

ASHTABULA SUCCESSES...MACRO NOW OR FOREVER HOLD YOUR PIECES!

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ABSTRACT

As facility demolition and remediation continued at the DOE Ashtabula Environmental Management Project (AEMP), a DOE closure site located in Ashtabula, OH, the quantity of mixed waste increased by approximately twenty-fold from the original Site Treatment Plan estimates to over 567 m³ (20,000 cubic feet). Also, a greater variety of low-level mixed waste (MW) was identified that was suitable for alternate debris treatment like macroencapsulation (MACRO) instead of traditional shredding, stabilization, and solidification to improve the overall safety and cost-effectiveness. Macroencapsulation is required for lead and authorized for hazardous debris under the alternate debris treatment standards per 40 CFR 268.45.

Several polymer encapsulation processes were being explored, developed, and deployed in the mid-1990's by various groups including the DOE Mixed Waste Focus Area, DOE EM-50 Office of Science and Technology, Brookhaven National Laboratory, DOE Macro Working Group, DOE-Albuquerque Mixed Waste/Mobile Treatment Unit, and Envirocare of Utah, Inc. As a result, technically-proven macroencapsulation and microencapsulation processes using extruded polyethylene beads were verified as being technically acceptable for waste treatment to RCRA standards. The AEMP had a variety of waste forms where technically-proven systems were needed to perform on-site treatment of challenging mixed wastes (MW) from production operations (i.e. HEPA filters, barium salt contaminated steel) containing high concentrations of enriched uranium, graphite, salts, and RCRA metals.

The AEMP continued with a technology development and deployment process to license, permit, install, and safely operate two proven polymer encapsulation systems for both RCRA microencapsulation and RCRA macroencapsulation using surplus DOE equipment from Rocky Flats to establish cost-effective mobile treatment capability. The AEMP treated approximately 16 m³ (= 579 cf) of challenging mixed wastes onsite at approximately 50 wt% waste loading using polymer microencapsulation and macroencapsulation systems to isolate the hazards from the general public. These wastes were then profiled and buried in fifty-seven (57) containers containing approximately 33 m³ (1,194 cf) of LDR-compliant wastes at NTS and Envirocare of Utah, Inc. However, this paper summarizes only the MACRO technology approval, waste inspection/treatment/certification process, and technology transfer as deployed at AEMP and Sandia National Laboratories (SNL). It describes only the sequences associated with optimizing the process for the polymer MACRO system to meet overall DOE waste management needs. AEMP performed MACRO on 4 m³ (139 cf) of RCRA debris before the system was shut down. The shut down occurred due to new project direction, funding availability, and alternate offsite treatment capabilities at TSCAI and/or commercial facilities for the balance of the mixed wastes.

INTRODUCTION

The AEMP is a privately-owned and permitted facility containing many DOE buildings and equipment assets that heated, shaped, and extruded enriched and depleted uranium metal for the DOE and DOD to support the nuclear weapons program for over 30 years starting in the late 1950's. By 1990, DOE declared the buildings and equipment surplus to their needs and commenced the cleanup of the private site to a "free-released" condition based on decommissioning plan developed commensurate with Nuclear regulatory Commission closure standards. As such, DOE took ownership of all legacy wastes as well as those wastes that would be generated during facility, equipment, soil, and groundwater remediation and demolition.

In 1995 the AEMP showed only 25.5 m³ (=900 cubic feet) of mixed waste in the Federal Facilities Compliance Act Site Treatment Plan (FFCA STP). However, while legacy waste sorting/sampling, building/equipment demolition, and baseline development proceeded additional waste was located. By 1997, the baseline inventory projection had grown to about 567 m³ (20,000 cubic feet) of waste; and at least 57 m³ (2,000 cubic feet) of the newly-generated waste contained blended radioactive, hazardous, and salt contaminants that precluded offsite treatment at the very few facilities available. In short, the AEMP was storing waste that was essentially "stranded" at a site slated for closure by 2006.

To fill this treatment gap, the prime contractor RMI Environmental Services, commenced a technology development and deployment project in 1998 to identify, permit, and mobilize the appropriate waste treatment systems to meet regulatory milestones.

AEMP WASTE INVENTORY AND CHARACTERISTICS

The key restriction for processing AEMP wastes at proposed commercial offsite treatment facilities was the large amount of commingled and/or non-homogenized enriched uranium and graphite. Selected features of the challenging wastes are outlined in Table I below:

Table I. Partial List of Containerized Waste Forms: Description, Characterization, and Treatment Summary

Waste Form	Waste Volume (cf)	Max U-Enrich (wt%)	Range [U-235] (pCi/g)	Range Graphite (wt%)	RCRA Metals (type)	Barium Salt (yes/no)	RCRA Treatment
Salt Debris	150 cf (4 ea. B12)	1.25 wt%	12 - 234	1 – 50	Pb, Ba, Cd, Cr	Yes	MACRO
HEPA Filters	1,400 cf (2 ea. rolloff)	1.25 wt%	12 - 234	1 – 20	Pb, Ba, Cd, Cr	No	MACRO
D&D Debris	768 cf (8 ea. B25)	1.25 wt%	12 - 234	5 - 20	Pb, Ba, Cd, Cr	No	MACRO
Lube Buckets	44 cf (1 ea. B12)	1.25 wt%	12 - 234	5 – 20	Pb, Ba, Cd, Cr	No	MACRO
Die Head Residue	7,800 cf (100 dm)	1.25 wt%	12 - 234	50 – 100	Pb, Ba, Cd, Cr	Yes	Micro
Salt Sludge	78 cf (10 dm)	1.25 wt%	12 - 234	50 – 100	Pb, Ba, Cd, Cr	Yes	Micro
Lead Batteries	15 cf (2 dm)	1.25 wt%	12 - 234	1 - 5	Pb	No	Macro
TOTAL	=10,255 cf (293 m3)						

The total amount of fissile U-235 in the individual containers or waste streams was high and sometimes above the 350 gm U-235 license limit at typical commercial treatment facilities. In addition, the total weight of graphite (as a neutron moderator) could exceed one percent on a container basis. Together these posed additional administrative processing and handling restrictions for treatment or disposal facilities. These limitations would have increased sampling and processing costs to both the generator and processor. Therefore, alternatives were needed.

TECHNOLOGY OPTIONS AND SELECTION

RMI Environmental Services commenced a technology and literature search to identify existing DOE mobile treatment systems that might be available for immediate use and deployment at the AEMP site. Two-phase epoxies, polyethylene/polybutadine, and spin-welding all existed in literature and reality with various advantages and disadvantages. However, final review of DOE EM-50 program identified surplus polymer encapsulation equipment, expertise, and applicable cost and performance data at Rocky Flats where the technology program had recently been stopped in 1997.

The equipment throughput could process about two drums of waste per shift, was readily mobile, and matched the technology recently approved by Utah regulators for Envirocare so the chances of parallel success with this technology were rated as quite high. Furthermore, discussions with Envirocare identified a probable path forward by which off-site sampling and analysis requirements could be managed and performed at AEMP without destroying the MACRO forms. Finally, certain waste forms could be more safely, compliantly, and cost-effectively managed by microencapsulation (i.e. salts, graphite) and burial at NTS as LDR-compliant LLW and are excluded from the balance of this paper which focuses exclusively on the MACRO process.

The MACRO process meets the RCRA requirements for encapsulating lead or hazardous debris as per RCRA definitions. A commercial single-screw polyethylene extruder was used to melt and extrude Low Density Polyethylene (LDPE) with a Melt Index (MI) of 8 – 50 at up to 350degF into a mold and around a basket containing compacted hazardous waste. The Melt Index is an indicator of viscosity/flowability; for example, high MI's are more flowable and more brittle.

Treatability tests verified that molds with MI = 50 cracked too easily; whereas the optimum was melt index of 8 – 12. Basic LLW was used as ballast, as needed, to meet minimum density requirements at the TSD. A spin turntable, split-shell mold, and insulation were used to control the flow and cooling rate to obtain final waste forms that were well-encapsulated and resistant to cracks and failure. Repairs to surface anomalies (i.e. cracks, indents, and standoffs) were made with a heat gun and LDPE. The final waste forms were containerized to meet hazardous and radioactive shipping requirements. A schematic of the MACRO system is shown below (Figure 1):

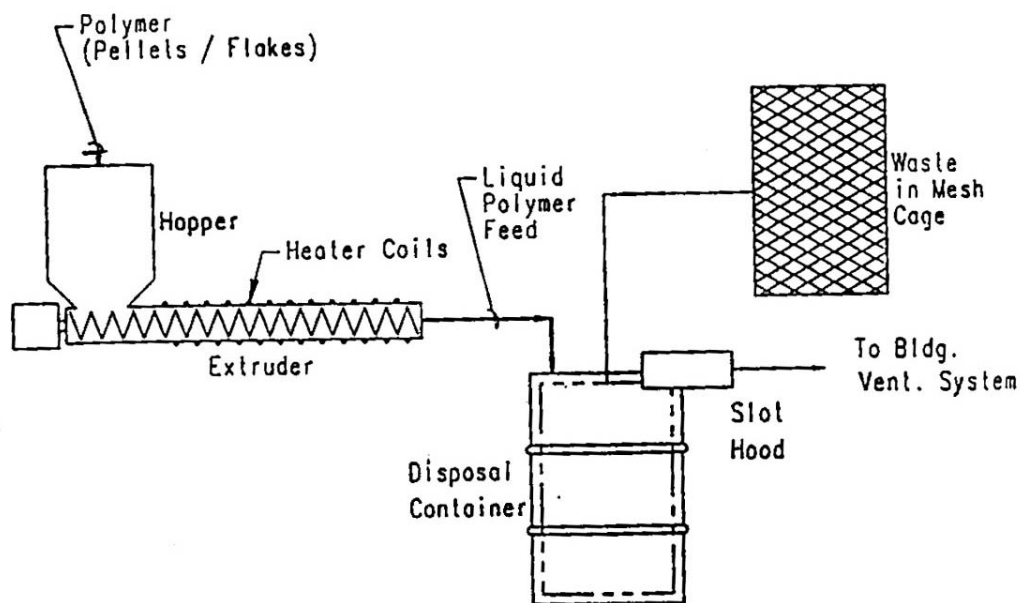


Figure 1. MACRO Extruder, Mold, and Turntable Layout

REGULATORY APPROVAL

The AEMP facility initiated talks with Ohio EPA to start RCRA permit modification to allow on-site encapsulation treatment and to add newly identified waste forms to the various permits and FFCA STP reporting documents. System design, operations and maintenance procedures, facility design, and emergency response procedures were submitted and discussed with regulators and stakeholders public meetings. It took approximately two years to complete the RCRA permit and air permit revisions and to upgrade the facility and process modifications to allow encapsulation treatment of waste.

The process approval by Utah Department of Environmental Quality (DEQ) and the Envirocare disposal facility in Utah was structured and controlled. RMI visited Utah DEQ to perform preliminary review of existing Utah-approved permits and procedures as used at Envirocare. These were reviewed and used as templates for AEMP

procedures to assure uniformity, familiarity, and expedited approval sequences. In addition, procedures and plans were submitted for Envirocare approval along with the waste profile for macroencapsulated forms.

FIELD TREATMENT AT AEMP

Polymer macroencapsulation of hazardous debris is a simple and safe process that isolates the public from the hazard by coating the debris and contaminant with an impermeable, long-lasting barrier to reduce leachability of contaminants.

Since RCRA chemicals were not chemically stabilized, the resulting waste forms are still considered hazardous waste requiring burial in a RCRA Subtitle C disposal cell. In fact, based on a hazards analysis, no ventilation was required while macroencapsulating the waste. but local air monitors were set up, as needed, for added safety awareness and response.

Outlined below are several process steps to treat waste with MACRO at AEMP. The initial form is a box of demolition debris, pads, gloves, and barium salt bath hangers. The final form is a white, clean, strong, tight monolith suitable for shipment and burial. As an additional barrier and handling feature, the finished molds were placed into metal containers for shipping as RCRA waste. The steps in sequence are:

- Step 1: Sort and sample Hazardous Debris (nominally >2" diameter)
- Step 2: Load Inner Basket (30-gallon) and Dry To Prevent Off-Gases During LDPE Coating
- Step 3: Stage Mold and Basket Assembly For MACRO
- Step 4: Coat Waste and Fill Mold with LDPE
- Step 5: Cool Mold then Top-off Axial Shrinkage with LDPE
- Step 6: Cool and Remove Final MACRO Form From Split-Shell Mold
- Step 7: Inspect and Repair MACRO Form

The collage picture below (Figure 2) pictorially overviews these key process elements to sample, size, load, compact, dry, pour, cool, and repair MACRO waste forms at AEMP:

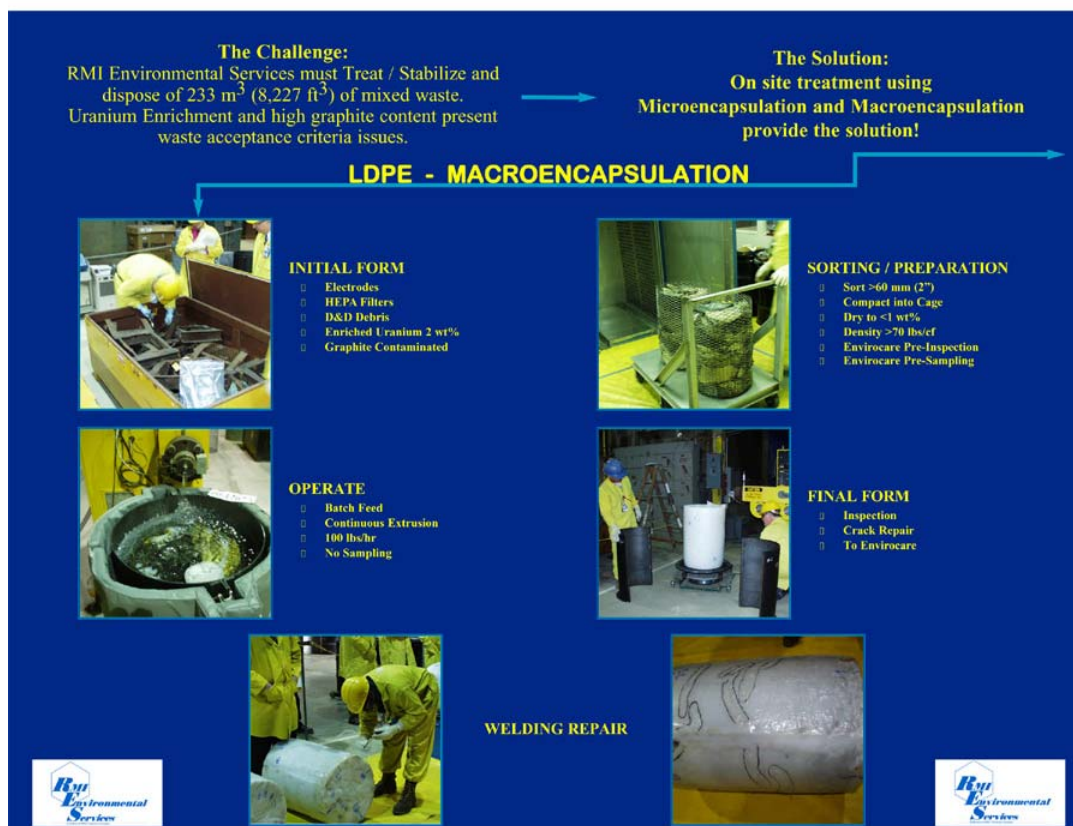


Figure 2: LDPE Macroencapsulation at AEMP

Many of the containers holding legacy waste had not been opened for 5 – 15 years. The most hazardous part of the MACRO process was performed inside an HEPA-ventilated high-flow waste processing booth. It involved opening, sorting, segregating, sizing, loading, compacting, and drying waste to fit into the 30-gallon baskets. These baskets fit within a 55-gallon drum size MACRO mold to provide a minimum 1" thick wall around the entire waste form. Although MACRO can be upscaled, the smaller size was appropriately sized to the smaller capacity of the mobile polymer extrusion unit. In addition, larger forms would have required a 2" thick wall of low-density polyethylene (LDPE). The final waste form loading was large and was required to be at least 70 wt% waste (plus ballast to meet disposal site density requirements) and nominally 55 vol% waste.

COST AND PERFORMANCE TO "TREAT-AND-BURY"

The overall cost and performance of MACRO at AEMP were acceptable and helped to accelerate schedule and achieve cost-savings. There were thirty-seven (37) MACRO waste forms treated, shipped, and buried over the 18-month period from October 2000 to April 2002. The mobile MACRO system capacity is 20 - 30 drums per month based on single shift operation; but funding limitations at AEMP restricted operation to less than 10% of this capacity. Even at these lower throughputs, cost and performance objectives were met; with ample margin for improvement as project needs dictate.

The initial budgetary scoping estimate to perform mobile MACRO "treatment-only" based on the technology development efforts at Rocky Flats in 1995 was \$4,655/m³ (= \$133/cf). In addition, mixed waste "burial-only" through the DOE-Oak Ridge contract was approximately \$2,450/m³ (= \$70/cf) which accounts for a twofold bulking factor typical of MACRO, so the total "treat-and-bury" estimate was \$7,105/m³ (\$203/cf). At the time, the available "treat-and-bury" estimate from commercial facilities for MACRO through other existing Federal contracts ranged from \$8,000/m³ (= \$230/cf) to \$21,000/m³ (= \$600/cf). The minimum difference of \$895/m³ (= \$26/cf) supported the goal that onsite MACRO could simultaneously meet project milestone and cost constraints.

The initial site-specific AEMP budgetary planning estimate for MACRO treatment was approximately \$6,195/m³ (= \$177/cf). Approximately \$504,000 was spent for permitting and infrastructure modifications to support a variety of mixed waste treatment systems. The actual accrued burdened costs for the treatability studies, startup, and operation of the MACRO process for the first thirty-seven forms was \$240,000. Ongoing MACRO operations were estimated at approximately \$7,175/m³ (= \$205/cf) based on lessons-learned during the startup campaign. Mixed waste burial through the DOE-Oak Ridge contract was approximately \$2,450/m³ (= \$70/cf) which accounts for a twofold bulking factor typical of MACRO, so the total actual ongoing "treat-and-bury" cost was \$9,625/m³ (= \$275/cf). This was consistent with historic information, project estimates, and roughly equal to the offsite option...but with more predictability and control.

TECHNOLOGY TRANSFER

A key goal of AEMP as a closure site is to reuse equipment at other DOE facilities, as applicable. To that extent, we identified several potential DOE sites (i.e. Mound, Fernald, Sandia National Laboratories (SNL), Paducah, Portsmouth, Rocky Flats) that had the potential for needing on-site mobile MACRO treatment on waste streams that were not suitable for treatment at offsite facilities.

Early in FY2002 SNL identified and confirmed a need to perform MACRO treatment on Class B/C mixed radioactive waste with higher dose readings and/or on classified materials/wastes that had security issues associated with potential offsite treatment. MACRO treatment had to be started by September 30, 2002 to meet FFCA STP compliance milestones. The MACRO system was transferred as a government property loan from AEMP to SNL where we immediately helped to mobilize, develop procedures, train operators, perform maintenance, and perform treatability studies.

The technology was mobilized at SNL in August 2002; treating waste that had been excavated from a landfill and that was not suitable for commercial treatment. SNL contracted and received technical assistance from the MACRO system experts to produce successful waste forms using surrogate waste and actual mixed waste. An example of waste mold setup and treatment at SNL is shown. (Figure 3, Figure 4).



Figure 3. MACRO Basket at Sandia



Figure 4. MACRO Pour at Sandia

With the onset of cooler weather, SNL has experienced problems with forms cooling too rapidly and cracking. Therefore, SNL is in the process of modifying the technology to include heating blankets on the forms to slow the cooling. Treatment of waste should resume in January 2003. The system is presently scheduled to finish MACRO by July 2003 and be transferred to another site or returned to AEMP for future use and disposition.

CONCLUSIONS

Mobile treatment using polymer MACRO is a valuable option to safely and cost-effectively treat challenging waste streams to meet fiscal, technical, and safety requirements of RCRA, waste generators, and disposal sites.