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# WASTE MANAGEMENT — LICENSING AND CRITERIA

RADIOACTIVE WASTE

**KEYWORDS:** *licensing, radioactive waste management, USAEC, regulations, plutonium, fuel cycle*

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*Waste management is a topic of great importance to industry and the general public, and one that receives a great deal of attention within the regulatory organization. The regulated fuel cycle includes uranium milling, $UF_6$ conversion, fuel fabrication, chemical reprocessing of spent reactor fuel, transportation of nuclear materials, and waste disposal.*

*Management of radioactive waste generated in the nuclear fuel cycle is of particular interest now. A number of policy decisions must be made in the near future and then implemented as regulatory requirements. These decisions must receive public acceptance for safety and protection of environmental values. The main issues pertain to management of high-level waste, management of plutonium bearing waste (including the fuel cladding hulls from reprocessed fuel), stabilization and long-term control of mill tailings, and the application of the "as low as practicable" concept of fuel cycle effluents in light of the current status of technology.*

*Two important studies are presently being carried out by the U.S. Atomic Energy Commission. The first involves the assessment of the environmental effects of utilizing plutonium fuel in light-water reactors; the second is an environmental analysis of the nuclear fuel cycle associated with high-temperature gas-cooled reactor operations. Waste management is significantly represented and evaluated in each of these studies.*

## INTRODUCTION

Waste management is a topic of great importance to industry and the general public, and one that receives a great deal of attention within the regulatory organization. My responsibility in the U.S. Atomic Energy Commission's (USAEC) Directorate of Licensing keeps me deeply involved in waste management issues.

The fuel cycle we regulate covers uranium milling, $UF_6$ conversion, fuel fabrication, chemical reprocessing of spent reactor fuel, transportation of nuclear materials, and waste disposal.

Management of radioactive waste generated in the nuclear fuel cycle is of particular interest now since a number of policy decisions must be made in the coming months that will eventually be implemented as regulatory requirements. These decisions must receive public acceptance for safety and protection of environmental values.

From the regulatory perspective, the important fuel cycle issues concerning waste generation and handling pertain to management of high-level waste, management of plutonium bearing waste (including the fuel cladding hulls from reprocessed fuel), stabilization and long-term control of mill tailings, and the application of the "as low as practicable" concept to fuel cycle effluents in light of the current status of technology.

## HIGH-LEVEL RADIOACTIVE WASTE

By "high-level liquid radioactive wastes" we mean those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels. The USAEC regulations governing such high-level waste management are contained in 10 CFR Part 50, Appendix F, and briefly state that

1. Facilities for the temporary storage of high-level radioactive wastes may be located on privately owned property.

2. A fuel reprocessing plant's inventory of high-level radioactive liquid waste will be limited to that produced in the prior five years.

3. High-level liquid wastes shall be converted to a dry solid as required to comply with this inventory limitation and placed in a sealed container prior to transfer to a Federal repository in a shipping cask meeting the requirements of 10 CFR Part 71.

4. The dry solid shall be chemically, thermally, and radiolytically stable to the extent that the equilibrium pressure in the sealed container will not exceed the safe operating pressure for that container during the period from canning through a minimum of 90 days after receipt at the Federal repository.

5. All of these high-level radioactive wastes shall be transferred to a Federal repository no later than 10 years following separation of fission products from the irradiated fuel.

6. Upon receipt, the Federal repository will assume permanent custody of these radioactive waste materials although industry will pay the Federal Government a charge which together with interest on unexpended balances will be designed to defray all costs of disposal and perpetual surveillance.

7. USAEC will take title to the radioactive waste material upon transfer to a Federal repository.

8. Disposal of high-level radioactive fission product waste material will not be permitted on any land other than that owned and controlled by the Federal Government.

The present emphasis for long term management of high-level waste is on retrievable surface storage rather than immediate disposal in salt or some other geologic formation—and questions have been raised by the fuel reprocessing industry regarding details of packaging requirements, physical and chemical form of the high-level waste, etc., that might be involved in this change of concept. These questions are valid and require timely answers. I would like to give you my point of view on what some of these answers might be.

Present USAEC responsibilities for handling of high-level wastes involve three major arenas of operation. First, the reprocessing plant—all safety and environmental aspects of managing such waste at the reprocessing plant site are controlled by the regulatory licensing and compliance processes. 10 CFR Part 50, Appendix F, speaks generally to this point and all technical specifications regarding design and operation of the plant are spelled out, both during the licensing review and stated in detail in the actual operating license issued.

Second, transportation of radioactive waste—also a regulatory responsibility. Requirements are imposed on the licensee for safe packaging design and other safety requirements with respect to transporting solidified waste to a Federal repository—the third arena. At this time, it is not planned that this repository will be a licensed facility, and for this reason it does not fall under 10 CFR regulations except as its existence is noted in Appendix F.

Some of the specific requirements contained in Appendix F could have been defined more generally. A better approach might have been to include a statement in the regulations to the effect that high-level waste sent to the Federal repository from the reprocessing plant must meet all specifications set forth by the repository operator, i.e., packaging requirements, physical and chemical form of high-level wastes, etc., and all specifications necessary for safe transportation of such material. Such regulatory requirements would obviously be broad enough to cover changing specifications laid on by the repository operator as new technical and economic issues are raised and resolved.

We have been asked what we would do if new legislation or regulation required regulatory review of the Federal repository. The answer appears to be straightforward. If such a requirement is imposed, our review would be of sufficient depth to ensure that the health and safety of the public would not be endangered and would cover, among other factors, the storage design as well as packaging requirements, and chemical and physical specifications for the high-level wastes.

## OTHER THAN HIGH-LEVEL WASTE

With regard to other than high-level waste, the matter of most pressing interest to us right now involves the disposition of plutonium containing waste. Currently, such waste generated by licensees may (by regulation) be buried at commercial land burial grounds if the plutonium in such waste is below acceptable limits. Quantities of plutonium wastes are presently very limited because of the limited nature of the plutonium business in the United States.

Our evaluation of a commercial burial site, of the type under discussion here, prior to making a licensing decision on its acceptability, involves two significant areas of safety consideration. First, the geological, hydrological, climatological, and demography characteristics of the site must be such as to assure that buried waste will not migrate into water supplies or otherwise become available for inhalation or ingestion by man. Second, commercial burial sites must be on land owned by the Federal or a state government to assure long-term control.

The quantity of plutonium thus far buried in commercial facilities is relatively small and is dispersed through a large volume of material. Chemical and physical characteristics of plutonium are such that migration in soil or groundwater is unlikely. Since available evidence indicates that the plutonium has remained immobile at the place of burial, we do not believe that the plutonium now buried constitutes a threat to man or the biosphere.

However, a sharp increase in the amount of plutonium contaminated waste is expected to occur in the future. For example, it is estimated that there will be a cumulative total of over 8 million $ft^3$ of uncompacted plutonium waste containing hundreds of kilograms of plutonium before 1985.

In view of the high degree of radiotoxicity and the long half-life of plutonium (24 000 years) as well as the large quantity of plutonium involved, we are studying the matter of whether or not disposal of low-level waste bearing plutonium should be discontinued in favor of disposition in a Federal repository where there would be a greater assurance of long-term control. We are also considering what the various options are for interim retrievable storage until a Federal repository becomes available.

Two important aspects of the study are how best to define the dividing line or threshold between those plutonium wastes that may go to commercial burial grounds and those that must go to the repository, and what other radionuclides besides plutonium should be considered for exclusion from commercial burial grounds. We believe plutonium is of principal importance and have, therefore, singled it out for first priority.

## MANAGEMENT OF PLUTONIUM BEARING WASTES

In the past 18 months, we have had discussions with executives in the nuclear fuel cycle industry stressing some of our key areas of concern for the future. One important subject involves management of the large volume of plutonium contaminated waste just noted. Looking to the future, burying millions of cubic feet of such waste each year may not be a viable alternative. Furthermore, setting up a Federal repository for permanent storage of such waste is not a very attractive prospect. Thus, I would think that this waste, generated in fabrication and other operations, will undoubtedly have to be reduced in volume to a more manageable quantity by techniques such as incineration, leaching, or compaction (or a combination of these and other techniques).

With such treatment comes substantial cost additions and potential safety problems. Obviously, the designer who can find ways to minimize plutonium waste generation during plant operations has minimized the potential safety problems and has eliminated a substantial handling cost—to himself and to his customers.

Incineration of plutonium wastes could cost hundreds of dollars per gram of processed plutonium. Since the plutonium is not worth more than a few dollars per gram, the waste management recovery operations are almost completely on the debit side.

It is our view that actions must be taken by the industry to minimize the generation of plutonium contaminated wastes. We recognize that there are limits to what can be done, considering today's technology. The USAEC, through its Division of Waste Management and Transportation, has some programs studying ways by which the technology can be improved to gain reductions in plutonium waste volumes. Industry could or should study other methods. Some of the areas the USAEC is looking at include the possibility of essentially eliminating plutonium and other similar long-lived radionuclides from the high-level waste stream from spent fuel processing, the reduction of the amount of plutonium and similar materials in waste generated by fuel fabrication, and the reduction of the volume of nonradioactive waste present in the radioactive waste. The overall objective, of course, is to minimize the amount of plutonium bearing waste which will require either surveillance or treatment.

As the plutonium industry develops, there will be a need for larger more modern production facilities designed to process the higher exposure plutonium with its increased radiation levels. Efficiency and safety may dictate automated operations behind shielding which may well further the objective of reducing waste through elimination of gloves, plastic bags, absorbent tissues, and other types of waste associated with manual operations.

We have mentioned costs through this latter brief discussion because we cannot eliminate costs from these regulatory considerations. By this I mean part of our responsibilities is to determine that the participating parties are financially able to meet all regulatory commitments, including future requirements for storage, possible processing and final disposition of waste.

Such requirements which could add substantial future costs (as noted above) may somehow have to be estimated in the near future. The problem is not easy, but it is not unique—as a matter of fact, there are similarities to the high-level waste problem. In this regard, the landlord of the repository might logically be expected to set specifications and charges for handling of such waste material in the not too distant future.

Closely allied to the subject of low-level waste is the handling of empty fuel hulls, i.e., hulls not dissolved during reprocessing of irradiated fuels. These hulls, although thoroughly leached, are expected to retain trace quantities of plutonium; however, we do not have sufficient experience as yet to know accurately enough for evaluation purposes what the residual quantities of plutonium will be. Present plans are to hold the hulls in retrievable storage at the reprocessing sites. Since the annual volume of uncompacted hulls per 1000 MW reactor is about 60 $ft^3$, if we assume 150 such reactors in 1980, the total annual volume would be ~9000 $ft^3$, approximately the volume of a two-car garage. This quantity would appear to be manageable, particularly when compared to the 8+ million $ft^3$ of plutonium contaminated waste predicted for 1985.

## MILL TAILINGS

Another area of waste management and disposal which has received considerable attention over the years is uranium mill tailings. In the processing of uranium ore to extract uranium, solid wastes in the form of sand tailings are accumulated at the mill sites. Approximately 91 000 tons of solid tailings are produced in the milling of sufficient ore to supply the uranium needed for the annual reload of a 1000-MW power reactor. The tailings contain uranium unrecovered by the milling process (0.02% by weight) and most of the naturally occurring radioactive daughters of the parent $^{238}U$. Of the daughters present, $^{226}Ra$ has been the radionuclide of principal concern.

Although we believe that the available data indicate that uranium mill tailings generally do not present a significant radiological risk, we think such tailing piles should be stabilized and subject to long-term control so as to minimize dispersal of the material, prevent unauthorized removal of the tailings for other uses and preclude human occupancy of the tailings areas.

The USAEC exercises jurisdiction over the accumulation of tailings at operating mills when these tailings are an integral part of the milling activities. The USAEC does not exercise authority through licensing, regulation, or procurement, under the Atomic Energy Act, over uranium mill tailings which contain <0.05% uranium or thorium at closed mills.

Under USAEC regulations in implementation of the National Environmental Policy Act (NEPA), uranium milling is one of the activities for which an environmental impact statement is required before issuance of the license. An important consideration in this environmental review is the applicant's plan for stabilization and control of mill tailings. As a consequence of this review, provisions pertaining to tailings control and stabilization have been included in the licenses for two new mills and we anticipate that this policy will be continued in connection with the issuance of other new licenses.

Recently, we have determined that we can use our authority under the NEPA to conduct an environmental review in connection with the termination of a uranium mill license. We are now in the process of implementing this authority which, incidentally, does not cover situations where the USAEC license is no longer in effect. This environmental review will deal principally with stabilization and long-term control arrangements for the tailings.

Over the years the Commission has encouraged the states in which mills are located to adopt regulations specifically dealing with stabilization and control of mill tailings. Currently, Arizona, Colorado, Oregon, Tennessee, Texas, and Washington exercise control of mill tailings through regulations or license requirements. New Mexico expects to implement such controls soon. At the 7th Session of the Federal-State Enforcement Conference on the Colorado River Basin held in February 1972, the Conference unanimously endorsed adoption by the states of model regulations (patterned after Colorado) which would require stabilization and long-term control of mill tailings. It is expected that other members of the Conference which include New Mexico, Utah, and Wyoming will adopt such regulations.

We believe that the Commission's authority under NEPA, and state authority and actions in this area, are generally sufficient to deal effectively with the problem of mill tailings at active mills. With respect to tailings at closed mills where licenses are no longer in effect, the Congress is considering possible legislation which would provide a means for dealing with such tailings.

## EFFLUENTS

With respect to effluents, as you know, we have the "as low as practicable" concept, referred to as ALAP, which is expressed in general terms in 10 CFR Part 20. The term, "as low as practicable," means that which can practicably be achievable taking into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and in relation to the utilization of atomic energy in the public interest.

Basically we are talking about a cost-benefit analysis. Effluents must be evaluated in terms of this concept for all activities subject to licensing. Definitive guidelines on ALAP for light-water-power reactors have been proposed in Appendix 1 of 10 CFR Part 50, and are now being prepared for adoption in final form.

Studies are underway to develop definitive guidelines on ALAP for other fuel cycle activities—milling, $UF_6$ production, fuel fabrication, and fuel reprocessing. The engineering part of these studies will develop the incremental capital and operating costs for charges and additions to systems to reduce effluent releases and will develop corresponding source terms for the radioactive emissions. The systems will cover the range from present practice to the foreseeable limits of available technology on the basis of expected typical and normal operation over the life of the plant. Following the engineering phase, the program will deal with the behavior of radionuclides in the environment, and assess radiation exposure to the public and the impact on the environment.

The information thus developed will enable a cost-benefit analysis to be made for effluent control. It should also provide a timetable for the availability of new technology so that plants being designed now can make necessary provisions for backfitting to incorporate new technology, if appropriately indicated by the cost-benefit analysis.

Further, with regard to ALAP and new technology, I would like to highlight the current status of effluent control for fuel reprocessing plants. Under current designs all radionuclides are treated and effectively removed from effluent streams with the exception of $^{85}Kr$ and tritium. For example, systems are operational for stripping iodine, plutonium, and other transuranic elements, strontium, cesium, etc. Thus, we believe that at present the effluent control systems of reprocessing plants are being designed and will be operated to maintain releases of radioactive materials to the environment at the lowest practicable level consistent with available demonstrated technology.

Atmospheric dispersal of $^{85}Kr$ and tritium reduces offsite concentrations to levels far below those considered acceptable in current USAEC regulations. New technology is being developed by the USAEC to remove $^{85}Kr$ and suitable equipment should be available for use in the future if needed. Tritium removal is also the subject of study by the USAEC in conjunction with the liquid-metal fast breeder reactor program. The safety aspects of such removal of $^{85}Kr$ and tritium and the management and disposal of the recovered materials will require careful evaluation to be sure we are not creating new safety problems. Based on current projections of the processing of irradiated fuel and considering the low population exposure projected from these sources of activity, we believe adequate time exists to develop safe systems.

I believe the industry's important continuing responsibility with regard to radioactive waste management is to understand fully the significance and the spirit of the ALAP concept in its broadest sense and to be innovative in its implementation.

## GESMO

I would like to add a few comments, which I think will be of interest, about the generic environmental statement on the use of mixed oxide fuels (GESMO) in light-water reactors (LWRs) which we are preparing.

The Commission has determined that any decision with respect to the wide-scale recycle of plutonium in LWRs constitutes a major Federal action significantly affecting the quality of the human environment and, as such, requires preparation of an environmental impact statement pursuant to NEPA. The Commission has also indicated that upon completion of the environmental statement, appropriate rule changes may be issued governing recycle of plutonium in LWRs. An announcement to this effect was published in the Federal Register on Feb. 12, 1974, and comments and data were invited from all interested parties.

The generic environmental statement which we are preparing will necessarily assess the environmental impacts, on a total industry basis, of the entire mixed oxide fuel cycle, i.e., from mining of uranium to the reprocessing of spent fuel, including the power reactor itself, as well as radioactive waste management and transportation of radioactive material. Further, the assessments will include the matter of safeguarding nuclear materials from theft or diversion and facilities and materials from sabotage. The statement will identify and evaluate the principal changes in the LWR fuel cycle which may occur as a result of plutonium recycle. These should be most evident in the areas of fuel fabrication, fuel reprocessing, waste management, transportation, and safeguards. The environmental impacts from both normal operations and potential abnormal and accident situations will be evaluated for each fuel cycle activity involved.

With respect to the waste management aspects of plutonium recycle, the most significant changes over the $UO_2$ fuel cycle concern the characteristics of the high-level waste from reprocessing and the generation of plutonium bearing waste in the "other than high-level waste" category from reprocessing and fuel fabrication. I have already discussed the issues with respect to disposition of plutonium bearing waste. I would now like to mention some of the changes in the characteristics of high-level waste from reprocessing recycle fuel.

The fission products content of the high-level wastes generated at the reprocessing plants will not vary greatly whether or not plutonium is recycled. The fission product yields from plutonium are somewhat, but not greatly, different than the fission product yields from $^{235}U$. The transuranium actinide content of spent fuels, however, will be significantly increased as a result of plutonium recycle. The presence of the higher isotopes of plutonium and the increased quantities of americium and curium will result in changes in the characteristics of the high-level waste.

The heat generated in a canister of solidified high-level waste (i.e., that generated from processing 3.2 MT of fuel) of an *average* mixture when plutonium is used is $\sim 30\%$ higher than that released by the waste from enriched $UO_2$ fuel without plutonium recycle. If the waste from plutonium recycle fuel were segregated, the heat released would be about 4 times that from $UO_2$ fuel. The increase is due mainly to the increased formation of $^{244}Cm$ which is not recovered and stays with the high-level waste. In addition, the rate at which the heat will decrease is affected. A canister of waste from reprocessing enriched $UO_2$ fuels will decay to 5 kW in about 6 years; a canister of waste containing the *average* mixture with plutonium recycle will decay to 5 kW in about 7 years; and a canister containing waste segregated from mixed oxide fuel will not decay to 5 kW until about 30 years. These are some of the facts we will take into account in preparing the GESMO and they will involve fuel reprocessing, transportation, and high-level storage.

Our original schedule for preparation of the statement called for completing the DES in August of this year and the FES in January 1975. However, because of the importance of a timely decision in this matter, we have accelerated the schedule so as to complete the DES in June of this year and the FES by the end of October.

## HTGR SURVEY

It might be of interest to know that we are preparing an environmental survey of the high-temperature gas-cooled reactor (HTGR) fuel cycle. Our work in this area has revealed some interesting things about the wastes to be generated from this fuel cycle which uses uranium as the fissile material and thorium as a fertile material.

The heat content of a canister of waste is about midway between that of waste from an LWR and the waste from an LWR using plutonium as a recycle fuel because of the relative amounts of americium and curium contained in the various wastes. Perhaps the most significant difference in waste characteristics would be the presence of large amounts of $^{238}Pu$ in the HTGR waste that is anticipated. Each canister of HTGR waste will contain about 1.5 kg of plutonium (about 65% $^{238}Pu$ and 15% $^{239}Pu$) compared to $<0.1$ kg (mostly $^{239}Pu$) in a canister of LWR waste.

Thus, you can see that we must not only deal with the problems of managing the high-level wastes generated today, we must also plan for the future when other fuels may be utilized in reactors generating high-level wastes with entirely different characteristics than today's waste.

## CONCLUSION

In closing, I think it might be appropriate to note that about a year and a half ago we prepared and published for comment a document entitled "Environmental Survey of the Uranium Fuel Cycle." We did this to support a proposed rule-making action regarding the manner in which the fuel cycle environmental impacts would be factored into the cost-benefit analysis in LWR environmental statements. A rule-making hearing was held in Feb. 1973, and publication of the final rule is imminent.

In the survey, we included an analysis of, among other things, radioactive waste management for the total fuel cycle. Our findings were that with currently operating plants and those designed to be operational in the near future, radioactive waste handling techniques and procedures were effective in keeping the impact on the environment small in comparison with current standards.

I mention the survey and the results to be sure that the issues we discussed on radioactive waste management are kept in perspective. On the other hand, it is clear that both the USAEC and industry have major obligations to assure that problems on the horizon are recognized and dealt with effectively and in a timely manner.