MIXED WASTE CHARACTERIZATION AND TREATMENT TECHNOLOGY DEVELOPMENT AT ROCKY FLATS *

Jerry L. Stakebake and Charles E. Baldwin
EG&G Rocky Flats, Inc.
Golden, CO 80402

ABSTRACT

Rocky Flats has accumulated a substantial quantity of mixed waste, which falls under the land disposal restrictions (LDR) of the Resource Conservation and Recovery Act. Characterization of these mixed wastes is required for such activities as storage, waste treatment, waste treatment system development, LDR compliance, and waste disposal certification. A three-phased approach is being used for characterization; process knowledge, screening analysis, and physical sampling and analysis. Information from waste characterization is used first to determine if the waste form is actually LDR or "mixed" and if it is LDR to provide the necessary information to develop treatment technologies. Two technologies currently being developed are polymer encapsulation and microwave melting. A general overview of the waste streams involved, the characterization process, and the status of the treatment technology development is presented in this paper.

INTRODUCTION

Rocky Flats Plant(RFP) located approximately 16 miles northwest of Denver, Colorado, was designed and built as a manufacturing facility for the production of nuclear weapons components. As a manufacturing facility, RFP generates a variety of wastes from the various production processes. Because of the materials associated with the fabrication and processing of weapons components, the waste generated creates unique problems generally not associated with industrial waste.

For nearly 40 years, RFP has generated radioactive waste forms that are believed to be land disposal restricted (LDR), and therefore fall under the provisions of the Resource Conservation and Recovery Act (RCRA). These waste forms represent wastes generated at 2000 to 3000 locations at Rocky Flats. About 11,269 cubic yards plus 28,965 gallons of this waste is low level mixed (LLM) less than or equal to 100 nCi/g activity. Approximately 1,119 cubic yards is transuranic mixed waste (TRM) with radioactivity levels above 100 nCi/g. If emptied from their storage containers, the combined volumes of these wastes would fill an area the size of a football field to a depth of about ten feet. The major categories of these wastes are shown in Fig. 1.

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), which has since been amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA). Under HSWA, the EPA was tasked with promulgation of regulations to prohibit the land disposal of untreated hazardous waste (LDR regulations). As a result of the promulgation of the LDR regulation, and due to the unique nature of mixed wastes, DOE notified EPA in 1989 that RFP was storing mixed wastes that were subject to the LDR regulations. Furthermore, it was stated that such storage might not be solely for the purpose of accumulating sufficient quantities necessary to facilitate proper recovery, or disposal, since the methods and technologies for doing so did not exist. This led to the initiation of an agreement between EPA, DOE, and the Colorado Department of Health (CDH), commonly referred to as the Federal Facility Compliance Agreement I (FFCA I).

The FFCA I agreement, which was signed in September of 1989, required DOE to take actions to ensure the accurate identification, safe storage and minimization of certain LDR mixed wastes prior to their ultimate treatment and/or disposal. Under FFCA I, DOE provided to EPA Treatment Reports and Plans that proposed the framework under which RFP would obtain the capability to treat its mixed waste. The treatment approach included an assessment of available technologies, the applicability of those technologies to RFP mixed wastes, and schedules to treat RFP mixed wastes.

Recognizing that the allotted time was not sufficient for DOE to achieve total compliance, the DOE and EPA entered into a follow-on agreement commonly referred to a FFCA II in May of 1991. FFCA II, like FFCA I, requires that DOE shall take all steps necessary to address and resolve the LDR issues at RFP including the accurate identification, safe storage, development and implementation of treatment methodologies, and minimization of wastes covered under the agreement. As required by FFCA II, DOE has prepared a Comprehensive Treatment and Management Plan (CTMP) that describes DOE's strategy and commitments for bringing LDR waste at RFP into compliance with applicable requirements. Accordingly, the CTMP has been developed in large part to identify the overall strategy for developing and implementing treatment systems (and other management systems) for the purpose of achieving compliance with LDR. The following discussion elaborates on the strategies outlined in the FFCA as well as the CTMP and describes the current activities being carried out in the areas of waste characterization and treatment.

STRATEGIES FOR COMPLIANCE

The strategy for achieving compliance focuses on a plan of characterization and treatment. The options chosen are ones that EG&G and DOE believe will achieve compliance with RCRA storage prohibitions. Characterization is of prime importance and is the key to the possible options for waste disposal, which are described below. The following characterization options for attaining compliance are currently being pursued: (1) Characterization for Delisting or Reclassifying, and (2) Characterization for Treatment.

* Work performed under the auspices of U. S. Department of Energy Contract DE-AC04-76DP03533.

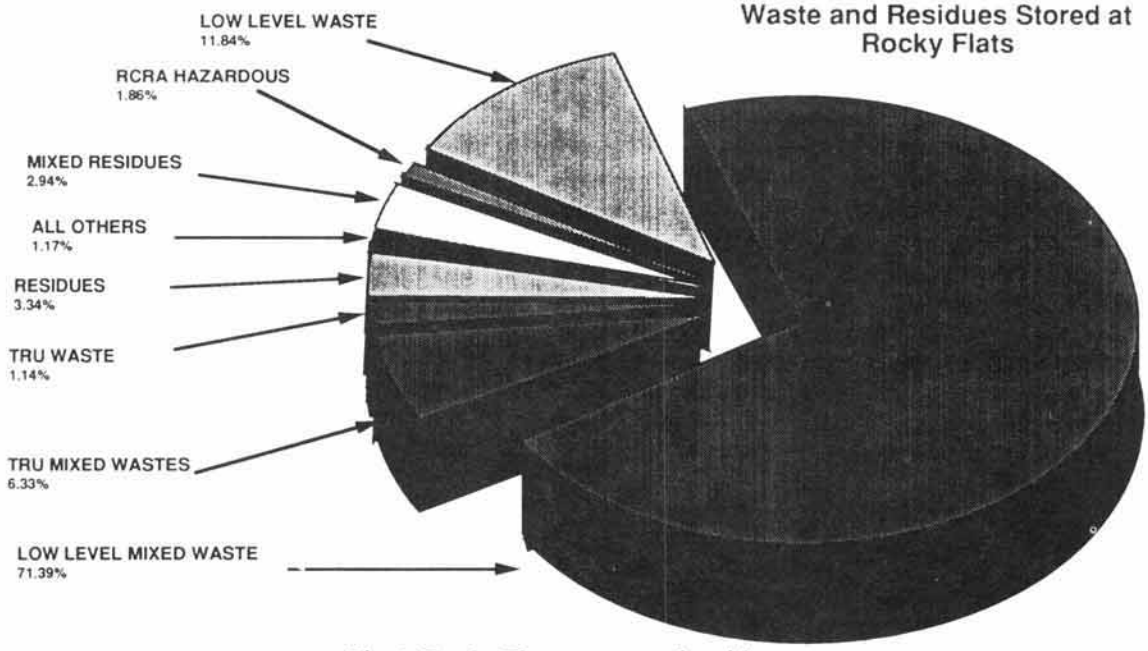

Fig. 1. Rocky Flats wastes and residues.

The first option for attaining compliance is to "delist" or "reclassify" some of the wastes identified as LLM. Delisting according to 40 CFR 260.22 appears to be fairly difficult to obtain at the present time. Reclassification, on the other hand, may be possible for several of the Rocky Flats waste forms that are now identified as LLM. Candidate waste forms may have been erroneously identified by the generator as containing RCRA regulated constituents. If it can be shown by process knowledge plus some type of screening analysis that the waste form contains no hazardous constituents, there is a good chance it can be reclassified as LLW and shipped to the disposal site in Nevada.

Related to the above reclassification option is a second characterization task to determine if any wastes currently being identified as LLM actually contain radioactive materials. A significant portion of the LLM inventory is believed to have been classified on the basis of generation location and in fact may not be a low level radioactive waste. Rocky Flats is currently engaged in a program entitled the No-Radioactivity-Added (NRA) Verification Waste Program. The focus of this program is to develop methods for performing "rad" analyses in order to demonstrate the NRA concept and verify that no added radioactive material in present in at least some of the waste produced at RFP.

The second option for compliance encompasses the broad subject of characterization and treatment. The strategy for achieving compliance through characterization and treatment includes six primary pathways; four for LLM and two for TRM. These pathways are shown in Fig. 2. Low-level mixed wastes and transuranic mixed wastes have different compliance strategies. For LLM, the strategy is to treat the waste to meet applicable LDR restrictions, and then ship to the Nevada Test Site (NTS) for long term storage or disposal. For TRM, the DOE strategy is to achieve RCRA compliance with LDR prohibitions through the process of obtaining a no-migration exemption for the Waste Isolation Pilot Plant (WIPP).

Pursuit of Path A (Fig. 2) will result in the determination of whether or not a waste form is non-hazardous or meets LDR treatment standards through process knowledge or minimal characterization. If the waste meets the standards, LDR treatment will not be required and only minimal processing to meet U. S. Department of Transportation (DOT) requirements and repository waste acceptance criteria (WAC) may be needed.

Following Path B, RFP's LDR waste will be treated offsite at existing, or planned, DOE or commercial treatment facilities. This path is being pursued because there is the potential for lower cost and shorter schedules by utilizing existing or planned facilities. However, significant regulatory and permitting uncertainties are associated with this path. Shipment of RFP mixed wastes to alternate facilities may be complicated by the unwillingness of certain states to allow entry of out-of-state DOE mixed waste into or through their particular state.

Path C represents the baseline path and requires new treatment systems and facilities be developed and implemented at Rocky Flats to treat RFP wastes. This path includes six primary treatment systems:

1. LLM Solar Pond Cleanup Treatment System. This system will utilize cementation of pond sludge, backlog pondcrete, and saltcrete.
2. LLM Solidification Bypass Sludge Treatment System. The baseline technology for this system is microwave solidification.
3. LLM Building 374/774 Treatment System. The baseline technologies for this system include thin film evaporation, nitrate destruction/recycle, polymer solidification, and microwave solidification.
4. LLM Miscellaneous Waste Treatment System. The baseline technology for these varied and small quantity wastes is cementation.
5. LLM Surface Organics Removal, Leaded Gloves and Bulk Lead Treatment System. The baseline technologies include volatilization and macro encapsulation.

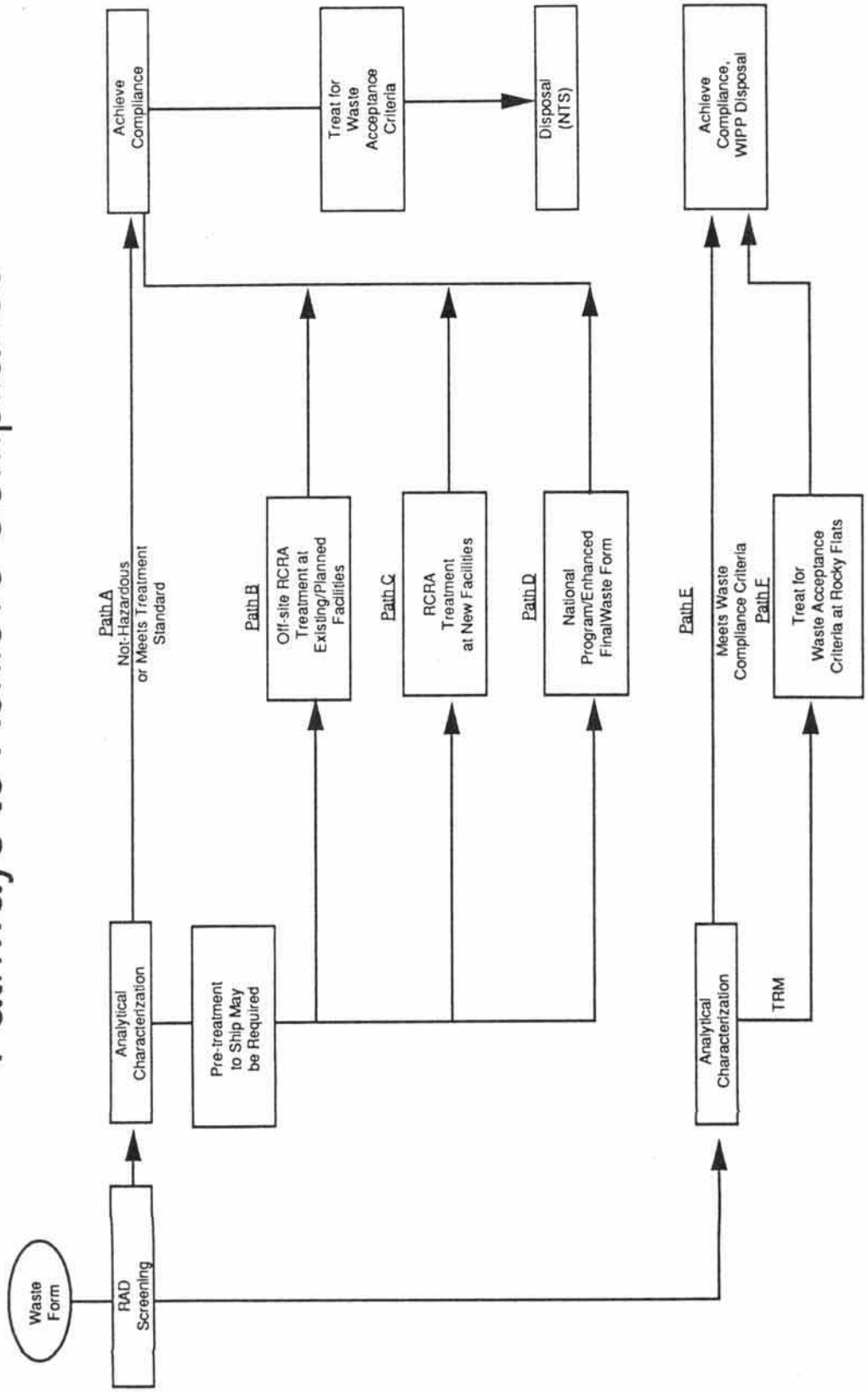

Fig. 2. Options for characterization and treatment of mixed wastes.

6. LLM Solvent Contaminated Waste Treatment System. The baseline technologies include thermal treatment, off-gas capture, and microwave solidification.

The *fourth path* for LLM waste, Path D, is pursuing a national program that focuses on producing an enhanced final waste form. The technologies pursued in this path are designed to accept a large variety of waste forms. The benefits of this path are: a single treatment system; savings in characterizations may be possible; less waste volume; and a final waste form which may reduce long term environmental risk.

Paths E and F pertain strictly to TRM waste forms. Since it is assumed that WIPP will receive a no-migration variance and will be permitted to dispose of untreated TRM, it is not necessary to treat TRM to meet LDR. However, treatment for WIPP WAC and to meet DOT requirements may still be necessary.

WASTE CHARACTERIZATION

Stored and newly generated LLM LDR wastes at RFP require waste characterization for disposal regardless of the path (A through D) selected. Under the RCRA regulations, before any hazardous waste can be treated, stored, or disposed, a detailed chemical and physical assessment must be made on the waste. In addition to the compliance requirements, development and implementation of treatment processes also require analytical data. In the development stages, characterization data are required in order to specify initial system parameters. During the design and pilot stages, sufficient information must be obtained to evaluate system performance and ensure the final waste form meets the applicable treatment standards.

Rocky Flats is using a three-phased approach to meeting the waste characterization needs. (See Fig. 3) This method is not only cost effective but it also is time efficient. In this approach the least expensive characterization techniques are used initially to determine if further analyses are required. The first phase is Process Knowledge. Process knowledge consists of past and present data that can help identify the physical parameters and chemical constituents in the waste. At RFP, most of the waste is stored in drums and process knowledge generally consists of container-specific paperwork associated with the drums. Some additional process knowledge consists of analytical data available from analyses of the generation process and process information available from knowledgeable operators.

The second phase is a Screening Analysis that provides a quick, inexpensive, and qualitative indication of the existence of physical or chemical constituents in the waste material. These methods include Real Time Radiography (RTR), headspace analysis, and radioactive material screening. All waste containers are examined by RTR to determine if any unacceptable wastes are present. Radioactive material screening is currently being performed to differentiate between low level and TRU waste. Development is under way to establish methods for conducting No-Radioactivity-Added screening. This screening coupled with process knowledge has identified eleven waste forms as having a reasonable chance of meeting current LDR restrictions with little or no additional treatment.

The third and final phase in waste characterization is actual Physical Sampling and Analysis. Sampling will closely follow the procedures and statistical analysis set forth in SW-846. However, because these methods were developed without regard to the radioactive component contained in mixed waste, a variety of problems were found in applying these methods. These problems are now being addressed. Analytical plans have been prepared for the waste treatment technologies being developed at Rocky Flats. These plans describe the characterization and analytical needs of each technology. Sampling and characterization plans are also being prepared for the various backlog waste forms. These plans detail the methodology for obtaining samples and the analyses required for complete waste characterization.

At present there are no methods for sampling heterogeneous wastes. Since a significant portion of the RFP wastes are heterogeneous, this presents a major problem. Efforts are underway to develop acceptable methods for sampling these wastes by either modifying existing SW-846 methods or developing new techniques.

WASTE TREATMENT TECHNOLOGIES

The six treatment systems discussed earlier for treating LLM wastes via Path C are illustrated in Table I along with the waste forms they are projected to treat. Treatment technologies under development at Rocky Flats include; microwave melting, polymer solidification, supercritical CO_2 extraction, and fluid bed incineration. Due to the need for brevity, only two of the technologies under investigation at Rocky Flats as part of these systems will be described.

Polymer Solidification (1)

Polymer solidification and macroencapsulation are key technologies for several described treatment systems. The applicability of polymer solidification technologies for nitrate salts and bypass sludge, lead metal, incinerator ash, crushed fluorescent light bulbs, beryllium dust, and several miscellaneous sludges is being evaluated at RFP. Several types of polymers and processes are being investigated due to dissimilarities in physical characteristics and chemistry of the wastes. Polymer encapsulation of mixed wastes produces mechanically superior waste forms with much less volume increase than conventional solidification technologies.

Development efforts to date have focused on polyethylene extrusion of nitrate salts, RFP's largest LLM waste stream. The polymer solidification team has two lab-scale extrusion systems (see Fig. 4) operating and is conducting experiments using simulated waste. RFP is currently conducting experiments to determine the ability of the process to produce a waste form that consistently passes the Toxicity Characteristic Leaching Procedure (TCLP). Because of the large buffering capacity of ordinary cements, polymer encapsulated waste forms may not perform as well with TCLP as cemented waste forms. One of the experiments currently being conducted is to evaluate the feasibility of adding various metal oxides to the waste prior to solidification to chemically stabilize heavy metals. Initial results from these experiments are currently being evaluated. The SW-846 procedure for TCLP requires sizing of the samples prior to performing extractions. In the case of the encapsulated waste, the method used for size reduction has been found to affect the results of TCLP tests. Experiments are underway to quantify this effect. Treatability studies using actual wastes are scheduled to begin in the spring of 1993.

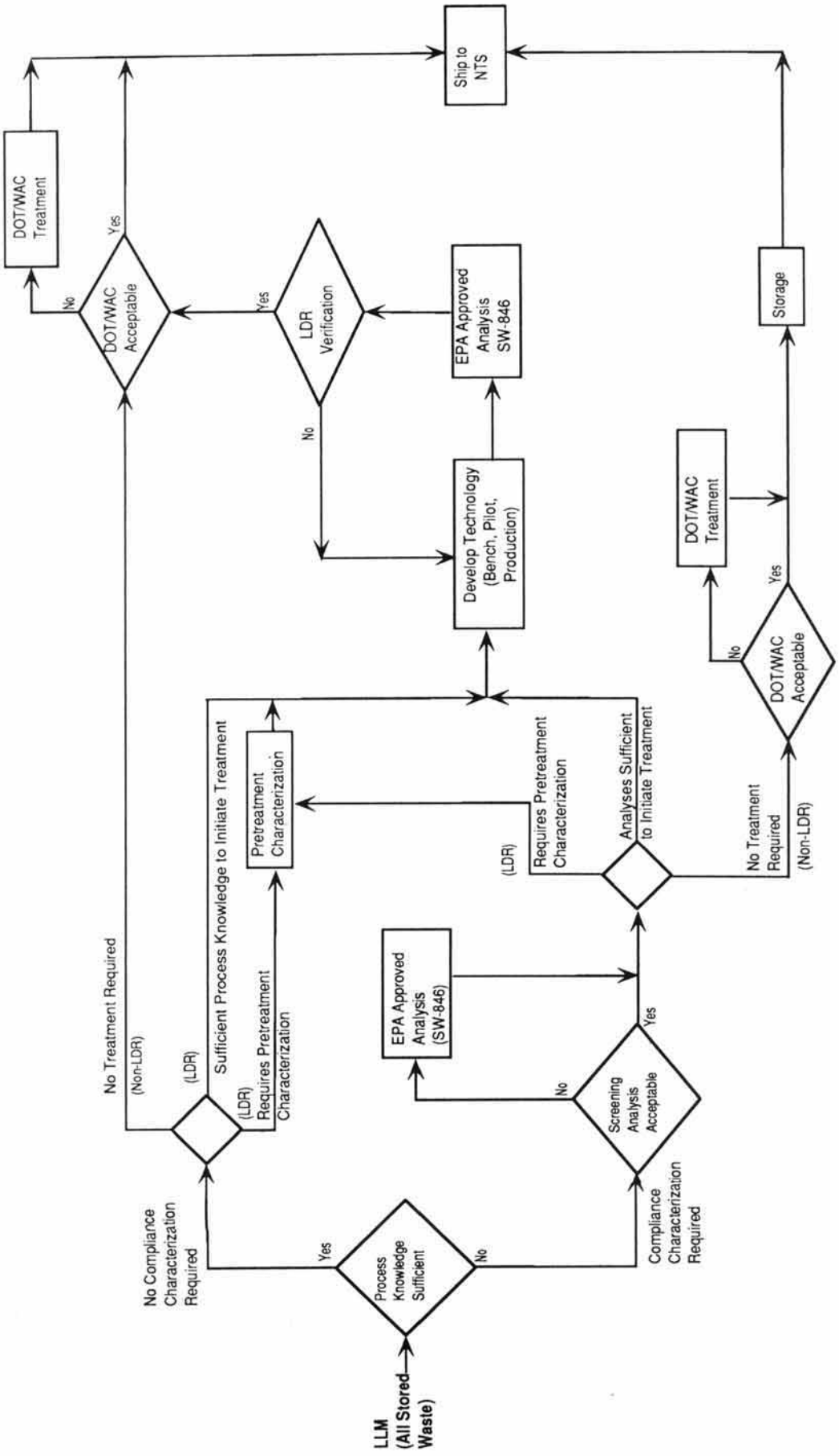

Fig. 3. Rocky Flats waste characterization and treatment strategy.

TABLE I
Baseline Technology Treatment Systems for LLM Waste Forms

WASTE TREATMENT SYSTEM	TECHNOLOGY BASELINE	WASTE FORM
1. Solar Pond Cleanout	Dewatering + Cementation	Pondcrete, Solar Pond Water, Saltcrete (backlog)
2. Solidified Bypass Sludge	Microwave Solidification	Solidified Bypass Sludge
3. Bldg. 374/774 System		
System 1	Drying + Polymer Solidification	Saltcrete (new generation)
System 2	Drying + Microwave Solidification	Bypass Sludge (new generation)
4. Miscellaneous Waste Forms		
System 1	Neutralization + Cementation	Acid, Laboratory Solutions
System 2	Cementation	Beryllium Fines, Silver Nitrate, FBI Ash (backlog)
5. Surface Organic Removal: Bulk Lead and Leaded Gloves	Volatilization + Microencapsulation	Glass, Glovebox Parts, Metal Heavy Metals, Bulk Items
6. Solvent Contaminated Waste	Thermal Option	Cemented Chips, Chemicals Combustibles, Cutoff Sludge, Oil, Filters, Organics, Paints Particulate Sludge, PCBs, Roaster Oxide, Soil, Turnings Used Absorbents

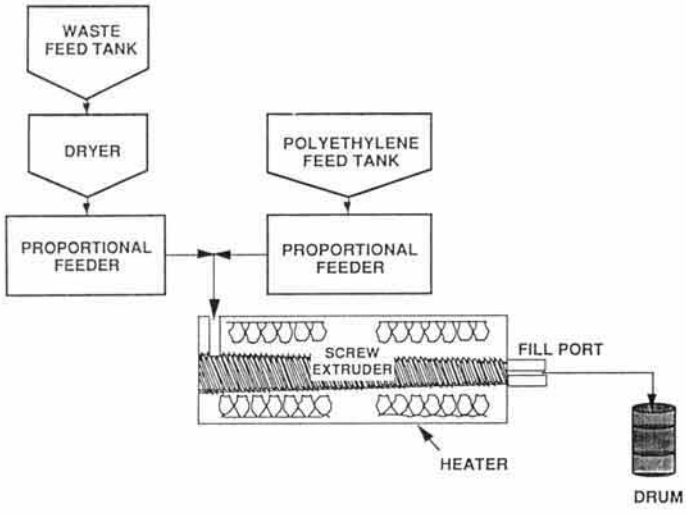

Fig. 4 . Polymer Encapsulation System for waste treatment.

Microwave Solidification (2)

Microwave solidification is another of the key technologies being incorporated in the treatment systems. In this process, solid wastes are melted to a glass form in a microwave melter. The waste material is first size-reduced, mixed with diatomaceous earth and borax (to aid in melting and vitrifying), and then formed into pellets. These pellets are introduced to the microwave melter where the waste is vitrified to a solid waste form. A flow diagram illustrating this system is shown in Fig. 5.

Laboratory scale vitrification of calcined high-level nuclear wastes using microwave energy was accomplished by the Idaho National Engineering Laboratory in 1979. Microwave solidification of wastes has been performed at RFP since 1985. Waste forms successfully processed include precipitation sludge, incinerator ashes, and nitrate salts. The process developed at RFP is an in-drum melting system designed to isolate the molten waste in the shipping container during processing. This system offers advantages over other thermal processes in areas of energy transfer efficiency, higher waste loading and densities, and a leach resistant matrix.

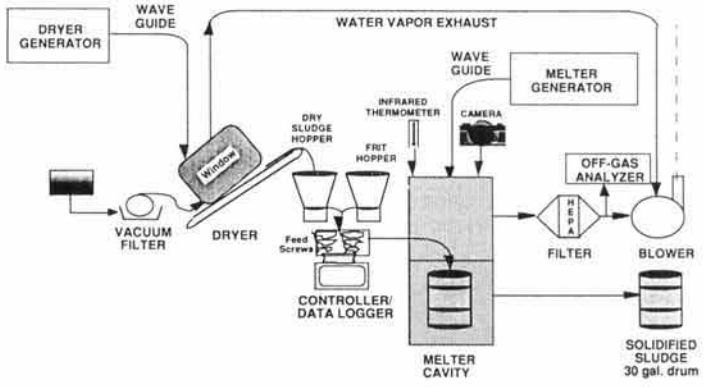

Fig. 5. Microwave Solidification Treatment System.

Currently a demonstration scale 50 KW, 915 MHz microwave system is being tested using a simulated sludge waste. Initial tests were performed at 30 and 40 KW with 60% waste loading. The resulting product resembled a synthetic low grade iron ore with a bulk density of approximately 3.2 g/cc and a volume reduction of about 70%. Future work will involve other waste forms and confirmation TCLP tests on the melted product.

CONCLUSION

The requirement under FFCA II to bring radioactive hazardous waste into compliance with RCRA and, at the same time, to stay in compliance with LLM and TRM storage limits presents unique problems not found in industry. Furthermore, potentially significant volumes of LDR waste are expected in the future from the residue treatment, environmental restoration, and D&D activities. RFP has an existing, active technology development group focused on providing the technologies necessary to bring RFP into compliance with LDR regulations.

REFERENCES

1. A. M. FAUCETTE, EG&G Rocky Flats, Inc., Golden, CO, personal communication, January, 1993.
2. G. S. SPRENGER, EG&G Rocky Flats, Inc., Golden, CO personal communication, January, 1993.