FEMP-2500
PAPER

CONF-960804--24

CHEMICAL TREATMENT OF MIXED WASTE AT THE FEMP

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For Presentation at the
Spectrum '96 - Nuclear & Hazardous Waste Management
International Topical Meeting
Washington State Convention & Trade Center
Seattle, Washington
August 18-23, 1996

*Fernald Environmental Restoration Management Corporation with the U.S. Department of Energy under Contract No. DE-AC24-920R21972

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ABSTRACT

The Chemical Treatment Project is one in a series of projects implemented by the Fernald Environmental Management Project (FEMP) to treat mixed waste. The projects were initiated to address concerns regarding treatment capacity for mixed waste and to comply with requirements established by the Federal Facility Compliance Act. The Chemical Treatment Project is designed to utilize commercially available mobile technologies to perform treatment at the FEMP site. The waste in the Project consists of a variety of waste types with a wide range of hazards and physical characteristics. The treatment processes to be established for the waste types will be developed by a systematic approach including waste streams evaluation, projectization of the waste streams, and categorization of the stream. This information is utilized to determine the proper train of treatment which will be required to lead the waste to its final destination (i.e., disposal). This approach allows flexibility to manage a wide variety of waste in a cheaper, faster manner than designing a single treatment technology diverse enough to manage all the waste streams.

I. INTRODUCTION

The FEMP site is a government owned, former uranium processing facility located near Cincinnati, Ohio. The site is on the National Priorities List and is currently undergoing remediation under the Comprehensive Environmental Response, Compensation, and Liability Act in accordance with the 1991 Amended Consent Agreement (ACA) between the Department of Energy (DOE) and the U. S. Environmental Protection Agency (EPA).

Closure of FEMP production operations in 1989 left a large inventory of legacy waste including low level radioactive waste (LLRW), LLRW Resource Conservation and Recovery Act (RCRA) hazardous waste or mixed waste, and polychlorinated biphenyls (PCB) waste. Disposal and treatment options have been available for the LLRW include the Nevada Test Site, the FEMP advanced wastewater treatment system (AWWT), and decontamination of surface contaminated wastes. These options can manage a wide variety a waste with limited restrictions when compared to the mixed waste options. Disposal and treatment options for mixed waste include the FEMP AWWT, Toxic Substances Control Act (TSCA) Incinerator in Oak Ridge, TN, and the Envirocare mixed waste land disposal facility in Utah. The FEMP AWWT is limited to aqueous liquids with low concentrations of contaminants and must meet the National Pollutants Discharge Elimination Standards (NPDES) and limitations regarding the systems use of surface impoundments. The FEMP is limited to sending liquids to the TSCA Incinerator is limited to liquids, and waste for Envirocare must meet land disposal restrictions (LDR) and restrictive radioisotope limitations.

The Chemical Treatment Project is one of three major projects for treating and disposition of mixed waste. The Liquid Mixed Waste Project prepares shipments for incineration of organic liquids at the TSCA Incinerator by bulking the containerized the liquids into holding tanks. The Liquid Mixed Waste Project also prepares the disposition of aqueous liquids through the FEMP AWWT. The Stabilization Project stabilizes containerized solid mixed waste with inorganic hazardous constituents (D004 through D011) utilizing Portland cement. The Chemical Treatment Project will establish treatment for the remaining mixed waste stored at the FEMP.

II. WHY TREAT?

Why does the waste require treatment? RCRA requires hazardous waste to meet LDRs prior to disposal in a land based unit (40 CFR 268). LDRs include treatment technology standards and concentration based standards. Technology standards require the use of a specified treatment technology prior to land disposal. Concentration based standards do not require the use of a specific technology, but do require that the treatment meet concentration standards.

In 1992 the Federal Facility Compliance Act was signed requiring each federal facility to prepare plans [i.e., Site Treatment Plans (STP)] for developing the required treatment capacity for their mixed waste. Each plan required USEPA and State approval and must include consultation with other affected states and consideration of public comment. The projects described above were presented in the FEMP Site Treatment Plan. On October 4, 1995, approval of the FEMP STP was provided by the State of Ohio in the form of a Director's Final Finding and Orders (DF&O). In the DF&O, the State of Ohio approved the FEMP STP and enforced the milestone dates for implementing each mixed waste treatment option described in the FEMP STP. The milestone for completing Chemical Treatment at the FEMP is September 2001. During this time, the existing mixed waste inventory in the Chemical Treatment Project must be treated and dispositioned.

III. HOW WILL THE FEMP ACCOMPLISH THE TREATMENT? TREATMENT TRAINS!

The treatment options developed in the STP were based on the concept of treatment trains. Treatment trains are the methods waste will travel the path of treatment to the final destination or disposal. The path has stops where a treatment step will be performed. Each stop at a treatment step will take it closer to its final destination. The path of a waste is contingent upon the waste's characteristics and the applicable LDRs. The final destination of each path is disposition to a permitted treatment or disposal facility. Final destinations for the FEMP wastes include the TSCA Incinerator, the FEMP AWWT, and Envirocare.

Utilization of the treatment train concept simplifies treatment by using interchangeable and shared treatment steps to manage multiple waste types. The use of interchangeable and shared components minimizes the cost and time required to develop complete treatment processes for each type of waste. For example, a waste whose destination is the same as other wastes may require an addition or different treatment step. Instead of creating another complete "track" leading to the same destination, the "track" will be modified or detoured to add an additional or remove a stop minimizing cost, time, and effort.

Treatment trains may be as simple as a single stop, others may require five or more stops. The treatment technologies utilized at each stop in a treatment train have been designed to ensure hazardous constituents will be treated in a logical sequence. For example, the logical sequence for the treatment of waste streams containing lead and 1,1,1-trichloroethane would first be to treat the organic component, followed by treatment of the lead. Treatment technologies for lead (i.e., immobilization through cementation) are ineffective on 1,1,1-trichloroethane and if implemented first would create a waste matrix far more difficult to treat than the original waste.

Figure 1 provides a logic flow for an example of a treatment train. The diagram includes the route of treatment, testing. and disposal. Treatment trains are set up so the proper path is established and the final destination can be reached. The absence of proper stops in the treatment train or failing to properly order the stops will result in substantial delays and failure to make the final destination.

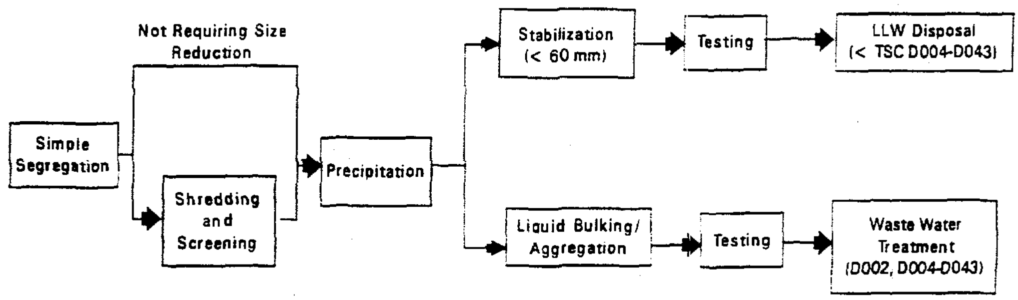

Figure 1
Example Treatment Train

IV. WHO ARE THE PASSENGERS ON THE TREATMENT TRAIN?

The passengers on the treatment train are the waste streams. Each waste stream will follow the path riding the treatment train and making the appropriate stops to reach its final destination. However, having each waste stream ride its own treatment train would be an expensive and time consuming task. Therefore, the similar waste streams with similar paths will ride the treatment train together. Essentially the similar waste streams are placed into a "railcar" called a waste category.

Categorization of the waste streams into "railcars" required determination of the waste streams characteristics, treatment needs, and destinations. An evaluation was performed for each waste stream utilizing available information from the FEMP waste characterization files and supplemental information from Real Time Radiography performed on individual drums of waste. Waste streams with similar characteristics, treatment needs, and destinations were then placed into the railcars. Caution must be taken not to place individual waste streams into a railcar which will require unnecessary stops for all the other waste streams. This delays treatment of the majority for the sake of the minority. However, designating too many "railcars" creates the need to have additional trains creating additional expenses.

The FEMP mixed waste was separated into nine waste categories or "railcars". Each waste category has similar physical and chemical characteristics and treatment needs. The categorization was performed by reviewing available process knowledge, analytical data, real time radiography results, and visual inspection for each individual waste stream. A description of the categories and corresponding treatment requirements are provided below.

Debris: This category includes waste meeting the regulatory definition of debris which is a solid material having a particle size of 60 millimeters (2.5 inches) or larger in any dimension. This includes rags, absorbent pads, paper, personal protective clothing, wood, metal, rubber, glass, plastic, etc. Primary contaminants are listed and characteristic spent solvents (halogenated and non-halogenated), and toxicity characteristic (TC) metals. The primary radioactive contaminant is uranium. The LDRs require the debris to be treated via extraction, destruction, or immobilization.

Fines, sludges, and soils: This category includes dry granular solids, wet and dry sludges, oily sludges, soils, sump cakes, etc. Primary contaminants are listed and characteristic organic solvents (halogenated and non-halogenated), and TC metals. Organic concentrations vary widely from lows of a few ppm to highs of 200,000 ppm. The primary radioactive contaminant is uranium. The LDRs require the fines, sludges, and soils category to travel through treatment stops for extraction, destruction, and immobilization of hazardous constituents to specified concentrations.

Lead solids: This category includes material such as lead bricks, lead shielding, lead wire, and lead tools with uranium surface contamination. LDRs require macroencapsulation to treat these wastes. However, the waste will be decontaminated and surveyed for free release so the waste can be recycled removing it from regulation as a hazardous waste.

Reactives and oxidizers: This category includes waste with different hazards. They are combined due to the similarity in treatment requirements. Reactives include fine metals exhibiting the characteristics of ignitability and/or reactivity (e.g., magnesium, calcium). Oxidizers include material as defined under 49 CFR 173.127,(i.e., uranium nitrate, thorium nitrate, solidum nitrate, and potassium nitrate). LDRs require deactivation to remove the hazardous characteristics.

Barium chloride: This category includes furnace salt, brick, and floor sweepings which contain varying concentrations of barium chloride salt. Barium chloride is highly soluble in water. LDRs for this waste are concentration based and treatment must sufficiently immobilized the barium.

Polychlorinated biphenyls (PCBs): This category includes light ballasts, soils, sludges, scabbled concrete, and debris containing PCBs and RCRA hazardous constituents. This waste must not only meet the RCRA concentration based LDRs, but also must meet TSCA treatment and disposal regulations.

Corrosive waste: This category includes caustic and acidic aqueous liquids with a pH greater than 12.5 or less than or equal to 2.0 respectively. These wastes also include organic and inorganic contaminants which would require further treatment. These waste must be neutralized, then the contaminants destroyed or stabilized.

Mercury waste: This category includes elemental mercury, various elemental mercury contaminated matrices including debris and water, mercury contaminated salts, and crushed fluorescent light tubes. These waste require stabilization via amalgamation.

Uranium residue: This category consists of process residues containing uranium concentrations above the economic discard limit (EDL) (i.e., uranium in sufficient concentration to make recovery economical). The material primarily includes uranium oxides contaminated with TC metals and waste which were derived from oxidation of F-listed solvents. Treatment processes for this waste are unique in that they target the radioactive component rather than the RCRA hazardous component.

V. WHAT TREATMENT TRAIN SHOULD A WASTE RIDE?

The first step in identifying the path of each "railcar" is to identify the treatment needs of that "railcar". The FEMP utilizes a management tool of projectization to place the railcars into the proper treatment train. This administrative process is progressive and functional based allowing for quick placement of the waste into the "railcars" and is flexible enough to move waste streams from one "railcar" to another as necessary when additional information obtained through further evaluation dictates. The radioactive component of these waste streams is simply along for the ride.

The initial step in the process is to segregate the waste into the designated "railcars" (described above). At the FEMP, projects are the management tool for planning, budgeting, and scheduling, and implementing a treatment train. A project may contain one or more treatment trains. First, the RCRA hazardous and TSCA wastes are separated based on the presence of radioactive contamination. If the waste contains no radioactive contamination, it will be shipped directly off-site for treatment to a licensed commercial treatment, storage, or disposal facility. Radioactively contaminated waste continues through the process.

Next, a general evaluation of the mixed waste is performed by evaluating existing information beneficial to the management of the mixed waste. This information includes waste characterization, EPA waste codes, and general material description. Based on the general evaluation, the mixed waste is assigned to one of several of the above described "railcars". The projects provide the necessary mechanisms for implementing the stops each treatment train must make to meet LDR treatment standards. The stops or treatment technologies needed to treat a group of waste are linked together and diagrammed in treatment trains.

After being assigned to a project, the waste stream will go through a detailed evaluation to determine if supplemental information is required. Sources of this information include waste characterization files, radiological concentrations, visual inspection, real time radiography, and sampling and analysis results. As additional information is obtained on the waste, it may be determined that the assigned project is not appropriate. Then the waste can be easily reassigned through the management system to a different project. This is particularly important because some waste streams will require a multi-step treatment approach (i.e., chemical treatment followed by stabilization). This management system allows for easy transfer of treated waste residues to other projects without losing the information obtained during previous evaluations.

VI. WHAT STOPS WILL A TREATMENT TRAIN TAKE ALONG ITS PATH?

Selection of treatment technologies is contingent upon the LDR treatment standards, effectiveness of the technology to treat the waste to meet those standards, the availability of the technology, and stakeholder preferences. To support the selection of viable treatment options, the FEMP is performing treatability studies. The treatability studies provide bench scale testing to determine whether a particular treatment process is applicable and feasible. Due to stakeholder input, preference was given to those technologies which are performed at ambient temperatures. Specifically, incineration. If ambient temperature treatment is not feasible, treatment processes using elevated temperatures will be investigated. Chosen treatment technologies must be capable of handling the wide variance in waste types, matrices, hazardous constituents, and constituent concentrations.

The availability of permitted off-site mixed waste treatment facilities is limited, therefore the FEMP will require the majority of the treatment train stops to occur on-site. The Chemical Treatment Project will primarily utilize vendor provided mobile treatment services augmented by existing on-site facilities. Use of mobile treatment processes is motivated by two primary factors. First, is the limited availability of facilities permitted to accept the mixed waste types in the Chemical Treatment Project inventory. Second, the utilization of mobile treatment facilities is more cost effective than permanent facilities and does not require the additional approvals. Cost effectiveness is based on the elimination of designing, constructing, and decommissioning a permanent facility. A secondary benefit of on-site mobile treatment is the limitation of state-to-state waste equity issues.

VII. WHAT TREATMENT TRAINS MUST WASTE RIDE?

All aboard!: The initial stop for all the treatment trains is waste segregation. Currently, a container may contain waste meeting the definition of multiple waste categories which are eligible for several "railcars". Segregation will assure that subsequent treatment stops will be performed efficiently and will limit delays. The first step in segregation will be to identify the containers which require manual sorting. This is performed by reviewing all available visual inspections and real time radiography results. Containers with homogenous waste will not require manual sorting. Waste segregation will be performed on each container of waste to further segregate wastes into the defined categories.

Debris Washing Train: The FEMP has identified two potential stops for treating the debris. The first is local stakeholders did not want to utilize on-site through the use of chemical extraction. The extraction process will utilize an extraction reagent (e.g., detergent) in a treatment unit similar to a laundry washing machine. Cleaning of hard solids will be conducted in a similar manner but may incorporate the use of a high pressure spray wash. Debris treated to a clean debris surface may be disposed as LLRW. The second stop may use macroencapsulation via placement in a nondegradable sealed container, use of Portland cement as an encapsulating agent, or a combination of both. The macroencapsulated waste would require disposal in a RCRA permitted disposal facility. The selected option will be dependent upon evaluation of the feasibility, benefits, and costs of each option. Additional treatment stops for the waste waters will included the TSCA Incinerator or the FEMP AWWT.

Solvent Extraction Train: The leading treatment option for the fines, sludges, and soils is solvent extraction using an organic solvent (e.g., propane, butane, acetone, or alcohol). Treatability studies and research is being performed to identify the optimum solvent and to identify alternative treatment options including chemical oxidation, drying and condensing, and thermal desorption. [Note: Drying and thermal desorption are not preferable due to the use of elevated temperatures. However, if ambient temperature treatment is not feasible, these processes will be investigated.] Solid wastes treated in this train will make a stop at stabilization for the metal constituents before final disposition to Envirocare. The waste solutions final disposition will be the TSCA Incinerator.

Decontamination Treatment Train: Decontamination to remove the radioactive surface contamination will be implemented using a detergent or a bath, then monitoring for free release. Lead meeting free release criteria will be sent to a recycling facility. Lead which cannot be free released must be macroencapsulated. Nickel-cadmium batteries will be managed in the same manner as the lead solids. An additional option includes shipment of contaminated lead directly to a recycling facility permitted to manage radioactively contaminated lead waste for recycle. The final destination for waste removal of contaminants to a clean debris surface waters will be the FEMP AWWT.

Deactivation Treatment Train: The treatment standard for these wastes is deactivation. Deactivation will be performed using stabilization by mixing the waste with a cement (i.e., Portland or Petroset). The specific cement selected is dependent upon the sensitivity of the waste to the use of water and Portland cement. Final destination is disposition as LLRW.

Precipitation Treatment Train: Treatment will be performed using precipitation. The waste will be slurried with water to completely dissolve the barium chloride, then precipitated with an inorganic sulfate to form an insoluble barium sulfate. The resulting slurry may then be stabilized/solidified with the addition of Portland cement. Final destination for the treated solids is disposition as LLRW. Wastewater will be processed through the FEMP AWWT.

PCB Treatment Train: Current regulatory requirements specify the use of incineration as the treatment standard for PCB regulated waste. However, the FEMP will pursue the use of a non-incineration treatment alternative. The preferred treatment process for the PCBs is solvent extraction using an organic solvent (i.e., propane, butane, acetone, and alcohol). Regulatory approval of an alternative treatment technology will be required to for the PCBs to ride this train.

Neutralization Treatment Train: The waste will be neutralized by mixing the caustic and acidic streams to a pH within a specified range. Use of waste to treat waste will reduce the need to purchase reagents and will limit the secondary waste generated as a result of treatment. The neutralized wastewater will then be evaluated for further disposition. Final disposition includes either the FEMP AWWT or the TSCA Incinerator.

Amalgamation Treatment Train: The treatment standard for elemental mercury contaminated with radioactivity is amalgamation. All the waste in this category will be addressed in a treatability study which will be performed in two phases. Phase I will be bench scale scoping tests to identify treatment processes which successfully treat each waste matrix. Phase II will be proving tests to provide "Proof of Process" and to optimize the treatment methods identified in the scoping tests. The information gathered from the treatability study will be distributed throughout the DOE complex to support future mercury remediation needs (e.g.,Y-12 in Oak Ridge, TN). Final destination is disposition as LLRW.

Uranium Recovery Treatment Train: The uranium residues will be purified to create a marketable product. The purification process will include dissolution in nitric acid followed by precipitation with hydrogen peroxide. If future research indicates no market exists for the uranium, then alternative waste treatment methods will be evaluated. Residues from this train will stop at stabilization, and final destination will be disposition as LLRW or Envirocare.

VIII. CONCLUSION

Despite the limited availability of permitted facilities for acceptance of mixed waste and the limited availability of on-site facilities capable of treating mixed waste at the FEMP, mixed waste treatment can be accomplished. This can be done without the use of a "super" technology designed and constructed at the FEMP. The FEMP can import available technologies to accomplish the treatment and put the waste into a form acceptable to the available destinations of the TSCA Incinerator, the FEMP AWWT, LLRW program, and Envirocare. Use of the treatment trains provides the ability to perform this treatment in a timely and cost efficient manner. Ultimately this will solve a major environmental problem at the FEMP and will lead to the final restoration of the site. Use of this methodology is applicable for any site with a mixed waste problem.