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UNITED STATES OF AMERICA

BEFORE THE NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
PROPOSED RULEMAKING ON THE STORAGE AND DISPOSAL OF NUCLEAR WASTE	)	PR-50,51 (44 FR 61372)
	)	
(Waste Confidence Rulemaking)	)	

STATEMENT OF POSITION

OF THE

NEW ENGLAND COALITION ON [illegible]CLEAR POLLUTION

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I. Introduction

The question of whether and how nuclear waste can be disposed of safely has confronted American society since the dawn of the atomic age in the early 1940s, and the nuclear industry since the early 1950s. An orphan of the perceived need for nuclear weapons and the false hope for an energy utopia through commercial nuclear power, the issue of radioactive nuclear waste was largely ignored for many years and only recently has become the object of fitful efforts to find an answer that will protect the public health and safety. Previous efforts in the area of radioactive wastes, such as the S-3 and GESMO proceedings, have touched only peripherally on these fundamental issues.

At long last, and only after it was ordered to do so by the United States Court of Appeals for the District of Columbia Circuit, the NRC must answer the basic question: When and how, if at all, can the problem of highly radioactive nuclear waste be solved? The immediate question is whether a permanent disposal solution can be found within approximately the next thirty years, and if it cannot, whether spent fuel can be stored safely beyond that time. Lurking behind those questions, however, is the ultimate issue of whether it will ever be possible to protect the public health and safety from the radioactive wastes generated by the nuclear industry.

In this case, if the NRC finds that high-level wastes can be disposed of safely, the development of nuclear power will continue, probably to the detriment of efforts to develop alternative sources of electricity. We will not know for decades whether the NRC was right in reaching that conclusion. If it turns out that the NRC was wrong, the costs will have been enormous -- massive commitments to an unsafe technology and the growth throughout the country of a huge inventory of highly radioactive wastes that will contaminate the human environment for thousands of years.

The New England Coalition on Nuclear Pollution (NECNP) submits the comments in this Statement of Position in an effort to assure that the record on which the NRC bases this crucial decision is as complete as possible. NECNP will demonstrate that the NRC cannot, given the current state of knowledge, find a reasonable assurance either that a waste disposal solution will be found before existing operating licenses expire or that spent fuel can be stored safely at reactor sites or anywhere else past the expiration of those licenses.

In submitting these comments, however, NECNP must note at the outset that the record of this proceeding will be incomplete, unbalanced, and woefully inadequate unless the NRC takes affirmative steps to assure that the full range of expertise is brought to bear. Due to its limited resources, NECNP has been able to obtain the assistance of only one recognized expert, Dale G. Bridenbaugh, of MHB Technical Associates. We understand that some of the experts identified by the Natural Resources Defense Council in its Supplemental Filing of December 7, 1979, may provide information through other parties to this proceeding, but it appears that most of them will not. The inevitable result will be a biased record in which the vast resources of those whose responsibility is the promotion of nuclear power -- the industry and the Department of Energy -- simply overwhelm the record with self-serving assertions. The NRC must not permit this proceeding to become an "industry forum." The safety of hundreds of generations depends on the validity of the NRC's decision, and it should act affirmatively to ensure that the Nation's foremost authorities are consulted.

After describing its own experience and position with respect to nuclear waste, NECNP addresses three major points. First, what is the standard for determining whether a showing of "reasonable assurance" has been made? This question has been ignored by the Department of Energy, but it must be answered by the NRC before the great mass of technical information to be submitted in this proceeding will have any meaning. Second, the DOE Statement of Position on its face fails to provide a basis for a finding of "reasonable assurance" that waste disposal will be possible before the expiration of existing operating licenses. Third, the available information, including the DOE Statement, cannot support a finding of "reasonable assurance" that spent fuel can be stored safely at reactor sites or in away-from-reactor (AFR) facilities for an indefinite period beyond the expiration of existing licenses. This analysis has been prepared for NECNP by Dale G. Bridenbaugh.

The only conclusion that the NRC can reach is that the information available today is not sufficient to provide any confidence that high-level nuclear wastes can be handled safely for an indefinite period. As a result, the NRC must immediately halt the production of radioactive wastes until it can be assured that those wastes will not threaten the public health and safety. The NRC may not issue any new licenses for nuclear reactors or for expansion of spent fuel storage at existing reactors, and it must order existing reactors shut down so that the production of commercial high-level wastes does not continue.

II. Background and Perspective of the New England Coalition on Nuclear Pollution

The New England Coalition on Nuclear Pollution (NECNP) has been actively involved in the issues of nuclear power and the proceedings of the Nuclear Regulatory Commission for more than a decade. It has, for example, been involved in every licensing proceeding related to the Vermont Yankee Nuclear Power Plant since the application was filed for an operating license. Only recently, NECNP presented argument and evidence directly to the Commission on the question of seismic hazards at the Seabrook site. NECNP is thoroughly familiar not only with the range of issues involved in nuclear power, but also with the history of both the industry and the Nuclear Regulatory Commission.

While NECNP has provided evidence to the NRC on critical questions ranging from emergency planning to financial qualifications and technical issues of reactor safety, one of its consistent and major concerns has been the fact that the NRC has permitted the production of high-level nuclear wastes with no assurance that those wastes could be effectively disposed of in the future. Nearly four years ago, NECNP predicted what has now come to pass at Vermont Yankee:

> Thus Vermont Yankee is already on the verge of an involuntary shutdown because it has not solved the very problem -- waste disposal -- which the Court found the NRC had erroneously excluded from consideration in the hearing. Absent an off-site solution to the spent fuel storage problem, Vermont Yankee will have to retain the highly toxic wastes on site for a substantially longer period than originally

> claimed in the FSAR. In fact, with the fate of reprocessing completely open and no available off-site spent fuel storage available, it can only be concluded that by necessity, and not by design, Vernon, Vermont has become the permanent waste disposal site for Vermont Yankee wastes.

Memorandum in support of Suspension of Vermont Yankee Operating License (Docket No. 50-271, filed October 6, 1976).

Unfortunately, the proceeding in which that memorandum was filed never resulted in a serious examination of the fact that Vernon, Vermont, was indeed becoming a permanent waste disposal site. Rather, the NRC waited until NECNP once again raised that issue in the licensing proceedings involving Vermont Yankee's application for permission to expand the amount of spent fuel stored at the reactor site. Again, NECNP pleaded that the NRC recognize that in failing to confront the issue of waste disposal, it was effectively adopting a policy of requiring expanded and perhaps permanent on-site storage. Petition for Leave to Intervene and Brief on Exceptions to Initial Decision at 5, Vermont Yankee Nuclear Power Corporation (Vermont Yankee Nuclear Power Station), Docket No. 50-271 Amendment (Increase Spent Fuel Storage Capacity) (1977).

Again the NRC ignored NECNP's plea. With no recognized basis in fact, the NRC relied on its opinion -- its "policy" -- that it had a reasonable assurance that the waste problem would be solved.

NECNP then sued the NRC to force it to support its bald statement of policy with factual findings arrived at in a manner consistent with due process and administrative procedure. In State of Minnesota v. NRC, 602 F. 2d 412 (D.C. Cir. 1979), the D.C. Circuit agreed that the NRC must squarely address the waste disposal and storage issues and could no longer simply hope or assume that a solution would be found after the waste had already accumulated. In reaching that decision, the Court quoted the concurring opinion of Judge Tamm in NRDC v. NRC, 547 F. 2d 633 (D.C. Cir. 1976), which clearly expresses the concern that has motivated NECNP from the outset and that must set the tone for this proceeding:

> NEPA requires the Commission fully to assure itself that safe and adequate storage methods are technologically and economically feasible. It forbids reckless decisions to mortgage the future for the present, glibly assuring critics that technological advancement can be counted upon to save us from the consequences of our decisions.

602 F. 2d at 417, n. 6, citing 547 F. 2d at 658. (Emphasis supplied).

NECNP has argued, and the D.C. Circuit has agreed, that Judge Tamm's reasoning applies as well to the requirements of the Atomic Energy Act. At long last, the NRC must address the question of whether high-level wastes being produced today threaten the health and safety of future generations. If it does so honestly and prudently, on the basis of the factual record, it must find that there is no reasonable assurance that waste disposal will be possible before existing licenses expire or that spent fuel can be stored indefinitely on-site or in AFR facilities.

III. The NRC Must Establish Criteria To Govern The Degree Of Assurance Or Confidence Required For A Finding Of "Reasonable Assurance."

Pursuant to the mandate of the D.C. Circuit in State of Minnesota v. U.S.N.R.C., supra, and its own Notice of Proposed Rulemaking, 44 FR 61372 (October 25, 1979), the Commission must determine whether there is a "reasonable assurance" that high-level radioactive wastes can be disposed of before the expiration of existing operating licenses, and if they cannot, whether there is a "reasonable assurance" that the wastes can be stored safely at reactor sites for an indefinite period until an off-site solution is found. Unfortunately, neither the Court's opinion nor the Commission's Notice provide any guidance concerning the criteria that must be considered in reaching this decision.

Although the courts have definitively upheld the Commission's use of the "reasonable assurance" standard in various situations, e.g., Power Reactor Development Co. v. Electrical Workers International, 367 US 396 (1961), Nader v. NRC 513 F. 2d 1045 (D.C. Cir. 1975), North Anna Environmental Coalition v. U.S.N.R.C., 533 F. 2d 655 (D.C. Cir. 1976), they have never explored in any depth the question of what factors the Commission must consider in deciding whether "reasonable assurance" exists in a particular case. The closest that any of them have come to grappling with this issue is in Nader v. NRC, supra, in which the Commission's new emergency core cooling system criteria were upheld on the basis of what the

Court referred to as "a formidable record," which included a "substantial showing scientific and engineering support." Id. at 1049, 1050. Certainly that is the least that is required, yet it provides little guidance here, where there is no historical or operating experience to support scientific or engineering judgments, as there was in Nader.

Faced with the need to base a "reasonable assurance" decision on events that must be projected decades and centuries in the future, the Commission must consider carefully how to apply the basic concept of "reasonable assurance" in the context of this case. Ultimately, it is a matter of Commission judgment based on the record. Before that judg-- ment can be made, however, the Commission must establish and understand the criteria by which it will be governed.

In his concurring opinion in NRDC v. NRC, 547 F. 2d at 658, Judge Tamm suggested an analogy that provides nearly perfect guidance to the Commission in this proceeding. He referred to the National Environmental Policy Act as forbidding "reckless decisions to mortgage the future for the present . . ." In effect, the question here is whether the Commission will act as a prudent banker in deciding whether to lend the health and safety of future generations to the nuclear industry and the Department of Energy on the basis of their promises of future performance.

In this circumstance, a prudent lender would consider two basic types of information. First, what has been the historical performance of the prospective borrower? If he has borrowed $5.00 twenty times and repaid it each time as agreed, history offers an indication that another $5.00 loan would be a good risk. On the other hand, if he has borrowed $5.00 many times over the years and has made only fitful and, to date, unsuccessful efforts at paying off any of the debt, history indicates that he is an unacceptable risk.

Second, what does current information indicate about the prospective borrower? In particular, is it strong enough to support a finding of reasonable assurance that a new loan would be repaid despite poor historical performance? Someone with a full savings account, a high-level, secure civil service position, and no existing debts would be an excellent risk, probably even in spite of some past poor performance. On the other hand, someone with no job and no savings would likely be a bad risk even with good historical performance. In between the two is the person with an unsalaried job that pays only on commission, or the person who has only the promise of a job sometime in the future. For these people, past performance is crucial. If the man on commission has a past performance of high earnings in a similar job and of paying his debts, he appears to be a good risk. But the company that has consistently operated at a loss and that has accumulated an enormous debt will not be given a loan simply because it believes it might obtain several small contracts, but is not sure of any of them.

As the NRC approaches the question of "reasonable assurance," it must consider how the historical performance and current information criteria apply to its prospective borrowers, the nuclear industry and the Department of Energy. The record of this proceeding will demonstrate that these borrowers have come to the bank with massive unpaid debts, consistent failures to secure permanent employment, and present positions that are at best comparable to the man on commission with no experience in sales. The NRC must demand greater assurance than that before it lends the future to the nuclear industry.

NECNP understands that the Natural Resources Defense Council and others will address the sorry history of fits and starts that has characterized the industry's and the government's half-hearted attempts to address the nuclear waste issue seriously for more than thirty years. NECNP will touch on that point to some degree in its discussion of spent fuel storage issues (Part V). However, the bulk of NECNP's comments will be addressed to the "current information" question with respect to these "borrowers." Taken together, this record will establish that the nuclear industry and the Department of Energy are not worthy of the loan that they are requesting.

Lest the lending analogy be allowed to trivialize the grave issues involved in this proceeding, NECNP emphasizes that the consequences of an error by the NRC here are far more serious than the consequences of any improvidently granted loan. They demand a conservative approach on the part of the NRC that is at least the equal of the most hidebound and prudent banker. In effect, the nuclear industry and the Department of Energy have come to the NRC as the Chrysler Corporation went to its bankers -- bankrupt on the issue of nuclear waste. Chrysler's bankers refused to take the risk without a federal guarantee enacted by Congress. The NRC, facing a risk to public health and safety far more profound than the mere financial risks involved in the Chrysler case, must reach the same conclusion as the bankers -- the loan must be denied.

As did Chrysler, the nuclear industry and its supporters will undoubtedly attempt to paint a picture of dire economic and social consequences if the NRC finds that there is no "reasonable assurance" that wastes can be safely disposed of or stored for indefinite periods. Those arguments are not relevant to the NRC's decision, which must be based solely on whether the public health and safety can be protected from high-level radioactive wastes. Even assuming predictions of adverse economic consequences to be correct, which is highly questionable, an NRC finding of no "reasonable assurance" will not inevitably cause the predictions to be realized. It will then be up to Congress to consider whether economic arguments outweigh public health and safety considerations.

IV. The DOE Statement Of Position Fails To Establish "Reasonable Assurance" Of Waste Disposal At Any Foreseeable Date

More than anything else, the DOE Statement of Position is remarkable in the number of times that it states, restates, and summarizes what the Department has to say. The Department appears to believe that if it says something often enough in what appears to be a logical sequence, someone will believe its conclusions. As one reads through the Statement of Position, it is easy to be misled by this approach. After all, DOE has said it so many times in so many pages and with such conviction that it must be true, particularly since DOE seems to have met all of the "objectives" that it has chosen to govern the final decision.

In fact, the opposite is true with respect to the likelihood of waste disposal. As is often the case, masses of words, and particularly repetition of arguments or discussions, mask a lack of fundamental substance in DOE's position. Careful analysis of DOE's Statement demonstrates that the factual underpinnings for its conclusions are extremely weak.

Since DOE comes to the NRC with a poor history of efforts to resolve the waste disposal issue (See NRDC Comments), it must rely on solid current information to establish that the NRC should take the substantial risk involved in approving its position. That information falls into two basic areas: (1) the availability and adequacy of basic data on which to base a decision, and (2) the availability and adequacy of methods by which to evaluate the data. In addit n, DOE must show that its underlying assumptions are valid and that it has adequately considered all of the relevant issues.

On its face, DOE's Statement fails to meet these standards. It demonstrates that existing data are inadequate to determine whether any site exists that would be safe for a spent fuel disposal facility. It even admits that many of the methods that will be needed to determine whether a facility is safe have not yet been developed. Given these fundamental weaknesses, it is forced to adopt unsubstantiated and invalid assumptions in order to argue its case. Finally, even if the Statement dealt adequately with the technical issues, it fails to address in any serious way the political, social, and institutional questions that will have to be resolved before a waste disposal facility can be devel ed.

A. Existing Data Are Inadequate To Support A "Reasonable Assurance" Finding.

As with any responsible effort at predicting the future, DOE must begin with the present. In effect, it can only assert that it has so much knowledge about existing conditions and how those conditions will be influenced by man or nature in the future that there is a "reasonable assurance" that its vision of the future will come to pass. In the terms used by DOE, it must have such complete data and such an accurate model in which to use the data that the NRC can rely on the results as assuring the protection of future generations.

Although DOE itself has admitted this obligation, DOE Statement at I-7, its Statement is replete with admissions that there are serious inadequacies in the existing data which necessarily preclude any assurance of safe waste management. Data are lacking with respect to general issues involved in waste disposal and with respect to site specific information that will be needed to determine whether any sites are suitable or can be made suitable for waste disposal.

1. General Data Inadequacies

Perhaps the most telling statement in DOE's position document concerning whether the NRC can be confident in DOE's assertions is the following quotation from the Draft Environmental Impact Statement on Management of Commercially Generated Radioactive Waste:

> 3. Adequacy of Data Base -- Further research is required to resolve some deficiencies in the data base before repository performance can be confidently predicted.

DOE Statement at II-30. If even DOE believes that confident prediction is not yet possible, how can the NRC be expected to have a reasonable assurance that predictions will show that waste disposal can be done safely? If the NRC cannot be confident in current predictions, it cannot be confident that later predictions based on more complete data will show the same things as today's admittedly premature predictions.

Before pursuing its mined geologic disposal reference planning strategy, DOE briefly discusses nine other possible approaches to handling high-level wastes. DOE Statement at II-32-41. In each case, major uncertainties exist, and DOE makes no pretense that any of these approaches would be feasible within the next several decades. Clearly DOE is relying solely on the mined geologic disposal option as the basis for any demonstration of "reasonable assurance" that waste disposal will be available by the year 2006.

Although the vulnerability of DOE's position becomes clearer when site specific data inadequacies are considered the lack of data with respect to major generic waste disposal issues eliminates any basis for a "reasonable assurance" finding. In the area of examining natural systems, one of the most disturbing points is DOE's admission that

> . . . present measurement techniques for hydraulic conductivity in nearly impermeable rocks may be in error by up to a few orders of magnitude . . .

DOE Statement II-95-96. While this is couched in language that seeks to avoid the problem by arguing that the use of conservative values results in acceptable readings, the NRC cannot ignore the gross inaccuracy of available measurement techniques. This is of great concern with respect to hydrology in particular because, as DOE acknowledges,

> Knowledge of ground water hydrology is perhaps the most important requirment for understanding the long-term behavior of a mined geologic repository. The transport of radionuclides away from the waste-emplacement zone by moving ground water is by far the most likely mechanism by which radionuclides might migrate from a repository to the biosphere.

DOE Statement at II-76. The Commission cannot find a "reasonable assurance" where data gathering in such a critical area may be in error by several orders of magnitude.

While it appears that the problem of inadequate data is not as great with respect to the man-made waste package system as with respect to the surrounding natural system, it also appears that the available data and information are not sufficient to support a finding of "reasonable assurance" that an acceptable waste package will be available by the year 2006. For example, referring to extensive testing and development studies being performed on the waste package, DOE states,

> Most of these studies are not complete, but the data and results generated during the past few years do indicate that components of the waste package system can prevent or minimize release of radionuclides to the natural system by functioning as effective chemical and physical barriers.

DOE Statement at II-137 (Emphasis supplied). In other words, things look good so far, but we cannot know yet how well the waste package systems will perform because we have not completed most of the tests. Despite DOE's bland assurance, there is simply no factual basis for confidence that the ultimate outcome of the tests will show that the waste package will be acceptable within just over twenty years.

Basically the same situation is true with respect to tests of metals that might be used in the waste package systems. DOE Statement at II-145. The situation is worse, however, with respect to the technology for sealing repositories after they have been filled with waste. Recognizing that existing information concerning repository sealing has been developed in such areas as oil and gas production and mining operations, DOE admits that,

> The experience accumulated to date must be supplemented with further research and development, because repository seals must retain their integrity for much longer periods of time than those considered in previous applications.

DOE Statement at II-193. In effect, DOE has only begun to investigate repository seals and is forced to rely on a promise of "significant advances in sealing technology. . . before final sealing during repository decommissioning is required." That promise has no basis in fact. DOE Statement at II-185.

DOE makes a similar admission with respect to the approaches required to protect future generations from being endangered by accidentally intruding upon a waste repository. Although DOE admits as a basic premise of its argument that it is responsible for protecting future societies from the waste that we create today, it finds that

> considerable additional study is required to fully develop methods to protect against the occurrence of human-induced releases.

DOE Statement at II-189. Accordingly, DOE cannot argue in favor a finding of "reasonable assurance" that a waste repository will be available in the near future without violating its basic premise.

In making its argument that the performance of waste disposal systems can be adequately evaluated today such that a "reasonable assurance" finding can be made, DOE relies almost exclusively on the use of mathematical models, which in turn rely entirely on the adequacy of available data. The flaws in the data that have been discussed and that will be addressed below raise serious questions concerning the validity of DOE's use of these models. A striking example of this problem is illustrated by DOE's discussion of modeling of the thermo-dynamic properties of certain materials:

> The data needed for describing the basic thermodynamic properties of some actinides, fission products, and minerals of crystalline rocks have been identified. Some of these data are being obtained in NWTS-sponsored programs.

DOE Statement at II-222. If DOE has only identified the data that it needs, and only some of them are being obtained, it cannot hope to suggest that the NRC can make a "reasonable assurance" finding before the data are accumulated. DOE and the NRC are simply unable to evaluate those materials and to support a "reasonable assurance" finding until the data are available.

2. Site Specific Data Inadequacies

The failure of DOE's program to reach a stage at which it can be the basis for any finding of "reasonable assurance" of waste disposal in the next few decades is conclusively demonstrated by an examination of the data that it has obtained and that it needs with respect to potential repository sites. By admitting that its data base is seriously deficient in several critical areas, DOE also admits that it is assuming that facts will be found which support its conclusions. This type of predetermined decisionmaking in the absence of factual support is clearly improper and must be rejected by the NRC.

In its discussion of factors influencing the choice of a natural system in which to site a waste repository, DOE Statement at II-70-80, DOE identifies four categories of factors that must be considered: geologic, hydrologic, tectonic, and resource factors. In each case, DOE is forced to acknowledge that it lacks site-specific information necessary for an understanding of how to judge the factors. For example, DOE notes that thermal and mechanical properties, which are among the geologic factors, are "measured by various techniques on rock samples collected at the site." DOE Statement at II-75. Similarly, with respect to hydrologic factors,

> The effects of fracture systems on flow conditions at individual sites must therefore be assessed in relation to the containment and isolation capabilities of the site.

DOE Statement at II-77. Therefore, based on DOE's analysis, it is essential to examine particular sites in detail in order to know whether any of them will be acceptable. It is, therefore, not possible to generalize from experience elsewhere to establish that a particular site is acceptable.

<u>Geologic Data</u>

DOE also admits that the data regarding geologic factors are incomplete:

> The knowledge that must still be gathered pertains to site specific factors, and the techniques for gathering it are presently available.

DOE Statement at II-87. Although couching its problem in optimistic terms, DOE is unable to hide the underlying reality that current data are incomplete and that, therefore, DOE cannot judge the adequacy of potential sites. In this connection, it should be noted that even if DOE had the data, DOE also admits that

> Interpretations of the resulting data are often difficult and are best made in conjunction with other geophysical surveys.

DOE Statement at II-94. Since the data do not even exist yet, and eventual interpretation will be difficult, the NRC can have no confidence that fundamental geologic questions will be resolved before the expiration of existing operating licenses.

Hydrologic Data

DOE has the same problem with respect to hydrologic factors. The best that it can say is that

> Although the development of a detailed, accurate hydrologic model for each site will require considerable time, bounding assumptions about hydrologic parameters can be applied during the screeing process to assess the general quality of hydrologic systems and to identify areas requiring better definition.

DOE Statement at II-98. In other words, DOE is able to develop a vague idea of the hydrologic characteristics of the various sites, but it is unable to determine the specific performance of hydrologic systems in a manner that will allow a conclusion that a site is qualified for a waste repository. All that DOE can do at this point is identify the questions that must be asked. It cannot provide the answers essential to any finding of "reasonable assurance" that a waste disposal facility will be in place by the year 2006.

Data on Specific Sites

The glaring lack of data and inability to resolve site specific issues is graphically illustrated in DOE's discussion of sites that have been examined thus far. DOE Statement at II-103-126 and Appendix B. The first set of potential sites is the Gulf Interior Region Salt Domes, which encompasses seven salt domes currently under consideration. In each case, to use DOE's words,

> data are insufficient for a quantitative subsurface hydrologic characterization.

See DOE Statement at B-10, 11, 12, 14, 15, 16, and 18. Although the question of groundwater water movement is crucial to potential use of any salt-based repository, DOE does not know today how the hydrologic systems operate at any of these domes. Therefore, none of them can be considered as providing any support to DOE's "reasonable assurance" argument.

Substantially more disturbing than the lack of data with respect to these domes is the fact that an eighth dome, once under consideration, was dropped as recently as last year because it was apparently discovered to be dissolving, causing surface collapses that eventually came to DOE's attention. DOE Statement at II-106. Nothing that NECNP could say would speak as eloquently as the recent rejection of the Palestine dome in support of the proposition that a "reasonable assurance" finding cannot be made until DOE has all of the information that is needed to evaluate potential sites. If the NRC does not know how many potential sites will meet the same fate as the Palestine dome, for whatever reasons, it cannot have any assurance that any other sites will ultimately avoid that fate.

A review of the remaining potential sites establishes that they all suffer to a significant degree from a lack of important data or information necessary to evaluate them. "Existing information on the Paradox basin is not yet sufficient for assessing the suitability of individual parts of the region for a repository." DOE Statement at II-109. Data for the Palo Duro and Dalhart Basins in the Permian Basin are only "preliminary," DOE Statement at II-112, and serious unresolved resource conflicts exist with respect to the Los Medanos site. DOE Statement at II-112 and B-41. No field investigations have been carried out by DOE in the Salina Basin, detailed geological screening has not been done, and potential resource conflicts are severe in the area. DOE Statement at II-117. Questions about the location and movement of the water in the inter-beds and interflows of Wanapum and Grande Ronde Basalts at the Basalt Waste Isolation Project have not yet been answered and will not be for two or three years. DOE Statement at II-118. Data on tectonic phenomena at the Nevada Test Site are only preliminary, and more data are needed to characterize ground water velocities in the area. DOE Statement at II-121 and B-70.

DOE's knowledge is seriously incomplete with respect to all of the potential sites, in some cases more than in others. In only a few cases, perhaps the Los Medanos and Basalt Waste Isolation Project sites, does it appear that full information will be available within the next few years. Since that new information could disqualify <u>any</u> of the potential sites, as it did at the Palestine dome, there is, as yet, no basis for a "reasonable assurance" that an acceptable site will be available for a waste repository in the time period at issue here.

Repository Performance, Modeling, and Laboratory Validation

Just as site specific information is needed to evaluate the sites themselves, so it is needed to evaluate the performance of the proposed repository system, to provide data for the mathematical models, and to validate laboratory experiments. In each area, data are lacking to such an extent that confident predictions cannot be made.

With respect to repository performance, for example, the design and performance of the repository seal depend entirely on site specific factors. However, tests have only just begun, and results cannot be considered conclusive. Indeed, DOE is specifically relying on technological advances in the future to solve this problem. DOE Statement at II-180-185. Reliance on future technological developments cannot form the basis for a present NRC finding of "reasonable assurance."

Since the validity of any mathematical model depends upon the quality of the data on which it is based, those data must be complete. In particular, as DOE admits, site specific data are necessary because "unequivocal statements about the safety of mined repositories will be possible only for specific sites." DOE Statement at II-225. Accordingly, to the extent that site specific data are not available, as has been shown to be the case, DOE cannot evaluate the safety of mined repositories at the sites now under consideration.

DOE also discusses a series of in situ tests that are being undertaken around the world in an effort to lend validity to its models and its laboratory test results. DOE Statement at II-248-270. For the most part, it suffices to note that most of those test have only just begun and have not yet provided results on which a finding of "reasonable assurance" can now be based. To a large degree these tests have simply confirmed the need for more extensive investigation, and in one important case, the Climax test in granite, the test has not even begun. DOE Statement at II-261.

Finally, in a candid conclusion that shatters any confidence in DOE's projected time table, DOE states,

> Of the many factors that can influence construction schedules, the majority are associated with specific site conditions and environment, and are, therefore, resolvable as the site selection processes evolve.

DOE Statement at III-61. The assumption that factors are "resolvable" has no basis in fact and is another example of DOE's biased, predetermined approach. However, even if DOE is correct on that point, it has provided no basis for its conclusion that presently unknown site-related issues can be resolved within the time frame that it has proposed. If the details of the site are not known, there can be no basis for DOE's optimism that problems can be resolved within a specific period of time.

B. The Lack Of Methods And Criteria For Resolving Issues Is A Fatal Flaw In DOE's Presentation On Waste Disposal

If the only problem that DOE's mined geologic disposal program faced were a lack of data, at least the NRC would know that within a relatively short time, two or three years perhaps, all of the data would be available, and it would be able to evaluate the potential for successful waste dispoal at that time. Unfortunately, matters are not that simple. In addition to lacking crucial data, DOE admits that it has not even developed methods or criteria necessary to evaluate many aspects of the waste disposal issue.

Remarkably, DOE highlights just this issue in its performance objective 6, which states,

> Acceptable performance should be based on methods reasonably available and should not depend upon continued maintenance or surveillance for unreasonable times in the future.

DOE Statement at I-14. An examination of DOE's Statement of Position establishes that it has violated its own criterion by arguing for a finding of "reasonable assurance," while admitting that many methods and criteria for evaluating waste disposal performance have not yet been developed.

For example, with respect to the effects of fractures on rock properties, DOE states that "appropriate subsurface characterization and testing methods may need to be developed at each site before final decisions on suitability can be made." DOE Statement at II-73. Similarly, knowledge of sorption properties of rocks is only at a state-of-the-art stage of development and is heavily reliant on ongoing studies for the development of accurate models. DOE Statement at II-74.

Stumbling once again over the problem of inadequate site specific information, DOE notes that

> More quantitative criteria will be developed for each study location to guide site-specific decisions on suitability.

DOE Statement at II-81. If these basic criteria have not yet been developed, how can the NRC have any idea whether any sites will be suitable?

The lack of existing methods and techniques also cripples DOE's position with respect to hydrologic studies, which it agrees are probably the most important to assuring long-term safety of a respository. DOE Statement at II-76. Referring to the field data and test results that must be obtained, DOE states,

> The techniques for obtaining most of them are currently available; others, including improved techniques for ground water dating, fracture-flow modeling, and permeability determinations for low permeability rocks, need development.

DOE Statement at II-97. If essential techniques have not even been developed, there can be no confidence that a waste disposal repository will be in place in the forseeable future.

With respect to the development of models, on which DOE ultimately relies for its projections, DOE admits that a complete model for a waste disposal system will not be available until 1983, DOE Statement at II-203, that important models involving waste-rock interactions will not be verified and available until 1985, DOE Statement at II-222, and that models of thermo-mechancial impacts on ground water will not be verified until the end of FY 1987. DOE Statement at II-250. Finally, as it must, DOE is forced to admit that long-term models cannot be directly verified because the time scale is simply too long. DOE Statement at II-250. The most that the NRC can take from this is that models may be adequate by the mid-1980s to provide the information that would be needed to support a finding of "reasonable assurance" that a waste disposal repository can be in place by the year 2006. There is no support for such a finding today.

C. DOE's Reliance On Unsupported Assumptions Prevents A "Reasonable Assurance" Finding By The NRC

DOE's Statement of Position is rife with unsupported assumptions that may well ultimately appear as fatal flaws in its program. A simple example illustrates this problem. In referring to resource factors at the Richton salt dome, DOE notes that oil sand in the area "was shown to be noncommerical by extensive testing." DOE Statement at B-15. This bald statement is highly questionable in light of recent experience with potential sources of oil that had been abandoned or had been considered not developable. With permanently tightening oil supply and skyrocketing prices, virtually any oil resource may soon become commercially feasible. DOE must support its assumption with a demonstration that such likely developments will not render it invalid. Before it can have any degree of assurance on the basis of DOE's Statement of Position, the NRC must identify and demand support for all such questionable assumptions.

Far more important than unsupported assumptions on narrow factual issues is a fundamental fallacy that permeates DOE's entire Statement of Position. Given the inadequacy of available data and methods to evaluate its proposed waste disposal system, DOE is forced to fall back on the assumption that if it simply keeps working on the problem, it will one day find a solution. Indeed, DOE assumes that it will somehow find a solution within the relatively short time that is required to permit a waste disposal repository to be in full operation by the year 2006.

This assumption is reflected in DOE's summaries of the status of knowledge of natural systems and of the waste package:

> 6. The diversity of media under evaluation, the large number of potentially suitable sites contained in the areas and regions being studied, and the NWTS Program's ability to successfully screen for sites using criteria (II.D.3) and the available performance assessment techniques (II.F.1) will result in identifying, qualifying, and licensing repository sites.

DOE Statement at II-128.

> From this discussion, it is obvious that much remains to be learned about individual waste package components and their interactions within the waste repository environment. Nevertheless, a large body of information is available and it continually is growing. The large number of options open to the NWTS Program due to the diversity of the studies described provides a large measure of confidence that several acceptable waste package combinations will be identified. Based on currently availalbe knowledge, it is expected that the waste package system will meet the stated criteria.

DOE Statement at II-159-160.

In effect, DOE is saying that it is studying so many things in so many places that there must be an answer. In taking this approach to waste disposal, DOE is gambling with the future. Clearly, the NRC cannot adopt this irrational, dangerous theory.

While some degree of uncertainty in this area is inevitable, the NRC must make its prediction of future events on the basis of the factual record. To the minimal extent that DOE has a record on which the NRC can judge its ability to deal with the high-level waste issue, it is an abysmal one of fits and starts and failures. The only clear result of DOE's experience has been its recent loss of the Palestine dome. Surely, this failure cannot form the basis for confidence in DOE's future performance.

D. DOE Completely Fails To Address Political, Social, And Institutional Obstacles To Waste Disposal

In explaining the requirements that it must meet in order to show that the Commission can make a "reasonable assurance" finding with respect to waste disposal, DOE states that it must show that it is able

> (i) to understand and address in its program the technical, social, political, and institutional aspects of waste management....

DOE Statement at I-7. (Emphasis supplied). However, its Statment of Position is virtually devoid of any serious discussion of the obstacles posed by social, political, and institutional aspects of waste management or of how those obstacles can be overcome.

The social, political, and institutional obstacles to waste management have always been substantial and have grown considerably in recent years. For example, since 1976, approximately nineteen states have enacted some type of ban or moratorium on the siting of a waste repository within their borders. Countless local governments have done so as well, and both state and local governments have enacted severe restrictions on the transportation of nuclear wastes. Even the storage of low-level wastes is now uncertain with the recent closing or limiting of facilities in Nevada, South Carolina, and Washington. In addition, public acceptance of government and industry assurances is at a low ebb, and the public has virtually no confidence in the ability or credibility of the Department of Energy, the NRC, or the nuclear industry. Given the present situation, it is likely that more, rather than less, legislative action will be taken by state and local governments to restrict the options for waste management.

The lack of public confidence in DOE and the NRC and the unwillingness of the public to be saddled with the wastes of the nuclear industry pose major threats to DOE's ability to establish a waste repository and to the safety of that repository once it begins operating. DOE will have to obtain licenses or permissions at various levels, not the least of which should be an NRC license. With stiff public opposition likely, any public proceedings are likely to last for years. Eventually, DOE will probably be forced to take legal action to impose waste repositories on unwilling states and localities through Federal preemption. The result will be the imposition of a repository on an angry populace whose actions will be almost entirely unpredictable.

DOE has not seriously addressed any of these issues in its Statement of Position. Giving DOE the benefit of the doubt, its Statement contains less than ten pages on these points, DOE Statement at II-296, III-24-31, and III-87. Most of those consist of a discussion of how DOE hopes to communicate with state and local governments while the waste repository is being developed. DOE Statement at III-24-31. DOE simply assumes that state and public involvement will go well, and that its program will stay on track. DOE Statement at 31. DOE provides no basis for that optimism.

DOE concludes its treatment of sociopolitical issues with the following bland assurance:

> Because social concerns are less easily predicted, less confidence can be placed in assessment of their impacts on the repository program. Nonetheless, there is growing public recognition that nuclear waste management is a national problem and that solution of the problem should not be postponed for future generations.

DOE Statement of Position at III-87. That is nothing more than a convenient, self-serving assumption that the public will act as DOE would like. In fact, there is also a growing public resistance to the storage of nuclear wastes. Even those who support nuclear power do not want the wastes in their own back yard. It is quite possible that the Achilles heel of the nuclear waste program is public rejection rather than the technical issues that DOE discusses as such great length. DOE has shown nothing that provides any degree of confidence that political, social, and institutional problems can be overcome at all, much less in the time period at issue.

V. There Is No Basis For A Finding Of "Reasonable Assurance" That Spent Fuel Can Be Stored Safely On-Site Or Elsewhere For An Indefinite Period Beyond Expiration Of Existing Operating Licenses.

NECNP has obtained the services of Dale G. Bridenbaugh, of MHB Technical Associates, to address the question of long-term on-site spent fuel storage. His prepared statement, which is sponsored jointly by NECNP and the State of Illinois, constitutues this section of NECNP's Statement of Position. Mr. Bridenbaugh concludes, as the evidence dictates he must, that there is no basis for a present finding of "reasonable assurance" that spent fuel can be stored safely at the reactor sites or elsewhere for an indefinite period beyond the expiration of the existing operating licenses.

Since Mr. Bridenbaugh's statement was prepared as a single piece, NECNP has included all of it with its references and attachments in this part of NECNP's Statment of Position. All of the pages have been numbered to be in sequence with the rest of NECNP's statement. Mr. Bridengbaugh's page numbers are shown in parentheses.

By way of introduction, NECNP emphasizes the fundamental reason that the NRC cannot make a "reasonable assurance" finding on this issue -- the existing data and experience simply are not adequate to do so. DOE itself practically concedes this point when it states, with respect to its Draft EIS on waste management, that

> The data base for spent fuel's long-term stability is limited but is under development.

DOE Statement at II-31. If the data base is limited, long-term stability cannot be judged, and there is no basis for a "reasonable assurance" finding.

SAFETY OF SPENT FUEL MANAGEMENT
AND THE ADEQUACY OF
U.S. DEPARTMENT OF ENERGY WASTE PROGRAMS

Statement of Position

of

DALE G. BRIDENBAUGH

SECTION 1
INTRODUCTION

1.1: QUALIFICATIONS

I am a Professional Nuclear Engineer, technical consultant, and a founder and partner of MHB Technical Associates, technical consultants on energy and environment, with offices at 1723 Hamilton Avenue, Suite K, San Jose, California. I have participated as an expert witness in licensing proceedings before the U.S. Nuclear Regulatory Commission (NRC); have served as a consultant to the NRC; have testified at the request of the Advisory Committee on Reactor Safeguards; have appeared before various committees of the U.S. Congress and testified in various state licensing and regulatory proceedings, as is further discussed below. Additional details of my experience and qualifications are contained in Attachment A.

1.2: PURPOSE

The purpose of this statement is to provide input to the Waste Confidence Rulemaking proceeding on behalf of the New England Coalition on Nuclear Pollution (Coalition). My position, similar to that expressed by members of the Coalition, is that there is not at this time, based on past experience and the record of the responsible federal agencies, adequate assurance that safe waste disposal methods will be available between the years of 1997 and 2006, and, that on-site or interim storage can not be demonstrated to be suitably safe for the period of time that may be required before such safe ultimate disposal methods may become available. Lack of such assurance gives rise to concern over continued operation of commercial nuclear plants with licenses that may terminate before suitable disposal capability is available.

In general, this statement will be primarily limited to comments on those portions of the high-level waste program related to the handling and storing of spent fuel at reactor plants and/or at away-from-reactor or independent spent fuel storage facilities. However, since the time periods that may be involved at such "interim" facilities are strongly dependent on the schedule for the beginning of operation at the proposed National Waste Terminal Storage facility, input is also provided on the likelihood of NWTS schedule slippage, and its impact on the interim program is also provided.

SECTION 2

BACKGROUND OF WASTE DISPOSAL ISSUE

2.1: HISTORY

Until 1974, it was intended within the nuclear industry that spent fuel discharged from nuclear reactors would be commercially reprocessed in privately-owned reprocessing facilities. This was to have been a step in the ultimate disposal of the high-level radioactive waste,with the high-level waste product from the reporcessing plants to be turned over to the federal government within five years after separation. In 1977, the U.S. Government ruled that reprocessing of spent fuel would not be in the best interest of the United States due to the weapons proliferation hazard and declared a halt to all commercial reprocessing activities until further notice.

Subsequent to the cessation of reprocessing planning, in the fall of 1977, the U.S. Department of Energy (DOE) announced that a spent fuel disposal program would be offered to U.S. and foreign utilities. This program was to make available to the utilities on a full-cost recovery basis, a method for disposal of all fuel that had been discharged from operating reactors for five or more years. In the initial program, the DOE expected to build away-from-reactor (AFR) storage facilities to take care of the storage requirements until permanent disposal repositories had been developed, licensed, and placed in operation.

As of today, no federal AFR's have yet been built, or started, and the date for even beginning to work on permanent disposal facilities has not yet been determined.

The ability to manage and properly dispose of the high, intermediate, and low-level radioactive waste produced as a by-product of nuclear plant operation is a critical factor in assuring the safety and operating reliability of a nuclear plant. It must be recognized that governmental agencies other than federal may have vital stakes and influence on such matters. In one current licensing proceeding, the Shoreham plant being built by the Long Island Lighting Company, the transport of high-level waste from the Shoreham plant, located on Long Island, through the city of New York is an issue of vital concern to the city and the state. In recent actions by the respective governors, both the states of Nevada and Washington closed their borders to further transport of radioactive waste to the Beatty and Hanford storage facilities located within the states and they further have called for a drastic reduction of the amount of out-of-state generated waste that will be permitted to be "imported" in the future. [1/] Such actions vividly demonstrate the problems associated with the resolution of the multi-jurisdictional nuclear waste problem, and strongly indicate that early resolution cannot be expected with confidence.

2.2: CURRENT SITUATION

The absence of permanent high-level and low-level waste disposal capabilities has caused difficult problems for the planners and operators of the nation's commercial nuclear power plants. The potential disruption of the power supply to the nation's industry could cause vast losses, and backup supply plans are presently stymied. As a result of the lack of development of AFR storage facilities, almost all currently operating reactors are finding a need to expand the on-site storage capabilities.

Some currently operating plants are expected to fill all available on-site storage capability as early as 1983. Many will be short of spent fuel storage space by 1985. The NRC's Draft GEIS on Handling and Storage of Spent LWR Reactor Fuel [2/] estimates that even if fuel storage is compacted at all plants by a factor of 2.5, and if plants only operate at a 60% capacity factor, the following plants will lose storage and full core discharge capacity as indicated in Table 2-1.

Away-from-reactor facilities have still not been authorized, although the DOE Statement describes the expected schedule and details of project management. [3/] It is essential for both reliability and safety reasons that full core discharge capability be maintained for all operating reactors. Consequently, if no facilities are available by 1983-85, some of the operating plants listed in Table 2-1 may have to derate or shutdown in order to

TABLE 2-1

PROJECTED LOSS OF FULL CORE DISCHARGE

CAPACITY FOR U.S. PLANTS

YEAR	PLANT	STATE
1976	Point Beach-1 & 2*	Wisconsin
1980	Maine Yankee	Maine
1980	Prairie Island-1&2	Minnesota
1980	San Onofre-1*	California
1981	Oconee-1, 2, & 3	So. Carolina
1981	Robinson-2	So. Carolina
1982	La Crosse	Wisconsin
1982	Conn Yankee	Connecticut
1982	Turkey Point-3	Florida
1983	Fort Calhoun	Nebraska
1983	Indian Point-1	New York
1983	Calvert Cliffs-1 & 2	Maryland
1983	Kewaunee	Wisconsin
1983	Palisades	Michigan
1983	Surry-1 & 2	Virginia
1984	Turkey Point-4	Florida
1984	Indian Point-2	New York

* Some of the immediate pressure was relieved on these plants by shipment in 1978 and 1979 of some spent fuel to GE's Morris, Illinois Fuel Storage Facility. Future shipments are limited by the current small storage capacity of that facility.

ease the problem of disposal of spent fuel. The pressure to continue operation even though spent fuel storage is inadequate may ultimately lead to less conservative operations and an increased risk to the general public, as well as to persons working within the plants and storage facilities. It is therefore essential that adequate consideration be given to all aspects of the national waste storage program and the implications of delays and mismanagement on public health and safety.

SECTION 3

COMMENTS ON DOE'S STATEMENT OF POSITION

3.1: INTRODUCTION

The position of the U.S. Department of Energy regarding the likelihood that high-level commercial nuclear waste can be safely stored and disposed of is presented in the April 15, 1980 Statement of Position of the U.S. DOE. [4/] This document contains an extensive description of past, current, and expected future programs to be conducted by the DOE and other government agencies necessary to resolve the scientific, technical, and institutional issues needed to safety manage, store, and permanently dispose of spent fuel from commercial reactors. A review of the DOE statement was made to determine areas of technical or programatic weakness that might give evidence of a lack of confidence that the problem can be safely resolved by the time period of 1997 through 2006 as specified in the Proposed Rulemaking Order.

This section (Section 3) of this statement summarizes comments developed during our review of the DOE Statement. The comments are summarized in the following four categories:

1. Inadequacies of Evaluation Criteria and Regulations (Section 3.2)
2. Inadequacies in Consideration of Safety Issues (Section 3.3)
3. Technical Uncertainties (Section 3.4)
4. Schedule and Cost Uncertainties (Section 3.5)

As might be expected, a number of the issues overlap and are considered more than once for purposes of completeness. The following discussion addresses these issues:

3.2: INADEQUACIES OF EVALUATION CRITERIA AND REGULATIONS

The basis of the scope of the DOE Statement of Position is described on page I-2 of the DOE Statement. 5/ DOE's interpretation of the February 1, 1980 Order 6/ and, for that matter, the wording of the Order itself, appears to have resulted in an extremely narrow scope of consideration which causes the DOE Statement to be a less than adequate discussion of the issues. The key scope instructions contained in the February 1 Order were:

- That the proceedings should deal only with the disposal of spent fuel. 7/
- That the proceeding is concerned solely with high-level waste. 8/
- That reracking of spent fuel pools in various nuclear reactors is beyond the scope of the proceeding. 9/
- That the safety of transportation of spent nuclear fuel is beyond the scope of the proceeding. 10/

While it could be argued that placing these restrictions on the scope of the proceeding will make the evaluation narrow and incomplete, such argument is beyond the scope of this technical discussion. It must be recognized, however, that the aforementioned issues are real, are controversial in many cases, and could lead to substantial delay in the final implementation of permanent spent fuel disposal, and that these issues can impact heavily on the "timely" achievement of the desired objective. For example:

- In the issue of spent fuel versus reprocessing, it is precisely that issue which caused the current five to ten-year disruption to the high-level waste disposal program that began about 1974. At that time, the commercial viability of spent fuel reprocessing began to be heavily questioned, causing a serious disruption to the planning for high-level waste disposal as a result of the ultimate change in national policy.

- Low-level waste disposal has recently emerged as a point of major conflict between the various agencies at the federal and state levels and provides indication that similar problems may occur when attempts are made to move high-level waste accross state boundaries. 11/

- Spent fuel pool reracking has been defined as beyond the scope of this proceeding. It must be recognized that reracking of fuel pools at existing power plants has been an issue of contention at a number of plant sites with state governments taking a role in deliberating these issues in at least three different states. [12] Interim storage of spent fuel, as proposed by the DOE Spent Fuel Management Plan, calls for approximately 90% of the spent fuel to be stored in At-Reactor (AR) facilities up until the year 1995. If reracking cannot be achieved in a timely fashion, this will interfere significantly with DOE's plan and schedule.

- Transport safety has been identified as being beyond the scope of this proceeding. However, DOE does include in the DOE Statement a fairly extensive discussion of transportation considerations,[13] and it is recognized (at least by DOE) that successful transportation must play a major role in achieving the interim Away-From-Reactor (AFR) storage objectives. Considering the halt to licensing and extensive re-evaluation of objectives caused by the Three Mile Island accident, it is not difficult to imagine that a serious transportation accident in a major population center could cause a complete re-evaluation and re-thinking of the high-level waste transportation plan.

It is therefore our opinion that the proceeding's scope limitations imposed by the Presiding Officer of the Waste Confidence Rulemaking should be re-evaluated by DOE and other participants and that additional information and consideration be given concerning the impact that substantive changes in these four areas could make on the achievement of successful and permanent waste disposal in a timely fashion. This requirement is, in fact, recognized in the DOE Statement on page I-5, wherein DOE states:

> "In considering whether or not individual licensing proceedings should address the possibility that spent fuel might have to be retained at reactors beyond the expiration of their operating licenses, it is necessary for the Commission to determine whether or not off-site facilities for the disposal or storage of spent fuels will be available on a timely basis." (emphasis added) 14/

Additionally on that page:

> "The Department does not attempt to prove that safe disposal of these radioactive wastes, with the required approval of the appropriate regulatory authorities, can be achieved today. Rather, the Department shows that such disposal can be achieved within reasonable times (which are specified) upon completion of its current research and development and site exploration programs." (emphasis added) 15/

It is disconcerting to see that the re-institution of consideration of reprocessing has emerged as a serious possibility as recently as mid-June (1980). The House Interstate and Foreign Commerce Committee voted to amend the NRC's fiscal year-81 Authorization Bill[16/] to mandate the resumption of the GESMO proceeding. While this is only an indication of a possible change in national policy, it certainly demonstrates that the path to disposal of spent fuel as high-level waste is not a clear one.

In addition to problems with inadequacies in the DOE Statement evaluation criteria, the DOE Statement also suffers from serious deficiencies stemming from incomplete assessment of major programs. Following are examples of some of the more serious defects found:

- <u>Licensability</u>

  On page II-1, it is stated that the DOE's National Waste Terminal Storage program (NWTS) is designed to "develop licensable High-Level Waste (HLW) disposal systems during this century." In a footnote, licensable is defined to mean "consistent with regulatory requirements set forth by the Nuclear Regulatory Commission and the Environmental Protection Agency." While these are certainly regulatory requirements that must be met, they are by no means the only requirements that must be met. In fact, on that same page, it is found that the President's statement of February 12, 1980 concluded "the technical programs must meet all relevant radiological protection criteria as well as all other applicable regulatory requirements." 17/ The DOE's re-statement and re-definition of licensable, limiting it to mean only those regulatory requirements of the NRC and EPA, could lead one to believe that the NWTS program may not be considering all possible roadblocks.

- Quantification of Containment

  On page II-9 of the DOE Statement, DOE indicates that a portion of one objective is requiring containment systems be resistant to catastrophic failure. This requirement is further defined as:

  > "Any losses of containment would result in low release rates over long periods of time." 18/

  The problem with this statement is that there appears to be no quantified requirement for the definition of a "low release rate over long periods of time." Subsequent discussion in the DOE Statement could lead one to believe that low release rates may be quantifiable by the ALARA standard used in licensing nuclear plants. However, discussion at other places in the DOE Statement implies that release rate requirements for permanent waste disposal facilities must be more stringent than those for operating nuclear plants.[19/] This vague definition of containment is a defect that must be corrected.

- Cost Benefit Analysis

Objective 4 as discussed by the DOE Statement on page II-16 implies that decisions regarding the environmental impacts associated with waste disposal systems must be shown to be reasonable considering the "costs and benefits associated with potential mitigative measures and reasonable alternative courses of action." [20/] Throughout the remainder of the DOE Statement, discussion of costs and alternatives appear sporadically but nowhere in the Statement are details of how the cost benefit analysis is to be performed or when it will be performed. Certainly, the cursory discussion of disposal alternatives contained in DOE's Statement (pages II-27 through II-42)[21/] does not provide detail to perform a cost benefit analysis nor indicate that such an analysis is expected to be possible in the foreseeable future.

An additional category of concern in the DOE Statement has to do with findings of confidence of conducting the high-level waste disposal program in accordance with appropriate standards and regulations. DOE seems convinced that this represents no problem, but readily admits that standards and regulations do not yet exist. For example:

- On page II-4, DOE finds that "although specific technical criteria from NRC and EPA would be useful at this time in directing the NWTS program, they will not be critical to the conduct of the program until detailed waste disposal system designs are being developed." 22/ A primary tenet of the NRC's quality assurance criteria is that quality cannot be legislated, it must be designed in from the beginning. Taking such a cavalier approach to lack of standards from EPA and NRC seems tantamount to setting the system up for failure.

- Delineation of DOE's "pertinent points" considered in structuring objectives as listed on page II-6, is generally useful but in some cases the points are so rudimentary as to be of little value in evaluating confidence. 23/ For example, the fact that "the environment must be protected" seems hardly to be a revolutionary concept.

- Information as to when the EPA will issue numerical standards concerning long-term releases is not yet available. For example, the DOE Statement indicates that the EPA numerical standards, to be designated 40 CFR 191, are not yet proposed. 24/ General guidelines concerning comparison of releases to the impact of background radiation are contained in the Statement but agreement on establishment of universally-accepted standards will require considerable time, particularly since they deal with countless future generations who may receive no benefit to counterbalance the risk imposed. Some of the alternatives to mined geologic disposal would seem to incompass near-impossible regulatory or jurisdictional resolution. For example, subseabed disposal of high-level waste is reported to be in violation of the U.S. Marine Protection, Research and Sancturary Act of 1972 and similarly, is probably in violation of international laws. 25/ This fact alone may remove it from the status of a viable contender for the period of time in question.

- The DOE Statement contains conflicting discussion of the probable requirements of waste disposal facilities. On page IV-4 it is indicated that:

> "If adopted as presently written, the guideline value of 10 CFR 72.67(b) will impose a substantially more conservative requirement on independent spent fuel storage installations than is imposed on reactor and fuel reprocessing facilities." 26/

However, on page IV-23, DOE states that:

> "None of these regulations (10 CFR 30, 10 CFR 40, 10 CFR 50, and 10 CFR 70) is completely applicable to licensing of spent fuel storage facilities when they are separate from either reprocessing plants or nuclear power plants, for several reasons. The prospective duration of storage activity at an AFR is comparable to that at power reactors, but the requirements of 10 CFR 50 are unnecessarily stringent for an independent facility storing aged fuel." (emphasis added)

To summarize our comments on evaluation criteria and regulations, our review leads us to believe that the state of development has not proceeded to the point that the confidence has been demonstrated that safe waste disposal will be achieved by the year 2006. Substantial additional safety, technical, and schedule uncertainty additionally exists and will be discussed in subsequent sections of this report. However, it seems unlikely that a finding of confidence can be demonstrated when the basic elements for evaluating compliance and adequacy have not yet been devised.

3.3: SAFETY ISSUES

Review of the DOE Statement has identified a number of safety issues related to the management and handling of spent fuel where DOE has presented incomplete or inadequate information to permit a finding of "confidence." Following is a discussion of some of those considered to be more significant:

- Incomplete Safety Analysis

  The DOE Position Statement does not include a complete safety analysis of the integrated operation of the storage and disposal systems. The basic reason for this deficiency is that it is not known at this time what will make up the integrated system. DOE reports, for example, that:

  > "studies to optimize the integrated system have not been completed." 28/

  and:

  > "Operational phase risks can be partially assessed in terms of those Commission requirements which appear relevant." 29/

  The DOE Position Statement does contain a discussion of example safety analyses and commitments to perform safety analyses as system designs are completed. 30/ This does not, however, assure that appropriate action or design changes will be accomplished to correct any shortcomings.

- Inadequate Consideration of Retrieval

The DOE Statement of Position contains a description of waste implacement and retrieval considerations. 31/ Three retrieval cases have been considered. The most difficult retrieval case considers the retrieval of waste and abandonment of the repository that could be required if tests and acquired data show that a sufficient degree of confidence (of long-term acceptability) could not be provided. 32/

Unfortunately, this retrieval case is assumed to occur near the end of the repository operational phase and thus is not the worst case since all of the repository would not have been backfilled and facilities and experienced personnel would still be in place. DOE should evaluate retrieval from a completely filled repository after a sufficient period of time that temperature and exact location would make retrieval and handling of the fuel a more uncertain operation. This would then be followed by surface handling of the fuel, presumably in water-filled storage pools, trans-shipment, etc.

- Higher Exposure Fuel

  The DOE Position Statement discusses to some extent safety considerations for the storage of fuel that developed defects in reactor and for handling of fuel damaged during storage and/or shipment.[33/] Subjective predictions were made that past experience with handling of fuel indicates this will present no problem in the future. However, little experience has been developed to date with the handling and storage of aged or defective fuel with the high burnups now anticipated for future fuel design. This should not be an insurmountable problem but is one that does impose some uncertainty on the safety of extended interim storage and handling of fuel.

- Emergency Unloading of Pools

  It is quite likely that extended interim storage of spent fuel at reactor sites will be required. DOE anticipates that AR storage facilities will contain 90% or more of the spent fuel at least through 1995.[34/] No consideration appears to have been given in the DOE Statement of Position concerning the possible emergency requirement to unload spent fuel storage pools. Possible scenarios for this requirement are discussed in testimony presented before the California Energy Commission. [35/] Selected portions of this testimony are attached as Appendix B. Evaluation of this possible action should be included by DOE in their Statement.

- <u>Inadequate Assessment of Regulatory Change Impact</u>

  Continual re-evaluation of regulatory requirements concerning operating nuclear plants has become a fact of life and will undoubtedly be true regarding interim AR, AFR, and IFSF facilities. In most cases, modifications can be made to reactors and primary systems at nuclear plants because it is possible to unload reactor fuel into on-site storage pools and perform necessary modifications. Should storage pool regulations change, modifications are much more difficult since there is in general no convenient redundant storage facility into which the spent fuel can be discharged. This could be overcome by modular design of pools at AFR's, but such a requirement has not been imposed on existing facilities. Accordingly, the DOE Position Statement should be expanded to consider the potential impact of such backfit requirements.

- Lack of Design Requirements on Existing Storage Pools

  The DOE Position Statement contains an extensive section entitled, "Achieving Safe and Environmentally Acceptable Water Pool Storage." 36/ This section contains a number of misleading statements concerning spent fuel storage pool design. Following are some of the more significant omissions.

  - Multiple Containment Systems

    The statement is made on page IV-30 that:

    "Multiple containment systems are a feature of the design of spent fuel storage facilities."

    Included in the multiple barriers are the ceramic fuel pellet, the fuel cladding, and the storage pool and water purification system. While it is true that these three factors inhibit the release of radioactive material to the environment, these features are in no way provided to uniquely improve the design of the spent fuel storage facility. They are a design requirement for reactor operation and provide, as a side benefit, some benefit for long-term or interim fuel storage.

- Fuel Unloading Pools

  Page IV-31 describes the design of the fuel storage pool to prevent leakage and discusses features provided to prevent damage to the pool through the dropping of a fuel shipping cask or tipping of same. It should be pointed out that "Control of Heavy Loads Near Spent Fuel" continues to be identified by the NRC as one of the "Unresolved Safety Issues." 37/

  Most existing operating reactors which will contain most of the spent fuel in their storage pools through the year 2006 were not originally designed with the storage pools in compliance with the generic criteria that are to be developed. Since very little fuel has been shipped from operating reactors, rapid implementation of plant modifications has not been considered essential. It should be recognized as a potential problem at most existing AR pools.

- Criticality Prevention

  The DOE Position Statement indicates on page IV-33 that proposed regulation 10 CFR 72 would require use of a "double contingency principle" to assure subcriticality at all times during fuel handling and storage activities. It again must be emphasized that regulation 10 CFR 72:

a. does not yet exist,

b. will not apply to AR pools, at reactor plants, and

c. may not be applicable (in a practical sense) at the AR pools that will contain more than 90% of the spent fuel for the next 15-20 years.

- Other Design Requirements

The DOE Position Statement specifies on page IV-35 that proposed 10 CFR 72 will:

a. Require design basis earthquake to have a peak horizontal ground acceleration of 0.25g with a recurrence interval of at least 500 years.

b. A design basis tornado with a maximum wind speed of 360 mph.

c. Require that vent stacks be so designed and located so that collapse or fall of a stack would not result in damage.

Additional requirements are delineated in Table IV-6.[38/] It again must be emphasized that proposed 10 CFR 72 does not yet exist, it will not apply to AR storage pools, and that the 70 to 100 reactor facilities and associated storage pools now in operation or under construction will not likely comply with the requirements specified.

3.4: TECHNICAL UNCERTAINTIES

Our review of the DOE Statement of Position has disclosed a number of technical areas where uncertainty exists as to the adequacy of knowledge concerning the long-term performance of materials and systems to ensure safe, fully contained waste storage. Many of these problem areas were previously identified in the MHB Spent Fuel Disposal Costs Report. 39/ A copy of Section 2 of that report is provided in Appendix C for ready reference. These uncertainties generally do not represent potential causes of "catastrophic accidents," but are technical problems requiring resolution before confidence in the program will exist. They are, by their nature, problems that require years of investigation or testing as opposed to technological breakthroughs. This fact is demonstrated by the DOE Objective stating that disposal should not depend upon "scientific breakthroughs." 40/

The DOE program does discuss the need for ongoing research and investigation. The remainder of this section will highlight where the DOE Position Statement is dependent upon the timely resolution of certain technical issues.

- Fuel Integrity During Handling and Pool Storage

  The major technical concern during the uncertain interim storage period is whether or not the discharged spent fuel bundles will maintain integrity and adequately contain the radioactive materials isolated within the rods. Statements in the DOE Position indicate that experience with water pool storage of spent fuel typical of today's design and burnup is limited to 20 years for Zircaloy-clad fuel and 12 years for Stainless steel-clad fuel. However, DOE speculates that the studies of corrosion rates indicate "no obvious degradation mechanisms" which would be expected to cause failures before 50 years or longer. 41/

Details of spent fuel storage experience are found in the DOE Statement with both burnup and storage time experience found on pages IV-50 through 62. Some rather high exposure fuel is reported (62,000 MWd/MTu) but these were only high burnup demonstration rods and do not represent bulk commercial fuel. It must be recognized that the burnups and storage times indicated in the DOE Statement do not represent exhaustive experience with significant quantities of commercial fuel. One of the key documents referenced on experience by DOE is a report by A.B. Johnson, Jr., of Battelle Northwest. 42/

Dr. Johnson appeared as a witness on corrosion of fuel and metals in the Zion Reracking Hearing. 43/ Under cross-examination, Johnson stated that most of information in his study came from third parties and that most of the data upon which he based his Zion assessment of long-term integrity fuel cladding was acquired through visual inspections, inspections which can detect only advanced stages of cladding degradation.[44/] Additional information on technical uncertainties was uncovered in the Zion case cross-examination of expert witnesses. Although the Atomic Safety and Licensing Board ultimately ruled against the State of Illinois in that case, portions of the State's Proposed Findings of Fact and Conclusions of Law in this case are attached as Appendix D. for background information on the state of technical uncertainties concerning long-term spent fuel storage. These were prepared and verified by my partner, Gregory C. Minor, as an accurate reflection of the record.

- Storage Facility Problems

Some uncertainty exists as to the long-term performance of materials and systems making up the water pool storage facility. One of the major concerns affecting the technical uncertainty of storage facility life is the fact that the majority of the AR facilities were not designed with long-term storage in mind. This has been discussed previously in Section 3.2. The DOE Position Statement indicates generally that no problems are to be expected as the technology is fairly standard and no problems of rapid degradation or failure are expected. This is generally true, but the concern still exists that fuel storage has only existed for approximately 30 years and there is no assurance that it will not be required for substantially longer periods of time. Corrective action could be difficult if problems develop since few alternate storage facilities are available. Potential problems that could jeopardize the ongoing operability of pool storage facilities are:

- Material Failures in the Pool Liner and Cooling Circuits

  An example of such failures are those identified the NRC's I&E Bulletin No. 79-17, which reported a generic problem with pipe cracks in stagnant, borated systems at PWR plants.[45] These problems are continuing to be investigated and provide some degree of uncertainty that long-term interim storage can be safely accomplished without modifications and fuel shuffling.

- Maintenance of Multiple-Barrier System

  One of the key points made in the DOE Statement is that spent fuel storage has the benefit of multiple barriers inhibiting the accidental release of radioactive materials. There are points of weakness in the design however, and current material failures seen in BWR's and PWR's gives evidence of potential failures that could accidentally release radioactive liquids to the evironment. For example, at the Morris Operation Fuel Storage Facility in Illinois, the spent fuel storage pool cooling is accomplished by an externally located water-to-air fin-fan cooler. Pool water is pumped directly through this cooler for removal of decay heat. Several years ago, the fin-fan cooler experienced a freeze failure during unusually cold winter weather and subsequently leaked contaminated water to the environment.[46/]

- Structural Integrity of Racks and Neutron Absorbers

  Almost all existing AR pools are being modified to provide for high-density fuel storage. In some cases, this requires the addition of neutron-absorbing materials in the racks. Boral plate is the most commonly used material. Problems have been experienced with boral swelling due to hydrogen generation as a result of the aluminum-water reaction.[47/] The fix proposed for this problem in some cases has been to provide gas vent holes in the stainless steel sheath surrounding the boral, but this then gives rise to questions concerning the long-term corrosion rate of boral in stagnant high oxygen water. Testimony on these problems was provided in the Zion case by a Dr. Draley. Under cross-examination, Draley acknowledged that boral corrosion testing has been limited and that little long-term experience is available. 48/ Additional information on this subject is found in the attached Appendix D.

- Assurance of Continuing Programs

The DOE Statement contains information regarding the proposed on-going programs to investigate and evaluate integrity of spent fuel during storage. 49/ It must be recognized that these programs are very modest in scope and could be easily terminated from year to year through budget limitations imposed by the U.S. Congress on DOE and NRC. To give some idea of the scope of the programs, Dr. Johnson acknowledged under cross-examination in the Zion hearing that the data base for physical testing of spent fuel cited consisted of a total nine spent fuel rods, tested in Great Britain. 50/ Hopefully, the on-going program will be more extensive than that, but there is no assurance that that will be the case.

In summary, a number of technical uncertainties exist that must be considered when evaluating the confidence that long-term interim storage of spent fuel can be accomplished safely. (See also Appendix C.) Until several years ago, little attention was given to this subject since long-term storage was not contemplated and no research programs were in place to consider the impact of long-term storage. Uncertainties exist in understanding the long-term corrosion rates of fuel and storage pool materials under conditions of high oxygen and stagnant water. Catastrophic-type failures are not expected, but a slow degradation of all materials, coupled with inability to establish a viable facility for the terminal disposal of spent fuel could result in uncontrolled leakage of radioactive materials to the environment.

3.5: SCHEDULE AND COST UNCERTAINTY

One of the most certain factors in the U.S. nuclear program is that schedules and cost estimates are almost always under-predicted. Design and construction time factors are presented in some detail in the DOE Statement. The reference schedule for activities leading to a geologic repository operation shows earliest repository operation in 1997. 51/ We find no fault with the logic underlying the assumptions of task times presented on the network schedule but history has seldom demonstrated that schedules for complex projects of this nature are achieved. It would appear that the following aspects have been omitted or underestimated:

- The reference schedule shows a "public interaction" function as a non-critical path activity culminating in site acceptance in 1987 and repository acceptance in 1997. In an undertaking of this nature with the intention of licensing to be conducted in compliance with NEPA requirements, it is likely that substantial delays will be experienced in the hearing process. It is not uncommon today for the design, licensing, and construction of a relatively standard nuclear power plant to take as long as 15 years, so it is not likely that the complex assortment of tasks involved in the establishment of the NWTS could be accomplished in the same time.

- No time appears to be specifically designated on the network as "contingency" time, time to reorient project direction in case of changing national policy, etc. While the text of the DOE Position Statement implies that appropriate time has been included in the tasks for such activities, it would be a more conservative approach to specifically identify such possible delays.

As to schedules for the establishment of Away-From-Reactor storage facilities, the DOE Statement readily admits that only the conversion of existing facilities (Morris, Barnwell, and/or West

Valley) would provide the possibility for the establishment of AFR's near term. [52/] "Near term" is defined as within the next 8 to 9 years. Recognizing that the conversion of these facilities to long-term interim storage capacity will likely be contested by local citizens and their respective state governments, it is quite likely that the 8 to 9 years may be an optimistic schedule even for existing facilities. This illustrates what has been, and is likely to be, the greatest difficulty in achieving resolution of high-level spent fuel storage. The institutional problem of decision-making with the various and overlapping governmental bodies is near impossible to overcome. This is recognized as a problem and discussed to some degree in the DOE Statement under "Cooperation With States." [53/] Given the difficulty of estimating the impact of such institutional problems, it does not appear that a suitable basis for confidence that schedules will be met has been demonstrated.

Cost estimates are also briefly addressed in the DOE Statement. The estimates seem to be limited to those involved only with the physical design and construction of waste facilities and therefore seem to greatly underestimate the total cost of ultimate waste disposal. The section of the DOE Statement summarizing the total Away-From-Reactor storage and geologic disposal costs of spent fuel is less than 2 pages long.[54/] No mention is made of R&D costs, and the primary references cited are a preliminary estimate published in 1978 by DOE [55] and citation of general conclusions reached by the International Nuclear Fuel Cycle Evaluation Study. [56] While it is recognized that the purpose of the DOE Statement in this proceeding was not to accurately quantify the total cost of the program, it would appear that a much more extensive financial discussion of the total program, including expected level of R&D costs, commitment of manpower, etc. should be developed to fully describe the program underway.

SECTION 4

OPERATING EXPERIENCE AND OTHER RELEVANT INFORMATION

4.1: INTRODUCTION

The DOE Statement of Position has taken the nuclear industry's general position that the interim storage of spent fuel is technologically a non-demanding task and that pool storage represents a benign activity. This attitude undoubtedly stems from the fact that comparing the demands of operating the at-reactor pool storage facility to the demand of operating a reactor safely for one year could easily lead to the conclusion that pool storage is no concern. There are, however, a number of issues associated with the storage of spent fuel that can impact on plant safety and on the possibility of accidental release of radioactivity to the environment. These additional concerns should be evaluated thoroughly and included in the consideration of the adequacy of the DOE Statement of Position.

4.2: IMPACT OF EXTENDED ITERIM FUEL STORAGE AT REACTOR SITES

One aspect of the waste storage program not completely considered in the DOE Position Statement is the potential impact that expanded and extended at-reactor storage of spent fuel on plant operations. The storage of spent fuel at reactor sites has very little effect during normal operation, but substantial interaction can occur during periods of shutdowns or unusual maintenance activities. Several of these interrelationships are discussed in Appendix B, but will be repeated here because of their importance in this issue.

At the present time, there is no requirement specified by the NRC that operating reactors should maintain full core discharge capability. The basis for the NRC's position in this regard is that full core discharge capability is not a safety consideration but is rather, desirable from an operating flexability standpoint. Before allowing pools at reactors sites to fill up with large quantities of spent fuel, this position should be re-evaluated. It is not uncommon for failures of one kind or another to require that reactor cores be fully discharged so that radiation levels can be reduced or water levels be lowered in reactor vessels in order to accomplish special maintenance activities Examples of such activities are:

- Repair of BWR feedwater spargers.
- Repair of BWR feedwater nozzle cracks.
- Removal of fuel for inspection of lower vessel surfaces.
- Draining of complete primary system for repair of non-isolatable piping systems, etc.

It is possible to postulate certain sequences of events where a relatively rapid unloading of the reactor vessel could be required. Similar scenarios can be developed for the need to unload spent fuel storage pools. For example, Commonwealth Edison testified in the Zion reracking case that accidents are conceivable that could cause complete draining of the spent fuel storage pool in a matter of approximately one day.[57/] Also, as outlined in Appendix B, almost all spent fuel storage pools leak. Fuel handling activities continually impose the risk of liner ruptures and the need to drain and clean the spent fuel storage pool for repair or modifications is a real possibility that must be considered.

In evaluating the risk imposed by the increased at-reactor storage of spent fuel, a different perspective must be taken. Extended storage is not directly comparable to the risk of operating a nuclear plant. If a problem develops with an operating plant, multiple systems are provided to bring about achievement of safe shutdown of the nuclear reaction. Safe shutdown of a spent fuel storage pool requires the removal to another secure place of the radioactive material it contains.

Additionally, the potential requirements of future regulations or the dictates of future experience must be considered before judging that the buildup of spent fuel at reactor sites can be managed with confidence. Consideration of the possible need for a plant design upgrade program which would bring spent fuel pool standards up to those alluded to in DOE's Position Statement under consideration for 10 CFR 72 should be studied. [58/]

The difficulty that such modifications may impose in the future, along with the likely reduction of occupational exposure standards must be evaluated. It is essential that the political expedient of "resolving" the high-level waste disposal problem in the United States does not serve to foreclose options that may become necessary or environmentally desirable in the future. Room for maneuvering and spa for re-evaluating direction must be provided in order to avoid the nuclear equivalent of a Love Canal.

SECTION 5

CONCLUSIONS & RECOMMENDATIONS

5.1: CONCLUSIONS

The conclusion reached from review of the DOE Position Statement and from re-evaluation of the associated plans and supporting documentation are that a great deal of uncertainty still exists in the U.S. Government's Program to develop safe high-level waste disposal no later than 2006. Much of the scientific/technical uncertainty resides in the selection and verification of the geologic (or alternate disposal method) medium. Much uncertainty exists in the institutional and decision processes involving the numerous local, state, national, and in some cases, international bodies. The total of these two uncertainty categories introduces substantial uncertainty into the overall waste disposal schedule and makes the task of planning for and managing the interim storage and handling program very difficult. Following is a summary list of the major points of concern leading to a lack of confidence that the program will produce the desired outcome:

- There is a lack of confidence that U.S. Policy will continue to call for spent fuel (as discharged from commercial reactors) to be the ultimate waste form for disposal.

- The length of time that At-Reactor (AR), Away-From Reactor (AFR), or Independent Fuel Storage Facilities (IFSF) may be required to function is uncertain.

- The quantity of fuel that will need to be handled in AR's, AFR's, and IFSF's is uncertain.

- Management and financial responsibility for the AR's and for privately-owned AFR's and IFSF's, if the interim time period becomes substantively extended, has not been clearly defined.

- Technical and safety problems associated with extended time periods at AR's and AFR's have not been carefully assessed. These problems include possible logistic interactions with operating reactors, long-term corrosion problems, and storage pool leakage problems.

- The need to impose more stringent standards and regulations on the large number of already existing AR facilities has not been assessed.

- Alternative emergency action plans, such as would fulfill the need to rapidly unload a filled AR storage pool, have not been developed.

- The potential impact of more restrictive occupational exposure or environmental release standards have not been considered in assessing the confidence of safe waste disposal.

5.2: RECOMMENDATIONS

Before a finding of confidence can be made, the following is the minimum additional work that should be completed to assure the safety of (extended) interim management and storage of spent fuel:

- Appropriate guiding standards and regulations must be developed and enacted.
- A program of re-evaluation of all existing and in-construction facilities to determine compliance with the new standards should be developed.
- Detailed emergency action plans, designed to mitigate the effects of conceivable events and policy and program changes should be developed.
- Firm commitments should be made to fund and complete necessary R&D programs, and to institute new programs as needs are determined.

- Evaluation of the waste disposal programs commitment to nuclear Quality Assurance requirements should be conducted and an overall Quality Plan developed.

- A complete safety assessment of the total integrated waste disposal program, including all expected or projection variations should be conducted. The assessment should be updated and publicly reviewed periodically.

DALE G. BRIDENBAUGH

JUNE 27, 1980

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1/ Science, Vol. 206, Oct. 26, 1979, pages 431-433.

2/ NUREG-0404, Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel, U.S. Nuclear Regulatory Commission, March, 1978, Vol. 2, page F-39.

3/ DOE/NE-007, Statement of Position of the United States Department of Energy, U.S. Nuclear Regulatory Commission, April 15, 1980.

4/ Ibid 3.

5/ Ibid 3, page I-2.

6/ First Prehearing Conference Order, signed by Presiding Officer Marshall E. Miller, February 1, 1980.

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8/ Ibid 6, page 10

9/ Ibid 6, page 10.

10/ Ibid 6, page 11.

11/ Ibid 1.

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14/ Ibid 3, page I-5.

15/ Ibid 3 page I-5.

16/ Nucleonics Week, June 19, 1980, page 12.

17/ Ibid 3, page II-1.

18/ Ibid 3, page II-9.

19/ Ibid 3, page IV-4.

20/ Ibid 3, page II-16.

21/ Ibid 3.

22/ Ibid 3, page II-4.

23/ Ibid 3, page II-6.

24/ Ibid 3, page II-13.

25/ Ibid 3, page II-33.

26/ Ibid 3, page IV-4.

27/ Ibid 3, page IV-23.

28/ Ibid 3, page I-29.

29/ Ibid 3, page II-275.

30/ Ibid 3, page II-276 & 279.

31/ Ibid 3, page II-280.

32/ Ibid 3, page II-281.

33/ Ibid 3, page IV-55 & 56.

34/ Ibid 3, page V-10.

35/ Testimony by D.G. Bridenbaugh before the California Energy Resources Conservation and Development Commission, March 10, 1977.

36/ Ibid 3, page IV-26.

37/ NUREG-0510, Identification of Unresolved Safety Issues Relating to Nuclear Power Plants, Report to Congress, U.S. Nuclear Regulatory Commission, January, 1979.

38/ Ibid 3, page 36.

39/ Spent Fuel Disposal Costs, report prepared for the Natural Resources Defense Council by MHB Technical Associates, August 31, 1978.

40/ Ibid 3, page II-18.

41/ Ibid 3, page I-26.

42/ Johnson, A.B, Annual Report - FY 1979, Spent Fuel and Fuel Component Integrity, PNL-3171, and earlier versions.

43/ U.S. NRC Docket Nos. 50-295 & 50-304.

44/ State of Illinois Proposed Findings of Fact and Conclusions of Law, Docket Nos. 50-295 & 50-304 (Zion Reracking), July 25, 1979.

45/ I&E Bulletin 79-17, Rev. 1, Pipe Cracks in Stagnant Borated Water Systems at PWR Plants, October 29, 1979.

46/ Verbal communication from General Electric.

47/ Weeks, J.R., Corrosion Consideration in the use of Boral in Spent Fuel Storage Pool Racks, BNL-NUREG-25582, Dec. 1978.

48/ Ibid 44, #61.

49/ Ibid 3, page IV-58.

50/ Ibid 44, # 52. & 53.

51/ Ibid 3, page III-81.

52/ Ibid 3, page V-20.

53/ Ibid 3, page V-14.

54/ Ibid 3, page VI-13 & 14.

55/ U.S. Department of Energy, Preliminary Estimates of the Change for Spent Fuel Storage and Disposal Services, DOE/ET-0055, July, 1978.

56/ International Nuclear Fuel Cycle Evaluation, INFCE Working Group 7, Waste Management and Disposal Summary, INFCE/WG.7/2, Rev. 2, page 10, Nov. 1979.

57/ Ibid 44, # 27.

58/ Ibid 3, pages IV-33 through IV-36.

APPENDIX A

EXPERIENCE AND QUALIFICATIONS
OF
DALE G. BRIDENBAUGH

I am a graduate engineer thoroughly familiar with the design, construction, and operation of nuclear generating plants, including the operational aspects of equipment and system failures, fuel supply, handling, and waste disposal, and other problems that could lead to adverse safety and reliability consequences. I received a B.S. in Mechanical Engineering from the South Dakota School of Mines and Technology in 1953, and have since been registered in the state of California as a Professional Nuclear Engineer.

For approximately twenty-two years, until February 1976, I worked as an engineer and manager with the General Electric Company on a wide variety of most aspects of power generation equipment design, manufacture, installation, and operation. During the last ten of those twenty-two years, I held management positions in the area of construction, operation, maintenance, and evaluation of nuclear power plants. My responsibilities included the development of cost estimates, schedules, and plans associated with the operation of those plants, and substantial effort was spent on resolution of problems affecting plant performance including primary system, containment, fuel, fuel storage pool leaks, fuel handling problems, and other portions of the plant and equipment.

Since the fall of 1976, I have been a partner and consultant with MHB Technical Associates. In this capacity I have analyzed reactor safety as a consultant to the Union of Concerned Scientists in a study of the Nuclear Regulatory Commission's Reactor Safety Study, WASH-1400 (the "Rasmussen Report"). Following completion of this study, my firm was engaged by the Swedish Energy Commission to perform a detailed risk analysis of the Barsebäck Swedish nuclear plant. This study was completed and presented to the Government of Sweden in April, 1978.

In 1978, I was retained as a consultant by the U.S. Nuclear Regulatory Commission to review the Light Water Reactor (LWR) Safety Improvement Plan. In 1979, I performed, along with my two partners, a major study for the U.S. Department of Energy, through the Sandia Corporation, to further define safety improvement programs for light water reactors.

In 1977, I testified before the New York State Public Service Commission considering approval of the Jamesport Nuclear Plant proposed by the Long Island Lighting Company, concerning the financial and power generating reliability aspects of unresolved safety issues of the proposed plant.

During the past two years, I have been a consultant to the state of New Jersey on three different projects. The first was a review of the proposed floating nuclear plant to be located off the coast near Atlantic City. The issue of concern to the state was the potential impact such a plant may have on the tourism and fising industries. The second project was to provide technical advice on the U.S NRC hearing concerning the proposed expansion of the fuel storage facilities at the Salem nuclear plant. The third project currently underway is to evaluate the causes of the extension of the Salem-1 1979 refueling and maintenance outage.

In 1978, I presented testimony before the Oregon Siting Council in the case of Portland General Electric's proposed Pebble Springs plant to be located in Oregon. The issues addressed in this testimony were the probable impact of the continued lack of resolution of high-level waste disposal on the reliability of the plant.

In 1978, I presented testimony before the Louisiana Public Service Commission in the case of the Gulf States Utility's River Bend Plant. Issues addressed in this study and testimony were the potential cost of unresolved safety issues, waste disposal, and decommissioning on the partially-completed plant which is scheduled for operation in 1985. The essence of this testimony was that the various unresolved problems confronting nuclear power could result in substantially increased costs to the consumer and in loss of generating capability due to a possible early shutdown of the plant.

In 1977, I was retained by the California Energy Commission to prepare and present information concerning the potential costs of decommissioning of nuclear power plants to be presented in the Sundesert case. The essence of my testimony was that decommissioning costs have not been carefully estimated nor have necessary provisions been made and that an amount equal to approximately 10% of the initial capital cost of the plant should be accrued for each plant and retained, with appropriate escalation provisions, to ensure that funds are available for future decommissioning.

In 1978, and continuing through to the present, I have served as a consultant to the Attorney General of the state of Illinois. Most of the work performed in that capacity has been involved with the assessment of environmental and public health risk imposed to the state by the presence of the General Electric Company's Morris Operation fuel storage facility located near Morris, Illinois.

In 1977 and 1978, I per formed a study of the expected cost of spent fuel disposal for the Natural Resources Defense Council, based on the proposed Spent Fuel Policy announced by the Department of Energy in 1977. This study was described in an August, 1978 report entitled Spent Fuel Disposal Costs. The study determined that much uncertainty exists in cost calculating but that disposal cost could add an increment of from 1.2 to 8.0 mills/KW-hour to the cost of electrical generation.

Additional details of my education, experience, and testimony and publications are summarized in my resume which follows.

RESUME

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San Jose, CA 95125
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EXPERIENCE:

1976 - PRESENT

Partner, MHB Technical Associates, San Jose, California
Co-founder and partner of technical consulting firm. Specialists in energy consulting to governmental and other groups interested in evaluation of nuclear plant safety and licensing. Consultant in this capacity to state agencies in California, New York, Illinois, New Jersey, Pennsylvania, Oklahoma and Minnesota and to the Norwegian Nuclear Power Committee, Swedish Nuclear Inspectorate, and various other organizations and environmental groups. Performed extensive safety analysis for Swedish Energy Commission and contributed to the Union of Concerned Scientist's Review of WASH-1400. Consultant to the U.S. NRC - LWR Safety Improvement Program, performed Cost Analysis of Spent Fuel Disposal for the Natural Resources Defense Council, and contributed to the Department of Energy LWR Safety Improvement Program for Sandia Laboratories. Served as expert witness in NRC and state utility commission hearings.

1976 - (FEBRUARY - AUGUST)

Consultant, Project Survival, Palo Alto, California.

Volunteer work on Nuclear Safeguards Initiative campaigns in California, Oregon, Washington, Arizona, and Colorado. Numerous presentations on nuclear power and alternative energy options to civic, government, and college groups. Also resource person for public service presentations on radio and television.

1973 - 1976

Manager, Performance Evaluation and Improvement, General Electric Company - Nuclear Energy Division, San Jose, California.

Managed seventeen technical and seven clerical personnel with responsibility for establishment and management of systems to monitor and measure Boiling Water Reactor equipment and system operational performance. Integrated General Electric resources in customer plant modifications, coordinated correction of causes of forced outages and of efforts to improve reliability and performance of BWR systems.

1973 - 1976 (Contd)

Responsible for development of Division Master Performance Improvement Plan as well as for numerous Staff special assignments on long-range studies. Was on special assignment for the management of two different ad hoc projects formed to resolve unique technical problems.

1972 - 1973

Manager, Product Service, General Electric Company - Nuclear Energy Division, San Jose, California.

Managed group of twenty-one technical and four clerical personnel. Prime responsibility was to direct interface and liaison personnel involved in corrective actions required under contract warranties. Also in charge of refueling and service planning, performance analysis, and service communication functions supporting all completed commercial nuclear power reactors supplied by General Electric, both domestic and overseas (Spain, Germany, Italy, Japan, India, and Switzerland).

1968 - 1972

Manager, Product Service, General Electric Company - Nuclear Energy Division, San Jose, California.

Managed sixteen technical and six clerical personnel with the responsibility for all customer contact, planning and execution of work required after the customer acceptance of department-supplied plants and/or equipment. This included quotation, sale and delivery of spare and renewal parts. Sales volume of parts increased from $1,000,000 in 1968 to over $3,000,000 in 1972.

1966 - 1968

Manager, Complaint and Warranty Service, General Electric Company - Nuclear Energy Division, San Jose, California.

Managed group of six persons with the responsibility for customer contacts, planning and execution of work required after customer acceptance of department-supplied plants and/or equipment--both domestic and overseas.

1963 - 1966

Field Engineering Supervisor, General Electric Company, Installation and Service Engineering Department, Los Angeles, California.

Supervised approximately eight field representatives with responsibility for General Electric steam and gas turbine installation and maintenance work in Southern California, Arizona, and Southern Nevada. During this period was responsible for the installation of eight different central station steam turbine generator units, plus much maintenance activity. Work included customer contact, preparation of quotations, and contract negotiations.

1956 - 1963

Field Engineer, General Electric Company, Installation and Service Engineering Department, Chicago, Illinois.

Supervised installation and maintenance of steam turbines of all sizes. Supervised crews of from ten to more than one hundred men, depending on the job. Worked primarily with large utilities but had significant work with steel, petroleum and other process industries. Had four years of experience at construction, startup, trouble-shooting and refueling of the first large-scale commercial nuclear power unit.

1955 - 1956

Engineering Training Program, General Electric Company, Erie, Pennsylvania, and Schenectady, New York.

Training assignments in plant facilities design and in steam turbine testing at two General Electric Factory locations.

1953 - 1955

United States Army - Ordnance School, Aberdeen, Maryland.

Instructor - Heavy Artillery Repair. Taught classroom and shop disassembly of artillery pieces.

1953

Engineering Training Program, General Electric Company, Evendale, Ohio.

Training assignment with Aircraft Gas Turbine Department.

EDUCATION & AFFILIATIONS:

BSME - 1953, South Dakota School of Mines and Technology, Rapid City, South Dakota, Upper ¼ of class.

Professional Nuclear Engineer - California. Certificate No. 0973.

Member - American Nuclear Society.

Various Company Training Courses during career including Professional Business Management, Kepner Tregoe Decision Making, Effective Presentation, and numerous technical seminars.

HONORS & AWARDS:

Sigma Tau - Honorary Engineering Fraternity.

General Managers Award, General Electric Company.

PERSONAL DATA:

Born November 20, 1931, Miller, South Dakota.
Married, three children
6'2", 190 lbs., health - excellent
Honorable discharge from United States Army
Hobbies: Skiing, hiking, work with Cub and Boy Scout Groups.

PUBLICATIONS & TESTIMONY:

1. Operating and Maintenance Experience, presented at Twelfth Annual Seminar for Electric Utility Executives, Pebble Beach, California, October 1972, published in General Electric NEDC-10697, December 1972.

2. Maintenance and In-Service Inspection, presented at IAEA Symposium on Experience From Operating and Fueling of Nuclear Power Plants, Bridenbaugh, Lloyd & Turner, Vienna, Austria, October, 1973.

3. Operating and Maintenance Experience, presented at Thirteenth Annual Seminar for Electric Utility Executives, Pebble Beach, California, November, 1973, published in General Electric NEDO-20222, January. 1974.

4. Improving Plant Availability, presented at Thirteenth Annual Seminar for Electric Utility Executives, Pebble Beach, California, November 1973, published in General Electric NEDO-20222, January, 1974.

5. Application of Plant Outage Experience to Improve Plant Performance, Bridenbaugh and Burdsall, American Power Conference, Chicago, Illinois, April 14, 1974.

6. Nuclear Valve Testing Cuts Cost, Time, Electrical World, October, 15, 1974.

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APPENDIX B

EMERGENCY UNLOADING AND POTENTIAL ACCIDENTS AT REACTORS AND AT-REACTOR FUEL POOLS

EMERGENCY UNLOADING OF REACTORS AND/OR SPENT FUEL POOLS

The following discussion of implications of expanded at-reactor storage of spent fuel was extracted from a:

STATEMENT BY DALE BRIDENBAUGH ON INTERIM SPENT FUEL STORAGE CONSIDERATIONS PRESENTED BEFORE THE CALIFORNIA ERCDC MARCH 10, 1977

Regulatory Guide 1.13 requires that seismic Class I care be given to the structural design, that accidental criticality be considered, that adequate cooling be provided and that mechanical damage will considered. No requirements are spelled out as to spent fuel storage capacity. The Standard Review Plan states that most pools will be sized to hold one and one-third to one and two-thirds full core load equivalent fuel batch shipments of discharged fuel would be made after the nominal cooldown period and, therefore, the requirement would be that the pool be sized large enough to hold a discharged batch of fuel plus maintaining storage space adequate to unload the total core in the event that failures or other circumstances might require rapid unloading of the total reactor core. In my ten years in management positions for the General Electric Company's Nuclear Energy Division, I have known a number of cases where complete core unload was required in order to make repairs or modifications. The fact that a number of plants in the United States cannot now unload because of inadequate spent fuel storage space i a serious deficiency that may affect the continued operation of those plants. It is also possible to develop accident scenarios that result from the inability to rapidly unload reactors. For example, I personally know of at least one occasion at Tarapur Atomic Power Station in India where control rod drive maintenance operations in the lower head of the reactor vessel resulted in leakage of reactor primary coolant in such large quantities that the lower section of the containment was beginning to flood. It was only by a near super-human effort that the maintenance personnel were able to insert the control rod drive and bolt up the flange and prevent a severe accident where recovery would be extremely difficult. Had they been forced to abandon their rapidly flooding quarters only a few minutes before they were able to stop the leak, they would have suffered a LOCA. Such situations are not restricted to boiling water reactors with bottom entry control rod drives. Many pressurized water reactors contain attached piping systems which often times do not have isolation valves between the steam generators and the reactor vessel or which may require maintenance on the first isolation valve. This presents the plant operator with a difficult maintenance operation. I am aware that such a situation existed at the San Onofre Unit I plant several years ago. The decision was made to isolate the line with a "freeze plug" using liquid nitrogen to freeze the water in the pipe thus isolating the first valve from the reactor vessel. After an effective plug is frozen into the line, the valve bonnet is removed and the necessary maintenace work is performed. This is an accepted procedure for small lines, but one can easily see that, if the freeze plug is lost with the down stream valve open or the pipe cut for repair, one can postulate an accident sequence that might require the relatively rapid unloading of the fuel to be able to recover from such an event. In my view to insure maintainability and reliability of the plant, it is essential that full core unloading capability be retained at all plants.

The current plans at existing operating reactors seem to indicate that high density fuel storage is planned for most plants. This will increase the storage capability of the fuel pools by a factor of 2 to 5. As an example, th- t uni Brunswick plant in North Carolina, has submitted a proposed amendment which would permit them to not only increase the storage capacity of their fuel storage pools for fuel produced in that plant, but also enable them to store fuel discharged from H.B. Robinson a PWR in their system. Therefore, it is entirely possible and probable that relatively large inventories of spent fuel and the associated radioactive material inventory will be built up and maintained at operating reactors over the next ten to twenty years. The concern, therefore, that must be considered is what is the probability and consequence of accident modes that could release substantial fractions of that inventory into the environment in an uncontrolled manner. Following is brief summary of the accident modes should be considered. There are perhaps other scenarios that will be developed at a future date; unfortunately, in the nuclear business the event that turns out to be a problem is one that was not considered in the original safety analysis. (For example the Browns Ferry candle).

1. Missile Strikes - During the plant licensing evaluation the applicant and NRC are required to consider the probability of missiles striking the spent fuel and causing the rupture of fuel elements, releasing gaseous fission products or further dispersion of the radioactive material. Such missiles may range from aircraft and tornado propelled objects to high energy impacts that could result from the burst of a operating or overspeeding turbine rotor. For the most part the accident evaluations done in the past on missiles have concluded that the probability is very low and that the consequence of such an

accident would probably be no greater than a fuel bundle drop kind of event and, therefore, the accident is of no concern. For example, WASH-1400, the RSS, comes up with numbers in the 10^{-7} to 10^{-9} range and says that major accidents due to missiles striking the fuel storage pool are basically impossible.

2. Loss of Coolant Accidents - The Applicant is required to design and build the spent fuel storage pool in such a manner that the probability of Loss of Coolant Accidents are minimized. This includes making sure that no graviity drains are available to provide for accidental draining of the pool, that structural integrity of the pool is such that it will withstand the events that may be expected such as seismic or tornado induced missiles, and that adequate fuel pool cooling systems are provided so that a loss of coolant accident through the mode of boil off will be avoided . Another event that is now being considered is the spent fuel shipping cask drop that could rupture the spent fuel storage pool. All such possibilities,with the exception of the spent fuel shipping cask drop,have been considered in initial reactor design analysis and these same factors are reevaluated when fuel storage pools are expanded by the modification of high density rack additions. However, it is common practice to provide for the additional burden of additional spent fuel storage by eating into the original design margin that was provided. For example,high density storage racks are being

added at most plants currently and few, if any, changes are being made to the structural or fuel pool cooling aspects of these plants. While the individual analyses may judge this to be not a safety problem, it should be recognized that there has been in each case a degradation of safety margin. The cask drop accident is another matter in most existing plants. When these plants were designed little information was available on the size to be expected for shipping casks and a complete analysis on the effect of a cask drop accident was not initially made. Subsequent to this NRC has issued orders to nuclear plant operators advising them of their concern over the cask drop accident. This is a particular problem for those plants with elevated fuel storage pools where cask drops could rupture the pool and cause a catastrophic loss of coolant. Most plants have been evaluating this accident and have been considering the addition of redundant crane features, cask drop mitigating elevators or energy absorbing materials on the bottom of the pool and of structureal guides to preclude a cask accident from damaging the fuel stored in the pool. This is an ongoing effort which has not been completed in many plants since no immediate shipments of fuel were expected.

3. Accidental Criticality - NU REG 75/087 states that spent fuel storage pools will be designed in such a way so that accidental criticality is precluded. This is generally accomplished by geometry or structural element shielding and in most

pressurized water reactors the fuel pool water is further borated to provide some additional criticality safety margins. Criticality could come about either by insufficient care in the original design, errors in handling and placement of fuel in non-authorized spaces or through the event of structural failure of the racks resulting in a reconfiguration of the fuel elements. As in the case of spent fuel pool cooling systems in the newer high density storage systems, criticality is reanalyzed, but it is apparent that some degradation of safety margin results, since you are compacting more fuel, which has the radioactivity to attain criticality into less space.

4. Loss of Pool Integrity - This is a class of accident which is generally discussed in the preceding paragraph on loss of coolant accidents. However, the long-term storage concept has implications that should be given further considerations. For example, most onsite storage pools will be unavailable for detailed inspection and maintenance because they will contain fuel that it will be essentially impossible to remove for periods of time of ten or more years. There are no tight requirements for what is an allowable leakage rate through the stainless steel liners. In the past the general rule that has been followed is that, if the leakage can be handled by the plant radioactive waste facility, it is of little concern. In my former capacity with General Electric I was involved with several fuel pool leakage problems on a warranty basis and

I am reasonably confident that this is the common industry practice. Most pool liners are made of one-eighth or less thick stainless steel material. GE's original practice was to use one-eighth thick welded stainless plate. A reduction in plate thickness was made at the Millstone plant as a material cost savings and a three-thirty/seconds material was used there. During installation, however, this material was found to be hard to weld and serious leakage problems were discovered when the pool was later begun to be filled for the first refueling operation. General Electric spent, through contractors, a number of months and hundreds of thousands of dollars attempting to repair this liner. A study was made, under my direction, to determine what would be done if irradiated fuel was loaded into the pool and excessive leakage developed. It was not extensive, but it indicated that serious problems would be encountered. For example, the availability of casks and lack of alternate storage space would probably mean that it would take six months to a year or more to get the pool unloaded for repairs.

This same potential condition exists at almost every reactor plant and will be further complicated by the fact that substantially more fuel will be in storage at those plants. Surge storage space may be at a premium since the problem is common to the industry. This then means that there is potentially a problem in the industry in terms of long-term integrity of the fuel storage pools. We have, of course, one report of a leaking pool that has been quite evident in the press in the past year; that is the Turkey Point plant in Florida which has announced leaks that are uncontrolled that have developed over the past several years. Undoubtedly there are others that have not been reported since they are able to divert their leaks through their normal floor drain systems into the radioactive waste treatment facilities.

5. Sabotage - The increased inventory of radioactive material in the storage pool and, in many cases, the pool's location outside the reactor building in relatively easily penetrable building construction make it a potential target for determined and skillful saboteurs. Testimony has been presented at previous hearings about the General Electric's study of spent fuel pool sabotage consequences. This was based, of course, on the General Electric Midwest Fuel Recovery Plant configuration which has considerable structural difference from the typical nuclear power plant storage pool configuration. Also, it should be remembered that Witness Robert Bernaro of the NRC Fuel Reprocessing Branch indicated that General Electric's request to the NRC that security requirements be waved were denied by the NRC. In addition to that, the Australian Environmental Inquiry, commonly known as the Fox Commission, evaluated the probability and consequence of acts of sabotage to spent fuel storage facilities. They concluded that substantial damage to the

general health and safety could result from such acts and posed a warning in their first environmental report on such matters. There is obviously some additional risk to the public and to the operability of the plant if sabotage attempts are made on targets with higher destructive capability then this additional risk must be taken into consideration.

6. Fuel Cladding and Structural Integrity for Long-Term Storage - An unresolved question regarding the safety and environmental effects of long-term storage of spent irradiated fuel has to do with the life to be expected from the fuel structural material (cladding and castings) to ensure that fuel rod integrity is maintained for periods of ten years or more. A few fuel bundles have been in storage for periods of ten years or more but very few of these have been operated to the expected design burnup of in excess of 30,000 MWD per T. Fuel pool water chemistry impurities are not as closely monitored or controlled and it is possible that long-term storage will result in clad perforations, crack of the end plug welds and/or other means by which the gaseous fission products could be released and other solid fission products leached out of the fuel rods.

Recommendations:

1. Safety Evaluations

The existing operating plant license evaluations were conducted on the basis that the spent fuel storage pool would contain at the most approximately 1½ core load of fuel. It is obvious that using these same pools to store, for long periods of time, up to 4 or 5 core loads of fuel, results in some jeopardy to the design safety margin. It is recommended that the Nuclear Regulatory Commission be requested to evaluate in detail the extent of this degradation and to justify the continued operation on nuclear plants. This could require improved safety features or procedures to insure that the original safety of the plant is maintained.

2. Surveillance Requirements

At the present time ASME Boiler Code Section XI requires a periodic inspection of pressure containing boundary and other safety related primary system equipment. No such requirement exists for periodic surveillance or testing of the integrity of fuel pool structures, liners or storage racks. In view of the changed nature of the use of the storage pool, it is recommended that on-going surveillance requirements be developed and enforced by the NRC.

3. Emergency Core Unloading

It is recommended that all operating plants maintain the storage capacity required to permit the "emergency" unloading of the core should conditions require that. This currently is not a requirement, and is quite likely to be not provided in view of the lack of adequate storage space that industry is facing. In additi n, it it recommended that a study be done concerning cask availability and alternate storage space availability to determine how long it would take to unload fuel storage pools on an emergency basis should the structural damage occur either by accident or seismic event to determine what the risk may be of the new storage requirements that are being considered.

4. Fuel Failure Mechanisms

It is not apparent at this time that the high burn-up design objectives that are currently being planned for fuel will be achieved on an industry-wide basis. It is recommended that a study be conducted on the impact of a new fuel failure mechanism developing resulting in higher spent fuel storage capabilities.

5. Plant Modifications

It is recommended that individual plant reviews be made as to their specific provisions to mitigate cask drop accidents, fuel drop accidents, fuel pool cooling accidents, and seismic design margins to insure that all possible action has been considered to reduce the risk to the health of the general public, and to evaluate the viability of continued plant operation for the benefit of the public. Modification commitments and schedules should be required for each operating plant.

APPENDIX C

SPENT FUEL DISPOSAL COSTS

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SECTION 2

WASTE MANAGEMENT UNCERTAINTIES

This section describes the main areas of technical uncertainty facing the radioactive waste disposal program in general, and more specifically, the spent fuel disposal program covered by this study. The technical uncertainties are considered in the selection of cost ranges in Section 5, but it must be emphasized that there is a substantial amount of judgment in the quantification. References to various reports and sources address the uncertainty in greater detail.

Uncertainties can be grouped into five separate categories: waste form, engineered barriers, geologic factors, monitoring, and regulatory/institutional/financial. Each of these areas is addressed in greater detail in the following sub-sections.

2.1 WASTE FORM

There has been a substantial amount of debate in the planning for high level radioactive waste disposal as to the form in which the waste material will be prepared for insertion into the final repository. Appendix F of 10 CFR Part 50 requires that high-level waste, as defined in that section, must ultimately be solidified for final disposal. Current federal reports indicate that spent fuel, in the form as discharged from the reactor, should be considered as high-level waste. This seems to be a logical step since it is for the most part in solid form, and encased by a metallic cladding. There are, however, some unanswered questions as to the acceptability of spent fuel as the waste form for disposal. The uncertainties include the following:

a. Zircaloy or other fuel cladding corrosion rate.
The basic design criteria for fuel clad have been developed for the relatively brief performance of that material in the reactor core. At least two reports [1] [2] reviewed refer to the lack of knowledge concerning long-term performance of zircaloy in the environment of water storage. Rapid deterioration may not occur in view of the rather mild environmental conditions when compared to the operating condition for which the materials are designed, but the BNWL report by Johnson[1] does recommend that corrosion rates and corrosion mechanisms need further evaluation for justification of extended fuel storage.

b. Handling of gaseous material.
Even though the majority of fission products and radioactive waste materials are contained within the fuel rods in solid form, a significant fraction does exist in the gas plenum and fuel rod gap as a gas. No specific criteria have been developed to specify whether or not such gaseous material must be removed from the rods and if it were to be removed, what further processes would be required.

EPA standards have been under formulation to address these issues in consideration for gaseous releases at spent fuel reprocessing plants. If spent fuel is to be the form of the high-level waste for permanent disposal, the question must be resolved.

c. Geometrical configuration.

Some consideration has been given in the past to the disassembly of fuel bundles and the reconfiguration of the disassembled rods into canisters or other containers for more efficient handling. Should this prove to be desirable for one or more reasons, substantive questions regarding heat transfer, that is, the method by which decay heat is removed from the more closely compacted rods, and of guarding against accidental criticality, arise. In fact, criticality control remains a nagging problem throughout the hundreds or thousands of years following geologic disposal. Disruption of the repository configuration by geological shifts or massive external forces, could presumably initiate an uncontrolled and accidental criticality. The possibility must be faced that physical modification of the waste form may be required to preclude this possibility.

2.2 ENGINEERED BARRIERS

A standard design practice of the nuclear industry is to follow the "single failure criteria." (3) Single failure criteria requires all critical systems be designed in such a way that the consequences of a single failure in any component or system will not result in loss of the capability of the safety system to perform its safety functions. As a result of these concepts, a common design practice is to use multiple systems or barriers to guard against release of radioactive materials to the environment. In an operating nuclear plant the multiple barriers consist of fabricating the fuel material itself into ceramic form, enclosing it with a metallic cladding, containing the fuel in a pressure vessel, which in turn is enclosed in the reactor protective containment.

The multiple, or engineered barrier concept, can be utilized for a portion of the high-level waste disposal cycle. There is a difference, however, between waste disposal and operation of nuclear power plants. The multiple barrier concept at operating nuclear plants must depend ultimately upon some overt human action sometime after the single failure to restore control over the malfunctioning process. In high-level waste disposal, overt human action can be counted upon during the early years of the disposal action, but at some point it must be assumed that the human or social structure has changed so radically that the proper action cannot be assumed. It is for this reason that geologic isolation currently is the disposal method that must ultimately provide the absolute barrier between the radioactive material and the biosphere.

Waste disposal system engineered barriers are, however, required to provide multiple barrier protection against accidental release of the material during that portion of the disposal cycle prior to achieving absolute geological containment. Since the disposal of spent fuel as high-level waste is a relatively new concept, and because little research and development of proof-testing has been devoted to this concept, uncertainties do exist on the effectiveness of the engineered barriers. Following are some of the major areas of concern or uncertainty:

a. Stability of fuel material.

Spent fuel as discharged from the reactor is assumed to be still in a stable, ceramic condition and the major portion of th fission gases are assumed to be captured within the confines of the ceramic pellet. The effectiveness of this barrier over long periods of time has not been demonstrated.

b. Fuel cladding.

The clad of the fuel bundle itself is considered to be a second barrier to guard against release. As described in Section 2.1, the corrosion resistance of the fuel clad itself for long periods of storage has some uncertainty.

c. Encapsulation.

A significant portion of the fuel as discharged from reactors can be assumed to have clad perforations. In addition, the integrity of the clad cannot be assured for long periods of time, so it is most likely that the fuel assemblies themselves will be required to be encapsulated prior to emplacement in the geologic repository. This would probably be required for protection during the handling process alone, and, if retrievability of the material is a requirement, it would surely be required. At this point in time, however, no decision has been made as to how long retrievability must be considered and no firm design criteria have been developed for design of the encapsulation. Similar concerns have recently been expressed in a report by Dr. Greogry J. McCarthy and associates at Pennsylvania State University.(4) McCarthy's study has re-evaluated the effect of ground water on radioactive waste stored in the glass or calcine solid form. This re-evaluation finds that radioactive material leaching is of little concern if the ground water is 25°C or less and at atmospheric pressure. However, since the water is likely to be at elevated pressures and temperatures because of the radioactive decay heat, extensive leaching could occur if the water penetrates the waste containers.

d. Repository closure.

The geologic repository is assumed to be a deep, underground mining-type operation. Once all wastes have been emplaced in the repository, the drifts and shafts must be backfilled and sealed. The effectiveness of the backfilling and sealing to prevent the intrusion of surface water or the extrusion of gaseous or liquid effluents from the waste material is unproven. Geologic stability of penetrated deposits has not been demonstrated for the time periods involved with high-level waste disposal.

2.3 GEOLOGIC UNCERTAINTIES

As indicated in Section 2.2, the ultimate barrier must be considered to be the geologic isolation of the waste material from the biosphere. To quote a recent article (see Appendix H) from Science(5):

> "For more than 20 years, deep geologic disposal has been reguarded as the leading technical option for getting rid of the most dangerous and troublesome forms of nuclear wastes, with salt formations generally viewed as the most promising of the geologic media considered. Moreover, an assertion often made by government officials, scientists, and engineers associated with the waste management program, has been that the feasibility of the geologic disposal concept is not in doubt. For instance, in late 1976 a top official of the Energy Research and Development

> Administration declared that fulfillment of ERDA's plans to establish six deep geologic repositories, with the first (in salt) to be available by 1985, would require only 'straightforward technology and engineering development.' It comes as a surprise, therefore, to discover now that there seems to be an emerging consensus among earth scientists familiar with waste disposal problems that the old sense of certitude was misplaced." (Emphasis added)

The uncertainty involved with the effectiveness of geologic disposal has to do with the extreme difficulty of proving the long-term effectiveness of this method. This uncertainty is further confirmed in the Science article,(4) wherein it is reported in a study performed for the Environmental Protection Agency by Raymond Siever of Harvard, and Bruno Giletti of Brown University, that:

> "We are surprised and dismayed to discover how few relevant data are available on most of the candidate rock types even thirty years after waste began to accumulate from weapons development. These rocks include granite-types, basalts and shales. Furthermore, we are only just now learning about the problem of water in salt beds, and the need for careful measurements of water in (salt) domes."

The need for additional work in this area has apparently been recognized at the federal level. As reported in the May 4, 1978 Nucleonics Week,(6) the Department of Energy and the U.S. Geological Survey have proposed a significant increase in geologic research to attempt to avoid what the U.S.G.S. has identified as "significant potential stumbling blocks." The proposed program would more than double the current level of geologic research in fiscal year 1979.

Numerous reports exist on geologic concerns facing repository development efforts, but the most recent and complete single report is the U.S.G.S. Circular 779.[7] This report identifies the following major geologic uncertainties:

a. Behavior of rock salt.

The major question involves rock salt's high solubility and the possibility that relatively small amounts of brine could cause changes in the media mechanical strength and possible movement of waste during relatively short periods of time.

b. Investigation of media other than salt.

The disadvantages of salt seem to indicate other geologic media may be preferable. As quoted from the Science article,[5] relatively little work has been done in evaluation of alternatives to salt storage.

c. Ground water transport system characterization.

The flow of ground water is considered to be the most likely method by which geologically disposed radioactive waste material could be transported to the biosphere. Data on water flow through fractured geologic media and on the chemistry of the radioactive materials in the water flow needs to be more thoroughly understood.

d. Development of repository evaluation methods.
Additional work is needed to devise methods of dating ground water and performing volumetric examination of rocks around proposed repositories.

e. Effect of repository on the geologic environment.
Additional research is needed to further define the short and long-term effects of repository construction and of the waste and associated heat load on the rock and the geologic environment of the repository.

f. Geologic prediction.
There is a great deal of uncertainty involved in the predictions of behavior for geologic-type time spans. Scientists can determine which sites have been stable in the past but they "cannot guarantee future stability." (Emphasis added)

2.4 MONITORING

Almost without exception, all recommendations on spent fuel geologic disposal concepts include a period of time during which retrievability would be assured so that repository conditions could be monitored to determine if unforeseen failure modes may be developing. Subsequent to repository closure, monitoring is also planned to forewarn of any potential release of radioactive materials to the environment. The problem with developing an effective monitoring system is twofold. First, it is not clear what condition or phenomena should be monitored, since for the most part, if a detectable condition exists, by definition it is almost too late to take preventive measures. Second, monitoring must be, in effect, passive and non-destructive in nature. This being the case, instrumentation must be permanently implaced and function essentially forever, since penetration of the repository for monitoring purposes negates the condition that is being attempted to be maintained. These two principles, therefore, lead to the following major uncertainties in developing an effective monitoring system:

a. <u>What to monitor</u>?

Since the failure mode or transport mechanism is unknown, it is not clear what parameter or what substance must be monitored to provide advance warning of an early failure. Should the monitoring system detect gross physical movement, deterioration of the canister, transport of radioactive materials beyond certain boundaries, increasing environmental radiation levels at the repository surface, radioactive gases, temperatures or pressures, combinations of all of the above or other factors unlisted?

b. <u>Instrumentation system</u>.

Once it is decided what parameters to monitor, a decision must be made as to the design life of the monitoring system. Should it be multi-channel to minimize the possibility of loss of a critical system? Must it be functional effectively forever? Must it be emplaced so as to be reparable without disruption of the geologic containment?

c. Inspection.

What frequency of physical inspection should be scheduled? If access for physical inspection is designed into the repository, accidental release initiated by human error is not safeguarded. Additionally, if access is not engineered into the repository, future access as required to verify that the material is being contained in a safe condition would jeopardize the integrity of the geologic confinement. Nondestructive inspection methods are essential but unavailable at this time.

d. Time.

One central issue of high-level radioactive waste storage is time. How long must the waste material be safeguarded? How long must a monitoring system remain functional? If no movement has occurred within five years, can the emplacement be assumed to be safe? If not five, what about 50? 500? 5000?

2.5 REGULATORY, INSTITUTIONAL, AND FINANCIAL UNCERTAINTIES

Regulatory uncertainties facing the spent fuel disposal program today are substantial and varied. Following are listed some of the major unresolved issues that could significantly affect the scope, complexity, and eventual cost of implementing the spent fuel policy.

a. Lack of goals and standards.

No federal regulations exist on which to base the licensing of a spent fuel repository or interim storage fácility. The NRC has indicated that regulations (10 CFR Part 72) are currently being written, but it is highly unlikely that they can be properly developed without benefit of established national goals for guidance of the waste disposal program. Development of Environmental Protection Agency standards faces this same uncertainty.

b. Gaseous release

No federal regulations yet exist describing the requirements for handling of "leaker" fuel assemblies; no decision has been made as to whether or not degasification of the fuel will be required nor what disposal requirements might be issued to govern disposal of the gas thus collected.

c. <u>Occupational exposure</u>.

Substantial discussion has recently been heard regarding the adequacy of the occupational radiation exposure limits. It appears quite possible that exposure limits will be reduced by a factor of 10, if not immediately, at least at a time in the future that would impact significantly on spent fuel disposal. Additionally, low-level radiation effects may well dictate changes to the requirements governing releases and exposure of the general public. Such changes could materially affect the spent fuel disposal program.

d. <u>Commercial viability</u>.

It is not clear that the federal government will require that all utilities make an early decision to transfer their spent fuel to a federal AFR or repository for permanent disposal. Such regulations could be issued, but the current policy announcement seems to make optional the reactor owners decision to turn fuel over to the government. The decision of whether or not to consider spent fuel as high-level waste will quite likely not totally be made until a final decision is made on the U.S. breeder reactor program. Accordingly, it seems likely that utilities will make "non-decision decisions" and the federal spent fuel facility costs will be allocated to only a small percentage of the available spent fuel. If this situation develops, it is then quite likely that an indequate transport system will be built, making it impossible to handle the backlog of fuel when a decision finally is made.

e. Financial forecast factors.

The long-range trends of financial factors employed in long-range forecasts are subject to a high degree of uncertainty. All of the factors that impact upon the direction of change of interest rates or construction costs over time are difficult to identify. In addition, fluctuations due to major economic events, such as war or depression, cannot be forecast with any degree of reliability. Therefore, it is necessary to employ historical data in order to estimate the trend and general behavior of interest rates and construction costs.

The use of historical data imply that the past is in some way indicative of the future. To some degree the hypothesis is correct. Historical data indicate that interest rates tend to exhibit long-run cyclical behavior. Historical data also appear to indicate a long-run trend of increase in costs as measured in dollars. However, since the systematic collection of economic data is largely an event of this century, behavior trends over very long periods of time are based upon data that lacks reliability. The specific historical data selected for this study were selected because they are comparable as to type with the future costs and interest rates that are being forecast and because the data are generally reliable for forecasting purposes. However, since the data are from relatively current periods, they do not exhibit all of the long-term characteristics that one would desire for a long-term forecast. See Appendix D for more details on the quantification of financial uncertainty.

2.6 QUANTIFICATION OF UNCERTAINTY

The foregoing sections on uncertainties facing the spent fuel disposal program seem to indicate that the magnitude of the technical uncertainty is extremely large. The largest total uncertainty resides in the acceptability of the geologic media for isolation of the material for geologic time periods. Determination of the unsuitability of salt and other selected geologic media at some time in the future might require mining out of material previously buried and moving it to a repository alternative of, as of now, undefined design. Performing this material shift, while complying with as yet undefined regulations and standards, could cause orders of magnitude changes to anticipated disposal costs. An attempt has been made to quantify the potential cost impact of these uncertainties in Section 5.

SECTION 2

REFERENCES

1. BNWL-2256, "Behavior of Spent Nuclear Fuel in Water Pool Storage," A.B. Johnson, September 1976.

2. Z.A. Munir, "An Assessment of the Long Term Storage of Zircaloy Fuel Rods in Water," October 15, 1977.

3. 10 CFR 50, Appendix A, See "Definitions and Explanations," plus for example, GDC 17 and GDC 21.

4. Nature, 273, 216 (1978).

5. "Nuclear Wastes: The Science of Geologic Disposal Seen as Weak," Science, Vol. 200, June 9, 1978, page 1135.

6. Nucleonics Week, Vol. 19, No. 18, May 4, 1978, page 6.

7. U.S. Geological Survey Circular 779, "Geologic Disposal of High Level Radioactive Wastes - Earth Science Perspectives," J.D. Bredehoeft, et al

APPENDIX D

Extracts From:

STATE OF ILLINOIS' PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

JULY 25, 1979

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-295
	)	50-304
(Zion Station, Units 1 and 2)	)	

STATE OF ILLINOIS'S PROPOSED FINDINGS
OF FACT AND CONCLUSIONS
OF LAW

July 25, 1979

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D. Accidents

1. Drop of Heavy Objects

Contention 2(f) states:

There has been insufficient development of credible accident scenarios. For example:

(1) There is insufficient documentation to establish the methods by which the Applicant will positively prevent the movement of heavy objects, such as shipping casks or empty fuel racks over the pool during modification; thus accidental droppings of such heavy objects, which could lead to unacceptable damage to spent fuel or the pool liner and consequent release of radionuclides, has not precluded.

(2) There is insufficient information regarding the methods by which accidental damage to stored spent fuel assemblies will be prevented during the installation of the new poisoned spent fuel storage racks.

14. Applicant's witness, Mr. John P. Leider, former plant superintendent at Zion, described how the proposed rack replacement was being developed. He stated that no racks would be carried over the spent fuel (Leider, prepared testimony at 3, Tr. 758).

15. Some of the rack movement will be controlled by crane interlocks which prevent loads from moving over the pool. At other times, to allow movement over the pool, the interlocks will be bypassed. At that time written procedures are planned to prevent movement of the racks over spent fuel (Id.) Reliance is placed on administrative controls because it is difficult to design a scheme of mechanical interlocks to handle crane movement in many directions [Leider, Tr. 1390-91]

16. The written procedures for rack installation and the written procedures which will set forth the administrative controls had not been developed at the time of the evidentiary hearing (Leider, Tr. 1900-1902)

17. Applicant testified that there would be no casks carried over the pool as there are no casks in the plant and there are no plans to bring any into the plant (Tramm, Tr. 1903).

18. The NRC Staff testified that it plans to restrict the movement of heavy loads over the stored spent fuel. During the proposed modification the Staff would require notification of plans to handle heavy loads in the vicinity of the spent fuel pool. The Applicant has committed to notify the NRC as requested. (Staff, Ex. 1A § 2.3). There was no specific testimony as to what NRC action would be taken upon notification that a heavy load would be lifted in the pool area, although Mr. Kohler, resident NRC inspector at Zion did state that commitments can be enforced (Kohler, Tr. 1972) and that

he would stop the job if he detected a heavy load being above the core. (Kohler, Tr. 1975).

19. The Staff intends to issue a technical specification which will preclude handling loads of greater weight than a single fuel assembly plus the spent fuel handling tool over stored spent fuel. (Staff Ex. 1A, § 3.2). The technical specification is in draft form. It is intended to be included in any license amendment issued for the proposed rack replacement.

20. Applicant's contractor, Nuclear Services Corporation has analyzed the consequences of dropping a single fuel assembly onto a rack. The analysis generally addresses the consequences in terms of criticality. (Hossain, prepared testimony, Tr. 1700; Ap. Ex. 4 §3.4.3.5 and 3.4.4). The assembly is hypothesized to drop from a height of 24 inches because that is the maximum height a fuel assembly can be carried over the pool when the crane interlocks are on. (Hossain, prepared testimony, Attachment B, Tr. 1700).

21. When there are no interlocks on the crane it will be possible to lift loads higher than 24 inches above the pool. (Leider, Tr. 1899-1900).

22. Applicant's witness Leider testified that if a rack fell into the pool, the greater the height from which it fell the larger the impact on the pool would be (Id.)

23. Administrative controls have been proposed to control lifting heavy loads more than 24 inches above the pool, but no technical specifications were envisioned by Applicant to be part of those controls (Leider, Tr. 1901).

24. Although Administrative controls were proposed as the means by which certain loads would be precluded from being carried over the pool, neither the procedures describing the rack placement, nor the controls had been developed at the time of the hearing (Leider, Tr. 1900-1902).

25. It is credible that a dropped rack could tear the stainless steel pool liner (Tramm, Tr. 1903, Zudans, Tr. 1970).

26. Although Staff and Applicant have made assertions that a rack drop would not cause major damage no analysis was made of this accident.

27. Should a heavy drop cause the stainless steel pool liner to be torn, water could leak from the pool at 288 gallons per minute and the pool could drain in 23 hours. (Tramm, prepared testimony at 10-11, Tr. 564; Tramm, Tr. 1917).

28. Leakage would drain from the pool through six 1 1/2 inch drain lines (Tramm, Tr. 1904, 1912). There are no valves on those drain lines. Either the drainage pipes would have to be crimped mechanically or the leak would have to be plugged with metal or plastic sheeting to cut off the flow. (Tramm, prepared testimony at 11, Tr. 564).

29. Based on the foregoing, the Board finds that all credible drop accidents associated with the proposed rack replacement have not received sufficient attention to assure the public health and safety. The major concern would appear to be the drop of a rack onto stored spent fuel. We find that the administrative controls and Technical Specification described by the Licensee and the Staff, are likely to be less positive and less predictable than the mechanical schemes normally employed. We expect the Licensee's management and the NRC's Office of Inspection and Enforcement to devóte sufficient attention to the rack replacement operation to confirm that the administrative controls and Technical Specification are followed during the rack replacement. However, we also find it desirable to have the Applicant devise a scheme for mechanically interlocking the crane movement during installation, to prevent movement of the racks over spent fuel.

ii. Pool Boiling

Contention 2(g) states:

> The Applicant's discussion of spent fuel boiling is inadequate in that (1) there is no consideration given to the possibility that the pool might boil, and (2) there is no discussion of possible damage to fuel cladding or of the consequent release of radionuclides under such conditions; therefore, there is no assurance that public health and safety will not be endangered.

In addition, the heat removal capacity of the spent fuel cooling system has not been shown to be adequate to support the expanded pool capacity.

30. Intervenor accepts the Applicant's proposed finding 84 as it described the Zion spent fuel pool cooling system and rejects all other proposed findings on this issue, numbers 83 and 85 to 108 and in their place offers the following proposed findings.

31. Applicant utilized two computer programs to compute pool heat and cooling: POOLHT, which analyzed maximum bulk pool temperatures,.(Licensee Exhibit 4) and CIRCUS, which calculated natural circulation flow rates within the pool (Id.)

32. For the purposes of its POOLHT calculations, the Applicant's assumption was that the temperature of the component cooling system water at the inlet to the spent fuel heat exchangers is 80°F. On cross examination the Applicant's witness admitted that the corresponding temperature assumed in the FSAR is 95°F. (Tramm, Tr. 1454-5). Tramm testified that if the Applicant had used a base of 90° instead of 80° for the component cooling water temperature that the pool temperatures would have been calculated at about 15°F higher (Tramm, Tr. 1459-60).

33. The Board finds the discrepancy between the temperatures assumed by the codes POOLHT and CIRCUS and the FSAR creates some doubt as to the accuracy of the Applicant's calculations regarding pool boiling.

34. According to Licensee's witness, Mr. Tramm, the performance of the spent fuel pool cooling system is related somewhat to the other heat loads which are transferred by the component cooling system in that such performance is a function of the temperature of the component cooling system water. Postulated plant upset conditions such as a loss of coolant accident ("LOCA") could increase the temperatures in the component cooling system and therefore possibly cause a temporary reduction in spent fuel pool cooling (Tramm, prepared testimony at 29, Tr. 564, Tr. 1460-1). Neither POOLHT nor CIRCUS calculated the temperature of the component cooling system during a LOCA, nor was there an analysis of the effect of a LOCA in the reactor on the spent fuel pool cooling system (Tramm, Tr. 1464-66).

35. Intervenor's witness Dr. Marvin Resnikoff testified that the computer programs used to calculate pool heat are based on asssumptions that are not sufficient to forecast effects of LOCA in the spent fuel pool. (Resnikoff, Tr. 1574). Resnikoff agreed with Tramm's testimony that a malfunction of the component cooling system could lead to loss of pool cooling (Resnikoff, prepared testimony at 5, Tr. 1528).

36. Tramm testified that single failure in the spent fuel pool cooling system could cause both cooling trains to malfunction (Tramm,Tr. 1441). Both Staff and Applicant concede that a single failur of the inlet pipe which returns water from the spent fuel cooling systen to the pool is a credible event. (Lantz,Tr. 1677; Tramm,Tr. 1514).

37. The failure of both cooling trains to operate would cause the pool to boil in 6-12 hours, depending on the temperature at the point of LOCA in the spent fuel pool, unless sufficient cold water was added to pool. (Tramm, prepared test at 20-21,Tr. 564; Lobel et al, prepared testimony at 8,Tr. 1632; Resnikoff,prepared testimony at 2, TR. 1528).

38. Resnikoff testified that localized boiling could take place where a full core discharge followed a refueling discharge by 10 days or less and only one cooling train was operative. Localized boiling can also be caused by blockage of the hole in each storage tube which allows entry of cooling water. (Resnikoff prepared testimony at 9-10, Tr. 1528).

39. On cross examination Dr. Resnikoff agreed that the question of pool boiling would be negated if there was a guarantee of a continuing source or readily available makeup water for the Zion spent fuel pool,(Resnikoff,Tr. 1556) but Resnikoff questioned whether the sufficient quantities of makeup water would always be readily available. Resnikoff raised questions about mechanical failures which could prevent the makeup systems from operating (Resnikoff,Tr. 1557. If those events occured it would become

necessary to use some method such as cross ties or pumping water from the Lake, which necessitate human intervention (Resnikoff, Tr. 1557-8). Resnikoff questioned whether it would always be possible for manual methods of supplying makeup water to be used. (Id.)

40. One possible event that could preclude the entrance of workers into the pool room to provide makeup water would be the presence of radioactive steam or condensates in the spent fuel pool area. Staff witnesses testified that if boiling were to occur, some non-violatile radioactivity normally present in the pool water could be entrained in water droplets in the air above the pool. (Lobel et al., prepared testimony at 6, Tr. 1632). These droplets could also condense out on surfaces on the fuel building (Id.) The Staff opined that workers would be able to enter the pool area. Lobel et al, Tr. 1652). But on cross examination it was shown this opinion was based on mere speculation as no calculations had been performed (Lobel et al, Tr. 1651-2). The Staff witnesses did state that access to the area could have to be controlled should such an event occur.

41. In the event that boiling continued for a period of time access to the pool area would become even more difficult because high humidity would disable the prefilters and HEPA filters in the building's filter system, thus the additional radioactivity would not be removed from the environment of the pool building (Donahew, Tr. 1678-82).

42. Staff witnesses testified that boiling in the pool would be in the nucleate mode (Lobel et al, prepared testimony at 1, Tr.1632). Dr. Resnikoff testified that localized boiling and bulk pool boiling could both occur in a pool where cooling were not availabl (Resnikoff, prepared testimony at 5, Tr.1528, Resnikoff Tr. 1569). Resnikoff testified that the effects of unchecked bulk pool boiling would lead to uncreased hydrogen in the fuel building. Potentially a hydrogen explosion could occur and the effects of such an explosion could include release of radioactivity into the environment surrounding the station.

43. Resnikoff hypothesized that a zirconium/steam explosion or other major accident in the nuclear facility could prevent workers from getting to the pool in order to supply makeup water. He therefore recommended total automation of all makeup water systems to assure that the pool heat would be maintained below the boiling level (Resnikoff, Tr. 1570-71).

44. The Board requested information about the location of valves which would make water available in case of overheating. The Staff's witness Lantz testified that valves could be reached without going past the pool by entering the fuel building on the ground level. The valves are located on the lower level of the same building that houses the pool. (Lantz, Tr.1688).

45. Resnikoff reiterated his concern that workers would not be able to enter the building at all under certain extreme circumstances such as a LOCA occurring in the reactor.

46. NRC Staff and Applicant's witnesses testified that under certain conditions the temperatures in the spent fuel pool could rise sharply, yet would remain below the Boiling point. Staff witnesses estimated that the pool could heat to 170° with one cooling train out (Lobel, et al., prepared testimony 8-9, Tr. 1632). Tramm estimated the pool could reach 180° with one cooling train out (Tramm, prepared testimony at 18, Tr. 564). These temperatures correspond to those cited by Draley in his recitation of conditions that would lead to accelerated corrosion in Boral. (see § E infra).

47. The Staff testified that cumulative spent fuel pool experience has shown that no commercial water reactor fuel has yet been observed to develop defects while stored in spent fuel pools under normal spent fuel pool conditions. (Lobel et al prepared testimo at 2, Tr. 1632) No evidence was put forth about the reaction of fuel stored under abnormal boiling or post-boiling conditions, or at condit: such as those hypothesized in the Zion pool when one cooling train becomes inoperative. Nor was there any testimony regarding the history of Boral tubes stored in any spent fuel pool.

48. The effects of Boiling on the corrosion of the Boral was alluded to in the testimony of Dr. Draley and Almeter (See § E infra). Accelerated evaporation would tend to concentrate boric acid in the pool and lower pH (Lantz, Tr.1664). This condition combined with temperatures of 170° and higher can lead to accelerated corrosion of the aluminum matrix and clad of the Boral. (See § E, infra).

49. Applicant's witness did not calculate time it would take for all water to boil off, or the consequences of pool boiling in terms release of radioactivity or the possibility of exothermic reactions. The staff and Mr. Tramm all testified that it was not necessary to do such calculations because in their judgment the events were not credible (Staff, Tr.1655) (Tramm,1655) Tr. 1486-7) However the Staff testified that the rate of boil off could be 1/2 1/hr and it would take 80 hours for the pool to boil dry (Lantz, Tr.164[illegible]

50. In response to a question from the Board, the Staff testified that boiling would have no effect whatever on the neutron absorbing material Boral present in the proposed storage racks (Lantz, Tr. 1683-4). Boiling would tend to increase the concentration of boron present in solution in the pool water, since the water would boil away, but the boron would remain (Lantz, Tr. 1664). Licensee's expert witness, Dr. Draley testified that if higher concentrations of boric acid were continued for periods of at least two weeks, they

could have any possible effect on corrosion of the metals within the storage tubes (Draley, Tr. 1324-1327). Accordingly, boiling probably will not increase the risk of criticality in the spent fuel pool; unless, possibly, there is sufficient heat to cause overheating, fuel clad failure and possible reconfiguration of the fissionable material.

51. The Board believes Intervenor has raised a valid concern that the pool boiling/loss of water accident represents an accident with possibly serious consequences which has not yet been analyzed by the Applicant and Staff. According to Dr. Resnikoff, there would be a critical period of three to six days to add water to the pool to prevent this occurrence. Although the supplies of makeup water at the Station are adequate for this purpose, Dr. Resnikoff has raised a question whether human intervention to add makeup water would be possible under all circumstances. The Licensee and the Staff have testified that such intervention would always be possible, but have not conducted the analysis to prove their assertions. Thus, the Board requires that the Applicant conduct an analysis of the spent fuel pool loss of water accident and append it to their application.

E. Corrosion

Intervenor's contention 2(e)(3) and (4) state:

> The amendment request and supporting documentation do not adequately discuss monitoring procedures. In the light of the proposed modification and long term storage of nuclear spent fuel the Applicant should clarify the following:
>
> (3) Methods for detecting the loss of neutron absorber material and/or swelling of stainless steel tubes in storage racks.
>
> (4) Details of a corrosion test program to monitor performance of materials used in the construction of racks.

Intervenor's contention 2(h) states:

> The amendment request and supporting documentation have not analyzed the long term (including storage during the operating lifetime of the reactor) electrolytic corrosion effects of using dissimilar alloys for the pool liners, pipes, storage racks and storage rack bases, such as the galvanic corrosion between unanodized aluminum as is used in Brooks and Perkins storage racks, and the stainless steel pool liner.

Intervenor's contention 2(i) states:

> The Applicant has not discussed whether the proposed modification and long term storage may cause the following effects on the stored fuel: acclerated corrosion, micro-structural changes, alterations in mechanical properties, stress corrosion, cracking, intergranular corrosion, and hydrogen absorption and precipitation by the zirconium alloys.

Intervenor's contention 2(j) states:

> The amendment request and supporting documentation do not give sufficient data to fully assess the durability and performance of the Boral-stainless steel tubes which form the spent fuel storage racks:

(1) there is inadequate analysis of the corrosion rate of the tubes.

(2) there is no calculation of the effect of water chemistry on the Boral within the stainless steel.

(3) there is no mention of the possible swelling of Boral within the stainless steel tubes, a condition which could effect, among other things, removal of fuel assemblies from the racks.

Intervenor's contention 2(k) states:

The amendment request and supporting documentation do not cons[illegible]er possible degeneration of the Boral density due either to generic defects or to mechanical failure which would diminish the effectiveness of Boral as neutron absorber, thus leading to criticality in the spent fuel pool.

Intervenor adopts Applicants finding No. 110.

Intervenor's reject the remainder of the Applicants Proposed Findings of Fact on the issue of corrosion, Nos. 109 and 111-133 and sets forth its own findings on this issue.

Applicants presented Dr. A. B. Johnson, Jr., as a witness on corrosion of fuel and metals in the spent fuel pool, and effects of vented racks on any corrosion. Dr Joseph E. Draley testified to corrosion of the Boral and the corrosion test program. NRC staff testified on all the contentions regarding corrosion.

52. Dr. Johnson is known as an expert in the [illegible]havior of spent fuel in storage pools, primarily because he has authored 2 articles in the area. (Johnson prepared testimony, Tr.1057). On cross examination

Dr. Johnson admitted that most of the information in his studies came from third parties, not from personal knowledge (Johnson,Tr. 1074-5, 1081-2, 1088-9). Dr.Johnson also admitted that most of the data upon which he has based his assessments of long term integrity of fuel cladding was acquired through visual inspections, and visual inspection can detect only advanced stages of cladding degradation (Johnson,prepared testimony, Attachment B at 167, Tr.1057;Tr.1072-1075).

53. The data base for all physical testing of spent fuel cited by Dr. Johnson, consists of a total of 9 spent fuel rods, tested in Great Britain. No other data on spent fuel rodsare yet available (Johnson, Tr.1077-8). The data cited for rates of fuel failure and embrittlement are speculative based on developing experience, not broad previous experience. (Johnson, Tr. 1089).

54. No tests or observations have involved fuel stored in Brooks and Perkins racks, vented or unvented.

55. Although Dr. Johnson concludes that there is an adequate basis at this time to proceed with long-term storage of spent fuel in a pool environment, he expressed concern that surveillance should continue to be provided for the spent fuel over whatever time period the spent fuel will be stored (Johnson, Tr. 1113,1117). The NRC Staff is in agreement with Dr. Johnson (Almeter and Lantz, prepared testimony at 9-11, Tr. 1141, 1149).

56. The Board finds, therefore, that the State's Contention 2(i) has been answered sufficiently to permit the addition of a greater volume of zirconium-clad fuel to the Zion spent fuel pool without undue concern for cladding corrosion and degradation effects over the short term, less than forty years. However, the Board finds that there is insufficient data to substantiate any claims regarding fuel stored in Brooks and Perkins boral tubes for a period of forty or more years; therefore, licensing should be limited to the shorter period of forty years or the life of the reactor.

57. In its "Order following Prehearing Conference" dated January 19, 1979, and again at the hearing, the Board requested information regarding the effects of vented racks on the storage of spent fuel. (Tr. 1100).

58. On cross examination Dr. Johnson testified that damaged fuel could give off helium as well as other gases. Without analysis one cannot determine whether the gas bubbles were helium from leaking fuel or hydrogen from a rack. (Johnson, Tr. 1084-85). Johnson testified that krypton-85 is among the gases that can be released by leaking fuel. Krypton-85 is difficult to monitor. (Johnson, Tr. 1116). Applicant's witness Nestel, testifying in response to Contention 2(e), stated that noble gases, such as krypton-85, could only be detected by the final effluent monitor. Krypton-85 would not be detected in the spent fuel area partly because it would be

difficult to get an air grab sample that could accurately indicate the source of the leaking gas. It would not be possible to determine, at the final monitoring point, whether the gas came from defective spent fuel or from another source, such as the reactor. [Nestel, Tr. 995-6].

59. Neither Applicant nor staff presented evidence on how the vented rack design would effect corrosion of fuel and racks. Witness Johnson was unprepared to answer a question relating to changes in the rack design and corrosion. Although he said he could not see the relationship, he admitted he had not studied the question (Johnson, Tr. 1099).

60. The Board finds that the use of vented racks, which exhibit bubbling activity, combined with the lack of monitors and the inability to sample air for noble gases in the spent fuel pool area may lead to a masking of the existence of defective fuel leaking radioactive materials.

61. Dr. Draley was called by Applicant to testify about corrosion in the Boral. Dr. Draley stated in his testimony that he has done some short term experiments on corrosion of Boral in the early 1960's. The tests lasted only a few weeks and many of the details were lost. No official report was ever made of the results of these experiments. These experiments were never followed up. Draley has done no research on Boral since those early tests. Since 1965 he has had no other involvement with Boral, or with the inter-

action between Boral and stainless steel except for preparing for this hearing (Draley, Tr. 1292-1296). Draley has done no research specifically into the behavior of materials in spent fuel pools (Id. at 1296).

62. The Board finds that Dr. Draley's expertise in the area of aluminum corrosion may be helpful in assessing some of the contentions at issue in this hearing, but his expertise in the area of Boral deterioration is more limited both by lack of available data and lack of personal research experience.

63. Dr. Almeter was presented by the NRC to be an expert on corrosion generally. On cross examination he stated that he had no personal experience with Zirconium and that he had done no corrosion work with Boral. (Almeter, Tr. 1146-7). He has done neither destructive or non-destructive examination of spent fuel(Almeter, Tr. 1148-9). Almeter stated most of his knowledge of the spent fuel corrosion field came from literature searches and previous research work on materials he thought were similar to those used in the fuel and in the Boral racks (Almeter, Tr. 1146). Almeter's written testimony is based in large part on his reading of reports by Draley and Huddle. These studies were done 10-25 years ago(Almeter prepared testimony, Tr. 1141; Almeter Tr. 1201, 1203, 1204). The Huddle report was "theoretical"; based on no actual experiments or statistical sample. (Almeter, Tr.1208) Although Almeter is supposed to be an expert in the spent fuel area he has had this NRC assignme[illegible] for just over one year and he admits he has not visited all the pools he has been "involved with" in his capacity as NRC evaluator (Almeter, Tr. 1147).

64. Based on his knowledge of spent fuel pools Almeter testified that he found no objection to Dr. Johnson's testimony.

65. The Board finds that as Dr.Almeter's knowledge of corrosion in spent fuel pools is based primarily on reading reports of others, his experience in this area is neither extensive enough nor specific enough to give weight to the opinions presented in his testimony regarding corrosion of zircalloy or Boral in the spent fuel pool.

66. Galvanic corrosion will occur between the stainless steel and the Aluminum in the Boral racks (Almeter/Lantz prepared testimony at 8, Tr. 1141; Almeter, Tr. 1145; Draley, prepared testimony at 5-7, Tr. 1290). Dr. Almeter stated that thereis a major difference in electric potential between aluminum and stainless steel and therefore galvanic corrosion will occur between the aluminum cladding in the Boral and the stainless steel tubes which encapsulate the Boral. (Almeter and Lantz, prepared testimony at pp. 3-9, Tr. 1141). Dr. Draley agrees on this point. (Draley, prepared testimony at 5-7, 9, Tr. 1290).

67. General corrosion of the Aluminum in the Boral will probably take place within the first 5 days of immersion (Almeter, Tr. 1202-3, 1239-40, 1250). Dr. Draley states that one can expect some pitting of the edges of the Boral plate and perhaps the 1100 aluminum cladding which forms the outside layer of the Boral where the electrical

contact with the stainless steel tube is good. (Draley, prepared testimony at 5-6, 10, Tr. 1290).

68. Although Draley and Almeter tended to minimize the serious consequences of pitting in the Boral, the State of Illinois introduced into the record evidence of testing which indicates that the pitting problem may not be fully understood. During an <u>in camera</u> session Intervenor questioned Dr. Draley about several proprietary reports describing galvanic corrosion experiments conducted by Brooks and Perkins, Inc., the manufacturer of Boral, and by Battelle, Columbus Laboratories for Brooks and Perkins (Intervenor's <u>In Camera</u> Exhibits 1 and 2). The Brooks and Perkins report (Intervenor's <u>In Camera</u> Exhibit 1) contains a conclusion that maintaining a significant oxygen concentration in the water surrounding the Boral could lead to unacceptable corrosion behavior. Probably on the basis of this research the Licensee changed its rack design so that the vent holes through the stainless steel tubes are located only at the top of the tubes. This change will limit the amount of oxygen bearing water in the tube. (Draley, <u>In Camera</u> Tr. 1342-3). On cross examination Intervenor also questioned Dr. Draley on the Battelle, Columbus report (Intervenor's <u>In Camera</u> Exhibit 2) which reports experiments in which a high rate of galvanic attack of Boral in a concentrated boric acid solution was observed. Dr. Draley testified that this experiment did not influence his testimony very strongly because the boric acid solution involved in the experimentas quite a bit more aggressive than the conditions in the Zion spent fuel pool. Therefore Dr. Draley testified that the results in the Battelle Columbus report do not apply to the Zion spent fuel pool (Draley, <u>In Camera</u> Tr. 1345-49).

69. Dr. Draley did not deny that the results of the Brooks and Perkins and Battelle-Columbus tests were accurate. In fact his own experiments showed similar results. Of these Draley testified that it was his recollection that Boral subjected to high temperatures (about 300° C) would swell, blister andultimately disintegrate because a protective film of corrosion would be unable to form. Draley also testified that an aluminium clad would not stop disintegration of the type described. (Draley, Tr. 1293-4).

70. In formulating his opinion as to the relationship between the high corrosion rates seen in the recent tests and the performance of Boral racks in the Zion spent fuel pool Draley did not consider abnormal conditions that could credibly occur in the pool. NRC Staff and Applicant have both testified that the loss of one cooling train could boost pool temperature to 170° - 180°: (See §D(ii) <u>supra</u>). It has also been calculated that a loss of coolant accident could lead to pool boiling and consequent evaporation of water and concentration of the boron to create the higher temperature and lower pH solution which would lead to accelerated corrosion (See §D(ii), <u>infra</u>).

71. Another means by which pH could be raised was suggested by Applicant's witness,Mr. Tramm, who stated that in the event of an increase in the current leakage rate from the pool it might become necessary to lower the level of the pool water.

Dr. Draley testified that lowering pool water would increase concentration of Boron in pool, but unless the pH in the Boron tubes were lowered there probably would not be a great effect over a short period of time. However, when asked if the lower pH in the pool would have no effect on the metals in the tube, Draley admitted that given a "long enough time" there would be an effect. (Draley, Tr. 1325-6). Draley hypothesized that a week would be too short a time for accelerated corrosion; but within a month a significant difference in concentration would become observable.

Although on cross examination Dr. Draley testified that he had never seen a pH of 4 for the Zion spent fuel pool, the basis of this answer was a series of pH values recorded in the past 3 years at Zion. In that time the Zion pool has not lost an excessive amount of water through boiling, leakage or evaporation which has not been promptly replaced. (Draley, Tr. 1359).

72. Draley stated that he had considered the conclusion of the Battelle-Columbus test that both the average and localized rates of attack are probably too high to guarantee a 40 year life for the Boral. But it did not strongly influence his testimony. Draley indicated that he had discussed both the Brooks and Perkins and the Battelle results with Commonwealth Edison. Although he did not recommend closing the racks, Commonwealth Edison decided to change the rack design after the Brooks and Perkins tests and recommendations to close the racks had been reviewed (Draley, Tr. 1343, 1350; Almeter, Tr. 1233).

73. Dr. Almeter, when questioned about his opinion on the design change was unable to state a conclusion. (Almeter, Tr. 1234).

74. Several other pieces of evidence brought the question of pitting to the attention of the Board. Dr. Draley appended to his prepared testimony an article by Weeks entitled "Corrosion Considerations in the Use of Boral in SpentFuel Storage Pool Racks". (Draley prepared testimony, Reference 4, Tr. 1290). Weeks cites experiments which yielded pitting of depths up to 45 mils at pH of 5, at 100°C in 1 1/2 years (Gaton Lake Panama) and 30-40 mils in 1 1/2 - 2 years (Potomac R., Washington). The pitting was due to galvanic corrosion between Aluminum and Stainless Steel. The general corrosion of this alloy was negligible in both environments.

Weeks recommends a surveillance program which would include couples of aluminum and stainless steel to be installed in spent fuel pools where boral cavities are vented because venting which is used to eliminate swelling due to hydrogen may produce pitting corrosion of the Boral (Id., at 6).

Additionally Weeks recommends that there should be no contact between Aluminum and Zircalloy because that could lead to hydriding of Zircalloy cladding.

75. Dr. Almeter testified about tests done by Exxon (See Draley, prepared testimony, Reference 6, Tr. 1290). This study clearly showed that where pitting was begun the areas of pitting deepened in one year. (Almeter, Tr. 1210).

Almeter testified that in an affidavit in support of motion for summary diposition filed January 31, 1979 he cited rates of corrosion for Boral which, when extrapolated over to 40 years, indicated total corrosion of the Aluminum clad on the Boral. These original figures were based on the Exxon study and an additional report not in evidence in this proceeding.

No figures were listed in the testimony filed by Almeter prior to Hearing in May. Almeter admitted that the figures which cited complete deterioration of the Boral Clad were correct as they applied to pitting. (Almeter, Tr. 1217, 1218).

76.

Almeter's prepared testimony, p 4, states that accleration in corrosion will occur with <u>either</u> increase in aqueous temperature, change in electrical potential differential, change in ionic concentration of the aqueous environment, or coupling of dissimilar metals where one is nobler than another. On cross, Almeter testified that Stainless Steel is nobler than Aluminum and therefore galvanic corrosion can occur, in the Zion pool that temperature will increase in the pool at certain times, for instance when fuel from reactor is placed in pool, and that the ionic concentration in the pool is subject to change, e.g. when there is not a continuous clean up of pool (Almeter, Tr.1144).

Almeter stated that the entire surface of the Boral would be subject to pitting with the initial attack around the top vent hole (Almeter, Tr. 1212-1213).

77.

Based on the testimony, the Board finds that Intervenor's co ntention 2(h) has raised valid concerns about corrosion of aluminum and stainless steel in a spent fuel environment. Based on the testimony, the Board finds that additional testing and analysis is needed to predict the corrosion effects on Boral in proximity to stainless steel in an oxygen-saturated boric acid solution (i.e., the spent fuel pool water). The Board also finds that the continued integrity of the Boral within the tubes is of sufficient concern to merit a corrosion surveillance program.

78.

Additionally Almeter stated the Exxon study shows that in cases where there were defects in the matrix and/or bonding of the Boral, bulging could be expected. (Almeter, Tr. 1223-1226). He indicated that he did not expect to see such bulging in the Zion pool, but it "would depend on the quality control formulation of the Boral plates the particle size of the boron carbon, and the uniform mixing of the aluminum bonder the boron carbon in the formulation of these plates".

79.

Applicant's witness Mr. Shewski, testified that Brooks and Perkins quality control had been deficient and some boral tubes that did not correspond to specifications had been shipped to Leckenby (See § F, infra).

80.

Dr. Draley testified that he expected that there could be measurable swelling of the Boral itself within a vented tube. The degree of swelling is expected to be from .1 to .234 inches. The cause of this swelling would be the replacement of the aluminum in the Boral matrix with corrosion products. (Draley, Tr. 1316). In his opinion the swelling would be greater in an unvented tube that leaked than in a vented tube, but the amount of additional swelling was not estimated (Draley, Tr. 1318).

81.

Dr. Draley testified that another kind of Boral swelling which might occur would be related to local corrosion or pitting which might be induced by galvanic interaction between the aluminum in the Boral and the stainless steel tubes where the two plates are pressed together. The solid corrosion product has a greater volume than that of the corroded metal, and local swelling could result.

Using the density of the predominent aluminum corrosion product, Bayersite, Dr. Draley calculated that the corrosion product will occupy a volume some 3.2 times that of the aluminum from which it is formed. Draley estimated that even if a Boral plate in a Zion storage tube corroded all the way through cladding and core material the maximum swelling produced by the corrosion product would be .234 inch. (Draley, prepared testimony at pp. 12-13, Tr. 1316-1318).

This type of swelling is found in the Boral itself, not the stainless steel tube. There was no estimate made for the degree of swelling that could be anticipated in a tube or shroud if some of the gas produced by the corrosion of the Boral became entrapped between the Boral and stainless steel.

82. Dr. Remick asked witness Almeter for information about blistering in Boral Control Rods. Almeter testified that Boral had been used in control rods in a research reactor. This Boral experienced blistering problems. Almeter stated that he thought the cause of the blistering was helium gas generated by the boron fission from neutrons. He did not know if the rods were subsequently vented. (Almeter, Tr.1270).

83. Having reviewed the testimony of Applicant and Staff on the possible corrosion rates of the storage tubes and on the effect of water chemistry on the Boral, the Board finds that swelling within the storage tubes must still be considered a possibility. Therefore, the Board finds that an adequate test and surveillance program must be developed to detect such swelling.

84. Dr. Draley testified about the sufficiency of the Commonwealth Edison neutron attenuation test plan. (Draley, prepared testimony, Attachment 4, TR 1290). On cross examination Dr. Daley admitted he had not prepared the plan or its predecessor which was submitted to the NRC in response to a question asking for a proposed surveillance program for boron. (Draley, TR. 1298-9, 1303). Draley was unable to state whether neutron attenuation tests would be performed prior to installation of the racks and was unable to testify as to the sensitivity needed in the test. (Draley, TR. 1301) The witness did testify that a neutron attenuation test conducted under water would be less sensitive than a test conducted prior to installation of the racks (Draley, TR. 1302). This testimony was corroborated by NRC witness Lantz who testified that underwater test results would give "insufficient accuracy" (Lantz, TR. 1237). Draley stated that the plan as presented in his testimony was "adequate" but he would not make a statement that it was "complete" except if complete were defined as describing the "current commitment of the company" to carry out the plan as written. (Draley, TR. 1302).

85. Both Draley and Lantz testified about testing for B-10 content at the Zion station. Lantz testified that Commonwealth Edison did not have the accuracy to determine the B-10 content of the Boral that had been fabricated into racks. Given that adequate testing for B-10 would be available, Draley stated that he did not know what measures would be taken in the event that neutron absorber

tests detect the B-10 content of the samples fell below .02.

On cross examination by Mr. Miller, Mr. Lantz gave an opinion that Commonwealth Edison's existing license might require a report to NRC of an unanticipated loss of neutron absorbing capacity or some structural deficiency in the absorber plate. No provisions of the license were placed in evidence. (Lantz, TR. 1257).

86. Lantz testified that the NRC has not developed any criteria to monitor Boral content, nor does the NRC staff plan to issue Technical Specifications in this area (Lantz, TR. 1238).

87. The Board finds that the accumulated evidence shows that the possible degeneration of Boral density due to mechanical failure or boron depletion in the pool is unlikely, accordingly we find the risk of criticality from loss of Boral after installation is small. However, there is a greater probability that deficiencies in manufacture and/or quality control will lead to inadequate concentrations of B-10 in the Boral matrix or failure to properly encapsulate Boral sheets in all racks, therefore we find an adequate program to test for neutron absorber capacity should be implemented at the Zion station before rack installation.

88. Applicant and Staff witnesses testified about the in pool corrosion testing program. (Draley, prepared testimony, Attachment 4, TR. 1290; TR. 1297-1321). Draley testified that the coupons would provide data on corrosion and loss of boron. He stated that visual inspections would be used to monitor swelling (Draley, TR. 1305). Draley testified that there were no plans to monitor generation of gas in the Boral tubes, and that there were no plans to monitor the creation of corrosion products in racks being used to store fuel, and that there were no plans to observe accumulations of corrosion products around the vent hole. (Draley, TR. 1308-1310).

89. Lantz testified that the coupon testing program would be useful in detecting whether or not boron would be lost but that it would not be useful in detecting swelling. (Lantz, TR. 1158). Lantz also testified that at time of hearing there were no plans or procedures developed to deal with any swelling that might occur, or were there any plans or procedures developed to deal with fuel that was damaged or otherwise affected by swelling or racks (Lantz, TR. 1242-1243). According to Lantz the only effective means of determining whether a rack had become swollen is to insert a fuel assembly into the rack thus to insure that any specific rack was not swollen before placing actual fuel in it, it would be a "good idea" to test it with a dummy fuel assembly. (Lantz, TR. 1158-9).

90. Almeter testified that at the time of the hearing the NRC had not set standards for the corrosion monitoring program and it was not known if any reports of monitoring or of unanticipated events would be required by NRC unless it was so specified in the license amendment as issued (Almeter, TR. 1244-6). Neither Almeter or Lantz was able to testify to whether NRC planned to oversee the surveillance program or if I & E would check the accuracy of the testing devices and procedures(Almeter/Lantz, TR. 1241).

91. In response to a question by Chairman Wolf, witnesses Almeter and Lantz agreed that monitoring and event reports generally should be required by the NRC but the requirement would have to be articulated in a technical specification or written into the license amendment (Almeter, Lantz, TR. 1245-6).

92. The Board finds the surveillance program described by the Applicant is, in general, adequate to protect the public health and safety, however several revisions are required to assure a complete program. Pre-installation neutron attenuation tests are more significant and can achieve the intent of assuring proper neutron absorber capacity. Surveillance of swelling by visual means is not accurate, therefore dummy fuel tests of each installed rack are necessary to avoid the insertion of fuel into swollen racks. The Board finds that the NRC has a responsibility to oversee the monitoring program. Finally, the Board also finds that there is a need for the the documentation of Licensee's acceptance criteria for the surveillance test samples in order to specifically establish conditions under which further actions will be necessary.

Contention 2K:

> The amendment request and supporting documentation do not consider possible degeneration of the Boral density due either to generic defects or to mechanical failure which would diminish the effectiveness of Boral as neutron absorber, thus leading to criticality in the spent fuel pool.

Contention 2L:

> The Applicant has not described the procedures it intends to employ to prevent the installation and use of damaged and defective racks.

The State adopts Licensee's Proposed Findings No. 134, 136, 137 and 142.

93. Licensee has retained Nuclear Services Corporation ("NSC") to perform independent inspections of Brooks and Perkins' fabrication of the boral tubes to be used in the new racks. (Shewski, Tr. 719). NSC has been to Brooks and Perkins several times to do inspections. (Shewski, Tr. 719). During its inspections NSC reviews Brooks and Perkins documentation on a random basis. (Shewski, Tr. 720).

94. The Licensee has also done three of its own audits of Brooks and Perkins: in March, April and early June 1979. (Shewski, Tr. 720, 721). During its audits the Licensee looks at some of the inspection, data, audit, and surveillance reports kept as part of Brooks and Perkins's quality control and quality assurance programs. (Shewski, Tr. 723).

95. Brooks and Perkins is required to assure that the

boron-10 loading in the tubes be a minimum of .0200 grams per square centimeter. (Shewski, Tr. 724, 753). On March 14 and 23, 1979, NSC released five boral tubes from Brooks and Perkins that had boron-10 loadings of less than 0.02 g/cm^2. (Shewski, Tr. 725, 726). This deficiency was first discovered by Brooks and Perkins on May 4 and 11, 1979, in the course of a review of previous shipments precipitated by two May shipments of apparently non-conforming tubes(Shewski, Tr. 738, 739, Intervenor Exhibit 3). Licensee was not aware of the March shipments of non-conforming tubes until Monday, June 11, 1979, when Mr. Shewski received Intervenor's Exhibit 3. (Shewski, Tr. 735). Licensee did not discover the non-conforming shipments during its April 1979 audit of Brooks and Perkins (Shewski, Tr. 737).

96. Licensee first ordered the boral tubes from Brooks and Perkins for the new Zion racks in July 1978. The original purchase order did not specify that the fabrication of the tubes was "safety-related," so that Brooks and Perkin's quality assurance program was not required to conform to 10 C.F.R. Part 50, Appendix B. (Shewski, Tr. 737). Licensee subsequently reversed its decision and in November 1978 required that the tube fabrication be safety related. (Shewski, Tr. 738). Licensee has not required that the suppliers of the component parts of the tubes have quality assurance programs conforming to 10 C.F.R part 50, Appendix B. (Shewski, Tr. 739).

97. According to Licensee's plan, the new dense racks would be installed in the spent fuel pool this year. Some of the racks will sit in the pool for a period of years before spent fuel assemblies are placed in them. Yet no dummy fuel assembly tests will be performed at any time after the racks are installed in the spent fuel pool to determine whether they

still conform to their original shape. (Leider, Tr. 763).

98. The in-pool neutron attenuation test will not be performed on every tube. Licensee has not established the number of tubes that will be tested. (Tramm, Tr.1942-43). Mr. Tramm could not quantify the contribution of the boric acid in solution in the pool to the neutron attenuation measured by this test. (Tramm, Tr. 1943-44). If these tests reveal that boral plates are missing in the sample tubes, Licensee plans to subject every tube to a neutron attenuation test. Any tube that is missing a boral plate will be plugged to prevent insertion of a fuel assembly. (Tramm, Tr. 1947-48, 1950).

99. Dr. Olsen testified on behalf of the Licensee that if one boral plate was missing out of every four tubes, and there was an extra fuel assembly at the side of the rack, the K-effective, or criticality coefficient, would exceed .95. (Olsen, Tr.1738). On the basis of the K-effective calculations that NSC performed in the Licensing Report (Licensee Exhibit 4), Dr. Olsen stated that it is very important to know whether missing boral plates would be permitted in the racks because it is not likely that the missing plates would be uniformly distributed. If the plates were locally all missing from a series of tubes in one spot, and all the rest of the racks were as designed, it would create a problem. (Olsen, Tr. 1740).

100. The Licensee has not sustained its burden of demonstrating that its quality assurance and testing programs

are adequate to protect against the installation and use of tubes containing insufficient neutron absorption material. Routine procedures implementing the quality assurance program failed to prevent or detect the shipment of non-conforming tubes to the rack fabricator. The presence of five nonconforming tubes in one shipment illustrates that deficient tubes are not likely to be distributed uniformly. Licensee proposes in situ neutron attenuation testing, but has not specified the number of tubes to be sampled. The Board finds that Licensee's assurances are too vague to form the basis for the conclusion that its program is adequate. Accordingly, the Board finds that Licensee's testing and Quality Assurance procedures must be augmented by a neutron attenuation test of every boral tube in each rack before installation in the spent fuel pool. Licensee must, in addition, perform a dummy fuel assembly test on each tube in the pool shortly before a spent fuel assembly is inserted in it.

Changes in Accidents Postulated in Previous Licensing Reviews

Board Questions 4(c), 4(d), 4(e) and 4(f) state:

(c) What postulated accidents, which might affect the safety of plant operating personnel in the spent fuel storage building or which might result in the release of radiation or radioactive materials from the spent fuel storage building, were specifically analyzed in the FSAR, SER, ER and FES utilized in the CP and OL licensing reviews of Zion Units 1 and 2?

(d) Which, if any, of the postulated accidents in (c), above, will be increased in probability, magnitude or consequence (to personnel, to the general public or to the environment) if the proposed spent fuel pool modification are carried out?

(e) What provisions have been made or procedures developed to protect the workmen and/or plant personnel from the consequences of such postulated accidents during the period when the proposed spent fuel pool modifications are being performed?

(f) Which, if any, of the postulated accidents in (c), above, will be increased in probability, magnitude or consequence (to personnel, to the general public or to the environment) as a result of the completion of the proposed spent fuel pool modifications and the proposed subsequent usage of the increased spent fuel storage capacity.

Intervenor adopts Applicant's proposed findings of fact numbered 165, 167, and 169 and rejects the remaining findings numbered 170 and 174, in place of which the following findings of fact are propo

101. The Board finds that NRC concern about the radiological effects of dropping a shipping cask is such that casks should not be permitted within the pool area until any modification activity that might occur has been fully carried out.

102. With respect to Board questions 4(d) and 4(f), Mr. Tramm stated that since the proposed modification will necessitate additional fuel moves, the likelihood, and corresponding risk of a fuel drop accident will increase slightly. The incremental risk will however be minimal since the number of fuel moves necessary to accomplish the modification will add less than 1% to the total number of fuel moves which will be accomplished during the plants lifetime. (Tramm, prepared testimony at p. 27, TR. 564). The Staff testified that since the fuel which will be moved during the modification will have decayed at least one month prior to being moved, this will be a decrease by a factor of 10 in the magnitude or consequences of a fuel handling accident postulated to occur immediately after shutdown because of radioactive decay of the gaseous fission products contained in the fuel.

103.The Board finds the risk of additional probability of accidental dropping must be balanced against the potential consequences of a drop in determining ultimate risk.

Pool Liner Leak

Board question 4(h) states:

> The Applicant and Staff are asked to provide a history of the apparent leak in the liner of the spent fuel pool. Specifically, the following should be addressed:
>
> (1) Has the leak intensified with time?
>
> (2) What is being done with the water leaking from the pool?
>
> (3) Why has the leak not been repaired?
>
> (4) How will possible future leaks be located and repaired if the proposed increase in storage capacity is permitted?

Intervenor adopts the Applicant's proposed findings of fact numbered 181-188, and in addition proposes the following.

104. The Board finds that at the present rate of leakage there is no danger that water loss will lead to a deficiency of cooling or shielding potential in the spent fuel pool. Also, as it is impractical to measure leaks of less than .005 gal/min. there is no adequate measure of leakage available. However, in the interest of public safety it is desirable to maintain leaks to a minimal amount, therefore the Board finds that the Applicant has a responsibility to measure the leak periodically. If it is found that the leak has increased to 10 gal./day measures must be taken to repair the leak. If the leakage rises to 20 gal./day, no additional spent fuel will be allowed to be placed in the pool until the leak is repaired.

Component Cooling System Leak

Board Question 4(i) states:

> The Applicant and Staff are asked to address the contention made during the limited appearance statements that the component cooling system has had a number of leaks which have not been repaired.

Intervenor adopts the Applicants proposed findings of fact numbered 189 and 190. Intervenor rejects findings 191 and 192 and in their place propose findings of fact as follows.

105. Applicant's witness, Tom Tramm has stated in his testimony there is an interrelationship between the component cooling system and the spent fuel pool cooling system, in that the cooling of the spent fuel is a function of the temperature of the component system water. Postulated plant upset conditions which affect the component cooling system therefore could affect the spent fuel pool cooling system.

106. The Board finds that as there is an interrelationship between the component cooling system and the spent fuel pool cooling system the leaks in the component cooling system could possibly cause an adverse effect on the spent fuel pool. Therefore the Board finds that as a condition precedent to the grant of a license amendment authorizing modification of the racks in the Zion pool Applicant must correct the existing leaks in the component cooling system.

Fuel Building and Groundwater Monitoring

Contention 2(e)(1), (2), and (5):

(e) The amendment request and supporting documentation do not adequately discuss monitoring procedures. In the light of the proposed modification and long term storage of nuclear spent fuel the Applicant should clarify the following:

(1) The monitoring equipment that is used and the ranges of sensitivity;

(2) The method by which incremental airborne radioactive emissions created by the spent fuel pool expansion will be measured;

(5) Procedures to monitor groundwater movement in the vicinity of the plant to detect leakage from the spent fuel pool.

The State adopts Applicant's Proposed Findings Nos. 198 through 211 and in addition proposes the following.

107. Mr. Jack Leider also testified for the Applicant on the demineralizer system that processes spent fuel pool water and on air monitoring in the spent fuel pool building..

108. In response to Ms. Little's questions regarding the demineralizer system for the spent fuel pool, Mr. Leider testified that the two demineralizers for the pool also process the cavity water during refueling and the refueling water storage tank water prior to refueling. The demineralization of the spent fuel pool water is intermittent, not continuous. (Leider, Tr. 771).

109 Grab sampling of pool water is the only method used to determine whether the capacity of the demineralizing bed resin

has been exhausted. (Leider, Tr. 771, 772). The demineralizer system does not have available for it a device that automatically indicates when the resin capacity is exhausted, unlike the majority of commercially available demineralizer systems. (Leider, Tr. 772). Licensee has no hard exact schedule for taking these grab samples.

110. Licensee uses the clarity of the spent fuel pool water as an indication whether the demineralizer is operating properly (Leider, Tr. 772). The removal of the particulate material that contributes to turbidity does not, however, indicate that all of the soluable radioactivity has been removed. (Leider, Tr. 772, 773). The controls for operation of the demineralizer system are located in the fuel handling building,.not in the control room (Leider, Tr. 776).

111. There are two area radiation monitors in the spent fuel pool building and a continuous air monitor in the exhaust ventilation system. (Leider, Tr. 776, 777). The ventilation system monitor is the more sensitive and accurate of the two. The station usually runs the exhaust ventilation system, but when it is not running only the area monitors could detect gaseous effluent from the fuel in the pool. (Leider, Tr. 779).

112. Applicant samples water at the Zion Station intake and discharge structures in Lake Michigan, which are 2500 feet and 700 feet from the shore, respectively. (Golden, Tr. 1013). The closest public water supply intake monitored by the Applicant is the Lake County Public Water Supply intake, which is about one mile north of the Station. (Golden, Tr. 1012, 101[illegible]).

113. The area immediately surrounding the Zion Station is a permanent recreation area. (Golden. Tr. 1021).

114. The Board finds that the Applicant's program for monitoring the spent fuel pool building and Lake Michigan is generally sufficient to protect public health and safety and the environment, however, it fails to protect the health and safety of the public using the Lake in the recreation area immediately adjacent to the Station. In addition, no surveillance of groundwater down-gradient of the Station is done to signal leakage from the spent fuel pool into the soil. Therefore, the Board finds that the Applicant should be required to install at least two groundwater monitoring stations between the spent fuel pool building and Lake Michigan. Each station should consist of two wells, one each to sample the deep and shallow aquifers.

VI. Conclusion

Thirty years ago, nuclear power seemed the answer to a nation's dreams. Relying on man's apparently unlimited capacity for technological progress, we would have a nearly inexhaustable supply of clean power that would cost virtually nothing. Even the wastes would not be a problem. Some of them could be reused, and surely we would soon discover what to do with the remainder. Certainly there was no reason to solve all of the possible problems immediately; we were solving them so quickly that they would soon be behind us.

That vision is a cruel joke in the cold light of intervening decades. None of it was true. We do not have an unlimited capacity for technological progress -- at least not within thirty years' time. We now know that uranium is far from inexhaustible, and there is no longer any question that nuclear power requires capital in amounts unheard of until very recently. And high-level radioactive wastes in the form of thousands of spent fuel bundles now languish in temporary storage pools across the country in numbers beyond those for which the pools were designed, with no final disposal facility in sight for well over a decade, even under DOE's most optimistic projections.

It is in this context that the NRC must examine the question of whether it can find a "reasonable assurance" that a waste disposal facility will be available before the expiration of existing operating licenses or that spent fuel can be stored safely at reactor sites for an indefinite period.

Historical experience offers no basis for confidence in the ability of DOE or the nuclear industry to achieve these goals. Their efforts to date have been fitful, inconsistent, and half-hearted at best. NECNP has demonstrated here that presently available information also offers no basis for a "reasonable assurance" finding on either issue. Data are seriously incomplete, methods of measurement and evaluation are lacking, and the experience with spent fuel storage technology simply does not justify long-term projections of assured safe storage.

For these reasons, NECNP submits that the NRC has no choice but to find that there can be no reasonable assurance either that a waste disposal solution will be in operation by the time existing operating licenses expire or that spent fuel can be stored safely in spent fuel storage pools for an indefinite period of time.

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