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Project Summary

Impact of Resource Conservation and Recovery Act on FBC Residue Disposal

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The Resource Conservation and Recovery Act of 1976 (RCRA) created a new level of regulatory control of solid waste disposal. The emphasis of the Act is on identifying hazardous wastes, regulating hazardous waste from cradle to grave (RCRA Subtitle C), and improving nonhazardous waste disposal practices (Subtitle D). The fluidized-bed combustion (FBC) process for electric power generation produces large quantities of residue (spent sorbent and ash) which are subject to RCRA control. The key provisions of RCRA that have the greatest impact on FBC residue disposal are Subtitles C and D. This report provides an assessment of RCRA and its current regulations with respect to FBC residue disposal and, of special importance, the proposed Sec. 3001 regulations for hazardous waste identification. RCRA tests, in particular the Sec. 3001 extraction procedure (EP), were performed on a variety of FBC residues representing several process variations. Results indicate that FBC residue is nonhazardous. The impact of RCRA regulations and criteria proposed prior to promulgation on May 19, 1980, on FBC residue disposal is assessed.

This report on the impact of RCRA contains the results of work defined and completed as part of the spent sorbent and ash disposal task of the contract. Work on this specific task was performed from January 1979 to March 1980. Related documentation is found in the following reports:

"Disposal of Solid Residue from Fluidized-Bed Combustion: Engineering and Laboratory Studies," EPA-600/7-78-049 (NTIS PB 283-082), issued in March 1978, which presented the results of work performed from January 1976 to January 1977

"Experimental/Engineering Support for EPA's FBC Program: Final Report, Vol. III, Solid Residue Studies, EPA-600/7-80-015c, issued in January 1980. The report documents work performed from January 1977 to January 1979 and subsequent extensions from review of the draft through October 1979."

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Fluidized-bed combustion (FBC) is an emerging technology that is being developed to utilize coal in an environmentally acceptable manner. FBC processes, operated at atmospheric (AFBC) or at elevated (PFBC) pressure, employ limestone or dolomite to remove sulfur during combustion, thus eliminating the need for flue gas desulfurization

(FGD). Unlike the scrubber sludges, dry granular solids of 0 to 6 mm in diameter result from the FBC process. There are two major sources of solid residue from an FBC system: spent bed overflow material and entrained carry-over. The former consists largely of partially sulfated limestone or dolomite sorbent (calcium sulfate [$CaSO_4$], calcium oxide [CaO], calcium carbonate [$CaCO_3$], magnesium oxide [MgO]); and the latter consists of finer particles of partially sulfated sorbent and coal ash and char entrained from the bed and captured by a particulate control system. The carry-over is typically collected in several stages of the particulate control system commonly represented by cyclones, baghouses, electrostatic precipitators, granular-bed filters, etc.

Major concerns for FBC residue disposal are the high pH, total dissolved solids (TDS), calcium, and sulfate (SO_4) levels in the leachate; the thermal activity; and the quantity of solid to be disposed of. Heavy metal elements and total organic carbon (TOC) in FBC leachate are typically below the drinking water standards (DWS) or the detectable levels.

On the basis of our findings, we have concluded that residue disposal will not be an obstacle in the commercialization of the FBC process, but further investigation is required. For example, will FBC residue be classified as hazardous or nonhazardous waste under the Resource Conservation and Recovery Act (RCRA), and how will RCRA regulations affect FBC residue disposal?

Conclusions

The fluidized-bed combustion (FBC) process for electric power generation produces solid wastes that fall under the jurisdiction of RCRA. The key provisions of RCRA that could have the greatest impact on FBC residue disposal are Subtitle C on hazardous waste management, in particular the hazardous waste identification criteria under Sec. 3001 and Subtitle D, which regulates disposal of nonhazardous waste.

Impact of Hazardous Waste Identification Criteria on the Classification of FBC Residue (Subtitle C)

RCRA Sec. 3001 of Subtitle C requires EPA's Office of Solid Waste (OSW) to promulgate criteria for identification of hazardous waste, which OSW began to develop in 1977. In March 1978, a first draft was released which contained tentative hazardous identification methods. A toxic extraction procedure (TEP) was drafted to determine the toxicity of a waste. Those wastes whose TEP leachate had 10 times the National Interim Primary Drinking Water Regulations (10 x NIPDWR) would be considered hazardous. Public comments were requested on the draft regulations. We responded by testing typical FBC residues and reference materials (raw sorbent and conventional FGD residue). Results of our TEP testing and recommendations on the TEP procedure were communicated to EPA in 1978.

On December 18, 1978, EPA formally proposed in the *Federal Register* RCRA Sec. 3001 regulations which were scheduled to be promulgated in April 1980, following completion of this report. The TEP was significantly modified on the basis of the additional information supplied by public comments (including our recommendations) and was renamed the "extraction procedure" (EP) with 10 x NIPDWR of heavy metal elements as the hazardous criteria. According to proposed Sec. 3001, a waste can be classified as hazardous either by being on the hazardous lists (proposed by EPA on December 18, 1978, and August 22, 1979) or by possessing any of the proposed hazardous characteristics. The FBC residue is not on the hazardous lists and, therefore, its classification must be determined from the proposed criteria for hazardous characteristics—ignitability, corrosivity, reactivity, and toxicity. Of the four characteristics, toxicity, for which EPA has proposed an extraction procedure (EP) and hazardous criteria (10 x NIPDWR), causes the most concern for FBC residue. Because of the potentially large volume of residue from various industrial sources and the limited data on their potential hazard, EPA has proposed a list of "special wastes" under Sec. 3004; "utility waste" is among these five special wastes. Should FBC waste be deemed hazardous according to Sec. 3001, we expect it would be classified as a utility waste under the special waste category and would be regulated with partial exemption from the cradle-to-grave regulations under hazardous waste management Sec. 3002 to 3005. On the other hand, should FBC waste be identified as nonhazardous, it would fall under the jurisdiction of Subtitle D, and its disposal would then be regulated as a sanitary landfill waste.

FBC residue is not ignitable, corrosive, or reactive according to the proposed criteria. To determine if it is toxic, 17 FBC residues representing several process variations, [atmospheric (AFBC) and pressurized (PFBC) fluidized-bed boilers/PFBC adiabatic combustor, bed/carry-over, with/without carbon burnup cell (CBC), once-through/regenerative operation, limestone/dolomite sorbents] together with reference materials (FGD residues, conventional ash, and raw sorbent) were tested using the former TEP and the proposed EP tests. Results that showed the EP leachates to have Ag, As, Ba, Cd, Cr, Hg, Pb, and Se below 10 x NIPDWR indicated in the FBC residue to be nontoxic and, thus, nonhazardous. The only exception among the EP leachates of 17 FBC residues was the leachate from an Exxon PFBC run with sorbent regeneration which had an average As concentration of 0.94 ppm (compared to the criterion of 0.5 ppm). AFBC and PFBC fines ($< 15\ \mu m$) from the third-stage cyclone and bag filter and PFBC regenerator bed material had Cr concentrations in their EP leachates (0.15 to 0.4 ppm) much higher than the others (< 0.1 ppm) and were close to the criterion for Cr, 0.5 ppm. Future investigations, therefore, should emphasize samples from these sources.

We assumed that the FBC residues would not contain chlorinated organic pesticides and herbicides and, thus, did not perform EP analyses for Lindane, Methoxychlor, Toxaphene, or 2.4-D and 2.4.5-TP Silvex, which were also proposed in Sec. 3001.

Bioassays and testing for radioactivity were not included in the proposed identification methods for hazardous characteristics (ignitability, corrosivity, reactivity, and toxicity) and thus were not carried out in our investigation on FBC residues. However, EPA is considering expanding the hazardous characteristics to include radioactivity, genetic activity, bioaccumulation, and additional aspects of toxicity (Advanced Notice for Proposed Rulemaking, *Federal Register*, December 18, 1978). Oak Ridge National Laboratory (ORNL) conducted bioassays on fossil fuel residues under DOE and EPA contracts and reported that FBC residue showed negative results in mutagenicity, in aquatic and phytotoxicity, and in metal elements, agreeing with our conclusion that the FBC residue is nonhazardous. ASTM D19.12 also carried out bioassay tests; results are less conclusive due to difficulties encountered in sample preparation, test procedures, and interpretation of test results.

Impact of Nonhazardous Waste Disposal Regulations on FBC Residue Disposal (Subtitle D)

According to the current regulations promulgated on September 13, 1979, eight criteria, including site selection and leachate monitoring, apply to the nonhazardous solid waste sanitary landfills, where FBC waste would most likely be disposed of. The most important issues that can affect the FBC residue disposal, however, are the standards for ground and surface water. Compliance with RCRA and the National Pollution Discharge Elimination System (NPDES) under the Clean Water Act (CWA) is required of a sanitary landfill. Efforts by EPA are under way to consolidate the solid waste permit system. Since effluent guidelines for FBC units and FBC residue disposal facilities are currently unavailable, engineering judgment must be applied for designing, operating, and managing the disposal facility to avoid potential adverse environmental effects. Because FBC leachates meet the primary DWS which consists of eight heavy metals, fluoride (F), and NO_3, FBC residue disposal is expected to meet the current standards for sanitary landfill—groundwater at the "disposal facility boundary" must satisfy the primary drinking water standards (NIPDWR). Should the secondary DWS (NSDWR) be included as they are currently proposed (*Federal Register*, September 13, 1979), however, FBC leachate pH would be a major concern as the pH of a typical FBC leachate ranges from 9 to 12 while the pH of NSDWR ranges from 6.5 to 8.5. Total dissolved solids and SO_4 exceed DWS but are marginally within 10 x DWS if a ten times attenuation/dilution factor is assumed. As soil attenuation and dilution can play a major role in reducing leachate pH, TDS, SO_4, and calcium, site selection and disposal facility design are critical factors in controlling potential ground-water contamination. In addition, contamination of groundwater due to those trace metal elements and the microbiological activity included in the DWS is not expected because FBC test leachates meet both the NIPDWR and the secondary drinking water regulations (NSDWR). Radioactivity, if any, should be similar to that of a conventional power plant residue.

Impact of RCRA on Siting of FBC Facilities

The key aspects of RCRA that would affect the siting of new FBC facilities are provisions for hazardous and solid waste disposal (Subtitles C and D) and provisions for resource recovery (Subtitle E). The increased costs of transportation and disposal of the waste brought on by RCRA as well as the marketability and transportation costs of FBC waste products (should FBC residue be utilized) will play an important role in siting FBC facilities. Also, in light of the public awareness created by RCRA, public support or opposition is becoming increasingly more important in siting decisions for fossil-fuel energy facilities.

Impact on FBC Economics

The economics of FBC systems are sensitive to the total cost of sorbent, including purchase, transportation, and disposal. The major increase in disposal costs resulting from RCRA are expected to be associated with disposal site selection, site operation, and solid residue transportation. The sensitivity of FBC economics to total sorbent cost may lead FBC developers to consider more seriously alternatives for reducing the total amount of sorbent consumed, or methods to reduce disposal cost such as residue processing or utilization, if the expected increase in the cost of solid waste disposal resulting from RCRA is significant. The technical and cost effects of RCRA on FBC residue disposal are such that they must be incorporated in the development of the integrated FBC system.

Recommendations

This report presents an assessment of the effect of RCRA on FBC residue disposal based on current regulations, some of which were proposed but not promulgated until this study was completed. We, therefore, recommend close review of RCRA development and updating its impact as new rules and amendments come into existence with specific attention to the issues that follow.

Hazardous/Nonhazardous Waste Identification

This investigation was based on the proposed RCRA Subtitle C regulations in the *Federal Register* of December 18, 1978, in particular Sec. 3001 hazardous waste identification. Changes in the following may have an additional impact on FBC residue disposal, and reassessment may be required:

- EP test and leachate criteria
- Corrosivity/pH criteria
- Reactivity criteria with respect to exothermic hydration of CaO and CaS/concentration
- Bioassays, radioactivity testing methods, and interpretation. Although currently not a requirement, FBC residues should be investigated for radioactivity and genetic effects, in terms of both legislative requirement and better understanding of the potential hazard from a technical point of view.
- Approach to identifying hazardous waste—signal test versus multistage screening.

In addition, Cr and As in the leachate from FBC carry-over fines ($<15\ \mu m$) and from the residue resulting from regenerative runs should be closely examined in future investigations to confirm their classification as nonhazardous.

FBC Disposal Practice

Based on this investigation, FBC residue is nonhazardous and, therefore, will be disposed of in a sanitary landfill. Regulations and disposal criteria for sanitary landfills under the RCRA Secs. 4004 and 1008 and the CWA will determine FBC disposal practice.

Since the groundwater criteria are applicable at the "disposal facility boundary," which will incorporate effects of soil attenuation and dilution, these effects should be investigated further. These effects are especially important with respect to leachate pH, TDS, SO_4, and Ca should the secondary DWS be included as part of the groundwater criteria in the future. Control technologies for major leachate variable (i.e., pH, TDS, SO_4, and Ca) should be evaluated in the event that dilution/attenuation effects might not be sufficient for some specific sites.

Other aspects of disposal, such as the proper procedures for handling the FBC residue, disposal site selection, facility design, construction, operation, and

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management, need to be investigated. Engineering and economic evaluations of FBC waste disposal should be carried out, incorporating RCRA requirements as part of an integrated effort to develop commercial FBC systems.

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The complete report, entitled "Impact of Resource Conservation and Recovery Act on FBC Residue Disposal," (Order No. PB 81-150 617; Cost: $11.00, subject to change) will be available only from:
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