NEWLY PROMULGATED LAND DISPOSAL RESTRICTION TREATMENT STANDARDS FOR MIXED WASTE DEBRIS

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ABSTRACT

The U.S. Environmental Protection Agency recently promulgated land disposal restriction (LDR) treatment standards for hazardous debris in a final ruling published in the August 18, 1992, Federal Register. The debris ruling requires that hazardous debris contaminated with radioactive constituents (i.e., mixed waste debris) be treated in accordance with the LDR treatment standards. In general, mixed waste debris is defined as discarded solid material with a particle size greater than 60 millimeters (mm) that exhibits a characteristic of hazardous waste or is contaminated with a listed hazardous waste and is regulated under the Atomic Energy Act. The debris treatment standards describe how hazardous and mixed waste debris must be treated prior to land disposal. Seventeen best demonstrated available technologies (BDAT) are identified for treating hazardous and mixed waste debris. The BDATs either extract, destroy, or immobilize the hazardous constituents that contaminate the debris. The debris rule is unique in that the treatment standards are more easily adapted to mixed waste than previous LDR rulings. This paper describes the BDAT technologies and treatment standards identified in the debris rule, as well as the implications for managing mixed waste debris.

INTRODUCTION

On August 18, 1992, the U.S. Environmental Protection Agency (EPA) established LDR treatment standards for hazardous debris (1). This final ruling, hereafter referred to as the debris rule, requires hazardous debris that is also regulated under the Atomic Energy Act (AEA) due to radioactive contaminants (i.e., mixed waste debris) to be subject to the debris treatment standards. The debris rule establishes treatment standards based on performance and/or design and operating requirements for 17 BDATs. The treatment standards describe how mixed waste debris must be treated prior to land disposal and how, under certain circumstances, treated debris is no longer regulated as a hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA). The implications of the debris rule are important to managing potentially large volumes of mixed waste debris that could be generated by environmental restoration and decontamination and decommissioning activities at U.S. Department of Energy, U.S. Department of Defense, and commercial nuclear facilities. Figure 1 presents a simplified flow diagram of applying the debris rule to mixed waste debris. The information presented in this paper describes the specific requirements and exceptions for the BDAT technologies and treatment standards covered under the debris rule, as well as potential impacts to mixed waste debris.

DEFINITION OF DEBRIS

Debris is defined as "solid material exceeding a 60-mm particle size that is intended for land disposal and that is a manufactured object, plant, or animal matter or natural geologic materials (e.g., cobbles and boulders)" (1). Mixtures of debris and other materials, such as soil, are considered debris as long as debris comprises the majority of the mixture (based on volume). Debris is not required to be dry and may contain liquids; however, any liquids that separate from debris must be managed separately (2). Materials commonly referred to as debris include glass, metal, plastic, rubber, brick, cloth, concrete, paper, pavement, rock, and wood.

In addition to understanding what materials are considered debris, it is equally important to understand what materials are not debris. Materials that meet the definition of debris but have a previously established treatment standard, such as radioactive lead solids, are not debris. Process residuals generated from waste treatment, such as stabilized wastes, are not debris. However, the final ruling specifies that discarded process equipment, such as pumps and filters, are debris and are not considered process residuals. Finally, intact containers are never considered debris, regardless of the contents of those containers (2).

Debris is classified as mixed waste when the debris exhibits a characteristic of hazardous waste (i.e., ignitable, corrosive, reactive, toxic), is contaminated with a listed hazardous waste, and is contaminated with radioactive constituents regulated under the AEA. Typical examples of mixed waste debris include high-efficiency particulate air filters; process equipment; concrete and steel; tanks, piping, and pumps; reactor components; monitoring equipment and electronic components; personal protective equipment; refractory brick; laboratory equipment (e.g., glassware, filter paper, etc.); and glove boxes.

BDAT DESCRIPTIONS

The debris rule identifies 17 BDATs for treating mixed waste debris. These 17 technologies are classified into three general treatment categories that include extraction (physical, chemical, and thermal), destruction, and immobilization. Table I lists the BDATs and a brief description of each technology.

DEBRIS TREATMENT STANDARDS

The treatment standards for hazardous and mixed waste debris are based on performance and/or design and operating requirements established for each BDAT in Table I. Performance standards establish the effect a particular technology must have on debris to ensure effective treatment, whereas design and operating standards define acceptable characteristics of debris and specific operating parameters that will ensure effective treatment. Although any BDAT can be used to treat any debris, the final rule does prohibit the use of certain technologies for treating specific RCRA contaminants.

The treatment standards for thermal desorption, biodegradation, chemical oxidation, and chemical reduction require

TABLE I

Best Demonstrated Available Technology Descriptions

	Physical Extraction Technologies
Abrasive Blasting:	Removal of surface contamination or contaminated surface layers from debris using water and/or air pressure to propel a solid media (e.g., aluminum oxide grit).
Scarification, Grinding, and Planing:	Use of mechanical tools to remove surface contamination or contaminated surface layers from debris.
Spalling:	Drilling or chipping holes into debris surfaces and exerting lateral force to split away contaminated surface layers.
Vibratory Finishing:	Process involving scrubbing media, flushing fluid, and vibratory energy to strip away surface contamination or contaminated surface layers (process is not compatible with certain debris and contaminant combinations).
High-Pressure Steam and Water Sprays:	High-pressure scouring of debris using either steam or water to physically remove surface contamination or contaminated surface layers.
	Chemical Extraction Technologies
Water Washing and Spraying:	Similar to high-pressure steam and water sprays but enhanced with reagents, such as acids or detergents, to dissolve and flush hazardous constituents.
Liquid-Phase Solvent Extraction:	Dissolution and removal of hazardous constituents into nonaqueous liquids or solutions (process is not compatible with certain debris and contaminant combinations).
Vapor-Phase Solvent Extraction:	Dissolution of hazardous constituents into an organic vapor (process is not compatible with certain debris and contaminant combinations).
	Thermal Extraction Technologies
High-Temperature Metal Recovery:	Separation of metals from debris in slagging or nonslagging furnaces.
Thermal Desorption:	Indirect heating to volatilize and separate hazardous organic contaminants from debris (thermal desorption is distinguished from thermal destruction in that the purpose of thermal desorption is to volatilize contaminants for subsequent destruction or other form of treatment).
	Destruction Technologies
Biodegradation:	Aerobic or anaerobic digestion of hazardous organic contaminants and nonmetallic inorganic compounds, such as nitrates.
Chemical Oxidation:	Oxidation of hazardous constituents with reagents, such as hydrogen peroxide and ozone (process is not compatible with certain debris and contaminant combinations).
Chemical Reduction:	Reduction of hazardous contaminants with reagents, such as sodium and potassium (process is not compatible with certain debris and contaminant combinations).
Thermal Destruction:	High-temperature destruction of hazardous organic contaminants and organic debris in an incinerator (or other thermal treatment unit).
	Immobilization Technologies
Macroencapsulation:	Application of surface-coating materials (e.g., polymers, resins, and plastics) or use of a jacket of inert inorganic materials to reduce exposure of debris surfaces.
Microencapsulation:	Stabilization of debris with materials, such as Portland cement or lime/pozzolans.
Sealing:	Application of an appropriate material that adheres tightly to the debris surface to reduce exposure of debris surfaces.

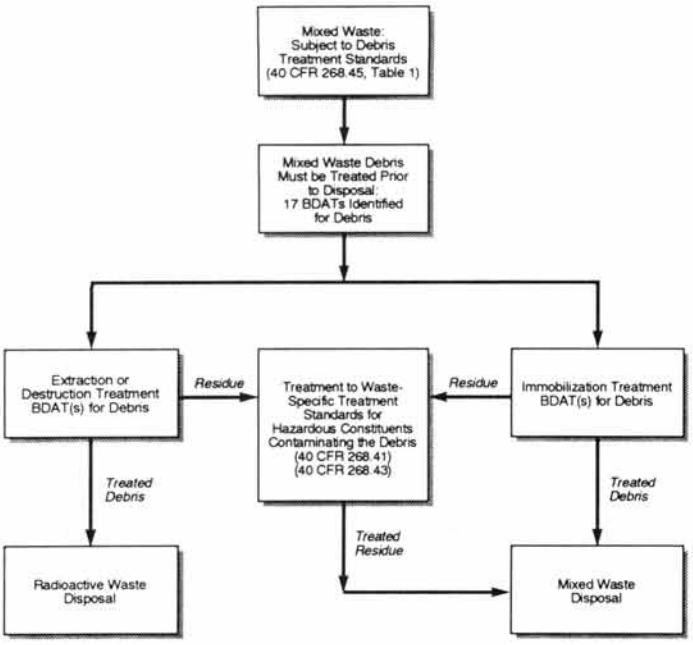

Fig. 1. Mixed waste debris management cycle.

an Equivalent Technology approval under 40 Code of Federal Regulations (CFR) 268.42(b). This requirement is a result of the EPA being unable to establish performance and/or design and operating standards for these technologies to ensure effective treatment of RCRA contaminants. The purpose of the Equivalent Technology demonstration is to ensure that these technologies will be as effective for treating RCRA contaminants as the other BDAT in Table I.

It is important to note that all mixed waste debris is not subject to the debris treatment standards. Mixed waste debris contaminated with RCRA constituents that have a technology-based treatment standard in 40 CFR 268.42 are not subject to the debris treatment standards. In this situation, mixed waste debris must be treated with the technology specified. The RCRA constituents subject to the debris treatment standards are those listed hazardous wastes identified in 40 CFR 268.41 and 268.43, toxic metals and pesticides (D004-D017), and the reactive characteristic (D003) resulting from cyanide.

Physical Extraction Technologies

Physical extraction technologies are designed to remove contaminated surface layers from debris or to remove contaminants adhering to debris surfaces. As a result, the performance standards for all physical extraction technologies listed in Table I are based on removing contaminants from the surface of debris or the contaminated surface layer from debris. First, all debris must be treated to a clean debris surface, which is defined as a surface free of all visible contaminated soil and hazardous waste, except residual staining consisting of no more than 5 percent of each square inch of surface area (1). In addition to a clean debris surface, brick, cloth, concrete, paper, pavement, rock, and wood debris must be adequately processed to remove a minimum of 0.6 centimeter (cm) of each surface. No design and operating standards are established for the physical extraction technologies, and there are no restrictions on the RCRA constituents that can be treated using these technologies.

Chemical Extraction Technologies

Chemical extraction technologies are designed to remove RCRA contaminants from debris by dissolution into a cleaning solution. Therefore, treatment standards established for these technologies are based on dissolving contaminants contained in debris or adhering to debris surfaces. The performance standard is the same for all three chemical extraction technologies listed in Table I and requires all debris to be treated to a clean debris surface. The chemical extraction technologies must also meet specific design and operating standards when treating brick, cloth, concrete, paper, pavement, rock, and wood debris:

- Debris is limited to no more than 1.2 cm in thickness.
- Debris surfaces must remain in contact with the cleaning solution for at least 15 minutes (water washing and spraying or liquid-phase solvent extraction).
- Debris surfaces must remain in contact with the cleaning solution for at least 60 minutes (vapor-phase solvent extraction).

Several contaminant restrictions are placed on the chemical extraction technologies. For example, RCRA constituents that are not soluble to at least 5 percent by weight in the cleaning solution are restricted from treatment by these technologies. In addition, chemical extraction technologies are restricted for treatment of debris contaminated with dioxin-listed wastes (F020, F021, F022, F023, F026, F027), unless an Equivalent Technology approval is obtained.

Thermal Extraction Technologies

Two separate high-temperature metal recovery (HTMR) technologies are discussed in the final ruling—slagging and nonslagging. These technologies are designed to separate metals from debris but may also be used separate organics from debris. No performance or design and operating standards are established for slagging HTMR furnaces due to the effectiveness of this treatment for most RCRA contaminants (one exception being chlorinated dioxin wastes) and debris types (1). The treatment standards for nonslagging HTMR furnaces require that both metals and organics be separated from debris. By definition of the treatment, metal contaminants will be removed from debris; however, additional requirements are established to ensure organic contaminants are removed. Treated debris must be separated from treatment residues using physical or mechanical methods, such as vibratory screening or water washing. The separation process does not need to produce a clean debris surface as described previously, although separated debris must be free of residues adhering to the surfaces. The separated residues are then used as a surrogate to establish the effectiveness of the treatment for removing organics from debris. Treatment is considered effective if the separated residues meet the waste-specific treatment standards for those organic compounds contaminating the debris. Finally, both HTMR technologies are restricted from treating debris contaminated with dioxin-listed wastes, unless an Equivalent Technology approval is obtained.

The treatment standards for thermal desorption require an Equivalent Technology demonstration, regardless of the contaminants and debris to be treated. Similar to nonslagging HTMR furnaces, treated debris must be separated from treatment residues, and those separated residues must meet the waste-specific treatment standards for organic compounds contaminating the debris to ensure effective treatment. One

design and operating requirement is established for thermal desorption when treating brick, cloth, concrete, paper, pavement, rock, and wood debris, which limits the thickness of these materials to no more than 10 cm. Also, this technology is restricted from treating debris contaminated with metals other than mercury.

Destruction Technologies

The treatment standards are the same for biodegradation, chemical oxidation, and chemical reduction and require an Equivalent Technology approval. Treated debris must be separated from treatment residues (as described previously), and the separated residues must meet the waste-specific treatment standards for organic compounds contaminating the debris to ensure the process is effective. In addition, these technologies must satisfy the design and operating standard requiring brick, cloth, concrete, paper, pavement, rock, and wood debris to be no more than 1.2 cm in thickness. Finally, these technologies are restricted from treating metal-contaminated debris.

The treatment standards for thermal destruction do not require an Equivalent Technology demonstration (unless treating debris contaminated with dioxin-listed wastes), but they do require the same separation of treated debris and residues as described for the other destruction technologies. The effectiveness of thermal destruction is also based on whether treatment residues satisfy the waste-specific treatment standards for organic compounds contaminating the debris. Thermal destruction is restricted from treating inorganic debris such as brick, concrete, glass, metal, pavement, and rock contaminated with metals other than mercury. However, these contaminant restrictions do not apply to the thermal destruction process of vitrification.

Immobilization Technologies

Immobilization technologies are designed to produce a final waste form that will, after land disposal, substantially reduce the likelihood of contaminant migration. Therefore, nonobjective performance standards are established for the immobilization technologies. These technologies are not restricted from treating any RCRA contaminants that may be contained in mixed waste debris. In fact, debris that is inherently hazardous must be treated by an immobilization technology. Inherently hazardous debris is defined as any debris that is hazardous because it is comprised of a toxic material, such as a cadmium reactor component.

The performance standard for macroencapsulation specifies that debris must be completely encapsulated, and the encapsulating material must be resistant to degradation by the debris itself, the waste contained in the debris, and other materials (such as leachates and microbes) that may contact the treated debris after disposal. The performance standard for microencapsulation requires only that the leachability of hazardous constituents contained in debris is reduced. The performance standard for sealing is the same as macroencapsulation in that the sealing material must prevent exposure of the debris to leachates and must be resistant to degradation by the debris, contaminants contained in the debris, and other materials that may come into contact with the treated debris after disposal.

Additional Options and Requirements

In lieu of the treatment standards described above, mixed waste debris can be treated to the waste-specific treatment standards for the RCRA constituents contaminating the debris. An Equivalent Technology approval under 40 CFR 268.42(b) can be obtained to allow debris treatment using an alternative technology to those listed in Table I. The Equivalent Technology demonstration can also be used to waive the thickness limitation required by treatment standards for several BDATs when treating brick, cloth, concrete, paper, pavement, rock, and wood debris.

All treatment residues must be separated from treated debris and are required to meet the waste-specific treatment standards for the RCRA constituents contaminating the debris prior to disposal. Residue from spalling is the noted exception, in that spalled materials are considered untreated debris subject to the debris treatment standards.

In some instances, size reduction may be required to comply with certain treatment standards, such as the 1.2-cm-thickness limitation on brick, cloth, concrete, paper, pavement rock, or wood debris treated by water washing and spraying. If size reduction reduces the particle size below the 60-mm minimum requirement for debris, the material remains debris as long as the debris surfaces were free of any adhering soils or other waste prior to size reduction. If the surfaces of debris are not cleaned of adhering waste prior to size reduction, then any material below the 60-mm particle size is not debris and is subject to the waste-specific treatment standards for the RCRA constituents contaminating the debris. As described previously, cleaning and separating debris from adhering soils or other waste can be accomplished with simple physical or mechanical techniques.

IMPLICATIONS ON MANAGING MIXED WASTE DEBRIS

On July 3, 1986, the EPA published a notice in the Federal Register (51 FR 24504) that established radioactive mixed waste as being subject to RCRA regulation (3). Subsequently, a number of waste management concerns have been raised regarding the application of RCRA LDR requirements to radioactive mixed waste. Previous LDR rulings have typically not taken into account the unique considerations involving mixed waste treatment, such as:

- Applicability of treatment technologies to the radioactive component of mixed waste
- Health and safety issues involving handling mixed waste
- Sampling and analysis difficulties in determining treatment effectiveness
- National capacity of established treatment facilities capable of treating mixed waste.

The LDR treatment standards established in the debris rule, however, are more easily adapted to mixed waste than previous LDR rulings. Generators of mixed waste debris should be aware of the implications the debris rule will have on treating these wastes for land disposal, such as:

- Providing flexibility in selecting treatment technologies
- Managing mixed waste debris treated by extraction or destruction technologies as nonhazardous waste

- Minimizing and potentially eliminating sampling and analysis requirements for RCRA constituent concentrations to verify treatment effectiveness.

Flexibility in Using BDATs

Mixed waste debris consists of many different materials with different properties and characteristics. Previous LDR rulings established treatment standards for individual RCRA constituents, which made treatment of such diverse materials difficult. The debris rule establishes a total of 17 different BDATs from which the generator or treatment operator can select and use the simplest, safest, and easiest technology for implementing treatment(s) that will enable compliance with the debris treatment standards. In the preamble to the final rule published in the Federal Register, the EPA stated that "there is sufficient flexibility in the debris treatment standards to enable generators or treaters to select a technology that will effectively treat the hazardous contaminants without posing an unreasonable risk to human health and the environment because of the radiological nature of the waste" (1).

The debris rule establishes specific restrictions and requirements that prevent the use of BDATs for situations in which the technologies will not be effective. Therefore, the generator or treatment operator must select technologies that will be effective, based on the physical properties of the debris as well as the contaminants. Although the debris rule allows the use of any BDAT to treat any debris, the treatment standards vary for many technologies according to the type of debris treated (1). Physical extraction technologies, for example, must remove 0.6 cm of the surface layer from porous debris to comply with the treatment standard. These technologies would not be applicable to porous debris that does not have 0.6 cm of surface to remove, such as thin paper or cloth. The debris rule also prohibits the use of certain BDATs for treating specific RCRA constituents; for example, thermal desorption is prohibited from treating debris contaminated with metals other than mercury. The debris treatment standards are designed, however, such that several BDATs will be applicable for treating any particular debris-contaminant combination.

Managing Treated Debris as Nonhazardous Waste

Possibly the most important aspect of the debris rule is that under certain circumstances, treated mixed waste debris is no longer considered a hazardous waste under RCRA Subtitle C regulation. This can be accomplished in either one of two ways: EPA can determine on a case-by-case basis that the debris no longer contains RCRA hazardous waste; or debris may be treated, which ensures compliance with the debris treatment standards for extraction or destruction technologies (provided the treated debris does not exhibit a characteristic of hazardous waste). This represents a significant change from previous LDR rulings, in that there has typically been no means of removing a listed hazardous waste code from a contaminated material due to the derived from and/or mixture rules (with the exception of the delisting process).

Under the debris rule, mixed waste debris is not considered a hazardous waste regulated under RCRA Subtitle C once treated to the performance and/or design and operating standards for an extraction or destruction technology, rather than an immobilization technology, and provided the treated debris does not exhibit a characteristic of hazardous waste (1). Mixed waste debris treated by an immobilization technology, however, remains a mixed waste subject to RCRA Subtitle C regulation and must be disposed of in a mixed waste landfill.

The potential for mixed waste debris to be rendered nonhazardous by an EPA determination or treatment would significantly simplify the requirements involved with managing these wastes, such as handling, storage, transportation, and disposal. Treated mixed waste debris that is no longer hazardous can be disposed of as radioactive waste, as opposed to mixed waste. This is a significant implication of the debris rule, because the current national capacity for mixed waste disposal is limited at best. Even if the capacity for mixed waste disposal increases in the future, the cost of disposing mixed waste will inevitably be higher than for radioactive waste.

Reduced Sampling and Analysis

Sampling and analysis requirements are important when managing mixed waste because of safety considerations for workers that handle, sample, and analyze these wastes. Previous LDR rulings have required analytical verification of contaminant concentrations to validate compliance with treatment standards. Debris, in particular, is difficult to analyze due to uncertainties in establishing a representative sample (3). The debris rule simplifies sampling and analysis requirements after treatment by establishing treatment standards based on performance and/or design and operating requirements. These treatment standards do not require analysis of hazardous constituent concentrations to verify LDR compliance. However, debris treated by extraction or destruction technologies must not exhibit a characteristic of hazardous waste prior to exiting RCRA Subtitle C regulation.

The debris rule does not necessarily require sampling and analysis; therefore, the generator or treatment operator is responsible for determining whether there is reasonable suspicion that debris treated by an extraction or destruction technology still exhibits a characteristic of hazardous waste. Debris that did not exhibit a hazardous waste characteristic prior to treatment would not be suspected of exhibiting a characteristic of hazardous waste after treatment. Conversely, debris that exhibits a hazardous waste characteristic prior to treatment might be suspected of exhibiting that characteristic after treatment. Determining whether or not sampling and analysis will be required could be based on bench-scale treatment test results, full-scale treatment results for similar debris-contaminant combinations, or simply the type of debris and BDAT used. Immobilized debris, as noted previously, remains a mixed waste after treatment and therefore does not require sampling and analysis to verify compliance with treatment standards.

SUMMARY

The EPA has established a final ruling on LDR treatment standards for hazardous debris. The debris rule requires that hazardous debris that is also contaminated with radioactive constituents must comply with the debris treatment standards prior to land disposal. Mixed waste debris is generally defined as discarded solid material having a particle size greater than 60 mm that contains a listed hazardous waste, or exhibits a characteristic of hazardous waste, and is contaminated with radioactive constituents regulated under the AEA. The debris rule differs from previous LDR rulings in that the treatment standards are more easily adapted to mixed waste debris. The debris rule establishes 17 BDAT for treatment and allows the generator or treatment operator to select the most

implementable technology that will effectively result in compliance with the treatment standards while ensuring safety of human health and the environment. The debris rule establishes treatment standards in the form of performance and/or design and operating requirements that reduce or eliminate sampling and analysis to establish compliance with those treatment standards. The most significant aspect of the debris rule is that debris treated by extraction or destruction technology is no longer regulated as a RCRA hazardous waste, provided the treated debris does not exhibit a characteristic of hazardous waste.

REFERENCES

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