ORNL RADIOACTIVE WASTE OPERATIONS

J. D. Sease
E. M. King
J. H. Coobs
T. H. Row

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

INTRODUCTION

Radioactive waste management at the Oak Ridge National Laboratory (ORNL) is a major operation, requiring the talents of a large number of individuals from various disciplines to function properly. About 3 percent of the Laboratory's operating budget is required to run the waste processing and disposal facilities. The waste management operations are also indirectly responsible for significant additional spending if the various radwaste monitoring programs, R&D projects, and current radwaste system capital improvements projects are considered. In terms of both activity and volume, large amounts of radwaste must be handled each year at ORNL. To put this in perspective, the amount of liquid and solid waste generated is roughly five times the amount produced by a typical 1000 MWE boiling water reactor power plant.[1,2,3] Since the Laboratory was created in 1943, a rather large and complex network of interconnecting collection, processing, and disposal facilities has evolved to handle these wastes. Although some systems are old, these facilities perform these functions adequately and the rules and regulations presently applicable to ORNL are being met in full. Both liquid and gaseous waste releases are below allowable limits, and available information indicates that current solid waste disposal activities are not releasing significant amounts of activity into the groundwater. The following Sections will briefly describe the various radioactive waste systems currently operating at ORNL.

SOLID WASTE

Solid radioactive waste (SRW) generated at ORNL is collected and packaged in various types of containers and then trucked to solid waste storage areas (SWSA's) for retrievable storage or disposal by means of shallow land burial. ORNL handles only transuranic and low-level radioactive solid waste.

There are six SWSA's at ORNL; however, SWSA-1 through SWSA-4 and the burial areas of SWSA-5 are filled and closed. Currently, a portion of SWSA-5 is used for retrievable waste storage and SWSA-6 is used for shallow land burial. At the present rate of waste generation, SWSA-6 will be filled to capacity in about ten more years.

From 1955 to 1963, ORNL served as the Southern Regional Burial Ground for low-level SRW. Since 1963, when ORNL ceased to serve in this capacity, very little SRW has been received from other sites.

For much of the waste buried at ORNL before 1971, little is known about the physical and radiological characteristics. Since 1971, detailed records have been kept of both the volume and activity content of all waste packages stored in the SWSA's. These are kept in a computerized Solid Waste Information Management System (SWIMS) for ease of retrieval, updating, trend studies, etc.

Transuranic Solid Waste

At ORNL, about 75 M^3/y of transuranic (TRU) waste are stored retrievably. TRU wastes are wastes containing >10 μCi/kg of ^{233}U or transuranic nuclides and are handled according to the radiation level of the individual packages.

TRU waste reading less than 200 mr/hr on contact is normally packaged in stainless steel 30 or 55-gal drums by the waste generator. The waste generator also separates this waste into combustible and nonconbustible portions as much as possible before packaging. After tagging, the waste drums are transferred to the Retrievable Drum Storage Facilities, which are concrete block structures 85 percent below grade, having total storage capacity for approximately 3500 drums. About one-half of this capacity has been filled to date.

To reduce the volume of drummed TRU waste requiring storage, a TRU waste assaying system is being installed to assay and sort drums containing <10 μCi/kg for disposal as low-level waste. This system which has been developed at Los Alamos National Laboratory[4] will be operational this summer and should reduce TRU waste in storage significantly.

TRU waste reading more than 200 mr/hr on contact is normally packaged in reinforced concrete casks by the waste generator. The casks are available in 1.66 m^3 and 0.66 m^3 capacities, having 15.24 cm and 30.48 cm wall thicknesses, respectively. The casks are stored retrievably in trenches, and since January 1980, in a (below grade) reinforced concrete building.

TRU wastes with very high beta-gamma activity levels (some as high as several thousand R/hr) are packaged on a case-by-case basis in appropriate containers of various sizes and stored in stainless steel lined wells with a concrete shield plug closure. These wells are about 2.5 m deep and have diameters ranging from 20.3 cm to 76.2 cm.

Low-Level Solid Waste

Low-level solid waste is also handled according to the radiation level of the waste. The Laboratory handles about 2000 M^3/yr of low-level solid waste. Low-level solid waste reading greater than 200 mr/hr is packaged by the waste generator in suitable containers (plastic bags, can, etc.), tagged for identification and then placed in shielded dumpsters, shielded casks or shielded "hot" trucks. Once filled, these are transported to the burial ground where their contents are emptied into trenches or unlined auger holes. These trenches are limited to a maximum length of 15.25 m and maximum width of 3 m. Depth is usually 3 to 4.5 m and is always at least 0.6 m above the highest known groundwater level. The trenches are sloped toward one end, and a perforated pipe extends vertically to the bottom of the lower end of the trench to serve as a monitoring well. Ditches are provided around the trenches to direct surface water away from the trenches. Appropriate barriers are placed around the open portion of a trench for personnel safety. After the trenches have been filled, the waste is covered with a minimum of one meter of overburden including 0.3 M of native soil; 0.2 M layer of bentonite clay/native soil mixture for sealing; and 0.5 M of native soil and top soil. After covering, the area is seeded to control erosion. For long-term care of the filled trenches, periodic ground-water monitoring and vegetation control are required.

Low-level solid compactible waste that reads less than 200 mr/hr is packaged by the waste generator in various types of containers that are suitable for compaction. These packages (plastic bags, cardboard boxes, thin metal cans, etc.) are tagged to show the originator and major radioactivity and placed in specially marked yellow dumpsters located in convenient locations near the waste generators. After the dumpsters are filled, they are taken to a compaction facility where the contents are removed and compacted in a baling machine. The baling machine produces bales of waste in rectangular plastic lined cardboard boxes measuring 50.8 × 76.2 × 101.6 cm (0.425 m^3) weighing about 305 kg and bound by four metal straps. The baled waste is then transported to SWSA-6 and stacked in trenches as described above.

Low-level solid waste <200 mr/hr and not compactible is packaged by the generator in containers that will prevent spillage or the spread of contamination while handling the packages. Typical packages are mild steel drums, trash cans, paper boxes, and plastic bags. These are tagged and collected in specially marked yellow dumpsters located near the generators. After a dumpster is full, it is transported to SWSA-6 where the contents are disposed of in burial trenches as described above.

Volume Reduction of Solid Radioactive Waste

Beginning in early FY 1978, efforts to reduce the volume of low-level solid radioactive waste for burial at ORNL were intensified. These actions consisted of (1) strict control of materials entering contamination zones; (2) segregation of noncontaminated waste from contaminated waste and by administrative control of the waste entering contaminated waste collection bins; (3) separation of low-radiation-level radioactive waste into a compactible (with compaction at the burial ground prior to burial) and a noncompactible part; (4) when practicable decontamination and returning to service equipment items that would normally be buried; and (5) charging of generators for disposal of contaminated waste.

Educating and keeping the generators aware of the long-term problems associated with the disposal of solid radioactive waste has been a major thrust of this effort. Charging the waste generators for the full operating costs of current disposal and annual follow-up sessions with the generators are important elements of the program.

Facilities currently operating at ORNL for the treatment of waste for volume reduction is a baler for low-activity compactible waste and a small-items decontamination facility. The baler, which was placed into operation in 1978, provides a volume reduction of about 9/1. Compactible waste normally accounts for about 20 percent of the total amount of low-level waste generated at ORNL. An electropolisher is currently being installed for decontaminating small metal objects. A TRU waste assaying system is also being installed.

LIQUID WASTE

ORNL routinely handles relatively large amounts of liquid radwaste in terms of both volume and activity. For example, although most process liquid waste normally contains less than 10 μCi/cc, waste streams can be as high as 5000 μCi/cc. Putting this in perspective, the highest activity level in the sump water from TMI-2 after the accident there in March 1979 never exceeded 200 μCi/cc. Overall, ORNL's record in handling these highly radioactive liquids has been very good.

Liquid wastes are segregated into three separate categories for collection, processing, and disposal. These are: low-level waste (LLW); intermediate-level waste (ILW); and high-level waste (HLW). A waste stream is placed into one of these subsystem categories on the basis of activity level and/or its origin. A simplified block diagram of the process flow paths for the liquid process system is shown in Fig 1.

Low-Level Waste

Liquid low-level wastes are slightly contaminated aqueous solutions consisting of floor drainage, steam and cooling water leakage, flush drains, etc. A complex system of underground piping is provided to collect these wastes and consists of over 30,000 meters of 10.2 cm diam through 76.2 cm diam pipe, most of

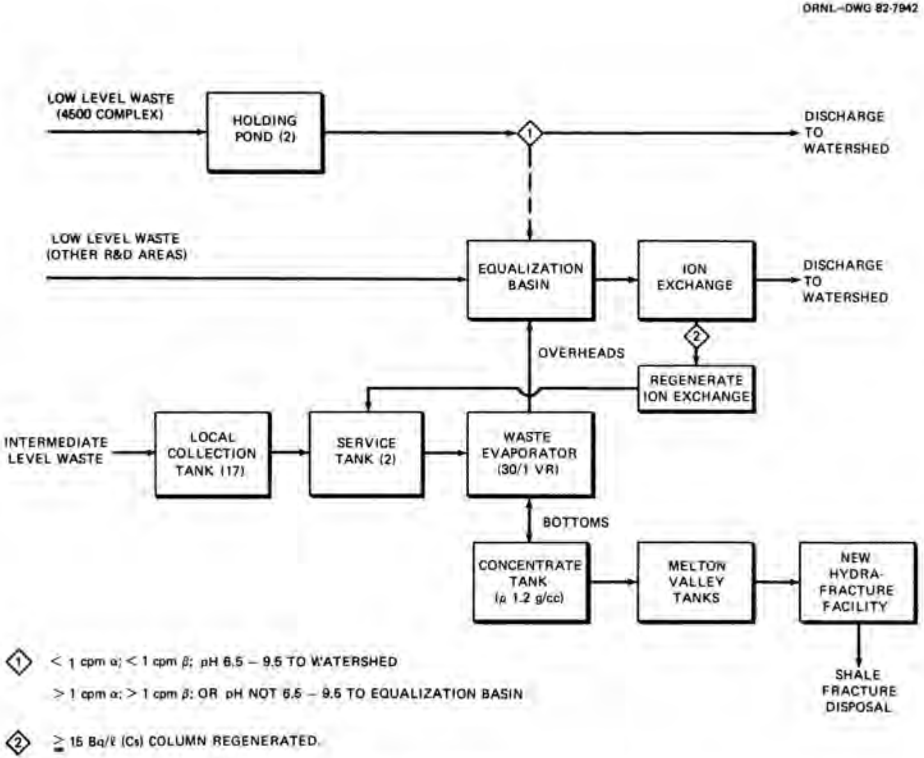

Fig. 1. Schematic of ORNL Liquid Radioactive Waste Systems

which is constructed of vitrified clay. The waste water flows through this piping system by gravity from the source generators to open collection ponds. At various points along the way, the flow rate and activity level in major branches of this collection system are automatically measured and read out in the Waste Operations Control Center (WOCC). After collection in the ponds, the waste water is sampled and then either sent to the LLW processing system or discharged directly, depending upon the activity level found in these samples and/or the radiation readings on the monitors upstream of the ponds.

The liquid low-level wastes were processed using the Scavenging Precipitation - Ion Exchange process flow sheet[5] until late summer of 1981. The Scavenging Precipitation - Ion Exchange process consists of (1) a scavenging precipitation step in which dissolved magnesium and calcium salts are precipitated with sodium hydroxide along with iron hydroxide and removed by the sludge blanket in a clarifier, (2) a waste stream filtration step using anthacite filters, (3) an ion exchange process step using columns loaded with Duolite CS-100[a] ion exchange resin, and (4) an ion exchange resin regeneration step using nitric acid followed with a sodium hydroxide conditioning step. The liquid LLW system is designed to process waste water at a rate of 757 liter/min (200 gal/min) and to remove 99.9 percent of the radioactivity in the water. It has operated essentially trouble free since 1976 and has consistently discharged effluents to the water shed with radionuclide concentrations well below maximum permissible concentrations;[6] but the accumulation since 1976 of about a million liters of sludge from the first step in the process has, because of environmental considerations, made it necessary to test a substitute flow sheet that eliminated the sludge formation. Hence, in late summer of 1981, a Modified Clarification - Ion Exchange flow sheet was implemented. The precipitation step is eliminated and the waste stream is passed directly to the anthracite filters and then through the ion exchange columns loaded with Dowex HCRS[b] resin. In this flow sheet the hardness ions (calcium and magnesium) are trapped on the ion exchange resin bed along with the radioactive contaminants (^{90}Sr and ^{137}Cs) and are removed with the column regenerating solution. Approximately three months of essentially trouble free operation has indicated the desirability of incorporating this flow sheet as part of the routine operation of the system and to install an additional ion exchange column to take care of the increase in frequency of the ion-exchange column regeneration. The engineering design of the new system is essentially complete and column installation should begin in the summer of 1982.

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[a] Manufactured by Diamond Shamrock Company, Redwood City, California. CS-100 is a weak acid carboxylic-phenolic action exchange resin.

[b] Manufactured by Dow Chemical Company, Midland, Washington. Dowex HCRS is a sulfanated-strong acid resin.

Intermediate-Level Waste

Intermediate-level waste is an informal designation used at ORNL to categorize low-level liquid wastes which are segregated for processing purposes. These wastes are from "hot" sinks and other drains from R&D laboratories, hot cells, pilot plants and research reactors. There is no rigorous definition of ILW; however, the upper limit on beta-gamma activity level for ILW is about 5.3 Ci/liter and the heat generation criterion is (0.2 BTU/gal) ~0.015 watts/liter. The average activity level in the ILW after collection and intermixing is about 8 mCi/liter. The ILW drains by gravity from hoods, glove boxes, sinks and cells; or is discharged by steam jets from process vessels to one of the 23 stainless steel collection tanks.

The major radionuclides present in the ILW are ^{90}Sr and ^{137}Cs, with lesser amounts of ^{60}Co, ^{106}Ru, and various rare earths. The ILW contains small amounts of organic material but consists primarily of aqueous waste solutions. As generated, these wastes are usually nitrate solutions; but in the intermediate collection tanks, sodium hydroxide is added to neutralize any acidic conditions. Therefore, when these wastes reach the ILW processing system, they are normally an alkaline mixture of dilute sodium hydroxide and sodium nitrate. Together, these compounds account for 75 percent of the total chemical content of the dilute ILW. Total solids concentration in the dilute ILW ranges from 5,000 to 10,000 ppm. Over the past ten years, an average yearly volume of 7.2×10^6 liters of liquid ILW has been generated.

The collection tanks vary in capacity from 1900 to 57,000 liters depending on the requirements of each source. Waste accumulates in each tank to an administrative limit set by the operations staff. Underground transfer lines connect the source collection tanks to the collection headers and the central evaporator storage tanks.

Two 38 liter/min evaporators are provided for evaporation of ILW. These stainless steel evaporators are single vessel, pot-type, natural circulation evaporators. Steam heats seven seamless coils located in the lower 91.4 cm of the evaporator. If cooling is required in the vessel, water can be injected in the coils for proper temperature control. Each of the evaporator vessels has anti-foam injection capability and remote internal decontamination spray headers. The evaporator is operated on a batch feed system. The vessel is filled with waste and additional feed is forwarded to the vessel as boil-off occurs. When the vessel operating level is filled with concentrated waste based on a density sample, the evaporation process is terminated and the waste concentrate is batch fed to the concentrates surge tank. Concentrates are subsequently pumped about 3 KM in a new 5 cm diam stainless steel line to the hydrofracture site storage tanks. The evaporation is controlled locally with a malfunction alarm in the WOCC. Evaporator distillates are collected in a surge catch tank. Following radiation monitoring, the distillates are normally piped to the equalization basin; or if high in activity, they are returned to the ILW system.

Disposal of concentrates from the liquid waste processing systems is handled by hydrofracture. This is a batch process, in which waste is mixed with a solids blend of cement and other additives; the resulting grout is then injected into an impermeable shale formation at a depth of 200 to 300 m (700 to 1000 ft), well below the level at which groundwater is encountered. During the course of the injection, the grout forms a thin pancake-like horizontal layer about 10 mm thick and about 100 to 200 meters in diam. The sheet solidifies within a few hours to permanently fix the radioactive waste in the shale formation. The grout used is specially formulated to provide excellent leach resistance for an added safety measure. A detailed description of this disposal technique is discussed in another paper at this conference.[7]

TRU and High-Level Waste

High-level liquid waste (HLW) is not routinely produced in significant quantities at ORNL. However, in the early 1960's, it was anticipated that some future processing operations would produce liquids with substantially higher concentration and heat generation rates than could be handled by the existing systems. Consequently, in 1964, the elements of a high-level waste system were installed. The system includes two internally and externally cooled 190,000 liter stainless steel tanks located in an underground reinforced concrete vault adjacent to the evaporator building. This installation consists of two HLW storage tanks designed to accommodate hot acidic wastes with activities up to 740 Ci/liter, and heat generation to 2.5 watts/liters (32 BTU/hr/gal). The tanks are of all welded construction, fabricated of ASTM A240-61T Type 304 stainless steel, 1.27 cm thick. The 18.6 m long by 3.7 cm diam horizontal tanks were designed to meet the requirements of ASME Code Section VIII. Only one tank is used to receive HLW input with the second tank available as a standby to receive the contents of the first tank in case of leakage. The system has been used only on a very limited basis.

Transuranic liquid waste are administratively segregated and forwarded to collection tanks. Efforts are made to minimize the amount and concentration of liquid TRU waste by converting as much as possible to solid form. A new doubly contained 39,000 liter collection tank was recently placed into service for TRU liquid waste.

GASEOUS RADIOACTIVE WASTE

Radioactive waste gases originate from ORNL research activities such as chemical processes, reactor operations and routine experimental laboratory operations. The major quantity of gaseous wastes from these operations are collected in the ductwork at the source generating facilities filtered and discharged to the atmosphere from one of six stacks. Waste gas streams emanate principally from cell ventilation (which represents approximately 99 percent of the volume but very little activity) and off-gas process systems (which contain most of the activity but very little volume).

The waste gas generator is primarily responsible for first-order cleanup of the gas stream prior to discharge into the gaseous waste vent systems. Numerous laboratory operations which generate small quantities of radioactive gases are not connected to one of the vent stacks but discharge their waste gases directly after local cleanup. A variety of cleanup equipment (i.e., roughing, absolute, HEPA, and charcoal filters) are employed both at the stacks and in local work areas for treating gas streams prior to release to the atmosphere.

The principal ORNL release point is the 3039 Stack through which most of the measured gaseous activity generated at the Laboratory is discharged to the atmosphere. Negative pressure for the 3039 Stack main cell ventilation system is produced by electrically-driven fans capable of moving approximately 5520 m^3/min (steam-driven auxiliary fans - 2690 m^3/min). High efficiency particulate filters are provided to remove contaminants prior to release from the 76 m Stack. The main off-gas system, also connected to 3039 Stack, is served by a 113 m^3/min electric blower (standby steam blower - 113 m^3/min). Since the off-gas system must dispose of organic vapors and acid/caustic fumes in addition to radioactivity, a caustic scrubber is provided. The gaseous waste system was installed 20 to 30 years ago and has undergone periodic modifications since then. It is presently in need of repair and upgrading to the current state of the art. These conditions have been recognized and a capital improvement project at cost of approximately $13M is currently underway to replace and upgrade the 3039 Stack area off-gas and cell ventilation system.

EFFLUENT RADIATION MONITORING CONTROL

The system consists of instrument sensing detectors located at many operating and effluent monitoring locations with readout in the central Waste Operations Control Center (WOCC). The WOCC provides the quality control and safety serveillance to monitor and record the operating characteristics of the liquid and gaseous radwaste system at ORNL on a continuous basis.

The type of data monitored at the WOCC include the following:

- wind direction, velocity, temperature;
- stack and duct gaseous effluent flow rate;
- local air monitor radioactivity;
- stack and duct gaseous effluent radioactivity;

- stack and duct radiation monitor alarm modules;
- cell blower status;
- pH, oxygen, temperature of liquid waste streams;
- process waste flow rate;
- process waste water radioactivity;
- OR-ILW tank levels;
- evaporator foam level alarms.

A new WOCC is currently under construction as a part of a capital improvement project at a cost of approximately $2M that will replace the existing building and system with new building and a modern data acquisition system.

SUMMARY AND CONCLUSION

Since its beginning in 1943, ORNL has generated large amounts of solid, liquid, and gaseous radioactive waste material as a by-product of the basic research and development work carried out at the laboratory.

The waste system at ORNL has been periodically modified and updated to keep pace with the changing release requirements for radioactive wastes. Major upgrading projects are currently in progress. The operating record of ORNL waste operation has been excellent over many years. Recent surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 4 percent of the permissible concentration and intake guides for individuals in the offsite environment.[6] While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.[8]

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