DISPOSAL OF ROCKY FLATS RESIDUES AS WASTE

D. F. Dustin and V. S. Sendelweck
EG&G Rocky Flats, Inc.

M. A. Rivera
Lamb Associates, Inc.

ABSTRACT

Work is underway at the Rocky Flats Plant to evaluate alternatives for the removal of a large inventory of plutonium-bearing residues from the plant. One alternative under consideration is to package the residues as transuranic wastes for ultimate shipment to the Waste Isolation Pilot Plant. Current waste acceptance criteria and transportation regulations require that approximately 1000 cubic yards of residues be repackaged to produce over 20,000 cubic yards of WIPP certified waste. The major regulatory drivers leading to this increase in waste volume are the fissile gram equivalent, surface radiation dose rate, and thermal power limits. In the interest of waste minimization, analyses have been conducted to determine, for each residue type, the controlling criterion leading to the volume increase, the impact of relaxing that criterion on subsequent waste volume, and the means by which rules changes may be implemented. The results of this study have identified potential changes to be proposed in regulatory requirements in order to minimize the costs of disposing of Rocky Flats residues as transuranic wastes.

INTRODUCTION

The Rocky Flats Plant near Denver, Colorado is currently storing a backlog of approximately 1000 cubic yards (3700 55-gallon drums and 3500 smaller containers) of plutonium-bearing residues. Residues comprise a category of materials with sufficiently high concentrations of plutonium that the recovery of that plutonium for the purpose of providing raw material for weapons production was at one time considered to be economically more favorable than the production of new plutonium in a reactor facility. The Rocky Flats residues have been accumulating in anticipation of the construction of a full-scale, operational plutonium recovery facility. With the change in mission for Rocky Flats from weapons production to environmental restoration and waste management, plutonium recovery operations will not be required for the foreseeable future. The problem remains, however, as to the ultimate disposition of the residue backlog.

Residues were generated at Rocky Flats as a by-product of the production of plutonium components since the early 1950's. They consist of a variety of materials such as incinerator ash, pyrochemical salts, casting materials, paper, cloth, plastic, metal, glass, rubber gloves, filters, insulation, firebrick, and ion exchange resins. The designation of these materials as residues precluded their disposal as transuranic (TRU) wastes at a repository such as the Waste Isolation Pilot Plant (WIPP). At Rocky Flats, each residue type is given a unique identifier known as an Item Description Code (IDC). Residues (and wastes) are packaged according to their IDC. There are currently 88 residue IDC's at Rocky Flats awaiting disposition. Approximate 90% (by volume) of these residues have been determined to be hazardous as defined by the Resource Conservation and Recovery Act (RCRA) and, as such, are subject to regulation as mixed wastes.

For about the first twenty years of operation at Rocky Flats, plutonium recovery operations were performed at a level that was commensurate with the rate of weapons production. In the 1970's, however, production requirements increased to the extent that recovery capability was soon exceeded, and the inventory of residues awaiting recovery began to grow. Residues continued to accumulate at a rate that exceeded recovery capability through 1989 when all plutonium production operations at the plant were curtailed. Small amounts of mixed wastes potentially identifiable as residues continue to be generated at the site due to ongoing caretaker operations such as maintenance, utility support, and liquid waste treatment.

This report addresses the issues relating to one potential course of action to dispose of the Rocky Flats residues. That option is to declare the residues to be wastes and ship them to an appropriate repository meeting all transportation requirements and repository waste acceptance criteria. The rationale for having to eliminate the residue backlog from the plant, the requirements that must be met in order to ship residues to a repository, and the consequences of applying those requirements to the residue backlog are described. Finally, some alternative considerations in terms of proposed criteria changes and the potential impact those changes might have on shipping efficiencies are discussed. The opinions expressed in this report are those of the authors and do not necessarily reflect those of DOE.

BACKGROUND

On November 3, 1989, the Department of Energy and the Colorado Department of Health (CDH) entered into a Settlement Agreement and Compliance Order on Consent No. 89-10-30 in response to a Notice of Violation issued in August 1989. The Notice of Violation alleged that certain "residue" materials stored at Rocky Flats were subject to regulation under the Colorado Hazardous Waste Regulations. The Settlement Agreement further provided for a series of reports to be prepared by DOE which would inventory, classify, and characterize residues at the plant in order to determine the population of mixed residues. The Settlement Agreement required the submittal of a Residue Compliance Plan which was to propose, for CDH review and approval, actions to be taken to reduce the amount of residues in storage that were determined to be hazardous wastes. In response to the Settlement Agreement, DOE submitted the Mixed Residues Compliance Plan in September 1990. In a further action, on April 12, 1990, the United States District Court, District of Colorado, granted a Sierra Club motion for partial summary judgment in Sierra Club v. Department of Energy, No. 89-B-181,

finding that the hazardous portion of mixed residues at Rocky Flats was subject to RCRA regulation.

In July 1991, the CDH issued Compliance Order 91-07-31-01 to DOE. The Order found that portions of the Mixed Residues Compliance Plan dealing with the reduction of the mixed residue inventory at Rocky Flats were inadequate. In August 1991, the CDH filed Colorado v. Department of Energy, Civil Action No. 91-B-1326, in the United States District Court, District of Colorado. Colorado sought an order requiring DOE to comply with the 1991 Compliance Order and with the Colorado Hazardous Waste Act with respect to mixed residues. The Compliance Order further required DOE to submit a mixed residue reduction report to the CDH describing a program to reduce the inventory of mixed residues at Rocky Flats, including a schedule for implementation. While negotiations over the terms of the Compliance Order continue, DOE has been complying with certain provisions in order to satisfy CDH concerns.

In February 1992, DOE submitted the Mixed Residue Reduction Report which described the means by which DOE expected to eliminate mixed residues from Rocky Flats. The Mixed Residue Reduction Report included several options for residue elimination depending on the particular residue type or IDC. These options were further described in an update to the report prepared in November 1992. The primary means for accomplishing the residue elimination mission were described as follows:

A. Repackage the residues, with appropriate pretreatment as necessary, and ship them to a repository (the Ship-as-Waste alternative).

B. Repackage the residues, with appropriate pretreatment as necessary, and ship them to another DOE site for conversion into suitable waste forms or for storage (the Ship-as-Residue alternative).

Path A addresses the removal of residues from Rocky Flats by converting them into forms that are compliant with transportation requirements and repository waste acceptance criteria. An additional consideration in determining the amount of pretreatment necessary prior to the shipment of any given residue type is waste minimization. Pretreatment may consist only of repackaging and/or minor processing to meet current requirements or could involve more extensive processing to include actinide separation and/or concentration via aqueous, pyrochemical, or physical means to meet waste minimization goals.

Path B addresses the shipment of residues from Rocky Flats to another DOE site for conversion into suitable waste forms or for storage. Residues shipped to another DOE site could undergo a similar type of waste pretreatment and/or repackaging as that envisioned to take place at Rocky Flats via Path A. Alternatively, they could be stored at that site for an indefinite period of time pending a decision as to their ultimate disposition.

REGULATORY DRIVERS

Any shipment of TRU waste (or residues to be considered as wastes) to WIPP must meet the criteria described in Waste Acceptance Criteria for the Waste Isolation Pilot Plant (1). Included in Reference (1) are waste form requirements, transportation requirements, RCRA requirements, and performance requirements which relate to the long-term disposal of waste at the facility. The requirements that are the bases for the evaluations described in this report include the WIPP waste form requirements and the requirements imposed by the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) for transporting TRU waste.

The WIPP Operations and Safety Criteria address the issues of respirable fines, free liquids, pyrophoric materials, explosives, compressed gases, mixed wastes, specific activity, package weight, fissile gram equivalent (FGE) limits, surface radiation dose rate, removable surface contamination, thermal power, gas generation, labeling, and certification. Those criteria which have significant impacts on the ability of Rocky Flats to ship its residues in their current form to WIPP are those which require the immobilization of respirable fines, the oxidation of pyrophoric materials, the limitation of 200 FGE per drum, and the 200 mrem/hr surface radiation dose rate limit.

Transportation requirements are described in TRUPACT-II Authorized Methods for Payload Control (TRAMPAC) which was developed as part of the TRUPACT-II Safety Analysis Report (2). TRAMPAC also includes requirements specified by the DOT and the NRC. Many of the TRAMPAC requirements duplicate those in the WIPP Operations and Safety Criteria described above. Additional restrictions relevant to this report are weight limitations per drum, a 325 FGE limit for a single TRUPACT-II container, and further limitations on the thermal power and gas generation rates per drum as defined in the TRUPACT-II Content Codes (TRUCON) (3). TRAMPAC requirements also prohibit the use of internal shielding to meet surface radiation dose rate limits.

An evaluation of the WIPP, TRAMPAC, and TRUCON requirements indicate that there are three criteria (beyond the waste form requirements) that control the number of waste containers used to ship a given quantity of waste (or residue) from Rocky Flats to WIPP. These controlling criteria are the FGE limits of 200 grams per drum or 325 grams per TRUPACT-II, the 200 mrem/hr surface dose rate limit, and the thermal power or wattage limits.

CONSEQUENCES OF APPLYING CONTROLLING CRITERIA TO ROCKY FLATS RESIDUES

A quantitative assessment was made to determine the number of drums of waste that would be generated if the controlling criteria defined above were applied to the inventory of backlog residues at Rocky Flats. In order to complete this assessment, several assumptions were made. These assumptions were as follows:

1. Residues containing respirable fines or pyrophoric materials would be pretreated by immobilization and/or oxidation using standard processing techniques to meet WIPP Operations and Safety Criteria.
2. All residues, including those not requiring pretreatment, would be repackaged to meet FGE, surface radiation dose rate, and thermal power limits.
3. All pretreatment and repackaging operations would generate secondary wastes that would consist of both TRU and low-level wastes (LLW). Typical secondary wastes would consist of combustibles, metal, glass, leaded rubber gloves, filter media, and solidified sludges from the processing of liquid waste streams.
4. All packaging and repackaging operations would result in waste forms contained within two layers of plastic

(double-bagged) except where alternatives are specifically allowed by TRUCON provisions.

5. No shielding would be permitted other than what was provided by the drum and packaging materials per TRAMPAC requirements.
6. All residues were assumed to be mixed residues, and the WIPP no- migration variance would be in effect at the time that shipment was to begin; therefore, no treatment to meet Land Disposal Restrictions was proposed.

The assessment was made on an IDC-by-IDC basis. As an example, IDC 409 is defined as 30% unpulverized molten salt. This particular residue type was generated as a result of molten salt extraction (MSE) operations where the pre-processing concentration of magnesium chloride in the salt mixture was 30%. The MSE process was used to extract americium from plutonium in site-return metal; consequently, IDC 409 contains elevated concentrations of americium. It may also contain pyrophoric plutonium and americium metal dispersed throughout the salt matrix which would require that the residues be removed from their current package, placed in a furnace, heated to a molten state, and sparged with air to oxidize all reactive constituents. The backlog of IDC 409 consists of 271 55-gallon drums and 17 smaller containers. The net weight of the residue backlog is about 1400 kg.

The TRUCON content code for IDC 409 is RF124A (shipping category II.2AM) which allows the salts (after oxidation) to be packaged in a sealed metal can to the 200 FGE and 40 watt limits. The metal cans would be double-bagged out of the glove box and placed in a 55-gallon drum which would also be limited to 200 FGE and 40 watts. Therefore, it is conceivable that only one can of oxidized salt could be placed in a drum and only one drum placed in a TRUPACT-II container (due to the 325 FGE limit for the TRUPACT-II). In actuality, the most limiting of the controlling criteria is the surface radiation dose rate due to the high concentration of americium, and only about 100 grams of the bulk salt may be placed in a single drum. The remaining volume of the drum would be void space or filled with dunnage. As a result, the 1400 kg of bulk salt must be redistributed into approximately 14,000 partially filled drums to meet WIPP, TRAMPAC, and TRUCON requirements. Once the secondary wastes are considered, the total waste inventory amounts to 241 LLW and 14,498 TRU drums. These quantities of drums would require two truckloads to the Nevada Test Site (NTS) and 346 TRUPACT-II shipments to WIPP. Since IDC 409 is not FGE limited, each TRUPACT-II container may be filled to its design capacity of 14 drums, and each shipment can accommodate 42 drums.

A similar type of analysis was conducted with each of the remaining 87 residue types. Some were found to be limited by FGE, some by dose rate, and some by thermal power. In each case, the number of drums of waste was determined by applying the most restrictive of the controlling criteria to the inventory of that residue following any pretreatment, if required. Estimates of the number of drums of secondary wastes generated were included also. The net result is that the shipment as waste of the 7278 total containers of residues in the Rocky Flats residue backlog would generate 72,145 drums of TRU waste (nearly 20,000 cubic yards) and 2619 drums of LLW. These quantities of drums would require 14 trips to NTS and 5700 TRUPACT-II shipments to WIPP, each TRUPACT shipment consisting of three TRUPACT-II containers.

ALTERNATIVE CONSIDERATIONS

The results of the analyses described above indicate that the backlog of residues at Rocky Flats would have to be converted into an extraordinarily large number of waste drums in order to meet current repository and transportation requirements. Furthermore, both drums and TRUPACT-II containers would be packaged inefficiently. The primary reason for this result is that when the TRU waste disposal and transportation systems were first envisioned, plutonium recovery was a key element in the weapons production cycle. Residues undergoing recovery operations yielded a waste product that was typically less than about 0.1% by weight of plutonium. Some of the residues of concern today contain levels of plutonium that are in excess of two orders of magnitude greater than what are found in traditional TRU wastes. Hence, the requirement exists to perform extensive subdivision and redistribution of the residues to meet current waste disposal requirements.

Continuing analyses are being performed in order to identify means to make the packaging and/or shipment of residues more efficient and cost- effective. The goal of the analyses is two-fold: to reduce the number of drums to be generated and to reduce the number of shipments to be made. In order to achieve such reductions in support of residue disposal operations, it will be necessary to either relax one or more of the current requirements or provide means to mitigate the effects of exceeding the requirements. Sensitivity analyses have been conducted to determine where the most benefit could be derived from the least amount of perturbation of current requirements (4). As might be expected, significant potential reductions in the number of waste drums and/or shipments could be realized as a result of relaxations of the FGE, dose rate, and thermal power limitations.

Once again, an analysis was conducted on an IDC-by-IDC basis. The most restrictive controlling criterion for a given IDC was assumed to be relaxed to the point at which the second most restrictive criterion would take effect. For IDC 409, the second most restrictive criterion is the FGE limit. If the 200 mrem/hr dose rate were relaxed or, alternatively, each drum of MSE salt could be shielded to the extent that the drum could be filled to the 200 FGE limit, the number of drums could be reduced by greater than 90%. If all residue types were subjected to the same manner of relaxation, the total number of TRU waste drums shipped to WIPP would potentially decrease from 72,000 to approximately 19,000. However, the more efficiently drums are packaged, the more inefficiently TRUPACT-II containers must be packed, so the number of TRUPACT-II shipments would not be decreased by a corresponding amount but would actually increase.

It may be unrealistic to assume that a safety-related requirement such as surface radiation dose rate could be relaxed beyond the 200 mrem/hr limit. Site-specific programs to keep personnel exposure as low as reasonably achievable (ALARA) often mandate much lower dose rates. For example, in order that the WIPP ALARA objectives are met, a surface dose rate of only 6 mrem/hr has been proposed. What may be a more feasible alternative is to allow packaging in a manner that provides additional shielding thereby allowing a larger inventory of material to be contained in a 55-gallon drum. Again, using IDC 409 as an example, the 200 mrem/hr

restriction prohibits more than 100 grams of MSE salt from being packaged in a single waste drum. Placing 1000 grams of such salt in a drum would increase the unshielded surface dose rate to approximately 2000 mrem/hr. However, if 1000 grams of salt were to be packaged within a section of steel pipe (6-inch diameter NPT Schedule 40 pipe with a nominal wall thickness of 0.280 inches), the 2000 mrem/hr dose rate would be attenuated to meet not only the 200 mrem/hr limit but the proposed 6 mrem/hr ALARA limit for WIPP as well. Shielding calculations were based on attenuation of the 60 keV gamma from Am^{241}.

For those IDC's like MSE salts which are limited by the surface radiation dose rate, several options exist for improving the efficiency of their transportation and ultimate disposal. Aside from a self-shielding internal container, additional options are: 1) provide for an internally shielded 55-gallon drum (currently prohibited by TRAMPAC requirements), 2) switch from 55-gallon drums to remote-handled canisters or casks (which would require the continued development of a new transportation system), and 3) immobilize the material in a self-shielding matrix.

Fewer options exist for those IDC's whose most restrictive controlling criterion is the thermal power limit. To increase the payload of a 55- gallon drum, the amount of hydrogenous material in contact with the residue must be minimized in order to preclude pressurization due to the buildup of gases from radiolytic decomposition. Thermal power limits are based on a graduated scale that is dependent on both the nature of the material and on the number of layers of plastic in which it is packaged. Little can be done about the nature of the residue material itself with the possible exception of incineration of combustibles and the subsequent disposal of the resultant ash. Another option is to reduce the number of plastic bags used to remove the material from the glove box line. The assumption that has been used thus far in the analysis has been two layers of plastic which is probably an irreducible minimum if traditional bag-out operations are to be conducted. Bagless posting operations may have some applicability, but a more feasible approach may be to propose changes to TRUCON codes to allow more IDC's to be packaged in metal cans. The cans may still need to be bagged out of the glove box, but the thermal power limits would be based on zero layers of plastic in immediate contact with the residue. Yet another alternative is to monitor gas evolution from drums for a period of time prior to their shipment to WIPP. If gas generation rates are acceptably low, then shipment could possibly be permitted regardless of the nature of the material or the layers of plastic in which it was contained.

The criterion that may be the most difficult to change is the FGE limit for individual drums. FGE limits are based on accident scenarios and are established to minimize the risk of a criticality occurring during credible accidents. A criticality represents the accident situation with the most serious consequences. Some relief may be possible if the residue were to be immobilized in a non-leachable material that also functioned as a nuclear poison, e.g., borosilicate glass. Also, WIPP has already approved a 500 FGE limit for the DOT 6M container, another contact-handled package which includes a section of Schedule 40 pipe as an inner container.

Another approach would be to propose raising the TRUPACT-II FGE limit from 325 to 400 grams. If drums are packed to their 200 FGE limit in order to minimize the total number of drums, then only one drum may be placed in a TRUPACT-II container without exceeding the 325 gram limit. One shipment would then consist of three waste drums instead of the 42 drums for which the TRUPACT-II system was originally designed. Increasing the TRUPACT-II FGE limit to 400 grams has the potential of cutting the number of shipments in half.

Rocky Flats personnel are discussing options with the WIPP Project Integration Office to pursue possible changes to the criteria that cause the shipment and ultimate disposal of residues to be accomplished in an inefficient and costly manner. For example, requests for evaluation of rule changes have been submitted for consideration, and indications are that WIPP has been very receptive to these proposals. Specific areas that are currently under investigation are: 1) modification to TRUCON requirements allowing additional IDC's to be packaged in metal cans, 2) approval of a thick-walled, self-shielding inner can, 3) increasing the FGE limit for the TRUPACT-II container from 325 to 400 grams (or some multiple of 200 grams), 4) evaluation of canisters and transport systems to use in place of the TRUPACT-II system for the shipment of Rocky Flats residues, and 5) approval of pre-shipment gas evolution testing as an alternative to meeting current thermal power limits.

Several levels of approval will be required before any proposed rule changes can be implemented, and the extent of the approval cycle will vary depending on the rule change in question. As a minimum, approval will be required from the WIPP Waste Acceptance Criteria Certification Committee and from the NRC and DOT through the Westinghouse Packaging and Transportation Group. Any approval will most likely have to be preceded with hazards assessments, safety analyses, and accident scenario tests. Changes, if any, will then be promulgated through revisions to the Waste Acceptance Criteria for the Waste Isolation Pilot Plant, TRAMPAC, and TRUCON documents. Subsequent revisions will then be made to the appropriate Rocky Flats waste management, transportation, and quality assurance documents. Such reviews, approvals, and revisions will probably take several years to implement.

Although WIPP is not expected to be fully operational in the immediate future, there is some urgency in determining the feasibility of effecting some of the rule changes discussed in this report. Long-range planning for the elimination of residues from Rocky Flats is underway. If the ship-as- waste alternative proves to be a viable pathway for the ultimate disposition of some or all of the residue backlog, then planning for the development of an appropriate facility can proceed. If rule changes are not considered feasible, on the grounds of safety or environmental considerations, then alternative plans for the elimination of Rocky Flats residues must be developed. Since the root cause of packaging and shipping inefficiencies is the presence of plutonium and americium, then some form of actinide separation may prove to be a more economically favorable course of action.

CONCLUSIONS

The disposal as TRU waste of the existing backlog of plutonium- bearing residues at the Rocky Flats Plant would result in a twenty-fold increase in volume in order to meet existing waste acceptance criteria and transportation regulations. In addition to meeting WIPP restrictions such as the limitations on respirable fines and pyrophoric materials, TRAMPAC and TRUCON criteria must also be met. The

criteria that contribute most to the volume increase are the FGE, surface radiation dose rate, and thermal power limits. Analysis of each of 88 residue types has identified the most restrictive of these three criteria as well as the potential benefit in terms of volume reduction that could be achieved should that criterion be relaxed to the point that the second most restrictive criterion took effect. Relaxation of the most restrictive criterion for all residue types would result in a combined volume reduction of about 75%, i.e., the net volume increase would be only about five-fold rather than twenty-fold. The feasibility of actually relaxing key WIPP, TRAMPAC, and TRUCON requirements is under continuing investigation.

REFERENCES

1. "Waste Acceptance Criteria for the Waste Isolation Pilot Plant," WIPP-DOE-069, Revision 4 (December 1991).
2. "Safety Analysis Report for the TRUPACT-II Shipping Package (SARP)," Docket No. 71-9218, Revision 9 (1990).
3. "TRUPACT-II Content Codes (TRUCON)," DOE/WIPP 89-004, Revision 4 (April 1991).
4. G. N. MOORE and M. A. RIVERA, "Sensitivity Analysis," Residue Elimination Project Report No. DOE-010-001 (January 20, 1993).