IDENTIFICATION AND CHARACTERIZATION OF DEPARTMENT OF ENERGY SPECIAL-CASE RADIOACTIVE WASTE*

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ABSTRACT

This paper identifies and characterizes Department of Energy (DOE) special-case radioactive wastes. Included in this paper are descriptions of the special-case waste categories and their volumes and curie contents, as well as discussions of potential methods for management of these special-case wastes. Work on extensive inventories of DOE-titled special-case waste are still in progress.

INTRODUCTION

With the issuance of Department of Energy (DOE) Order 5820.2A in September 1988, DOE established policies, guidelines, and minimum requirements to manage its radioactive wastes. The Order addresses three major categories of radioactive waste: high-level, low-level, and transuranic. The Order does not apply to DOE's management of commercially generated spent nuclear fuel or high-level wastes (HLW), nor to the geologic disposal of HLW produced by DOE. It also does not apply to DOE management of commercially generated greater-than-Class C (GTCC) wastes.

All radioactive waste is characterized to determine its waste category. Some wastes may have characteristics of more than one of the major waste types. These characteristics may prevent such wastes from being managed as typical high-level, low-level, or transuranic waste. DOE has termed these wastes special-case wastes. Special-case wastes may require special management and disposal schemes.

Because of these special considerations, DOE-Headquarters (HQ) required the identification of all existing and potential DOE-owned special case waste to determine future management planning and funding requirements. The inventory effort includes all commercially held, DOE-owned radioactive materials. The Low-Level Waste Technical Support Program (LLWTSP), managed by EG&G Idaho, Inc., is responsible for the special-case waste identification task.

BACKGROUND

DOE Order 5820.2A, Radioactive Waste Management, establishes requirements for managing all DOE radioactive wastes. The Order identifies management practices for the storage, treatment, and disposal of radioactive wastes. These practices support waste management strategies that are cost effective and protective of public health and safety.

Some wastes may have characteristics, or pose institutional problems, that prevent them from being managed as typical high-level, low-level, or transuranic wastes. Such wastes have been designated special-case wastes. DOE Order 5820.2A establishes that disposal systems designed for special-case wastes require a specific performance assessment through the National Environmental Policy Act (NEPA) process, and concurrence of DOE-HQ. For this reason, special-case wastes are primarily those wastes that have limited or no planned disposal alternatives.

Special-case wastes include the following categories:

- Low-level wastes (LLW) that contain radioisotopes in concentrations that a site could not dispose of and still meet its risked-based performance objectives
- Wastes that exceed the limits shown for Class C waste in Tables 1 and 2 of 10 CFR 61.55
- Transuranic (TRU) wastes that cannot be disposed of at DOE's Waste Isolation Pilot Plant (WIPP)
- TRU wastes that do not meet requirements of the payload compliance plan for the TRUPACT-II shipping container
- Nuclear fuel and fuel debris used for research purposes
- Excess nuclear materials at or near the economic discard limit (EDL) that cannot be safely or economically recovered.

Special-case wastes that have currently been identified include mixed wastes. Mixed wastes contain a hazardous waste constituent that is regulated by the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA). However, for the purposes of this project, the radiological waste management re-

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straints will serve as the primary criteria for distinguishing special-case wastes.

Special-case wastes require special treatment, storage, and disposal schemes. Accordingly, the DOE has required that all existing and potential special-case waste be identified and characterized. Comprehensive data are necessary to develop technical alternatives for both reuse or recovery of all valuable nuclear materials, and waste management strategies that are cost effective and protective of public health and safety.

A preliminary survey, using DOE-HQ memorandum requests for information, to identify special-case wastes began in July 1988. All field offices were requested to provide information on wastes that exceed the limits shown for Class C waste in Tables I and II of 10 CFR 61.55. This effort was completed in April 1989, with the conclusion that a physical survey of the sites was necessary to gather information on all special-case wastes and excess nuclear materials that are potential wastes.

EXCESS NUCLEAR MATERIALS BACKGROUND

DOE facilities have unusable excess nuclear materials that, in some instances, are considered special case waste. Excess nuclear materials are nuclear materials with potential value for either reuse or recovery of the special nuclear material (SNM) fraction. Excess nuclear materials include unirradiated nuclear materials, irradiated nuclear materials, or nuclear materials containing decay products.

DOE routinely evaluates unirradiated nuclear materials against the economic discard limit (EDL). The EDL is the concentration of nuclear material in residues below which the nuclear material is uneconomical to recover. The economical assessment primarily considers the cost of producing new materials but includes some waste management costs. DOE calls materials above the EDL "scrap" nuclear materials and processes these to recover the useable SNM.

Excess nuclear materials are usually near or above the EDL. However, many are not processed because of capacity or capability restraints of present processing facilities. Some excess nuclear materials are not processed because of regulatory restraints. Therefore, without the development of a safe and economical recovery process, excess nuclear materials can become special-case wastes.

Uncertain waste management options and rising cost of managing special-case wastes may require that all excess nuclear materials, that would otherwise be special-case wastes, be evaluated for recovery of useable nuclear material. This includes unirradiated nuclear materials slightly below the EDL, irradiated nuclear materials, and nuclear materials that contain decay products. This evaluation should compare waste management costs with the cost of new production, and the cost of recovering the useable nuclear materials.

Recovery of the SNM in excess materials that would otherwise be declared waste could significantly reduce waste management costs because the resultant waste form would no longer be a special-case waste. The reduction in costs may offset the increased costs of recovery as opposed to new SNM production. Even if the cost is higher, the greatest benefit is the recycling of valuable nuclear materials and the environmental benefits of a less toxic waste form.

DOE SPECIAL-CASE WASTE SURVEY

The Low-Level Waste Technical Support Program (LLWTSP) began the DOE site surveys in August 1989. Site visits conducted as part of the survey included making contacts with waste management, materials management, and any facility managers that could have special-case wastes or excess nuclear materials. Site visits were completed in November 1989, and a preliminary data report will be completed in March 1990.

Site visits to the major DOE facilities have resulted in identification of most special-case wastes, however, many wastes are still poorly characterized. Adequate waste characterization is required for identification of proper waste treatment, storage, and disposal. All wastes must be adequately characterized to determine if they meet the performance objectives of the disposal site.

In addition to the DOE site surveys, information was needed on nuclear materials owned by DOE and held by universities or other federal agencies. This information was obtained from the University Reactor Assistance Program (URAP) and the Nuclear Materials Loan Program (NMLP).

In February 1989, the URAP began a survey of 465 universities that could be holding DOE loaned, leased, and/or granted nuclear material. The purpose of the survey was to forecast future material returns, determine disposal constraints, and project the required funding. This effort is scheduled to be completed in March 1990.

The NMLP manages loans of nuclear materials to federal agencies, primarily plutonium in the form of plutonium-beryllium neutron sources. In order to assist with the DOE-HQ special-case waste inventory effort, NMLP requested that all current loan holders provide detailed material descriptions and forecast information on material returns. These data have been included in the current inventory summary.

DOE SPECIAL-CASE WASTE DATA

At least 9.50E + 5 m^3 of special-case wastes exist. Special-case wastes include a wide variety of forms and isotopic mixtures. These wastes are primarily either TRU waste that cannot be disposed of at WIPP, or performance assessment limiting wastes. Most of the special-case wastes are not well characterized. Characterization efforts were limited because the requirements were minimal, waste forms were difficult to sample and costly to analyze, and as low as reasonably achievable (ALARA) considerations restricted detailed examination of the waste.

A summary of the special-case waste data collected as of January 1990 is shown in Table I. This is data from approximately eighty percent of the facilities that were requested to supply data.

The following is a description of the specific special-case waste categories and summary data obtained as of January 1990.

Non-Certifiable Defense TRU Waste

Non-certifiable defense TRU wastes are DOE Defense Programs generated transuranic wastes that are not certifiable for disposal in the Waste Isolation Pilot Plant (WIPP) or cannot be transported in the TRUPACT-II shipping container. These are special-case wastes because, without WIPP acceptance, they have no present disposal options. In order to be approved for WIPP, the wastes must be made certifiable to the WIPP waste acceptance criteria (WAC) and packaged for the TRUPACT-II container.

As of January 1990, the preliminary data for non-certifiable defense TRU wastes indicate an existing volume of 8.86E + 5 m^3 containing 2.01E + 8 Ci of activity. In addition to activity from transuranic isotopes, some of the wastes also contain mixed activation products and/or mixed fission products. Examples of these wastes include: (1) wastes resulting from the decontamination and decommissioning of hot cells, (2) solidified and non-solidified sludge, (3) liquid wastes produced incidentally during fuel processing, (4) large metallic structures containing or contaminated with transuranium elements, and (5) large pieces of alpha-contaminated equipment that require remote handling.

Wastes resulting from hot cell decommissioning contain a wide variety of wastes depending on the various uses of the hot cell. They include combustibles, non-combustibles, pieces of metal, equipment, and glass. Some waste packages contain liquids and/or oils.

Hot cell wastes that are non-certifiable are primarily packaged wastes that could not be packaged for transport in the TRUPACT-II shipping container. These packages contain large objects that are impractical to reduce in size. The same is also true for large pieces of equipment and large metallic structures. Such wastes would require a special handling facility for waste reduction and repackaging in order to meet all applicable requirements.

There are several instances of wastes that contain oils and other organic liquids. Alpha radiolysis on organic liquids can cause a high rate of gas generation in the packages, which precludes shipment in the TRUPACT-II container.

Non-solidified sludges may contain particulates in excess of the WIPP WAC. These wastes could be made certifiable with solidification by cement. The solidification process would increase the waste volume and render it LLW. However, the waste may remain special-case as a performance assessment limiting waste.

Non-certifiable defense TRU wastes are those that are impractical to certify and for which there are no current plans for reprocessing. Some of these wastes contain potentially valuable amounts of SNM. If a recovery scheme were available, the resultant wastes might be reclassified as recoverable scrap or residue and no longer be special-case wastes. A facility may be required that can perform size reduction of very large metal items, some of which require remote handling.

Non-Defense TRU Waste

Non-defense TRU wastes are DOE-titled TRU wastes generated by a DOE Nuclear Energy Program or an NRC licensee contracted to DOE. Although these are TRU wastes, they can not be disposed of at the WIPP because

TABLE I
Preliminary Special-case Waste Inventory Data

Waste Category	Volume (m^3)	Curies
Non-certifiable defense TRU	8.86E + 5	2.01E + 8
Non-defense TRU	1,217	1.18E + 5
Performance assessment limiting	3.49E + 4	1.19E + 8
Fuel and fuel debris	8,302	2.16E + 7
Uncharacterized	1.48E + 4	2.00E + 5
Excess nuclear materials	43	2,773
Sealed sources	[4,131]	2.12E + 6
DOE-titled, held by others	[1,027]	9,789

[ ] indicates number of items, primarily sealed sources

only defense TRU waste can be accepted for disposal in accordance with current regulations.

As of January 1990, the preliminary data for non-defense TRU wastes indicate an existing volume of 1,217 m^3 containing 1.18E+5 Ci of activity. In addition to activity from transuranic isotopes, some of the wastes also contain mixed activation products and/or mixed fission products. Examples of these wastes include: HEPA filters from hot cells, dewatered ion-exchange resin, wastes containing americium, a reactor vessel, submerged demineralizer systems, and wastes generated from the decontamination and decommissioning of fuel fabrication and plutonium production facilities. These wastes are usually packaged to meet storage criteria similar to the WIPP WAC, however, they are not necessarily well characterized.

The non-defense TRU wastes are essentially orphans because there is no designated location for their disposal. As with non-certifiable defense TRU, some of this waste requires repackaging and/or size reduction to meet the final WAC. Recovery of any valuable nuclear material fractions should also be considered. Future management of these wastes may involve disposal at the WIPP or in a greater confinement disposal facility with acceptable performance objective limits.

Performance Assessment Limiting Waste

Performance assessment limiting wastes are DOE-titled LLW that contain concentrations of radionuclides that exceed the site-specific performance assessment limits for disposal. This typically applies to waste that contains radionuclides in concentrations greater than those shown for Class C waste in Tables 1 and 2 of 10 CFR 61.55. These are special-case wastes because they are not generally acceptable for near surface disposal and cannot be disposed of at the site of generation.

As established in DOE Order 5820.2A, disposal of wastes that exceed the Class C limits require a specific performance assessment through the NEPA process and the concurrence of DOE-HQ. The organizations that now store performance assessment limiting wastes have limited options for their disposal.

As of January 1990, the preliminary data for performance assessment limiting wastes indicate an existing volume of 3.49E+4 m^3 containing 1.19E+8 Ci of activity. The majority of this activity comes from mixed fission products, tritium, and radium-226. There are also some transuranic isotopes present. Current data also indicate that as much as 7,000 m^3 of performance assessment limiting waste will be generated within the next 5 years.

These wastes include items such as: Sr-90 Radioisotope Thermoelectric Generators (RTG); Three Mile Island-2 Submerged Demineralizer System (SDS) liners; hot cell wastes from destructive examination of fuels; equipment contaminated with alpha and mixed fission products that also contain activation products; moist uranium solids and associated decay products; absorbed tritiated liquid; and ion exchange resins, sludges, and powders that contain uranium and Tc-99. Such wastes are packaged to meet the storage criteria of the generator site, however, most are not well characterizedor packaged in a manner suitable for disposal.

Performance assessment limiting wastes may be disposed of by greater confinement disposal if they meet the site performance objective limits. These wastes may also be shipped to a site that has suitable performance objective limits for their disposal. Essential to this disposal scheme is adequate waste characterization, which is necessary for the performance assessment. Some of this waste may need repackaging and/or size reduction to meet the final performance assessment criteria and/or the transportation requirements.

Fuel and Fuel Debris

This category includes DOE-titled fuel and fuel debris wastes. The fuel and fuel debris are similar to the material that is destined for the High Level Waste (HLW) repository. However, most of it is in packaging configurations that are different from normal commercial fuel elements and may not meet a HLW repository WAC. Since the final disposal method and location for these wastes have not been determined, they are considered special-case wastes.

As of January 1990, the preliminary data for fuel and fuel debris indicate an existing volume of 8302 m3 containing 2.16E+7 Ci of activity. The majority of the activity comes from mixed fission products but there are some transuranic isotopes present.

Fuel and fuel debris wastes contain items such as: material from the core of the TMI-2 reactor; fuel from various DOE test reactors; and fuel and debris from various DOE research and development projects. These wastes are stored in water pools and dry storage casks and are usually well characterized. However, additional characterization, processing, or packaging may be very costly due to the high levels of radiation in the wastes.

Fuel and fuel debris wastes may finally be disposed of at the HLW repository. However, this has not been decided and the acceptance criteria for disposal has not been determined. Therefore, these wastes require safe, long-term storage. Water pools deteriorate and require periodic maintenance. The advantages and disadvantages of dry storage configurations should be evaluated to determine the safety and cost effectiveness of long-term storage of this type of waste.

Uncharacterized Waste

Any containers of waste with unknown contents were included in this category. These wastes were suspected to contain nuclear materials at or near the limits of GTCC or TRU wastes. Current data indicate an existing volume of 1.48E+4 m^3 of uncharacterized waste. The approximate curies of activity are 2.00E+5. Further characterization of these wastes are planned.

Excess Nuclear Materials

As of January 1990, preliminary data indicate an existing volume of 43 m^3 of excess nuclear materials containing 2,773 Ci of activity. The majority of this activity comes from transuranic isotopes. There are also some uranium isotopes present.

Excess nuclear materials that have been identified include items such as 6-ft diameter metal spheres that contain plutonium isotopes, uranium hexafluoride gas cylinders from isotope separation research, and items in vaults that are suspected to contain significant quantities of fissionable uranium isotopes. These materials have not been packaged for disposal and in some cases, are not well characterized. If these materials are declared waste, the large metal spheres will need to be cut up so that they can be placed into standard disposal containers.

Many of the excess nuclear materials identified in this effort are either no longer useful to the present custodians, or require processing to recover the usable nuclear materials. Therefore, these materials may soon be considered special-case wastes. Most of the materials identified are above the economic discard limit but a process does not exist for recovery of the usable materials. There are some materials that contain RCRA-regulated constituents, which prevent processing because the recovery facility is not RCRA permitted.Dispositioning these excess materials will require coordinated effort between waste management and nuclear material processing organizations. An economic alternatives assessment is needed to compare the waste management options and materials recovery options for these materials.

Sealed Sources

Sealed sources are encapsulated radioactive material whose main purpose is the generation of known amounts of radiation. These sources are of special interest because the concentrations of their radioactive material usually make them performance assessment limiting waste at the time of their disposal.

As of January 1990, preliminary data for sealed sources indicate an existing total of 4,131 sources containing 2.12E+6 Ci of activity. More than 30 different radioactive isotopes are used as sealed sources. The isotopes Co-60, Sr-90, Cs-137, Pu-238 and 239, Am-241, and Cf-252 are present in the majority of the sources. However, Se-75, Sb-124, Pm-147, Tl-204 and many other isotopes are also present.

Most of the sealed sources are very small. However, substantial shielding is required for packaging and that increases the size of the disposal package. Sealed sources are usually very well characterized. A plan for sealed sources should be developed to include a central location for storing sources for potential reuse or recovery.

Disposal of sealed sources will depend upon the performance objectives of the disposal site. Remote handling capability may also be required in order to avoid disposal of any lead shielding used for source packaging.

University Reactor Assistance Program (URAP) - Status of Nuclear Material

The URAP was established to coordinate the use of nuclear materials leased or loaned from DOE to universities. A recent survey of the universities has identified 814 items, containing 4,011 Ci, at 262 universities. Approximately half of those items are owned by the DOE. These items include sealed sources, fuel elements, fission chambers, and uranium slugs. Forty-three universities have requested DOE to accept the return of 143 of these items.

Nuclear Materials Loan Program (NMLP) - Status of Nuclear Material

The NMLP was established to manage loans of nuclear materials from DOE to federal agencies. Current data indicate 213 items, containing 5,778 Ci, are on loan. These items are mostly sealed sources containing plutonium oramericium. Eleven federal agencies have requested to return 66 sources.

CONCLUSIONS

Management of special-case wastes involves technical, institutional, and regulatory issues. A DOE system-wide approach is being used to determine management alternatives that are cost effective, protect the environment, and protect public health and safety. Collaboration between DOE's Defense, Nuclear Energy, and Environmental Programs is necessary to resolve management issues concerning special-case wastes.

An immediate issue is the need for more detailed characterization of special-case wastes. In the past, characterization was conducted to alleviate operational safety concerns, and usually resulted only in the identification of major radioactive constituents. Additional characterization is now required for waste classification, disposal performance assessment, establishing treatment requirements, and determining economic viability of recovery of valuable nuclear materials.

Treatment facilities are planned for processing and certification of TRU wastes. However, such facilities may not have the capacity or capability to process all special-case wastes. Special-case wastes mixed with RCRA-regulated materials may require the development of best demonstrated available technology (BDAT) in order to meet RCRA land disposal restrictions (LDR). Regionalized treatment may be an economical answer for the relatively limited (i.e., as compared to LLW, TRU, and HLW) quantity of special-case wastes.

There currently are no urgent storage problems but continued development of RCRA-permitted storage areas must proceed. Increased emphasis on storage options, such as dry cask storage, may be needed for fuel and fuel debris wastes.

The most critical issue for special-case wastes is the lack of disposal options. Performance assessment limiting wastes must be disposed of in an environment wherein conditions meet comprehensive performance objective limits. A disposal system performance assessment is even more critical for disposal of TRU, and fuel and fuel debris wastes. Comparable disposal systems for these special-case wastes are geologic repositories, such as WIPP, and the HLW repository.

Excess materials and special-case wastes that contain potentially valuable quantities of SNM require an economic assessment for recovery of nuclear materials. DOE environmental policies urge the recycling of all useable materials and minimization of wastes. From both an environmental and long-term economic standpoint, development of nuclear material recovery technology is justified.

A routine procedure does not exist for the return of DOE leased and loaned nuclear materials. Certain materials are difficult to return because those materials may have limited future uses. The major problem is the limited need for reuse of these materials and the lack of available recovery methods. A procedure is needed to ensure that material ownership is documented; a mechanism is delineated for the material's return; and once returned, an economic evaluation is made for reuse, recovery, and waste management.