

UNITED STATES  
DEPARTMENT OF LABOR  
MINE SAFETY AND HEALTH ADMINISTRATION  
COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION  
Fatal Underground Coal Mine Explosion  
May 20, 2006

Darby Mine No. 1  
Kentucky Darby LLC  
Holmes Mill, Harlan County, Kentucky  
ID No. 15-18185

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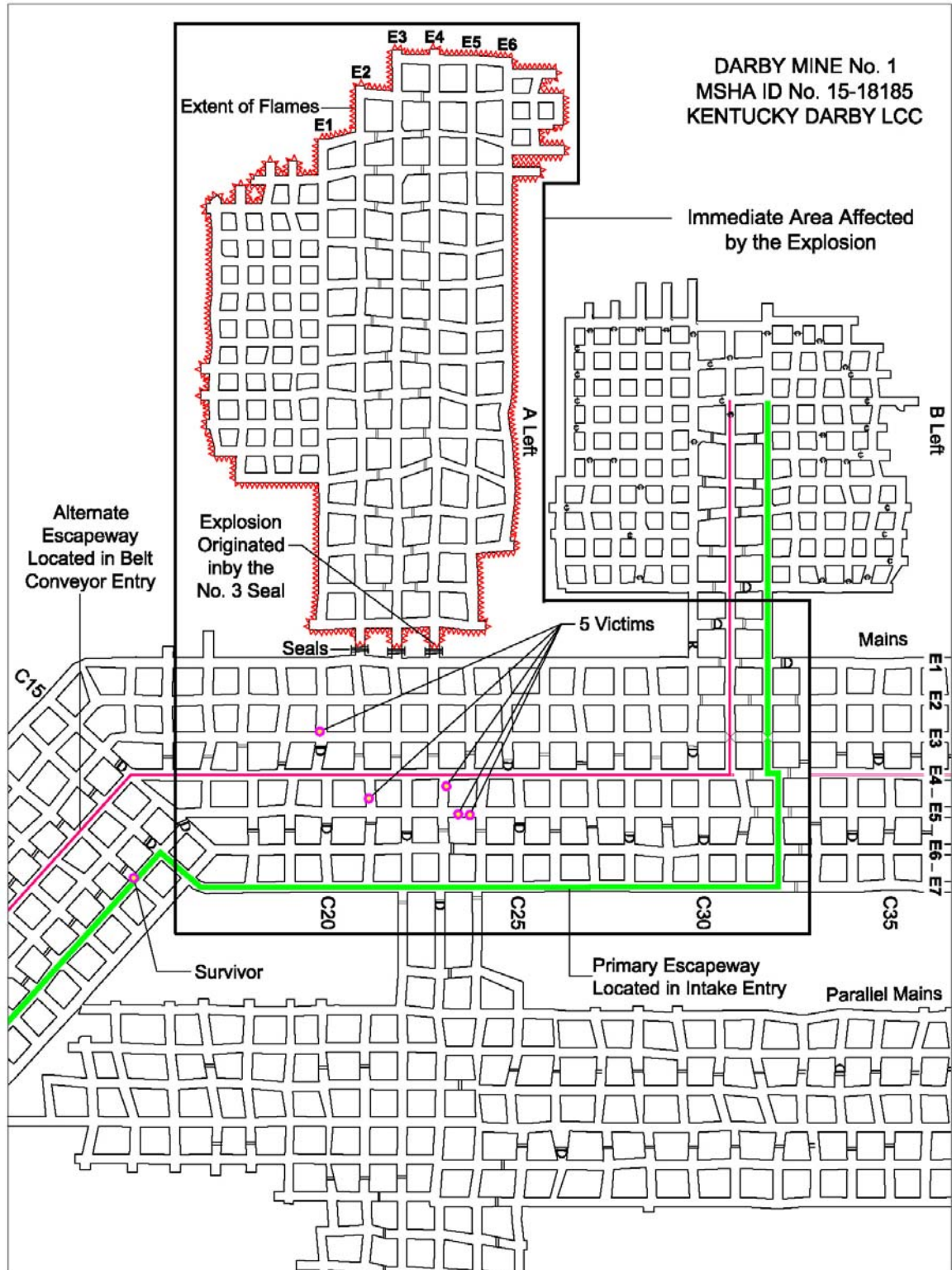
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## OVERVIEW

On Saturday, May 20, 2006, an explosion occurred at approximately 1:00 a.m. in the sealed A Left Section of the Kentucky Darby, LLC, Darby Mine No. 1, resulting in fatal injuries to five miners and injuries to one miner. At the time of the explosion, six miners were underground during a non-producing shift. Appendix A lists miners injured or fatally injured as a result of the accident.

Prior to the explosion, four miners were on the B Left Section preparing to perform routine maintenance work on equipment. Two miners from the B Left Section who had worked the afternoon shift remained after their shift and traveled to the seals which were constructed to isolate the abandoned A Left Section from the active mine. The two miners rode a non-permissible battery-powered personnel carrier (buggy) down the return airway with a set of oxygen - acetylene torches for the purpose of removing metal roof straps from the roof that intersected the No. 1 and No. 3 Seals. One of these miners was the afternoon shift section foreman. A methane explosion occurred behind the seals at A Left, which was caused by the cutting of a metal roof strap that passed through the No. 3 Seal. The forces from the explosion resulted in fatal injuries to the two miners and complete destruction of the seals. Forces from the explosion also damaged conveyor belt structure, roof supports, and ventilation controls.

The four miners who were working in the B Left Section attempted to evacuate and encountered thick smoke approximately four crosscuts outby the section power center. At this point they donned their CSE SR-100 self contained self rescue (SCSR) devices and attempted to continue their evacuation. During the evacuation, at least two of the miners intermittently removed their SCSR mouthpieces to communicate. The miners eventually became separated from each other. One miner survived and three died due to carbon monoxide poisoning with smoke and soot inhalation.

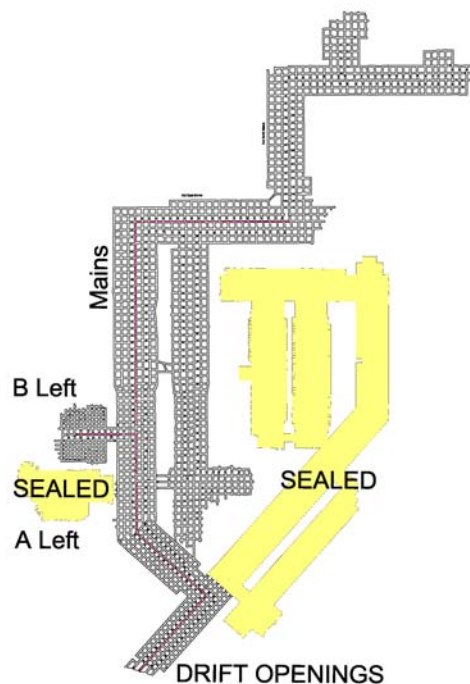
The accident occurred because the operator did not observe basic mine safety practices and because critical safety standards were violated. Mine management failed to ensure that proper seal construction procedures were utilized in the building of the seals at the A Left Section. Mine management also failed to ensure that safe work procedures were used while employees attempted to make corrections to an improperly constructed seal. Furthermore, mine management failed to adequately train miners in proper SCSR usage and escapeway routes.

In addition to a 103(k) Order, the company was cited for six conditions and/or practices which contributed in some way to the accident. An additional thirty-seven citations and orders were issued during the investigation, but were not considered to have contributed to the accident.

## GENERAL INFORMATION

Darby Mine No. 1 (Darby) is an underground coal mine located approximately 26 miles east of Harlan, Kentucky, on State Route 38. The mine is operated by Kentucky Darby, LLC, of Middlesboro, Kentucky, under contract with Jericol Mining, Inc., of Cumberland Gap, Tennessee. The Kentucky Darby, LLC articles of organization list Ralph Napier, John D. North, and Connie G. Napier as members of the limited liability company. The principal official at the mine is Ralph Napier, who is the superintendent and the person in charge of health and safety.

The mine began production on May 28, 2001, in the Darby coal seam, which has an average thickness of 56 inches. The Owl coal seam, which has an average thickness of 36 inches, is above the Darby seam and was mined with the Darby seam in various locations. The resulting mining height varied from approximately 40 inches to 144 inches. At the time of the last regular health and safety inspection, the daily methane liberation rate was 38,707 cubic feet.



**Figure 1 - Map of Darby Mine No. 1**

The mine had one advancing room and pillar section, designated as B Left. Figure 1 provides an overview of the mine with a detailed map of the mine shown in Appendix B. Production equipment used on the section included a continuous mining machine, two shuttle cars, a battery-powered scoop, and a roof bolting machine. Coal was transported from the coal producing section to

the surface stockpile using a series of four conveyor belts. Coal was loaded onto trucks and transported to the Sigmon Coal Company, Inc., preparation plant in Keokee, Virginia, where it was processed and shipped to various consumers.

At the time of the accident, the mine employed 31 persons underground and three persons on the surface. The mine normally conducted two production shifts and one maintenance shift daily and operated six days per week. The total coal production reported for the first quarter of calendar year 2006 was 60,058 tons. At the time of the accident, the employees of the mine were not represented by a labor union or other bargaining unit.

The last complete quarterly safety and health inspection conducted by the Mine Safety and Health Administration (MSHA) was concluded on March 30, 2006. During this inspection, the operator received a total of seven citations, five of which were designated as significant and substantial. The most recent safety and health inspection was started on April 7, 2006, and was in progress at the time of the accident. Twenty-one citations were issued during this inspection prior to the accident, nine of which were designated as significant and substantial. Table 1 summarizes the enforcement actions taken by MSHA during the last six inspection quarters.

An examination of the inspection records of the most recent on-going regular inspection as well as the sworn testimony of the inspector conducting the inspection show that the A Left Seals had not been examined prior to the explosion of May 20, 2006. The inspector conducting the inspection had not yet examined the A Left Seals, the return or traveled with the mine examiner during the weekly examination for hazardous conditions when the seals would have been examined.

**Table 1 - MSHA Enforcement Actions**

Fiscal Year	Inspection Quarter	Citations, Orders, and Safeguards			Total Issuances
		S&S	Non-S&S	Other	
2005	2	2	11	0	13
2005	3	9	22	2	33
2005	4	7	7	0	14
2006	1	5	7	0	12
2006	2	5	2	0	7
2006	3*	9	12	0	21

\* Through May 19, 2006.

Prior to the fatal accident that occurred on May 20, 2006, the mine had not reported a lost-time accident in over two years. The last accident resulting in



days away from work or restricted duty occurred on April 4, 2004. Table 2 summarizes the fatal and non-fatal incidence rates at the mine for the last five years.

**Table 2 - Incidence Rates**

Calendar Year	Quarter(s)	Darby Mine No. 1		National	
		NFDL	Fatal	NFDL	Fatal
2001	1-4	17.83	0	7.13	0.0760
2002	1-4	9.25	0	7.13	0.0329
2003	1-4	6.26	0	6.31	0.0330
2004	1-4	5.49	0	5.68	0.0356
2005	1-4	0	0	5.15	0.0325
2006	1	0	0	5.62	0.1696

## DESCRIPTION OF ACCIDENT

Approximately two months prior to the accident, the company completed mining in the A Left Section and built three seals, constructed of Omega 384 blocks, to seal off the worked-out area. The seals were built over the course of three working shifts under the supervision of Amon Brock, afternoon shift foreman, and Mark Sizemore, day shift outby foreman. After construction, the seals were referred to as the “return seals” to differentiate them from another set of seals located off the intake air course. The return seals were also referred to by number, with the No. 3 Seal being the furthest inby of the three.

On May 19, 2006, the weekly examination for hazardous conditions was conducted on the day shift by Mark Sizemore. During this examination, Sizemore was accompanied by Mitchell (Tom) Lunsford, mine examiner, and the two traveled to the areas requiring examination by non-permissible battery-powered personnel carrier. At approximately 9:00 a.m., they arrived at the No. 3 Seal in the return air course and Sizemore performed a visual examination and tested for methane with a hand-held instrument. The maximum methane concentration was reported to be 0.1 percent, and no hazards were noted by Sizemore.

At approximately 3:45 p.m., the afternoon shift crew entered the mine to begin the scheduled production shift. The crew consisted of Amon Brock; Jimmy Lee, shuttle car operator; Travis Blevins, shuttle car operator; Randy Fields, continuous mining machine operator; Jeff Coker, roof bolting machine operator; Clark Cusick, roof bolting machine operator; James Philpot, miner helper; and Patrick Cupp, belt attendant. The shift progressed normally until the conveyor chain on the continuous mining machine broke. A new link was installed in the

conveyor chain and the crew continued mining throughout the remainder of the shift.

At approximately 11:00 p.m., the midnight (maintenance) shift began. The midnight shift crew consisted of George (Bill) Petra, foreman; Roy Middleton, electrician; Paris Thomas, mechanic; and Paul Ledford, roof bolting machine operator. Petra and Middleton traveled by battery-powered personnel carrier to the working section. Shortly after this, Thomas and Ledford traveled underground on a separate personnel carrier to the No. 4 Belt Drive (see Appendix B) where they discussed the status of the conveyor belts with Cupp. After this discussion, they separated to observe the conveyor belt drives for the remainder of the afternoon shift. Ledford traveled to the No. 3 Belt Drive and Cupp went to the No. 2 Belt Drive. Thomas remained at the No. 4 Belt Drive area.

At approximately 12:35 a.m., Ledford returned to the No. 4 Belt Drive. He and Thomas then traveled to the working section. Cupp concluded his activities at the No. 2 Belt Drive and exited the mine at approximately 12:40 a.m.

At approximately 12:45 a.m., the afternoon shift crew, with the exception of Brock and Lee, boarded a battery-powered mantrip and traveled toward the surface. They passed the oncoming midnight shift crew in the vicinity of the section power center. Brock and Lee boarded a personnel carrier loaded with an oxygen cylinder, an acetylene cylinder, a cutting torch, and other tools. They traveled in the return air course to the A Left Seals.

The physical evidence suggests that Brock and Lee arrived at the area of the return seals and commenced to cut metal roof straps (see Figure 2) that had been placed in the area as roof support but which had not been removed when the seals had been built. The acetylene cylinder and cutting torch were found in the area as was a piece of roof strap that gave indications that it had been cut with a torch. Brock had a methane detector with him but it is clear that it was not being used to check continuously for methane given that it was found in his pocket after the explosion. The detector was functional since it was giving off an alarm when the body was found. There is no indication that any test for methane was made behind the seals before the cutting commenced. There was no means available to sample the atmosphere behind the No. 3 Seal. Therefore, a cutting torch should not have been used in the vicinity of the seals.

The afternoon shift crew arrived safely on the surface at approximately 1:00 a.m. A few seconds after exiting the mine, they were buffeted by a gust of air, dust, and debris coming out of the portals of the mine. Initially they believed that either a massive roof fall or a collapse of the highwall had occurred. The crew

concluded that an explosion had occurred when the odor of burned coal reached the portals.



**Figure 2 - Roof Straps at the No. 3 Seal Location for A Left**

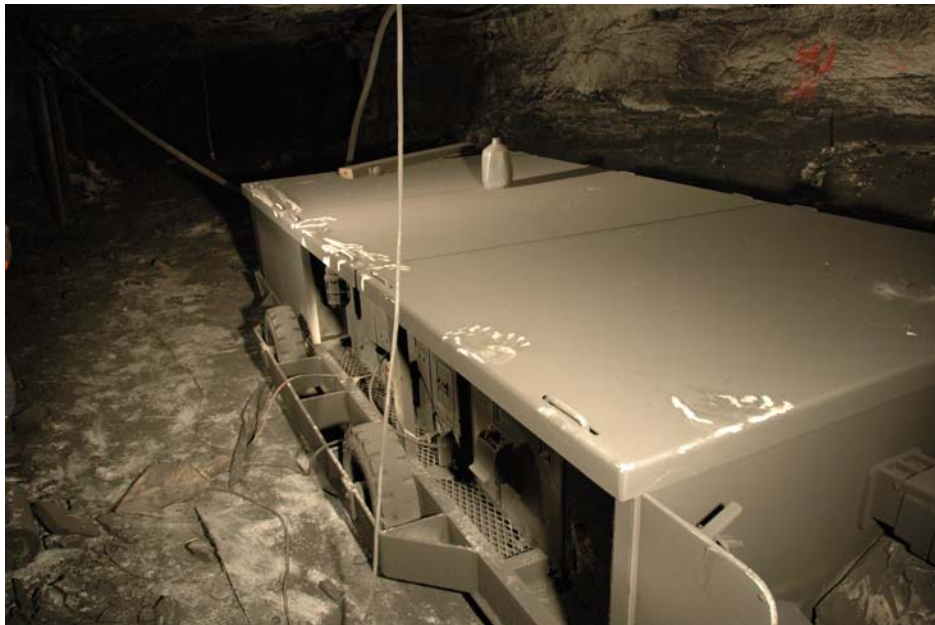
Meanwhile, after the afternoon shift crew departed from the working section, Petra began examining the face areas for hazardous conditions. Middleton, Ledford, and Thomas dispersed to perform other duties on the section. While on the working section, they also heard the explosion. Petra gathered the crew together and informed them that an explosion might have occurred because Brock and Lee had taken tanks and a cutting torch into the return. The crew boarded two personnel carriers and began traveling in the outby direction in the intake travelway, which was the primary escapeway. They encountered dense smoke approximately four crosscuts outby the section power center, at which point they stopped and donned SCSRs. They boarded a single personnel carrier and continued traveling in the outby direction. The crew did not have a detector capable of detecting carbon monoxide.

After traveling approximately 300 feet, the personnel carrier became lodged on debris from an overcast that had been extensively damaged by the force of the explosion (see Figure 3). The crew got off of the vehicle and proceeded on foot until they reached the power center located one crosscut inby the No. 4 Belt Drive. Somewhere near this point, Ledford and Middleton removed their SCSR mouthpieces and discussed how they should exit the mine. Ledford informed Middleton that he had located the high-voltage power cable and that he intended

to follow it to the surface. Middleton told Ledford that he was going back to find the power center (see Figure 4). After another short discussion, Ledford began walking outby in the No. 5 Entry, using the high-voltage power cable as a guide. Ledford had no further contact with the other miners.



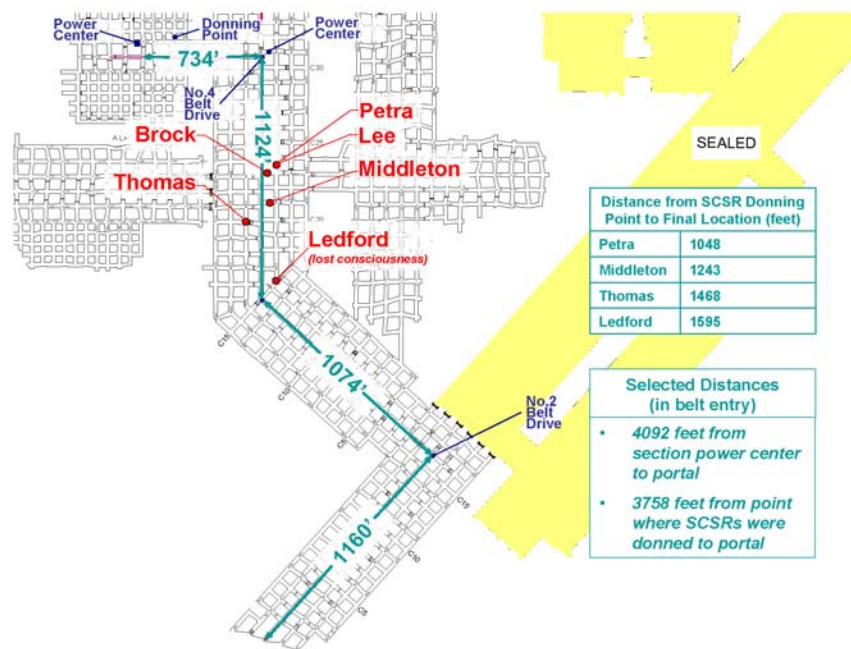
**Figure 3 - Personnel Carrier Lodged on Overcast Debris**



**Figure 4 - Power Center at No. 4 Belt Drive**

Ledford traveled approximately 1,050 feet in the No. 5 Entry until he reached a point just inby the No. 3 Belt Drive, where he collapsed and lost consciousness. Ledford regained consciousness at approximately 3:05 a.m. and crawled into the No. 6 Entry, where he was discovered by rescuers. Ledford was taken out of the mine on a battery-powered personnel carrier. He was transported to Lonesome Pine Hospital in Big Stone Gap, Virginia, where he was treated.

Petra, Middleton, and Thomas attempted to escape but eventually succumbed to carbon monoxide poisoning at different locations in the mine. Petra was found in the No. 5 Entry approximately 500 feet outby the No. 4 Belt Drive power center. Middleton was found approximately 700 feet outby the No. 4 Belt Drive power center in the left crosscut off of the No. 5 Entry. Thomas was found 800 feet outby the No. 4 Belt Drive power center in the crosscut between the No. 2 Entry and No. 3 Entry in the return air course. Figure 5 shows the distances from where the SCSRs were donned to the location where the miners were found.



**Figure 5 - Distances from SCSR Donning Points to Final Location of Miners**

Brock and Lee were located at or near the No. 3 Seal in the return air course when the ignition occurred and were both fatally injured by the forces resulting from the explosion. Brock was found 240 feet from the No. 3 Seal in the crosscut between the Nos. 4 and 5 Entries. Lee was found in the No. 5 Entry, approximately 340 feet from the No. 3 Seal and 20 feet outby where Petra was found.



## RESCUE AND RECOVERY OPERATIONS

Actions taken during the initial rescue and recovery operation did not follow accepted past practices that have been developed from previous rescue and recovery operations. Though the intent of these actions was to expeditiously rescue trapped or injured miners, rescuers were also at times exposed to potential danger. The following description of the rescue and recovery operations has been reconstructed based on individual recollections, testimonies, and logs which at times are in conflict. Appendix C is a timeline of the rescue and recovery events with Appendix D listing the personnel involved.

Robert Rhea, MSHA District 7 Harlan, Kentucky, Field Office Supervisor, was notified of the explosion by Napier at approximately 1:05 a.m. Rhea notified John Pyles, MSHA District 7 Assistant District Manager-Inspection Division, who notified Norman Page, MSHA District 7 District Manager, and MSHA headquarters personnel. Rhea notified MSHA Inspectors Kevin Doan, Dale Jackson and Brad Sears about the explosion. Once Rhea arrived at the Harlan field office he notified MSHA Inspector Roger Wilhoit about the event. MSHA's Mine Emergency Unit (MEU) was subsequently notified.

Doan arrived at the mine and verbally issued a 103(k) order at 1:54 a.m. The mine fan was operating. He took tests for carbon monoxide at the fan, as no one at the mine site at this time had a carbon monoxide detector. Doan used a MSA Solaris multiple gas detector and detected 2.6 percent methane and over 500 ppm carbon monoxide at the fan, indicating that significant combustion from an explosion or fire had occurred underground. Doan then took an air sample at about 2:01 a.m. Air sample, D-7889, was later analyzed and found to contain 0.23 percent methane, 19.26 percent oxygen, and 6,162 ppm carbon monoxide. Rhea and Jackson arrived at the mine site at 2:00 a.m. MSHA periodically monitored the fan for explosive and harmful gases. Jackson was informed that the underground mine power was disconnected.

Ronnie Hampton, Supervisor, Kentucky Office of Mine Safety and Licensing (KOMSL), arrived and along with MSHA and Napier, established a command center. Air quality readings were taken at the fan and in all mine openings. The fan readings were 0.20 percent methane, 20.8 percent oxygen and over 500 ppm carbon monoxide. The intake entry had 13 ppm carbon monoxide with no methane and good oxygen. A decision was made by the command center for the rescuers to walk one of the main intake entries barefaced until they encountered 50 ppm carbon monoxide, low oxygen, or an explosive atmosphere. Some of the rescue team members entering the mine were equipped with hand-held radios provided by KOMSL.

Rhea, Jackson, Doan, Inspector Todd Middleton (KOMSL), and Mark Sizemore (Kentucky Darby employee) entered the No. 5 intake entry barefaced at 2:32 a.m., leaving Napier and Hampton in the command center. J.J. White, mine rescue team member, KOMSL, was stationed at the intake portal to relay information from the team to the command center.

Using a MSA Solaris multiple gas detector, the rescuers traveled the No. 5 Entry taking carbon monoxide readings every crosscut and detected 12 to 18 ppm. They arrived at the intake seals and examined all six seals. They took quality readings at all the seals and had 19.8 to 20.8 percent oxygen, 3 to 12 ppm carbon monoxide, and 0 percent methane.

At 3:08 a.m., John Pyles called the command center and was informed that non-mine rescue personnel were underground. Pyles gave instructions for those persons to be withdrawn from the mine. At about the same time, a light was observed in the intake entry, and the rescuers informed the command center that they saw a light and traveled towards it. They found Paul Ledford (survivor) at about 3:10 a.m. with his SCSR donned (without goggles or nose clip in place) in the No. 6 intake entry one crosscut in by survey station No. 494. The rescuers talked to Ledford, who said that the other three miners were approximately three to four crosscuts behind him. Ledford was unable to walk so the rescue team called for a personnel carrier. Jackson and Middleton advanced to crosscut No. 15 where the equipment door between the neutral and intake entries had been blown out by the explosion. Napier and Lunsford arrived with a personnel carrier. Napier transported Ledford outside while Lunsford remained underground. Communication between the command center and the underground personnel was not always maintained.

Jackson, Middleton and Sizemore then walked to the No. 3 Belt Drive. Tests for methane indicated 0 percent. The phone line installed in by that location was disconnected. The mine phone located at the belt drive was then used to establish communications back to the command center.

Ventilation controls were damaged during the explosion at crosscut Nos. 17, 18, and 19 between the belt and return entries. Jackson advanced in by the No. 3 belt entry for about three crosscuts when he encountered carbon monoxide ranging from 80 ppm to off scale. The rescuers retreated to the No. 3 Belt Drive area. A fresh air base (FAB) was established at survey station No. 507 in the No. 6 Entry in the main headings; Jackson advanced in the No. 5 neutral entry about three crosscuts until he encountered approximately 80 ppm carbon monoxide. The rescuers retreated to the FAB.

Communications were established to the command center from the FAB using the mine phone. The FAB was manned by Doan. The rescuers advanced in the No. 7 intake entry to crosscut No. 22 where three entries were mined from the Parallel Mains to connect the Mains. At this time they encountered concentrations of 80 ppm carbon monoxide and retreated back to the FAB.

Hampton and the Harlan KOSML mine rescue team arrived at the FAB. Team members went under oxygen and advanced inby the FAB. The team traveled inby the No. 3 Belt Drive one crosscut and then crossed the belt to get to the return entries, intending to explore in an outby direction or "tie back" to connect to areas previously explored.

When the team reached the return air course, they observed a cap lamp light inby. They traveled toward the light and discovered Paris Thomas, Jr. at approximately 4:30 a.m. He was located one crosscut outby survey station No. 517 in the No. 3 Entry in the crosscut between Nos. 2 and 3 Entries. The team found high concentrations of carbon monoxide (actual value not specified). Thomas was checked for vital signs and none were found. No call was made to the command center at that time to report the carbon monoxide concentration or the identification and location of Thomas.

Several members of the Lone Mountain mine rescue team, accompanied by an MSHA MEU team member, arrived at the FAB. Jim Vicini, Lone Mountain Mine Rescue Team Trainer, was informed by the command center to take charge of the FAB. The FAB was moved from the No. 3 Belt Drive to a location two crosscuts inby survey station No. 506 in the No. 7 Entry of the Mains. Air-quality tests were made inby and the FAB was advanced to the third location at survey station No. 523. The FAB could not be advanced any further due to high concentrations of carbon monoxide migrating out of the cut-throughs between the parallel mains and main entries. Vicini requested curtains be installed across the cut-through entries to advance the FAB.

The Lone Mountain team members that arrived first and an MSHA MEU team member donned apparatus and advanced inby toward the B Left section using 1,000 feet of communication hard line with headsets. The remainder of the Lone Mountain team accompanied by an MSHA MEU team member arrived at the FAB. Until this time, mine rescue teams had been advancing inby the FAB without the presence of backup mine rescue teams at the FAB.

The first Lone Mountain team advanced toward the B Left section and observed one light outby in the No. 5 Entry and two lights inby toward the section. The team explored inby toward the two lights. The tail captain traveled to the end of the communication line at the No. 4 Entry. A personnel carrier with its lights on



was found on top of the debris from the destroyed intake overcast. A search was made around the personnel carrier and no persons were found. End caps from two SCSRs were found on the personnel carrier. Footprints indicated someone may have traveled inby in the Mains toward the old works.

The first Lone Mountain team observed a second light inby. They advanced to and found a personnel carrier located at survey station No. 1193 in the No. 3 Entry on the B Left section. A MX250 handheld detector was found in the deck of the personnel carrier and indicated over 20 percent oxygen. The end caps from two SCSRs, one pair of SCSR goggles, and footprints were found one crosscut inby the personnel carrier between the No. 3 Entry and the second room turned right. The footprints indicated someone had traveled into these rooms. The team split up to travel the No. 3 Entry and three of the rooms on the right side to the faces of the B Left entries. The team reported detecting 480 ppm carbon monoxide at the section power center and 70 ppm carbon monoxide at the faces of the B Left entries. No one was found. One team member had approximately 900 psi of oxygen remaining so the team retreated back toward the FAB.

During their retreat, the first Lone Mountain team met Middleton, who was traveling inby. Middleton said that a team member from Harlan KOMSL was advancing inby in each of the seven entries of the Mains toward the B Left section. The first Lone Mountain team accompanied by Middleton then retreated to the No. 5 Entry where they had previously seen a light. The team advanced outby toward the light leaving the low man with the tail captain.

At approximately 5:16 a.m. they found George "Bill" Petra and another victim that could not be identified, located about 35 feet inby survey station No. 526. Petra and the second victim were checked for vital signs, and none were found. The team then retreated to the FAB, called the command center and informed them of the location of both victims, one of which was identified. At this time, three victims had been located.

The Barbourville KOMSL team arrived at the FAB with ventilation curtains. The Harlan team then returned to the surface. Vicini instructed the Barbourville team to install the ventilation controls in the three cut-through entries, at crosscut No. 17 (near survey station No. 505), and in the crosscuts inby, where stoppings had been damaged between the intake and neutral entries. The FAB was then advanced to the fourth location, one crosscut inby survey station No. 559 in the No. 7 Entry.

The Barbourville team advanced from the FAB to the A Left seals and found that the seals had been destroyed. Air quality readings were taken at the seal

locations. The team reported readings for the No. 1 seal entry as 19.1 percent oxygen, 1.5 percent methane, and carbon monoxide over range. The team then explored the return entries inby to the mouth of B Left section. They reported what was thought to be a roof fall close to crosscut No. 21 in the belt entry.

The Hazard team traveled underground to the FAB. The team was instructed to travel the return entry toward the surface and meet the Martin KOMSL team that traveled from the outside toward the sealed area.

Vicini instructed three members of the Lone Mountain team to travel outby in the belt entry to check on what was reported as a roof fall. The remaining members were instructed to travel inby in the Mains to the worked out areas. The teams were instructed to check each crosscut as they advanced.

The team traveling outby had two members in the belt entry and one member in the No. 3 return entry. What had been reported as a possible roof fall was actually the belt and structure deposited against the rib. They also found the personnel carrier that Brock and Lee had been using. The wreckage of the personnel carrier was located in the belt entry at survey station No. 525 (see Figure 6). During further exploration the team located the body of Paris Thomas for the second time.

The Lone Mountain team advanced to the No. 3 Belt Drive. They retreated in the No. 5 neutral entry and searched each crosscut for the remaining victims. At approximately 8:45 a.m. one team member found Roy Middleton in crosscut No. 21 between the Nos. 4 and 5 Entries. Middleton was checked for vital signs and none were found. Middleton had his SCSR on with the mouthpiece dislodged from his mouth. He was wearing his goggles, but it is not known if the nose clip was in place. The team retreated to the wreckage of the personnel carrier, examined the crosscut and at approximately 8:45 a.m. found the last victim, later identified as Amon Brock, in crosscut No. 23 between the Nos. 4 and 5 Entries. Vital signs were checked and none were found. At this time, all victims had been located.

The team retreated to the FAB and informed the command center of the location of both victims, one of whom was identified. The entire Lone Mountain team was then instructed to return to the surface.

Pat Turner, Mike Elswick, and Todd Middleton, KOMSL rescue team members, traveled underground to make a ventilation change. A regulator was installed one crosscut inby survey station No. 470 in the No. 7 Entry at the mouth of the Parallel Mains. The stopping line was examined and repaired up to the FAB. This was done to increase the quantity of air to the FAB.



**Figure 6 - Damaged Personnel Carrier on top of Conveyor Belt Debris**

The Pikeville KOMSL team arrived at the FAB. The Pikeville, Hazard, Barbourville, and Martin teams made the ventilation change and the FAB was relocated to survey station No. 523. The area where the victims were located was then cleared of high concentrations of carbon monoxide. MSHA MEU team members placed the victims in body bags. KOMSL team members transported the victims back to the FAB, where they were transported to the surface. At approximately 10:55 a.m., the victims were brought to the surface and transported to the coroner's office.

The command center made a decision to make another ventilation change. The James River mine rescue team and an MSHA MEU team member traveled underground to the FAB. The James River team advanced inby the FAB toward the second set of cut-throughs located at survey station No. 593 in the No. 7 Entry. Air quality readings were taken in the cut-throughs, in the Parallel Mains entries, and in the Mains inby the cut-throughs. The team reported 0.2 to 0.4 percent methane, 20.0 to 20.3 percent oxygen, and 85 to 150 ppm carbon monoxide. The team retreated to the FAB. A decision was made to allow the mine to ventilate without an air change over the weekend. All mine rescue personnel returned to the surface.

On May 22, 2006 members from the MSHA MEU and Harlan KOMSL teams entered the mine. Quantity and quality readings were taken at specific locations to determine how to re-ventilate the mine.

On May 23, 2006 representatives from KOMSL, the operator, and MSHA traveled to the FAB. MSHA and KOMSL teams explored the A Left section. Air quality checks were made at every crosscut. The lowest oxygen reading obtained was 20.6 percent. The highest methane and carbon monoxide readings obtained were 0.4 percent and 14 ppm respectively. The A Left section was ventilated with approximately 30,000 cubic feet per minute (cfm).

MSHA, KOMSL, and company representatives traveled the worked out areas located in the northern section of the mine. Air quality readings were taken to assure the old works were ventilated. The team encountered 0.5 percent methane and retreated. Ventilation controls were examined and it was determined that the equipment doors located at the top end of the Parallel Mains had been blown out during the explosion. The team returned to the surface. A decision was made to install curtains at these doors and allow the mine to ventilate overnight.

On May 24, 2006, MSHA, KOMSL, and company representatives traveled to the FAB. MSHA and KOMSL explored the B Left section. Air quality checks were made at every crosscut. The lowest oxygen reading obtained was 20.7 percent. The highest methane and carbon monoxide readings obtained were 0.4 percent and 10 ppm respectively. The B Left section and rooms were ventilated with approximately 18,000 cfm.

The worked out areas located in the northern section of the mine were traveled again after the ventilation was established and air quality readings were taken. The lowest oxygen reading obtained was 20.7 percent. The highest methane and carbon monoxide readings obtained were 0.5 percent and 40 ppm respectively. At this point, temporary ventilation controls had been established throughout the entire mine.

## **INVESTIGATION OF ACCIDENT**

On May 23, 2006, MSHA commenced an investigation of the accident pursuant to Section 103 of the Mine Safety and Health of 1977. The Administrator for Coal Mine Safety and Health assigned an investigation team consisting of personnel from MSHA Coal Districts 2, 3, 4, 6, and 8; MSHA Pittsburgh Safety and Health Technology Center; MSHA Educational Field Services, and the Office of the Solicitor, Department of Labor. Thomas Light, Assistant District Manager for District 2, was assigned as the accident investigation team leader.

Preliminary information was gathered and records were obtained from the MSHA District 7 office in Barbourville, Kentucky; the MSHA Field Office in

Harlan, Kentucky; and from the mine operator. The team conducted physical investigations at the mine from May 24 to August 17, 2006. During the on-site investigations, team personnel were accompanied by representatives from Kentucky Darby LLC, the State of Kentucky, the United Mine Workers of America, and other designated miners' representatives. At the time of the accident, the miners were not represented by any labor organization. After the accident, several miners designated the United Mine Workers of America and other parties to act as their representatives.

Persons were identified for the purpose of interviews. Thirty-two interviews were conducted by the MSHA investigation team. The interviews were attended by representatives from Kentucky Darby LLC, the State of Kentucky, the United Mine Workers of America, and other designated miners' representatives. The State of Kentucky also conducted interviews, which an MSHA accident investigation team member and an attorney from the Office of the Solicitor attended.

Other contacts were made and information was obtained from contractors and State and local authorities. Pertinent and relevant records were collected and reviewed during the investigation. Physical evidence such as methane detectors, cap lamp assemblies, cutting torch parts, and various electrical components from the battery powered mantrip were examined or tested as necessary at designated testing facilities. Interested parties were informed of, and allowed to attend, testing. Samples collected during the investigation were analyzed and evaluated through the various testing facilities.

Appendix E lists those persons who participated in the investigation. Physical evidence collected in the accident area is depicted on the map in Appendix F. The A Left Section and the debris field are depicted in Appendices G through M.

## **DISCUSSION**

### **Mine Development**

The mine began production in the Darby Coal Seam on May 28, 2001, using the room and pillar mining method. Mining started in the A Left Section in middle to late October 2005. A Left was developed by three entries driven from the return side of the Mains starting at crosscut No. 21. At the first crosscut in A Left, one additional entry was added to each side of the section. An additional entry was added at the third crosscut on the north side for a total of six entries. Starting at the fifth crosscut, rooms were driven to the left (south). The A Left Section was mined to a distance of approximately 1,130 feet from the Mains. Five entries were driven to the right (north) for rooms near the furthest extent of the

section. Mining in the rooms was discontinued on March 3, 2006 and the A Left Section was sealed with three seals constructed between March 18 and 22, 2006. These seals were referred to as the “return seals.” No retreat mining was conducted in the A Left Section.

On March 6, 2006, mining started in the B Left Section. B Left was developed by three entries driven from the return side of the Mains starting at crosscut No. 30. Starting at the second crosscut in B Left, rooms were driven on each side of the section. The section had advanced to a distance of approximately 665 feet from the Mains at the time of explosion.

### **Mine Ventilation**

The mine was ventilated by a single, exhaust fan installed on the surface and connected by corrugated ductwork to the No. 1 drift opening. The fan was a Vortex, Model No. 54D-1139, and was belt-driven by a 100 horsepower electric motor. Measurements during the investigation indicated the fan was exhausting 114,206 cubic feet per minute (cfm) of air from the mine at a pressure of 3.2 inches of water. The second return opening had an equipment door to provide access to the return air course and to serve as an explosion-relief door. Overall mine ventilation prior to the accident is depicted on the map in Appendix B.

Air entered the mine through the remaining three drift openings, including the belt entry. The intake, return, and belt air courses were separated by 8-inch hollow-core concrete block stoppings that were dry-stacked and coated with sealant on the high pressure side. The only exception was in the sealed A Left Section where several stoppings were built of Omega blocks instead of concrete blocks. Overcasts were constructed using a combination of concrete blocks, steel plates, and steel beams. The only two overcasts in service in the mine were located at the intersection between the Mains and the B Left Section.

The mine had developed a sixth entry, common with the belt entry, at the second crosscut inside the mine. A seventh entry, utilized as a third return air course, was added near the intake split point for the Parallel Mains, about 1,500 feet into the mine.

In the Mains, a stopping line across the intake and belt entries directed air into the B Left Section. Three entries provided access to the B Left Section. From there, the section expanded into rooms on the left and right sides of the development starting at the third crosscut. On May 3, 2006, during an MSHA inspection, an air quantity of 18,600 cfm was measured in the last open crosscut for the B Left Section.

According to the approved Ventilation Plan, the airflow for the belt entry should have been coursed to the return air courses outby the section belt feeder for the B Left Section. The accident investigation team, however, did not find a regulator to direct the belt air to the return air course. The only regulator shown on the mine map was located in the return air course between the first and second crosscut for the B Left Section and consisted of an equipment door (constructed of two hinged panels) in a stopping.

The return air flow in the Mains ventilated the front of the seals for the A Left area. During the recovery of the mine, line curtain was used to replace some of the damaged ventilation controls to reestablish air flow throughout the mine, including directing the entire Mains return air flow into the formerly sealed A Left area. The accident investigation team measured 51,256 cfm of return air at the mouth of A Left.

### *Mine Ventilation Plan*

The Ventilation Plan in effect at the time of the explosion was approved on September 1, 2005 and included one addendum. The plan addressed specific requirements for the continuous mining machine development section using blowing face ventilation in conjunction with machine mounted scrubber. For extended cut mining, the plan required at least 8,000 cfm of air be provided at the inby end of the line curtain where coal was cut, mined or loaded. The line curtain was required to be maintained a maximum distance of 14 feet from the scrubber discharge.

The plan also addressed specific requirements for the use of Omega block as an alternate method of seal construction (see Appendix N). The plan required that for the use of Omega block seals:

1. Seals will be hitched 6 inches into the bottom and 6 inches into the ribs.
2. An approved bonding and sealant agent (i.e. "BLOCKBOND" or Rite-wall) shall be used between all joints (horizontal, vertical, and in-between blocks) on all surface areas including the inby and outby walls.
3. Seals and pilaster thickness will be indicated in sketches.
4. A gas sampling tube with a shutoff valve will be provided in the highest seal per set of seals.
5. A U-type drain will be provided for water drainage in the lowest seal per set of seals.
6. Seals will be constructed of Omega 384 blocks as per one of the attached three drawings.
7. Omega 384 block seals shall be wedged to the mine roof as indicated in the sketch.

8. All wood will be flush with walls of seal and coated with sealant passing ASTM E162-87.
9. A single layer of 1 inch thick wood planking shall be placed between the top of the seal and the mine roof.
10. When the entrances to worked-out areas are sealed, the seals shall be erected in a sequence such that positive ventilation is furnished to the affected area until the erection of the two (2) final seals, with the last seal to be erected being the furthest upwind.
11. Seals shall be installed at least 10 feet inby rib corners, in solid competent material.
12. Evaluations of the inby areas will continue during seal construction.
13. The middle seal will be constructed first.

The presence of the metal straps made it impossible for wood planking to be placed on the top of the seal between the seal and the mine roof. This would make it impossible to comply with mine ventilation plan seal construction requirements.

### ***Methane Liberation***

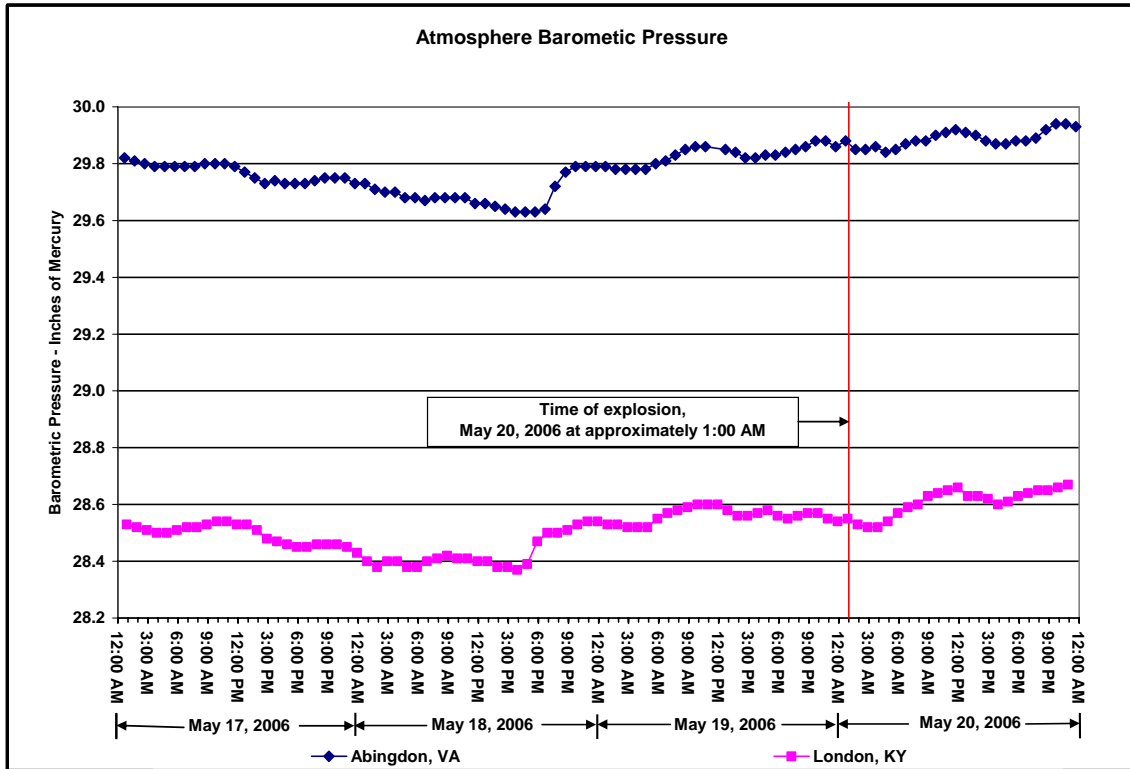
Vacuum bottle samples and air quantity measurements taken by MSHA on January 31, 2006 revealed a total mine methane liberation of 38,707 cubic feet per day. Vacuum bottle samples and air quantity measurements taken by MSHA on February 13, 2006 in the A Left Section return when coal was being mined revealed a total of methane liberation of 6,797 cubic feet per day.

Vacuum bottle samples and air quantity measurements taken by the accident investigation team in the A Left Section return after the explosion revealed total methane liberation of 4,307 cubic feet per day. The A Left area had been sealed for 63 days. Based on the liberation rate, it is estimated that 271,341 cubic feet of methane had been liberated in the sealed area indicating an average homogeneous methane concentration of 9.6 percent. However, it is unlikely that a homogenous mixture of 9.6 percent was present throughout the sealed area at the time of the explosion.

### ***Barometric Pressure***

Records of the barometric pressures for Abingdon, Virginia and London, Kentucky for May 17 through May 20, 2006 were obtained from the National Oceanic and Atmospheric Administration (NOAA) and are depicted in Figure 7.





**Figure 7 - Graph of Barometric Pressure**

In the five hours prior to and after the accident, the barometric pressure fluctuated over a narrow range of 0.05 inches of mercury and appeared to reverse direction and started down near the time of the accident. A decreasing barometric pressure would cause the atmosphere behind the seals to expand in accordance with Boyle’s Law, which states that the volume of a gas varies inversely with the absolute pressure. The gas expansion would cause the atmosphere in the sealed area to mitigate towards the seals and into the active workings through any openings.

**Roof Control**

The Roof Control Plan, approved on October 17, 2001, required, as a minimum, 42-inch fully grouted, 42-inch conventional, or 48-inch tension rebar roof bolts to be installed on 4-foot by 4-foot spacing. Steel roof straps could be used in conjunction with roof bolts and plates to aid in controlling the immediate roof/drawrock. Entries and crosscuts were approved to be developed a maximum of 20 feet wide and centers were to be a minimum of 70 feet by 70 feet in entries. A minimum of 50 feet by 50 feet centers was approved for rooms with 700 feet of cover or less. The maximum depth of cover over the mine was 1,400 feet. The plan required rib bolts to be installed on 4-foot centers when 50-foot centers were used.

In the A Left panel and in the main entries near the A Left panel, 42-inch long, 5/8 inch diameter, grade 60 fully grouted roof bolts were installed using 6 inch by 6 inch plates. Galvanized steel straps, 16-gauge, were installed in-cycle with the roof bolts in a "grid" pattern to help control the immediate roof. Each strap measured approximately 5 inches wide by 54 inches long and had two raised U-shaped ribs or channels, approximately 1/4 inch deep, formed along the length of the straps (see Appendix O).

### **Examinations**

Mine examinations were conducted by various certified mine examiners pursuant to the requirements of 30 CFR Sections 75.360, 75.362 and 75.364. The certified examiners included both management and non-management employees.

Section 75.360 requires an examination by a certified person within 3 hours preceding the beginning of any 8-hour interval during which any person is scheduled to work or travel underground. The certified examiner is required to examine for hazardous conditions, test for methane and oxygen deficiency and determine if air is moving in its proper direction at specific locations such as travelways, working sections, and seals along intake air courses. The mine operated two production shifts that began at 7:00 a.m. (day shift) and 3:45 p.m. (afternoon shift). The midnight shift was a maintenance shift that started at 11:00 p.m. Preshift examinations were performed within the required timeframes for these shifts.

The practices adopted by the mine operator for the recording and performance of preshift examinations were examined by the accident investigation team. The foreman working on the midnight shift preshifted the working section between 4:00 a.m. and 5:00 a.m. (for the oncoming day shift) and called out the results of the examination to either the mine superintendent or a surface attendant before 5:00 a.m. A record was made of this call out. The examiner called out the results of the preshift examination of the working section only, yet the records showed that the examination of the entire mine had been completed. At 5:30 a.m. a foreman and a mine examiner, traveling together, would enter the mine to conduct the preshift examination for the outby areas of the mine. Both the foreman and the examiner conducted various parts of the examination. However, only the mine examiner certified that the examination was made. This examination (for the oncoming day shift) included the travelways, intake seals, power centers, scoop battery chargers, and belt drives.

The investigation revealed that the examiners' practice was to examine the intake travelway up to the No. 2 Belt Drive, intake seals, and the No. 2 Belt Drive power

center and then wait for the dayshift production crew to travel to the working section. The crew would travel through an area of the mine that had not been preshifted. The production crew would call and instruct the examiners to turn on the water pressure pump for the section. After starting the pump, the mine examiners would examine the other areas that were required to be examined during the preshift examination.

The day shift section foreman preshifted the working section for the afternoon shift. The preshift examination was conducted between 1:30 p.m. and 2:00 p.m. and the results called out to the surface attendant usually between 2:00 p.m. and 2:30 p.m. The mine examiner conducted the preshift examination for the outby areas. However, the mine examiner did not conduct a complete preshift examination along the entire length of the belt lines where miners would be required to work. He only examined at the belt drives and power installations. The mine examiner would travel outside and make a record of his examination.

The section foreman working on the afternoon shift preshifted the working section for the midnight shift maintenance crew. The afternoon shift foreman generally conducted the preshift between 9:00 p.m. and 10:00 p.m. and called out the results of the examination to the surface attendant usually at 10:20 p.m. The called out results were inaccurate in that the examiner stated the examination of the entire mine was completed when it was not. Consequently, the required records of the examinations were also incorrect. The maintenance foreman who worked the midnight shift would enter the mine before the midnight shift started and conduct the preshift examination of the outby areas which the second shift production foreman did not examine. No records were made of these examinations. On May 19, 2006 there was no record that a preshift examination had been conducted of the outby areas which included the travelways, intake seals, power centers, scoop chargers, and belt drives prior to the afternoon shift miners traveling underground to work.

Miners said their job assignments on a routine basis were to clean and maintain the conveyor belt lines. This would require them to travel along the belt lines between belt drives in order to perform their duties. The preshift record book indicates, and the mine examiners stated preshift examinations were being conducted only at the belt drives and power centers. Additionally, miners stated on two different dayshifts, they were assigned to work on completing the construction of the A Left No. 3 Seal. There was no record of any preshift examination having been made prior to the miners entering the area.

Interviews indicated that Brock and Lee were staying behind at the end of the afternoon shift on May 19, 2006. Statements from miners who worked on Brock's crew indicated Brock never left the section that afternoon. Evidence indicated

that Brock traveled with Lee to the A Left No. 3 Seal together. Brock's notebook, which was found near the No. 3 Seal, included an entry referring to cutting metal straps. There was no record of a preshift examination having been made prior to Brock taking Lee to the No. 3 Seal.

Two mine examiners testified they would not always record small percentages of methane detected during required examinations. Zero percent methane was routinely entered into the record book.

Section 75.362(b) requires during each shift that coal is produced, a certified person shall examine for hazardous conditions along each belt conveyor haulageway where a belt conveyor is operated. This examination may be conducted at the same time as the preshift examination of belt conveyors and belt conveyor haulageways, if the examination is conducted within 3 hours before the oncoming shift. The mine produced coal on the day shift and afternoon shift. Mine Examiner Lunsford conducted the on-shift examinations on all the conveyor belts for the day shift. The record of these examinations included notations of hazardous conditions. The record book also indicated that on-shift examinations were being conducted on the afternoon shift along the conveyor belts up until June 15, 2005. No records were made after that date for the afternoon shift.

Lunsford testified that he was originally the mine examiner conducting the on-shift conveyor belt examinations on the afternoon shift. He performed this function until about June, 2005, when he was asked to move to the day shift by Ralph Napier. No one was designated to replace Lunsford.

Section 75.364 requires a weekly examination at least every seven days of worked-out areas, the bleeder system, an examination for hazardous conditions at specific locations that include at least one entry of the intake and return air courses in their entirety, at each seal along a return or bleeder entry, and measurements of air volume and tests for methane at specific locations. A foreman and a mine examiner routinely traveled together and jointly conducted the weekly examinations.

Documentation in the Weekly Examinations for Methane and Hazardous Conditions Record Book stated the first weekly examination for the A Left seals was conducted on March 27, 2006. The record indicated that the methane concentration was 0 percent, the oxygen content was 20.8 percent and no hazards were noted. Subsequent examinations were recorded as being conducted on April 3, May 5, May 12, and May 19, 2006. These records indicated consistently that there were no hazardous conditions, that the methane concentration was 0 percent and that the oxygen content was 20.8 percent. The records also revealed

that the A Left seals were not examined for four consecutive weeks. The examinations were required by April 10, 17, 24, and May 1.

On the dayshift of May 19, 2006, the A Left seals were examined as a part of 75.364 examination of the mine. Sizemore conducted the examination. He utilized his methane and oxygen detector and traversed the perimeter of each seal checking for methane and oxygen deficiency. During these examinations no methane or low oxygen was detected. He did not observe any unusual features of the seals and no hazards were found. The record made in the weekly examination book reflected this.

The accident investigation determined that proper 75.364 examinations were not being performed. Evidence and testimony indicates that several worked out areas in the mine were not being examined to the point of deepest penetration and portions of some air courses were not being examined.

### **Emergency Mine Evacuation**

The Emergency Temporary Standard (ETS), entitled "Emergency Mine Evacuation", became effective on March 9, 2006. The ETS required underground mine operators to conduct emergency escapeway drills at periods of time so as to ensure that all miners participated in such drills at intervals of not more than 90 days. Miners were required to travel the primary or alternate escapeway to the surface. An evacuation drill was not to be conducted in the same escapeway as the immediately preceding drill. Mine operators were to provide lifelines in the escapeways, an additional SCSR for each miner, training as to the locations of these devices, and training in donning of SCSRs. In accordance with the ETS preamble, MSHA accepted purchase orders or contracts to buy lifelines and/or SCSRs as a means of temporary compliance with the ETS. However, MSHA expected all other requirements of the ETS to be complied with immediately. The ETS required the operator to submit a revised Mine Emergency Evacuation and Firefighting Program of Instruction (Program of Instruction) by April 10, 2006.

The investigation revealed that Kentucky Darby had valid purchase orders for lifelines and additional SCSRs for the mine. The accident investigation revealed that a revised Program of Instruction was not received by MSHA prior to the date of the accident.

## Escapeways And Emergency Evacuation

### *Escapeway Drills/Fire Drills*

Section 75.380 requires that two separate and distinct escapeways be provided from the working section. One escapeway must be ventilated with intake air and be designated as the primary escapeway. The other escapeway is designated as the alternate escapeway (sometimes referred to as the secondary) and it can be ventilated with intake or return air. The two escapeways must be separated from each other for their entire lengths.

The ETS required escapeway drills every 90 days for all miners. During drills required, miners are required to travel either the primary or alternate escapeways to the surface. The escapeway drills are to be alternated between the primary and alternate escapeways. The ETS required that the mine operator certify in a record book that the drills were held. The names of miners participating in the drills are required to be listed.

The third shift crew began evacuation of the mine immediately after the explosion by first attempting to escape out the intake travelway (primary escapeway). After their personnel carrier became stuck on top of a damaged overcast, the crew attempted to escape out the No. 5 Entry following the high-voltage line rather than the adjacent belt entry located in the No. 4 Entry which was designated as the alternate escapeway. Ledford traveled out the high-voltage line entry for approximately 1,050 feet and then eventually crawled over to the intake entry where he was later found by rescue personnel. The other three miners apparently traveled in the high-voltage line entry before succumbing to carbon monoxide poisoning with smoke and soot inhalation at different locations in the mine.

The mine operator kept a record book entitled "Fire Drill Record" of fire drills held approximately every 90 days with miners on each shift. During these fire drills, miners were instructed in some general firefighting procedures. These instructions were given in a "safety talk" fashion and included procedures to follow if a fire were to occur on various pieces of machinery or equipment. As part of the evacuation instructions given to miners, the crew was told, in case of emergency, to evacuate the mine through the primary escapeway. Typically, miners then loaded onto personnel carriers and rode out of the mine through the main travelway (primary escapeway). Proper training in the use of the alternate escapeways was not given.

According to the record book and testimony, the emergency escape/fire drills were not properly conducted. The drills were not alternated between the intake

and the alternate escapeways. The record book did not reflect that any miners ever traveled out the alternate escapeway during drills. The drills were mostly limited to section personnel.

Given that the miners had to escape on foot due to the explosion, the lack of practice relating to the alternate escapeway, more likely than not, added to the delay in evacuation of the mine. The lack of training in the location of the alternate escapeway and the unfamiliarity with the alternate escapeway most likely affected the miners' response to the emergency of May 20, 2006. The miners did not use the designated alternate escapeway and at least one of the miners had to turn back to gain orientation. Had the miners been more familiar with the alternate escapeway, it is reasonably likely that the miners would have fared better in their escape attempt from the mine.

### *Escapeway Maps*

Regulations requires a map showing designated escapeways to be posted and kept up to date on working sections and on the surface. Any changes in route of travel, locations of doors, or directions of airflow are to be shown on the maps by the end of the shift on which the changes are made, and the miners must be informed of the changes prior to entering the underground areas of the mine.

The accident investigation revealed that maps designating the escapeways from the B Left working section were not provided on the surface and for miners who worked on the B Left working section (MMU 001). Two maps were posted in the mine office on the surface and a map was located on the working section. Neither the maps on the surface nor the map on the section clearly identified the escapeways or distinguished the escapeways from other available entries. Several entries were color-coded with markers or highlighters but none of these entries were labeled as escapeways or otherwise clearly designated as escapeways. The map provided on the B Left Section did not accurately show active workings of the B Left Section.

None of the maps designated the escapeways and properly distinguished them from other available entries. The investigation revealed that miners were unclear as to where the alternate escapeway was actually located. Some miners thought that the alternate escapeway was in the high-voltage line entry and at least one miner testified that he thought the alternate escapeway was located in the return.

## *Mine Emergency Evacuation and Firefighting Plan*

The Mine Emergency Evacuation and Firefighting Program of Instruction (Program of Instruction), required by Section 75.1502(a), was approved by the District Manager on February 6, 2003. The plan contained several requirements whereby all miners were to be instructed in firefighting and evacuation procedures. Among the requirements, the plan required miners to travel the intake or secondary (alternate) escapeways from the working section to the main escapeway every 90 days. Additionally, two miners and a supervisor were to travel the intake or alternate escapeways every six weeks alternating between the two escapeways. Escapeway maps were required to be posted on sections and on the surface and were to reflect any changes made in escapeway routes. Miners were to be notified of any changes to escapeways prior to their entrance into the mine or immediately after changes were made. The plan included instruction that during emergency evacuation SCSRs were to be donned immediately upon encountering smoke.

Several items of The Program of Instruction, approved February 6, 2003, had not been followed by the mine operator. Escapeway drills were not alternated between the primary and alternate escapeways and required escapeway maps were not provided.

## **Rock Dusting and Cleanup**

A program for the regular cleanup and removal of accumulations of coal and coal dusts, loose coal, and other combustibles must be established and maintained by the mine operator. Rock dust is required to be applied in all underground areas of the mine to maintain specified percentages of incombustible content.

Darby employed some methods to provide for cleanup and removal of accumulations of coal dust and for rock dusting the mine workings. The company employed an outby crew on the day shift that was responsible for maintaining the outby areas of the mine which included rock dusting. They used a scoop-mounted rock dusting machine to rock dust outby areas. This equipment was also used to rock dust the working section on idle shifts. The crew on the working section hand dusted the face areas as coal was being mined through the week. Rock dust was purchased in 50-lb bags.

Additional dust control measures were required by the Ventilation Plan. The Ventilation Plan described the dust control practices to be implemented and maintained for conveyor belt transfer points, loading points, belt haulage systems, all roadways, roof bolting machine dust collecting systems, and the



continuous mining machine. The dust control measures included water sprays, water application, maintaining permissible dust collecting systems, and using rock dust.

Thirteen violations of section 75.400 were issued during the 12-month period preceding the accident. Two of these citations were not terminated at the time of the accident.

According to statements of miners, the return entries from near the working section to outby the A Left return seals were recently rock dusted. The incombustible content of mine dusts was determined by analyses of samples collected mine-wide after the explosion. Analyses revealed that 84.3 percent of the samples collected were below the required amount of incombustible content.

### **Mine Dust Analysis**

A mine dust survey was conducted to assist in determining the cause and origin of the explosion and to determine the incombustible content throughout the affected and other areas of the mine. The incombustible content of the combined coal dust, rock dust, and other dust must be maintained to at least 65 percent in the intake air courses, and at least 80 percent in the return air courses, in the absence of methane, to meet the regulatory requirements.

A total of 363 samples were collected during seven different time periods from June 6 to June 22, 2006 as the underground portion of the investigation progressed. The type of samples collected included band samples, taken around the perimeter at each location, floor-only samples, roof-rib samples, and rib-floor samples. The samples were transported to MSHA's laboratory in Mt. Hope, West Virginia for analysis.

A total of 146 samples were collected throughout the affected area which included A Left Section and a portion of the Mains. In the Mains, samples were collected from survey station No. 506 to one crosscut inby survey station No. 559 in the No. 7 Entry. Of these samples, 129 (88.4 percent) were below an incombustible content of 65 percent in the intake air courses and 80 percent in the return air courses.

A total of 217 samples were collected from remaining areas of the Mains, Parallel Mains, Old East Mains, Old North Mains, and the B Left Section. A total of 54 samples were collected on the active B Left Section and in rooms off B Left. Of these, 50 (92.6 percent) were below an incombustible content of 65 percent in the intake air courses and 80 percent in the return air courses. A total of 163 samples were collected in the remaining areas of the Mains, Parallel Mains, Old East

Mains, and Old North Mains. Of these, 128 (78.5 percent) were below an incombustible content of 65 percent in the intake air courses and 80 percent in the return air courses. It is unlikely the samples in these areas were affected by the explosion.

Sloughage is a result of coal and rock breaking and falling from the ribs and accumulating on the mine floor. Because of the characteristics of the coal and the mining method, some sloughage was present throughout the mine. This would have had very little effect on the sample results. Virtually all of the sloughage material was too large to be included in the mine dust samples because it would not pass through a No. 10 mesh sieve.

Samples of the rock dust used at the mine were collected for analysis. All of the analysis results conformed to the 30 CFR 75.2 standard except that only 63 percent passed through the No. 200 mesh sieve. The particle size of the rock dust would not change the incombustible content of any sample. However, the purpose of fine rock dust is to provide protection from explosions involving float coal dust. With only 63 percent of the rock dust passing through a No. 200 mesh sieve, the explosion protection provided by the rock dust was not as high as it should have been. A copy of the laboratory analysis is included in Appendix P.

Three rock dust surveys were conducted by MSHA within the 12-month period prior to the explosion. Two of the three surveys indicated noncompliance with standards of 30 CFR 75.403. The last rock dust survey taken in A Left was on March 6, 2006. Two samples were taken in each of the 6 entries plus crosscuts, beginning at survey station No. 148 in the No. 4 Entry, and ending one crosscut outby survey station No. 189 in the No. 4 Entry. One of the eighteen samples analyzed was below the minimum level for incombustible content. The previous survey taken in this area was on November 11, 2005. One sample was taken in each of the 6 entries where A Left Section turned off the Mains. One out of six samples analyzed was below the minimum level for incombustible content.

### **Construction of Seals**

The Ventilation Plan, approved by the District Manager on September 1, 2005, specified the construction sequence and installation procedures for Omega 384 blocks to be used as an alternative method of seal construction (see Appendix N).

The A Left Section had been developed off the left side of the Mains such that Nos. 1 through 3 Entries were the return air course, belt entry, and intake air course respectively. The section was advanced 1,130 feet and stopped on March 3, 2006 due to bad roof and water. The section equipment was removed from A

Left on Saturday, March 4, and moved to the B Left Section. Mining started in B Left on March 6.

Based on the results of the investigation, it appears that seal construction was started on Saturday, March 18. Miners were all assigned at some point to work on the construction of the seals using Omega 384 blocks. Testimony given by the miners indicated Brock directed the miners on how to construct the seals and the sequence in which to build them. He directed personnel to install the air sampling tube in the No. 1 Seal and the water trap in the No. 3 Seal. In testimony, Ralph Napier stated that he gave Brock and Sizemore a copy of the approved sealing plan prior to the construction of the seals.

The sealing of the A Left Section began with the construction of the No. 1 Seal. The construction of the No. 1 Seal left the entire A Left Section in by the construction site unventilated. Based on information obtained through the accident investigation; a one inch or inch and a half diameter PVC pipe with a brass valve was installed in the No. 1 Seal to serve as a sampling tube. The No. 2 Seal was constructed next, across the belt entry. These seals were sprayed by TC Spray on the front and back sides. According to statements, several courses of block were laid for the No. 3 Seal but the seal was not completed due to the ending of the shift.

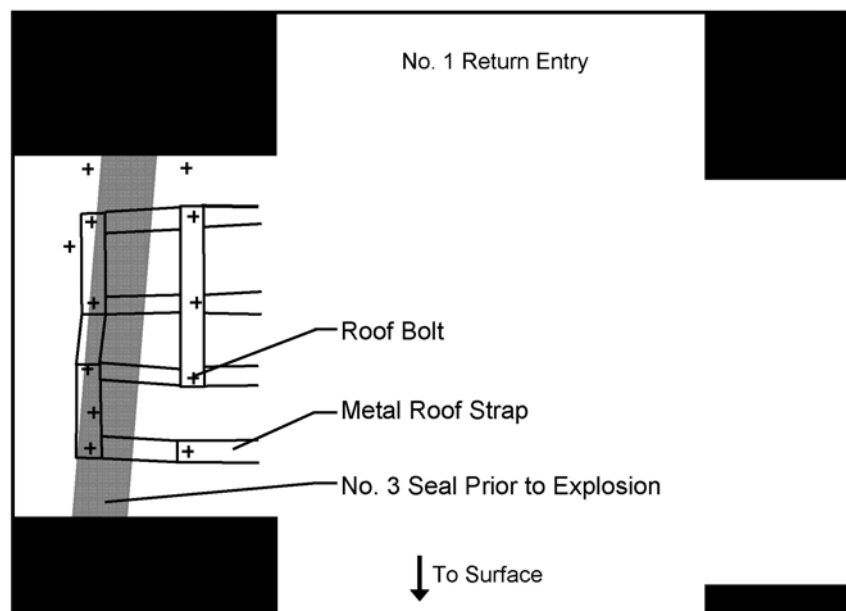
Normal operations resumed at 11:00 p.m. on Sunday, March 19, with the maintenance crew going to work, and the production shifts following on day and afternoon shifts on Monday, March 20. Testimony from miners indicated that they completed installing the Omega blocks in the No. 3 Seal during the day shift on Tuesday, March 21. Sizemore directed the miners on how to construct the seal. Pyrochem TC spray was reported to have been applied to the outby side of the No. 3 Seal on Wednesday, March 22. A metal pipe was installed in the No. 3 Seal to serve as a water trap.

Sizemore testified that he was in contact with Ralph Napier while the seal was being built. Coal was being mined in the B Left Section during the construction of the No. 3 Seal. The A Left Section was left unventilated and unsealed from March 18, 2006 until the following Wednesday, March 22, while miners were permitted to work in the mine other than those involved in the intentional ventilation change.

Testimony from miners who built the seals as directed and evidence obtained during the investigation revealed that the approved plan was not being followed. The following deficiencies were identified:

- a. The Omega blocks were dry stacked with no mortar between the joints.

- b. The seals were not hitched 6 inches into the solid rib and floor for the entire perimeter.
- c. The seals had been spray coated with a bonding and sealing agent not approved for this purpose.
- d. The pilaster was not properly constructed as it did not extend in by the seal as depicted in the plan and was only one 16 inch block wide.
- e. A single layer of 1 inch wood planking was not provided between the Omega block and the mine roof.
- f. The No. 3 Seal was located 6 to 7 feet from the outby rib corner whereas the plan requires a minimum distance of 10 feet.
- g. One metal roof strap extended through the No. 1 Seal and four metal roof straps extended through the No. 3 Seal. The use of Omega 384 block for seal construction was tested and approved by MSHA without any metal straps passing through the seal. The metal straps interfered with the installation of wood planking on the top of the seal. The wood planking could not be positioned flush with the mine roof. Figure 8 is a sketch of the metal roof straps at the No. 3 Seal.
- h. The seals were not built in the approved sequence.



**Figure 8 - Sketch of Metal Roof Straps at the No. 3 Seal**

The A Left seals were not the only set of Omega block seals constructed underground. During 2003, six seals were constructed across the Mains just in by where a new set of Mains was turned off to the left. This set of seals was commonly identified by mine personnel as the "intake seals." A miner stated that he helped build these seals and that the seals were constructed in the same manner as the A Left seals.

After the explosion, seven solid concrete block seals were constructed which complied with 75.335(a)(1) to replace the Omega seals at the intake seals. The plan approved by the District Manager for the construction of the new seals required that the existing No. 4 Seal (Omega) be breached prior to completing the solid concrete block seal that would replace it. Figure 9 is a picture of the No. 4 Intake Seal prior to being breached.



**Figure 9 - No. 4 Intake Seal**

On June 7, 2006, team members of the MSHA's Mine Emergency Unit, while under apparatus, breached this seal. The team observed the following deficiencies:

1. The thickness of the seal was 16 inches and not 24 inches as approved.
2. The blocks were dry stacked with no mortar between the joints.
3. The mine floor and ribs were not hitched.
4. The pilaster was undersized and did not extend to the inby side of the seal.
5. The outer wall was coated with Pyrochem TC spray. This product is not approved for use on Omega block seals.
6. The inner wall was not coated with any sealant.
7. Cap block and wedges were installed on top and sides of the seal and were in direct contact with the Omega block.

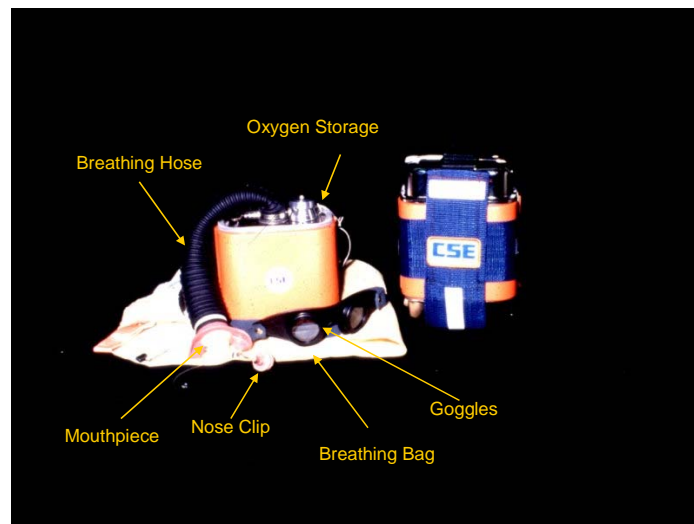
### **Self Contained Self Rescuers**

Darby provided miners with the CSE SR-100 Self Contained Self Rescuer (SCSR). The SR-100 self contained oxygen breathing apparatus utilizes a bi-directional

rebreathing system in which exhaled gas makes two passes through a carbon dioxide (CO<sub>2</sub>) absorption/oxygen generation canister before the gas returns to the user. Potassium super oxide (KO<sub>2</sub>) and lithium hydroxide (LiOH) are used to produce oxygen (O<sub>2</sub>) and remove or scrub exhaled CO<sub>2</sub>. The unit produces approximately 100 liters of oxygen. The unit is NIOSH/MSHA approved as a one-hour SCSR in accordance with 42 CFR, Part 84.

## SCSR – As Deployed

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**Figure 10 - SCSR Deployed**

Of the four miners who donned SCSRs, only one miner survived. Accident survivor Paul Ledford donned CSE SR-100 serial number 93609. Accident victims Roy Middleton, Paris Thomas and Bill Petra, donned CSE SR-100 serial numbers 84784, 89692, and 105936, respectively.

National Institute for Occupational Safety and Health (NIOSH) collaborated with MSHA in the post-incident evaluation of the five SCSRs recovered from the Darby Mine No. 1. NIOSH generated a report (“Investigation of Self-Contained Self-Rescuers (SCSRs) Recovered from the Darby Mine Disaster”, NIOSH Report to MSHA, January 2007) summarizing the SCSR evaluation. Four of these five SCSRs were used by miners during evacuation of the mine. These four SCSRs exhibited conditions consistent with partial use. The single intact SCSR failed visual inspection. A dent in the bottom case lid crossed the location of the moisture indicator. The indicator was dislodged and the case open to the external atmosphere, a condition that causes it to fail visual inspection. However, it is not possible to know that the SCSR would have failed the visual inspection prior to the explosion, or if the damage observed occurred as a result

of the explosion. In either event, it is in a condition that makes it unsuitable for use.

The evaluation of the recovered SR-100's was conducted at NIOSH, National Personal Protective Technology Laboratory (NPPTL) facilities in Bruceton, Pennsylvania. The evaluation was conducted by NIOSH and MSHA. Past experience with accident investigations has revealed that one of the most important products of the evaluation is an accurate visual record of the evidence. To this end NIOSH and MSHA cataloged and created a complete visual record using digital photographs and video tape. Photographs were made of all SCSRs, as received, and the inspection of the SR-100's was recorded on video tape. During this inspection, examiners assessed the condition of both external and internal system components. To the greatest extent possible, examiners inspected each SCSR according to the manufacturer's approved visual inspection criteria. It was not possible to follow the manufacturer's inspection procedure completely since the units had already been opened for use and the lids were separated from the SCSRs along with the closure straps which contain the serial number and manufacturing date, but all observable aspects of the manufacturer's visual inspection were noted. All crucial steps and observations were also documented with digital photographs.

**Table 3 - Results of Quantitative Analysis of SCSRs by NIOSH\***

Exhibit No.	Location of SCSR	Serial No.	MFR. Date	Dust Shield Cracked	Canister Dented	Notes	Start-up Oxygen Activated	Spent KO <sub>2</sub>	Evidence of Oxygen Production
D-01 Paul Ledford	Outside	93609	07/02	Yes	YES	Bottom Bushing out of place, "Jim Lewis" on dust cover. (Survivor)	Yes	45%	Yes
D-02 Roy Middleton	In Mine	84784	06/01	No	Yes	No Comments	Yes	40%	Yes
D-03 Paris Thomas	In Mine	89962	01/02	YES	No	"Pariss" on dust cover	YES	75%	Yes
D-04 George Petra	In Mine	105936	07/04	Yes	No	Goggles have smoke residue and scratch	YES	15%	Yes
D-05 Amon Brock	In Mine	84698	06/01	Yes	N/A	Unopened SCSR. Pulled freely from pouch, bottom moisture indicator dented into lid, unit open to atmosphere, dents in corner lids, Dent in middle of bottom lid. Did not attempt to open SCSR pending future tests			

\* From NIOSH's "Investigation of Self-Contained Self-Rescuers (SCSRs) Recovered from the Darby No. 1 Mine Disaster". Names have been added to the table for clarification.

Independent testing of the Darby SCSRs was conducted by Alternative Testing laboratories, Inc. located near Uniontown, Pennsylvania. Personnel representing MSHA and NIOSH observed all tests. A chemist from CSE witnessed the tests to make sure the lab followed the proper procedures. Alternative Testing laboratories, Inc. had their Technical Director and a chemist participate. The chemical analysis revealed that Paul Ledford used approximately 30 percent of the available KO<sub>2</sub> within the SCSR. Roy Middleton, Paris Thomas and Bill Petra used approximately 23 percent, 48 percent and 10 percent respectively. The approximate percentage used was determined by an average derived from the results of the chemical analyses performed by both laboratories. Based on the statement of the lone survivor Ledford, SCSRs were not donned at the time that the explosion occurred, but were donned after the crew began exiting the mine via a battery-powered personnel carrier and encountered smoke in the intake.

**Table 4 - Comparison of Percent KO<sub>2</sub> Used**

Exhibit #	S/N	Miner SCSR	Visual Estimate	CSE Lab. Analysis	Independent Lab. Analysis	Average Lab. Analysis	Location	Notes
D-01	93609	Yes	45%	30%	29%	30%	Paul Ledford	
D-02	84784	Yes	40%	25%	20%	23%	Roy Middleton	
D-03	89962 (89692)	Yes	75%	42%	53%	48%	(Paris Thomas)	Use visual estimate - fused bed
D-04	105936	Yes	15%	10%	9%	10%	Bill Petra	
D-05	84698	Yes	Not Used	#N/A	#N/A	#N/A	Amon Brock	

The four men donned their SCSRs and began traveling to the surface via the personnel carrier until their route was obstructed by a fallen overcast and they were forced to abandon the ride and start walking. The four men discussed their options and decided to follow the high-voltage cable due to the presence of thick, dense smoke that considerably reduced visibility. Ledford and Middleton were in the lead with Petra and Thomas following. At some point, Middleton told Ledford that he was going back to find the power center. Ledford told Middleton that they had to exit the mine. Ledford then followed the high-voltage cable to exit the mine. Ledford related that he crawled for a while then stopped and rested because he became exhausted and would have to rest. Ledford stated that when he arrived at the No. 3 coal conveyor belt head that he lost consciousness due to exhaustion. Ledford stated that after regaining



consciousness he crawled into the intake entry where he saw lights and was able to signal rescuers.

Ledford sustained first and second degree burns to his chest, which he believed were caused by the SCSR.

All self contained self rescue devices are required to be examined for damage and for the integrity of the seal after each time worn or carried by a person. During the interviews with mine personnel, it became apparent that this was not done regularly.

An examination of the operator's records of the 90-day testing and evaluation of the SCSRs at the mine revealed that the operator conducted the required examinations with an Acoustic Solids Movement Detector (ASMD); however the method used was not the method described in section four of the manufacturer's instructions. The manufacturer prescribed that the unit be moved in an up and down motion while conducting the test. The mine personnel used a horizontal motion while conducting the test. This horizontal motion is not a reliable method of checking that the chemical bed is intact. The records of the quarterly examinations of the SCSRs indicated that units that did not pass the ASMD test were removed from service and replaced. An examination of the operator's records indicated that at least thirteen SCSR units had been removed from service during the eighteen month period prior to the explosion.

Personnel at Darby were instructed in the operation and maintenance of the CSE SR-100 SCSR by a contract safety instructor during their annual retraining class using an actual training SCSR. For training conducted at the mine site, miners were trained using an expired or damaged SCSR that had been removed from service. This SCSR was found hanging in the mine storage room and did not have its top and bottom covers, goggles, or security band. Because of the lack of these parts, miners were unable to simulate the removal of the security band and the opening of the device. These steps are part of proper SCSR donning procedures as instructed by the manufacturer and required by the standard.

The instructions provided with the SR-100 SCSR state that there are several factors of concern regarding the usage of the SCSR. Persons are to be instructed that after the unit has been started, they should not remove the mouthpiece to talk. The removal of the mouthpiece would likely lead persons to breathe contaminated air. The removal of the mouthpiece typically allows the breathing bag to deflate. If it deflates, the uncontaminated oxygen is lost. Persons exposed to carbon monoxide that are actively exerting themselves or panicking will have a more rapid increase of carbon monoxide in their bloodstreams. Increased workload such as walking or carrying items will result in symptoms of exposure

sooner, and at lower concentrations. Carbon monoxide levels in normal nonsmokers are approximately zero to three percent of total hemoglobin. Persons who smoke can have levels of carbon monoxide ranging from four to nine percent of total hemoglobin.

The medical examiner's report revealed that Middleton, Petra, and Thomas, succumbed to carbon monoxide poisoning with smoke and soot inhalation. The carbon monoxide saturation in their bloodstreams was 55 percent, 46 percent and 45 percent, respectively. The carbon monoxide saturation in the blood of the only survivor Paul Ledford was 29.4 percent as measured at the hospital. The analysis of the SCSRs worn by Middleton, Petra and Thomas showed that the SCSRs had sufficient breathable oxygen capacity left to allow the miners to escape the mine. These factors indicate that proper SCSR usage procedures were not followed.

Paul Ledford stated during his interview with MSHA that SCSRs were not donned until they encountered smoke, and not immediately after they had realized that an explosion had occurred. Ledford stated that the mouthpieces of the SCSRs were removed when he and Middleton were talking during their escape from the mine.

The evidence indicates that elevated levels of carbon monoxide in the bloodstream may be accounted for because of the following factors: (1) The SCSRs were not donned until the miners encountered smoke at which time the atmosphere may have already become contaminated. (2) The removal of the mouthpiece to talk would have allowed the miners to breathe contaminated air. (3) Reports from mine rescue personnel indicate that the three deceased victims were found without nose clips on. The examination of the SCSRs indicated that the nose clips were still attached to the breathing hoses of each unit. Paul Ledford, although found wearing the SCSR, was observed by rescuers not having the nose clip in place. Without nose clips on, they would have breathed an atmosphere contaminated with carbon monoxide.

An Emergency Temporary Standard (ETS) became effective on March 9, 2006. That standard requires mine operators to have at least two SCSRs for every miner underground during any shift, requires outby caches of additional SCSRs in both the primary and alternate escapeways at specific distances, and requires coal mine operators to install lifelines in the escapeways at their mines. It also mandates that flame resistant lifelines are to be equipped with cones or devices, whereby a person can distinguish the proper direction of travel to safety, even with reduced visibility. The ETS allows operators to show evidence that additional SCSRs and lifelines had been ordered, recognizing that there would be a problem in material availability.

A deadline of April 10, 2006, was set forth in the ETS preamble to require the mine operators to show that the material had been ordered. Darby had ordered lifeline supplies on March 8, 2006. The additional supplies of SCSRs were ordered April 24, 2006.

### **Origin, Flame and Forces**

#### *Origin*

During any underground coal mine explosion investigation, it is necessary to locate the origin of the explosion. Identifying the origin is essential in determining the circumstances surrounding the accident and to help prevent similar, future occurrences. The ignition source and the fuel are located at the origin of the explosion. Ignition sources that are not located at or near the origin can be eliminated as potential ignition sources. The origin would be identified as the location from where primary explosion forces propagated in all directions.

Evidence was observed in the underground areas affected by the explosion at Darby Mine No. 1. This evidence was evaluated by MSHA investigators and it was used to establish the point of origin, the extent of flame, and the direction of the primary explosion forces. Appendix Q is a mine map that details the extent of flame and the direction of the primary explosion forces.

The sealed area designated as A Left was sealed through the installation of only three alternative-type seals constructed of Omega blocks. During MSHA's investigation, the locations of these three seals were meticulously evaluated, along with extensive areas on both sides of these seal locations. The direction of primary explosion forces, as shown on the mine map in Appendix Q, indicates that the explosion was initiated at the No. 3 Seal. Primary forces propagated away from the location of the No. 3 Seal in all directions, thus identifying this location as the origin of the explosion.

#### *Flame*

At the time the explosion occurred, there is no reason to believe that any coal dust would have been in suspension on either side of the A Left Seals. When the minimum explosive concentration of coal dust is suspended, the cloud is so dense that vision or breathing is impossible. Suspension is a necessary component of explosion propagation. Methane is naturally suspended as it enters the mine workings. Research has shown, as documented in MSHA Informational Report 1119, that the ignition of as little as 13 cubic feet of methane, diluted to within the explosive range, would be sufficient to suspend and ignite a coal dust cloud. Although methane provided the primary fuel for

the explosion, MSHA investigators believe that coal dust became involved to a limited degree throughout the sealed area as the flame propagated further inby into the sealed area. The extent of flame is shown on the mine map in Appendix Q.

A mine dust survey was taken after the explosion. A total of 146 samples were taken on approximately 100 foot centers in the affected area which included A Left Section and a portion of the Mains. Sampling the mine dust on 100 foot intervals or less minimizes the effect of any dust transport that may occur during the explosion. The samples were all sent to MSHA's Mt. Hope Laboratory for analysis. Each sample was subjected to an Alcohol Coke Test and each was analyzed for incombustible content. The results of the mine dust survey are recorded on the mine map in Appendix R. The results of the Alcohol Coke Test are summarized in Table 5. The results of the Alcohol Coke Test indicate the quantity of coke in each sample as either none, trace, small, large, or extra-large. MSHA has used these results to identify the extent of flame that has occurred during underground coal mine explosions.

**Table 5 - Alcohol Coke Test Results**

<b>Location</b>	<b>Number of Samples</b>	<b>No Coke</b>	<b>Trace Coke</b>	<b>Small Coke</b>	<b>Large Coke</b>	<b>Extra Large Coke</b>
A Left	66	0	0	3	34	29
B Left	57	57	0	0	0	0
Mains	149	127	21	1	0	0
Parallel Mains	42	40	2	0	0	0
Old East Mains	27	27	0	0	0	0
Old North Mains	22	22	0	0	0	0

Areas containing large or extra-large quantities of coke in the post-explosion analysis are indicative of explosion flame. However, it is possible for mine dust samples within the flame zone to show none, trace, or small quantities of coke. There are a variety of reasons that this may occur. For example, the explosion flame can travel at a velocity that is too fast to allow sufficient time for coal to coke. The entire area inby the location of the three seals was involved in the flame of the explosion. Flame did not extend beyond the seals into the active workings.

The flame of the explosion can be extinguished due to a lack of fuel, heat, oxygen, suspension, confinement, or a combination of these five factors. Explosion propagation occurred in the inby direction in No. 4 Entry, inby No. 3

Seal. As the explosion neared the inby end of the sealed area, the flame speed began to decrease. When the speed of an explosion is reduced to below approximately 150 feet per second, the explosion loses its ability to further suspend mine dust from the roof, ribs, and floor. Although coal dust was not able to be continually suspended in sufficient quantities to fuel an explosion, the explosive methane continued to be consumed as the explosion propagated inby. Therefore, the lack of sufficient suspended fuel did not help to extinguish the explosion in this case.

Methane requires about 1,000 degrees Fahrenheit to ignite, whereas a suspended cloud of coal dust requires about 834 degrees Fahrenheit to ignite. Explosion flames easily exceed these temperatures. Sufficient heat remained within the area of the flame front to continue propagation for the duration of the explosion. The explosion flame was not extinguished because of a lack of heat.

Coal dust and methane require 13 percent and 12 percent oxygen respectively to become, or to remain involved in, any combustion process. Since flame evidence existed throughout the sealed area, it is certain that oxygen concentrations at or above these minimums existed behind the destroyed seals. Also, the active workings would have contained an oxygen concentration of about 21 percent before and during the explosion. Although oxygen concentrations prior to the explosion would have been between 12 percent and 21 percent, the flame of the explosion would have consumed most of the oxygen present as it burned. The flame of a methane explosion would not be able to burn back through the same area because of the lack of oxygen immediately after the explosion. Expected oxygen concentrations after a typical methane explosion would be approximately 4 percent or less, depending on the initial methane concentration. The explosion flame propagated inby from the point of origin at the No. 3 Seal until it encountered the solid faces. As the flame front progressed inby, it consumed the available oxygen. The flame could not travel through the same area twice during the explosion because of the lack of oxygen. The lack of oxygen did not cause extinguishment of the propagating flame. The flame could not travel in the outby direction from the faces because oxygen levels were insufficient.

In order for an explosion to propagate, the fuel must be suspended. Coal dust can become suspended when overpressures occur. Coal dust can remain in suspension only when sufficient flame speeds continue during an explosion. When the flame speed decreases, the ability of the explosion to suspend coal dust diminishes. Methane is naturally suspended as a gas. Methane provided the primary fuel for the explosion and remained in suspension for the duration of the explosion. The lack of suspension was only responsible for extinguishment of that portion of the flame attributed to coal dust.

The flame did not pass out of the sealed area into the active workings. Confinement within the sealed area remained constant. The flame remained totally confined for its entire duration. Therefore, the lack of confinement was not responsible for the extinguishment of the explosion flame.

In summary, the explosion flame began at the location of the seals and propagated inby to the solid block of coal. There was an insufficient quantity of methane present outby the seals to support combustion. Extinguishment occurred because the flame could no longer propagate in the inby direction. After it reached the solid block of coal, the flame could not travel in the outby direction because oxygen levels were insufficient

### *Forces*

Explosion flame heats the mine atmosphere as it propagates. This action results in rapid expansion of the mine atmosphere and the generation of forces. As the flame speed increases, the magnitude of the explosion forces increases. Explosion forces affect a larger portion of the underground workings than the flame. Forces from the explosion damaged conveyor belt structure, roof supports, and ventilation controls. The force of the explosion caused the No. 3 personnel carrier to tumble approximately 260 feet, eventually coming to rest against the rib in the No. 4 Entry. The direction of the primary explosion forces are shown on the mine map in Appendix Q.

The explosion flame and forces initially propagated inby from the No. 3 Seal in the No. 4 Entry of A Left and continued to the most inby locations of the sealed area. Evidence indicated that explosion flame and forces split from the No. 4 Entry into both the No. 3 Entry and the No. 5 Entry as it propagated inby. The explosion flame immediately engulfed the Nos. 1, 2, 3, and 5 Entries and rapidly traveled throughout the entire sealed area.

In order for any explosion resistant seal to withstand the forces generated during an explosion, the seal must be properly constructed. Prior to this incident, all explosion resistant seals which were allowed to be constructed in underground coal mines had passed explosion testing to 20 pounds per square inch and had been deemed suitable for the intended purpose. Properly constructed Omega block seals have been subjected to explosion pressures of up to 27 pounds per square inch without failure occurring. However, explosion resistant seals must be constructed in the same manner as those that passed explosion testing. Any deviation from this manner of construction results in an untested seal with dubious explosion resistance.

The Omega block seals constructed underground for A Left were not constructed according to the manner in which those seals passed explosion testing. For example, there is no evidence of a complete hitch being cut from the floor and from both ribs into which these seals were to be set. Hitching is an essential characteristic of properly constructed 24-inch thick Omega block seals. Additionally, the blocks from these seals were reportedly stacked dry, without any mortar between the joints. This is a serious deviation from the manner in which those Omega block seals previously tested had been constructed. Also, only one mortar, BlocBond, is currently allowed for the construction of Omega block seals. Although a face mortar was applied, in construction of the return seals, the mortar was not BlocBond, and therefore, was not suitable for this particular application. Also, a full, interlocking pilaster must be incorporated into this type of seal. Such a pilaster was reportedly not built into the center of any of the three Omega seals that failed. Each of these construction deficiencies resulted in seals with questionable ability to withstand explosion forces.

Each of the three A Left Omega seals was completely destroyed during the explosion. Observations were made by MSHA investigators concerning the damage to the remnants of the Omega blocks. Many Omega blocks were reduced to small pieces of block and fine powder. The amount of pressure needed to cause this damage is not specifically known because the damage may be related to the strength of the mortar used for construction. Tests conducted at NIOSH's Lake Lynn Experimental Mine confirmed that structures in the path of a propagating explosion cause the primary forces of the explosion to be reflected. If the structures fail, the magnitude of the force is reduced. The total pressure reduction is dependent on the strength of the structure. For example, an explosion against a properly constructed 40-inch thick Omega block seal at NIOSH's Lake Lynn Experimental Mine resulted in pressures outby the seals decreasing from 51 to 6 psi and from 93 to 8 psi. However, an explosion against weaker structures, such as dry-stacked concrete block stoppings, resulted in pressures outby the stopping decreasing from 12 to 4 psi and from 8 to 6 psi.

The personnel carrier that was parked at the No. 3 Seal at the time of the explosion was displaced a distance of approximately 260 feet. This distance includes a deflection of 30 feet to the left after the personnel carrier collided with a coal pillar. Utilizing information regarding the dynamic pressure, it was estimated that the minimum explosion pressure exerted on the carrier appeared to be at least 22 psi. This calculation was determined in a report by MSHA entitled "Dynamic Calculations of the Explosion Pressures Exerted on the Personnel Carrier at the Darby Mine No. 1". This calculated explosion pressure was based on the total displacement distance of the personnel carrier. The total distance would have been greater if the personnel carrier had not impacted a coal pillar. This would have resulted in a calculated pressure greater than 22 psi.

## Calibration and Maintenance of Handheld Detectors

Several different types of multiple gas detectors were utilized at this mine site. They consisted of Industrial Scientific CMX270 and MX250; CSE 301, 102, and 102LD; CD210; and MSA Solaris. These detectors were used when making the required preshift, on-shift, weekly examinations, and the required methane test in the face area while mining coal on the producing section.

Mine management statements and records provided by the contractor who performed calibration tests, revealed that the detectors were not being calibrated at least once every 31 days. The only calibration test performed on the detectors occurred when they were sent in for repairs.

A MX250 detector was found on one of the personnel carriers used by the miners located on B Left Section at the time of the explosion. This detector was tested at MSHA's Approval and Certification Center. The test results showed that when the detector was turned on, it had a low battery warning signal. After the detector was charged, calibrating gas was applied through the Horiba gas analysis machine using a MX250 calibration cup at the recommended flow rate of 0.5 liters per minute (lpm). After applying methane to the detector, the readout indicated 0.1 percent regardless of the concentration of methane being applied. It was determined that the span on methane had been turned down and the electric zero was turned up.

Several tests were conducted on the MX250 using the Industrial Scientific calibration kit following the same procedure as above. The span potentiometer (pot) was returned to its original position and calibration gas was applied. The span pot was then turned 9.75 turns clockwise resulting in readings of 2.5 percent methane and 20.9 percent oxygen. These tests indicated that the MX250 was functional but was adjusted such that it would not properly detect methane.

This problem with the MX250 was not an isolated incident. Four to five out of every 10 detectors sent to be repaired by Darby were found to be out of calibration. Similar to this detector, some detectors were so far out of calibration that regardless of how much methane was applied the detector would only indicate 0.0 or 0.1 percent. Information obtained during the accident investigation revealed that some of the methane detectors had been rendered in such a way that an accurate reading was not possible. An examination of the methane detector that was carried by Amon Brock on the day of the explosion showed that the detector, although reading high, was functioning properly but it did not appear to have been deployed continuously at the time of the explosion. Due to the fact it was found in his pocket, it could not have been deployed continuously at the time of the explosion.



Through interviews, information was obtained that miners performing some of the required methane tests had not demonstrated to an authorized representative of the Secretary that they were qualified to properly test for methane.

### **Ignition Sources Considered**

#### *Oxygen/Acetylene Torch*

The accident investigation team recovered several components of an oxygen/acetylene torch assembly from the debris field created by the force of the explosion (see Appendix S). The team also recovered a 251 cubic-foot oxygen cylinder, a 140 cubic-foot acetylene cylinder, and approximately 50 feet of 3/8 inch diameter torch hose from the scene of the accident. These pieces of physical evidence, along with information acquired during the formal interview process, clearly indicate that the oxygen/acetylene torch was located at or near the No. 3 Seal at the mouth of A Left Section at the time of the explosion.

The torch handle (Victor Model WH36FC) was equipped with valves to control the flow of oxygen and acetylene to the cutting attachment. When the torch handle was found by investigators, the oxygen valve appeared to be open and the acetylene valve appeared to be closed. The cutting attachment (Victor Model CA35) was also equipped with a valve to control the flow of oxygen to the cutting tip. This valve appeared to be closed when found by investigators.

The oxygen cylinder valve was still attached to the oxygen tank when found by investigators and it was determined onsite that this valve was in the open position. The acetylene cylinder valve was sheared off during the explosion and was separated from the tank. This valve was also determined to be in the open position by onsite investigators. The pressure regulators for the oxygen and acetylene lines were heavily damaged in the explosion and no determination could be made regarding their individual settings.

The torch handle, cutting attachment, regulators, and cylinder valves were taken into custody by MSHA and transferred to MSHA Approval and Certification Center for examination and testing. The valves on the torch handle and cutting attachment were individually tested by applying compressed air (40 psi for the oxygen valves and 5 psi for the acetylene valve) to see if the valves were open or closed. The results of this test confirmed the assessment made by onsite investigators, with the exception of the acetylene valve on the torch handle, which leaked slightly when the compressed air was applied.

Further testing was conducted using compressed air and a flow meter to determine how small changes in valve position affected flow rate. These tests

were conducted using a new cutting torch identical to the one involved in the accident. When compressed air was applied to each of the oxygen valves, approximately 90 percent of full flow was developed by turning the valves one quarter turn counterclockwise from the off position. When the acetylene valve on the torch handle was tested, approximately 56 percent of full flow was developed by turning the valve one quarter turn counterclockwise from the off position.

The new torch assembly was then connected to compressed oxygen and acetylene tanks in order to determine the minimum valve settings required to sustain a neutral flame. Pressures were regulated to 5 psi for acetylene and 40 psi for oxygen. With the oxygen valve on the torch handle fully open and the acetylene valve opened 3/16 of one turn, a neutral flame was obtained when the oxygen valve on the cutting attachment was opened 1/8 of one turn.

These tests demonstrated that very small changes in valve position can have a substantial affect on flow rate. The oxygen/acetylene torch found at the mine site was subjected to a violent explosion. As a result, the torch components traveled several hundred feet and inevitably contacted the mine roof, floor, and ribs many times before being deposited along the debris path. It is highly likely that the valves on the torch handle and the cutting attachment were altered to some degree by the violent motion resulting from the explosion. Therefore, the exact position of the torch valves at the instant the explosion occurred could not be determined with certainty.

Four galvanized steel roof straps had been installed in the mine roof over the No. 3 Seal. Each strap was 54 inches in length and contained two "U" shaped grooves. The straps were oriented perpendicular to the seal and intersected the seal to varying degrees. A section, approximately 25 inches in length, was missing from the middle of the strap installed closest to the left rib (facing inby toward the A Left section). The remaining pieces of this strap were still attached to the mine roof when observed by investigators. This strap appeared to have been cut with an oxygen/acetylene torch at the point where the strap intersected the outby edge of the seal. The strap also appeared to have been severed (partially cut, partially torn) at a point approximately 25 inches outby the edge of the seal. A section of roof strap, roughly matching the dimensions of the missing piece, was found in the No. 5 Entry approximately 550 feet from the No. 3 Seal. This section of roof strap also appeared to have been cut with a torch and was partially covered with the type of sealant used during the construction of the seals.

The section of roof strap found in the No. 5 Entry was taken into custody by MSHA and designated as Exhibit P13. A portion of the inby section of the

severed roof strap was removed from the mine roof and taken into custody by MSHA. This piece was designated as Exhibit P43. The outby portion of the severed roof strap could not be retrieved because it was essentially covered by the roof bolt bearing plate. A diagram depicting the sections of the roof strap is included in Appendix T.

Exhibits P13 and P43 were transferred to MSHA Approval and Certification Center for analysis and testing. Microscopic analysis of the edges of the straps revealed that one of the edges of Exhibit P13 had been completely cut with an oxygen/acetylene torch and the other edge had been partially cut with a torch and partially severed by some other means. It was also determined that one edge of Exhibit P43 (“outby edge of No. 3 Seal” as noted in Appendix T) had been completely cut by a torch.

During the course of the investigation, a small notepad, identified by mine employees as belonging to Brock, was discovered lying on the mine floor in the main return just outby the location of the No. 3 Seal. The phrase “Cut straps & 2 Buckets sealant” was written on the first page of the notepad. A photograph of this page of the notepad is included in Appendix U.

The most likely ignition source for the explosion was the heat generated in the process of cutting the metal roof strap. Tests were conducted by engineers from NIOSH and MSHA Approval and Certification Center in which metal roof straps were cut with a torch while temperature recordings were made with an infrared camera system (see Appendix V). These tests demonstrated that the torch flame and the hot metal slag ejected during the cutting process were well above the ignition temperature of methane. This test also demonstrated that sparks and slag could be projected through the channels in the metal roof straps. The temperature of the metal edges created by the cut remained above the ignition temperature of methane for up to 20 seconds after the cut was completed.

### *Roof Falls*

A roof fall can ignite an explosive methane-air mixture either by generating frictional heat or by the release of piezoelectric energy. The rocks comprising the immediate and main roof rub against one another as the roof breaks and falls. The friction from rubbing or from impact can result in temperatures above the ignition temperature of methane. The United States Bureau of Mines (USBM) has conducted rubbing friction and impact friction experiments. Under carefully controlled laboratory experiments, the USBM was only able to ignite methane-air mixtures in a small percentage of tests, even when the methane concentration was optimum for ignition.

An ignition can also be generated by piezoelectric discharges during certain roof falls. This situation is usually found with rock containing crystalline structures such as tourmaline, quartz, topaz, and Rochelle salt. These crystals produce electric charges on parts of their surface when they are rapidly compressed in particular directions. In coal mining, the most notable crystal formation found is the quartz content of sandstone.

The immediate and main roof of the Darby Mine No. 1 was comprised of sandstone and shale; however, there was no evidence of roof falls in the A Left area. Therefore, roof falls were eliminated as an ignition source.

### *Lightning*

A lightning strike analysis was performed by Vaisala, Inc., of Tucson, Arizona, to address the possibility of lightning as an ignition source. The geographic center point of the analysis was specified as 36.8786°N, 82.9525°W, which corresponds to the digitizing coordinate nearest to the A Left Section on the mine map. A 5-mile radius and a 12-hour time period, from 6:00 p.m. on May 19 to 6:00 a.m. on May 20, were selected for the analysis.

The resulting report, entitled STRIKENet® Report 162412 (see Appendix W), clearly shows that there were no lightning strikes within a 5-mile radius of the mine at the time of the explosion. The closest lightning strike, with respect to time, occurred approximately 1.5 hours before the explosion, and was 12.5 miles from the specified location on the mine map. This strike had a peak current of 5,100 amperes. The closest strike, with respect to geographic location, occurred approximately 2.5 hours after the explosion, and was 1.4 miles from the specified location on the mine map. This strike had a peak current of 7,900 amperes. Based on this information, it was concluded that lightning did not contribute to the explosion.

### *Mine Electrical Distribution System*

Power was supplied to the main substation through a 34.5-KV service drop from the utility company. At the substation, the voltage was transformed from 34.5 KV to 4.16 KV by a bank of three 500-KVA transformers connected in a delta-wye configuration. The wye-connected secondary side of the transformers was grounded through 96-ohm, 25-amp grounding resistor. A 600-amp oil circuit breaker (OCB) was installed in the main substation to provide protection for the 4,160-volt circuit supplying power to both the surface and underground areas of the mine. A gang-operated disconnect switch was installed on the primary side of the transformers to allow the utility power to be disconnected. Lightning arrestors were installed on the line side of the gang-operated disconnect switch.

Power exited the substation on a set of uninsulated overhead lines. A high-voltage branch circuit was established at a totally-enclosed switch house located on the surface between the Nos. 3 and 4 Portals. The switch house contained a vacuum circuit breaker (VCB) and a visible disconnect switch to isolate and protect the #2/0 AWG mine power feeder cable, which entered the mine at the No. 4 Portal and supplied power to all underground circuits. Lightning arrestors were installed on the surface approximately 80 feet from the point where the underground circuit branched off of the main 4,160-volt line.

The underground mine power feeder cable was installed in the entry adjacent to the conveyor belt entry, which was identified as No. 4 for the first 1,500 feet and as No. 5 thereafter. The mine power feeder cable terminated at the B Left Section power center, approximately 4,100 feet from the point where it entered the mine.

There was no evidence to indicate that the high-voltage distribution system contributed in any way to the occurrence of the explosion. The mine power feeder cable was, at the closest point, at least 300 feet from the A Left seals.

### *Section Electrical Equipment*

The following pieces of mobile mining equipment were located on the B Left working section at the time of the accident:

- 1) One continuous mining machine (Joy, Model 14CM-10A).
- 2) Two shuttle cars (Joy, Model 21SC).
- 3) One battery-powered scoop (Long Airdox, Model 601).
- 4) One coal conveyor belt feeder (Stamler, Model BF-17).
- 5) One roof bolting machine (Fletcher, Model HDDR-13CF).

The electrical equipment on the B Left working section was ruled out as a possible ignition source based on the distance from the origin of the explosion. The face of the B Left working section was approximately 1,500 feet from the seals located at the mouth of the A Left Section at the time of the explosion. A map of the location of all electrical equipment in the mine at the time of the explosion is included in Appendix X.

### *Outby Electrical Equipment*

The mine had three underground conveyor belt drive installations, designated as No. 2, No. 3, and No. 4. The drives received power from 300 KVA power centers positioned near each of the respective belt drive installations. Two battery charging stations were present underground: one located near the No. 4 Belt

Drive, and the other located two crosscuts inby the portal in the intake air course. A permissible pump was positioned in the No. 1 Entry, 13 crosscuts inby the portal. A 25 hp pressure pump was installed approximately one crosscut outby the No. 2 Belt Drive in the No. 3 Entry. A battery-powered scoop (S&S, Model 488) was parked at the charging station near the No. 4 Belt Drive at the time of the explosion.

All of these potential ignitions sources were also ruled out based on the distance from the origin of the explosion. The No. 4 Belt Drive, located approximately 750 feet from the mouth of the A Left Section, was the unit of outby electrical equipment nearest to the point of origin of the explosion.

### ***Battery-Powered Personnel Carriers***

There were four battery-powered personnel carriers underground at the time of the explosion, none of which were approved as permissible. Two of the personnel carriers, designated as “No. 1” and “No. 2”, were located just outby the B Left Section power center. A three-wheeled personnel carrier, referred to as the “maintenance buggy”, was parked three crosscuts from the face in the B Left working section. The other personnel carrier, designated as “No. 3”, was located at or near the No. 3 Seal and was heavily damaged in the explosion.

The electrical components from the No. 3 personnel carrier, with the exception of the batteries (which were completely destroyed in the explosion), were recovered from the mine and taken to MSHA Approval and Certification Center for analysis.

The vehicle was manufactured by Johnson Industries of Pikeville, Kentucky, and the model was specified only as “super car”. There was no visible serial number printed or stamped on the frame of the vehicle. The unit was equipped with a 5 horsepower, totally enclosed, direct current motor, which received power from a set of six, 6-volt, deep cycle, 260 ampere-hour batteries connected in series (36 volts). The motor was controlled by a solid state controller in conjunction with forward and reverse contactors. A potentiometer operated by the foot pedal provided speed control for the vehicle. A single light, operated by a toggle switch, was mounted on the front of the vehicle.

The force of the explosion caused the No. 3 personnel carrier to tumble approximately 260 feet, eventually coming to rest against the rib in the No. 4 Entry. The motor and one of the contactors separated from the vehicle and were found lying approximately 30 feet from the personnel carrier (see Appendix F).

The motor was disassembled at MSHA Approval and Certification Center and examined for indications that an ignition occurred inside of the enclosure. No evidence of flame or burning of any kind was found inside of the motor enclosure. The enclosed solenoid was also disassembled and examined for signs of ignition. None were found. The remaining components were thoroughly examined and no evidence was found to indicate that the No. 3 personnel carrier caused an ignition of methane. Furthermore, it is unlikely that an explosive mixture of methane and air would have been present at the probable location of the vehicle at the time of the explosion, due to the ventilating current in the main return and the fact that the water trap valve in the seal was closed. The three personnel carriers located on or near the B Left Section were ruled out as possible ignition sources due to their distance from the point of origin of the blast.

### *Battery-Powered Cap Lamps*

At the time of the explosion, there were two Koehler battery-powered cap lamps in use at or near the No. 3 Seal at the mouth of the A Left Section. The components of these cap lamps were found deposited at various locations along the debris path created by the force of the explosion, indicating that the lamps were being worn by Amon Brock and Jimmy Lee at the time of the accident.

The cap lamp components recovered from the mine included portions of two headpieces, two cap lamp cables, two plastic battery covers with electrical accessory receptacles, and one intact battery. The battery for the other cap lamp was not recovered from the mine because only a portion of the external shell was located by the investigation team. The cap lamp components taken into custody by MSHA were analyzed at MSHA Approval and Certification Center in an effort to determine if they contributed to the ignition.

The examination of the cap lamp cables revealed no short circuits or other conditions indicating the cables were the source of a spark or thermal ignition. The electrical accessory receptacle (PTO) on one of the battery covers had been altered in such a way as to permit external access to both the positive and negative contacts. Battery-powered cap lamps are required by 30 CFR Part 19 to be constructed such that both polarities of the battery are not accessible externally. While this alteration was a violation of 30 CFR 75.507-1(a), it could not be determined whether or not the PTO was used in a manner that contributed to the explosion, though the low voltage of the lamp made it an unlikely ignition source.

One of the headpieces, designated as Exhibit P-18, contained a short circuit within it, but it was not possible to determine if the condition was caused by the explosion or if it was pre-existing. This type of headpiece, when maintained in

permissible condition, was previously found to be capable of containing an ignition when filled with an explosive mixture and ignited with an external source. The bulb ejection mechanism on the other headpiece, designated as Exhibit P-39, did not initially function due to dust on the interior of the socket. However, after the mechanism was operated several times, the bulb would eject properly from the socket. The dust was most likely deposited in the socket as a result of the explosion.

Due to the condition of the headpieces recovered from the accident site, it was not possible to conclusively rule them out as possible ignition sources. Bulb filaments are capable of causing a thermal ignition of an explosive methane-air mixture under certain conditions. However, in order for a bulb filament to present an ignition source in an assembled cap lamp, the following sequence of events must occur: (1) the bulb filament must be energized; (2) the lens must be broken; (3) the bulb envelope must be broken; and (4) the ejection mechanism must fail or the lens must be broken in a manner that retains the bulb in the socket.

The cap lamp battery recovered from the mine was subjected to spark ignition testing in an 8.3 percent methane-air mixture, with a cadmium disc, and two #24 AWG wire electrodes. The battery underwent 800 cycles of spark testing using the ISIB spark test apparatus. The battery was fully charged at the beginning of the test and was charged for one hour every 200 cycles during the testing to restore it to a fully charged condition. There were no ignitions of the methane-air test gas within the spark test apparatus throughout the testing process.

### *Hand-held Methane Detector*

Following the accident, an Industrial Scientific, Model MX250 (MSHA Approval # 8C-59), was found in the right front pocket of the pants worn by Amon Brock. The unit was taken into custody by MSHA at the Harlan Funeral Home and transferred to MSHA Approval and Certification Center for examination and testing. The detector was checked for calibration and functionality, which is discussed elsewhere in this report, and as a possible ignition source.

The worst-case short circuit current was calculated based on open-circuit battery voltage and internal resistance. The results clearly indicated that the 4.8-volt, nickel-cadmium battery pack could not produce a spark with sufficient energy to ignite an explosive mixture of methane and air.

The two internal backlight bulbs, with glass envelopes intact, were temperature tested after being energized continuously for two hours. The temperature of both bulbs was found to be less than 30 degrees Celsius at the end of the two-



hour period. The minimum ignition temperature of methane is approximately 537 degrees Celsius. A visual examination of the unit revealed no evidence of faults or overheated components within the detector that would be the source of a spark or thermal ignition.

Finally, the unit was energized and placed in a 7.7 percent methane-in-air mixture for 2.5 hours to see if the catalytic sensor would become hot enough to cause an ignition. The detector did not cause an ignition in the test mixture.

## **Training**

Training records were reviewed for all underground and surface miners who were employed at the mine at the time of the accident. Approved Part 48 training plans with lesson plans and training material used to conduct training were also reviewed. Darby employees received their annual refresher training at the Sigmon Training Center. The annual refresher training classes were conducted by George Carr.

Experienced miner training was conducted at the mine by Ralph Napier, a certified MSHA Instructor. Brock also conducted experienced miner training. The mine map was reportedly reviewed with participants regarding the colors on the map used to indicate the escapeways. Napier stated that when he went over the color code with the employees, they often forgot by the next day what the colors indicated. The mine map did not clearly distinguish which of the entries were designated as escapeways. Company health and safety rules were discussed with a tour of the mine at completion of the class.

Management and non-management personnel conducted task training at the mine. Task and hazard training were both recorded on the same MSHA form 5000-23. An explanation of the types of training required and the proper method of recording that training was given to the operator, who did not differentiate the types of training required for persons specified by Part 48.2 (a)(1) and 48.2 (a)(2). Part 48 training was recorded on MSHA form 5000-23 for the annual refresher training.

A CSE SR-100 SCSR specially designed by the manufacturer to be a training model was not provided at the mine. The operator used a SCSR that had been taken out of service to train miners. The unit could not be donned using the 3+3 method because the end caps and goggles were missing. The unit was normally stored in the changing room, hanging on the wall in an open position. Because of this, miners received inadequate SCSR training during hazard, new miner, and experienced miner training sessions. However, this unit was not used to

train the miners who died as a result of the accident as those miners received their training at another facility.

The annual refresher training the miners received on December 10, 2005, was significantly deficient. Training in the Mine Emergency Evacuation and Firefighting Plan did not include the use of non-verbal communication techniques when using a SCSR device. In addition, the SCSR 3+3 donning procedures training did not include complete donning procedures where the miners assumed a donning position and opened the device.

## ROOT CAUSE ANALYSIS

An analysis was conducted to identify the most basic causes of the accident that were correctable through reasonable management controls. During the analysis, root causes were identified that, if eliminated, would have either prevented the accident or mitigated its consequences. The following root causes were identified as a result of the investigation. In each case, an effective management system, procedure or policy was not in place to assure compliance with the regulation or safe mining procedure.

1. Root Cause: Mine management failed to ensure that prudent seal construction procedures were utilized in the building of the seals at the mouth of A Left Section. The top of the No. 3 Seal at A Left was intersected in several locations by metal roof straps. The metal straps interfered with the installation of wood planking on the top of the seal. The wood planking could not be positioned flush with the mine roof. The metal roof straps each contained longitudinal channels which, under certain conditions, could create a conduit for gases to flow from the sealed area into the active workings. It is most likely that such a conduit was created on May 20, 2006, when one of the metal straps was cut with an oxygen/acetylene torch, allowing an explosive mixture of methane and air to come into contact with either the torch flame or materials heated by the torch flame. One metal roof strap extended through the No. 1 Seal and four metal roof straps extended through the No. 3 Seal. The use of Omega 384 block for seal construction was tested and approved by MSHA without any metal straps passing through the seal.

Corrective Action: Mine management should assure either the straps are removed prior to seal construction, or seals are located to avoid contact with straps.

2. Root Cause: Mine management failed to ensure that safe work procedures were used while employees attempted to make corrections to an improperly constructed seal. On May 20, 2006, an oxygen/acetylene torch was used to cut through a metal roof strap installed at the No. 3 Seal at the mouth of A Left Section. Mine management allowed the use of the torch in an area where there was an obvious ignition hazard. In addition to this, proper tests for methane were not continuously made while the torch was being used. A proper test for methane would have included testing on both sides of the seal. A gas detecting instrument was available at the time the cutting was performed, but evidence indicates that it remained in the pants pocket of the afternoon shift foreman.

Corrective Action: Mine management should consider hazards and select safe work practices, such as the use of non-sparking cutting tools where methane hazards may exist. Management should assure that welding, burning or cutting operations are not performed where proper tests for methane cannot be conducted. Because of the inability to conduct adequate tests for methane in by the No. 3 Seal, there would have been no safe mechanism for cutting the metal strap intersecting the No. 3 Seal.

3. Root Cause: Proper SCSR usage procedures were not followed while four miners attempted to escape from the mine following the explosion that occurred on May 20, 2006. After the devices were donned, at least two of the miners removed their mouthpieces for some period of time in order to communicate verbally. Evidence indicates that the miners did not immediately don the SCSR units after the explosion, but waited until smoke was encountered several minutes later. Three of the four miners eventually succumbed to carbon monoxide poisoning with smoke and soot inhalation. The fourth miner survived the incident, but required medical treatment for carbon monoxide poisoning. Tests conducted on the SCSR units used by the victims indicated that the units were capable of providing sufficient oxygen to allow unimpaired miners to escape from the mine.

Corrective Action: Management should train and retrain miners, in realistic conditions, to increase the likelihood that they will react and perform properly should an actual emergency occur underground.

4. Root Cause: Management failed to provide adequate training regarding escape procedures. Escapeway drills were not properly conducted, in that, alternate escapeways were never traveled. Maps serving as escapeway maps, required to be used for training miners, did not identify the escapeways or show the current working section. This lack of training and familiarity with the alternate escapeway most likely delayed the escape of the miners following the explosion.

Corrective Action: Management should train and retrain miners to assure that they are familiar with all emergency escape procedures, and requirements.

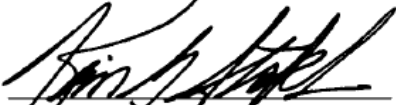
The mine did not resume production following the accident. On November 14, 2006, MSHA personnel confirmed that the mine was sealed. The mine was placed in abandoned status on November 15, 2006.

## CONCLUSION

An explosion occurred at approximately 1:00 a.m. on May 20, 2006, inby the A Left No. 3 Seal. The explosion resulted in the immediate deaths of two miners who were located at the seal. Three of four miners evacuating from the B Left Section succumbed to carbon monoxide poisoning with smoke and soot inhalation.

The accident occurred because the operator did not observe basic mine safety practices and because critical safety standards were violated. Mine management failed to ensure that proper seal construction procedures were utilized in the building of the seals at the A Left Section. Mine management also failed to ensure that safe work procedures were used while employees attempted to make corrections to an improperly constructed seal. Furthermore, mine management failed to adequately train miners in escapeway routes and proper SCSR usage.

Approved by: )



Kevin G. Stricklin  
Acting Administrator for  
Coal Mine Safety and Health

4/12/2007  
Date

## ENFORCEMENT ACTIONS

In addition to a 103(k) Order, the company was cited for six conditions and/or practices which contributed in some way to the accident. Thirty-seven other citations and orders were issued during the investigation, but were not considered to have contributed to the accident.

### 1. 104(d)(1) Citation No. 7061230, 30 CFR 75.333(h), S&S, Reckless Disregard

Condition or Practice: "On May 20, 2006 the integrity of the No. 3 Seal in A Left was compromised when a metal roof strap intersecting the seal was cut with a torch. As a result of the cutting of the metal strap, this seal was not being maintained for its intended purpose of separating the sealed area in A Left from the active portion of the mine. This resulted in methane from behind the seal coming into contact with the ignition sources that resulted from the cutting of the metal strap. The resulting methane explosion contributed to the deaths of five miners."

### 2. 104(d)(1) Order No. 7061231, 30 CFR 75.1106, S&S, Reckless Disregard

Condition or Practice: "Evidence indicates that adequate tests for methane were not continuously performed during the cutting operation of a metal roof strap at the No. 3 Seal of the A Left section. A methane explosion occurred resulting in five fatalities. Four metal roof straps extended through the No. 3 Seal. On May 20, 2006 cutting of a metal roof strap located at the No. 3 Seal in A Left was performed with an acetylene/oxygen torch adjacent to an atmosphere containing an explosive mixture of methane and oxygen."

### 3. 104(d)(1) Order No. 7061232, 30 CFR 75.370 (a)(1), S&S, Reckless Disregard

Condition or Practice: "Results of a fatal accident investigation revealed that the three Omega block seals installed to seal the A Left Section from the active workings were not constructed to comply with page 14 "Omega Block Seals" of the Ventilation Plan approved September 1, 2005. This portion of the approved plan specifies specific construction procedures to meet the requirements of 30 CFR 75.335 "Construction of Seals". Omega blocks were used to construct the seals, but the construction did not follow the plan as follows:

- a. The Omega blocks were dry stacked with no mortar between the joints.
- b. The seals were not hitched 6 inches into the solid rib and floor for the entire perimeter.
- c. The seals had been spray coated with a bonding and sealing agent not approved for this purpose.

- d. The pilaster was not properly constructed as it did not extend in by the seal as depicted in the plan and was only one 16 inch block wide.
- e. A single layer of 1 inch wood planking was not provided between the Omega block and the mine roof.
- f. The No. 3 Seal was located 6 to 7 feet from the outby rib corner whereas the plan requires a minimum distance of 10 feet.
- g. The Omega 384 lightweight block were approved to be used for underground mine ventilation seals without any metal roof straps or other extraneous metal passing through the seal. The metal straps interfered with the installation of wood planking on the top of the seal. The wood planking could not be positioned flush with the mine roof."

4. 104(d)(1) Order No. 7488601, 30 CFR 75.383(a), S&S, High Negligence.

Condition or Practice: "On May 20, 2006, an explosion occurred at the No. 3 Seal for the A Left worked out area which resulted in the deaths of five miners. Two of the miners died immediately from the force of the explosion and three miners died while attempting to escape from the mine. The accident investigation revealed that escapeway maps showing the designated escapeways were not provided on the surface and for miners who worked on the B Left working section (MMU 001). Two maps were posted in the mine office on the surface and a map was located on the working section. Neither the maps on the surface nor the map on the section clearly identified the escapeways or distinguished the escapeways from other available entries. The map on the working section did not show the active workings of the B Left Section."

5. 104(d)(1) Order No. 7488603, 30 CFR 75.383(b)(1) S&S, High Negligence

Condition or Practice: "On May 20, 2006, an explosion occurred at the No. 3 Seal for the A Left worked out area which resulted in the deaths of five miners. Two of the miners died immediately from the force of the explosion and three miners died while attempting to escape from the mine. The accident investigation revealed that during the emergency evacuation drills, escapeways were not alternated so that the alternate escapeway was traveled by miners. The records indicated and testimony revealed that miners only traveled out the intake escapeway during drills."

6. 104(d)(1) Order No. 7168187, 30 CFR 48.8(b)(8); S&S, High Negligence

Condition or Practice: "On May 20, 2006, an explosion occurred at the No. 3 Seal for the A Left worked out area which resulted in the deaths of five miners. Two of the miners died immediately from the force of the explosion and three miners

died while attempting to escape from the mine. Based on information gathered during the course of a fatal accident investigation, it was determined that the annual refresher training the miners received on December 10, 2005, was significantly deficient. Training in the Mine Emergency Evacuation and Firefighting Plan did not include the use of non-verbal communication techniques when using a SCSR device. During evacuation following the explosion, at least two miners removed the mouthpieces of their SCSRs to verbally communicate. In addition, the SCSR 3+3 donning procedures training did not include complete donning procedures where the miners assumed a donning position and opened the device.”