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LOW-LEVEL-WASTE-TREATMENT HANDBOOK

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LOW-LEVEL WASTE TREATMENT HANDBOOK

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INTRODUCTION

At the present time, one of the major obstacles for nuclear power expansion is public concern regarding radioactive waste dispoal. Wastes are generated in all phases of the commercial nuclear fuel cycle, ranging from large volumes of slightly radioactive uranium mill tailings to relatively small volumes of high-level radioactive wastes resulting from the processing of nuclear fuels. Commercial nonfuel-cycle wastes result from operations by private organizations which are licensed to use radioactive materials. These include institutions and industries engaged in research, medical, and various industrial activities. The federal government operations that generate radioactive wastes include defense activities as well as basic research and development studies at several Department of Energy (DOE) sites.

The largest volume of radioactive wastes generated is termed low-level waste and is the subject of this Handbook. Low-level waste (LLW) is defined in a negative sense as radioactive contaminated material not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material as defined by the amended Atomic Energy Act of 1954 (1). The radionuclides in LLW vary widely. Uranium (natural and depleted) and its

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daughters dominate in the conversion, enrichment, and fuel fabrication steps of the fuel cycle. Reactor operation and spent fuel storage generate LLW containing mostly activation products and fission products. A significant fraction of institutional LLW is contaminated with small quantities of tritium and carbon-14. Institutional and industrial LLW also contains cobalt-60, cesium-137, and other gamma-emitting nuclides. Government LLW is similar to the institutional and industrial waste and the commercial fuel cycle LLW. Of the 166,000 m^3 of LLW buried in the United States in 1980 (2), approximately 50 volume percent was attributed to government activities, 30 volume percent to the U.S. commercial fuel cycle, and 20 volume percent to institutional and industrial organizations. The treatment and disposal of special low-level radioactive wastes such as active uranium mill tailings and LLW generated by remedial action programs are beyond the scope of this Handbook.

OBJECTIVE

The objective of the Low-Level Waste Treatment Handbook is to present an overview of current practices related to the segregation, classification, volume reduction, solidification, handling, packaging, and transportation of LLW for disposal in a shallow land burial facility. The Handbook is intended to serve as a guide to individuals interested in the treatment and handling of low-level radioactive waste. The Handbook will not explicitly tell the user how to design and operate LLW treatment facilities, but rather will identify (1) kinds of information required to evaluate the options, (2) methods that may be used to evaluate these options, and (3) limitations associated with the selection of the treatment options. The focus of the Handbook is providing guidance on "how to do" waste treatment for disposal by shallow land burial.

BACKGROUND

At the present time, essentially all low-level radioactive waste is disposed using shallow land burial techniques similar to those employed by municipalities and industry for the disposal of solid wastes. Commercial wastes are currently disposed in privately operated burial grounds licensed by the U.S. Nuclear Regulatory Commission (NRC) or by a State, if the State has qualified as an Agreement State under the Atomic Energy Act. Government waste is mainly generated and disposed at DOE facilities. Existing DOE burial grounds are not licensed by NRC or the Agreement States; however, they are regulated by the DOE under the Atomic Energy Act. In 1980 about 74,000 m^3 of LLW was buried at DOE sites and about 92,000 m^3 at commercial sites. Projections of future LLW generation indicate that DOE wastes will remain relatively constant at 80,000 m^3/yr for the next twenty years, whereas commercial production is estimated to increase to about 225,000 M^3/yr by the year 2000 (2).

A major concern with the projected increase in commercial waste generation is the limited amount of disposal space available at existing sites, and the fact that the geographic distribution of disposal sites is not well matched with current waste sources. Although the problem is not severe at DOE sites at the present time, existing burial space will also be used up in the near future at certain of these sites. As a result, new burial grounds will be required in the near future.

To date, six commerial sites have been licensed to dispose of LLW; however, three of these sites have been closed. Of the remaining three, Barnwell, South Carolina, has placed limits on the amount of waste accepted for burial each month, and the other two operating sites at Beatty, Nevada, and Richland, Washington, are remote from waste sources in the eastern United States. It is estimated that from five to seven regional dispoal sites will be required to meet 1990 commercial LLW disposal requirements (3).

The loss of the most convenient LLW disposal sites for the majority of the commercial waste generation facilities resulted in immediate transportation cost increases. These cost increases were compounded by what has become a steep spiral in the burial charges for the three remaining sites, aggravated by the recent addition of local government taxes and restrictions, inspection requirements and burial volume limitations. During the past five-year period, the radioactive waste burial charges per unit of volume have increased over 500 percent (4).

With the diminishing availability of LLW disposal facilities and continuing escalation of burial cost, a quotation from the NRC's policy statement (5) is apropos: "The Commission hereby adopts a policy calling on all generators of low-level radioactive waste to reduce the volume of waste for disposal...NRC believes it is in the best interest of licensees and the public that licensees extensively explore means by which volume may be reduced." One goal of volume minimization is to exercise better administrative controls to limit the production of waste, such as contaminated dry trash. Volume minimization can also be achieved by more efficient waste treatment options. However, maximum volume reduction will dictate equipment modifications involving capital investment and licensing considerations. The commercial introduction of more sophisticated systems, such as incineration for combustible wastes, can significantly reduce the LLW volumes to be disposed.

At the present time, the NRC has proposed licensing requirements for the commercial disposal of low-level radioactive wastes (6). The most direct impact of these requirements on volume reduction systems will be in the limitations to be imposed on specific isotope activities per unit volume of LLW buried. Depending on input waste activities, some of these isotopic limits would typically be exceeded if maximum volume reduction is achieved. As a result, the NRC proposal could challenge the viability of high technology volume reduction systems. In addition, the proposed classification system requiring segregation of certain wastes will impact the operating philosophy of volume reduction systems which would significantly concentrate the radioactivity (e.g., incinerators which reduce combustibles to an ash form). Both of these potential concerns may be partially offset by blending input wastes and accounting for the dilution in a solidification binder and/or waste container. However, additional operational controls will probably be required to measure critical isotope concentrations.

QUALITY ASSURANCE

Quality assurance is defined as the planned and systematic actions that are necessary to provide confidence that a structure, system, component, facility, or operation will perform satisfactorily in service. A quality assurance (QA) program should be included in all major steps from the generation of LLW to the successful disposal. This program should develop a QA plan, which is a document describing potential significant quality failures, a presentation of the QA actions that are required to provide confidence that the postulated failures are unlikely to occur, and specifies the responsibility and timeliness for carrying out the QA actions. Quality assurance is not limited to design, but can be a key feature in assuring satisfactory treatment, handling, packaging, and shipment of generated LLW to the burial facility.

ORGANIZATION OF THE HANDBOOK

In the six chapters of the Handbook the subject of low-level radioactive waste treatment is described from source to ultimate disposal. An abbreviated Table of Contents is shown in Table 1. In general the Handbook applies to both commerical and government sources of LLW, although some of the treatment practices may be unnecessary at DOE facilities which are not licensed by the Agreement States or NRC. The critical step in treating LLW is to become thoroughly familiar with the NRC proposed rules concerning waste classification requirements (e.g., concentrations may be averaged over the package volume). With a characterized waste for disposal and a known volumetric burial charge, a cost effective waste treatment procedure can be developed by the radioactive source generator. The treatment options available to achieve the permissible volume reductions will probably require equipment modifications involving capital investment and licensing considerations.

Chapter 1 is an introduction to the low-level waste treatment problem. Chapter 2 deals with the sources and characteristics of low-level radioactive wastes, disposal criteria at the shallow land burial facility, and treatment options for dry and wet wastes. Included are discussions of wastes generated in the commercial fuel cycle; institutional, industrial and governmental wastes; and special category wastes such as uranium mill tailings and remedial action wastes.

Chapter 3 describes conceivable volume reduction techniques for both dry and wet wastes. The unit operations involving physical and chemical treatments will have a significant impact on the volume of low-level radioactive waste shipped to the shallow land burial facility for disposal. Included are discussions of compaction, incineration, evaporation, filtration, reverse osmosis, ion exchange, coagulation and sedimentation.

Chapter 4 presents details on LLW solidification techniques including a discussion of sorbents, cement, asphalt, and thermosetting organic polymers. This chapter has significance for the ultimate waste form for disposal since the proposed NRC requirements specify that all LLW liquids must be packaged in sufficient absorbent material to absorb twice the liquid volume. In addition several waste classifications require structural stability which can be provided by processing the waste to a stable form or placing the waste in a structurally stable disposal container.

Chapter 5 treats the general subject of low-level radioactive waste handing and deals with the specific topics of waste segregation, monitoring, accountability, and conditioning prior to packaging.

Chapter 6 covers the packaging and transport of low-level radioactive wastes to the dispoal facility. The shipping requirements are regulated by the NRC, the Department of Transportation (DOT), the Postal Service, and the individual states. These regulations are summarized, and the responsibilities of shippers and carriers are outlined. Procedures for reporting of incidents are discussed.

SUMMARY

The initial draft of the Low-Level Waste Treatment Handbook has been prepared and submitted to the DOE Low-Level Waste Management Program for review and comment. A revised draft is scheduled to be delivered to DOE Headquarters in December 1982. The Handbook is designed to be useful to all individuals and groups concerned with low-level wastes. It is one of several volumes that will ultimately comprise a Low-Level Waste Technology Handbook.

REFERENCES

1. U.S. Congress. 1980. Low-Level Waste Policy Act. 96th Congress, Second Session, Public Law 96-573.
2. U.S. Department of Energy, Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980, DOE/NE-0017 (September 1981).
3. U.S. Department of Energy, Low-Level Radioactive Waste Policy Act Report - Response to Public Law 96-573, DOE/NE-0015 (1981).

4. R. B. Wilson and D. Ferrigno, "Background and Regulatory Aspects of Volume Reduction at Nuclear Facilities," presented at American Nuclear Society Power Division Topical Meeting, Charleston, SC, March 28-31, 1982.

5. U.S. Nuclear Regulatory Commission, NRC Volume Reduction Policy, Generic Letter No. 81-39, November 30, 1981.

6. U.S. Nuclear Regulatory Commission, Licensing Requirements for Land Disposal of Radioactive Waste, Proposed 10 CFR 61, Federal Register Vol. 46, No. 142, pp. 38081-38105 (1981).

Table 1. Abbreviated Table of Contents for Low-Level Waste Treatment Handbook

Chapter	Title
1	Introduction
2	Waste Types, Characteristics, and Treatment Options
	• Waste Sources and Characteristics
	• Criteria for Disposal
	• Treatment Options
3	Volume Reduction
	• Dry Wastes
	• Wet Wastes
4	Solidification Techniques
	• Sorbents
	• Cements
	• Asphalt
	• Thermosetting Organic Polymers
5	Waste Handling
	• Segregation
	• Monitoring
	• Records
6	Packaging and Transportation
	• Regulations
	• Package Type and Size
	• Labeling, Marking, and Documentation
	• Reporting of Incidents