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THIRTEENTH ANNUAL NATIONAL ENERGY DIVISION CONFERENCE

SESSION K: ON-SITE WASTE STORAGE

# ASSURING THE SUCCESS OF ON-SITE, LOW-LEVEL NUCLEAR WASTE STORAGE

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## ABSTRACT

Waste management has reached paramount importance in recent years. The successful management of radioactive waste is a key ingredient in the successful operation of any nuclear facility. This paper discusses the options available for on-site storage of low-level radioactive waste and those options that have been selected by the Department of Energy facilities operated by Martin Marietta Energy Systems, Inc. in Oak Ridge, Tennessee. The focus of the paper is on quality assurance (QA) features of waste management activities such as accountability and retrievability of waste materials and waste packages, retrievability of data, waste containment, safety and environmental monitoring. Technical performance and careful documentation of that performance are goals which can be achieved only through the cooperation of numerous individuals from waste generating and waste managing organizations, engineering, QA, and environmental management.

## INTRODUCTION

One factor in the successful operation of any nuclear facility is the successful management of radioactive wastes. The large U.S. Department of Energy (DOE) facilities in Oak Ridge, Tennessee, operated by Martin Marietta Energy Systems, Inc. (Energy Systems), are among those organizations which must be concerned daily with the numerous public, regulatory, institutional, and economic requirements that accompany nuclear waste management activities. This paper will discuss the quality assurance (QA) features that enhance the probability of success of the DOE radioactive solid waste management systems. These features include accountability and retrievability of waste materials and waste packages, retrievability of data, waste containment, safety, and environmental monitoring.

Success in waste management operations can be described as meeting program objectives of protecting public health and the environment, managing radioactive and hazardous waste, meeting the regulations, and designing, constructing and operating in a cost-effective manner.

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Radioactive waste is generally categorized as 1) high-level, 2) low-level, 3) transuranic (TRU), 4) spent fuel, or 5) mill tailings. The definitions for these types of waste are given in DOE Order 5820.2 (1)* and also in the glossary at the end of this paper (adapted from the Order). The DOE order defines LLW by excluding the other waste types: "radioactive waste not classified as high-level waste, TRU waste, spent nuclear fuel, or by-product material." The working definition of LLW used by Energy Systems is beta-gamma-emitting radioactive waste with <100 nCi/g alpha-emitting transuranium nuclides (having an atomic number >92 with half-lives >20 years).

## SOLID LLW MANAGEMENT POLICY AND PRACTICE OF THE MARTIN MARIETTA ENERGY SYSTEMS FACILITIES

Energy Systems operates four facilities for DOE. Three are located on the DOE Oak Ridge Reservation: the Oak Ridge National Laboratory (ORNL), the Y-12 Plant (weapons development), and the Oak Ridge Gaseous Diffusion Plant (ORGDP). The fourth facility, the Paducah Gaseous Diffusion Plant, is located in Paducah, Kentucky. This plant generates the smallest amount of solid LLW of the four plants. Each of these facilities stores LLW at its own site, and in addition, may transfer LLW to the ORGDP for interim storage, until additional storage facilities are available at each site. This paper considers all Energy Systems' stored solid LLW as "on-site." Table 1 gives the radionuclide characteristics and volumes of LLW buried at the four sites. The total volume, as of 1984, was 367,000 $m^3$ (2). ORNL is the largest solid LLW generator in terms of volume (~2000 $m^3$/yr) (2,3) and fission products and will be used for further illustration in this paper.

For the past 40 years, ORNL has disposed of solid LLW using shallow land burial at its own site. In 1981, work was begun for a "Central Waste Disposal Facility" (CWDF) for the three Oak Ridge plants (4). The idea was to pool technical and financial resources to develop and operate disposal facilities in order to take advantage of economies of scale. The CWDF was to utilize state-of-the-art shallow land burial. Because of concern expressed by federal and state agencies and private citizens on the draft environmental impact statement, the project was delayed. One major public and government concern was that Energy Systems had not thoroughly evaluated all possible alternatives and technologies, such as above-ground storage versus shallow land burial. Also in question were the long-term stability of the proposed site, the extent of and ability to monitor groundwater contamination and the ability and commitment to integrate new technologies and techniques into the operation of the facility.

DOE and Energy Systems have responded to this setback with a new set of plans known as the "Oak Ridge Model" (5,6,7). These organizations are more determined than ever to tackle their waste and environmental problems. The model is actually an approach to waste management which includes the following elements: 1) technology research, development, and demonstration; 2) increased interaction with the Environmental Protection Agency, and State regulators such as the Tennessee Department of Health and

*Numbers in parenthesis refer to similarly numbered references in Bibliography at end of paper.

Environment and universities; 3) increased public information; and 4) technical interface and technology transfer. The model is based on the philosophy that those affected by waste management decisions should have a role in the decision-making process, that all available resources such as universities and private contractors should be used to solve problems, and that information exchange among all involved organizations and groups is vital. The methods for carrying out the philosophy include remedial actions, waste generation reduction, interim storage at ORGDP, improved operations, and technology development and demonstration projects.

Past practice at ORNL was to accept a variety of waste forms at the solid waste storage areas (SWSA), such as boxes, plastic bags, drums, and loose contents from dumpsters. As a result of suspected environmental contamination resulting from violation of the waste acceptance criteria of the SWSA, the decision was made to tighten the criteria and to require additional data on the waste package contents. The task of accomplishing this was simplified because of the recent effort to implement a TRU waste certification program for shipping waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, beginning in 1989. Certified waste is waste that has been confirmed to comply with the site waste acceptance criteria (1). As mentioned earlier, solid waste is also now being sent to ORGDP for interim storage. The waste acceptance criteria for ORGDP are given in Fig. 1. Simply, LLW destined for the ORGDP site must 1) be packaged in a Department of Transportation (DOT) Type A container; 2) contain no free liquids, corrosive materials, pyrophoric materials, explosive materials, compressed gases including aerosol cans, or radioactive mixed waste; 3) have particulates such as powders and ashes immobilized; 4) have a maximum surface dose rate $\leq$10 mrem/h at contact; and 5) contain less than 100 nCi/g of TRU waste (8). The acceptance criteria for the ORNL SWSA are less stringent since wastes will not be transported over public roads. Requirements are 1) a strong, tight container, 2) no detectable liquids or corrosive materials allowed, and 3) no TRU waste >100 nCi/g (9).

## QUALITY ASSURANCE REQUIREMENTS AND METHODS OF THE ORNL SOLID LLW PROGRAM

The increased control, accountability and reporting that is now required of waste programs has necessitated the use of many more formal QA techniques than have been used in the past. Table 2 gives some of the QA requirements for ORNL solid radioactive waste management. The most extensive requirements apply to TRU waste due to the certification program requirements for shipment off-site (to the Waste Isolation Pilot Plant). The QA requirements are prescribed in a series of documents beginning with DOE Order 5700.6A, "Quality Assurance" (10). The DOE Oak Ridge Operations Office Order OR 5700.6 (11) further references the ANSI/ASME NQA-1 Standard, "Quality Assurance Program Requirements for Nuclear Facilities," (12) as the preferred standard for nuclear waste programs. Energy Systems and ORNL documents further specify QA requirements. Essentially, all 18 elements of the NQA-1 standard apply (see Fig. 2). The following paragraphs explain how current solid LLW practices meet the intent of selected NQA-1 elements.

ORGANIZATION

The organization for carrying out all of the QA aspects of the programs is complex — comprised of waste generators, packagers, analysts, and inspection and data management personnel. The responsibilities of these staff members are documented in the ORNL Health Physics Procedure Manual (9).

QUALITY ASSURANCE PROGRAM

The QA program for on-site storage of LLW is documented in QA assessments and plans and newly prepared plans (such as Reference 8). A formal training program instructs waste generators and operators in the proper handling, packaging and documentation required for solid waste. Training files are maintained by each individual's line organization.

IDENTIFICATION AND CONTROL OF ITEMS

Each waste package requires a unique identification number (bar coded on the package). This allows for careful tracking of the package and its contents until it is buried or stored and also for retrievability of packages that will be placed in interim storage at ORGDP. Assay results can also be keyed to a specific waste package via the identification number.

PROCUREMENT CONTROL

The major items to be procured are the Type A drums. Specifications to be used on purchase requisitions are included in the operating and QA procedures for the SWSA. In the future, vendors will be required to furnish to ORNL documentation of tests verifying that the drums supplied pass the tests specified by DOT for Type A Specification 17H containers. ORNL has already initiated on-site tests on the mild steel drum stock on hand. These include drop, compression, and penetration tests.

TEST CONTROL AND CONTROL OF MEASURING AND TEST EQUIPMENT

Health physics surveys are performed on each waste package before it leaves the waste generation site. A recall system ensures that all health physics equipment is calibrated and receives routine maintenance.

INSPECTION

Perhaps one of the most valuable features of the solid LLW system is the use of several waste assays (shown in Table 2). These inspections or nondestructive examinations help verify what the waste generators have recorded on the data forms as the contents of the packages. The real time radiography (RTR) unit has served as an excellent verification method as well as a training tool. Free liquids and aerosol cans are easily recognized on the x-ray videotape, and the hazardous waste, lead, can be discerned by its extreme density. The RTR videotapes are used in the training sessions to illustrate how RTR can detect violations of the waste acceptance criteria. Once an operator or technician sees the sensitivity of inspection methods and what waste acceptance criteria violations are, he or she is much more likely to remember what is required.

## CONTROL OF PROCESSES

Practically all of the QA methods enter into control of the process of safely packaging, transferring and storing LLW. Some of these inputs are training of the staff, written waste acceptance criteria and operating procedures, the inspection techniques used, and radiation and environmental monitoring. As an example of environmental monitoring, a series of monitoring stations on streams and lakes in the vicinity of the SWSA check the concentrations of various radionuclides and heavy metals which may have migrated through surface water pathways from the storage sites. Plans are also being formulated to add additional groundwater monitoring wells.

## CONCLUSIONS AND DIRECTIONS FOR THE FUTURE

In today's political and environmental climate, it is not sufficient just to do a good job. Work must be documented and often verified. This is certainly true of the nuclear waste management business. The efforts of numerous individuals from many organizations are required. Plans for the future include using the best available technologies for volume reduction and waste stabilization, careful siting of new disposal areas so that contact with surface and groundwater is minimized, and expanding environmental monitoring systems. At ORNL, the long-term goal is to have a disposal site that requires minimum active maintenance but operates in full compliance with the regulations (3).

The best results will be achieved if emphasis is placed on the front end of the waste management programs. The waste certification programs rely on the integrity of the work of the waste generators and packagers. Figure 3 illustrates the relative importance of applying QA techniques. If operators are not properly trained, if procurement of waste containers is not carefully controlled, if isotopic contents are not recorded and/or verified, then the waste package that arrives at the storage site is simply not certifiable. What this really means is that the packages may not be stored. It means extra work, time, and money (taxpayers' money) will be involved in transferring the package back to the waste generator for proper packaging and/or documentation or repackaging at the storage site. The philosophy of getting it right the first time certainly applies in the case of packaging radioactive wastes. Every QA principle known is being applied to waste management activities at the Energy Systems plants so that the jobs will be done well, and to enable the facilities to get on with the work they are funded to do — to conduct high technology research and development and to aid in the defense of the country.

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# GLOSSARY

By-product Material. Waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface waste resulting from uranium solution extraction processes. The term excludes fission products and other radioactive material covered in 10 CFR Part 20.3(3).

Certified Waste. Waste that has been confirmed to comply with disposal site waste acceptance criteria.

High-Level Waste. The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing any solid waste derived from the liquid, that contains a combination of TRU waste and fission products in concentrations as to require permanent isolation.

Low-Level Waste. Radioactive waste not classified as high-level waste, TRU waste, spent nuclear fuel, or by-product material as defined by DOE Order 5820.2.

Radioactive Waste. Solid, liquid, or gaseous material of negligible economic value that contains radionuclides in excess of threshold quantities except for radioactive material from post weapons test activities.

Radioactive Waste Management. The planning, coordination, and control of those functions related to handling, treatment, storage, transportation, and disposal of radioactive waste, and associated with surveillance and maintenance activities.

Shallow Land Burial. Disposal of waste in near-surface excavations that are covered with a protective overburden.

Spent Nuclear Fuel. Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

Storage. Retention of waste in a retrievable manner that requires surveillance and institutional control.

TRU Waste. Without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g.

Waste Container. A containment vessel for radioactive waste, including any liner or shielding material that is intended for disposal.

Waste Package. The radioactive waste, waste container, and absorber that are intended for storage or disposal as a unit. In the case of contaminated, damaged, leaking or breached waste packages, any overpack shall be considered the waste container, and the original container shall be considered part of the waste.

Table 1

Volumes and Undecayed Radionuclide Characteristics of Low-Level Radioactive Waste Buried at U.S. Department of Energy/Defense Sites, operated by Martin Marietta Energy Systems, Incorporated. Source: Adapted from "Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics," prepared by Oak Ridge National Laboratory for the U.S. Department of Energy, December 1985, p. 152. [a]

| Site | Accumulated Volume Buried ($10^3$ $m^3$) | Summation of Activities at Time of Burial,[b] Ci | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fission Products | Induced Activity | Tritium | Alpha (<10 nCi/g) | Other Activity | Total Gross Activity |
| ORNL[c] | 200.5 | $1.69 \times 10^5$ | $4.16 \times 10^4$ | $7.01 \times 10^3$ | $1.01 \times 10^2$ | $4.22 \times 10^5$ | $6.40 \times 10^5$ |
| PAD[d] | 7.4 | $8.56 \times 10^{-1}$ | 0 | $6.00 \times 10^{-1}$ | 0 | 0 | $1.46 \times 10^0$ |
| ORGDP[e] | 75.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Y12[f] | 83.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 366.7 | $1.69 \times 10^5$ | $4.16 \times 10^4$ | $7.01 \times 10^3$ | $1.01 \times 10^2$ | $4.22 \times 10^5$ | $6.4 \times 10^5$ |

[a]Data for this table were obtained from the Department of Energy Solid Waste Information Management System, Schedule Nos. P67SR001 and P67SR005; maintained at EG&G, Idaho, Idaho Falls, Idaho. No TRU waste is included. As of December 31, 1984. All volumes are based on container volumes.

[b]Decay has not been allowed for. Present activities are less than the sum of what was buried.

[c]Oak Ridge National Laboratory, Oak Ridge, Tennessee.

[d]Paducah Gaseous Diffusion Plant, Paducah, Kentucky.

[e]Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee.

[f]Y-12 Weapons Development Plant, Oak Ridge, Tennessee.

Table 2

Quality Assurance Requirements for ORNL[a] Solid Radioactive Waste Onsite Storage

| Waste Type | Storage Location | Waste Generator and Operations Training Program | Waste Package ID No. | Data Forms Required[b] | | Health Physics Surveys of Waste Packets and Packages | Waste Assays Required | | | | Data Input to SWIMS[d] | Data Input to IDB[e] | Data Certification Package | Waste Package Procurement Requirements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Form 2822 | Login Sheet | | Gamma Scanning | Neutron Assay | Real Time Radiography | Drum Integrity Scanning[c] | | | | |
| LLW | ORNL | X | X | X | X | X | | | X | | X | X | X | |
| | ORGDP[f] | X | X | X | X | X | X[g] | X[h] | X | X | X | X | X | X |
| HLW | ORNL | X | X | | | X | | | | | X | X | | |
| TRU Waste | ORNL | X | X | X | X | X | X | X | X | X | X | X | X | X |

[a] Oak Ridge National Laboratory, Oak Ridge, Tennessee.
[b] Form 2822 and the login sheet contain detailed information on type of wastes in a package, estimated radioisotopic content, and surface radiation readings.
[c] The ultrasonic drum integrity scanner is scheduled to be operational in the latter part of 1986.
[d] Solid Waste Information Management System; maintained by EG&G Idaho for the U.S. Department of Energy.
[e] U.S. Department of Energy Integrated Data Base; maintained by ORNL for the U.S. Department of Energy.
[f] Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee.
[g] Performed on random basis.
[h] Performed on LLW drums originating from TRU facilities.

Figure 1

Low-Level Waste Acceptance Criteria for Interim Storage at the Oak Ridge Gaseous Diffusion Plant (Adapted from Reference 8)

**Waste Container Criteria**

Noncombustible

DOT Type A

Design life of 10 years

Package size - Type A, DOT Spec. H steel drum (55 gal.)

Package weight - 300 lb. for solid LLW, 800 lb. for sludge

**Waste Form Criteria**

Particulate immobilization required

Detectable liquids not acceptable

Pyrophoric materials not acceptable

Explosive materials not acceptable

Compressed gases, including aerosol cans not acceptable

Radioactive mixed waste with reportable quantities of hazardous waste materials as identified in 40 CFR 261 not acceptable

Corrosive materials not acceptable

**Waste Package Criteria**

Nuclear safety - quantity of fissile materials must be $\leq$ 1g

Surface dose rate - maximum surface dose rate at any point $\leq$ 10 mrem/h at contact

Surface contamination - removable surface contamination no greater than $10^{-5}$ $\mu Ci/cm^2$ for beta-gamma emitting isotopes and $10^{-6}$ $\mu Ci/cm^2$ for alpha emitting isotopes

Nuclear heating - quantity of radioactive materials (waste form and container) limited so that nuclear decay heat will not affect physical or chemical stability of the contents or package integrity

Activity limits - radioactivity/package shall be below $A_2$ values given in 49 CFR 173.435 for Type A packages

TRU waste - TRU waste (>100 nCi/g) not acceptable

Figure 2

ANSI/ASME NQA-1* Basic Requirements

1. Organization
2. Quality Assurance Program
3. Design Control
4. Procurement Document Control
5. Instructions, Procedures, and Drawings
6. Document Control
7. Control of Purchased Items and Services
8. Identification and Control of Items
9. Control of Processes
10. Inspection
11. Test Control
12. Control of Measuring and Test Equipment
13. Handling, Storage, and Shipping
14. Inspection, Test, and Operating Status
15. Control of Nonconforming Items
16. Corrective Action
17. Quality Assurance Records
18. Audits

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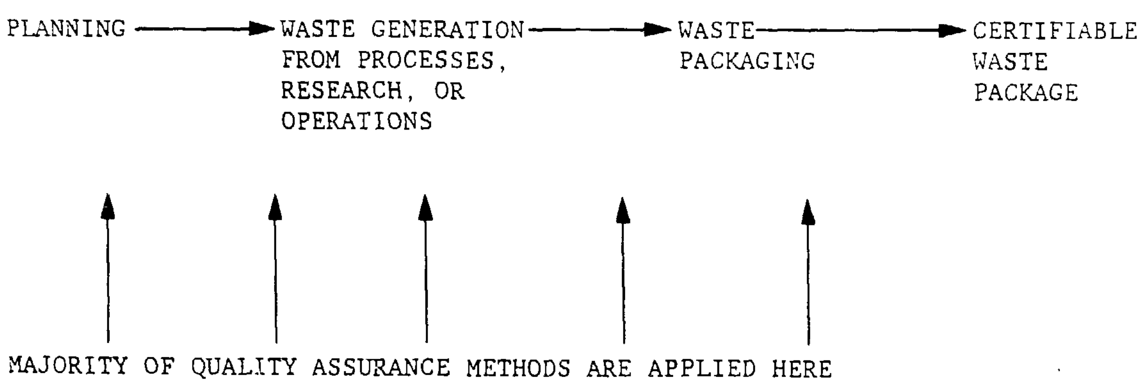
*American National Standards Institute/American Society for Mechanical Engineers NQA-1 Standard, "Quality Assurance Program Requirements for Nuclear Facilities," (Reference 12)

Figure 3

Simplfied Waste Package Generation Flow Chart and the Timing of Application of Quality Assurance Methods



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