REVIEW OF HANDLING AND USE OF FGD MATERIAL

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ABSTRACT

Annual production of flue gas desulfurization (FGD) material is projected to rise significantly as proposed regulations related to coal-fired power plant emissions result in increased installations of FGD systems. This production increase coupled with future federal guidance on the disposal and mine placement of coal combustion byproducts (CCBs), including FGD material, may have a significant impact on utility CCB managers and others involved in CCB management.

Currently, there is a lack of information in open literature on FGD methods. The Utility Solid Waste Activities Group and the Energy & Environmental Research Center's Coal Ash Resources Research Consortium industry representatives, with funding from the U.S. Department of Energy National Energy Technology Laboratory, have joined forces to develop baseline information related to the character and management of FGD material. This paper is a summary of an in-depth white paper study and includes information on the state of the FGD production, a review of various FGD systems, and a discussion of current practices for handling, disposing of, and utilizing these materials.

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INTRODUCTION

In 1987, the American Coal Ash Association (ACAA) reported that 14.2 million tons of flue gas desulfurization (FGD) material was produced in the United States (1). In 2000, that number nearly doubled to 26 million tons (2). In 1987, only about 1% of the FGD material produced was utilized, but in 2000, nearly 20% of the annual production was utilized. Despite the large increase in utilization, FGD materials still remain valuable and vastly underutilized. Emission control regulations generally have a direct impact on coal combustion byproducts (CCB) production, and while the U.S. Environmental Protection Agency (EPA) "encourage[d] the utilization of coal combustion byproducts and support[ed] State efforts to promote utilization in an environmentally beneficial manner," federal actions are expected to significantly impact the volume of FGD material produced annually in the United States and potentially some management options for CCBs, including FGD material.

BACKGROUND

Emissions from electricity-generating facilities such as SO_2, NO_x, and mercury are known to cause detrimental impacts to human health and the environment. Electric generation facilities account for the majority of SO_2 emissions in the United States, and the Clean Air Act Amendments of 1990 were designed to reduce those emissions. U.S. utilities generally employ one of two strategies to control SO_2 in the flue gas stream: 1) FGD units or 2) compliance fuel. Other methods, including fluidized-bed combustion (FBC) units, can also control SO_2. Many western coals and some eastern coals are naturally low in sulfur and can be used to meet SO_2 compliance requirements. Utilities may also physically clean or wash all or part of the fuel prior to combustion. Blending coals of different sulfur contents to achieve a mix that is in compliance with applicable regulations is also common. Nearly 70% of utilities use compliance fuel to achieve the SO_2 emission levels currently mandated.

Approximately 22% of utilities in the United States use FGD systems to achieve the currently mandated SO_2 emission levels. This percentage is expected to double in the next 7 years in response to emission regulations (3).

DISTRIBUTION OF FGD SYSTEMS

Today, there are approximately 1140 coal-fired boilers in the United States. The most widely used FGD systems in the world are wet scrubbers using calcium-based sorbents. Wet FGD systems are currently installed on about 25% of the coal-fired utility generating capacity in the United States, representing about 15% of the number of coal-fired units (4). Spray dry scrubbers and sorbent injection installations are growing in use in the United States and Europe, especially on small units. Table 1 presents various types of FGD systems commercially available today.

TABLE 1: Available FGD Systems

Wet	Dry
Limestone Forced Oxidation	Lime spray drying
Limestone Forced Oxidation/Organic Acid	Duct sorbent injection
Lime Dual-Alkali Process	Furnace sorbent injection
Magnesium-Promoted Lime	Circulating fluidized bed
Seawater Processes	
Sodium Scrubbing	
Ammonia Scrubbing	

FGD PROPERTIES

Wet FGD systems frequently utilize calcium-based sorbents and produce either wet FGD material (sludge or unoxidized wet FGD material) or FGD gypsum (from forced-oxidation systems). These materials have similar bulk chemical compositions, but have different mineralogical compositions. The chemical composition of wet FGD material depends largely on the sorbent used for desulfurization and the proportion of fly ash collected with the FGD residues. Wet FGD material is composed primarily of calcium sulfite hemihydrate (hannebachite). Both wet FGD material and FGD gypsum are primarily crystalline in their morphology. The purity of FGD gypsum ranges from 96%–99%. The physical properties of wet FGD materials vary significantly depending on the relative proportions of sulfate and sulfite from each system (5).

Like wet FGD materials, the chemical composition of spray dryer material residues depends on the sorbent used for desulfurization and the proportion of fly ash collected with the FGD residues. The fly ash in dry FGD materials has similar particle size, particle density, and morphology to those of conventional fly ashes, but FGD materials have lower bulk densities. The difference in bulk density is due to variations in the chemical and mineralogical characteristics of the reacted and unreacted sorbent. Dry FGD materials contain higher concentrations of calcium and sulfur and lower concentrations of silicon, aluminum, and iron than fly ash.

HANDLING OF FGD MATERIAL

Both wet and dry materials are produced wet in the scrubbers and are then thickened and dried for handling and/or recycling. The complexity of the dewatering process is determined by the chemical composition and crystalline formation of the spent sorbent and whether the end product is to be utilized or disposed of. Sometimes when commercial-quality gypsum is made, a pelletization process is used.

Handling FGD gypsum can be difficult because the material is abrasive, sticky, compressible, and considerably finer (<0.2 mm) than natural gypsum (6). The adhesiveness of this material decreases with:

- Increasing particle size.

- Decreasing needle/chip configuration of the particle.
- Decreasing free water content.
- Increasing smoothness of the contact surface.
- Increasing water contact angle with the surface.
- Decreasing pressure between the gypsum and the contact surface.
- Decreasing angle of internal friction.

Temperature and relative humidity have little effect on the adhesiveness of the material in storage.

The bulk physical properties of dry FGD materials are similar to fly ash; therefore, they must be handled similarly. Although the physical properties of these materials are similar, dry FGD material is primarily crystalline in its morphology, and fly ash is primarily glassy or amorphous. As a result, flow characteristics of dry FGD material may vary significantly from fly ash. Some dry material may require conditioning to transport. The typical moisture content of the conditioned material is about 10%. The majority of dry FGD materials can be transported by rail, road, water, or pipeline (5); however, it is suggested that residues discharged directly from the spray dryer FGD unit are best transferred using mechanical conveyors (7).

DISPOSAL PRACTICES AND REQUIREMENTS

Currently, EPA classifies FGD material as a solid waste under the Resource Conservation and Recovery Act (RCRA) Subtitle D. This classification places the responsibility to regulate disposal of FGD material on individual states. The following disposal options have been used for wet FGD material (8):

- Hydraulically conveyed and ponded
- Dewatered and stacked
- Interbedded with fly ash
- Stabilized with lime, cement, and/or fly ash

In general, three options exist for the ultimate disposal of waste FGD material: landfills, ponds, and gypsum stacks. An important issue concerning wet FGD disposal is its thixotropic properties. These materials can stiffen in a relatively short time on standing, but upon agitation or manipulation, they can change to a very soft consistency or to a fluid of high viscosity.

FGD material disposal is likely to be impacted by rules for utility landfills/surface impoundments that are currently being developed by the EPA Office of Solid Waste. The final rule is scheduled for completion in March 2004. Discussions with industry representatives indicate some concern that the EPA rule for utility landfills/surface impoundments will require the phasing out of wet disposal sites. Wet FGD material would then need to be dewatered or stabilized prior to final disposal.

FGD UTILIZATION

According to the Combustion 2000 Project (9), the technical challenges of producing commercially usable byproduct gypsum have mostly been resolved, and the operating changes required to use these materials in commercial applications are becoming relatively well established. The area that remains a significant challenge is structuring successful relationships between producers and consumers. Ultimately, economic issues are the driving force that will determine the level of utilization. However, a byproduct that is less expensive than a raw material will not automatically be sought after for industrial use. The factors which govern its desirability as a product are much more diverse.

During the next several years, the use of mined gypsum may decline significantly in the United States as greater quantities of synthetic gypsum are produced. The U.S. FGD market is expected to grow by 5000 MW annually over the next 7–8 years as a consequence of the recently proposed Clean Skies Initiative (10). Today, synthetic gypsum represents about 18% of the gypsum used in the United States (11), and some forecasts predict this percentage will increase to 30% by 2005 (12). According to 2000 ACAA statistics, illustrated in Figure 1, wallboard is the predominant use application for FGD material (2). Table 2 contains a partial list of current commercial utilization practices for wet FGD materials. Dry FGD materials have received limited commercial use; however, as noted in Table 3, these materials have the potential to be utilized in a variety of applications.

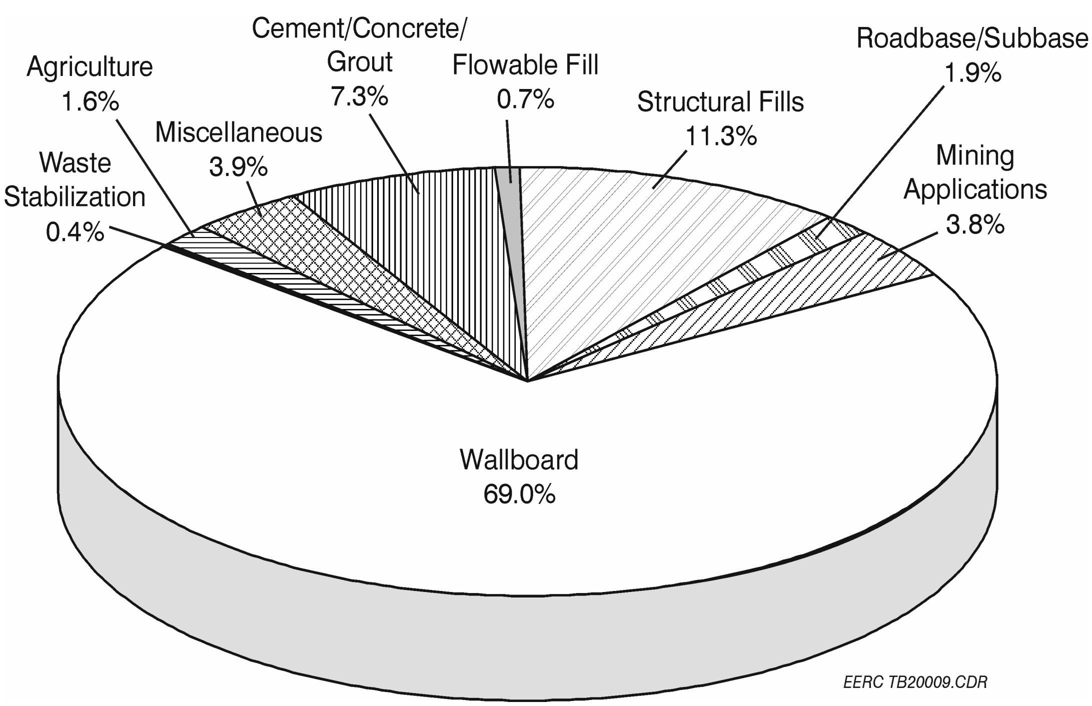

Figure 1. FGD material utilization applications.

TABLE 2: Commercial Uses of Wet FGD Material

Wallboard	Glass making
Structural Fill	Pharmaceutical filler
Aggregate	Paper
Mining Applications	Plastic
Portland Cement	Floor systems
Plaster	Mortars
Agriculture Uses	Fuel additive
Soil Stabilization	Soil neutralization

TABLE 3: Potential Uses of Dry FGD Material

High Potential	Moderate Potential	Low Potential
Structural Fill	Cement production	Gypsum/wallboard
Grout/Mine Backfill	Cement replacement	Metals extraction
Stabilized Roadbase	Soil stabilization	
Synthetic Aggregate	Sludge stabilization	
Lightweight Aggregate	Mineral filler	
Mineral Wool	Agricultural use	
Brick Production	Ceramic products	
	Liner material	

CONCLUSIONS

FGD technology is well established and can be used to achieve the SO_2 emission reductions required in the proposed Clear Skies Initiative. The issue of mercury associated with FGD material and its potential release to the environment is part of investigations funded by EPA, the U.S. Department of Energy (DOE), and industry. Results of these studies may impact management of FGD material in the future.

Federal regulations are currently driving future emission control for coal-fired power plants, and based on the information currently available, it is likely additional FGD systems will be installed on existing boilers. The increased production of FGD material will make it increasingly important to optimize utilization. As was recommended in the 1993 Energy & Environmental Research Center (EERC) Report to DOE on the Barriers to Utilization of Coal Combustion/Desulfurization By-Products by Government and Commercial Sectors (13), procurement guidelines should be implemented at the federal level to encourage the use of CCBs including FGD material. The CCB industry needs to be vigilant in following government actions in order to identify and take advantage of opportunities to effectively maintain or perhaps increase the current FGD material utilization rate of 20%. All levels of government and industry need to work together in order to achieve optimum utilization of CCBs including FGD material.

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