-DOE technical exchange meetings to focus its review on relevant portions of DOE's technical basis documents. Other source material for the review included DOE's process model reports (PMRs), analysis model reports (AMRs), science and engineering report, TSPA-SR, DOE's repository safety strategy (RSS), and (to a very limited extent) SSPA. The Committee provided a separate report on its vertical slice review of HLW chemistry in its letter dated August 13, 2001 and the TSPA-SR in its letter dated September 18, 2001.

<u>The Template Questions</u>

1, Are the NRC staff's tools, guidance, and capability sufficient to conduct a sufficiency review or LA review?

In general, the NRC staff appears to be well equipped to conduct a sufficiency review and an LA review. The staff has its own analytical tools [e.g., total-system performance assessment (TPA) code and more detailed codes] to use in reaching conclusions about DOE's ability to meet regulatory requirements for licensing.

The NRC staff and the staff of the Center for Nuclear Waste Regulatory Analyses (CNWRA) have impressive expertise in the areas that the ACNW evaluated, (i.e., repository chemistry, TSPA, saturated zone, and thermal effects on flow). The Committee also commented in its chemistry vertical slice review report that the NRC and CNWRA staff seem to be well positioned to deal with the impacts of evolutionary repository design changes.

However, as noted in the chemistry report, we believe that deficiencies may exist in some engineering areas and that the staff lacks the computing capability to run DOE's Goldsim TSPA code in a Monte-Carlo mode. We also noted in the chemistry report that DOE's and NRC's treatment of coupled chemical processes is inadequate as a result of their complexity and difficulty in incorporating them in the modeling. In addition, the Committee noted that the staff needs to more fully address in-package chemistry issues as it develops an integrated chemistry model to be implemented in the NRC's TPA code, and that it is essential to develop an appropriate source term model for the TPA code. We are pleased to note that the NRC and CNWRA staffs are in the process of updating the TPA code to address the above deficiencies and to allow for more realistic assessments of the waste package, source term, and coupled processes.

2. Is there sufficient evidence to support the results of DOE's TSPA, process model, or model abstraction?

   On the basis of our collective reviews, more evidence may exist for treating the saturated zone in the TSPA model than for treating repository chemistry and thermal effects on flow. For the latter areas, we believe that DOE's understanding of system behavior may be derived more from modeling than from data. We also observed that neither the evidence supporting the TSPA-SR modeling assumptions, nor the importance of the assumptions to performance are made transparent. For example, DOE cites a variety of assumptions as "conservative." This is a concern because: (1) use of multiple "conservative" assumptions masks the risks posed by the repository and compromises the opportunity for a risk-informed analysis on the basis of the evidence, and (2) in many cases, assumptions are labeled as conservative without the supporting evidence. We also observed that verification and qualification of data and models are inconsistent and sometimes lacking.

3. Is the staff's approach adequate for using the TPA code to review the TSPA, process models, and/or model abstractions?

   Although the staff's TPA code lacks the detail and sophistication of DOE's Goldsim TSPA code, we believe that the staff is well positioned and equipped with its own, independent code to review information contained in a possible LA. A possible advantage of the simpler TPA code (compared to DOE's Goldsim code) is that it should be conducive to more realistic, scenario-based approaches that may be useful for verifying DOE's analysis.

   It is not obvious, however, whether or how the staff used information and performance assessment tools to focus its sufficiency review on the most risk-significant issues, and whether or how it used its TPA code to develop risk insights to support the sufficiency review.

4. Is the issue resolution process sufficient, given review of the integrated sub-issue (ISI)? Has integration between KTIs and ISIs been achieved?

   The staff's public technical exchange meetings were organized around KTIs and their sub-issues, while the staff's sufficiency review is structured around the ISIs. The Committee believes that the ISI format effectively captures and integrates material from the KTIs, and appears to have enabled the staff to integrate technical information across various KTIs in conducting its sufficiency review. Overall, the staff seems to be doing an excellent job of tracking issue resolution as the emphasis shifts from KTIs to ISIs.

5. Is the relative risk of the sub-issue (ISI) known or understood by the NRC? By DOE? Is it a principal factor?

   In the case of saturated zone flow, the staff recognizes the saturated zone as a geological barrier that is important to the safety case. The saturated zone flow regime itself is not a principal factor; however, because radionuclide transport relies on groundwater flow as input, the flow path ISI is seen to be important to both the NRC and

DOE. In the areas of repository chemistry and thermal effects on flow, the NRC's understanding of the relative risk is less apparent and was not documented in the corresponding IRSR.

We observed that DOE tends to use very "conservative" assumptions in some cases but not in others, and does not integrate the differing approaches in a consistent way. The inconsistent use of conservatism throughout the TSPA-SR models makes it difficult to identify issues that are important to risk and to ascertain if particular errors or problems are significant to overall performance. The complexity of the TSPA-SR model and code make it difficult to evaluate the individual contributors to risk. We discuss our review of the TSPA-SR in more detail in the September 18, 2001 letter.

6. Does NRC's YMRP/Guidance reflect an RIPB approach?

Although the Committee has not yet reviewed the draft YMRP, several Committee members perused the draft document last year at the Commission's request and offered comments to the staff on how to better meet the Commission's expectations for making the document RIPB. Until we are briefed on the YMRP, we cannot assess how the staff might use the YMRP to conduct an RIPB review by taking advantage of such factors as risk insights derived from previous PAs, results of the TPA code, and sensitivity analyses.

The Committee believes that the staff is on its way toward making the YMRP an RIPB guidance document, but still faces a significant challenge in making its issue resolution process and possible LA review RIPB and documenting how this was achieved.

7. Are the KTIs consistent with the issues that the PA identified as being important?

As part of the issue resolution process, the original 10 KTIs have now been subsumed into the 14 ISIs. It would appear that the KTIs remain important issues for determining repository performance. In addition, the staff effectively uses the KTIs to highlight important issues in interactions with DOE, and the KTI-IRSR process has proven to be a flexible framework for identifying significant technical issues.

8. Are the staff's IRSRs and agreements logical, defensible, and focused on the most risk-significant issues?

DOE and the NRC appear to have covered the important issues, but it is not obvious whether the NRC staff has made a concerted effort to focus on the most risk-significant issues. Although the staff appears to be in the process of identifying the most important issues, the discovery process is still underway. We are concerned that the defensibility of the staff's issue resolution process and technical exchange agreements may be challenged if the staff does not document how it is focusing on the most risk-significant issues. Although it was beyond the scope of our vertical slice review, a Committee member observed a technical exchange meeting on preclosure that caused him to question the defensibility of the NRC's agreements and request for information from the DOE. However, we believe that if the staff succeeds in making the YMRP an RIPB document and uses it to guide its LA review, the conclusions reached should be logical, defensible, and focused on the most risk-significant issues.

9. Are the staff's agreements well documented, transparent, and traceable?

   The Committee believes that the NRC staff's issue resolution process is well documented in the IRSRs. However, the existing IRSRs do not reflect the most current information supporting the recent agreements; this discrepancy will make it difficult to trace the bases and criteria that the staff used to develop its sufficiency comments.

10. How has uncertainty been evaluated? Are the issues treated with bounding assumptions, or are they realistically assessed?

    In the chemistry area, DOE handles uncertainty with differing degrees of realism, largely depending on what information is available. In the area of thermal effects on flow, it appears that DOE uses bounding assumptions together with probability distributions, but uses more bounding assumptions (taken to be "conservative") than "best estimates" by about 10:1. We believe that sensitivity analyses that are founded on bounding values for parameters (rather than on best estimates) are of questionable value and are more likely to be misleading than informative.

    A recurring theme in ACNW's review is that reliance on bounding analyses or "conservative" assumptions can obscure a true performance assessment. Although "sufficiency" relates only to the adequacy of the evidence (and not to performance per se), the staff must make a judgment about whether the philosophy behind the information-gathering process is adequate to support realistic performance for a license application. ACNW maintains that the use of conservatism upon conservatism makes a risk-informed approach impossible.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

January 14, 2002

OFFICE OF
ACRS/ACNW

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: RISK-INFORMED ACTIVITIES IN THE OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

Dear Chairman Meserve:

The Joint Subcommittee of the Advisory Committee on Reactor Safeguards (ACRS) and the Advisory Committee on Nuclear Waste (ACNW) met on January 19 and November 14, 2001, to discuss the status of risk-informed activities in the Office of Nuclear Material Safety and Safeguards (NMSS). This matter was subsequently discussed at the 131st meeting of the ACNW on January 8-9, 2002. Our discussions covered the proposed Standard Review Plan (SRP) Chapter 3 (NUREG-1520) for Integrated Safety Analysis (ISA), activities of the NMSS Risk Task Group, and development of a probabilistic risk assessment (PRA) for dry cask storage. This report focuses primarily on SRP Chapter 3 and the use of ISA. Although the ACNW has the responsibility for advising the Commission on this subject, input has been received from the ACRS through the Joint Subcommittee.

DISCUSSION AND RECOMMENDATIONS

ISA as a Logical Path to PRA

In our letter dated July 27, 2000, we challenged the NRC staff on the decision to develop the ISA method to risk-inform NMSS activities, rather than employ PRA methods directly. The decision appears to be based, in part, on the fact that fuel cycle and nuclear materials facilities are sufficiently different from nuclear power plants to warrant a different and "simpler" approach. We continue to question the effectiveness of ISA in leading to desired outcomes, but believe that the ISA can be a foundation from which a risk-informed methodology can evolve.

We believe that the ISA method should be a logical step toward adopting PRA as a preferred process for risk-informing NMSS activities. Ideally, NMSS should treat ISA as a transparent building block for developing a PRA. The incorporation of accident scenarios, likelihoods, and consequences in the ISA approach is an important step towards quantification of the risk. Important issues for completing the transition of ISA to a more risk-informed approach are the treatment of dependent failures, human reliability (e.g., operator error by either omission or commission), the treatment of uncertainty, and the aggregation or assembly of the scenarios into overall facility or system measures of risk (e.g., a release of toxic material above a certain threshold, or the dose at the restricted area or site boundary).

Recommendation

- The NRC staff should move the ISA process systematically in the direction of quantitative risk assessment to enhance the overall understanding of total system risk. As experience is gained, 10 CFR Part 70 and the associated SRP Chapter 3 should be modified to be more risk-informed and, therefore, more effective and efficient.

Dependent Failures

Appendix A to SRP Chapter 3 describes an example of an ISA method for displaying accident sequences. We found very little evidence in Appendix A to indicate that the ISA methods systematically and explicitly search for and address dependent failures. An important lesson learned from nuclear power plant PRAs is that dependent failures are especially significant contributors to risk and that they can neutralize the redundancy and diversity of systems, especially accident mitigation systems. There are differences between nuclear reactors and fuel cycle facilities, but there is no technical basis for the assumption that the differences include immunity of fuel cycle facilities from dependent failures.

Appendix A alludes to the issue of dependent failures in recognizing the need to establish "independence" of items relied on for safety (IROFS). For example, fires can cause the loss of independent and redundant IROFS. Other indirect evidence in Appendix A that indicates some awareness of dependent failures is the reference to "surveillance tests for hidden failures." Nevertheless, we are concerned that dependent failure analysis does not appear to be a deliberate and explicit component of the ISA process.

Recommendation

- The NRC staff should revise Appendix A to provide guidance on the explicit treatment of dependent failures in the conduct of ISAs. The guidance should be specific to fuel cycle facility operations.

Risk Measurement

We are concerned about the emphasis in ISA on indexing and scoring of specific accident sequences, as well as the lack of emphasis on the underlying analytical process for developing consequences, likelihoods, and measures of risk. In particular, the ISA approach emphasizes compliance with the regulations at the individual accident sequence or "credible event" level, whereas for the reactor and waste field, compliance is demonstrated by aggregating all of the important accidents to generate probability density functions or frequency of exceedance curves of key risk measures. We believe that aggregating the event sequences into an integrated measure of risk is essential, since individual event sequences are not well defined and may be described in significantly varying degrees of detail.

It is also important to note the differences between the ISA approach, as discussed in Appendix A, and quantitative risk assessment in relation to the issue of conservative calculations. The tradition of PRA is to present to the stakeholders an assessment of what the experts believe to be the actual risk associated with the operation of a technological system, not an upper bound of the risk except as can be interpreted by the probabilistic form of the results. Such results provide a meaningful technical basis for quantifying safety margins.

Recommendation

- SRP Chapter 3 and Appendix A should be revised to stress the importance of the total risk, that is, the aggregate risk.

Quantitative Versus Qualitative Assessment

We were informed by the staff that the absence of accident/event data posed a challenge to the use of PRA for safety assessment. Another challenge expressed was that PRA involves complex and detailed models that are difficult to justify for many NMSS applications. Among the important lessons learned in the widespread application of quantitative risk assessment is that the lack of data is not a good reason for not doing PRA. Once a system model has been developed and the data requirements are defined tightly, practice indicates there are usually sources of data available. Moreover, all data have uncertainties associated with them and require the use of uncertainty analysis to make risk calculations defensible. Embracing the concepts of uncertainty analysis (in both information and modeling) allows the analyst to address the actual risk more convincingly. In particular, the assertion that there is too much uncertainty to develop meaningful results is contrary to the risk analysis philosophy. If there is large uncertainty, that is the meaningful result of a risk assessment.

We agree with the staff that if simple bounding analysis can preclude the need to be concerned about risk and safety and the analysis can be defended, that is the best course to pursue. Often, safety practitioners prejudge PRA complexity on the basis of the analysis of complex systems such as a large nuclear power plant. Those models are not representative of PRA applications on simpler systems. Simple PRA models have been used with considerable success. It is the complexity of the application that dictates the degree of PRA complexity, not the PRA methods.

Recommendations

- The staff should encourage licensees to utilize data and data treatment methods in the ISAs to account for uncertainties and to move assessments in the direction of increased quantification. SRP Chapter 3 and Appendix A guidance should provide for explicit consideration of these methods.

- The staff should be strongly encouraged to increase the use of risk assessment techniques in implementing ISAs to facilitate the transition to a transparent and quantitative process of risk-informing NMSS activities.

Sufficiency of the ISA Summary

We had some concern that only an ISA Summary of the integrated safety analysis is necessary in the license or renewal application for fuel cycle facilities. We find it difficult to assess the ISA Summary as a basis for considering ISA to be sufficient. The ISA Summary would simplify communications with the licensee on the timely reporting of changes to the facility. However, we question how sufficient ISA Summaries will be for regulatory decisionmaking (e.g., licensing actions, oversight process, IROFS reliability and maintenance, license renewal, etc.) for fuel cycle facilities. We were unable to reach a conclusion on this point, as there is neither actual experience with processing an ISA Summary nor a "pilot plant" ISA Summary to review.

Future Considerations

We believe that much will be learned from the initial staff reviews of ISA Plans and ISA Summaries and would like to discuss this matter with the staff and stakeholders at the appropriate time. The staff has agreed to discuss insights from their review of ISA Plans in early 2002.

We were pleased to see the initiatives being pursued by the NMSS Risk Task Group to develop safety goals, risk case studies, and associated training. Likewise, we are pleased to note that most of the technical work and technical capability is being developed within the NRC for the dry cask storage PRA. We view these as necessary incremental steps in making risk-informed regulations more effective and efficient. We encourage the increased use of PRA methods of analysis to NMSS activities.

Sincerely,

George M. Hornberger

George M. Hornberger
ACNW Chairman

<u>References</u>:

1. U.S. Nuclear Regulatory Commission, Draft NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," Chapter 3, "Integrated Safety Analysis (ISA) and ISA Summary," and associated Appendix A, "Example Procedure for Accident Sequence Evaluation," dated September 20, 2001.
2. Letter dated July 16, 2001, from Felix M. Killar, Jr, Nuclear Energy Institute, to Yawar H. Faraz, Office of Nuclear Material Safety and Safeguards, Subject: Comments on June 14, 2001, revision of Standard Review Plan (SRP) Chapter 3 ('*Integrated Safety Analysis (ISA) and ISA Summary*') of Draft NUREG-1520.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

January 17, 2002

The Honorable Richard A. Meserve
Chairman
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: TOTAL SYSTEM PERFORMANCE ASSESSMENT AND CONSERVATISM

As a result of the Committee's vertical slice review of the staff's issue resolution process and sufficiency review, the Committee issued three letters to the Commission (referenced). In all of these letters, the Committee expressed an overarching concern that over-reliance and inconsistent use of "conservative" assumptions in the TSPA-SR prepared by the US Department of Energy (DOE) precludes a risk-informed analysis. In this letter the Committee would like to clarify further what we consider to be a "risk-informed regulatory decision" and what is meant by a "realistic and reasonable risk-informed performance assessment." In part. the motivation for this letter is derived from the Executive Director for Operations' responses to our letters (referenced).

We want to begin by clarifying what the Committee considers to be the distinction between an "evidence-supported" analysis and an "assumption-based analysis" in performance assessment. In an evidence-supported analysis "evidence" is substituted for "assumptions" wherever possible and, where not possible, the assumptions are supported with the best available scientific information. Assumption-based analysis, on the other hand, is based on arbitrary assumptions that are generally not supported by the available evidence and that are sometimes called conservative assumptions and used to avoid conducting a realistic risk analysis. Furthermore, the Committee's position is that the evidence-supported analysis is synonymous with a defensible and realistic risk-informed analysis, but that the assumption-based analysis is not.

With regard to the "risk-informed regulatory decision," the Committee wants to stress that it recognizes that regulatory decisions must be conservative. We strongly believe that what provides confidence that a regulatory decision is in fact conservative is a defensible analysis of what the real risk is; this means an evidence-supported risk assessment that relies more on quantifying uncertainties than on opaque assumptions about them. The identification of the important contributors to risk, together with an assessment of the origins and magnitudes of the uncertainties of critical risk measures, can only be achieved using a "realistic" performance assessment. Such an analysis provides a reference point for arguments about defense-in-depth, conservative assumptions, and quantification of safety margins. Without such transparency in the safety assessment, the question, "How safe is the repository?" is unanswerable. The underlying question of "what is the risk?" must be answered if the concept of conservatism in regulatory decisionmaking is to have a scientific basis. It is in this context that we criticized the TSPA-SR — the spirit of calculating the real risk was not evident. We did note, however, that DOE has recognized this shortcoming and is taking corrective actions subsequent to the TSPA-SR (e.g., Supplemental Science and Performance Analyses or SSPA). Therefore, we remain optimistic that a risk-informed analysis will be available should a license application be submitted.

The Committee believes that assumption-based conservatism in a performance assessment may not provide an adequate basis for making appropriately conservative regulatory decisions. Lessons learned from applying quantitative risk assessment to other systems, such as nuclear power plants have indicated too often the difference between assumption-based conservatism and evidence-supported, risk-informed conservatism. For example, an early assumption in the nuclear industry was that the design-basis accident for nuclear power plants involving *large break* loss-of-coolant accidents was a conservative representation of the risk of a nuclear plant accident. Although this approach resulted in a very safe nuclear power industry, it was not a risk-informed, conservative representation. In fact, risk-informing nuclear power plant safety revealed that the major contributors to risk came from such events as *small break* loss-of-coolant accidents, losses of offsite power, transients, and such external events as fires and earthquakes. What was thought to be a conservative approach led, in fact, to a nonconservative representation of the major contributors to risk. Simply put, decisions that are founded on assumption-based conservatisms are prone to mistakes.

As for the Committee's position on a "realistic and reasonable risk-informed performance assessment," we note that DOE's approach in its TSPA-SR presumed that a large number of assumption-based conservatisms embedded in a very complex analysis would lead to a demonstration of conservatism in the overall performance of the repository. The Committee questions this premise. For example, assumptions about complex coupled processes are not obviously conservative from a risk perspective — at least they are not obviously conservative to the Committee. In preparing its TSPA-SR, DOE's strategy has been to make conservative or bounding analyses of many of the coupled processes to simplify their treatment. The Committee agrees that where it is possible to screen an issue by doing a simple bounding analysis, it should be done. The problem arises in identifying which conservative or bounding analyses are reasonable. For the TSPA-SR, the supporting evidence for many assumptions is often obscure. Thus, a finding of conservatism from a risk perspective is often difficult to conclude. We believe that coupled processes and their sometimes nonlinear behavior could be underrepresented contributors to risk. Our position is that the contribution to risk from coupled processes should be quantified and made transparent. The quantification should include an uncertainty analysis and the identification of risk contributors based on the evidence.

The evaluation of risk depends on both the likelihood of an event and its consequences. Thus, an assumption-based, "conservative" performance assessment can be doubly wrong in terms of representing risk. This can result in unnecessary expenditures, increased worker exposure, and unjustified burdens on society. In addition, while it is the NRC's primary responsibility to protect the health and safety of the public and the environment, it is also the Commission's responsibility to enable society to receive the benefits of the nuclear industry (energy, medicine, and industrial processes). Numerous assumption-based conservatisms can underestimate — as well as overestimate — the actual risk, just as it can unintentionally deny society important benefits. Our view is that the appropriate way to introduce conservatism into regulatory decisions is to base safety margins on *a realistic assessment of risk, where risk includes the quantification of uncertainty.*

SUMMARY

- The Committee believes that risk-informed regulatory decisionmaking should be conservative, but be based on realistic and reasonable analyses.
- A risk-informed performance assessment should be a realistic representation of the risk, including a quantification and importance ranking of the sources of uncertainty. That is, the performance assessment should represent the best attempt of the experts at quantifying the risk, and it should not be obscured by assumption-based conservatisms.
- The use of the assumption-based conservative analysis for performance assessment compromises the regulator's ability to quantify defensible safety margins.
- Assumption-based modeling conservatisms can be wrong in both the likelihood and consequences of events and may not result in the best risk-informed regulatory decisionmaking.

Sincerely,

George M. Hornberger

George M. Hornberger
Chairman

References:

1. Letter dated September 18, 2001, from George M. Hornberger, Chairman, ACNW, to Richard A. Meserve, Chairman, NRC, Subject: Total System Performance Assessment-Site Recommendation.
2. Letter dated November 29, 2001, from William D. Travers, Executive Director for Operations, NRC, to George Hornberger, Chairman, ACNW, Subject: Response to the ACNW Letter Dated September 18, 2001, on Total System Performance Assessment -- Site Recommendation (TSPA-SR), Which Provided Recommendations to the US NRC Staff.
3. Letter dated September 28, 2001, from George M. Hornberger, Chairman, ACNW, to Richard A. Meserve, Chairman, NRC, Subject: ACNW Comments on NRC Staff's Issue Resolution Process for Risk-Informing its Sufficiency Review of DOE's Technical Basis Documents for the Yucca Mountain Site Recommendation.
4. Letter dated November 20, 2001, from William D. Travers, Executive Director for Operations, NRC, to George M. Hornberger, Chairman, ACNW, Subject: Response to the Advisory Committee on Nuclear Waste Letter dated September 28, 2001.
5. Letter dated August 13, 2001, from George M. Hornberger, Chairman, ACNW, to Richard A. Meserve, Chairman, NRC, Subject: Review of Chemistry Issues and Related NRC Staff Capability for the Proposed High-Level Waste Repository at Yucca Mountain.
6. Letter dated October 16, 2001, from William D. Travers, Executive Director for Operations, NRC, to George M. Hornberger, Chairman, ACNW, Subject: Review of Chemistry Issues and Related NRC Staff Capability for the Proposed HLW Repository at Yucca Mountain.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

March 22, 2002

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REVIEW AND EVALUATION OF THE U.S. NUCLEAR REGULATORY COMMISSION'S WASTE SAFETY RESEARCH PROGRAM

Dear Chairman Meserve:

The Advisory Committee on Nuclear Waste (ACNW) reviews the activities of the U.S. Nuclear Regulatory Commission (NRC) in the Nuclear Waste Safety Arena, as they relate to safety research and high-level waste (HLW) technical assistance. In this letter, we present our assessment of the quality of the research being conducted under NRC sponsorship, evaluate the methods for prioritizing research activities, and highlight a few observations from an ACNW-sponsored workshop on research needs.

Introduction

During several meetings of the ACNW between July 2001 and March 2002, we discussed the NRC's waste safety research and technical assistance programs. In preparing this letter report, the ACNW drew upon a number of sources of information. These included presentations by investigators on research sponsored by the Office of Nuclear Regulatory Research (RES); the findings of the expert panel chaired by Dr. Kenneth Rogers; meetings with the Office of Nuclear Material Safety and Safeguards (NMSS) and RES staffs; and discussions with the Center for Nuclear Waste Analysis (CNWRA) staff during a visit to the CNWRA on August 23–24, 2001. We also sponsored a workshop on research needs on November 27–28, 2001, during the 130th ACNW meeting. This workshop involved participation by the NRC staff and benefitted from presentations by and discussions with internationally recognized experts in geoscience, chemistry, hydrology, decision analysis, health physics, and policy and regulatory analyses.

Conclusions

- RES has a limited budget; however, the research it supports continues to involve the use of qualified scientists and is of very high quality.
- The technical assistance sponsored by NMSS and conducted by the CNWRA continues to be well managed, of very high quality, focused on important issues, and a substantial contributor to NRC's mission.
- The NMSS users' needs memorandum of October 31, 2001, provides a list of useful

projects but ones that, for the most part, do not address an anticipatory research agenda.

- The external peer review associated with the publication of CNWRA work in peer-reviewed journals or presentations at technical meetings adds significant value to this work and should be encouraged.

Recommendations

- The allocation of funds between nuclear reactor safety and nuclear waste safety research and between anticipatory research and technical assistance should be considered a policy matter to be decided by the Commission.

- We recommend that RES incorporates a decision analysis framework into its prioritization of waste-related research. RES should consider the approaches that were discussed at the ACNW workshop including the use of expert panels.

- We recommend that RES continue to develop collaborative arrangements with other government organizations, such as those outlined in the RES memorandum of understanding (MOU) on multimedia environmental models. Additional collaboration with other organizations, including industry organizations and organizations based in foreign countries, is important.

- We continue to recommend that the NRC expand its HLW programs to have a long-term anticipatory research component.

- We also recommend that RES consider the following suggestions made by experts at the ACNW workshop:

  - RES should identify existing waste sites, an examination of which could provide useful information. RES should develop cooperative agreements with interested organizations and the owners of the identified sites to obtain field data from those sites to refine and test conceptual models.

  - The development of improved sampling and monitoring techniques and the testing of sensors and related instrumentation could be performed at the identified sites.

  - RES should explore the use of outside experts to address specific technical issues associated with the design and prioritization of its anticipatory research program.

Assessment of Current Programs

(1) RES-Sponsored Research Related to Waste Safety

On several occasions, the ACNW reviewed reports from scientists involved in waste safety research sponsored by RES. This research addressed alternative conceptual models for flow and transport in groundwater aquifers, vadose-zone hydrology, and evaluation of surface complexation modeling at a field site in Colorado. We judge this work to be of very high quality.

(2) Work Performed at the CNWRA

The HLW work carried out at CNWRA is focused on resolving problems specific to the proposed Yucca Mountain repository. Although this work is categorized as technical assistance, the ACNW has been reviewing it within the framework of its annual review of NRC-sponsored research.

From our reviews, we conclude that the work at CNWRA is well managed, of very high quality, focused on important issues, and a valuable contribution to the NRC's effective review of the proposed Yucca Mountain repository. The expertise of the CNWRA staff complements the technical capabilities of the NMSS staff. The level of funding supports a group of experts with a range of technical expertise and experimental facilities that can be used to address key technical issues associated with the proposed Yucca Mountain repository.

The results of work performed at CNWRA are frequently published in peer-reviewed journals and presented at technical meetings. The ACNW believes that external peer review adds significant value to this work and should be encouraged.

In our report to the Commission on research and technical assistance dated February 5, 2001, we stated that the HLW program needed to be expanded to have a modest, long-term anticipatory research component, perhaps through collaboration between NMSS and RES. We continue to believe that work of this type is important to prepare the NRC to effectively carry out its regulatory responsibilities, including those involving future issues.

Prioritization

(1) RES-Sponsored Research Related to Waste Safety

In our report to the Commission on research and technical assistance dated February 5, 2001, we expressed the following observation concerning the Analytical Hierarchy Process (AHP):

> The Analytical Hierarchy Process devised for RES favors research projects on reactor safety. The process should be revised to reflect the importance of waste-related research.

The Committee has been briefed on the methods for prioritizing RES activities and the changes that have been made in the program plan for research on radionuclide transport. The Committee also discussed research prioritization with a variety of experts during our November 2001 workshop. Our concern regarding the process for prioritizing nuclear waste-related research has not been satisfied.

We are convinced that decisions about how to divide the limited resources between nuclear reactor safety and nuclear waste safety must be a Commission-level policy decision. We also have concerns about how projects are prioritized within waste-related research. In our last report to the Commission, we observed the following:

> The RES waste-related program is not large enough to support the full spectrum of NRC needs. The RES staff should develop a comprehensive plan, including realistic budget estimates, to support the case for either increasing the size of the program and/or refocusing the program.

In response to this observation, RES has issued a draft program plan for research on radionuclide transport. That plan contains a comprehensive discussion of research projects relevant to the NRC's needs and a plan for obtaining input from within the NRC and from external stakeholders. This is a positive step toward developing a coherent program. The scope of the research described in the draft program plan is beyond what can reasonably be addressed with available funding. RES recognizes this and is developing partnerships to support this effort and is using stakeholder input to help focus the program. RES has recently reissued the plan and will brief the ACNW during its meeting on April 16–18, 2002.

As noted above, RES uses an AHP-based tool to assist in making relatively high-level decisions about priorities. This is not a tool that is readily adapted to make decisions about projects within the waste field. Rather, the identification and prioritization of research projects within the waste field is best achieved through a documented process involving input from both NRC and other experts. Formalized methods for making decisions and metrics can provide a useful framework for discussion. We recommend that the NRC incorporate a decision analysis framework into its prioritization of research. RES should consider the approaches that were discussed at the ACNW workshop.

Another issue is the selection of sponsored work that is arguably "research," rather than "technical assistance." In conjunction with its comments on the RES draft radionuclide transport program plan, NMSS provided a user needs memorandum dated October 31, 2001, regarding waste management research. Funding the work requested in this memorandum would consume a significant portion of the RES resources allocated to waste-related safety research. More to the point, although the needs expressed in this memorandum appear to be reasonable, they are really needs for technical assistance. For example, many of the needs are for the upgrading of methods (e.g., a stochastic version of the RESRAD code). We do not judge such work to be in the spirit of anticipatory research, but we make no judgment regarding the relative value of anticipatory research versus technical assistance to the agency. The policy decision as to the allocation of RES funds between anticipatory research and technical assistance should be made by the Commission.

(2) Work Performed at the CNWRA

NMSS identifies and prioritizes tasks with the assistance of the CNWRA managers, using the following factors:

- contribution to risk
- sensitivity of repository performance to the issue under study
- level of model conservatism and uncertainty
- degree of agreement between DOE and NRC as to the treatment of the issue and the likelihood that the issue will be contentious in the hearing process
- factors related to legislative, regulatory, or other programmatic requirements

This process appears to be working well to define the most critical research and technical assistance that needs to be done at CNWRA.

Key Comments from the Research Workshop

Participants in the ACNW workshop provided valuable insights and identified a number of ways that research can be used to improve the understanding of waste safety issues (see Appendix). Of the observations that were emphasized by the workshop participants, the ACNW believes the following are particularly worthy of consideration by RES:

- A useful way to focus the NRC's research program might be to develop a clear understanding of lessons from past waste decontamination and decommissioning (D&D) activities using closed facilities and D&D facilities as "laboratories" and using environmental monitoring at closed sites to enhance modeling credibility.

- The NRC's research should be prioritized with full knowledge about work being done by others and with aggressive action to leverage research support through collaborative arrangements with other organizations. Active participation of the NRC staff in scientific activities associated with the disciplines important to the evaluation of waste management and disposal should be encouraged.

- The use of external peer-review panels is essential to ensure that work selected for sponsorship is indeed of the highest possible quality.

Sincerely,

George M. Hornberger

George M. Hornberger
Chairman

APPENDIX

HIGHLIGHTS FROM THE ACNW WORKSHOP ON NOVEMBER 27—28, 2001

The Advisory Committee on Nuclear Waste (ACNW) sponsored a workshop on November 27—28, 2001, during which the NRC's future waste-related research needs were discussed. The workshop objectives were as follows:

- Develop insights regarding the information and technical tools that will be needed for future regulatory decisions.
- Explore the views of workshop participants as to what new knowledge and technical tools will be needed for these decisions.
- Discuss how research can be used to develop the new knowledge and technical tools.
- Explore processes for the effective prioritization of research.

The invited speakers in order of appearance included the following recognized experts on geoscience, chemistry, hydrology, decision analysis, health physics, and policy and regulatory analysis.

• Ashok Thadani	NRC-RES
• Martin Virgilio	NRC-NMSS
• Kenneth Rogers	Consultant
• Malcom Knapp	Consultant
• John Kessler	EPRI
• Wes Patrick	SWRI-CNWRA
• Michael Ryan	Charleston Southern University
• William Hinze	ACNW Consultant
• Timothy McCartin	NRC-NMSS
• William Ott	NRC-RES
• Jane Long	Mackay School of Mines
• David Kocher	SENES Oak Ridge
• D. Kirk Nordstrom	U.S. Geological Survey
• John Wilson	New Mexico Tech.
• Jack Rosenthal	NRC-RES
• Warner North	Stanford
• Steven Rattien	RAND

The workshop participants identified the following areas as involving challenges that could be addressed through research:

- transmutation of wastes
- new high-level waste (HLW) management options
- more cost-effective methods for packaging and stabilizing low-level waste (LLW)
- design implications of sabotage
- improved techniques and instrumentation for environmental monitoring
- risk-significance of "greater-than-Class C" waste
- improved evaluations of assured LLW isolation facilities
- durability of institutional controls for decommissioned sites
- development of strategies for evaluating the physical conditions of entombed structures
- use of safety goals in site decommissioning
- evaluation of advances in health physics for decommissioning
- evaluation of test methods for HLW packages and additional evaluation of cask integrity
- improved evaluation of slow geologic and radionuclide release processes
- identification of performance indicators for long-term disposal
- use of remote sensory techniques to verify safeguards information
- issues associated with the management of spent fuel associated with high-burnup fuel and fuel from advanced reactors
- technical issues associated with license extensions for independent spent fuel storage facilities
- performance of engineered barriers
- performance of spent fuel pool storage facilities from a risk-informed perspective
- improved capability to conduct realistic performance assessments
- development of a performance confirmation program for the Yucca Mountain repository if a decision is made to go forward with site construction

The ACNW members held extensive discussions with the workshop participants as to what is needed in the way of new information and tools and to how research could be used to develop this new information. The highlights of these discussions are as follows:

- The meeting participants generally agreed about the importance of obtaining field data. Possible sources include work being performed for activities other than radionuclide waste disposal, from applicable natural analogs, and from existing waste sites. Inverse modeling was judged to be a valuable tool for developing model improvements.

- Additional model development is generally believed to be necessary. Particular improvements include the development of more realistic conceptual models, use of experience and data to create simple and credible models for individual complex sites, and the development of an accepted process for using the information obtained from multiple competing conceptual models in regulatory decisions.

- The meeting participants generally argued that realistic assessments are preferred, with conservatism being added at the end to correctly account for uncertainty. This type of process will provide the best assessment of a system and the importance of its system components, and can be used to identify needed research. The participants also noted that the piecewise elimination of conservatism does not necessarily introduce more realism in the analysis. Risk information, research results, and experience should be used in a systematic, system-based manner to provide the basis for eliminating inappropriate conservatism.

- It is important to design research to provide a better understanding of the effect of heterogenous structure on flow (for example, fracture-matrix interaction).

- The participants strongly encouraged using the resource embodied by the existing expertise and information in the scientific community. The participants also suggested that the use of panels of non-NRC experts would provide a cost-effective way to access state-of-the-art information.

- The participants encouraged cooperative work and the use of applicable information obtained from work done for purposes other than nuclear waste safety, as well as active participation of the NRC staff in scientific activities associated with the disciplines important to the evaluation of waste management and disposal.

- It is important to design research to provide a better understanding of the integrity of engineered barrier systems and the associated chemistry.

- Coupled processes are complex, can lead to unexpected results, and need to be better understood.

- An important purpose is to examine system assessments for significant flaws. The NRC's research program should be designed to help the agency discover and deal with the unexpected.

- Performance assessment can yield valuable information about where research is needed and what level of understanding is required for a regulatory decision. The participants noted that scientific research can have different objectives than research to provide information for a regulatory decision. Potential licensee and NRC research needs can also be different.

- The participants emphasized the need to base regulatory decisions on a clear, well-founded safety case. Research should be used to test this safety case. The participants also noted that the "safety-case" has many elements, and even an exceptionally complete and accurate performance assessment will not provide the complete basis for a safety case.

- The participants recognized the need to thoroughly understand and use existing work to avoid making incorrect assumptions about the performance of a site. The discovery of Chlorine-36 at the Yucca Mountain site and water in the tunnels at the Waste Isolation Pilot Plant site were cited as examples.

- Identified weaknesses in the basic health physics models are very important and there are areas where improvements are much needed. The linear-no-threshold dose health effects model was cited as an example.

- The inherent heterogeneity of sites and the need to preserve site integrity limit site characterization. Improved approaches to site measurement and improved instrumentation need to be developed.

- "Blind" model validations are useful for understanding and using conceptual models. The participants noted that the type and amount of data provided must be carefully evaluated to ensure meaningful results.

- It is a worthwhile strategy to design research in a way that could attract the interest of other research organizations, with the intent of those organizations funding the completion of the work. NRC involvement in outside scientific activities would promote this type of cooperation.

The last workshop discussion session addressed research prioritization. It is recognized that the NRC has a limited research/technical support budget with which to address a variety of regulatory needs. It is also recognized that NRR and NMSS needs for technical support must be met in order for the NRC to satisfy its licensing responsibilities.

The workshop participants generally believe that a research program must have a logical framework that provides clear measures of both relevance and importance and identifies a proper basis for research prioritization. The framework should ensure both the identification of all useful research and the performance of work that will provide the greatest benefit to the NRC. The AHP, as used by RES, was judged to be a worthwhile innovation but in need of improvement.

The workshop participants generally believe that the identification and prioritization is best achieved using quantitative means. Metrics, such as those used in the AHP, can provide a useful framework for discussion. External peer review provides cost-effective access to the resources of the scientific and technical community and increases the credibility of the result. The workshop participants generally believe that external peer review should be used and the NRC staff should be more active in external scientific and technical activities. The participants also stated that there will always be issues that need to be resolved by high-level policy decisions. Examples are the partitioning of research funds between reactor, materials, and waste safety, and the partitioning of research funds between anticipatory research and support of NRR and NMSS user needs.

Performance assessment and probabilistic risk analysis were judged to be valuable in identifying and prioritizing research projects. Cooperative work was judged to be an effective way of leveraging the NRC's resources, and it deserves a higher priority for this reason. Other suggested metrics were the expected impact on a regulatory decision, sunk costs, total cost and expected cost/benefit, and the likelihood of success.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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WASHINGTON, D.C. 20555-0001

April 29, 2002

Dr. William D. Travers
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: RESPONSE TO LETTER DATED MARCH 6, 2002 CONCERNING RISK-INFORMED ACTIVITIES IN THE OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

Dear Dr. Travers:

Thank you for your letter of March 6, 2002, in which you described the actions that the staff is taking to address issues in our report dated January 14, 2002, concerning the status of risk-informed activities in the Office of Nuclear Material Safety and Safeguards (NMSS). Your response relates to our January 14, 2002 report, resulting from the review by the Joint Subcommittee of the Advisory Committee on Reactor Safeguards (ACRS) and the Advisory Committee on Nuclear Waste (ACNW) of the proposed Standard Review Plan (SRP) Chapter 3 (NUREG-1520) for Integrated Safety Analysis (ISA). We appreciate your points of agreement. We would, however, like to offer clarification of certain issues in our January 14, 2002 report.

The ACRS and ACNW continue to view the ISA process as a stop-gap toward the more aggregated risk response provided by probabilistic risk assessment (PRA). We encourage the staff to continue its transition to risk-inform the regulatory process by more fully embracing PRA principles. We are sensitive to NRC and stakeholder concerns that the transition to a risk-informed framework might add unnecessary regulatory burden. We believe that an important reason for the licensees not performing a PRA is the perception that all risk assessments are similar to a full-scope nuclear power plant PRA. The typical nuclear power plant PRA is not representative of the risk assessment needs of most less complex process and hazardous material facilities. Furthermore, there is substantial evidence that the scope of a comprehensive, non-probabilistic safety analysis and a probabilistic risk assessment are comparable in many cases, once the capability to do such analyses is in place. The primary difference is the training and skill of the safety analysts. We recognize that there is some initial burden on both the licensee and the regulator in implementing any improvements in the analysis methods, a situation the NRC has faced many times in the process of enhancing nuclear safety regulation. To demonstrate the benefits and thereby facilitate industry adoption of a PRA approach, the NRC could sponsor the development of a simplified PRA methodology for non-reactor facilities.

We have encouraged the staff to pursue the use of risk assessment techniques consistent with the PRA Policy Statement and have focused on the need for integrated decisionmaking as described in Regulatory Guide 1.174 especially with regard to the matter of burden to the licensee and application of risk-informed concepts. The Commission's White Paper on risk-informed and performance-based regulation contributed substantially to establishing a consistent set of definitions and principles to guide the NRC's progress toward a risk-informed regulatory environment. Given that the agency has committed to a risk-informed regulatory practice, we believe that those principles should be rooted in the fundamental principles of quantitative risk assessment as discussed in previous reports.

We look forward to discussing the methods for obtaining risk insights as the transition continues to risk-inform the regulatory process. For example, during future meetings, we would like to discuss the treatment of dependent failures, risk-informing of accident sequence sets, criteria and guidance used by licensee panels in making decisions, and the progress in adopting PRA principles.

Sincerely,

George M. Hornberger
Chairman

References:

1. Report dated January 14, 2002, from George M. Hornberger, Chairman, ACNW, to Richard A. Meserve, Chairman, NRC, Subject: Risk-Informed Regulation in the Office of Nuclear Material Safety and Safeguards.
2. Letter dated March 6, 2002, from William D. Travers, Executive Director for Operations, NRC, to George M. Hornberger, Chairman, ACNW, Subject: Response to Advisory Committee on Nuclear Waste Letter-Report Dated January 14, 2002, to the Commission on Risk-Informed Activities in the Office of Nuclear Material Safety and Safeguards.
3. Report dated February 14, 2000, from Dana A. Powers, Chairman, ACRS, to Richard A. Meserve, Chairman, NRC, Subject: Impediments to the Use of Risk-Informed Regulation.
4. U.S. Nuclear Regulatory Commission, NRC PRA Policy Statement, dated August 16, 1995.
5. Letter dated March 1, 1999, from Annette Vietti-Cook, Secretary of the Commission, NRC, to William D. Travers, EDO, Subject: Staff Requirements - SECY-98-144 - White Paper on Risk-Informed and Performance-Based Regulation.
6. Report dated March 26, 1998, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Risk-Informed, Performance-Based Regulation in Nuclear Waste Management.
7. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," July 1998.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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WASHINGTON, D.C. 20555-0001

May 6, 2002

The Honorable Richard A. Merserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: PROPOSED AMENDMENT TO 10 CFR PART 63, "SPECIFICATION OF A PROBABILITY FOR UNLIKELY FEATURES, EVENTS, AND PROCESSES"

The NRC staff briefed the Advisory Committee on Nuclear Waste (ACNW) on a proposed rule to amend 10 CFR Part 63 on January 8, 2002, and on April 16, 2002. The purpose of the amendment is to specify a probability range for unlikely features, events, and processes (FEPs). The probability range proposed for unlikely FEPs is less than a 10% chance but greater than or equal to a 0.01 percent chance of occurring within the 10,000 year compliance period for the proposed Yucca Mountain repository. If adopted, the Commission's regulations will be modified to omit consideration of unlikely events for the ground water protection and human intrusion standards for the proposed Yucca Mountain Repository. Unlikely events will be considered in the all-pathway dose standard. Very unlikely events are not considered in any of the standards.

The ACNW supports the staff's proposed definition of unlikely events. The Committee believes that the staff's proposed approach is based on a reasonable rationale.

The Committee offers the following cautions on the use of screening criteria in risk assessments. First, care must be used to ensure individual scenarios are not subdivided arbitrarily and then screened out. Second, event sequences eliminated from consideration by screening criteria should be examined to ensure their cumulative effect is not risk significant.

Sincerely,

George M. Hornberger
Chairman

References:

1. Memo dated November 16, 2001, from William D. Travers, Executive Director for Operations, NRC, for the Commissioners, SECY-01-0206, Subject: Proposed Rule: 10 CFR Part 63: Specification of a Probability for Unlikely Features, Events, and Processes.
2. Letter dated April 10, 2002, from Frank Marcinowski, U. S. Environmental Protection Agency (EPA), to Annette L. Vietti-Cook, Secretary of the U. S. Nuclear Regulatory Commission, transmitting EPA comments on proposed rule entitled "Specification of a Probability for Unlikely Features, Events and Processes."
3. Letter dated April 10, 2002, from Charles J. Fitzpatrick, Egan & Associates, PLLC, Counselors at Law, to Annette Vietti-Cook, Secretary of the U. S. Nuclear Regulatory Commission, transmitting on behalf of the State of Nevada and the Nevada Agency for Nuclear Projects on Proposed Rule, 10 CFR Part 63, "Specification of a Probability for Unlikely Features, Events, and Processes."
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

June 27, 2002

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: FY 2002 AND FY 2003 ACTION PLAN FOR THE ADVISORY COMMITTEE ON NUCLEAR WASTE

Dear Chairman Meserve:

The Advisory Committee on Nuclear Waste (ACNW) has updated and finalized its Action Plan (Plan) to reflect new and continuing priorities for FY 2002 and 2003. The Committee will continue to update the Plan on an annual basis. The Plan identifies our mission, vision, desired outcomes, commitments, goals, objectives, and priority topics. The Plan supports the U. S. Nuclear Regulatory Commission's (NRC's) Strategic Plan for FY 2002–FY 2005 (NUREG-1614, Vol. 2). The Plan is also consistent with the ACNW's charter and will form the basis of the next updated ACNW operating plan.

A primary purpose of the Plan is to guide the Committee in carrying out its mission. In addition to the priority topics identified in the Plan, the ACNW identifies operational process improvements that it will implement this year to improve its efficiency and effectiveness. The ACNW will track progress and outcomes of these process improvements in a separate, internal planning document.

The Committee has identified four first-tier priority topics and four second-tier priority topics for FY 2002 and FY 2003:

First-Tier Topics:

1. Resolution of Key Technical Issues

2. Risk-Informing the High-Level Waste Licensing Process

3. Transportation of Radioactive Waste

4. Decommissioning Options

Second-Tier Topics:

1. Performance Confirmation and Long-Term Monitoring for Yucca Mountain

2. Waste-Related Research

3. Proposed Private Fuel Storage Facility

4. Low-Level Radioactive Waste

The Committee plans to address its first-tier priority topics over the next few years, and the second-tier priority topics if time and resources permit, unless otherwise directed by the Commission. New topics for this year include first-tier topics 1 and 2, and second-tier topic 1. Other changes in this year's Plan include shifting the transportation of radioactive waste topic from the second tier to the first tier due to increasing stakeholder interest. Many of the issues identified for review under last year's topics are still identified as issues for review under this year's new topics; the Committee has simply changed the degree of emphasis it will place on these issues.

In addition to reviewing issues identified under these eight priority topics, the ACNW will continue to participate in activities of the Joint ACNW and Advisory Committee on Reactor Safeguards Subcommittee. These priority topics are described in more detail in the enclosed Plan.

Sincerely,

George M. Hornberger
Chairman

Attachment:
FY 2002 and FY 2003 Action Plan for ACNW

FY 2002 AND FY 2003 ACTION PLAN
ADVISORY COMMITTEE ON NUCLEAR WASTE

PURPOSE OF PLAN

This Action Plan (Plan) provides strategic direction and guidance for fiscal years 2002 and 2003 to the Advisory Committee on Nuclear Waste (ACNW) for addressing the issues that are most important to the U.S. Nuclear Regulatory Commission (NRC) in carrying out its mission to protect public health and safety, promote the common defense and security, and protect the environment. The Plan defines the ACNW's mission, vision, desired outcomes, commitments, goals, objectives, and priority topics and issues selected for review. For each goal, the Plan indicates the relationship between the goal and the strategic arenas and management strategies in the NRC's FY 2000–FY 2005 Strategic Plan (NUREG 1614, Vol. 2).

This Plan also provides the Commission, NRC staff, and other ACNW stakeholders with information about the priority topics on which the ACNW plans to focus its reviews. The Committee selected the first- and second-tier priority topics in a top-down manner, designed to support our mission, vision, goals, and objectives. The priority topics consist of self-initiated topics and topics requested by the Commission, as well as topics requested by the NRC staff and other stakeholders.

SCOPE OF ACNW ACTIVITIES

The Committee reports to and advises the Commission on technical matters related to nuclear materials and waste management. The bases of ACNW reviews include Title 10, Parts 20, 40, 50, 60, 61, 63, 70, 71, and 72 of the *Code of Federal Regulations* (CFR), as well as other applicable regulations and legislative mandates. The ACNW will undertake studies and activities related to the transportation, storage, and disposal of high-level and low-level radioactive waste (HLW and LLW, respectively), including the interim storage of spent nuclear fuel; materials safety; decommissioning; application of risk-informed and performance-based (RIPB) regulations; and evaluation of licensing documents, rules, regulatory guidance, and other issues, as requested by the Commission. The Committee will interact with representatives of the public; the NRC; the Advisory Committee on Reactor Safeguards (ACRS); other Federal agencies; State and local agencies; Indian Nations; and private, international, and other affected organizations, as appropriate, to fulfill its responsibilities.

RISK-INFORMED, PERFORMANCE-BASED APPROACH

The Committee believes that it best serves the Commission by taking an RIPB approach to its activities. The Committee will accomplish this goal, in part, by supporting the Commission in applying the principles in the NRC's probabilistic risk assessment (PRA) policy statement, dated August 10, 1995 (60 FRN 42622), to waste and materials regulations. For example, in its reviews, the ACNW will encourage use of PRA principles and associated analyses (sensitivity studies, uncertainty analyses, and importance measures) to reduce unnecessary conservatism associated with the NRC's regulatory framework. The ACNW will also encourage realism, transparency, and consistency in risk and performance assessments, including the identification of uncertainty in these assessments.

In addition to supporting the PRA policy statement, the Committee will encourage implementation of a flexible, overall RIPB regulatory framework for the NRC's materials and waste-related regulations. An RIPB approach should reduce rigid interpretation and prescriptive approaches in the application of regulations. An RIPB framework should facilitate the use of more defensible and transparent regulation and will improve confidence in regulatory decisions. In this way, the NRC can develop more efficient regulations that have an obvious link to safety and encourage a more effective allocation of NRC and licensee resources.

ACNW MISSION

The ACNW's mission is to provide the Commission with independent and timely technical advice on nuclear materials and waste management issues to support the NRC in conducting an efficient and effective regulatory program that enables the Nation to use nuclear materials in a safe manner for civilian purposes.

ACNW VISION, DESIRED OUTCOMES, AND COMMITMENTS

The Committee has identified a vision statement and desired outcomes to guide the Committee's implementation of its mission, and commitments that will guide the Committee toward these outcomes.

Vision

The ACNW's advice and recommended solutions are forward-looking, are based upon best available science and technology, can be implemented, and reflect the need to balance risk, benefit, and cost to society to enable the safe use of nuclear materials.

Desired Outcomes

1. ACNW advice reflects the need for safety and the need to balance risk, cost, and benefit in all of the NRC's decisions.

2. ACNW advice is clear, concise, and easily understood.

3. ACNW provides an effective forum for the public to participate in the regulatory process, increases public confidence in the regulatory process, and ensures that communication paths with the public remain open and effective.

4. ACNW advice is provided in ample time for consideration by the Commission in making regulatory decisions.

5. ACNW advice reflects sound technical judgment and influences the NRC's regulations and guidance.

6. ACNW advice alerts the Commission to emerging and potentially challenging issues.

7. ACNW advice reflects consideration and awareness of relevant waste and materials issues that cut across other Federal agencies, institutions, and industry.

8. ACNW advice is valued by the Commission, the NRC staff, the public, and other stakeholders.

Commitments

To achieve its desired outcomes, goals, and objectives, the Committee makes the following commitments:

1. Make safety its highest priority.

2. Be responsive to the Commission's needs and requests.

3. Maintain technical excellence, independence, and credibility.

4. Adopt the NRC's plain language initiative.

5. Regard the public as its ultimate stakeholder and seek better ways to obtain meaningful public involvement.

6. Implement a risk-informed philosophy by asking: What is the risk? What are the important contributors to risk? What are the uncertainties associated with the risk?

7. Strive to examine issues and offer advice while regulatory solutions are still being formulated.

8. Foster an atmosphere of mutual problem solving with the NRC staff.

9. Remain flexible, anticipate change, and evaluate options and contingencies.

10. Keep informed of external trends and events that may adversely impact the NRC.

11. Keep abreast of international trends and developments that could affect the NRC's regulatory practices or approaches and apply the experience when practicable.

12. Identify relevant waste and materials issues that cut across the NRC and other Federal agencies, institutions, and industry.

13. Abide by the Committee's Action Plan to foster the efficiency and effectiveness of Committee activities and products.

GOALS AND OBJECTIVES

The ACNW has developed general goals and objectives consistent with its mission and vision. The following five goals provide strategic direction for the ACNW over the next 2 years and support selected goals and strategic arenas identified in the NRC's Strategic Plan. Each goal is followed by objectives to help the Committee better select and focus its priority issues.

Goal 1: **Assist the NRC in positioning itself to respond to external change in its regulation of the management of nuclear waste and materials.** [This goal supports the NRC's Nuclear Waste Safety and Nuclear Materials Safety strategic arenas and NRC's strategic goal and primary performance goal to maintain safety, protect the environment, and ensure the common defense and security.]

Objective 1: *Advise the Commission in a timely fashion on technical developments that may require changes in the NRC's regulations, policies, and practices.*

Objective 2: *Inform the Commission of issues that the NRC needs to address and recommend solutions.*

Goal 2: **Support the NRC in employing the best science in resolving key safety issues.** [This goal supports the NRC's Nuclear Waste Safety and Nuclear Materials Safety strategic arenas and the specific performance goal to make NRC activities and decisions more effective, efficient, and realistic.]

Objective 1: *Keep informed of methods and technologies being developed and used worldwide that are applicable for assessing and managing risks associated with the cleanup, disposal, and storage of nuclear waste.*

Objective 2: *Advise the Commission on enhancements to the NRC staff's technical capabilities that are needed to address current and expected Commission needs.*

Objective 3: *Advise the Commission and the NRC staff on ways to use risk-informed and performance-based approaches to develop efficient and effective regulations and regulatory framework.*

Goal 3: **Advise the NRC on how to increase its reliance on risk as a basis for decisionmaking, including methods that (1) implement a risk-informed approach, (2) quantify and reveal uncertainties, and (3) are consistent across programs.** [This goal supports the NRC's nuclear waste safety and nuclear materials safety strategic arenas and the specific performance goal to reduce unnecessary regulatory burden on stakeholders.]

Objective 1: *Encourage the NRC staff in seeking and proposing approaches to gain a better understanding of the inherent risks of activities within its regulatory responsi - bilities, as well as the relationship between regulations, cost, and safety.*

Objective 2: *Propose approaches that provide a better understanding of the inherent risks associated with nuclear power and the relationship between safety, regulations, and cost, and advise the Commission on the proposals.*

Objective 3: *Provide technically sound and realistic approaches for resolving new and emerging issues, and identify ways to utilize risk-informed and performance-based approaches related to the safe use of nuclear materials for civilian purposes.*

Goal 4: **Support the NRC in improving public involvement and understanding in its waste and materials programs and in gaining increased public confidence and respect.** [This goal supports the NRC's nuclear waste safety and nuclear materials safety strategic arenas and the specific performance goal to increase public confidence.]

Objective 1: *Provide opportunities through the Federal Advisory Committee Act process for more meaningful public involvement in the regulatory process.*

Objective 2: *Recommend ways for the NRC to achieve more meaningful public involvement in the regulatory process, taking into consideration lessons learned from international experience.*

Objective 3: *Assist the NRC in making the agency's decisionmaking process more transparent and ensuring that agency documentation is readily understandable and addresses the relevant issues.*

Goal 5: **Support the effectiveness and efficiency of NRC operations.** [This goal supports the NRC's Corporate Management Strategies to employ innovative and sound business practices.]

Objective 1: *Select and evaluate feedback from stakeholders on ACNW operations.*

Objective 2: *Evaluate and modify existing ACNW operational procedures as appropriate, to* accomplish "more with less."

PRIORITY TOPICS AND PROCESS IMPROVEMENTS

In support of its first four goals, the ACNW has identified its highest priority topics through FY 2003, and other important topics that it plans to address as time and resources permit. The highest priority topics are identified as first-tier priorities, while other important topics are identified as second-tier priorities. The Committee plans to place most of its emphasis on reviewing issues under the first-tier topics, unless otherwise directed by the Commission. The ACNW will address to a lesser extent or stay informed of issues under the second-tier topics, but is not likely to carry out a concentrated effort on any of these issues. The Committee has taken care to ensure that each priority topic supports one or more of the ACNW's goals.

The Committee has also defined the criteria it uses to select its priority topics. In support of its fifth goal, "support the effectiveness and efficiency of NRC operations," the ACNW has identified the improvements in operational processes it will carry out this year and next. The Committee will track its progress toward these process improvements in a separate, internal planning document, and will periodically evaluate their impact.

For each priority issue addressed, the Committee plans to prepare a task action plan that will identify the nature and scope of the issue and a strategy for addressing it. These task action plans will include a schedule, purpose, scope, planned products, and performance measures to evaluate the Committee's effectiveness.

Identified below are the criteria for selecting priority topics, followed by a brief background discussion of the selected topics.

Criteria for Selecting Priority Topics

The Committee uses the following criteria to select priority topics:

- the likelihood that a topic, if not properly addressed, will result in significant adverse impact on the environment, significant risk to the health and safety of the public, or unnecessary economic costs

- topics for which the Commission or the Executive Director for Operations requests ACNW review

- topics for which the ACNW can provide a unique input that will add significant value to the resolution of the issue

- the relevance of the topic in the NRC's near-term regulatory agenda and the need for timely ACNW review

- the level of interest shown by NRC's external stakeholders in a topic and the degree to which ACNW engagement of the topic will have a positive impact on stakeholder confidence

Background Information on Priority Topics

On February 15, 2002, President Bush submitted a recommendation to Congress that Yucca Mountain, Nevada, be developed as the Nation's first geologic repository for the disposal of spent nuclear fuel and other HLW. On April 8, 2002, the Governor of Nevada filed a notice of disapproval of the proposed Yucca Mountain project. The decision now rests with the Congress. If the Congress passes a joint resolution that allows work on the proposed Yucca Mountain repository to continue, the U.S. Department of Energy (DOE) will submit a license application to the NRC for construction of the repository. Any potential DOE license application for construction at Yucca Mountain would be reviewed in accordance with the NRC's risk-informed, site-specific regulations for HLW disposal in 10 CFR Part 63.

The NRC has conducted extensive prelicensing interactions with DOE concerning the proposed Yucca Mountain HLW repository. As part of these prelicensing activities, the NRC engaged the DOE in a pre-licensing issue resolution process, identifying key technical issues (KTIs) and sub-issues. By the end of 2001, the NRC and DOE reached a closed-pending status on all KTI sub issues, pending receipt and acceptance of information to be provided by DOE on some 293 agreements. Current DOE planning assumptions suggest a potential DOE license application sometime in 2004. Throughout 2002 to 2004, the NRC will continue to collect and evaluate information provided by DOE and hold technical exchange meetings to close, at the staff level, KTI subissues prior to licensing. Plans for performance confirmation testing and long-term monitoring will become increasingly more important as the program moves toward licensing. Some KTIs may remain open or closed-pending even into the performance confirmation period pending completion of long-term tests and analyses.

Transportation of spent nuclear fuel continues to gain increased national attention as the President's recent site recommendation to the Congress brought Yucca Mountain more into the pubic eye. A public discussion of the risks associated with the transportation of HLW and the roles and responsibilities of the various involved entities is needed to improve stakeholders' understanding of and confidence in this activity. Transportation of spent nuclear fuel is also one of the public concerns related to independent spent fuel storage. NRC adjudicatory hearings are currently in progress concerning an application from Private Fuel Storage to operate an independent spent fuel storage installation on the reservation of the Skull Valley Band of Goshute Indians in Utah.

Safe and efficient decommissioning of nuclear reactors and nuclear materials facilities continues to be a critical function of the NRC's mission, and a concern to the public, industry, and other stakeholders. Complex technical and policy issues remain unresolved. Such issues include those associated with the release of property under restricted conditions, such as, long-term institutional controls, the proposed rulemaking on entombment options for nuclear power reactors, control of the release of solid materials, and orphan and sealed sources. Because decommissioning waste must be disposed of in LLW disposal facilities, the failure of the Low-Level Waste Policy and Amendments Act of 1985 to bring about new LLW disposal facilities is also a concern. In addition to the absence of new disposal sites, the availability of existing LLW sites may become limited in the near future.

<u>First-Tier Priority Topics</u>

Resolution of Key Technical Issues

The ACNW has closely tracked the NRC's key technical issue resolution process since its inception. In 2001, the ACNW conducted a vertical slice review of several KTIs and subissues to evaluate the NRC's issue resolution process and sufficiency review. The ACNW's emphasis was on evaluating whether the issue resolution process was risk-informed, including whether the NRC staff was developing and using risk insights to inform its prelicensing agreements with DOE. As part of its continued evaluation of the issue resolution process, the ACNW may extend its vertical slice review concept to examine selected KTI sub-issues, such as modeling of igneous activity, and corrosion of waste packages, and continue to examine development and use of risk insights. In addition, the ACNW plans to closely follow the progress of the NRC's 293 issue resolution agreements, and review and comment on the draft Integrated Issue Resolution Status Report (IRSR), when it is made publicly available.

Risk-Informing the HLW Licensing Process

10 CFR Part 63 reflects the NRC's effort to implement an RIPB regulatory framework that relies primarily on the use of iterative performance assessment techniques to simulate the future behavior of the engineered and natural components of a geologic repository at Yucca Mountain. Over the next several years, the ACNW will review and comment on the Yucca Mountain Review Plan (YMRP), which would be used to review any potential DOE license application. In particular, the Committee will emphasize how the NRC staff uses risk insights from sensitivity analyses and other performance assessment investigations to resolve technical issues for improving the risk-informed focus of the YMRP. In followup to its vertical slice review of DOE's total system performance assessment-site recommendation (TSPA-SR), the Committee also plans to continue evaluating the DOE's TSPAs and supporting documents. The Committee

also plans to continue tracking progress in the NRC's performance assessment capability, including evaluating developments in the TPA 4.0 computer code. In FY 2003, the ACNW plans to hold a working group meeting to evaluate differences between DOE and NRC performance assessment assumptions and results, including the extent to which the respective performance assessment activities have been subject to independent scientific validation.

Transportation of Radioactive Waste

The Committee plans to convene a working group meeting on transportation to examine past and ongoing risk studies on transportation safety. Participants may include members from the NRC staff project office and representatives from the Department of Transportation, from DOE national laboratories involved in testing spent fuel transportation systems, international organizations, State and local governments, and the public. In addition to the working group meeting, the Committee will continue to follow developments in the staff's waste package performance study, and possibly review transportation risk as documented in the final Yucca Mountain Environmental Impact Statement.

Decommissioning Options

Decommissioning will continue to be a first-tier priority topic for the Committee. This year, the Committee plans to evaluate developments in controlling the release of solid materials, including reviewing the report by the National Research Council entitled, "The Disposition Dilemma: Controlling the Release of Solid Materials from the NRC-Licensed Facilities," dated March 21, 2002. The Committee also plans to explore developments in alternatives to restricted release criteria and use of institutional controls. The ACNW will continue to follow the development of decommissioning guidance, including the use of RIPB in decommissioning applications. Other issues may include the disposal of greater-than-class C wastes, including orphan and sealed sources; the decommissioning of the West Valley, New York Demonstration Project; and the application of the License Termination Plan to a complex site.

Second-Tier Priority Topics

Performance Confirmation and Long-Term Monitoring for Yucca Mountain

The ACNW plans to review the staff's plan to evaluate DOE's proposed performance confirmation program for Yucca Mountain. The Committee expects to review tests, experiments, and analyses proposed in DOE's performance confirmation program, or those suggested by the NRC. The Committee may also evaluate long-term, post-closure monitoring for Yucca Mountain as well as the techniques for testing and monitoring that could be useful for other prospective waste sites. The Committee may move this second-tier priority topic to the first tier next year, and plans to hold a working group meeting in 2003.

Waste-Related Research

The ACNW will continue to report once a year to the Commission on NRC's waste-related research and technical assistance programs. Specifically, the Committee will continue to examine the research performed by the NRC's Office of Nuclear Regulatory Research that is associated with nuclear waste safety and the technical assistance work performed by the Center for Nuclear Waste Regulatory Analyses. The ACNW will continue to monitor the integration of research and technical assistance programs. The Committee may consider elements of an appropriate anticipatory research program, and lessons-learned from past anticipatory research that can be applied to planning future research programs.

Proposed Private Fuel Storage Facility

In June 1997, Private Fuel Storage submitted a license application (LA) to the NRC to operate an away-from-reactor independent spent fuel storage installation on the reservation of the Skull Valley Band of Goshute Indians in Utah. After reviewing the LA, the NRC staff issued its safety evaluation report in September 2000. Adjudicatory hearings are currently in progress. The ACNW will continue to stay informed of the technical issues associated with this facility and its proposed operation and will provide such reviews as appropriate.

Low-Level Waste (LLW)

The ACNW will keep informed of any new developments related to issues under this topic. Possible issues of interest include growing concern over possible decreasing LLW disposal capacity, assured isolation, management of mixed-waste (waste with a hazardous and radioactive component), and possibly management of LLW or intermediate-level waste in other countries.

JOINT ACRS/ACNW SUBCOMMITTEE ACTIVITIES

The Commission authorized the establishment of the joint subcommittee in response to a request for ACRS/ACNW assistance on activities associated with risk-informing regulations developed by the NRC's Office of Nuclear Materials Safety and Safeguards (NMSS). The scope of the joint subcommittee's work now includes some activities that are within the purview of both Committees, so as to provide effective and efficient reviews utilizing the expertise of both committees. The joint subcommittee plans to continue its review of risk-informing NMSS activities, proposed PRA for spent fuel dry cask storage, proposed safety goals for NMSS activities, decommissioning issues that overlap both ACNW and ACRS assignments, and other technical issues that would benefit from a review by the joint subcommittee. One such activity is the review of the Integrated Safety Assessment (ISA) for the Mixed Oxide (MOX) Fuel Fabrication Facility.

MEASURES OF SUCCESS

The Committee will assess the extent to which the goals and objectives in this Plan have been met and report the results in the annual ACNW operating plan. The Committee has established performance metrics to measure its overall effectiveness. The performance metrics include the ACNW's effectiveness, efficiency, quality, timeliness, and success in contributing to the RIPB regulatory process. As part of its annual self-assessment, the Committee will solicit stakeholder feedback as one of the sources of information for evaluating the ACNW's effectiveness.

UPDATING THE PLAN

The ACNW will continue to conduct top-down planning on an annual basis to identify goals and priority issues for the coming year. Revisions to the plan will reflect input from the Commission, changes in legislation, changes to the NRC Strategic Plan, results from customer surveys and self-assessments, external events, and available resources. As part of its efficiency and effectiveness goal, the ACNW will track, in a separate planning document, outcomes of its operational process improvements, special projects, ideas for working group meetings, possible followup action to past ACNW letters, and items that the Committee considers important but cannot pursue this year due to time or resource limitations.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

June 28, 2002

The Honorable Richard A. Meserve
Chairman
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Meserve:

SUBJECT: PROPOSED PACKAGE PERFORMANCE STUDY TEST PROTOCOLS

During its 135th meeting on June 18, 2002, the Advisory Committee on Nuclear Waste heard presentations from Sandia National Laboratories on the proposed Package Performance Study (PPS) Test Protocols. These test protocols are part of the overall PPS to demonstrate the safety of spent fuel and other radioactive material shipments. During the presentations it was stated that the PPS has three goals.

1. Validate the assumptions and methodologies used to assess the appropriateness of U. S. Nuclear Regulatory Commission transportation regulations.

2. Demonstrate the safety of spent fuel and other radioactive material shipments.

3. Advance the knowledge base of cask and spent fuel behavior in transport accident environments.

The PPS supplements the existing knowledge on the safety of transporting spent nuclear fuel, which has an excellent operating record and is based on extensive research, analysis, and testing (see References).

The proposed report uses the results of NUREG-6672, "Reexamination of Spent Fuel Shipment Risk Estimates - Main Report," dated March 2000 and the "Spent Nuclear Fuel Transportation Package Performance Study Issues Report," dated June 2000 to help define the program.

OBSERVATIONS

We have the following observations regarding the proposed PPS Test Protocols.

- Testing casks to deformation and fuel to failure, when the test conditions significantly exceed realistic accident conditions, provides little benefit for assessing the risk associated with shipping spent fuel and other radioactive materials.

- Full-scale cask testing under realistic accident conditions may be a suitable demonstration to increase public confidence in the safe transportation of spent fuel and other radioactive materials, but will not contribute significantly to existing knowledge base.

- Testing to validate computer codes should be performed, but the approach in the proposed report is not an efficient use of resources. For example, codes can be effectively, economically, and accurately validated into the plastic deformation range using scale models.

RECOMMENDATIONS

We recommend the following items be considered regarding the proposed PPS Test Protocols.

- The approach should be designed to provide risk-insights; tests to validate codes should be separate from other tests performed to provide safety insights unless such tests do not distort the risk insight objective.

- The approach should utilize realistic accident situations, not unrealistic and extreme test conditions.

DISCUSSION

The ACNW reviewed the proposed PPS Test Protocols and determined that the tests focused too heavily on unrealistic testing designed to result in deformation of transportation casks and failure of the test fuel. We further determined that these tests were not consistent with the NRC's philosophy regarding risk-informed regulation. We are concerned with the lack of a risk assessment, that should include an uncertainty analysis, on which to base the tests.

The proposed PPS Test Protocols utilizes extreme conditions, well beyond those that would be encountered in actual transportation. The results of tests performed under an artificial set of extreme accident conditions could be misinterpreted and may lead to unwarranted changes in the transportation regulations.

We observed that the guidance for the proposed PPS Test Protocols is "test to failure" for fuel elements. Such information may add to the understanding of fuel response to extremely severe and hypothetical conditions, but does not provide risk-informed insight regarding the safety of transporting spent nuclear fuel.

The proposed PPS Test Protocols specifies test conditions that substantially exceed what is required to achieve the stated goals of the PPS. Therefore, the goals of the PPS were not all met because a program, designed to cause cask deformation under extreme accident conditions, does not validate cask safety under the realistic accident conditions that the cask was designed to meet. We believe the approach used in the proposed PPS Test Protocols should be reformulated to focus on realistic, risk-informed test methodologies and protocols, not unrealistic test-to-failure scenarios.

Sincerely,

George M. Hornberger
Chairman

References:

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2. U. S. Nuclear Regulatory Commission, NUREG/CR-4829, Vols. 1 and 2, "Shipping Container Response to Severe Highway and Railway Accident Conditions - Main Report," February 1987.
3. U. S. Nuclear Regulatory Commission, NUREG/CR-6672, Vol 1, "Reexamination of Spent Fuel Shipment Risk Estimates," Main Report, March 2000.
4. Sandia National Laboratories, "Spent Nuclear Fuel Transportation Package Performance Study Issues Report," June 30, 2000.
5. U. S. Nuclear Regulatory Commission, NUREG/CR-XXXX, Draft report prepared by Sandia National Laboratories, "United States Nuclear Regulatory Commission Package Performance Study Test Protocols," June 2002 (Draft Predecisional).

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10 SUPPLEMENTARY NOTES

11 ABSTRACT *(200 words or less)*

This compilation contains 10 reports issued by the Advisory Committee on Nuclear Waste (ACNW) during the Thirteenth year of its operation. The reports were submitted to the Chairman and Commissioners of the U. S. Nuclear Regulatory Commission (NRC). All reports prepared by the Committee have been made available to the public through the NRC Public Document Room, or from the Publicly Available Records System (PARS) component of NRC's document system (ADAMS) which is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room); the U. S. Library of Congress, and the Committee's Web site at http://www.nrc.gov/reading-rm/doc-collections/.

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

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