INNOVATIVE APPROACH TO LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT OF LARGE COMPONENTS FROM NUCLEAR D&D PROJECTS

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ABSTRACT

For over a decade, Envirocare of Utah, Inc. (Envirocare) has been disposing of radioactive waste in above-ground engineered disposal embankments constructed in successive 12-inch lifts. Disposal of radioactive waste utilizing a “cut and cover” process assures long-term stability within the disposal embankments and minimizes the potential for settlement. In recent years, Envirocare has developed an alternative disposal method utilizing Controlled Low-Strength Material (CLSM) for larger debris that exceeds the size requirements for waste placement within the 12-inch lifts. This disposal technology accomplishes the same design objectives by providing long-term stability and minimizing potential settlement.

The Utah Division of Radiation Control has approved an amendment to Envirocare’s Radioactive Material License to dispose of larger debris using the CLSM technology. With this approval, Envirocare has received and disposed of several large components from nuclear D&D projects during 2000 including reactor coolant pumps and motors, turbine rotors, turbine shrouds, auxiliary boilers and other miscellaneous components. Utilization of CLSM for placement and disposal of these large components has proven to be a safe and cost-effective solution while providing long-term structural integrity of the disposal embankment.

This paper discusses the CLSM disposal technology and provides case studies involving the packaging, transportation, and disposal of large components from the Maine Yankee Atomic Power Plant and San Onofre Nuclear Generating Station Unit I decommissioning projects at the Envirocare disposal facility in Clive, Utah. The steps outlining the engineering evaluation and waste acceptance process for large components will be presented. In addition, the case studies will demonstrate the effective use of creative packaging for transportation of large components to comply with Department of Transportation regulations.

INTRODUCTION

Envirocare of Utah, Inc. (Envirocare) in partnership with Maine Yankee Atomic Power and the Southern California Edison Company has created a new paradigm for cost-effective packaging, transportation, and disposal of large components from nuclear D&D projects. The technical innovations resulting from this new approach result in greater efficiency and substantial budgetary savings for D&D projects. These changes will be discussed and illustrated in the case studies.

From 1979 to 1994, the price for disposal of low-level radioactive waste material in the United States increased dramatically on a per cubic foot basis for metal, concrete, wood, and other materials generated by nuclear power plants and other commercial facilities in the United States. In April of 1995, Envirocare was allowed by the Northwest Interstate Low Level Radioactive Waste Compact Commission to accept low-level radioactive waste from nuclear power plants at
its Clive, Utah disposal facility. However, the amount of direct disposal by nuclear power plants at Envirocare continued to be limited due to the low concentration limits in Envirocare’s Radioactive Material License.

The radionuclide concentration limits were increased by the renewal of Envirocare’s Radioactive Material License in 1998. On October 5, 2000, the Utah Division of Radiation Control granted Envirocare a license amendment to dispose low-level radioactive material up to the full Class A limits specified in 10 CFR Part 61. As a result, Envirocare has constructed a new disposal embankment in order to receive higher activity waste.

In addition to the radionuclide license changes, other conditions in the license have been expanded to provide greater flexibility in the size of debris that can be received and disposed of at Envirocare. For over a decade, Envirocare has been disposing of radioactive waste in above-ground engineered disposal embankments constructed in successive 12 inch lifts. Disposal of radioactive waste utilizing a “cut and cover” process assures long-term stability within the disposal embankments and minimizes the potential for settlement. In recent years, Envirocare has developed an alternative disposal method utilizing Controlled Low-Strength Material (CLSM) for larger debris that exceeds the size requirements for waste placement within the 12 inch lifts. This disposal technology accomplishes the same design objectives by providing long-term stability and minimizing potential settlement.

These license changes have given low-level radioactive waste generators a new option for the direct disposal of larger debris including large components. This option, which includes the ability to access its facility by rail, has also lowered the cost of large component disposal. This is evidenced by the number of low-level radioactive waste generators who have decided to take advantage of this opportunity by disposing of their large components at Envirocare.

BACKGROUND

Founded in 1988, Envirocare is a proven, mature organization that has assumed and maintained a leadership position as operator of the nation's largest fully regulated commercial radioactive waste disposal and mixed waste treatment and disposal facility. The company is regulated by 13 federal, state and local agencies and maintains closely regulated closure funds to ensure proper closure and monitoring. Since inception, Envirocare has received and disposed of radioactive waste from over 600 different generators. Each month Envirocare routinely receives waste from 40 different generators who last year delivered nearly 15 million cubic feet of waste for treatment and disposal.

Envirocare customers represent large and small remediation projects from commercial entities that encompass electricity production, nuclear fuel processing, chemical manufacturing, telecommunications, agricultural and biomedical research organizations. In addition to its commercial customer base, Envirocare services a wide variety of government agencies that ship on a continual basis. The federal government, i.e., the Environmental Protection Agency (EPA), Department of Defense (DOD), and the Department of Energy (DOE) are the largest single customers of Envirocare of Utah. Some of those projects include Fernald, Oak Ridge, Rocky Flats, INEEL, US EPA, FUSRAP, and many others.
A significant aspect of Envirocare's business activity is devoted to nuclear power station decommissioning projects. Connecticut Yankee, Commonwealth Edison, Yankee Atomic Electric Company, Maine Yankee, Sacramento Municipal Utilities District, and Southern California Edison have shipped hundreds of thousands of cubic feet of decommissioning waste directly to Envirocare's disposal facility. Recent modifications to federal laws and Envirocare's Radioactive Material License enabling the acceptance of PCB-contaminated materials, bulk commodity metals, and large components, has allowed Envirocare to expand its capabilities. A significant change in Envirocare’s operation during the past year is the development of a capability and procedures to manage and dispose of large components from nuclear power plant decommissioning and other similar projects.

Envirocare began managing and disposing large components on December 23, 1999. On that date Envirocare successfully unloaded, transported and disposed of three reactor coolant pump motors (RCPMs) and associated assemblies shipped from the Maine Yankee Atomic Power Plant decommissioning project in Wiscasset, Maine. Stone and Webster Engineering Company managed the project for Maine Yankee. The RCPMs were transported by rail from the Wiscasset, Maine site to the Envirocare disposal facility in Clive, Utah. Each of the RCPMs weighed about 70,000 lbs. and had dimensions of approximately 14 feet tall and between 11 and 15 feet in diameter. Figure 1 shows one of the RCPMs being lifted from the transport vehicle for placement into the disposal embankment. Each RCPM was shrink-wrapped with plastic to comply with Department of Transportation (DOT) “strong, tight” packaging requirements.

In the past year, Envirocare of Utah has successfully bid and received large components from several other projects. The components include turbine shrouds, turbine shafts, reactor coolant pumps and other pieces of equipment. Large components from the San Onofre Nuclear Generating Station Unit I decommissioning project have been shipped to Envirocare by rail using gondola railcars and flatcars. Similar to the RCPMs previously discussed, shrink-wrap and tarps are used for DOT packaging purposes. These components are off-loaded onto a transport vehicle within the restricted area and then transported to the disposal embankment for placement. Figure 2 illustrates one of the components being placed in the CLSM disposal embankment. During 2001, Envirocare will receive other large components including 2 reactor pressure vessel heads and a 250,000-pound pressurizer.

Envirocare’s entry into the large component disposal business was preceded by major changes in its Radioactive Material License, construction engineering placement plans, procedures and quality assurance plan. The most important physical change was Envirocare’s development and use of a new technology for disposal of radioactive material. These changes to the operational and licensing activities at Envirocare were a direct result meeting the needs of the nuclear industry for more economic and practical alternatives for managing large components from D&D projects.
Fig. 1. Offloading and placement of a reactor coolant pump motor into the disposal embankment.
DISPOSAL METHODOLOGY

Envirocare uses two procedures for disposing of waste in above-ground engineered disposal embankments. Both disposal methods provide for long-term disposal with minimal need for active maintenance. The first method is used for debris, soil, and soil-like material that is placed in the disposal cell in 12 inch lifts. After placement, the lift is compacted to 90 percent of its optimum density based on the results of standard proctor tests (ASTM D-698) in a continuous cut and cover process.

Each disposal lift is limited to less than 10 percent standard debris by volume that must be uniformly distributed throughout the lift. In addition, the placement of debris is prohibited in certain parts of the disposal cell. In order to comply with these license criteria, Envirocare must add either clean clay or radioactive soil to debris in a nine to one ratio. Depending upon the conditions of the disposal agreement, some generators that have both soil and debris may be able to achieve cost savings by delivering these materials such that the debris does not exceed 10 percent (on a shipment basis) of the delivered volume of soil. An exception to this 10 percent restriction is provided for solid debris items such as concrete and stone. This material may be placed up to 25 percent by volume of the total lift and uniformly distributed throughout. All debris must be placed in such a way to minimize void space in the lift.

Fig. 2. Placement of large component in the CLSM disposal embankment.
The structural integrity of the disposal embankments at the Envirocare disposal facility has generally been provided through a combination of: prohibitions on the receipt of liquid media; the placement of radioactive material in 12-inch layers or lifts; the use of a specified ratio of a mixture of indigenous soil or clay with different types of physical products, i.e. paper, plastic, wood, metal, stone, concrete etc.; and the performance of various engineering tests following disposal to ensure the compactability of the disposal embankment. However, to be able to dispose of waste in a 12-inch lift, Envirocare’s Radioactive Material License requires a 10-inch dimension in any type of material. This requirement posed a serious hindrance to the disposal of larger debris. To comply with this requirement it was often necessary for the generator to size the debris to less than ten inches in at least one dimension.

Envirocare has developed and its regulators have approved another method for meeting the structural stability required by the 10-inch criteria. This technology is called Controlled Low-Strength Material (CLSM). CLSM is a grout material that has been tested and proven to perform according to the same criteria as the original stability requirements but without the need to size material. Using the CLSM technology, Envirocare is able to safely dispose large components and maintain the structural integrity of the disposal embankments.

The Utah Division of Radiation Control (DRC) has approved an amendment to Envirocare’s Radioactive Material License to dispose of “oversized debris” using the CLSM technology. Debris that does not have a dimension less than 10 inches or any dimension is greater than 12 feet is defined as “oversized debris”. With this approval, Envirocare has received and disposed of several large components from nuclear D&D projects during 2000 including reactor coolant pumps and motors, turbine rotors, turbine shrouds, auxiliary boilers and other miscellaneous components. Utilization of CLSM for placement and disposal of these large components has proven to be a safe and cost-effective solution while providing long-term structural integrity of the disposal embankment.

In accordance with the approved Construction QA/QC manual referenced in the Radioactive Material License, oversized debris can be accepted as either filled containers or as other oversized debris. Filled containers consist of:

- B-25 boxes (96 cubic feet capacity)
- B-12 boxes (48 cubic feet capacity)
- Standard drums of at least 50 gallon capacity
- Over-pack drums
- Intermodal/Sealand containers (up to 1,250 ft³ capacity)
- Twenty-five percent debris monoliths
- Ten percent debris monoliths
- Soil monoliths
- Other monolithic forms similar in size and shape to those listed above

Oversized debris that exceeds the dimensions of these containers must be approved by the DRC on a case-by-case basis. In such cases, Envirocare is required to prepare an Engineering Plan for placement of the specific large component to ensure structural stability of the disposal
embankment. This plan is prepared by Envirocare’s Engineering Division and is submitted to the DRC for review and approval.

The primary design considerations that must be met for placement of large components in the disposal embankments include placing the waste materials in such a manner to ensure long-term differential settlements are less than one percent below the embankment cover materials. Acceptable embankment cover behavior is expected for settlements within this one percent criteria. The additional weight of unique large incompressible debris on embankment settlements is therefore the principle design consideration.

Each large component is evaluated to determine the bearing capacity of the item on the embankment and the required thickness of structural fill below the component to support the bearing pressure. A maximum bearing pressure of 3,000 psf is used in the calculations to ensure that differential settlement will not exceed the one percent criteria. This “bearing pressure” is often used in design and construction of building foundations supported on compacted structural fill. The following example illustrates the bearing pressure calculations used in the Engineering Plan to ensure the bearing pressure is less than the allowable 3,000 psf.

Example:

Weight of Large Component = 210,000 lbs  
Volume of Component = 1,926 ft$^3$  
Weight of CLSM (Fill all voids) = 148,850 lbs  
Area of Influence (Component surface area on embankment) = 396 ft$^2$  
Total Load Weight = 358,850 lbs = 210,000 lbs + 148,850 lbs  

Bearing Pressure = $\frac{358,850 \text{ lbs}}{396 \text{ ft}^2} = 906 \text{ psf}$

Thus, the bearing pressure for this large component is a factor of 3.3 less than the allowable bearing capacity of 3,000 psf. The thickness of the structural fill can also be increased to further support and distribute the load of heavier large components.

**CONTROLLED LOW-STRENGTH MATERIAL (CLSM)**

Oversized debris, which includes large components, is disposed of using CLSM. CLSM is a cement mixture that is composed of water, cement, fly ash, and aggregate. CLSM is also commonly referred to as flowable fill, flowable mortar, or lean-mix backfill. The CLSM has a wet unit weight of at least 100 lbs/ft$^3$. CLSM differs from cements in the following ways: 1) quantity of cement in CLSM is much less than in concrete mixtures (typically 50 to 200 pounds per cubic yard versus 500 plus pounds per cubic yard); 2) the aggregate is finer (sand to pea gravel size); 3) the slump is much higher in CLSM mixtures than in cement mixtures (typically over 8 inches versus less than 6 inches); and, 4) lower compressive strength (1,200 psi or less versus over 3,000 psi).

Disposal of oversized debris using the CLSM technology begins with the forming of the CLSM boundary using standard concrete forming technology that will hold all of the containers and
large components. Figure 3 illustrates the placement of the containers and debris prior to pouring the area with CLSM.

Fig. 3. Placement of debris and containers prior to CLSM disposal

Containers of oversized debris and associated materials (e.g., container lids, pieces of debris that may fall off, etc.) must be placed in such a way that the void between the oversized debris and the form can be adequately filled with CLSM. All container lids must be removed or punctured to allow the CLSM to fill any void space within the container. CLSM is then poured in and allowed to fill the form as illustrated in Figure 4. When cured, the CLSM forms a single monolith without voids that prevents differential settlement within the cell.

The CLSM disposal area is constructed in a pyramidal shape to further reduce the potential for settlement within the disposal embankment. The design criteria for the CLSM disposal areas is identified in the Construction QA/QC manual and is summarized as follows: 1) stacked oversized CLSM lifts must form a pyramid with a maximum outside edge slope ratio of 3H:1V (thus, with a four foot box and six inch cap, the next stacked oversized CLSM lift must be constructed to minimum of 13.5 feet inside the edge of the lower lift); 2) the pyramid base dimensions and maximum 3H:1V side slope requirements will control the location of all subsequent stacked oversized CLSM lifts throughout the full height of the embankment; and 3) adjacent pyramids must not encroach the vertical limits of previous pyramids.
Fig. 4. CLSM being poured into formed disposal area

Large debris will be placed to minimize the entrapment of air in the CLSM pour. Large debris is spread horizontally across the lift and compactable debris is limited to less than or equal to 10 percent by volume. All compactable debris must be attached to non-compactable debris or secured within the large debris pour. Large non-compactable debris with enclosed internal voids may remain in the pour provided any single entrapment void is less than or equal to four cubic feet and encased in non-compactable material.

CONCLUSION

As presented in the paper, Envirocare has developed a proven, cost-effective disposal technology using CLSM to achieve long-term stability requirements and to minimize potential settlement within the disposal embankment. The bearing pressure of each component is evaluated based on the weight and area of influence on the structural fill for stability determinations. This evaluation is presented in an Engineering Plan which is submitted to the DRC for review and approval prior to Envirocare authorizing shipment of the waste. Two case studies were presented that demonstrate the methods used to package, transport, and dispose of large components that require CLSM disposal.

One of the major technical challenges facing decommissioning projects is the safe and cost-effective removal, transportation, and disposal of large, heavy pieces of equipment used in the nuclear industry. Envirocare has provided a viable option to support these D&D projects. With access to rail transportation, the costs and risks of transporting large components for final disposition via rail are significantly reduced compared to alternative options. The travel time for rail transportation from generator’s facilities to Envirocare is generally less than three weeks. The required time to off-load and place each component is accomplished in one or two days depending mainly on weather conditions.