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September 18, 1991

Dr. Peter B. Myers
Staff Director
Board on Radioactive Waste Management
National Research Council
2101 Constitution Avenue
Washington, D.C. 20418

Dear Mr. Myers:

Thank you for sending me the draft synopsis of last fall's Symposium on Radioactive Waste Repository Licensing prepared by the Board on Radioactive Waste Management. Although you indicated that the draft synopsis is in press, I have a few concerns about the content that are important enough to bring to your immediate attention. I also believe that these concerns could be resolved with minor corrections to the draft synopsis.

In particular, I am concerned with how some of the personal views of U.S. Nuclear Regulatory Commission (NRC) representatives are presented in the draft synopsis. In some cases these views are not documented accurately, and in other cases, statements that are personal views are recorded as official NRC positions. This is important because some of these personnal views are different than documented NRC positions. The net result is that NRC positions regarding many of the issues important to the U.S. Environmental Protection Agency's high-level waste standard are incorrectly documented. Because these important issues are complicated and sometimes difficult to clearly understand, I think it is imperative for the Board to prepare a clear and accurate record. I have also included in the attached markup some technical corrections. I recommend that you consider making the few minor corrections to the draft synopsis that I have attached.

I appreciate the opportunity you have given me as a speaker to look over this draft before it is completed and hope that you will consider my concerns. If you have any questions please give me a call on (301) 492-3352.

Sincerely,

/s/

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

OFC	:HLPD	:HLPD	:HLPD	:HLWM	:HLWM	:NMSS	:NMSS
NAME	:RJohnson/d	:JHolonich	:MFederline	:JLinehan	:BJYoungblood	:GArlotto	:RBernero
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RADIOACTIVE WASTE REPOSITORY LICENSING

DRAFT

Synopsis of a Symposium Sponsored

by the

Board on Radioactive Waste Management

Commission on Geosciences, Environment and Resources
National Research Council

NATIONAL ACADEMY PRESS
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D*R*A*F*T

PREFACE

The Board on Radioactive Waste Management (BRWM or Board) of the National Research Council convened the Symposium on Radioactive Waste Repository Licensing in September, 1990, while the U.S. Environmental Protection Agency (EPA) was in the process of revising the remanded standard, 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste." EPA planned to issue the new standard in early 1991.

The Board had recently issued "Rethinking High-Level Radioactive Waste Disposal" (Appendix G) which raised questions about the philosophy and methodology of the U.S. High-level Radioactive Waste program. The BRWM wanted to hear views on regulation and licensing issues from a broad spectrum of the radioactive waste community and the public in a neutral forum. The entities that comprise the radioactive waste management community - public agencies, public interest groups, international organizations, and advisory bodies - were invited to examine the status of radioactive waste repository licensing requirements.

The EPA, the State of Nevada, and the Natural Resources Defense Council (NRDC) asserted the validity of the basis of the standard and the release criteria. Most other participants thought that 40 CFR Part 191 should be supported by better science. They maintained that better quality scientific data would prove a case for a less prescriptive standard and allow for flexibility through a performance standard, rather than through the current subsystem performance criteria. They favored an iterative approach that could take

into account new information acquired during the construction process. These participants favored the dose-to-man or population dose criteria, rather than release criteria, as more valid measures of health effects. EPA and the Nuclear Regulatory Commission staff preferred to retain a multiple barrier approach ~~the standard's prescriptive approach~~ to repository design ~~and~~ to resolve uncertainty about expected performance. ~~construction in order to retain maximum control over the facility.~~ Inasmuch as plausible human intrusion scenarios based upon extreme assumptions may pose great problems for assuring repository safety over 10,000 years - a period longer than all of recorded history - some of the participants wanted the issue of human intrusion, which would involve relatively few people, to be considered separately from the performance standard.

James Curtiss, an NRC Commissioner, and many others expressed concern about the feasibility of implementing the ~~The U.S. NRC and many others suggested that the EPA change from~~ probabilistic standards as compared to deterministic standards because they felt that there was insufficient information on the distribution functions of many of the parameters, and because uncertainty in some of the parameters could cause modeling of a number of the scenarios to exceed the standard without a basis related to safety. The EPA, however, held that probabilistic standards are more appropriate for dealing with the long time-frame of 10,000 years over which the prospective repository must demonstrate safety.

The EPA maintained that recent radiation research demonstrating low-dose health effects supports the current limits. The New Mexico Environmental Evaluation Group pointed out that the standard's stringency was the catalyst for the Department of Energy's (DOE) consideration of engineering enhancements to the Waste Isolation Pilot Plant design. The State of Nevada and the NRDC asserted that newly recognized increase in ~~low-dose health effects~~ risk of health effects related to low dose rates called for even greater stringency. Most others advocated raising of the release

limits within the standard, in order to make the human exposure risk from nuclear waste more nearly commensurate with that of other radioactive wastes. They wanted the standard to require only sufficient stringency to protect human health. They also pointed out that the more stringent the standard, the more costly it is to demonstrate compliance.

There was a good deal of discussion about the lack of a technical connection between the EPA standard, 40 CRF Part 191, and the U.S. NRC regulation, 10 CFR Part 60. This connection was termed the "nexus" and generated an examination of ameliorative options. The possibility of a negotiated rulemaking for 40 CFR Part 191 and 10 CFR Part 60 was raised ~~and is still under consideration.~~

The Symposium generated detailed discussion of the science involved in modeling and assessing a repository and of the difficulties in the licensing process. Since the Symposium, the EPA has further revised the Working Draft of 40 CFR Part 191. While the Draft incorporates some recommendations from the BRWM's "Rethinking" report and from some of the Symposium participants, other recommendations -- including release v. dose limits, quantitative probabilistic criteria v. qualitative or deterministic criteria, and level of stringency -- were not addressed in Draft #3 of 40 CFR Part 191. The Draft does not incorporate suggestions made at the Symposium to consider the relationship between cost/benefit and stringency and to consider separately the human intrusion issue (although Draft #3 allows for adoption of diverse human intrusion assumptions by the implementing agency).

The following synopsis serves to identify the issues discussed at the Symposium on licensing a high-level radioactive waste repository. This synopsis does not present conclusions or recommendations, but, rather, presents scientific and policy concerns expressed by the radioactive waste management community and the public.

In addition to the agenda and lists of speakers and acronyms, there are several items appended to the synopsis. Appendices C and D are statements by John Matuszek and David Okrent, respectively, that expand on and elucidate comments cited in the synopsis. Appendix E, the Executive Summary of the 1984 EPA Science Advisory Board's "Report on the Review of Proposed Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste (40 CFR Part 191)," is included because it was cited in the synopsis. EPA's Office of Radiation Protection was asked for a response to these three statements; Appendix F consists of copies of Richard Guimond's symposium remarks as well as the EPA's written comments on "Rethinking High-Level Radioactive Waste Disposal" (Appendix G).

The Board on Radioactive Waste Management is grateful for the exceptionally active participation of the Symposium audience and especially wishes to thank the invited speakers.

Frank L. Parker
Chairman

SYNOPSIS

of the

Symposium on Radioactive Waste Repository Licensing
September 18-19, 1990 - Washington, DC

held by the

Board on Radioactive Waste Management,
National Research Council

INTRODUCTION

There is a worldwide scientific consensus that deep geological disposal, the approach being followed in the United States, is the best option for the disposal of high-level radioactive waste (HLRW). Despite this consensus, there is a concern within the radioactive waste management community ~~is concerned~~ that current federal regulations, by virtue of excessive stringency, may ultimately prevent identification and licensing of a site technically suitable for a repository.

Since 1955, the National Research Council of the National Academy of Sciences (NAS/NRC) has been advising the U.S. government on technical matters related to the management of radioactive waste, especially through its Board on Radioactive Waste Management (BRWM or "the Board"), a permanent committee of the NAS/NRC. After careful study, the Board concluded, in a recent position statement ("Rethinking High-Level Radioactive Waste Disposal," National Research Council, National Academy Press, Washington, D.C., 1990 - Appendix G), that the U.S. program for deep geological disposal of HLRW is unlikely to succeed if it continues on its current course because the present

DOE approach (in which every step is mandated in detail in advance) is poorly matched to the technical task at hand.

The Board believes that, based on public concern over safety and the implementing and regulatory agencies' perceived need for public credibility, a high degree of inflexibility with respect to both technical and schedule specifications has been built into the programs of those agencies. In "Rethinking High-Level Radioactive Waste Disposal" the Board warned that the HLRW program may well fail to site and open a repository because the various agencies involved set unnecessarily high and insupportable hurdles to regulatory compliance. Their policies promise to anticipate every imaginable problem, or assume that science will shortly provide all the answers. The Board encouraged the federal agencies to see that the choice is not between an "ideal" underground facility and a less-than-perfect one, but rather between disposal underground with reasonable assurance of safety and storage on-site at reactors where there is greater chance of disturbance. The inherent variability of the geologic environment, the Board suggested, necessitates allowing flexibility and iteration in design, construction, and scheduling of a repository. They also urged the federal agencies to take interested parties seriously and involve them substantively in the planning and construction of a repository.

Due to widespread scientific concern about these issues and interest in regulatory revisions planned by the U.S. Environmental Protection Agency (EPA) as a result of the court remand of 40 CFR (Code of Federal Regulation) Part 191 ("Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes"), the Board held a symposium on September 17-18, 1990, in

Washington, D.C., for the following purposes: to examine the status of repository licensing requirements and related issues in the United States and elsewhere; and to consider approaches to reconciliation of divergent viewpoints. Approximately 300 people including representatives from federal and state regulatory agencies, the Congress, national and international groups and laboratories, industry, public interest groups, and members of the public attended the symposium. A general synopsis of the proceedings follows. The agenda and a list of speakers and participants may be found in Appendixes A and B.

THE PROBLEM

High-Level Radioactive Waste In General

The challenge of high-level radioactive waste (HLRW) disposal is dominated by the spent fuel from nuclear power plants. At present, about 17 percent (20% in the U.S.) of the world's electricity is generated by some 413 nuclear power plants, (111 in the U.S.) although the generation rate is as high as 80 percent in France and 50 percent in Sweden. Each 1000 megawatt electrical nuclear power plant produces about 30 metric tons of spent fuel each year. In 1990, spent fuel temporarily stored at ground level in pools or dry casks at the 111 nuclear power plant sites in the United States constitutes about 21,500 metric tons of heavy metal (MTHM). By 2030, the last year of the Department of Energy's (DOE) Strategic Plan, spent fuel is expected to total 86,000 metric tons provided that no reactor licenses are renewed. The total U.S. radioactive waste to be disposed of includes spent nuclear fuel, transuranic (TRU) waste from processing of nuclear materials in the U.S.

nuclear weapons program, and some 10,000 metric tons of high-level solid and liquid defense wastes that have been stored pending permanent disposal since the inception of the U.S. nuclear program in the 1940s.

Most countries, including the United States, have concluded that the best means of long-term disposal of HLRW is deep underground geological burial, always including some form of engineered containment or encapsulation and generally with some limited retrieval capability, at least initially. The Nuclear Waste Policy Act of 1982 divides the responsibilities for regulation of HLRW disposal among three federal agencies: the EPA to promulgate generally applicable standards to protect human health and the environment from nuclide releases offsite; the U.S. Nuclear Regulatory Commission (U.S. NRC), to set criteria and fix technical requirements for specific implementation of the EPA standards; and DOE, to issue general guidelines for recommending and selecting sites for a geologic repository, and ultimately constructing and operating it. The Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico is authorized as a research and development facility in December 1979, by DOE's National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (PL 96-164), to investigate the disposal of TRU waste. In the 1987 amendments to the Nuclear Waste Policy Act, Congress designated the Yucca Mountain, Nevada, site as the single prospective location for a deep geologic nuclear waste repository and directed DOE to conduct site characterization and development. The Yucca Mountain site, by law, may store no more than 70,000 metric tons, although it has a maximum practical capacity of 100,000 metric tons that would be legally accessible once a second repository is licensed.

The EPA Environmental Standard - 40 CFR Part 191

Promulgated in September 1985, 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule," establishes a set of generally applicable standards for disposal of such wastes. While the EPA is charged with promulgating the standard, the U.S. NRC is responsible for issuing regulations and licenses to assure compliance with the EPA standard. The DOE, under U.S. NRC license, is responsible for disposing of spent fuel and HLRW. The DOE is directly responsible for implementing the standard with respect to defense TRU waste planned for the WIPP facility.

Subpart A of 40 CFR Part 191, Environmental Standards for Management and Storage, also covers temporary storage and long-term monitored retrievable storage (MRS). Subpart A also establishes dose limits to the "public in the general environment" for exposure during management and storage. Subpart A has not been remanded and the provisions of Subpart A were not discussed at the symposium.

As originally promulgated, Subpart B of 40 CFR Part 191, Environmental Standards for Disposal, applies to disposal-related releases to the accessible environment, doses to the public, and contamination of groundwater. The release limits set forth in the regulation were established based on general analyses of the possible performance of hypothetical repositories. ~~are in theory designed to~~ ensure that the risk to future generations ~~does~~ would not exceed that of a corresponding amount of unmined uranium ore. EPA's analyses suggest that such a level of performance would The containment requirements in the regulations set total quantitative limits on release of radionuclides into the "accessible" environment during the first 10,000 years following disposal. The EPA derived these limits by determining the amounts of radionuclides, singly or in combination, that would result in fewer than 1,000 cancer deaths during the 10,000 year period for each 100,000 metric tons

of heavy metal in spent reactor fuel. Generic assumptions were made about the behavior of various types of repository sites, pathways to man, and human populations over the next 10,000 years. The validity and apparent absoluteness of the assumptions has been widely questioned by technical review panels and individuals throughout the professional waste management community. There is no mechanism within the regulation to adjust the release limits according to the geologic or hydrologic variability of a specific site or geological medium. As many radionuclides are expected to be released over time, a weighting procedure is provided to ensure that the calculated total of all effects under the release limits is below the 1,000 cancer deaths in 10,000 years objective.

The containment standards also provide two probabilistic distribution requirements: first, that the cumulative releases of radionuclides should have a less than 1 in 10 chance of exceeding the specified limits, and second, a less than 1 in 1,000 chance of exceeding ten times those limits. These probability distributions are to be calculated by performance assessments to examine all credible possibilities for movement of radionuclides from the repository into the accessible environment. In conducting such analyses, DOE will rely heavily on computer modeling of the repository, taking into account the surrounding geological environment and all possible environmental transport pathways. The products of the various performance assessments are assembled into a "complementary cumulative distribution function" or CCDF, that indicates the probability of exceeding various levels of cumulative release. If the calculated CCDF lies within the numeric probability limits, the EPA assumes the site to be in compliance. Further, with the understanding that absolute assurance is not feasible, the EPA requires only a "reasonable" expectation that compliance would be achieved.

The protection requirements also provide for the population living near a repository. They are applicable for the first 1,000 years following disposal and assume an undisturbed site. One protection requirement specifies the maximum allowable annual radiation doses to individual members of the public. Other requirements pertinent to groundwater set numeric limits on radionuclide concentrations for 1,000 years for any nearby irreplaceable sources of drinking water that supply communities, i.e., thousands of persons.

The Court Remand

In July 1987, the First Circuit Court of Appeals vacated Subpart B of 40 CFR Part 191. Three portions of Subpart B were remanded to the EPA for further consideration and substantiation of the standards. The first dealt with administrative procedural matters (e.g., the manner in which the EPA promulgated the standard). Second, the court found the individual protection standard invalid because it did not protect underground sources of drinking water according to the mandates of the Safe Drinking Water Act, and directed the EPA to reconcile the inconsistency or to explain it. Third, the court found the 1,000 year duration of the individual protection standard also to be arbitrary and capricious because the EPA had relied solely on population, not individual, risks in setting it. EPA's reconsideration of these portions of the standard could result in a revision of the standard as a whole or merely the insertion of a better justification for the present requirement. None of the containment requirements were remanded.

The U.S. NRC Regulation 10 CFR Part 60

Promulgated by the U.S. NRC in June, 1983, 10 CFR Part 60, the Disposal of High-Level Radioactive Wastes in Geologic Repositories, applies to both defense and non-defense radioactive high-level waste. The regulation excludes TRU waste to be disposed of at WIPP; although DOE has agreed to meet the U.S. NRC regulatory requirements to assure conformity among standards and to ensure that WIPP will be in full compliance in case a future law should increase the jurisdiction of 10 CFR Part 60.

NRC is not aware of such an agreement.

10 CFR Part 60 establishes procedures and technical criteria for licensing geologic repositories. The most controversial provisions are those that extend the EPA's qualitative assurance requirements for multiple barriers in disposal systems. The U.S. NRC specifies quantitative criteria for each part of the subsystem: the minimum number of years (300 to 1,000) over which the waste package must provide containment, the maximum release rate (1/100,000 or 0.001% of the yearly inventory of each radionuclide for 1,000 years), and the minimum ~~maximum~~ groundwater travel time (1,000 years to the accessible environment). Some critics argue that these criteria are unnecessarily stringent, not cost-effective and, further, that too much emphasis is placed on the geology. Despite the growing view that scientists will not be able to engineer away all the uncertainties involved in a geologic repository, these critics believe that the uncertainty of geological performance can be offset by greater flexibility in reaching compliance with the standards by means of engineered barriers.

THE SYMPOSIUM

Reactions to "Rethinking High-Level Radioactive Waste Disposal"

"Rethinking High-Level Radioactive Waste Disposal" is reprinted in Appendix F. In general, the report was commended for bringing vital and contended issues to the forefront of debate. Nuclear industry representatives agreed with the report's flexibility recommendations and encouraged increasing the site-specificity of the standard. Repository program critics, however, focused on the idea that the HLW program was unworkable in its current form and dismissed the idea that the EPA standard was overly stringent, inflexible, or unworkable. DOE pointed out that the program is now much better run than it was at the time of the workshop from which the report was written, and there was heated opinion on both sides of the question of the validity of probabilistic release criteria. Several participants lauded the call for increased substantive public participation in the licensing process, including informal working relationships in addition to formal advisory functions. In response, Dade Moeller, chairman of the U.S. NRC's Advisory Committee on Nuclear Waste (ACNW), pointed out that the ACNW opens its meetings to the public and encourages their participation.

One participant pointed out that, although a successful program demands accord on a set of licensing regulations that are rational, reasonable, and firmly grounded in science, the issue at hand is not licensing. WIPP, not being subject to U.S. NRC licensing authority, is not yet able to start its experimental program due to a delay in land transfer from the Department of the Interior to DOE. Yucca Mountain is far from a license application as DOE struggles to obtain permission to investigate the geology of the mountain. At this point, the Yucca Mountain Project faces many stumbling blocks before it can tackle the intricacies of the U.S. NRC licensing requirements.

Critique of 40 CFR Part 191

Much of the debate at the symposium focused on various criticisms of EPA's final 40 CFR Part 191 rule. The rule was written in the early 1980s, based on 1970s technology, and it was suggested that the EPA make revisions to take into account newer technology and newly available data. James Curtiss, U.S. NRC Commissioner, made the point that, in his personal opinion, the standard was based on what was technically feasible, rather than on an overall health and safety goal. Lawrence Ramspott, of Lawrence Livermore National Laboratory, noted several changes since the 1970s: at that time there was a lack of data on actual radioactive waste, effects of water chemistry, and unsaturated sites. Since then, testing has been done with spent fuel and glass containing radioactive waste, and much work has been done with groundwater from sites and rock-equilibrated groundwater in the presence of container materials under a variety of pH and Eh conditions, including both saturated and unsaturated zones. In addition, much work has been done with container materials, such as copper, that greatly diminish the degree to which a repository needs to depend on geologic behavior. Other technical criticisms were as follows:

- The standard should be stated in terms of annual limits on the radiation dose to individuals rather than as release limits over broad time periods;
- The containment requirements should be directed towards the protection of individuals rather than populations;
- The standard poses requirements in terms of numeric probabilities, an approach which has never been used previously in a federal standard and which the agencies have no experience in implementing;

- The handling of the human intrusion scenario is inadequate because it relies on insupportable societal predictions 10,000 years in the future, thus suggesting that accurate predictions can be made over the far-term and rendering geologically different sites as virtually equivalent in risk. It was suggested that human intrusion be assessed for the role it plays in performance assessment, and considered separately from other licensing issues. This would incorporate a change in the methodology of performance assessment;
- The standard is unnecessarily stringent compared with similar limits for disposal of hazardous waste, especially considering the high-level of unavoidable background radiation, both naturally occurring and manmade;
- In protecting future generations, the standard pays insufficient attention to current worker exposure;
- The standard provides flexibility only at the discretion of EPA administrators; such flexibility should be built into the standards so that DOE may design to take advantage of the range of possibilities for demonstrating compliance; and
- Where the standard calls for "reasonable assurance" of meeting limits, "reasonable" should be defined so that DOE and contractors know how to measure it and when it has been achieved.

40 CFR Part 191 was also criticized for its blindness to cost-effectiveness considerations. It states in several places that compliance should not impose an unreasonably difficult or expensive burden on those seeking to comply. However, Ramspott pointed out, when the EPA said that site characterization was not unduly

expensive, they had not had any experience with it. It is now known that straightforward characterization, even without extensive litigation, is complicated and resource consuming. For example, most available data in the early 1980s assumed congruent dissolution and it has now been shown that dissolution in groundwater is non-congruent due to a difference in nuclide solubility. Determining the extent to which dissolution is not congruent will be time-consuming and costly.

Many speakers stressed the importance of taking a new look at the expense of implementation and how it relates to the benefits, since they perceive the standard as demanding protection that goes beyond that required for the public safety, incurring exponentially greater costs for each additional increment of protection. This stems from the fact that the 1970s understanding of what technology could achieve was far less costly than the 1980s version, in part because much smaller amounts of radioactivity can now be detected. Now that infinitesimal amounts of radiation exposure can be detected, infinite budgets may be spent on cleanup. David Pentz, an environmental and geotechnical consultant, asserted that it is questionable whether the extreme stringency of the standard is indeed furthering the public safety to any measurable degree. Pentz and Thomas Cotton, an environmental consultant, suggested that there should be a thorough study of the cost-benefit ratios resulting from implementation of 40 CFR Part 191 and the subsystem criteria of 10 CFR Part 60.

Probabilistic Release Standards v. Individual Dose Limits

Much opposition was expressed to EPA's selection of probabilistic release standards for protection of the public over the extended time frame of 10,000 years following waste disposal. James Mercer, a hydrogeologist, voiced doubt about the scientific basis for predicting transport of radionuclides for such a long period of time. He noted that projections for a 10 to 20 year time frame are difficult. An attendee at the symposium, David Okrent, a reactor safety physicist and consultant to the Advisory Council on Nuclear Waste (ACNW, a U.S. NRC advisory board), served on the subcommittee of the Science Advisory Board (SAB, EPA's advisory board) that advised the EPA that 10,000 year projections can be made with reasonable confidence (Appendix E). In Okrent's opinion, however, the probabilistic group that worked on the report had "strong questions about one's ability to estimate risk out to 10,000 years." He said that the "reasonable confidence" statement used by the EPA to back up their standard was an unfortunate choice of language that made its way into the Executive Summary of the SAB report.

At the symposium, several speakers pointed out that the International Commission on Radiological Protection and other groups, both national and international, had concluded that an annual limit dose to the individual was the best criterion by which to judge the long-term acceptability of solid waste disposal. An NRC staff representative discussed the possibility of ~~The U.S. NRC would like to see~~ a deterministic limit that closely parallels such common precedents for individual risk-based standards and regulations as the basis for licensing geologic repositories. An example would be a quantitative standard, such as 4 millirems per person annual dose. Such an approach has been found generally to ease interpretation and determination of compliance, to avoid the potential for large individual doses possible under a population-based standard, and to be less likely to lead to controversy. Another reason given to support annual dose limits to

individuals is the difficulty of determining the relative merit of any specific site by using the EPA probabilistic release limits, given the insufficient explanation by the EPA of how the generic standards were derived from the upper-bound population health risk goal. Though this portion of the standard was not remanded by the courts, various groups requested that further clarification be provided and, if probabilistic release limits are to be retained, that they become secondary to a primary annual risk or dose limit standard.

The EPA regulations do, it was pointed out, recognize the value of dose limits in requiring that engineered controls be able to prevent significant doses in the near term, i.e., for the first 1,000 years after disposal. The regulations also provide annual limits on individual dose and on average groundwater contamination from undisturbed performance in that initial period. Demonstrating compliance with individual dose limitations beyond 1,000 years was considered to be very difficult due to the complexities involved in estimating exposures rather than amounts of radioactivity released.

The EPA and others consider probabilistic release limits over the long term as preferable to annual dose/risk limits for several reasons. First, the performance of the repository must be judged over very long periods of time, during which determination of compliance by the physical processes of measurement or inspection cannot be assured. The EPA views probabilistic limits on total releases integrated over time as providing a meaningful, if not absolute, standard for evaluation that accommodates consideration of disturbed repository performance more readily at both the population and individual level. If annual dose limits for individuals were to be used, unlike present practice, they would have

to be evaluated on an incremental, multi-generational basis, taking into account the probability of events.

Second, probabilistic limits on total releases over time from the repository present a quantitative standard against which the criterion of success may be more readily measured. Use of individual annual dose limits over long time periods would complicate the analytical task, again probabilistic, by requiring predictions of environmental events, exposure pathways to man, and human behavior on a year-by-year, multigenerational basis. The potential for non-resolution of issues and for adversarial situations would thereby, according to the EPA, be enhanced. ~~Representatives for the U.S. NRC, however, argued that their experience in licensing nuclear power plants suggests that the probabilistic standards will not withstand the rigors of license hearings and litigation.~~ Curtiss expressed his concern over the continuing and unresolved debate over the feasibility of implementing the probabilistic portion of the standard and argued that a clear and unambiguous approach to implementing EPA's standard in a licensing review has not been identified. Support for probabilistic limits came from Robert Loux, representing the state of Nevada, who felt that if WIPP and Yucca Mountain cannot meet the licensing criteria, new sites should be chosen. He said that before the standard is rejected as unworkable, it should be tried on a less complicated site than Yucca Mountain. Robert Neill, of the New Mexico Environmental Evaluation Group, noted that the very concept of geologic isolation encompasses the acceptance of the ability to predict long-term geological integrity.

Robert Shaw, of the Electric Power Research Institute, recommended a compromise, retaining the probabilistic approach as an acceptable option for anticipated events. For unanticipated events, such as human intrusion, he recommended a separate release limit on an event-by-event basis for those processes sufficiently credible to warrant consideration.

Negotiated rulemaking was mentioned by several speakers as a process that might work well to bring the U.S. NRC and the EPA through some evolutionary change, provided that all parties felt they could achieve an outcome better than the status quo. The alternative, however, may be Congressional legislation that none of the participants wants. As a result of the exchange at the symposium, the EPA and the U.S. NRC are in the process of examining the feasibility of a negotiated rulemaking which, if implemented might lead to a proposed rule for public comment at the end of 1991.

Stringency of the Standard

EPA stated in its draft environmental impact statement related to the proposed standard that the risks calculated for 10,000 years would not appear unreasonable even if incurred by a single generation. Nonetheless, general concern was expressed at the symposium that the risks associated with disposal under the EPA standard, though acceptably small, might be unnecessarily small, especially when compared to similar limits for the disposal of other hazardous wastes and the much higher level of unavoidable, natural and manmade background radiation. For example, the risk of cancer death attributable to the repository would be less than one every ten years, compared to the risk from naturally occurring radon of one cancer death every three minutes.

Shaw observed that EPA's rationale for an acceptable level of risk from radioactive waste was based on the waste risk being a certain fraction of the fuel cycle risk, and therefore being lower than or equal to the total risk from nuclear reactor operations. He contended that there is no scientific basis for judging the EPA's fraction to be a reasonable

risk relative to other accepted societal risks. He views the EPA rationale as a judgment based on an emotional response to the idea of radiation, and would replace it with a rationale based on well-supported societal safety goals.

DOE and nuclear industry representatives worried that the existing standards might be restrictive to the extent that they slow or kill the repository. Although John Bartlett, Director of DOE's Office of Civilian Radioactive Waste Management, warned that the excessive stringency of the EPA standard is costing the HLW program a lot in time, money, and public confidence, he also insisted that DOE is not complaining about the standards; their role is to comply with them and develop methods for evaluating compliance. The question was raised as to the degree to which the release limits and associated residual risks might be raised and still provide an acceptable level of protection.

On the other hand, several participants suggested that the EPA standards are not too stringent with respect to acceptable levels of risk, and might even require tightening, in view of both increased estimates of health effects from low doses of radiation, and improvements in waste containment theory and technology. These participants suggested that the provisions of EPA's deep-well injection regulations (40 CFR Part 148) tracked the HLRW disposal standards, considering the First Circuit Court's finding that deep geological disposal is akin to deep-well injection of hazardous wastes. Such a comparison is considered by many to be inappropriate: deep-well injection is the pumping of liquids or semi-liquids such as grout through a well to a deep, uncontrolled environment. In contrast, geologic disposal of HLRW is the direct emplacement into a geologic medium of a solid waste that has three barriers to movement: waste form, engineered containment, and

known immediate geology. Moreover, such solid waste is retrievable in the near term, and possibly longer.

EPA explained at the symposium that public acceptance is an important factor in setting regulatory limits and the agency is confident that the requirements are perceived by most people as adequately protecting human health and the environment. EPA and Nevada officials asserted that the standards would be within reach if the repository were properly sited. Others held the view that compliance with the current standard would achieve a level of protection greatly exceeding that needed to protect human health and the environment. According to some participants, if the EPA were to adjust the requirements now, regardless of the rationale, the changes would seem to be politically, rather than scientifically, based. It would be thought that the requirements were being changed in order to ensure that the prospective Yucca Mountain repository be licensable. Richard Guimond, the EPA representative, warned that if the EPA relaxed the standard, public skepticism would grow and the program would face even greater problems. Cotton, however, submitted that it would be better to fix the regulations now, instead of later, when the program could be at a standstill due to its unworkability. A later adjustment would look much more like a diminution of standards than a technical adjustment. He also suggested that since the standard and the regulations were conceived at a time when many sites were being considered, and Congress has since changed the mission to one of approving or disapproving one candidate, it would be appropriate to revise agency rules in accordance with the new mission.

Another suggestion was that a consensus building effort be undertaken to produce a single set of regulations that is rational, reasonable, and firmly grounded in science and expert judgment.

Dan Reicher, of the Natural Resources Defense Council, called for the most radical action: starting over with a new process and a new set of sites. He suggested that this would be the only way the DOE could regain the public trust for its technical work, its honesty in dealing with the public, and its independence from political interests.

Flexibility of the Standard

Part of the problem of stringency for many of the participants lay in the specificity of the release limits of 40 CFR Part 191. It was argued by many that without relaxing the standard for the overall performance of the repository, design and planning could be made easier by restructuring the requirements. If the EPA and the U.S. NRC would provide a performance requirement, rather than the current subsystem requirements for a repository, the systems designers would have more freedom to engineer into the containers and waste forms a level of safety that could offset flaws in the geology of a site.

In the Guidance, Appendix B to 40 CFR Part 191, EPA allows for flexibility (by means of case-by-case exemptions) in implementation, but all the flexibility is left to the discretion of the regulator. Speakers argued that the flexibility should be defined in the regulation, in order to give designers the ability to design according to site characteristics, with the

knowledge that approval of specifications is not subject to the changing politics and regulatory conservatism of the regulating agency.

Reicher noted that an important drawback of iterative, flexible standards is that all too often, where rigorous compliance standards and detailed licensing requirements are not imposed on large, costly projects, corners are more likely to be cut in the name of program objectives or schedules. Frank Parker, of the BRWM, maintained that sound, definitive standards need not preclude flexibility in the method by which a repository meets compliance.

The Lack of a Technical Connection Between the Standard (EPA) and the Regulation (U.S. NRC)

Regulations are generally designed by federal agencies to assure achievement of a corresponding goal, for example, health protection or worker safety. Symposium participants repeatedly lamented the fact that compliance with the U.S. NRC regulations does not assure compliance with the EPA standard. At the symposium, Curtiss emphasized the significance of the discrepancy that lies between the EPA release limits and the U.S. NRC subsystem criteria specifying geological and container limits. The primary reason they do not mesh is that the U.S. NRC's methodology is deterministic, specifying quantitative criteria for multiple barrier performance, while the EPA's standard is probabilistic, based on CCDFs for containment limits. Because there is no compliance exchange, those seeking repository licenses are faced with complying with dual regulations simultaneously.

The missing linkage between the deterministic regulation and the probabilistic standard it seeks to implement was called the "technical nexus" by Curtiss. He stressed that an unambiguous technical nexus is needed because responsibility for implementing the HLRW program is divided: between the EPA, for setting generally applicable standards, and the U.S. NRC, for establishing the implementing regulations. As of yet, Curtiss noted, the U.S. NRC has been unable to identify a clear and unambiguous approach to implementing the EPA standard in licensing review. He believes the lack of a nexus stems, in part, from the fact that the U.S. NRC regulation is deterministic while the EPA standard is probabilistic, making their approaches distinctly different. It is also a factor that the U.S. NRC's final rule was promulgated while the EPA was still drafting its standard. (EPA's Final Rule states that the U.S. NRC's 10 CFR Part 60 incorporates the standards that the EPA was promulgating in 40 CFR Part 191 and that the U.S. NRC regulation was designed in concert with EPA's ongoing development of its standard. In addition, in its promulgation, the EPA stated that it expected that the U.S. NRC would revise 10 CFR Part 60 to bring it into full consistency with 40 CFR Part 191.) ~~Although the U.S. NRC did make an effort to bring 10 CFR Part 60 into consistency with 40 CFR Part 191, the inconsistency remains.)~~

A resolution of approaches could be effected by either or both agencies. Curtiss suggested that the U.S. NRC could restructure its subsystem performance criteria, during resolution of the court remand, to establish such a nexus. But first, the EPA must document the basis for its standard, in accordance with the remand. The EPA could go further, in Curtiss' personal opinion, by reevaluating and revising its standards to establish requirements that are realistic, technically achievable, and defensible with respect to possible litigation. Accomplishment of this task among the executive agencies is best

achieved now when technical adjustments may be made in light of clearer objectives and technical knowledge. If done later, the necessary modifications, relaxations, or stringencies may be interpreted incorrectly as excessive weakening or strengthening of public safety requirements. At the symposium, both the EPA and the U.S. NRC expressed a willingness to communicate about working towards the nexus, but the EPA did not want to waver from its reliance on the probabilistic standard, and the U.S. NRC is unlikely to abandon its ~~deterministic limits~~ incorporation of the EPA's probabilistic standard along with its deterministic subsystem requirements.

High Level Radioactive Waste Management Abroad

Representatives of French, Swedish, and Swiss HLW management programs described their countries' efforts at repository siting as less pressured for results than the U.S. program. Charles McCombie, of the Swiss radioactive waste disposal cooperative Nagra, said that Switzerland's first goal is technical consensus based on analytical assessment. The Swiss program differs from the U.S. program in that uncertainties don't have to disappear before a decision is made. European programs have more flexibility because, unlike in the U.S., repository schedules are tentative and not fixed by law. The earliest any European repository is expected to open is 2010, with most countries projecting more distant dates. McCombie noted that there is also less pressure because European countries have accepted that a buffer of 20 to 30 years before isolation in a permanent repository is essential; intermediate storage is planned either on-site or in MRS-like facilities.

One participant pointed out that in both Europe and Asia, countries have made national decisions to rely on nuclear power, and the goal of the licensing process is to support nuclear power. Every effort is made by the state and the licensing authority to rectify problems so that approval is obtained. The fundamental difference lies in the criteria for success: in the U.S., an agency is successful regardless of whether a repository is licensed; abroad, an agency's success is dependent upon the completion of licensing. Therefore, they avoid situations like that in the U.S., where there are two regulating and implementing agencies operating with two disparate philosophies. The European representatives acknowledged that their countries will likely have the same problems as the U.S. in convincing the public to accept a repository, but public opposition is building more slowly.

Another major difference among the programs is that the U.S. is the only country using release limits instead of dose-to-man limits.

Need for an Overall Public Health and Safety Goal

Underlying the issues of probabilistic versus deterministic standards and of excessive stringencies is the broader question of whether the regulatory agencies and the general public can be assured of adequate protection to health without an overall public health and safety goal. Such a goal, for example, is set qualitatively for nuclear reactors by the U.S. NRC, and is supported by probabilistic quantitative objectives to assure achievement of the primary goal. The lack of a safety goal for repositories is reflected in the radioactive waste community's focus on release limits rather than safety estimates. According to McCombie,

symposium participants lack a common appreciation of the need for transparency of safety standards. He advocated emulation of the Canadian radioactive waste program that enables public understanding, and advised U.S. colleagues to de-emphasize the licensing aspect of the repository and put the stress on safety.

At the symposium, many suggestions were made that a health and safety goal be applied to repository facility licensing in terms of standards, regulatory approaches, risk/benefit balances, and operational requirements. Considerations for the geologic waste disposal facility are more involved than for a reactor: not only must regulators examine the multi-generational populations at risk, but also the respective differences in risk/benefit balances, costs, and designed life of the facility. While nuclear reactor health and safety problems may be readily addressed during the life of a plant and the few generations that may be involved, the extremely long life of a repository requires unprecedented risk assessment. Although a proposal was made to allocate risks and benefits from a repository to the single generation initiating it, both of these parameters are found to be multi-generational in nature, and costs are seen to mount disproportionately with increased stringency of standards and associated time delays.

Given that an overall public health and safety goal is absent from the standards governing geologic repositories, a major concern to be resolved is whether the regulatory agencies, in striving for adequacy, can do less than the maximum that is technically feasible.