WET FGD PLACEMENT AT THE METTIKI MINE IN MARYLAND

by

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

From January 1997 through December, 2002 , Mettiki Coal, LLC injected alkaline flue gas desulfurization material from Dominion Resources Mt. Storm Power Stations' wet limestone scrubbers into abandoned portions of the active Mettiki mine. This paper provides an overview of the key regulatory, environmental, design, and placement issues faced during the project.

Additional Key Words: Coal combustion byproducts, flue gas desulfurization, hydroclones, underground injection, NPDES.

Introduction

Electricity constitutes a crucial 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 approximately 50% of the total net generation of electricity in 2005 according to the Energy Information Administration (National Energy Information Center, 2006). One of the concerns of fossil-fueled combustion is the emission of sulfur 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, affected approximately 435 generating units while Phase II, which is more stringent than Phase I, began in the year 2000 and affected more than 2000 generating units. Though fuel switching became the Phase I compliance method chosen by most utilities to meet these reduction requirements, flue gas scrubber systems have been installed on 248 generating units and has accounted for 32 percent of the 2005 SO_2 emission reductions, the second largest share after fuel switching (Energy Information Administration, March, 2005). In 2005, SO_2 emissions from electric power generation were more than 5.5 million tons below 1990 levels, resulting in reduced acid deposition and improved water quality in U.S. lakes and streams (EPA Acid Rain Program 2005 Progress Report, October, 2006).

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All scrubbing units utilize a chemical reaction with a sorbent 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 sulfite and / or calcium sulfate sludge byproduct. Approximately 25 million tons of these flue gas desulfurization (FGD) byproducts are being produced per year in the United States (EPRI, 1999). 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 behavior.

In November of 1994, Mettiki Coal , LLC (Mettiki) made application to the State of Maryland Department of the Environment (MDE), Industrial Permits Division for an underground injection permit modification to inject FGD material into abandoned sections of its underground mining operation in southwestern Garrett County. Material available for injection at that time was available from Virginia Power's Mt. Storm Power Station Unit #3 wet scrubber located approximately 17 miles away in Mt. Storm, West Virginia. In 2001, Units #1 and #2 were also "scrubbed" providing additional alkaline material availability.

Mt. Storm Unit #3 Scrubber

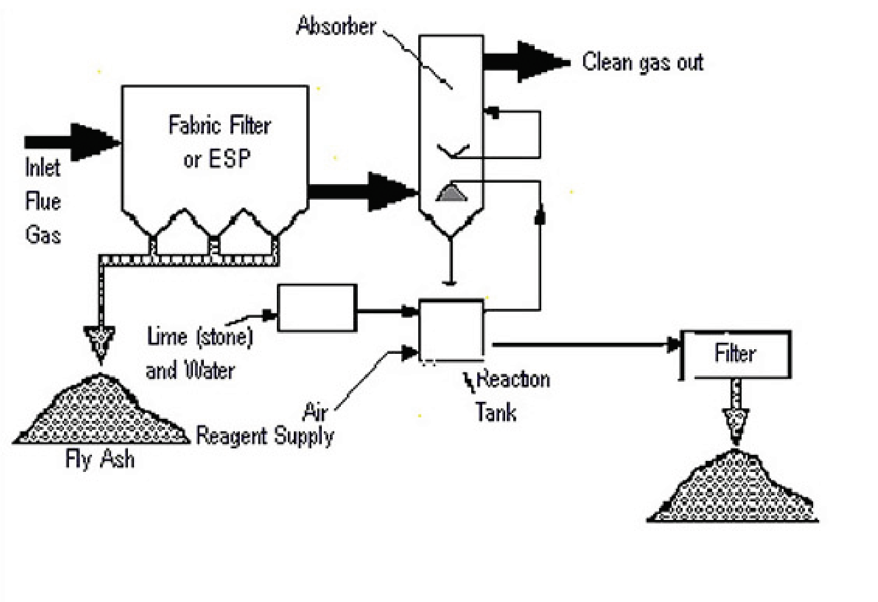
The Mt. Storm Unit #3 forced oxidation wet limestone scrubber is a General Electric Environmental Systems unit placed in operation in October, 1994. The SO_2 laden flue gas from Unit #3 enters an absorber vessel down stream of the precipitators and flows up through a spray of limestone ($CaCO_3$) slurry. 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 sulfite. Additional oxygen is provided to the reaction tank by oxidation air blowers resulting in a conversion of calcium sulfite to calcium sulfate (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 temporally 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 (Figure 2).

Figure 1

$$SO_2 + CaCO_3 + 1/2H_2O \rightarrow CaSO_3 \bullet 1/2H_2O + CO_2$$

$$SO_2 + 1/2O_2 + CaCO_3 + 2H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$$

Figure 2



MDE Regulatory Issues

In 1993, the Environmental Protection Agency (EPA) issued its final regulatory determination on FGD residues. They were deemed 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 from state to state.

Based on available research data at the time, it was felt that FGD addition would assist Mettiki in maintaining an alkaline environment in its underground mine pool at closure and aid in preventing acid generation. Since 1987, Mettiki 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 a MDE Underground Injection Control (UIC) permit. Though permitted under the Maryland UIC program, compliance monitoring and environmental impact assessment is managed through a National Pollution Discharge Elimination Systems (NPDES) permit.

Alkaline coal combustion byproducts are not considered hazardous materials under Maryland law. FDG in particular has its own line item hazardous material exclusion ((Code of Maryland Regulations 26.13.02.04-1.A(4)) and does not fail any of the required RCRA tests used to determine if it is a hazardous waste (Table 1).

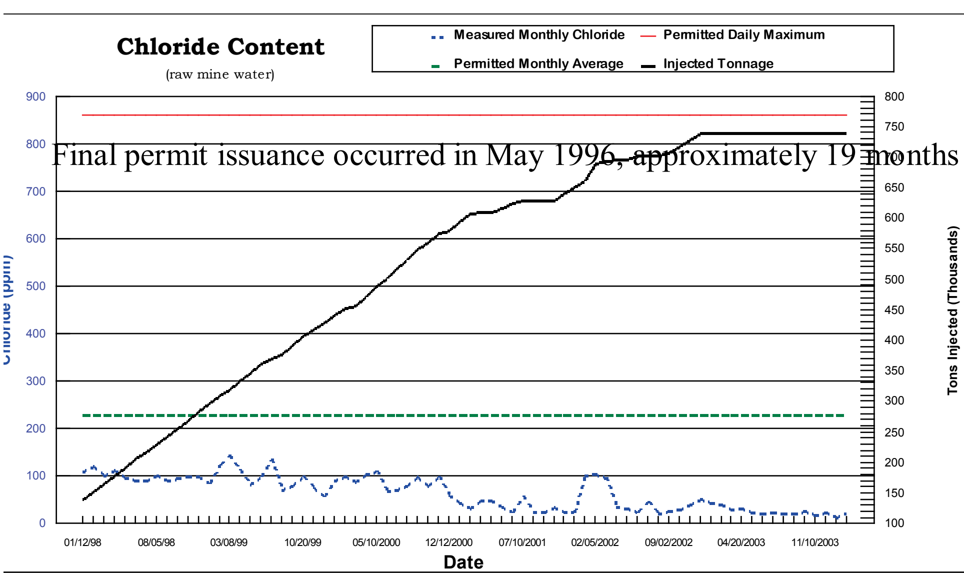
Table 1. - Chemical Analysis - Mt. Storm FGD (mg/L)

TCLP DATA[1]		SOLIDS DATA	
Arsenic	<0.10	Calcium	186,000
Selenium	<0.20	Magnesium	685
Barium	0.15	Iron	273
Cadmium	<0.01	Aluminum	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

[1]. Averaged analytical data. Tests performed with standard TCLP extraction fluid, raw mine water, and dilute sulfuric acid.

A modification of the existing NPDES permit was required and submitted to address and monitor what MDE felt could be a potential, despite TCLP testing, for dissolution of the material in the underground mine pool. Of particular concern to MDE were chloride levels. Accordingly, discharge limits based upon US Fish and Wildlife Service trout 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 trout production, Mettiki agreed to the limitations and additional monitoring. Table 2 shows pre and post injection raw mine water analysis indicating negligible dissolution impacts and beneficial AMD reduction impacts to date. Figure 3 shows chloride levels in the mine pool in relation to injected tons of FGD.

Figure 3. - Raw Mine Water Chloride Levels



Final permit issuance occurred in May 1996, approximately 19 months after initial application.

Underground Injection

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

Once slurried at approximately 15% percent solids content - controlled by a nuclear densometer and Allen Bradley SLC 503 programmable logic controller - the material is pumped in buried high density polyethylene pipelines to a disposal surge tank at the water treatment plant. Tank level controls cycle two Warmen 10 x 12 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 point required the high pressure, high volume pumps. Design capacity is 2500 gallons per minute at 260 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 the mine at current peak solid injection rates is over 13 years.

Mine Pool Impacts

Water which pools underground is either stage pumped through the mine in Mettikis' active works or flows by gravity in the inactive portions (including the decant solution from the injection) to an underground sump and is then conveyed to the surface via a combination of one 800 hp Layne, one 800 hp Goulds, or two Peabody Floway 800 hp deep well turbine pumps and treated at the water treatment plant. Under normal conditions, flow rates of from 2000 to 12,000 gal/min. are maintained depending upon what pump or combination of pumps are placed in operation. Treatment options consists of one High Density Sludge treatment system, capable of treating 20,000 gal/min. and one Techniflo in line aeration system presently capable of treating 4000 gal/min.

Raw mine water enters the neutralization tank initially and is mixed with a hydrated lime slurry. The slurry is made from clarifier sludge and or clear water taken from the clarifier. Lime addition is controlled by dual Great Lakes pH probes located within the neutralization tank. The neutralized water is aerated in the same tank through two 8 inch PVC pipes using 15 hp Roots blowers in the HDS system. The aerated water then discharges through a sluice-way where polymer is added prior to entering the 200 foot Eimco clarifier 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 classifier.

Metallic hydroxide accumulation in the bottom of the clarifiers is raked and suctioned to the combined sludge disposal tank via two Warmen sludge pumps or by a centerwell pump in the circular clarifier. Final sludge disposal into old underground workings is accomplished by the two Warmen 10 x 12, 400 hp disposal pumps.

Table 2. - **Raw Mine Water Analysis (mg/L)**

	6/13/1996 mg/L	7/10/1997 mg/L	4/18/2000 mg/L	3/6/2001 mg/L	1/5/2004 mg/L
pH	6.7		6.29	6.4	6.71
Al	0.4	1.32	0.81	0.322	0.331
Arsenic	<.025	<.025	0.005	<.010	<.01
Antimony	<.05	<.05	0.0084	<.02	<.02
Barium	0	0.033	0.0367	0.0254	0.0458
Beryllium	<.0025	<.0025	<.0011	<.002	<.005
Boron	0.065	0.937			
Cadmium	<.0025	<.0025	<.00081	<.0015	<.005
Calcium	224	541	533	327	266
Chromium	<.0075	<.0075	.0023(est)	<.003	0.005
Cobalt	0.1	0.137	0.0853	0.0296	0.0566
Copper	0	0.0095	<.0029	<.004	<.010
Iron total	37.8	34.4	31.8	17.9	1.32
Lead	<.025	<.025	<.0079	<.02	<.020
Magnesium	49.5	83.7	87.6	66	59.3
Manganese	2.72	4.8	2.95	1.43	2.47
Mercury			<.00010	<.0002	<.00020
Nickel	0.139	0.195	0.132	0.0504	0.0908
Potassium	7.43	10.2	8.97	8.31	7
Selenium			0.0085		<.010
Silver	<.0025	<.0025	<.0056		
Sodium	77.2	79.2	85.2	103	78.7
Sulfate	830	1345.7	1710		818
Thallium	<.13	<.13			<.020
Vanadium	<.0050	<.0050	.0032(est)	<.004	<.005
Zinc		0.266	0.227	0.0698	0.0524

Conclusion

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 MCCs' treatment facility offers a controlled environment to observe those interactions and potential benefits.

Public concern regarding management of coal combustion byproducts is founded in a belief that small quantity toxic constituents contained within the material could potentially damage human health and the environment. Public opposition can create major obstacles to beneficially using coal combustion byproducts for acid mine drainage mitigation and should not be underestimated. Though potentially toxic elements may be present in some materials and, at certain concentrations, these elements may have toxic effects, with approximately 750,000 tons of FGD material injected thus far, raw water heavy metals chemistry has remained similar to pre-injection conditions or improved.

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