MIXED WASTE TREATMENT AT ENVIROCARE OF UTAH, INC.

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ABSTRACT

Treatment technologies at the Envirocare of Utah, Inc. (Envirocare) mixed waste facility are being expanded to allow the treatment and ultimate disposal of a greater variety of mixed waste streams. Technologies are highlighted that can now allow greater flexibility with debris wastes from demolition and disposal (D&D) activities at different sites. Envirocare has always had limitations on the level of resource conservation and recovery act (RCRA) organics that can be accepted in a waste shipment. Technologies are being studied that can significantly raise the ceiling of RCRA organics in a waste stream. Finally, a technology for the treatment of mercury contaminated waste streams has undergone pilot-scale testing and is know in the process of being implemented at Envirocare on a full-scale level.

INTRODUCTION

Envirocare has been a treatment, storage, and disposal (TSD) facility for mixed low level waste (MLLW) for over four years. The initial process for the treatment of MLLW was chemical stabilization for heavy metals in the Mixed Waste Treatment building. This building was designed and is operated solely for the preparation and treatment of MLLW via stabilization. Treatment involves the addition of approved chemical reagents in accordance with waste-specific formula. Formula additions of waste, reagents, and water involve the following chemical processes: Stabilization, Deactivation, Neutralization, Oxidation, Reduction, Hydration, and Precipitation. Because of the uncertainties of stabilizing matrices with measurable quantities of RCRA organics, Envirocare has imposed a maximum limit of 200-ppm total RCRA organics on incoming waste shipments. For waste preparation prior to treatment, treatment systems include size-separation and size-reduction equipment. The equipment used to accomplish this are: shredders, vibrating screens, and a grizzly (a coarse size-grading device). This process has shown to be very effective in stabilizing heavy metals in a variety of matrices, but with the above limit of RCRA organic compounds.

In 1998, two microencapsulation treatment technologies were installed and permitted at the Envirocare facilities. Polyethylene microencapsulation is a technology used on wastes to achieve concentration-based treatment standards. Microencapsulation, achieved in either an extruder or kinetic mixer, involves the combining of waste with molten low-density polyethylene (LDPE) to form a material that does not leach hazardous constituents in excess of established treatment standards. For microencapsulation using an extruder, waste and LDPE are mixed at the feed and extruded together within the equipment. For the kinetic mixer, waste is placed into the mixer with the polyethylene. These are mixed together at a high frequency with shear and frictional forces until the polyethylene melts and mixes with the waste to create a microencapsulated form.

Microencapsulation is most advantageous for dry powder or salt wastes because of the process ability to completely encapsulated fine powders with LDPE. Microencapsulation using an extruder has a maximum particle size limit of 3 mm and moisture limit of 2%. Microencapsulation using the kinetic mixer has a maximum particle size of 16 mm and a 40% moisture limit. It is estimated that up to 3 tons of waste per day may be treated using the kinetic mixer and up to 5 tons per day using the extruder. Both technologies pour the molten waste and LDPE into 208 L (55-gallon) molds. Disposal activities are conducted after the molds have cooled and been inspected.

Envirocare treats mixed waste debris and radioactive lead solids using macroencapsulation (MACRO). The MACRO process uses LDPE as a surface coating material to encapsulate the lead and debris. LDPE is an inert, low-permeability thermoplastic material that is highly resistant to chemical, radiological, or microbial degradation. The MACRO process provides a durable, final waste form for radiological lead and many types of debris that are difficult to treat by other techniques.

At Envirocare, macroencapsulation is achieved by coating waste with low-density polyethylene to substantially reduce surface exposure to potential leaching media. The waste is suspended within specially designed molds and molten LDPE is extruded around the waste to create an encapsulated waste form. Following cooling, the plastic-waste forms are removed from the molds, inspected, stored, and then disposed. The polyethylene coating has a minimum exterior-surface coating of 25.4 mm for waste forms up to 0.11 m^3 (30 gallons) and 50.8 mm for larger-volume waste forms, unless approved by the State of Utah for an alternative thickness. Molten polyethylene for macroencapsulation is produced using a 114.3mm (4.5") diameter extruder with a 24:1 L/D (length/diameter) ratio. The two extruders used by Envirocare have five heating zones that are set to temperatures up to 260 ^{0}C (500 ^{0}F). One of Envirocare's extruders is vented and therefore can be used for microencapsulation in addition to macroencapsulation. After macroencapsulation, encapsulated waste forms are inspected to determine that the technology-based treatment standards are met as outlined in the permit. Following a successful inspection, Envirocare disposes of the treated wastes.

To further increase the treatment capabilities of MLLW at Envirocare, treatability studies are being performed and new technologies are being implemented. The following is a discussion of these technologies and their application at Envirocare.

NEW TECHNOLOGIES

Arrow-Pak Containers

Another form of macroencapsulation is just starting to be employed at Envirocare; this type of macroencapsulation is the use of Arrow-Pak containers. These containers consist of a form of high-density polyethylene (HDPE) (Driscopipe®) made to specific dimensions. The containers that have been accepted at Envirocare are 6.4 m (21 feet) long and 0.762 m (30") in diameter. The wall thickness for each of the Arrow-Paks is 25.4 mm (1"). The primary advantage of this form of macroencapsulation is that individual 208 L (55-gallon) drums can be surveyed at the point of waste generation to verify that they meet the Envirocare of Utah, Inc. waste acceptance criteria (WAC). The Arrow-Pak containers are only permitted for debris waste, no lead solids. 55-gallon drums will be filled at the point of waste generation. These drums will be compacted and placed in 85-gallon overpacks. It is expected that approximately 2 to 3 compacted drums will fit into the overpack (depending on the waste stream). The Arrow-Pak is loaded at the point of waste generation with the overpacks and sealed. Sealing involves welding a HDPE end cap on the Arrow-Pak using a thermal fusion process. The Arrow-Pak is transported to Envirocare, never opened again and buried directly in the Mixed Waste disposal cell. Figure 1 shows a schematic diagram of a full Arrow-Pak container.

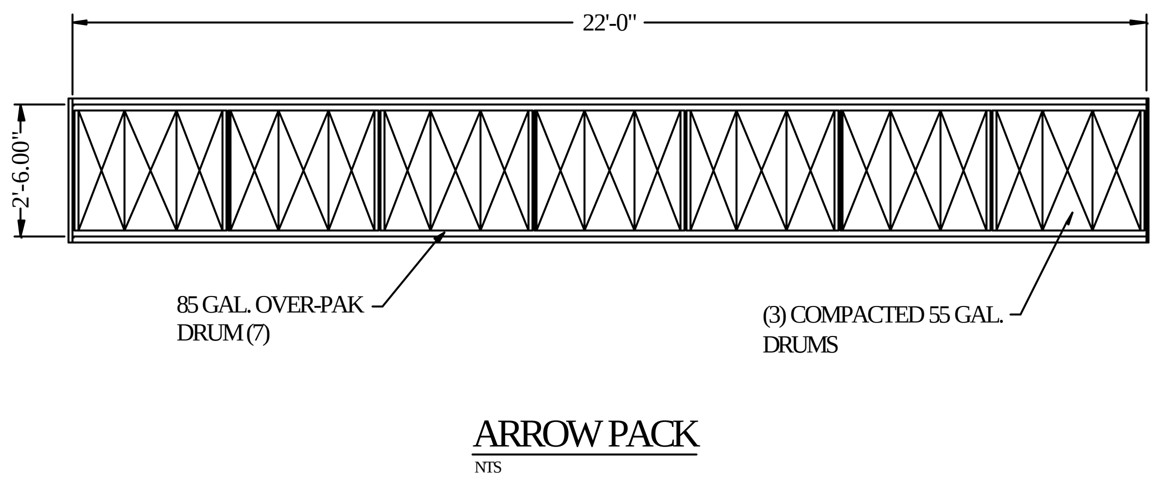

Figure 1. Diagram of Loaded Arrow-Pak Container

Prior to acceptance the presence of special nuclear materials (SNM) within the waste needs to be taken into consideration. If SNM is present within the waste certain conditions have to be met before the waste can be shipped to Envirocare of Utah, Inc. The conditions are generally:

- SNM Isotope Concentration Limits
- Spatial Distribution Requirements
- Bulk Chemical Limits
- Unusual Moderator Limits
- Soluble Uranium Limits

For more details regarding the acceptance of SNM materials at Envirocare please refer to the Waste Acceptance Guidelines (1).

A sampling plan must be approved by Envirocare and the State of Utah prior to acceptance of the waste. Sampling of the drums can be achieved by Envirocare personnel or by an independent third-party contractor. Analysis of these samples must be by a State of Utah approved laboratory. Individual drums are compacted and these compacted drums are placed in overpacks and loaded into the Arrow-Pak. However, prior to sealing of the Arrow-Pak container, the contents of each drum has to be approved by the Envirocare Director of Technical Services. After sealing, the Arrow-Paks can be shipped for direct disposal in the Mixed Waste disposal cell. Transportation of the waste in Arrow-Pak containers meets all Department of Transportation requirements for shipment of MLLW.

The advantage of this form of treatment for debris waste is that waste owner can witness the treatment process by ensuring the Envirocare WAC is being met prior to transportation and observing Arrow-Paks being filled and welded shut. The Arrow-Paks can then be transported to Envirocare for direct disposal.

Shipments of debris from D&D activities at Oak Ridge National Laboratory have just begun to arrive at the Envirocare facility in Clive, Utah

Sulfur Polymer Solidification/Stabilization (SPSS)

A patented technology developed at Brookhaven National Laboratory (BNL) has been transferred to Envirocare for full-scale implementation for the treatment of mercury contaminated wastes. The treatment process is called sulfur polymer solidification/stabilization (SPSS). This process is similar to the ongoing stabilization process except a unique reagent is used and the reaction chamber is thermally controlled. This process uses sulfur polymer cement (SPC), which consists of 95 wt% elemental sulfur reacted with 5 wt% of organic modifier to enhance mechanical integrity and long-term durability.

SPSS mercury treatment is conducted in two stages. The first step is a reaction between mercury and powdered SPC, forming mercuric sulfide:

$$Hg + S \longrightarrow HgS$$

Since the SPSS process includes chemical stabilization of mercury yielding mercury sulfide, it meets EPA requirements for the technology code AMLGM. The reaction vessel is placed under an inert gas atmosphere to prevent the formation of mercuric oxide (a water soluble and highly leachable compound), and a small quantity of additive is included to accelerate this reaction. The vessel is heated to approximately 40 ^{0}C during the stabilization phase to accelerate the sulfide formation reaction, and the materials are mixed until the mercury is completely reacted with the sulfur. Once the mercury is chemically stabilized, additional SPC is added, and the mixture is heated to about 130 ^{0}C until a homogeneous mixture is formed. It is then poured into a suitable mold where it cools to form a monolithic solid waste form. Off-gases from the heating of the medium pass through a heat exchanger to knock-out any condensation from matrix. Exhaust gases are then passed through a cryogenic trap, HEPA filter, and sulfur impregnated carbon before passing through a vacuum pump and being emitted to the atmosphere. Figure 2. Gives a schematic diagram of the mixer off-gas system (2).

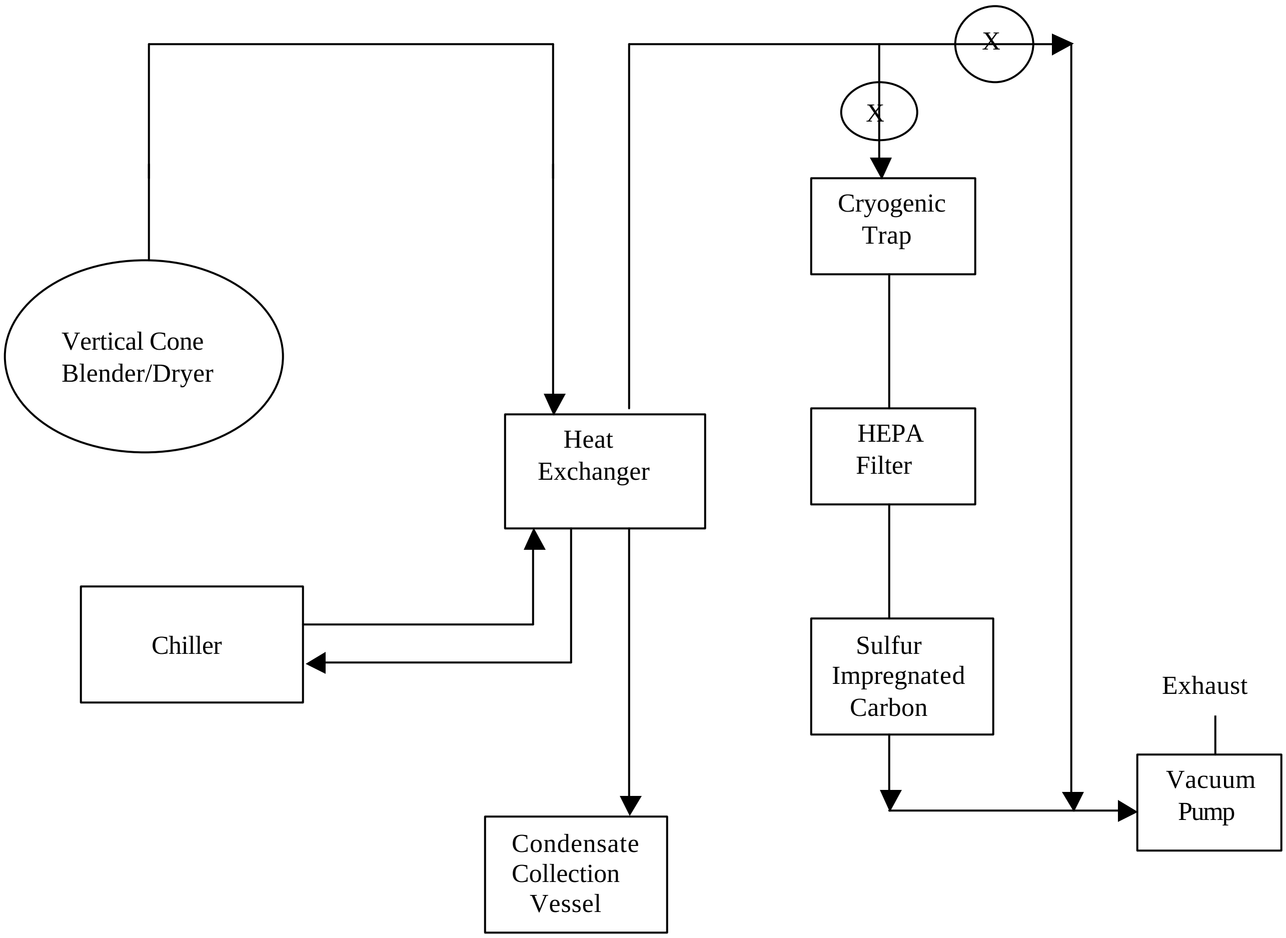

Figure 2. Schematic Diagram of Blender Off-Gas System

To date, all studies using the SPSS process has been on pilot-scale equipment at BNL. These studies have shown that mixed waste soils containing elemental mercury up to 18,000 ppm have been successfully treated using the SPSS process. Initial development work for the SPSS process demonstrated that as much as 33 wt% elemental mercury can be successfully encapsulated and still meet EPA TCLP leaching criteria (3).

The status of SPSS at Envirocare of Utah, Inc. is that a full-scale heated mixer and all ancillary equipment is being specified for ordering and purchase. It is anticipated that the full-scale SPSS process will be fully functional, permitted and operational by October 2000.

High Vacuum Thermal Treatment System

Treatability Studies are scheduled to be conducted using the SepraDyne high vacuum, thermal treatment system on a waste stream contaminated with RCRA organic compounds and heavy metals. After undergoing thermal desorption for the organic contaminants, the heavy metals will be stabilized using the Envirocare chemical stabilization process described in the Introduction to this paper. The matrix used for the studies was a flyash from a DOE incinerator.

The patented SepraDyne system provides an indirect application of heat to a rotating retort, which operates at high vacuum. Special seals on the rotating axis allow this high vacuum to be kept while processing. Bed temperatures of up to 900 ^{0}C are capable while maintaining a vacuum of 0.71 m of mercury. This vacuum produces an extremely deficient oxygen atmosphere so that oxidation of the organic contaminants is not a concern. Volatilized components of the waste stream are drawn from the retort through an impinger system operated with chilled water. A refrigeration unit provides the chilled water to a heat exchanger located within the impinger circuit. After the impinger system, the airflow passes through a condensate collection vessel and into the vacuum pumps. The exhaust gases then pass through a demister and on to a carbon column for collection of any remaining compounds before release to the atmosphere. The unit is operated in batch mode with the batch size for the Treatability Study unit being a nominal 100 lb/batch. This unit is designated as MDU-100.

Scoping studies were initially conducted at BNL to determine the effectiveness of desorbing/destroying dioxins/furans that were present in the flyash (4). For this study, a bench-scale indirectly heated, high vacuum rotary thermal desorption/destruction unit was used. The waste was heated under vacuum in the rotating process vessel where dioxins and furans are decomposed. Since the objective of this study was contaminant destruction, not removal and capture, the usual impinger/condensor unit was by-passed and off-gases were routed directly to a charcoal column prior to venting through a HEPA filtered ventilation hood.

A series of six process runs to destroy the dioxin/furan contaminated flyash were completed. Four runs were conducted at process temperatures of 700 to 800 ^{0}C and another two runs at 450 ^{0}C. The retort was valved off from the off-gas system during processing to allow a longer residence time for the destruction of dioxins/furans. The higher temperature runs resulted in a loss of vacuum as decomposition products began to evolve. Significant volume reduction (~40%) and weight loss (~20%) were a result of the decomposition, possibly from metal chlorides salts suspected to be contained in the flyash. No loss of vacuum for the test runs at the lower temperature was noticed. Volume reductions, or weight loss were much less severe at these lower temperatures. To investigate if the dioxins/furans had been released from the flyash and became trapped on the carbon column, the carbon was replaced and the original carbon placed in the retort for treatment during a separate run.

Composite samples were taken of the flyash before and after treatment in the high and low temperature process runs. In addition, the carbon media was analyzed before and after the final run. All samples were subject to SW-846 Method 8280 analysis. The results from all of these runs are presented in Table I.

Table I PCDD/PCDF Total Homologue Summary of Treated Flyash

Homologue	Initial Concentration (µg/kg)	700-800°C Composite (: g/kg)	450-470°C Composite (: g/kg)	Spent Carbon Untreated (: g/kg)	Spent Carbon 600°C Composite (: g/kg)
DIOXINS					
Total TCDD	15.062	ND	ND	ND	ND
Total PeCDD	44.048	ND	ND	ND	ND
Total HxCdd	126.227	0.040	ND	ND	0.054
Total HpCDD	176.169	0.067	0.018	ND	0.057
FURANS					
Total TCDF	46.953	ND	ND	0.030	ND
Total PeCDF	57.945	ND	ND	ND	ND
Total HxCDF	115.110	0.022	ND	ND	0.012
Total HpCDF		0.051	ND	ND	0.119

As can be seen from the above table all dioxins and furans were destroyed in the process and did not just volatilize and become captured on the off-gas carbon column. Destruction was effective at both high and low operating regimes. The primary objective of the scoping study was to determine if the SepraDyne process could reduce the total level of dioxins/furans to well below 1 ppb, the Land Disposal Restriction (LDR) for dioxins/furans. It is evident that the SepraDyne process is fully capable of destroying the dioxin/furan content of the flyash making it suitable for metals stabilization using the Envirocare microencapsulation, or other, process. Based upon the results of these scoping studies the SepraDyne100 lb/batch unit has been shipped to Envirocare for Treatability Studies using 1000 kg of the same flyash. Once permitted, similar bench-scale studies will be necessary on each waste stream prior to treatment at Envirocare.

Commodore SET™ Process

Another technology for the destruction of organic compounds in a variety of matrices is The Commodore Solvated Electron Technology (SET™). The treatment process is that the waste is initially mixed with anhydrous (water free) ammonia. Metallic sodium (or calcium or lithium) is then added to the mix and dissolved in the ammonia. The mixture is then agitated and turns a vivid blue, indicating the presence of free electrons. These electrons are expected to combine with, and neutralize, the chemical waste. This reaction is found to be extremely fast. Halogenated ions combine with ions of sodium (calcium or lithium) to produce simple salts that precipitate out and are collected. The neutralized waste is then removed for any additional processing. As long as free electrons are present and the mixture remains blue it has the power to reduce halogenated compounds. When all sodium, calcium, or lithium has been consumed in the process, the ammonia is recycled.

Treatability Study testing of this process is to be conducted in the Mixed Waste Operations building at the Envirocare facility in Clive, Utah. The unit in the study is designated as the SL2 process and is capable of treating 360 kg per day. The unit is skid mounted and has dimensions of 8' x 22' X 10' high. All utilities, water and electricity, will be connected to the system. The scrubber vents through a HEPA filter but the exhaust is still routed through the building air handling system. The waste streams used for Treatability Study testing are a variety of matrices (sludge, flyash, etc.) contaminated with a range of organic compounds.

Testing of this unit is scheduled to be accomplished in January 2000.

CONCLUSIONS

Envirocare is further developing its capabilities in the treatment and disposal of MLLW. A number of technologies for the treatment and disposal of a variety of waste streams have been highlighted. These technologies have either been implemented at Envirocare or are in the process of performing Treatability Studies to determine their effectiveness on typical waste streams. The SPSS technology for the treatment of mercury contaminated waste streams is being designed for full-scale implementation at Envirocare and should be available to receive waste streams in the latter part of 2000. Innovative technologies for the treatment of MLLW are constantly being investigated for use at the Envirocare facility. Additionally, treatment of small, specialized waste streams are being investigated. If a treatment technology appears to have the correct treatment process for these specialized streams, a Treatability Study will be investigated to verify its application. The Treatability Studies will also investigate scaling factors involved in taking a process from laboratory-scale through pilot-scale to full-scale. These Treatability Studies will be well documented in future Waste Management Journals and exhibitions.

REFERENCES

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