BEFORE THE UNITED STATES NUCLEAR REGULATORY COMMISSION

In the matter of Required Atomic Energy Act Safety Determination Regarding Disposal of High-Level Radioactive Wastes	)	NRC Docket No. PRM-50-18

PETITION OF THE
NATURAL RESOURCES DEFENSE COUNCIL
FOR A DETERMINATION, PRIOR TO
ISSUANCE OF REACTOR OPERATING
LICENSES, WHETHER RADIOACTIVE
WASTES CAN BE DISPOSED OF SAFELY

EXHIBIT D

RICHARD COTTON, ESQ.
(Natural Resources
Defense Council, Inc.)
2345 Yale Street
Palo Alto, California 94306

Attorney for Petitioner

364

EXHIBIT D

"Partitioning of Nuclear Wastes; How, Why, and When", M.J. Steindler, from Proceedings of Nuclear Regulatory Commission Workshop on The Management of Radioactive Waste: Waste Partitioning as an Alternative, pp. 380-395 (June 8-10, 1976).

NR-CONF-001

Proceedings of Nuclear Regulatory Commission Workshop on

The Management of Radioactive Waste: Waste Partitioning as an Alternative

June 8-10, 1976 at Battelle Seattle Research Center
Seattle, Washington

United States
Nuclear Regulatory Commission

Office of Nuclear
Material Safety and Safeguards

PARTITIONING OF NUCLEAR WASTES; HOW, WHY, AND WHEN

M. J. Steindler

INTRODUCTION

This workshop has been assembled by the Nuclear Regulatory Commission to provide views on partitioning that may aid the newly established Waste Management Branch in decisions dealing with criteria for waste management. It should be our intent, therefore, to provide an exposition of alternatives and rationales related to partitioning that can be used to determine the course of actions required for licensing. In order to do this effectively, I would first like to call attention to the scope of the partitioning process, since this term has been one of the most abused in the nuclear vocabulary.

The partitioning process is usually defined as the separation of nuclear wastes into an actinide fraction and a second fraction containing all other radionuclides. Further, the separation is commonly applied to the high-level waste because that stream contains most of the fission products. The objective of partitioning, however, is to reduce the time for which confinement of at least the major part of the radioactive waste must be assured. Therefore, the partitioning process must have a broader scope in order to include isolation of long-lived fission products such as iodine 129 and technetium 99 and long-lived activation products such as carbon 14. Further, the actinide content of wastes not extensively contaminated by fission products may well exceed that of

high-level waste, and therefore such streams should be included for treatment to separate long-lived radionuclides. The disposition of the collected long-lived radionuclides, including the actinides, is also an important adjunct to the rationale for the objective of the partitioning process. Hence, the steps required for the preparation of the long-lived fraction for subsequent transmutation, extraterrestrial elimination, or other disposal modes become part of the partitioning process. Consequently, reference to the scope of the partitioning process includes the broad range of separation processes applied to all types of nuclear wastes; the handling, fabrication, and recycle of actinides and other nuclides subjected to transmutation; and the elimination of packaged waste by extraterrestrial transport. Finally, the short-lived radionuclide fraction obtained by partitioning is to be stored for a modest period such as a few thousand years, but storage is not usually considered to be an integral part of the partitioning process.

RATIONALE FOR PAST ACTIONS

Waste disposal presents a set of unique circumstances to the licensing agencies that can best be illustrated by comparison with other fuel cycle processes. In my opinion there are no major technical reasons why the handling of nuclear wastes cannot be done as safely as most other operations in the nuclear business. However, there is no such convincing evidence regarding the final disposal of wastes. Further, during the licensing of fuel cycle facilities such as reprocessing and fabrication plants, review of place and process features are based on reasonably clear experimental data or verifiable models. Such bases for

critical reviews tend to assure the safety of the operations involved. Waste disposal, on the other hand, is in this respect quite different from the other parts of the fuel cycle, and long-term waste disposal poses qualitatively and quantitatively different problems both in the regulatory domain and in the eyes of the public. Finally, the principles employed in the licensing process for nuclear facilities are moderately well developed, have been accepted by the public, and deal with modest-term, operational safety. The corresponding principles for waste disposal facilities have not been developed, have not reached public acceptance, and deal for the first time with very long-term, passive maintenance of barriers.

We have become used to a very high degree of redundancy and reliability in nuclear safety matters. Design of this reliability is often based on exhaustive experimentation. We have become used to the application of such criteria in both the licensing and the operation of nuclear facilities, and we have even had to apply much of this redundancy to maintain the safety of the public. The lack of serious accidents in the nuclear industry demonstrates the effectiveness of this level of concern. Nevertheless, the excellent record of the industry and the care taken in licensing actions has not been enough to quiet the rumbles of the critics.

Now consider the long-term disposal of nuclear waste. The assurances used for the disposal of waste in geologic formations or elsewhere rest largely on geologic predictions and inferential evidence. There is not now, to the best of my knowledge, a significant program on predictive

geology being supported by ERDA or the USGS. I also understand that most geology departments in universities are not active in this field. It is not clear that any organization is currently pursuing a sufficiently thorough study of this particular field to furnish, in the foreseeable future, the kind of predictive data that we have been used to in other fields, for example chemical safety of reprocessing plant operations. I recognize that it is quite easy to generate reliable, predictive data based on the normal laws of chemistry and physics, particularly if we understand the mechanics of the phenomena. I also recognize that it is much more difficult to obtain the same kind of analyses in the area of geology. We generally do not understand the laws governing fundamental geological processes, we have only poor ideas about mechanisms and incomplete knowledge of structures, and therefore we have difficulty in providing reliable predictions. Especially important is the present inability to test the validity of models of geologic behavior.

This generally inadequate state of scientific information about the environment of the waste in the depositories is perhaps the major factor contributing to our inability to provide licensing reviews that will assure that the safety of the public will be protected. The perceived risk of gross errors increases rapidly with the length of the time-scale of the prediction.

Another part of the reliability problem for long-term predictions is worth mentioning. There is now no firm decision on the form of high-level waste to be assigned to the disposal site, though considerable effort has been expended to develop inert matrices for the waste. Some

of the methodology that seeks to assure, by calculation, that the emplacement of waste is safe is dependent on the prediction of the very long-term behavior of materials in only mildly aggressive environments. Here too the state of knowledge is inadequate to provide the level of reliability that has thus far been employed. These two aspects of the safety analysis problem are adequate to illustrate the effect of extending time scales to 10^5 or more years.

Because of these difficulties, licensing actions on waste disposal are likely to take on a radically different tone. When required to provide expert opinions on geologic phenomena in the long time frame required, few if any reputable geologists are likely to insist that a particular depository selected by ERDA or industry will remain stable. Further, materials scientists may encounter the same difficulties when discussing very long-term leach rates, transport properties, or other phenomena important to safety issues. Finally, the experimental bases for conclusions drawn about the interaction of waste and environment will be essentially absent. Under these conditions, the licensing agencies will have to proceed on bases with which neither the public nor the agencies are particularly satisfied or familiar. Specifically, most evidence used to evaluate the safety issues will be based on extreme extrapolations of uncertain information, little of which will be subject to test. The normal, strongly redundant approaches which the public has come to expect from the nuclear industry will be absent.

POTENTIAL IMPACT OF PARTITIONING

The technical issues of partitioning aside, the potential impact of partitioning on the licensing process seems reasonably clear. Reduction of time scales from a million years to, for example, a thousand years is not just three orders of magnitude. This reduction would allow a considerable increase in the reliability of estimates of geologic stability and materials behavior. While it would be naive to assume that all of the uncertainties that attend the predictions would be eliminated when the time scale is reduced, it seems reasonable to assume that the licensing process for depositories that are required to be functional for short periods could approach the rigor presently encountered in some of the more complex, but apparently acceptable, reactor safety questions. In short, ensuring the integrity of waste in a disposal site for a thousand years appears feasible; the same requirement extended to a million years appears at this time to be incredible.

The consequences of these differences can be profound. An industry already under attack for alleged laxity in the public safety domain can, in my opinion, ill afford to reduce the credibility of its safety posture. The inevitable reduction that would attend the licensing of waste repositories under present conditions may intensify the opposition to the point that nuclear power generation would be in jeopardy.

OTHER CONSIDERATIONS

We have addressed to some extent the "why" of partitioning. Of the other two questions, the "when" seems to depend more on economic

factors than on safety. Liquid storage of wastes for 30-50 years can, I believe, be made adequately safe and reliable. Solids of any type can be stored for similar periods under high-integrity conditions. The timing for partitioning, therefore, could be selected at leisure as long as solidification processes do not make subsequent treatment impractical. The glass form of high-level waste shows a distinct disadvantage in this regard.

The "how" of partitioning is again under study by ERDA, and there is no doubt that the details of a feasible technology will be developed in a few years. I favor an integrated waste management scheme carried out at a waste management plant that may look a great deal like a reprocessing plant but is able to handle all waste streams from nuclear power production operations. The products of this plant are a long-lived waste, packaged for burning or elimination; a nonnuclear waste stream, to be treated by conventional means or discharged directly to the environment; and the short-lived waste, packaged for transport and subsequent disposal in geologic formation.

CONCLUSIONS

In conclusion, the present ignorance of safety-related issues of very long-term geologic storage results in the weakening of traditional assurances employed in the licensing of such facilities. Such actions appear likely to endanger the public acceptance of nuclear power. Partitioning and consequent reduction in time scales for storage of wastes can remedy this difficulty to a large extent. it appears reasonable, therefore, to develop the technology of partitioning and to

integrate waste management into a single system. There appears to be no urgent, safety-related need to provide for final disposal of wastes very soon after their formation.

Conclusions specifically related to the NRC position are as follows:

1. The NRC should not take specific actions at this time related to partitioning except to direct policy toward provisions that maintain ready retrievability of waste containing long-lived components and toward provisions that do not preclude subsequent partitioning of retrieved waste.

2. The NRC should initiate efforts to determine if relaxation of the intense safety posture in nuclear affairs, when applied to long-term waste disposal, will result in unacceptably strong opposition to nuclear power generation.

3. The NRC should encourage the development of scientific information related to geologic disposal and materials behavior to ensure that the reliability of analyses for short-term disposal repositories is adequate to ensure public acceptance.

DISCUSSION OF M. J. STEINDLER'S PRESENTATION

Q. (B. L. Cohen): Why should we be worrying about the long-term security of waste that is buried far under the ground, when the mill tailings are obviously many orders of magnitude more dangerous than the buried waste will be after a thousand years? Also, can you guarantee that our burning up all of the gas, oil, and coal in the world won't be doing a lot of harm to people living 10,000 to 100,000 years from now? And what about all the sulfur that we're putting into the biosphere? In fact, with respect to our agricultural practices, the population explosion, or any aspect of human endeavor, there are no standards as stringent as those that you want from the nuclear industry.

A. The point that I'm making is that the kind of requirements for redundancy and safety that typify our present licensing arrangement--the requirements, in other words, with which the public has gradually become reasonably satisfied--are so stringent that we can't possibly apply them to waste management. I haven't said anything about any of the other things that go on in society because I'm not addressing the whole world and I'm not trying to solve the problems of the whole world. I think it's illegitimate to claim that we can ignore one poison because we've got a worse one somewhere else.

Now there are two assumptions that I'm making:

1. Technically competent people can agree that the perceived risk is different for a thousand-year time period than for a million-year time period.

2. If you choose to address the question of licensing in a different way from that used in the past, the public will not like it and may drive you out of the business.

I'm suggesting, then, that the current licensing process is extremely rigorous, and that if we attempt to maintain the same type of standard for waste disposal, we will have a problem. Now, one way to solve the problem would be to partition the wastes; this would solve a portion of the time scale problem and reduce some of the technical reliability problems, as well.

Q. (B. L. Cohen): What about the mill tailings?

A. The licensing people will tell you that that's not in their domain. This is a legitimate question, though, in the sense that it represents a very large waste. However, I do not propose to suggest that we partition mill tailings.

Q. (R. E. Isaacson): Do you think the laws of thermodynamics are going to change in the next million years?

A. There has to be something behind that question.

Q. (R. E. Isaacson): It's your perception that we can't predict what will happen in that time span. I believe, however, that we can put waste in any form that is thermodynamically stable with the certainty that there will be no interaction or reaction for the next million years.

A. Thermodynamics is a process of equilibrium. The problems that we are addressing here, however, are largely kinetic. The reason you can't find out what's going on in the stress curves in the stainless steel under a mild environment is not that you don't understand the thermodynamics involved, but that you don't know either the rates at which some of these processes go on or anything about the mechanisms of these processes. So I agree with you: if we were smart enough to understand the system, we could have reasonable faith in extrapolation. Our problem, however, is that we don't understand the rates because we have no idea of what the mechanisms are.

Q. (R. Chollister): You advocated that high-level wastes be stored in a readily retrievable form, presumably as a liquid. Where would you store this liquid?

A. I didn't specify a liquid form. I said that you can store it in a tank if you want to; however, it can be in solid form and still be retrievable. In fact, if you want fairly long-term retrievability, I would suggest that you insist on solids.

Q. (G. Graves): I don't necessarily agree with your implication that the rules for reactors and waste disposal should be the same. A reactor is a dynamic situation with a lot of stored energy in it, and if things were to go wrong you would have a reasonably definable set of consequences. Waste disposal, on the other hand, is a passive situation. There are various barriers--the glass, the can, the geologic formation; and there is evidence of geologic stability over thousands of millions of years. You also have to consider economic factors: any additional waste-processing costs will be passed on to the consumer in the form of higher electric power costs.

A. The ground rules I'm talking about are not the specific provisions for safety, but rather the safety criteria in general that are applied to nuclear facilities. At the moment, those redundancy requirements are very stiff; and what I'm saying is that, <u>if</u> similar requirements are applied to waste processing, they will cause problems. I'm not saying that they <u>should</u> be applied. In the area of reprocessing, in fact, a good case could be made for the position that present safety and redundancy requirements are too high. But if, after stressing redundancy to the public for so long, we suddenly shift to a nonredundant safety analysis for a particular portion of the cycle, we will have to be able to justify this to the public.

Q. (W. Nechodom): I suggest that a highly stable form of waste, backed up by a very high-integrity canister, backed up by a

stable geologic formation, and then backed up by Bernie Cohen's analysis, is surely redundant.

A. I'll bet you can't make that stick on the cross-examination stand.

Q. (Other speaker): Can any industry?

A. That's not the issue. We're not talking about the other industries. It can be said that we have "made it stick" so far in the nuclear business, and since we're still in the nuclear business, that's the standard that we'll be judged against.

Q. (T. H. Pigford): I'm still puzzled about your answer on the mill tailings. It was my understanding that NRC does license uranium mills, and the issue of mill tailings must surely be considered there. So why isn't there some precedent for that kind of consideration in licensing?

A. I'm not familiar with the details. I gather that the licensing that has started on mill tailings does indeed require stabilization. However, that does not address the question of the tailings that already exist.

Q. (R. F. Williams): I agree with your core concept: that too strict and too unthinking a safety analysis can certainly have an impact on the public acceptance of nuclear power. But you proceed from there to hypothesize that this unthinking safety analysis will lead

to either a finding that waste can't be disposed of or an undermining of public confidence in the licensing process. I disagree, because I think I can postulate a solution to the waste program given only that the safety review process is reasonably objective and rational.

A. I'm not prepared to argue whether your view or mine will prevail. The only solid benchmark I have is the normally accepted technical review process of technical evidence. In the licensing process, if someone comes in with a document saying that he has some material that won't blow up until it reaches 130°F and he has six systems to keep the temperature down, he must present evidence to show that (1) the six systems will work; and (2) the 130°F is a valid figure. What I'm saying is that, in the waste management mode, we're going to have a hard time providing that level of assurance.

(R. F. Williams): It seems that, in addition to a philosophical difference of opinion, we also disagree specifically as to the level of technological backup available. I would conclude that the data available are sufficient to convince a reasonable regulator, and you would conclude that they are not.

Q. (M. A. Molecke): You imply that there is a lack of data to prove the safety of this thing. There is currently a pilot plant program at Sandia that intends to measure many of these safety factors--for example, the effects of corrosion on canisters in the salt mine

environment, the transport migration of actinides, etc. I think that this program will provide us with many of the answers that you seem to think we cannot obtain.

A. My only comment is that the concept of a long-term waste disposal pilot plant is philosophically absurd.

(R. L. Schwoebel): I agree very strongly with many of the things you said--particularly with regard to geologic storage, transport, and all the questions that may be raised regarding the impact on the biosphere. There's a whole series of important questions that have not nearly been answered. With regard to this conference, we're very long on methods and detailed technology of how to partition, but we're very short on trying to understand <u>if</u> we really need to partition, in terms of the kinds of questions you raised. I'd like to see two things come out of this conference: (1) a list of some critical experiments that we would propose to test these theories in the usual way--and these may be long-term experiments; and (2) some sort of consensus as to what sort of priority we'd place on this sort of research in terms of the number of dollars we'd assign to it--as opposed to spending millions again next year on the technology of partitioning.

Q. (T. Hollocher): I wanted to make two comments. First, with respect to licensing agencies, it seems that such agencies need to consider two kinds of questions: (1) what is the hazard during normal operation; and (2) what happens in the case of a terrible

accident. With disposal, of course, in the normal operation there's no exposure at all, so only the second issue need be considered. Second, it seems like the Rasmussen study (WASH-1400) establishes an interesting precedent with respect to systems whose agreed-upon probability of failure is very low. People will take an event whose probability is highly improbable in the short range--let's say 10^{-12} of an event per year--and then extrapolate it out to periods on the order of 10^5 or 10^6 years.

A. I have no basic disagreement. My only point would be that a Rasmussen study on waste disposal operations would be a one-page document. The Rasmussen study relies very heavily on existing experimental data and uses this information as the predictive mode. It says: "Here's what we've done so far and, assuming that we continue to be as smart as we have been, here's what we can expect in the future." My problem is that in our present situation, we can't even do the "here's what we've done now" part.