MACRO – THE SAGA CONTINUES

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ABSTRACT

Sandia National Laboratories/New Mexico (SNL/NM) has mixed low-level waste (MLLW) with upcoming deadlines under a Compliance Order with the State of New Mexico and the waste doesn't meet the waste acceptance criteria at commercial treatment facilities. Because of the radiological content, the waste was more suited for alternate debris treatment such as macroencapsulation (MACRO) instead of traditional shredding and stabilization. In 2001 SNL/NM personnel visited the Ashtabula Environmental Management Project (AEMP) and observed their macroencapsulation process. In August 2002 the MACRO system was transferred from AEMP to SNL, and SNL/NM contracted with AEMP for technical assistance in deploying the technology.

The mixed waste debris treated by AEMP was bulk debris that had passed through a drying process. At SNL/NM, on-site treatment was needed for bagged waste, including waste that has been excavated from a landfill. Although soil has been brushed away from the debris items in the waste, there is residual moisture in the waste. In addition, work at SNL/NM is performed in a building without temperature controls and waste forms are exposed to the daily temperature swings typical in a desert environment. SNL/NM experienced problems with some waste forms cracking soon after being removed from the mold and with other "perfect" waste forms developing cracks weeks or months after creation.

This paper describes SNL/NM's efforts to develop an on-site MACRO process to provide crack-free waste forms and to optimize the process to meet SNL/NM waste management needs. SNL/NM modified the process by adding heat blankets to the exterior of the molds to control cooling and used additional reinforcement (hardware cloth from the local home improvement store) to relieve internal stresses in the waste form. This paper also describes SNL/NM's investigation into methods to repair cracked waste forms.

INTRODUCTION

The Environmental Protection Agency (EPA) has identified polymer macroencapsulation as the Best Demonstrated Available Technology for radioactive lead solids and mixed waste debris, defined as materials exceeding 60 mm in particle size. Under current regulations, macroencapsulated debris does not require performance testing such as EPA's Toxicity Characteristic Leaching Procedure (TCLP). Low Density Polyethylene (LDPE), an inert, low permeability, thermoplastic material that is highly resistant to chemical attack, microbial degradation and radiation damage. These properties combine to provide an extremely durable and stable final waste form for the disposal of DOE mixed waste streams.

Brookhaven National Laboratory first developed a LDPE encapsulation process for low-level radioactive, hazardous, and mixed wastes. Commercial application of polyethylene macroencapsulation was initiated by Envirocare of Utah (and permitted by the State of Utah) by the mid 1990s.

At the same time, SNL/NM had remote-handled mixed waste reactor components that required macroencapsulation and developed a successful process using radiation-resistant epoxies developed by nuclear weapons research at SNL/NM. The epoxy process was very effective, but was labor intensive, required excessive timing and coordination, and had health and safety issues associated with the products used.

As additional mixed waste items that were not acceptable for commercial macroencapsulation accumulated in the SNL/NM mixed waste inventory, it was necessary for SNL/NM personnel to explore other options. SNL/NM visited AEMP to observe their process and after AEMP had completed their mixed waste treatment activities, the equipment was transferred to SNL/NM.[1]

SNL/NM WASTE INVENTORY AND CHARACTERISTICS

The primary need for development of on-site MACRO at SNL/NM (rather than relying on commercial off-site treatment) was Treatability Group 24, Spark Gap Tubes. Spark Gap tubes are electronic switch tubes found in obsolete (waste) components. Certain spark gap tubes are mixed waste because they contain Ni-63, Kr-85, or Cs-137 and lead solder. Spark Gap Tubes are considered a source, plus many types have radiological content in excess of commercial radiological licenses. Therefore alternatives were needed. Other SNL/NM mixed waste streams that are candidates for on-site macroencapsulation such as controllatrons and sources.

PROCESS DESCRIPTION

The SNL/NM polyethylene macroencapsulation process utilizes a commercial single-screw plastics extruder to melt, convey and pump molten LDPE through a die and into a waste form mold. The extruder consists of an auger-type screw enclosed in a barrel to which polyethylene beads (melt index 9-10) are fed from a storage hopper resting above the feed throat. The polyethylene is gradually heated and melted as it is conveyed by the screw through independently controlled temperature zones. The heat for melting the polyethylene is provided through electric heaters and by frictional heat that is generated by a gradual decrease in the screw channel depth between flights along the screw. Temperatures are set to achieve a uniform molten output flow. The LDPE is heated well above the melting temperature so that the material will continue to flow long after it comes in contact with the waste being treated.

The molten polyethylene from the extruder die drops into a three-piece mold in which waste materials are contained in a 0.12 cubic meter wire mesh basket suspended above the bottom of the mold. A spin turntable is used to control the flow into the mold. Insulating jackets are used to control the cooling rate. The molds are also equipped with electric heaters that warm the mold prior to addition of molten LDPE and also control the cooling rate of the filled mold. The waste form is allowed to cool at the rate of 1.5°C/hour over a period of three days.

SNL/NM mixed waste inventory consists of waste that has been double bagged and secured with duct tape. Some air is trapped in the waste bags and rises to the surface as the bags melt after coming in contact with molten LDPE. The waste basket has a lid wired on prior to treatment to prevent "floating" of waste bags with trapped air.

A piece of hardware cloth is formed into a cylinder and placed outside the inner basket, but at an appropriate distance from the inner wall of the mold. This helps reduce stresses inside the cooling mold and has eliminated cracking of molds.

"Caps" are added to both the top and bottom of the waste form, after the original cooling period. The top cap is used to ensure that there is an appropriate thickness of LDPE on the top of the waste form, as volume is lost due to trapped air escaping from bags and from the normal shrinkage of LDPE as it cools. The bottom cap fills the voids left by the spacing devices that hold the waste basket at the appropriate distance above the bottom of the mold. The waste form is warmed with either a propane torch or an electric heat gun to get adhesion between the initial and subsequent LDPE pours.

Based on a hazards analysis [2],[3], no ventilation is required while macroencapsulating the waste. However, Continuous Air Monitors (CAMs) are used to monitor the air in the work area. PPE worn by workers includes fabric lab coats or coveralls, leather gloves and sleeves, safety goggles, and hearing protection.

Repairs to surface anomalies (i.e. cracks, indents, standoffs) are made with a propane torch or electric heat gun. The final waste forms are containerized in a standard 0.2 cubic meter metal drum to facilitate waste movements and storage.

SNL/NM received two molds from AEMP and originally planned to create four waste forms per week, pouring molds on Mondays and Thursdays. However, one form warped and is no longer useable. In the future SNL/NM plans to use molds similar to the molds used for caps, constructed from bands of spring steel.

TECHNOLOGY OPTIMIZATION AT SNL/NM

SNL/NM used the basic process developed at AEMP, but initiated the following process improvements that were amenable to typical SNL waste, and environmental and geographic conditions:

- Constructed 15cm wide spring steel forms to use as temporary molds while capping either the top or the bottom of the waste form. (Fig. 1)

- Added a false bottom to the inner waste basket to allow LDPE to flow completely below the waste and to provide a margin of safety when capping the bottom of the waste form.

- Placed a top constructed of wire to the inner waste basket, to keep bags of waste with trapped air from floating. (Fig. 2)

- The final process improvement was to add heating blankets to the molds to control the exact rate of cooling. (Fig. 3)

SNL/NM investigated whether waste forms that had developed deep cracks could be repaired by using the heat blankets to remelt the polyethylene. This appeared to repair some of the cracking, although additional spot heating and spot "welding" was required to repair all cracks and fill all voids. However, the blankets provided uneven heating; the blankets failed to melt the plastic at the bottom of the form and charred the plastic at the top of the form. Future repair efforts at SNL/NM will consist of removing excess LDPE from the outside of a badly cracked waste form and the placing the waste in a slightly larger mold and repeating the macroencapsulation process.

REGULATORY ISSUES

On-site treatment is performed under RCRA Part B interim status. Macroencapsulation satisfies the requirement of the Compliance Order with the State of New Mexico to treat mixed waste at SNL/NM. At this time, however, no disposal pathway exists for the waste subject to on-site macroencapsulation at SNL/NM. Each waste form is inspected for integrity by an independent waste certification official, placed in a drum, and is placed in storage. Storage will continue until the waste can be shipped off-site when a disposal option becomes available. SNL/NM will repeat the inspection of the waste (either visual or by radiography) just prior to off-site shipment.

COST AT SNL/NM

Actual costs for on-site macroencapsulation are estimated at $1200 / waste form, including $500 for LDPE and baskets, $100 for other supplies, and $600 for labor. Utility costs are not included in this estimate. Because there was no commercial option and there are compliance deadlines to meet, on-site macroencapsulation is considered priceless.

CONCLUSIONS

LDPE macroencapsulation of mixed waste debris is a simple and safe process that SNL/NM has implemented successfully to meet upcoming Compliance Order deadlines. However, some time and effort were required to develop a process that consistently provided flawless waste forms. The process used at SNL/NM is still relatively labor intensive and SNL/NM continues to pursue other options, such as the macro boxes and macro tubes currently under commercial development.

REFERENCES

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