CHARACTERIZATION OF NONDOE GREATER-THAN-CLASS-C LOW-LEVEL WASTE[a]

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ABSTRACT

The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned to the Federal Government responsibility for disposal of "nonDOE" "greater-than-Class-C" low-level radioactive waste (GTCC waste). Concentrations of radionuclides in GTCC waste exceed the Nuclear Regulatory Commission (NRC) limits for routine near-surface disposal.

Planning for disposal requires estimates of the projected volume and characteristics of GTCC waste. The projected volume of GTCC waste through the year 2020 is roughly estimated to be 2000 cubic meters. This estimate, however, is subject to large uncertainties because of (a) possible development of an NRC high-level radioactive waste definition that can affect the definition of GTCC waste, (b) limited waste generation experience and operating and decommissioning plans on which to base nuclear utility GTCC waste projections, and (c) difficulty in determining the concentration of some of the radionuclides of interest in activated metals. The projected GTCC waste is largely activated metals and other typical low-level wastes from the nuclear fuel cycle, trash from manufacturing of sealed sources, and solidified waste liquids from the use of carbon-14 in manufacturing "tagged" chemicals.

INTRODUCTION

In the Low-Level Radioactive Waste Policy Amendments Act of 1985 (the Amendments Act), Congress assigned to the Federal Government responsibility for disposal of a category of nonDOE low-level radioactive waste termed "greater-than-Class-C" (GTCC) that is generated by licensed activities. Information on the volumes and characteristics of this waste is needed to determine how the Federal Government should carry out its responsibility for disposal of this waste, in particular to evaluate disposal options and costs. This paper presents estimates of current and projected GTCC waste volumes and characteristics, discusses the uncertainties in projected GTCC waste volumes and characteristics, and identifies actions needed to resolve the uncertainties. Only waste from normal facility operations and from decommissioning of facilities is addressed.

Much of the information on waste characteristics and projected volumes is based on data contained in NRC's report, "Update of the 10 CFR Part 61 Impacts Analysis Methodology," which compiles data from many other sources (1). To estimate current volumes of waste in storage at generator sites, and further update the projected volumes for carbon-14 waste generation, 250 NRC and Agreement-State non-utility licensees were interviewed. The licensees were selected from groups identified as potential GTCC waste generators. These groups were fuel testing and fuel fabrication plants, sealed source manufacturers, major carbon-14 users, waste service companies, academic and medical institutions, industrial research and development facilities, and nonDOE federal agencies. When only a portion of the identified licensees in a given group was interviewed, results were projected for all the identified licensees in that group. All fuel testing facilities and major carbon-14 users were included in the study. Forty-one percent of sealed source manufacturers were included. For nuclear power plant licensees, estimates of current GTCC waste in storage were obtained from preliminary results of an Electric Power Research Institute (EPRI) survey (2).

In addition, a formal survey of NRC and agreement-state licensees identified as potential generators of GTCC waste has recently been completed by the Energy Information Administration (EIA) to provide additional information for a comprehensive data base on GTCC waste. Although complete analysis and results of this survey will not be available until later this year, preliminary results are incorporated in this paper.

DEFINITION OF GREATER-THAN-CLASS-C WASTE

GTCC waste is defined by 10 CFR Part 61, the NRC regulations for licensing land disposal of low-level radioactive waste. The regulations define radionuclide concentration limits for three classes of

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low-level waste (A, B, and C) that are suitable for routine near-surface land disposal. Under this regulation, if the concentration of radionuclides in low-level waste exceeded the Class C limits (i.e., was greater-than-Class-C), it could be disposed of in a near-surface facility only with the express permission of NRC or an Agreement State.

The long-lived radionuclides that have Class C limits are carbon-14, nickel-59, niobium-44, technetium-99, iodine-129, and alpha-emitting transuranic nuclides (TRU) with half lives greater than five years. Concentrations of plutonium-241 and curium-242 are also limited because these nuclides are short-lived precursors of long-lived transuranics. For the long-lived radionuclides and precursors, the concentration limits for Class C waste are ten times those for Class A waste.

The short-lived radionuclides that have Class C limits are nickel-63, strontium-90, and cesium-137. The Class C limit for nickel-63 is ten times its Class B limit, while the Class C limits for strontium-90 and cesium-137 are about 50 and 100 times the Class B limits, respectively. Other radionuclides are not considered in the Class C limits but may be of interest for operational reasons.

There is no defined upper limit on the concentrations of radionuclides in GTCC waste, although all low-level waste is defined by the Amendments Act to exclude spent nuclear fuel and high-level waste. Currently, high-level waste includes only the waste from reprocessing of spent nuclear fuel. However, NRC is contemplating a rulemaking that would define high-level waste in terms of radionuclide concentrations, which could redefine some waste now considered low-level waste as high-level waste. Therefore, this potential rulemaking creates uncertainty in GTCC waste volumes and characteristics needed for developing programs for disposal of the waste in the future.

To obtain a preliminary estimate of nonDOE GTCC waste quantities pending resolution of the definition of the upper bound for GTCC waste, the working definition of nonDOE GTCC waste used in this paper is: all low-level wastes that exceed the Class C limits and (a) are not within the existing legal definition of high-level waste, (b) are not spent fuel, (c) are not owned or generated by the Department of Energy, (d) are not owned or generated by the United States Navy as a result of the decommissioning of its vessels, and (e) are not owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon. In this paper, the term "spent fuel" is taken to include spent fuel hardware.

Some GTCC waste may also be defined as "mixed waste." Mixed waste is radioactive waste that is also classified as hazardous waste under the definitions of the Resource Conservation and Recovery Act (RCRA) and 40 CFR Part 261. A report from Brookhaven National Laboratory (3) has identified three major categories of hazardous waste that occur mixed with low-level radioactive waste: organic solvents, lead metal, (discarded shielding or lead containers), and chromates (nuclear power plant decontamination waste containing dichromates and waste from cleanup of cooling water in which chromates are used as corrosion inhibitors). There is considerable uncertainty, however, about which hazardous wastes might occur in GTCC wastes. The EIA survey of waste generators is investigating this question.

OVERVIEW OF GREATER-THAN-CLASS-C LOW-LEVEL WASTE SOURCES AND TYPES

Four major categories of generators and users of radioactive materials are sources of nonDOE GTCC waste:

1. Nuclear utilities
2. Nuclear fuel testing and burnup evaluation facilities
3. Sealed source manufacturers and users
4. Manufacturers of chemicals "tagged" with carbon-14 and other major users of carbon-14 as a "tracer."

Less than 0.04 m^3 of GTCC waste has been generated by at least one test reactor. Test and research reactor operators interviewed expect to generate very little, if any, additional GTCC waste. That waste and GTCC waste that may be generated by potential abnormal operating occurrences in industry or at power reactors are not addressed here.

Generally, GTCC waste types are similar to those in Class A, B, and C low-level waste. The GTCC waste generated by each category of generator is described in Table I and discussed below.

TABLE I.
Greater-Than-Class-C Low-Level Radioactive Waste Characteristics

Waste Source	Physical Form	Primary Isotopes of Concern for Disposal
Utilities[a]		
Operations	Activated metals, filters, instruments, ion-exchange resins, sludges	Ni-59, Ni-63, Nb-94, TRU
Decommissioning	Activated metals	Ni-59, Ni-63, Nb-94
Fuel Testing	Activated metals, absorbed and solidified liquids, metal cuttings, trash, glassware, equipment	C-14, Ni-59, Sr-90, Cs-137, TRU
Sealed Source Manufacturing and Use[b]	Trash, metal foils, sealed sources	C-14, Sr-90, Cs-137, Am-241, Pu-238 and -239
Other C-14 Uses[b]	Solidified process liquids	C-14

a. Data in table based on NRC data (USNRC 1986), preliminary EPRI data (2), (4), and (5).

b. Data in table based on NRC data (1) and telephone interviews of generators.

Nuclear Utilities

Nuclear utilities may generate GTCC waste during operation and decommissioning of nuclear power plants. Operational wastes include two waste streams. The first includes nonfuel reactor core components such as control rods, control rod channels, control assemblies, thimbles, in-core instrumentation, fuel channels, shim rods, poison curtains, and flux wires. This waste is mainly stainless steel, inconel, and other high-grade metals that contain neutron-activated elements.

The other operational GTCC waste stream from nuclear power plants includes neutron sources, fission chambers, spent ion-exchange resins, and sludges from periodic reactor decontamination and fuel pool cleanup.

If nuclear power plants are dismantled rather than mothballed or entombed for decommissioning, waste is expected to include stainless steel core shrouds (sleeves separating the reactor core from the reactor vessel) in which component elements in the metal are activated (1, 4).

Decommissioning activities can also generate spent resins, sludges, and other materials that may be greater-than-Class-C. However, it is expected that some of these materials could be maintained within the Class C limits through appropriate process controls and they are not discussed further here.

Fuel Testing and Burnup Facilities

Commercial facilities that perform radiochemical studies and fuel burnup analyses on reactor fuel are sources of GTCC waste. Some of this waste is also likely to contain chemically hazardous waste. Additional GTCC waste may result when these facilities are decommissioned. The decommissioning waste from these facilities is expected to be similar to the operational waste.

Sealed Source Manufacturers and Users

Sealed sources are small sealed capsules, usually stainless steel, containing radioactive material. These sources, used as calibration standards, medical irradiators, etc., may be designated waste after use is terminated.

GTCC waste is also generated in the manufacture of sealed sources. When sealed source manufacturing facilities are decommissioned, additional GTCC waste may be generated. The characteristics of the decommissioning waste are difficult to project, because they will depend on the design and size of the facility and the extent of contamination.

Carbon-14 Users

Other sources of GTCC waste are major carbon-14 users. This GTCC waste is primarily process waste resulting from the manufacture of carbon-14-"tagged" chemicals and from other uses of carbon-14 as a "tracer."

OVERVIEW OF GREATER-THAN-CLASS-C LOW-LEVEL WASTE VOLUMES

Figures 1 and 2 summarize the information currently available on the volumes of GTCC waste in storage and projected to be generated through the year 2020, respectively. Currently, there is an estimated total of 120 m^3 of GTCC waste in storage. The estimated volume to be generated by the year 2020 is about 2,000 m^3, over half of which will be produced by decommissioning of nuclear power plants after the turn of the century. Figure 3 displays the estimated total annual GTCC waste generation rates through 2020, with the largest changes in rate caused by decommissioning of fuel testing and burnup facilities and nuclear power plants. Figures 1 and 2 show that the volume of waste currently in storage is quite small compared with the total projected volumes.

Up to the year 2000, it is estimated that less than 40 m^3 of waste will be generated annually, at a relatively constant rate, from sealed source manufacturing, carbon-14 use, and operations of nuclear power plants and fuel testing labs. Small variations in waste generation rates will occur from year to year, as non-power-plant facilities are decommissioned. After the year 2000, significant increases in waste generation rates could occur as nuclear power plants are decommissioned, with a major peak occurring about 2014. This peak would be significantly later than 2020 if nuclear power plants extended their service life.

Nuclear Utilities

Based on preliminary EPRI survey data (2), there may be about 55 m^3 of operational GTCC waste in storage at nuclear power plants. Results from the EPRI and EIA surveys, however, indicate uncertainty as

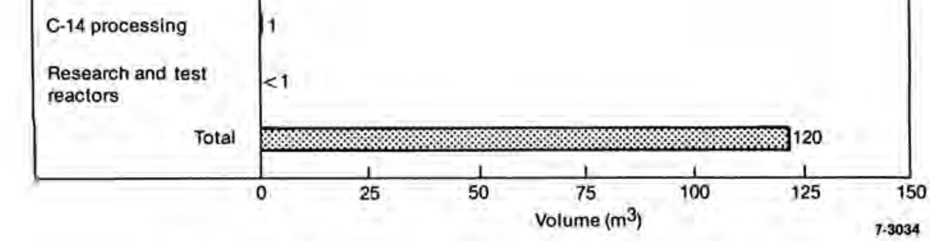

Fig. 1. Volumes of GTCC waste currently in storage.

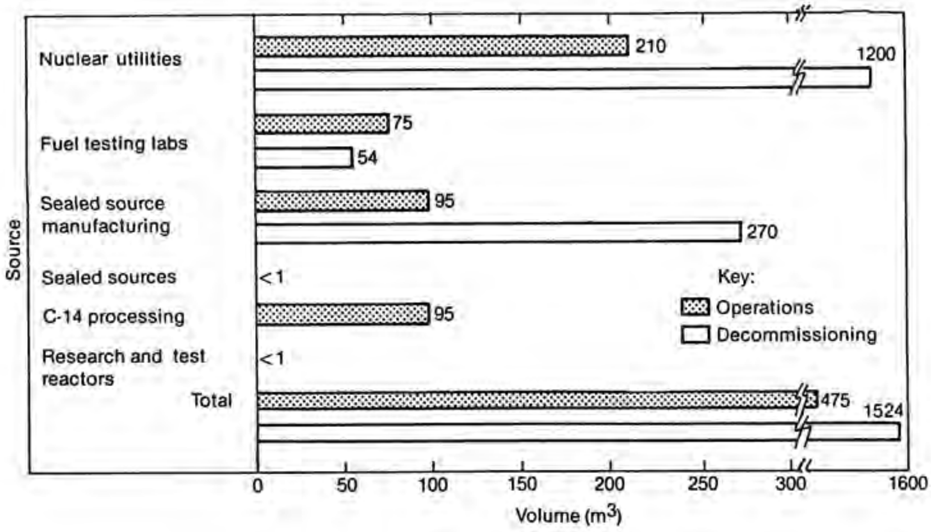

Fig. 2. Projected volumes of GTCC waste to 2020.

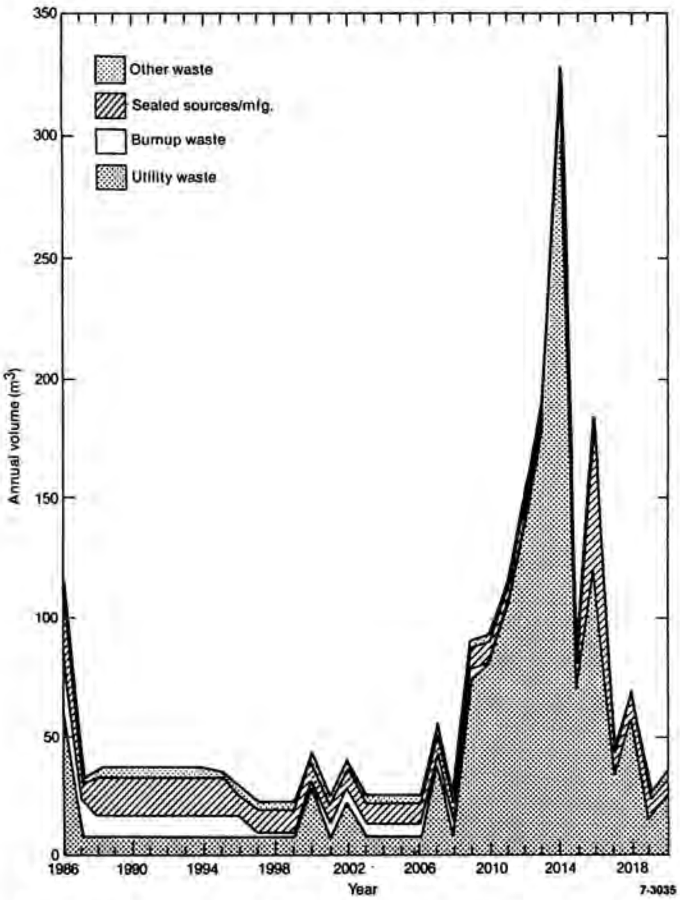

Fig. 3. Projected average annual generation rates for GTCC low-level waste.

to whether some existing and projected GTCC waste from nuclear power plants is actually greater-than-Class-C. The uncertainty arises partly because of a lack of reliable methods of analysis or calculation (prediction) of concentrations of several of the Class C limited radionuclides. For example, for neutron-*activated* metals, some of the Class C limited radionuclides are difficult to measure experimentally and the concentrations of some of the radionuclide-precursor elements in the metals are not known accurately enough to allow calculation of the concentrations of the activated species of interest (4). Also, the neutron irradiation history of the material may not be known well enough to be used in a calculation of the concentrations of the activated elements even if the precursor concentrations were known. The concentrations of the important impurities are now known only to the extent that they do not exceed a stated limit, whereas the actual concentrations when carefully analyzed may be much lower than this limit (4). As a result, even if the neutron irradiation history is known, calculated concentrations of the activated elements of interest would be quite high, throwing more waste into the GTCC category than would actually be produced. In another example, fission chambers currently in storage are considered GTCC waste primarily because of the presence of transuranic radionuclides for which concentration calculations and routine concentration determinations are similarly difficult.

It is difficult to project volumes of future utility operations GTCC waste as a result of these uncertainties. In particular, volumes of activated metal nonfuel reactor core components are difficult to project because (a) the components are usually replaced infrequently and nonroutinely (i.e., at nonpredictable intervals) and (b) as indicated above, data needed for waste classification is uncertain for activated metal nonfuel core components (4). Other operational GTCC wastes are also generated nonroutinely and infrequently, making prediction of volume difficult even if classification is not in question.

Because the existing data are insufficient to form an accurate basis for projecting operational GTCC waste volumes, it is assumed here that the volume of operational GTCC waste is proportional to the years of reactor operation for a given type of reactor and that essentially all existing GTCC utility waste was disposed before 1983, the year 10 CFR 61 took effect for GTCC waste. Thus, a rough estimate of the projected operational GTCC waste is developed by equating the amount of GTCC waste in storage in 1986 to the amount generated over the reactor years from 1983 to 1986 and projecting over the reactor years of operation from 1983 through 2020. Based on this calculation, 210 m^3 of operational utility waste would be generated by 2020. In addition to the uncertainties discussed above, this value may be slightly high because some of the waste in storage in 1986 may have been generated earlier than 1983.

GTCC wastes from nuclear power plant decommissioning are even more difficult to project than operating wastes. The difficulty is magnified because of the lack of decommissioning experience and uncertainty about (a) when decommissioning will take place, (b) what decommissioning mode will be used, and (c) the relationship between the amount and type of waste generated and the power plant size, type, and operating history.

Only core shrouds are included in the projections for decommissioning wastes, assuming no plant life extension and early dismantling as the decommissioning method. Based on NRC data (1), it is estimated that a maximum of 1,200 m^3 of this waste stream could be generated by the year 2020.

Thus, the total volume of nuclear power plant GTCC waste in storage and projected through 2020 is about 1500 m^3, most of which will be activated metals.

Fuel Testing and Burnup Facilities

It is estimated that less than 29 m^3 of GTCC waste is in storage from operation of fuel testing facilities. Approximately 75 m^3 of this type of GTCC waste is projected to be generated by 2020. Based on telephone interviews of the operators and NRC data, an additional 54 m^3 is projected from decommissioning of these facilities (1). Thus, a total of about 160 m^3 of GTCC waste is in storage and projected to be generated by fuel testing and burnup facilities through 2020.

Sealed Source Manufacturers and Users

For the sectors interviewed, there are estimated to be a few thousand sealed sources in storage that are in the GTCC waste category. Because of the very small size of sealed sources, the equivalent total raw waste volume currently stored is estimated to be much less than 1 m^3. Sealed source manufacturers also have 30 m^3 of other GTCC waste in storage.

It is difficult to estimate how many sealed sources currently in use will be designated GTCC waste in the future. Used sealed sources often can be returned to the manufacturer and the radioactive materials recycled into new sources. NRC estimates the total volume of sealed sources projected to be disposed as GTCC waste through the year 2020 is less than 0.02 m^3 (1). If lead shielding required for shipping and storage were considered part of the waste volume, the total waste volume might increase by a few cubic meters.

NRC projects a minimum of 95 m^3 of GTCC waste containing americium-241 from sealed source manufacturing through 2020 (1). NRC estimated that decommissioning of sealed source manufacturing facilities will generate another 270 m^3 of americium-241 waste. However, telephone interviews with sealed source manufacturers identified stored GTCC waste containing other Class C limited radionuclides from sealed source manufacturing. Therefore, a more detailed data base on other radionuclides is needed to project the total GTCC waste from sealed source manufacturers. Currently, about 400 m^3 of GTCC waste related to sealed source manufacturing and use is in storage or projected (for Am-241 wastes) through 2020.

Carbon-14 Users

The major industrial users of carbon-14 currently have about 1 m^3 of GTCC waste containing that nuclide in storage. Operators of these facilities projected they will generate waste in the future at rates that would result in another 95 m^3 by the year 2020.

CONCLUSIONS

The estimated GTCC waste volumes and characteristics are subject to large uncertainties. The uncertainties are (a) expected changes in the regulatory definition of high-level radioactive waste that can affect the definition of GTCC waste, (b) inadequate predictability of future waste volumes, characteristics, and dates of generation from nuclear power reactors, and (c) difficulties in determining and predicting radionuclide concentration in some wastes.

Resolution of many of the uncertainties in GTCC waste characteristics and volumes to be generated until late in the century would be assisted by

1. Completed rulemaking by NRC on the high-level waste definition.
2. Improvement in the ability to measure or calculate concentrations of the Class C limited radionuclides in activated metals and fission chambers from nuclear power plants. (To calculate concentrations from neutron activation, neutron irradiation histories will be necessary for fission chambers and activated metal components. For the activated metals, better knowledge of the initial concentrations of relevant impurities would then allow more accurate calculation of the radionuclide concentrations formed by neutron-activation of these impurities. If economically feasible, development and use of metal formulations that do not contain sufficient precursor elements to form GTCC radionuclide concentrations could eliminate the production of GTCC activated metal waste from new nuclear power plants and from replaced parts in existing plants.)
3. Continued collection of data on the generation of GTCC waste in nuclear power plant operations; with the object of providing a basis for potential projection of GTCC waste volumes for such operations.

Resolution of the remaining uncertainties in waste volumes resulting from nuclear power plant operations and decommissioning waste volumes rests primarily on individual utility decisions to be made on nuclear power plant life extension and decommissioning modes.

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REFERENCES

1. U.S. NUCLEAR REGULATORY COMMISSION (USNRC). Update of Part 61 Impact Analysis Methodology.

NUREG/CR-4370. Prepared by O. O. Oztunali, Envirosphere Company, and G. W. Roles, U.S. Nuclear Regulatory Commission, January 1986.

2. G. S. DALOISIO, Analytical Resources, Inc. Letter to M. A. Knecht, EG&G Idaho, Inc., Idaho Falls, ID. October 20, 1986.

3. B. S. BOWERMAN, et al. An Analysis of Low-Level Wastes: Review of Hazardous Waste Regulation and Identification of Radioactive Mixed Wastes. NUREG/CR-4406. Prepared by Brookhaven National Laboratory for U.S. Nuclear Regulatory Commission, December 1985.

4. A. T. LUKSIC, et al. 1986a. Spent Fuel Disassembly Hardware and Other Non-Fuel Bearing Components: Characterization, Disposal Cost Estimate, and Proposed Repository Acceptance Requirements. PNL/6046. Prepared by Battelle Pacific Northwest Laboratories for the U.S. Department of Energy, October 1986.

5. A. T. LUKSIC. 1986b. Battelle Pacific Northwest Laboratories. Personal communication with M. A. Knecht, EG&G Idaho, Inc., Idaho Falls, ID. September 11, 1986.