High Volume--High Volume Usage of Flue Gas Desulfurization (FGD) By-Products in Underground Mines

**Quarterly Report
July 1 - September 31, 1996**

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High Volume--High Value Usage of Flue Gas Desulfurization (FGD) By-Products in Underground Mines

Phase I: Laboratory Investigations

Cooperative Agreement No.: DE-FC21-93MC30251

Quarterly Report for the Period April 1, 1996 to June 30, 1996

Summary of Activity for the Quarter

The focus of activity for this quarter was the final selection and preparation of a mine site for the grout emplacement field demonstration. The site chosen is located in Floyd County, Kentucky and is owned by the Sunny Ridge Mining Company. Specifically, a northeast-trending highwall was selected that contains numerous auger holes of 31 inch diameter and varying depth. The coal has been deep-mined beyond the auger holes thus limiting their length. Access to the site is good, and the overlying strata are relatively un-weathered and competent.

Preparation of the site involved cutting a road to the highwall, followed by uncovering the auger holes which had previously been partially filled and graded with rock. The auger holes were then extensively characterized in the context of overall dimensions, condition, and extent of communication between holes. For this portion of the work, several types of apparatus were obtained, and constructed.

Selection of a grout emplacement method was also completed. It was decided that concrete trucks will transport the dry FBC flyash to the site whereupon a specified amount of water will be added. This grout will then be transferred to a concrete pumping truck that will be used to inject the material into the auger holes. In this quarter, the arrangements necessary to complete the emplacement have been made.

Task 4. Background Development for Field Studies

Subtask 4.1 Mine Selection/Site Preparation

Site Selection

The field demonstration site was moved to Sunny Ridge Mining Co.'s Job 20 due to the rapid advance of mining and subsequent loss of the Costain Coal Inc. site described in the January 1, to March 31, 1996 Quarterly Report. The Sunny Ridge mine is a contour and mountain top removal mine, and has an extensive body of background and operational environmental data. Complete and highly detailed geologic, resource, reclamation and environmental maps, as well as extensive water monitoring well and surface water records, are available from the company. To this will be added more geologic data and additional water resources information for the immediate area of the demonstration.

The mine is in the northeast section of the Harold 7.5 minute quadrangle, Floyd County, Kentucky. Figure 1 shows the location of the backfill site on an enlarged topographic map. The mine will be developed in the Middle Pennsylvanian Breathitt Formation Upper Peach Orchard coal bed, a coal previously auger mined. Auger holes are nominally 31 inches in diameter and are of varying length. The coal had been deep-mined beyond the extent of the auger holes thus limiting their length. The specific portion of the mine selected for the field demonstration contains numerous accessible auger holes, which have a thin covering of talus that is easily removed. For this project, 16 holes were uncovered.

The Upper Peach Orchard coal bed is up to 48 inches thick in the quadrangle, but is closer to 40 inches at the Sunny Ridge site. A generalized geologic column for the quadrangle is shown in Figure 2. At the mine face, the coal is overlain by several feet of dark gray shale, followed by massive sandstone. The sandstone cuts out the coal in places on the mine site, which has been an additional restriction to the extent of the auger mining.

Site Preparation

The first step in site preparation involved cutting an access road to the highwall using a bulldozer. Several sections of road were cut: one leading directly to the auger holes, and another at a lower elevation to place equipment, trailers, etc. The highwall was then faced-up. This activity is shown in Figure 3. The working area in front of the auger holes was leveled to a width of approximately 20 feet, and is approximately 100 feet long (along the highwall face). The equipment storage pad has approximately the same dimensions.

Subsequent to establishment of site access, the auger holes were uncovered using a bulldozer. The holes had previously been covered by Sunny Ridge Co. and filled in with several feet of rock debris. Photographs of the opened auger holes are provided in Figure 4.

Figure 1. Topographic map of study area. The site is located on the Harold 7.5 minute U.S.G.S. quadrangle, Floyd County, Kentucky.

Figure 2. Geologic section of the Ivy Creek area from Rice (1965; Geologic map of the Harold quadrangle, Floyd counties, Kentucky, USGS GQ-441). Interval thicknesses in feet, coal thicknesses in inches.

Figure 3. Bulldozer cutting access road to auger holes on the Sunny Ridge site.

Figure 4. Freshly exposed auger holes at the Sunny Ridge site.

Characterization of Auger Holes

After the auger holes were exposed and the highwall face prepared, the holes were surveyed using several techniques. As was mentioned above, the diameter of each hole was approximately 31 inches, but with varying depths. The condition of the auger holes was also not known. In order to survey the interior of the holes, without sending in personnel and thus having to provide roof support, sewer surveying equipment was employed. This comprised a small tracked vehicle upon which a video camera and floodlight were mounted (Figure 5), and the system remotely connected to a video cassette recorder (VCR) and monitor. A cable, marked with 5 foot gradations, was attached to the unit in order to measure hole depth. However, the tracked unit proved unable to negotiate the floor of the auger holes because of rock debris and mud obstacles.

In response to the problems encountered by the sewer surveying equipment, a unit was constructed at the CAER comprising a low light level (0.5 lux) black and white television camera with a resolution of 380 lines per inch was mounted on a radio-controlled model truck chassis (Figure 6). A four channel radio was used, with two channels used to control the truck's steering and throttle and the other two channels used to provide pan and tilt for the camera. Since the auger holes were too small (30" diameter) to allow room for the truck to turn around, a small stainless steel cable was attached to the rear of the truck, allowing it to be driven into the hole, then pulled out. The radio receiver's antenna was attached to this pull cable, effectively extending the antenna out of the auger hole. The truck also carried a lightweight television transmitter and a pair of small 12 volt lights. The camera, television transmitter and lights were all powered by a rechargeable onboard 12 volt x 3 amp-hour battery. A corresponding television receiver was positioned near the mouth of the auger hole and connected to a monitor screen, allowing the operator to remotely view the interior.

While the truck worked well in preliminary tests in the lab and in an underground culvert at the Lexington Fire Department's training facility, it proved unable to overcome the silty, sticky mud that was encountered in the auger holes. While it was planned that the truck would be able to reach the end of the holes (110-150 feet), the deepest penetration obtained was 70 feet in a relatively dry auger hole. 30-40 foot depths were more typical, with the truck eventually bogging down from the sheer weight of mud clinging to the tires. Changing tire tread patterns did not help, and after several trials the radio-controlled truck/camera concept was shelved. When not defeated by the mud, the truck did illustrate good maneuverability, being able to drive around smaller obstacles, and climbing over some of the larger ones. The camera's pan and tilt capability was also quite useful, allowing the operator to pause and inspect the auger hole's ceiling, floor and side walls from a single vantage point.

A survey of the auger holes was successfully completed with a third unit, also constructed at the CAER (Figure 7). Two sleds were built from PVC 1.25" pipe fittings and plywood, then outfitted with AC-powered incandescent lights with bowl reflectors and a television camera. The camera from the radio-controlled truck was mounted to the first sled while the second sled was given a higher resolution color camera (460 lines per inch at 0.5 lux, 560 lines per inch at 1 lux).

Figure 5. Track-mounted sewer surveying equipment entering an auger hole.

Figure 6. Radio-controlled model truck with camera entering an auger hole.

Figure 7. Skid-mounted survey equipment used at the Sunny Ridge site.

Neither camera had pan or tilt capability. Co-axial cable trailing from the sled carried the TV signal back to a monitor and videotape recorder while a second tethered line provided the sled with AC-power for the lights and camera.

Long runs of 1.25" PVC conduit attached to each side of the rear of the sleds were used to push the sleds into the auger holes. By using two runs of conduit, some maneuvering capability was retained, as the operators could alternately push or pull on one side or the other of the sled. The sled's runners were spaced about 18" apart, and the sled had a ground clearance between the runners of about 9", allowing them to straddle smaller obstacles. Pre-formed PVC long-radius bends formed the front of each sled runner, allowing the sled to be pushed over obstacles too wide to be straddled.

The surveying equipment, particularly the skid-mounted unit, revealed that the walls of the auger holes were generally in excellent condition, with only minor caving and weathering. However, there was evidence of communication between at least two holes; a small portion of the wall separating the holes had broken, thus establishing a connection between the holes. This is a potential problem for the grouting procedure because the material would be able to flow between the auger holes, making it difficult to determine extent of hole filling based on volume of grout placed. Accordingly, holes with structurally unsound walls will be avoided if possible during the field demonstration. The depth of the holes ranged from 25 to 130 feet and are essentially perpendicular to the highwall face. Table 1 provides data obtained for the uncovered auger holes.

All of the auger holes were essentially dry upon exposure with no standing water on the floor or seepage from the walls. However, subsequent rains have caused water to accumulate on the floor of several auger holes. It will be of interest to determine if grouting is successful in the wet auger holes as regards the strength of the hardened grout material. Therefore, in addition to examining the effects of grout water content (as measured by the slump) on the emplacement procedure and the hardened material strength, grouting will also be conducted in both the wet and dry holes.

Table 1. Selected data for Sunny Ridge site auger holes.

Auger Hole I.D.	Depth (ft.)	Wall Thickness (in.)
#1	28 ¹	7
#2	nd	15
#3	65 ²	9
#4	85 ²	16
#5	nd	nd
#6	nd	nd
#7	nd	9
#8	36 ¹	11
#9	26 ¹	10
#10	nd	8
#11	25 ¹	16
#12	33 ¹	12
#13	106	14
#14	109	18
#15	114	nd
#16	129	nd

¹ End of hole blocked by debris

² Caved wall between holes

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