

THE OAK RIDGE NATIONAL LABORATORY GREEN IS CLEAN—ACHIEVING WASTE REDUCTION AND EFFICIENCY GOALS

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ABSTRACT

Oak Ridge National Laboratory (ORNL) has reengineered its operating systems and culture, including waste management systems. The U.S. Department of Energy site office established aggressive goals for cost savings and dry active solid low-level radioactive waste (SLLW) reduction. Waste management teams reduced costs by \$9.4M, exceeding the \$8M goal, and reduced the volume of dry active SLLW by >50%, exceeding the 25% goal.

A waste management reengineering team focused on demonstrating a method to reduce SLLW as it is generated. Improved radiological surveys would allow segregation of potentially radioactive trash from waste that is known to be radioactive. The ORNL team identified, surveyed, sorted, and documented waste streams that were potentially radioactive. This prescreening process estimated that 83 wt % of the waste could be declared nonradioactive. GTS Duratek was subcontracted to use their state-approved process for monitoring potentially clean waste with a volumetric-based assay system—the “Green is Clean” (GIC) process allows waste to be unconditionally released. The GIC survey process cleared 66 wt % of the waste for unconditional release.

The waste management reengineering team demonstrated that the diverse array of radionuclides present in ORNL’s SLLW can be surveyed at extremely low levels of radionuclide contamination. Wastes that are potentially radioactive can be segregated from nonradioactive waste. This volumetric measurement technique is a powerful SLLW pollution prevention tool.

BACKGROUND

Since 1996, Oak Ridge National Laboratory (ORNL) has reengineered its operating systems and culture. This mandate for change challenged all Laboratory employees:

Reengineering ORNL is first and foremost a change in culture. . . .
If we are to survive and prosper as a national laboratory, we must become bolder, take justifiable risks, and look to the future, not dwell on problems of the past. Of equal importance is a cultural

change that must occur in each and every one of us. . . . These changes will not only enhance our efficiency and cut our costs; they will reinforce the very foundation on which our R&D enterprise is built. They will allow us to do more for less, allow us to maintain our creative juices, and ultimately make ORNL a more enjoyable and rewarding place to work.(1)

ORNL achieved this vision for change through the focused efforts of many employees:

Quite honestly, some reengineering efforts have been very successful, and have made ORNL a significantly better place to work. Procurements are significantly faster and less expensive, construction and design of facilities and modifications are far less expensive, the cycle time for consultant services has been cut in half, property transfers are automated, Environmental, Safety, Health, and Quality procedures have been rewritten to reflect industrial practices, and waste management costs have been reduced by more than \$8 million per year.(2)

The people involved in managing ORNL's waste reduced 1998 costs by "more than \$8 million per year" by nurturing the "cultural change that must occur in each and every one of us—greater trust; less aversion to risk; a tolerance for honest mistakes; a willingness to accept responsibility; and a desire to work together."(1)

An intensive evaluation of the ORNL waste management program was conducted from February to July 1997, resulting in 15 recommendations that redirected several waste management approaches.(3) These recommendations were transformed into action through the efforts of several teams.(4) The team-work approach to managing ORNL's newly generated waste is being fully implemented in 1999 through the leadership of a newly formed Laboratory Waste Services Group.

In 1998, one team focused on pollution prevention with increased use of commercial services. This focus was further sharpened to reengineer ORNL's solid low-level radioactive waste (SLLW) generation process.(2) The importance of this initiative was emphasized by the closure of the on-site SLLW disposal facility. Further, ORNL has the opportunity to significantly reduce SLLW generation rates. Employees who conduct radioactive work do not have a cost-effective, compliant process to segregate waste that may not be radioactive from waste that is known to be radioactive. Therefore, much of the waste that is declared "SLLW" is actually nonradioactive. The team's evaluation of a method to segregate SLLW and nonradioactive waste is the subject of this paper.

INTRODUCTION

Reducing ORNL's SLLW Generation Rate

ORNL has historically generated more than 1416 m³ of SLLW annually—453 m³ of this waste is dry active waste.(5) In 1998, a waste management reengineering initiative targeted dry active SLLW volume reduction and pollution prevention. To reinforce the importance of this initiative, the U.S. Department of Energy (DOE) ORNL Site Office established a 1998 milestone to “reduce generation of dry active SLLW by 25%.”

- Several ORNL divisions worked aggressively to reduce dry active SLLW by >50% by reducing the volume of 11 waste streams: the High Flux Research Reactor (HFIR), Plant and Equipment (P&E) Division, Chemical Technology Division (Chem Tech), and Engineering (see Fig. 1). The volume of dry active SLLW was reduced by >50% (238 m³), exceeding the DOE goal of 25%.
- HFIR staff volume-reduced construction debris generated by dismantling the cooling tower, eliminating ~113 m³ of SLLW (25% reduction in annual generation).
- P&E Division and Health Physics staff segregated radioactive and nonradioactive heating, ventilation, and air conditioning equipment and recycled both contaminated and noncontaminated scrap metal, eliminating ~71 m³ of SLLW (16% reduction in annual generation).
- Potentially contaminated soil that had not been disposed of for several years was evaluated and disposed of on site as noncontaminated soil (4% reduction in annual generation).
- Waste problems were solved, allowing three abandoned trailers to be sold as surplus.
- ORNL outsourced the survey and segregation of potentially bulk-contaminated radioactive trash to a state-approved vendor, eliminating 22 to 36 m³ of SLLW (5 to 8% reduction in annual generation). Outsourcing this survey method is the subject of this paper.

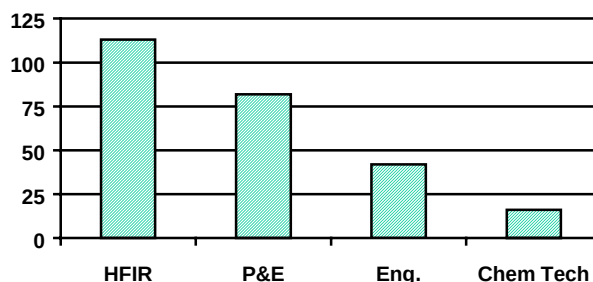


Fig. 1. ORNL Divisions Contributed to Meeting DOE's Goal for Reducing SLLW Generation.

The Need for Improved Waste Segregation

The diverse research and maintenance activities at ORNL generate $\sim 1416 \text{ m}^3$ /year of radioactive waste. These wastes have contained 118 different radioisotopes in 595 unique combinations.(3) More than 1,500 waste generators use the expert advice of 25 generator interface members to manage their radioactive waste. Through procedural requirements, documented in the Waste Certification Plan,(6) the Laboratory's management supports using these experts to ensure compliant waste management practices.

Radioactive waste is generated in radiological areas. Before work can be conducted, waste generators identify those radioisotopes that are present by preparing a waste stream profile (WSP). Analytical or smear data support this profile. As the work is conducted, radiological workers place waste in an SLLW container. If the worker knows that material has not become contaminated, a trained radiation control technician (RCT) can use a hand-held survey meter to check for potential contamination. ORNL procedures require the survey of all accessible surfaces—an RCT averages 3 hours to survey one standard bag ($\sim 0.08 \text{ m}^3$) of potentially contaminated waste. If survey results meet the residual surface contamination values as defined by DOE Order 5400.5 (7) (cf. Nuclear Regulatory Guide 1.86) (8), the waste can be unconditionally released (green-tagged) and disposed of as sanitary waste. Characterization to unconditional release standards is not required if waste generators chose to dispose of the potentially radioactive waste as SLLW. To ensure proper control of radiological hazards, ORNL's standard practice is to dispose of potentially radioactive waste as if it were SLLW.

Since up to 50% of SLLW may not be radioactively contaminated, reengineering the SLLW handling processes could "enhance our efficiency and cut our costs." To identify how to reengineer the SLLW handling process, the team demonstrated a method to survey for volumetric rather than surface contamination. The volumetric contamination assay method could replace the current practice of using a labor-intensive surface contamination survey technique. If suspect SLLW could be quickly and accurately surveyed to determine whether it contains radioactive contamination, potentially contaminated waste could be eliminated from SLLW, greatly reducing the volume of SLLW. DOE selected this SLLW pollution prevention initiative as one of the highest waste management reengineering priorities.

SOLID LOW-LEVEL WASTE POLLUTION PREVENTION DEMONSTRATION

Preparing Waste for Demonstration

The reengineering team determined that a small-scale demonstration would provide data on volumetric measurement of extremely low levels of radionuclide contamination that could demonstrate the applicability of volumetric assay techniques to ORNL's diverse array of radionuclides. Lockheed Martin Energy Research routinely shipped SLLW to GTS Duratek for treatment and return to ORNL for storage or disposal. This vendor also has the capability to assay potentially contaminated waste, making their process convenient to use—GTS Duratek could segregate and treat waste identified as radioactive without transferring it back to ORNL. The GTS Duratek "Green is Clean" (GIC) process was, therefore, selected for the demonstration.

Generators identified wastes that were ready to be disposed of as SLLW but that were potentially not radioactive. To represent ORNL's wastes, the team selected waste-generating activities that ranged from one-time events such as construction projects to routine laboratory waste. Since the waste had not been segregated as it was generated, extra precaution was required to ensure that it met the vendor's waste acceptance criteria (WAC). To take this extra precaution, waste examination and assay facility (WEAF) equipment was used to validate field survey data before transferring waste to the vendor. The material was handled as SLLW to comply with procedures, ensure proper documentation, and meet characterization and U.S. Department of Transportation requirements. Team members evaluated the data to ensure that waste transferred to the vendor met the receiving facility's WAC.

ORNL's existing waste procedures were used to characterize radioactive materials. WSPs are used to document each waste stream's physical, chemical, and radioisotopic characterization. In many cases, one waste stream is produced consistently by a generating facility. In other cases, waste generators collect sampling and analysis data on unique waste-producing campaigns. This documentation is kept on file to support more detailed characterization of waste items as they are generated. Team members used a graded screening approach to declare a waste stream as a candidate for the GIC process.

Team members identified GIC candidates by reviewing the WSP. This evaluation included screening for prohibited items such as liquids, asbestos, and biological wastes. The WSP documents the percentage of radioactivity contributed by each radioisotope. The vendor's equipment detects cobalt and cesium (gamma emitters) to establish whether waste is radioactive. The absence of other radionuclides documented on the WSP is inferred by scaling their isotopic content. If these gamma emitters are not detectable, other radionuclides (e.g., pure alpha and beta emitters) must also not be present. Candidate waste streams were, therefore, evaluated by isotopic content—team members selected waste streams with at least 7% of the potential radioactivity from Co-60 or Cs-137 to meet the vendor's WAC.

Selected waste streams are reported by the ORNL facility (see Table I). In some cases, multiple waste streams were generated in more than one facility, resulting in a range of isotopic distributions for a given facility. Waste meeting the GIC requirements were staged and sent to the WEAF for further processing.

Table I. Facility Distribution of Radioisotopes

Facility (Bldg.)	Waste-generating activity	Radioisotopic distribution
2600	Construction	Cs-137 (9%), Eu-152, U-233, Sr-90 (85%)
2523	Maintenance activities	Cs-137 (0.5-51%), Co-60 (18-45%), Co-57, Eu-152, Eu-154, Eu-155
3019	Filter media	Cs-137 (88%), Am-241
3092	Construction	Cs-137 (19%), Sr-90 (80%)
3517	Facility refurbishment, laboratory processes	Cs-137 (15%), Co-60 (2%), Sr-90 (83%)
3608	Construction	Cs-137 (9-97%), Cs-134, Sr-90 (85%), U-233

To ensure that the vendor's WAC were met, the team used a series of screening processes as follows:

- After the B-25 was transported to the WEAF, the area RCT surveyed the external surfaces of the box for loose contamination and identified any elevated radiation measurements on the exterior surfaces of the box.
- The B-25 box was x-rayed using the box real-time radiography chamber to identify any nonconforming items, including liquids and prohibited items such as aerosol cans that have not been punctured.
- As a safety precaution, a NaI detector was used to identify any high level of gamma emitters before opening the B-25 box.
- Each waste package was removed from the B-25 box and surveyed by the area RCT. Those packages with loose surface contamination and/or contact dose rates >3.0 nanosieverts/h were rejected from the GIC process.
- Each waste item was weighed and placed inside a plastic scintillation counting system (bag monitor) to obtain the gross specific activity. The minimum detectable activity (MDA) for this sensitive counting device was set at ~ 0.2 Bq/g (gross activity). However, the instrumentation was not rigorously calibrated to achieve an absolute value of 0.2 Bq/g because the instrumentation was used as a screening device.
- To provide a quality assurance check for transuranic isotopes, supplemental measurements were taken using the Active Passive Neutron Examination Assay device.
- The results were recorded, and those bags meeting requirements (see Table II) were processed as GIC candidates. Waste items that did not meet the vendor's WAC were managed as SLLW.

Table II. WEAFF Screening Criteria

Bag monitor (Bq/g)	Direct frisk (GM detector) results above background	Contact dose rate (nanosieverts/h)	Decision
<0.2	No detectable radioactivity	<3.0	GIC candidate
0.2-0.6	<1000 cpm	<3.0	Vendor sorting required
>0.6	>1000 cpm	>3.0	Process as SLLW

Vendor's Surveying Methods

The vendor received ORNL waste “to identify the portions of the waste that meet GTS Duratek’s state of Tennessee license conditions for unconditional release. GIC processing included assaying the waste for potentially present gamma-emitting nuclides (i.e., Cs-137 or Co-60) and separating the clean (uncontaminated) waste from the contaminated waste in each container.”(9) Processing steps included the following activities:

- Bags of waste were removed from a B-25 box, placed into a 208-L drum, and assayed with a Canberra Q² drum assay system that uses segmented high-purity germanium counters.
- The density of the waste was factored into the Q² system measurement; the end result was a measurement of radioactivity per gram.
- If no radioactivity was detected, the waste was green-tagged. All waste from an individual B-25 box that was determined to be clean was placed in a green bag and then placed back into the original B-25 for shipment back to ORNL.

Waste that was determined to contain radioactive contamination was removed from the counting system and staged for segregation.

- Items that are routinely contaminated, such as gloves and shoe scuffs, were segregated. The remaining waste was quickly scanned using hand-held monitors.
- Waste items causing an increase in the hand-held monitor reading were segregated. The nonradioactive waste was placed back into the Q² system and was re-assayed.
- If no radioactivity was detected during re-assay, the waste was green-tagged, placed in a green bag, and placed in the original B-25 box.
- If the re-assay detected the presence of radioactive contamination, the waste was identified as radioactive and was placed back into the original B-25 box.

The vendor conducted additional surveys of those waste streams that contained Sr-90:

- The exteriors of bags originating from Sr-90 waste streams were scanned.

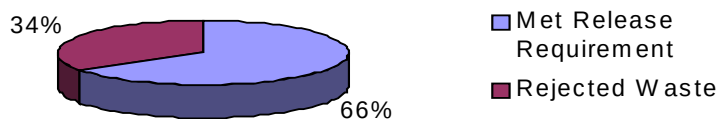


Fig. 2. The SLLW pollution prevention demonstration cleared 66% of the waste surveyed for unconditional release.

- If no radioactivity was detected, the waste was green-tagged, placed into a green bag, and placed into the original B-25 box.

Both radioactive and green-tagged waste were placed in the original B-25 box to ensure that the integrity of the waste stream was maintained for the demonstration. During normal operations, green-tagged waste would be disposed of at the sanitary landfill.

SLLW Pollution Prevention Demonstration Results

The pollution prevention demonstration cleared more than 71 m³ of waste for unconditional release. Of the 3,850 kg of waste surveyed, 2,275 kg (58%) met the GTS Duratek radioactive material license conditions for unrestricted release as approved by the state of Tennessee (4) (see Fig. 2). The predominant isotope found in rejected waste was Cs-137. The vendor demonstrated its ability to detect radioisotopes of cobalt, cesium, americium, europium, and strontium.

To qualitatively check the vendor's survey techniques, the mass of waste green-tagged by the vendor was compared with the mass of waste that was below the MDA of the WEAFF equipment (MDA ~ 0.2 Bq/g). Because the WEAFF bag monitor was set up as a screening tool, the equipment was not rigorously calibrated. The vendor's state-approved process is further calibrated by a factor that correlates the volumetric measure (Canberra Q² system) to the regulated surface area limits (see Nuclear Regulatory Guide 1.86). Therefore, data obtained by WEAFF equipment and the vendor's system can only be compared qualitatively. Data were collected on each waste stream and are reported by facility in Fig. 3.

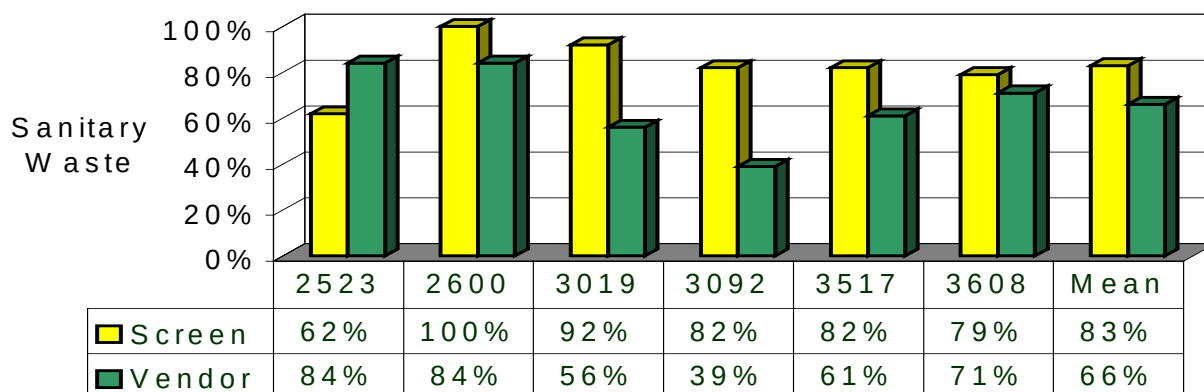


Fig. 3. Vendor's results were routinely more conservative than screening tests—less waste was below the vendor's MDA than the WEAFF screening MDA.

The gross specific activity of waste generated in Building 3092 fell below the MDA of GTS Duratek's process for only 39% (54 kg out of a total of 138 kg) of the waste meeting the requirements for unconditional release. When the same material had been surveyed at the WEAFF, 82% fell below the MDA level—a much less conservative value. Cesium-137 was the most prevalent isotope within this waste stream. The beta emitter Sr-90, which can be difficult to measure, was present in this waste stream.

Results for Building 3019 differed, with the vendor's results being more conservative. The vendor reported that 56 kg of waste (56%) would meet the release criteria, while the WEAFF reported that 92% of the waste was below the equipment's MDA. Cesium-137 was the most predominant isotope found within this waste stream, with Am-241 being difficult to detect.

The greatest efficacy between measurement data was found for Building-3608 waste. The WEAFF's survey process indicated that 79% of the processed material was <0.2 Bq/g, while the vendor's data indicated that 71% of the material had no detectable activity. The waste contained several isotopic distributions. Cesium-137 and Sr-90 were the most abundant isotopes. The minimum requirement for photon-emitting materials was always above the WAC requirement of 7%. Restrictive isotopes included within these waste streams were Sr-90 and U-233.

The gross specific activity of waste generated in Building 2523 fell below the MDA of WEAFF's plastic scintillation counting system (bag monitor) for 62% of the mass, while the vendor reported that 700 kg (84%) of the material met the GTS Duratek license conditions for unrestricted release. All radioisotopes reported on the WSP are gamma emitters, with the highest percentage of the radioactivity being attributed to Cs-137. The waste matrix was described as plastic, personal protective equipment, and paper; therefore, the density of the waste cannot be used to describe the anomaly in the otherwise consistent observation that the results reported by the vendor's process were more conservative than the results of the screening technique.

Descriptive statistics of both survey processes differed by 17%. Measurements taken at the WEAFF were below the MDA for an average of 83% of the processed materials. GTS Duratek's process indicated that only 66% of the material could meet the state of Tennessee release criteria. The WEAFF equipment provided a good screening tool for identifying potentially nonradioactive SLLW; as expected, the vendor's surveying method was more sensitive because it allows waste to be unconditionally released.

CONCLUSION

During 1998, ORNL reduced the volume of dry active SLLW generated by >50%. Divisions conducting research, construction, and maintenance activities achieved this accomplishment. Individuals within these divisions and the waste management reengineering team met this challenging objective.

An acceptable method for measuring radioactivity at extremely low levels was a key stumbling block to prevention of SLLW generation at its source. A vendor demonstrated a volumetric measurement process. This process green-tagged 66% of the potentially nonradioactive SLLW that was surveyed. This GIC process is approved by the state of Tennessee, which allows material to be unconditionally released. The demonstration laid a foundation for full-scale implementation of SLLW pollution prevention at ORNL.

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