Utilization of wet FGD material for AMD abatement in underground coal mines

by J.C. Ashby*

Synopsis

Electric utility response to certain amendments of the Clean Air Act has resulted in a production of several types of alkaline coal combustion byproducts. Alkaline combustion byproducts are gaining increased usage for acid mine drainage mitigation and abatement as research leads to a better understanding of their beneficial applications.

Since January of 1997, Mettiki Coal Corporation has been injecting alkaline flue gas desulphurization byproducts from Virginia Electric's Mt. Storm Unit #3 wet limestone scrubber into abandoned portions of the active Mettiki mine. This paper provides an overview of the key design, transportation, regulatory, and environmental issues faced in the project.

Introduction

Electricity constitutes a critical input in sustaining the nation's economic growth and development. Coal combustion has historically accounted for the bulk of electrical energy production in the United States, accounting for over 56% of the total net generation of electricity in 1996[1]. One of the concerns of fossil-fueled combustion is the emission of sulphur dioxide (SO_2) during the combustion process. Title IV of the Clean Air Act Amendments of 1990 was enacted to reduce the emissions of SO_2 in two phases. Phase I, running from 1995 through 1999, affects approximately 435 generating units in the United States while Phase II, which is more stringent than Phase I, begins in the year 2000 and affects more than 2000 generating units. Though fuel switching has become the Phase I compliance method chosen by most utilities to meet these reduction requirements, as of 1996 flue gas scrubber systems have been installed on 27 units at sixteen utilities and have accounted for 28 per cent of the 1995 SO_2 emission reductions, the second-largest share after fuel switching[2].

All scrubbing units utilize a chemical reaction with a sorbant material to remove SO_2 from combustion gases and are classified as either 'wet' or 'dry'. In the most widely used wet scrubber systems, combustion gases are contacted with a sorbent liquid which results in the formation of a wet solid byproduct. Most scrubber systems utilize an alkaline limestone sorbent, resulting in an alkaline calcium sulphite and/or calcium sulphate sludge byproduct. Approximately 20 million tons of these flue gas desulphurization (FGD) byproducts are being produced per year in the United States[3]. As increased cost of disposal and heightened regulations make disposal less desirable, alternatives to disposal are being investigated. Alkaline FGD byproducts are finding increased uses in environmental applications as extensive research provides a more comprehensive understanding of their benefits and behaviour.

In November of 1994, Mettiki Coal Corporation (Mettiki) made application to the State of Maryland Department of the Environment (MDE) for a permit modification to inject FGD material into abandoned sections of its underground mining operation in southwestern Garrett County. Material for injection was available from Virginia Power's Mt. Storm Power Station Unit #3 wet scrubber located approximately 17 miles away in Mt. Storm, West Virginia.

[1]Energy Information Administration/Annual Energy Review 1995.
[2]Energy Information Administration, 'The effects of Title IV of the clean air act amendments of 1990 on electric utilities: An update'.
[3]U.S. Department of Energy, Office of Fossil Energy. 'Barriers to the increased utilization of coal combustion/desulfurization byproducts by government and commercial sectors,' Report to Congress, July, 1994.

* *Environmental Affairs, Mettiki Coal Corporation, 293 Table Rock Road, Oakland MD 21550. U.S.A.*

Mt. Storm Unit #3 scrubber

The Mt. Storm Unit #3 forced oxidation wet limestone scrubber is a General Electric Environmental Systems unit placed in operation in October, 1994. The SO_2 laden flue gas from Unit #3 enters an absorber vessel downstream of the precipitators and flows up through a spray of limestone ($CaCO_3$) slurry. The SO_2 is contacted by the spray and falls into a reaction tank below. The initial collection of SO_2 is primarily with water, but once the slurry falls into the reaction tank, the SO_2 reacts with excess calcium to produce calcium sulphite. Additional oxygen is provided to the reaction tank by oxidation air blowers resulting in a conversion of calcium sulphite to calcium sulphate (gypsum) (Figure 1). The reaction tank provides suction for the recycle slurry pumps, which continually pump slurry to the spray headers in the absorber vessel. For Mt. Storm Unit 3, approximately 100 gallons of slurry is sprayed into the absorber vessel for every 1000 ACFM of flue gas. As the larger gypsum particles settle in the reaction tank , they are pumped by the absorber bleed pumps to the waste dewatering system which consists of a bank of hydroclones and a drum vacuum filter. The hydroclones separate the gypsum slurry into two streams. The overflow stream, containing less than 5% solids flows into a filtrate tank for recirculation back into the scrubber. The underflow stream, containing approximately 50% solids, is fed to the drum vacuum filters. The vacuum filters further concentrate the solids to approximately 80% solids with the resultant water also being recycled back into the scrubber. The byproduct solids are then temporarily stored in an enclosed building sized to hold a 3-day supply of product where it is loaded into trucks for transportation to Mettiki for injection. Production averages approximately 400 tons per day.

$$SO_2(l) + CaCO_3(l) + 1/2H_2O \rightarrow CaSO_3 \bullet 1/2H_2O(s) = CO_2(g)$$

$$SO_2(l) + 1/2O_2(g) + CaCO_3(l) + 2H_2O \rightarrow CaSO_4 \bullet 2H_2O(s) = CO_2(g)$$

'*l*' = liquid, '*s*' = solid, and '*g*' = gas.

Regulatory issues

In 1993, the U.S. Environmental Protection Agency (EPA) issued its final regulatory determination on FGD residues. EPA at that time deemed the material to be non-hazardous and therefore regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA). This determination gave individual States regulatory authority which can vary widely from state to state. EPA has since conducted additional studies on combustion wasted from fossil fuels and submitted its report to Congress on March 31, 1999.

Based on available data, it is felt that alkaline addition will assist MCC in maintaining an alkaline environment in its underground mine pool at closure and assist in preventing acid generation. Since 1987, MCC has been injecting alkaline metal hydroxide sludge from its 10 million gallon per day mine drainage treatment facility along with thickener underflow from its coal preparation plant under an Underground Injection Control (UIC) permit. Though permitted under the UIC program, compliance monitoring and environmental impact assessment is handled through a National Pollution Discharge Elimination Systems (NPDES) permit.

Being the first permittee in the state to request a permit to inject FGD material—coupled with the fact that the material is not available in the State of Maryland—added a level of complexity to permitting. Part of the problem faced by MCC was that coal combustion byproducts are not covered by any one regulatory unit in the State of Maryland.

In January of 1995, MDE requested a meeting of section heads from Solid Waste Management, Hazardous Waste, Underground Injection Control, and Mettiki to discuss which department would regulate the injection and maintain oversight.

Coal combustion byproducts—FGD—are not considered hazardous in Maryland. FGD has its own line item exclusion ((Code of Maryland Regulations 26.13.02.04-1.A(4)) and does not fail any of the required RCRA tests to determine if it is hazardous (Table I). This excluded the material from MDE Hazardous Waste oversight.

The fact that the material would not be landfilled excluded it from Solid Waste oversight .

Since the material was chemically and physically similar to MCC's current injection materials, it was decided within MDE that oversight would be handled under MCC's Underground Injection Permit. A modification of the existing NPDES permit was required to address what MDE felt was a potential for dissolution of the material in the underground mine pool. Of particular concern to MDE were chloride levels

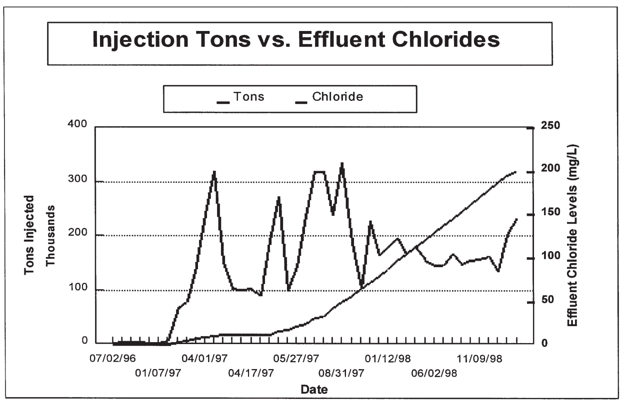

Figure 1

Table I

Chemical analysis—Mt. Storm #3 FGD (mg/L)*

TCLP Data			
Arsenic	< 0.10	Calcium	186,000
Selenium	< 0.20	Magnesium	685
Barium	0.15	Iron	273
Cadmium	< 0.01	Aluminium	229
Chromium	< 0.03	Potassium	< 500
Lead	< 0.10	Sodium	< 50
Silver	< 0.02	Zinc	< 10
Mercury	< 0.002	Chloride	6000
		Moisture	39.7 %
		pH	7.88

* *Mean analytical data. Tests performed with standard TCLP extraction fluid, raw mine water, and dilute sulphuric acid*

in the FGD material and the potential for dissolution. Accordingly, discharge limits based upon US Fish and Wildlife recommendations were set at 230 mg/L quarterly average and 850 mg/L quarterly maximum. Given MCC's cooperative trout-rearing facility location and potential impacts to production, MCC agreed to the limitations.

The permitting process was fairly straightforward once the information, test results, and applications were submitted. MDE issued tentative determination in late January, 1996 and scheduled a public hearing for March. At the hearing, sixteen citizens appeared to voice concerns that:

1. Injection of CCBs would cause subsidence.
2. Any heavy metals in the material would leach out of the material and contaminate drinking water supplies, both surface and groundwater.

The meeting lasted approximately two hours and no amount of technical information or explanation seemed to convince the public of the benign and ultimately beneficial effects the injection should have. Final permit issuance occurred in May 1996, approximately 19 months after initial application.

Underground injection

To handle the additional injection material, MCC modified an injection system upgrade occurring at the time designed to carry MCC through the life of the mine reserves. To accommodate the delivery of the material to the site, MCC constructed an unloading facility with slurry makeup water conveyed from existing deep well turbine pumps at the AMD plant.

Once slurried at an approximate 15% per cent solids content, controlled by a nuclear densometer and Allen Bradley SLC 500 programmable logic controls, the material is pumped in the existing thickener underflow lines to a disposal surge tank at the AMD plant. Tank level controls cycle two Warmen 12 × 16 discharge pumps arranged in series. Line velocities and the potential to sand out the line over the 14,000 foot distance to our B mine injection points required the high pressure, high volume pumps. Design capacity is 2500 gallons per minute at 200 psi at the pumps. Vertical elevation difference between the pumps and the highest point in the disposal line is 250 feet with approximately 150 feet of elevation to work with in the mine voids. Ultimate placement is 600 to 750 feet below surface elevations. Storage capacity within B mine at current peak solid injection rates is 13 years.

Mine pool impacts

Water which pools underground is either stage pumped through the mine in MCC's active works or flows by gravity in the inactive portions (including the decant solution from the injection) to an underground sump and then conveyed to the surface via a combination of one 400 hp Layne, one 400 hp Goulds, or two Peabody Floway 800 hp deep well turbine pumps and treated at the AMD plant. Under normal conditions, flow rates of from 2000 to 10,000 gal/min are maintained depending upon what pump or combination of pumps are placed in operation. Treatment options consist of two identical High Density Sludge treatment systems each capable of treating 4,000 gal/min and one Techniflo in line aeration system presently capable of treating 4000 gal/min.

Raw mine water enters the ferric tank initially and is mixed with a hydrated lime slurry. The slurry is made from clear water taken from the settling basins or can be mixed from the raw AMD. Lime addition is controlled by Great Lakes pH probes located at the effluent end of the ferric tanks. The neutralized water reports to the aeration tank through 12 inch PVC pipe and is aerated using 10 hp splash aerators in the HDS system. The aerated water then discharges through a sluice-way where Baker polymer is added prior to entering the 36 ft. × 280 ft. × 14 ft. clarification basin for precipitation of the hydroxide sludge.

The in-line aeration system differs from the above in the oxidization step. Oxidization is accomplished by an air inductor that entrains air by a venturi device which is powered solely by the pressure of the raw water pump. Post-aeration treatment involves anionic polymer addition to aid flocculation of the metal hydroxides and clarification in a concrete 115 ft. by 14 ft. circular clarifier.

Metallic hydroxide accumulation in the bottom of the clarifiers is raked and suctioned to the combined sludge disposal tank via two Hazelton sludge pumps or centerwell pump. Final sludge disposal into old underground workings is accomplished by two Warmen 12 × 16, 400 hp disposal pumps.

Table II

Chemical analysis—raw mine water (mg/L)

	06/13/96	10/25/97	04/15/97	07/11/97		06/13/96	10/25/97	04/15/97	07/11/97
Chloride	3	3.3	69.4	146	Thalium	0	0	0	0
Sulphate	830	1090	1240	1300	Barium	0	0.035	0.033	0.033
Bicarb	37				Barylium	0	0	0	0
Aluminium	0.4	1.06	0.194	1.32	Cadmium	0	0	0	0
Antimony	0	0	0	0	Chromium	0	0	0	0
Calcium	224	267	421	541	Cobalt	0.1	0.146	0.133	0.137
Iron	37.8	61.1	24.8	34.4	Copper	0	0.0431	0	0.0095
Magnesium	49.5	65.6	66.1		Lead	0	0	0	0
Manganese	2.72	3.87	4.28	4.8	Molybdenum	0	0	0	0
Potassium	7.43	11	10	10.2	Nickel	0.139	0.206	0.183	0.195
Sodium	77.2	86.4	75.3	79.2	Silver	0	0	0	0
As	0	0	0	0	Titanium	0	0	0	0
Se	0	0	0	0	Zn		0.273	0.201	0.266
Boron	0.065	0.073	0.47	0.937	TPH			<.3	

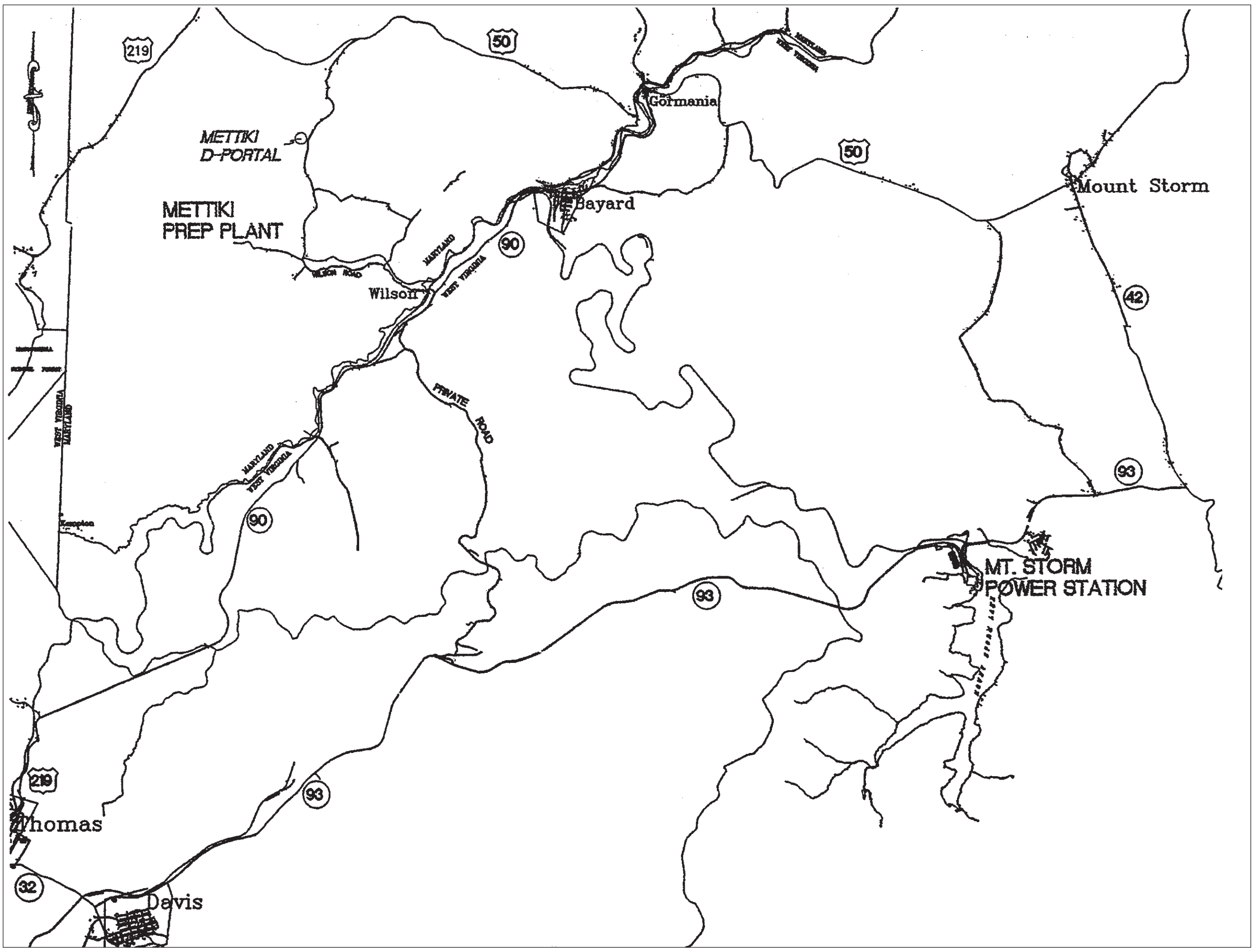

Figure 2

Transportation issues

To make the project possible and to economically deliver the FGD material to the site, transportation had to be included as part of a haul back arrangement on a coal contract. To move coal to the Mt. Storm plant and FGD material back, only two options were available; rail or truck. For economic reasons, trucking the materials was chosen but that choice presented its own unique problems. The two largest were infrastructure upgrades at the mine to convert from primarily rail shipments and route selection for the trucks.

Working with Savage Industries in Salt Lake City, Utah, a twin hopper aluminium trailer was chosen to convey the materials allowing for maximum payload potential.

To accommodate this new mode of transportation, route selection became an issue both publicly and economically. Three options were available:

- ➤ West Virginia Route 90 to 93—through the town of Thomas, West Virginia.
- ➤ US Route 50 to West Virginia Route 93.
- ➤ Upgrade 6.5 miles of a private haul road to highway standards.

Option 3 was chosen because it shortened the route somewhat but more importantly, it isolated the trucks as much as possible from public roads and local communities (Figure 1).

Conclusions

This project, though complex in implementation, is intended to quantify the benefits of CCB utilization and affords a unique opportunity to provide real-life data on CCB interactions with acid-producing mine waters. The fact that there are no exits to the environment other than the deep well pumps and through MMC's treatment facility offers a controlled environment to observe those interactions and benefits. ◆