DOCUMENT RESUME

06508 - [B1986996]

Major Unresolved Issues Preventing a Timely Resolution to Radioactive Waste Disposal. EMD-78-94; B-164052. July 13, 1978. 10 pp.

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Issue Area: Energy: Making Nuclear Fission a Substantial Energy Source (1608).
Contact: Energy and Minerals Div.
Budget Function: Natural Resources, Environment, and Energy: Energy (305).
Organization Concerned: Department of Energy; Nuclear Regulatory Commission.
Congressional Relevance: House Committee on Science and Technology; Senate Committee on Energy and Natural Resources.

Radioactive wastes vary widely in volume, composition, and intensity of radioactivity depending on the materials and nature of the operations from which they originate. Most of the radioactive wastes generated today are from the Department of Energy's (DOE's) weapons program, commercial nuclear reactors, and nuclear fuel cycle activities, mainly at fuel fabrication and reprocessing facilities. Findings/Conclusions: U.S. radioactive waste policy goals are presently unclear in that there is no clear differentiation of management, regulation (licensing), and research, development, and demonstration functions. In addition, no single agency has enough jurisdiction over all the aspects of nuclear waste operations to develop a comprehensive program. The safe development and demonstration of methods of collecting, temporarily storing, treating, packaging, and transporting these wastes present overwhelming challenges. Target dates currently envisioned by DOE are optimistic, and it is doubtful that they will be achieved. Goals for the future must include establishing specific criteria for radioactive wastes during each phase of management. These criteria should address not only those basic technological aspects of waste performance and repository characteristics, but also the specific institutional requirements. Unless the States and Federal Government join now in setting goals and assigning responsibilities for management and licensing, the radioactive waste management program will remain fragmented, publicly unacceptable, and undemonstrated. (SC)

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STUDY BY THE STAFF OF THE U.S.

General Accounting Office

Major Unresolved Issues Preventing a Timely Resolution to Radioactive Waste Disposal

GAO surveyed a portion of the literature on radioactive waste management and identified those major issues which could impede the timely and comprehensive removal of obstacles to demonstrating a national radioactive waste disposal program.

Presently, U.S. radioactive waste policy goals are unclear in that there is no clear differentiation of management, regulation (licensing), and research, development, and demonstration functions. Decisions on such important issues as

--regulatory responsibility over radioactive wastes,

--criteria for radioactive waste form and performance,

--method of final disposition, and

--repository site locations

must be made, and made soon, in order to assure public health and safety and adequate management of these potentially hazardous materials.

EMD-78-94
JULY 13, 1978

PREFACE

GAO surveyed a portion of the literature on radioactive waste management in an effort to identify and summarize those major technical and institutional issues which could prevent the U.S. from developing and demonstrating a national radioactive waste disposal program.

Nuclear power, while becoming an increasing source of energy, is also becoming an increasing source of criticism. This criticism is due, primarily, to the lack of a comprehensive program for managing radioactive wastes left behind by nuclear power operations.

Generally, radioactive waste is either classifed as high level or low level waste. For the purposes of this study, spent reactor fuel and uranium mill tailings are included under the generic term of radioactive waste, even though not currently defined as such. Each of the above varies in level of radioactivity, long-term isolation requirements, potential health hazards, handling and processing, and regulatory control.

Due to the long time periods required for isolation and the need for research and development to demonstrate such safe isolation, GAO believes that a unified effort is required to establish a national radioactive waste disposal program. In order to do such, however, institutional boundaries and authority must be clarified and realigned to insure public health and safety and adequate management.

This study is being provided to those congressional committees that have on ongoing interest in nuclear power. In addition, copies will be made available to interested persons upon request.

We hope this overview of the waste management situation, and our views on the more important issues to be focused upon, will help pave the way for progress in their timely resolution.

Director
Energy and Minerals Division

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INTRODUCTION

All operations that produce or use nuclear materials generate radioactive wastes. The wastes produced vary widely in volume, composition, and intensity of radioactivity, depending on the materials and nature of the operations from which they originate. Most of the radioactive wastes generated today are from the Department of Energy's (DOE's) weapons program, commercial nuclear reactors, and nuclear fuel cycle activities, mainly at fuel fabrication and reprocessing facilities.

High level waste has extremely high radioactivity concentrations and is characterized by intense penetrating radioactivity, extreme heat, and a long toxic life. This waste is created during reprocessing operations when reactor spent fuel elements are dissolved in acid to recover the unused uranium and plutonium for reuse as nuclear fuel. The remaining acid solution is referred to as high level waste. It contains many fission products and transuranics 1/--such as plutonium--which are not recovered during the reprocessing operations.

Currently, no commercial reprocessing facilities are operating and President Carter has indefinitely deferred such operations. The spent fuel which has been accumulating at nuclear power reactors since 1972 will have to be managed as high level waste since it has similar high concentrations of radioactivity, and is equally as hazardous to the public health and safety.

Low level waste may either be radioactive or suspected of radioactive contamination. This waste is disposed of according to its type and concentration of radioactivity. Liquid and gaseous wastes are usually treated, diluted, or held at the generating facility for radioactive decay and are then released into the environment. Solid waste, sludges, and liquids that have been solidified are transported from the generating facilities and are disposed of at one of eleven shallow-land burial sites around the country. One type of low level waste

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1/Transuranic elements are man-made, long-lived, and extremely toxic. These elements--such as plutonium--are created during the normal nuclear reaction process. These elements are found in several nuclear fuel cycle operations and are contained in nuclear wastes in varying degrees of radioactive intensity. Generally, the long-term hazards of nuclear waste are directly related to the transuranic elements they contain.

that has received increased attention from both DOE and the Nuclear Regulatory Commission (NRC) is uranium mill tailings. Uranium mill tailings are a sand-like radioactive waste material resulting from the extraction of uranium from uranium ore. About 85 percent of the radioactivity in uranium ore remains in the tailings after the milling process. Radium is the major radioactive waste product in the tailings and takes thousands of years to decay to innocuous levels.

DOE, NRC, the Environmental Protection Agency, and those States who have entered into formal agreements with NRC (agreement States) are the principal agencies involved in regulating and/or managing nuclear materials in order to protect the public and the environment from harmful radiation. NRC has the authority and responsibility to protect public health and safety through regulating the possession, use and disposal of radioactive materials by the commercial sector. It does this through establishing criteria and enforcing them through a licensing and inspection program.

DOE has established its own criteria at Government laboratories and production facilities that process, use, and dispose nuclear materials for protecting workers and the public from radiation hazards. In addition, DOE has responsibility for developing a program for the treatment, storage, management, and ultimate disposal of Federal nuclear wastes and the establishment of facilities for such.

Lastly, the Environmental Protection Agency is responsible for the establishment of overall environmental standards to protect the environment from radioactive hazards and the development of environmental assessments of various options in nuclear waste management.

Any comprehensive waste management program will have to address various types of waste--both commercial and Federal --that are now accumulating at disposal grounds, facilities, and nuclear powerplants. In addition, the program will have to delineate the agency(ies) responsible for coordinating activities required in demonstrating successful waste disposal. As of yet, such a comprehensive radioactive waste management program has not been developed. Due to overlapping or nonexistent authority over various waste forms and inadequate attention to some of the operations involved in safely disposing waste, full-scale demonstration of the waste management program will be significantly delayed.

HIGH LEVEL RADIOACTIVE WASTE DISPOSAL

Currently, about 74 million gallons of high level waste are stored in steel tanks and bins at DOE's three major laboratories (50 million gallons at the Hanford facility in Richland, Washington; 21 million at Savannah River, Aiken, South Carolina; and 3 million gallons at Idaho National Engineering Laboratory, Idaho Falls, Idaho). An additional 600,000 gallons from the commercial sector are stored at West Valley, New York. If spent fuel were reprocessed, an additional 152 million gallons of high level waste would be generated by the year 2000.

Most of this waste has been neutralized for cheaper storage. Neutralizing high level waste, which is originally in an acidic chemical form, has major disadvantages in that increased volumes are produced, the more radioactive isotopes become insoluble and settle as sludge on the tank bottoms, and technology to transform neutralized waste into a suitable stable form for long-term storage and disposal has yet to be demonstrated on a full-scale. Temporary storage in these steel tanks and bins cannot continue indefinitely, as some have already begun to leak, releasing radioactivity into the environment. Also, the waste will have to be removed from its temporary storage for processing into a more suitable form for permanent disposal, and cannisters must be designed and licensed for final transportation and disposition.

Major unresolved technological issues surrounding management of this high level waste include:

--Does DOE have the technological capability to extract the high level waste from its current storage tanks?

--Can DOE demonstrate, outside the laboratory, a waste form that is suitable for disposal?

--Can suitable disposal facilities be engineered and/or located to safely store this waste for the thousands of years required?

DOE is currently studying ways to remove waste from its storage tanks. The neutralized waste has separated and left a hard sludge layer on the tank bottoms. Consequently, mere pumping or flushing will not remove all of the sludge layer so that the waste can be converted into suitable disposal forms. In addition, some of the steel tanks have begun to develop cracks and flushing or adding more stress to these tanks could be highly dangerous. In the event that the waste cannot be removed, DOE is studying ways of solidifying the waste in situ

and immobilizing the tanks at their current sites for permanent storage. This option, however, is not too attractive, as the current sites are geologically unsuitable for long-term storage or disposal.

DOE is also studying various waste forms, such as glassification, which could be suitable for long term storage. Important waste form criteria which are included in these studies are particle size, resistance to sudden temperature increases, insolubility, steady state temperatures, and impact resistance during transport. DOE has had some success, to date, even with neutralized waste, in demonstrating these criteria on a laboratory scale. What is needed now, however, is a demonstration-scale facility to test some of the more promising options.

Another technological problem which must be overcome in developing a radioactive waste management program is where this waste will be permanently stored. It cannot be stored at present locations because of the various problems noted above. DOE has begun an ambitious program to demonstrate the feasibility of safely placing commercial and military radioactive high level wastes in deep geological formations by 1988, and is currently seeking sites for pilot facilities in three areas of the country (Carlsbad, New Mexico; Savannah River, Georgia; and salina basin salt beds in western New York). Concurrently, NRC is developing geologic site suitability criteria which sites must meet before they can be considered for waste disposal. These criteria include such factors as freedom from water movement, geologic stabililty, resistance to change due to radioactive heat, minimal natural resource trade-offs, and other aspects.

DOE has made some preliminary attempts (such as at Lyons, Kansas) and has failed, as of yet, to demonstrate that a site is stable enough for waste emplacement. Technologically, it is feasible that sites with specified geologic characteristics can be found and tested against the criteria, but some uncertainties will always exist as to future site and waste stability. These uncertainties cannot be resolved in our lifetime. All that can be assured is that specific criteria supported by adequate research and development have been developed and will be applied to proposed storage sites. As of this date, it has not been demonstrated that engineered structures can blend with geologic features in a way that radioactive isolation can be relatively assured for the next few thousand years.

Given adequate funding and effort, many, if not all, of these technological problems can be solved. However, their satisfactory resolution may not aid in demonstrating a

radioactive waste management program unless institutional problems are resolved. Indeed, the institutional obstacles may be as great, if not greater, than the technolgical obstacles. Some of the major institutional problems include

--lack of adequate regulatory control over all waste management operations,

--nonexistent standards for important operations in the waste management program, and

--NRC's failure to assign specific responsibilities to specific agencies in its draft waste management criteria.

There are some gaps in NRC's licensing authority in that not all facilities for the treatment, storage and disposal of wastes are required to meet NRC's criteria. NRC has licensing authority over DOE facilities used for the storage of commercial high level waste and retrievable surface storage facilities and other long-term storage facilities for DOE's high level waste. It does not have specific authority over research and development facilities or full-scale facilities for the temporary storage of DOE's high level waste. Any waste management program must insure that all waste storage and disposal facilities are licensed and regulated, since whether the waste is commercial, Federal, or transuranic does not change the fact that these waste forms are similarly as hazardous and will likely be stored and managed together.

Federal regulations and standards are not complete for the required solidification of waste for disposal, for transporting the waste from storage facilities to disposal sites, or for the cannisters which will be required during transport and disposal. For example, the Department of Transportation has responsibility for insuring safe transport in commerce of hazardous radioactive materials, establishing general criteria for packaging and handling waste, and allotting sole responsibility for licensing of waste transport to those agencies who agree to enforce their own standards and the Department's. These criteria are not yet complete and even when finalized, may permit reinterpretation and different application by the different agencies which handle radioactive materials.

The criteria NRC has developed for the radioactive waste management program are deficient in that States' roles and other Federal agencies' roles are not included. States' authority over waste management operations is basically preempted by the Federal Government's. States may only regulate non-radioactive aspects in a way that does not unduly interfere with Federal promotion and regulation of nuclear energy.

However, challenges to this preemption doctrine are continuing and political pressures from States can be effective in altering the Federal Government's position. For example, political pressures from a State which has a potential geologic repository may prevent development of a waste disposal site (such as Michigan). Unless States can be assured that an adequate waste management program exists, it is doubtful that they will trust the Federal Government to regulate and manage a site in their State. Specifically, States are concerned about such things as ultimate liability, cost to the State, reimbursement, continual management, and resource tradeoffs. They want to be included early in any site selection and review process and be kept informed of technological advancements, criteria to be met, and specific management responsibilities. In addition, they want to know what will be required of the State at each stage of site development, demonstration, and maintenance.

Along with the lack of regulatory and management delegations, the criteria are not clear as to who will be financially responsible for waste management operations and to what degree. Even before the first waste repository is ever demonstrated, the Federal Government, utilities, the States, and/or the public will be paying billions of dollars for such key aspects as research, collection of waste, and transportation.

SPENT FUEL MANAGEMENT AND DISPOSAL

Commercial nuclear powerplants are storing spent fuel at the plant sites in storage pools as there is no facility to ship them to for storage and there are no commercial reprocessors to process the spent fuel rods into high level waste and new fuel. There are now 65 nuclear powerplants in operation today with another 78 under construction. By the end of 1977 about 4,000 metric tons of spent fuel had been placed in storage pools, and this figure will increase yearly.

Utilities are currently having their licenses amended by NRC to allow more spent fuel to accumulate in their pools than they were originally designed and licensed for. Eventually, pools will become so full that the reactors will be forced to shut down due to lack of discharge/storage space unless more pools are constructed and licensed at the sites.

Decisions on what to do with the spent fuel have been delayed due to President Carter's decision to indefinitely defer commercial reprocessing. DOE is soliciting the commercial industry's reaction to DOE assuming ownership of spent fuel in exchange for a one-time fee to cover the costs of temporary storage and eventual geologic disposal. Utilities are finding it difficult to select a course of action, lacking DOE information on cost, schedule, location, and terms and conditions.

As of now, it is economically advantageous for them to expand their current storage pools and build more than to anticipate such decisions from DOE.

There really are no technological obstacles to demonstrating spent fuel temporary storage, but long-term and/or permanent disposal faces the same problems as does high level waste; that is, demonstrating structural integrity of a geologic site within a timeframe commensurate with industry's needs. Assuming that costs can be quantified and are acceptable to industry, DOE is planning on building 'away from reactor' storage facilities which will be, essentially, large storage pools. Their major purpose will be to provide the necessary 5-year cooling off period for the fuel elements and to hold the backlog of spent fuel until the geologic respository is built. DOE is planning retrievability for this repository in the event that reprocessing is allowed at some future date.

Other obstacles which may prevent this program from effectively developing include:

--Transportation problems due to the lack of an adequate supply of railroad cars and trucks licensed to transport spent fuel.

--Lack of a sufficient number of shipping cannisters and the ability of industry to manufacture enough in time.

--The potential of State veto power over temporary storage facilities located in their States.

--Setting adequate licensing criteria and authority over both the temporary storage and permanent disposal facilities. Currently, NRC does not have regulatory authority for such facilities, even though it is anticipated they will be licensed.

LOW LEVEL WASTE DISPOSAL

The current practice of managing solid low level radioactive waste consists of burying it in shallow land disposal sites either owned by DOE or private industry. DOE has 14 active and 2 closed burial grounds containing an estimated 44.1 million cubic feet of radioactive waste. There are six commercially operating low level waste burial grounds containing about 17 million cubic feet of waste. Three of these sites have been closed down for hydrogeological studies, limited burial capacity, or political and public opposition to continued use. Additional burial capacity will be required by both DOE and private industry by about 1990, at the latest,

given the amount of waste expected to be generated. Expansion of commercial burial sites is doubtful, due to licensing problems and public unacceptability. It is likely that DOE's shallow land burial sites will be needed to meet the needs of the commercial sector.

Regulatory authority for these sites is split between DOE--which sets its own criteria and manages its burial grounds--and NRC and the States. NRC licenses burial facilities, while the States are responsible for the long-term care (200 to 300 years) of the commercial site after the license is terminated.

Due to the large volumes involved in low level waste and the desire to avoid burial ground proliferation, decisions must be made on the maintenance of current closed sites, and alternative disposal options such as volume reduction and disposal in suitable deeper geologic formations. The cost of such an alternative, however, is high ($60 per cubic foot of waste as compared to $3 per cubic foot of waste under current low level waste disposal practices), and utilities may be unwilling to pay the increased cost unless required. Technologically, the methodology involved in waste reduction is commercially available. However, as with high level and transuranic wastes and spent fuel, geologic uncertainties exist and criteria need to be delineated.

Decisions must be made, also, on who will manage burial grounds. Criteria and standards must be developed which specify suitable site characteristics which ensure minimal radioactivity migration, and which define necessary actions to stabilize filled burial sites. On the commercial side, authority over closed burial sites must be given to a specific agency, and funding for long-term maintenance must be assured.

Uranium mill tailings present a slightly different management problem than low level waste. At 22 locations where uranium mills have shut down, about 500 million cubic feet of tailings have accumulated which will have to be managed due to the long decay life of the radioactive materials. It is estimated that by the year 2000, between 80 and 110 mills may be in operation and one billion tons of tailings will have been generated.

NRC and agreement States license mill operations through license provisions such as restricted access, isolating piles from water, and containing piles by using ground cover. Following license termination, however, regulatory agencies lose their control over the piles and have no authority to assure that the piles are not dispersing radioactivity, thereby

posing a health hazard. 1/ Even at sites where tailings have been stabilized through adequate ground cover and restricting water movement through the sites, none of the tailings can be considered adequately stabilized for long-term storage. NRC and DOE are currently assessing the situation and looking for more permanent methods for stabilization and methods for removal of the tailings piles if the site proves totally unacceptable for storage. The Environmental Protection Agency is performing an environmental assessment of these various options, and it is difficult to predict a suitable long-term waste management program for the tailings until such an assessment is completed. If removal were chosen because stabilization proves unacceptable for the time periods required, some form of compaction and processing would be required for disposal in geologic formations--if indeed there were enough burial space.

CONCLUSIONS

U.S. radioactive waste policy goals are presently unclear in that there is no clear differentiation of management, regulation (licensing), and research, development and demonstration functions. In addition, no single agency has enough jurisdiction over all the aspects of nuclear waste operations in order to develop a comprehensive program. The safe development and demonstration of methods for collecting, temporarily storing, treating, packaging and transporting the wastes discussed above are overwhelming challenges. Target dates currently envisioned by DOE are optimistic and it is doubtful that they will be achieved due to public unacceptability.

Goals for the future must include establishing specific criteria for radioactive wastes during each phase of management. These criteria should address not only those basic technological aspects of waste performance and repository characteristics, but also the specific institutional requirements. Some other issues which need to be considered are:

--Will States ban temporary storage facilities within their boundaries?

1/Because of problems with uranium mill tailings, NRC has instituted new licensing procedures. By 1978 all new and existing uranium mill licensees will require a tailings reclamation plan and bonding arrangements to finance stabilization after mill shutdown.

--Will political pressures force less suitable disposal alternatives?

--Who will be responsible for monitoring sites once they are closed?

--What burden are we placing on future generations?

These decisions are essential in developing a successful national waste management program, and their resolution may be as difficult, if not more so, than the resolution of technological problems. Unless the States and the Federal Government join now in setting goals and assigning responsibilities for management and licensing, the radioactive waste management program will remain fragmented, publicly unacceptable, and undemonstrated.