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

REPORT OF INVESTIGATION
Fatal Shaft Sinking Explosion
January 22, 2003

McElroy Mine
McElroy Coal Company
(Subsidiary of CONSOL Energy Incorporated)
Cameron, Marshall County, West Virginia
ID No. 46-01437

by

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View into water ring through mandoor frame from work deck.

OVERVIEW

At approximately 1:00 a.m. on January 22, 2003, an explosion occurred inside the McElroy Mine, 5 South #2 Airshaft being constructed by Central Cambria Drilling Company (CCD) for McElroy Coal Company, a subsidiary of CONSOL Energy Incorporated (CONSOL). Six miners were inside the shaft at the time of the explosion. The explosion fatally injured three miners and seriously injured three others. Appendix A is a list of miners on site at the time of the explosion. The explosion also damaged equipment on the work platform and placed dust into suspension.

Prior to the explosion, the miners were attempting to remove corrugated, galvanized steel sheeting (panning) which blocked access to the unventilated water ring being constructed**.** The miners first partially opened the panning with an axe, and the shift foreman placed a hand-held methane detector into the opening to test for methane. After reading 0.2% methane on his hand-held detector, the foreman directed the mechanic to cut the panning with an oxygen-acetylene torch. The mechanic ignited the torch and started to cut the panning. An explosion occurred when an explosive methane-air mixture contained inside the water ring was ignited by the torch cutting process.

An injured miner exited the shaft after unsuccessfully attempting to assist the two other injured miners. He then re-entered the shaft with a CCD surface worker (Top Man), but they were also unsuccessful in assisting the injured miners and returned to the surface. In response to 911 calls, emergency personnel arrived on site. Two deputy sheriffs, a paramedic, and the Top Man entered the shaft and recovered the two injured miners.

GENERAL INFORMATION

Location and Contract Information

The 5 South #2 Airshaft being constructed for the McElroy Mine (Appendix B) was located on Nauvoo Ridge, approximately 6 miles southwest of Cameron, Marshall County, West Virginia. The contract to construct this 24-foot diameter dual compartment airshaft was awarded to Central Cambria Drilling Company of Ebensburg, Pennsylvania on October 5, 2001 by McElroy Coal Company. A generic cross-sectional view of a shaft is contained in Appendix C. The projected completion date for this shaft was May 2003. Upon completion, the shaft was to be used to provide ventilation to underground areas of the McElroy Mine.

Principal Officers of Central Cambria Drilling Company

The principal officers of CCD at the time of the accident were Glenn R. Williamson, President, Jack Williamson, Vice-President, and Earl Rummel, General Superintendent. CCD has been constructing shafts and slopes primarily in the tri-state area of Pennsylvania, Ohio, and West Virginia since the spring of 1973. At the time of the accident, this shaft was CCD's only active construction operation.

Site Construction

Prior to CCD commencing shaft construction activities, other contractors were used by CONSOL to perform site preparation. CCD began working at the site in December 2001. Between December 2001 and January 2002, the construction and installation of surface facilities were completed, including the installation of the No.1 Hoist. Excavation and construction of the coping and collar commenced in February 2002. Appendix D depicts a plan view of the construction site. Normal shaft sinking construction activities began in mid-February. By mid-May 2002, the shaft had advanced to a depth of approximately 270 feet, where the first of two water rings was constructed. Work progressed until the end of June 2002 when the shaft construction was idled by CONSOL. During this period, the No. 2 Hoist was installed. CCD resumed shaft construction in September 2002. By mid-January 2003, the shaft was developed to a depth of approximately 950 feet and construction of the second water ring was in the final stages of completion.

Stratigraphic Description

Gamma ray logging had been performed by a contractor for CONSOL to verify the stratigraphy or geological characteristics at various depths below the ground surface for shaft construction purposes, and the results had been provided to CONSOL in a document dated February 2, 2000 (see Appendix E).

Numerous shale, limestone, and sandstone deposits were identified in the strata log. The explosion occurred at a shaft depth of approximately 950 feet. At this depth the strata log indicated that the shaft was at the bottom of the 30-foot thick Sewickley limestone formation and entering a 10-foot thick shale deposit. Coal seams identified in the strata log, including their approximate thickness and depth, are shown in Table 1. All are potential methane sources in close proximity to the shaft workings.

Table 1 – Coal Seams Intersecting the Shaft

Coal seam	Thickness	Depth
Waynesburg A	3 feet	665 feet
Waynesburg	6 feet	715 feet
Sewickley	4 feet	915 feet
Pittsburgh	8 feet	1,010 feet

Production Shifts

Normal production days consisted of two12-hour shifts that started at 8:00 a.m. and 8:00 p.m., respectively. The four crew work force alternated day shift and night shift working three days with four days off and then working four days with three days off. The general superintendent and superintendent worked on the dayshift on a regular basis, rotating three days on and three days off. The two night-shift foremen, referred to as Night Walkers, also rotated three days on and three days off. At the time of the accident, CCD employed 33 hourly and 4 salary employees at the site.

Shaft Construction Cycle

The shaft sinking construction cycle consisted of a series of steps (see Appendix F). Holes were drilled into the shaft bottom using a pneumatic Acme Jumbo Drill (jumbo drill). These holes were loaded with explosives, and detonated from the surface with a blasting unit. The loose material was loaded into two cubic yard buckets with an Eimco mucker, hoisted from the shaft bottom, and dumped on the surface during the mucking operation. These activities were repeated for the number of cycles required to achieve an excavation depth necessary for a 25-foot concrete pour and an additional 10 to 15 feet of loose material on the bottom.

The 25-foot concrete pour was completed in a series of four increments, starting at the lowest depth of excavation. The loose material on the shaft bottom was leveled, and panning was installed to create the outer wall of the form to be used to retain the concrete during pouring. Steel reinforcing rods (rebar) were then placed vertically and horizontally at predetermined distances. This was followed by the installation of utility pipes. A 4-piece set of 8-foot steel forms and keyways were bolted into place to create the inner wall of the form used to retain the concrete during pouring. Jacks were installed horizontally, and scaffolding was placed at the top of the forms to be used as a work deck. The concrete was then poured into these forms. This process was repeated two additional times. Each 8-foot steel form pour was referred to by ring number (e.g., Ring #114). To complete the concrete pour, a four piece set of 2-foot high steel forms, called the closure ring, was placed on top of the previous forms and against the surface of the existing concrete shaft lining. When this was filled with concrete, it created a continuous concrete wall connecting the existing concrete shaft lining to the new concrete pour. After the concrete cured sufficiently, the steel forms, scaffolding and jacks were removed in the reverse order of their installation and the shaft construction cycle was repeated.

Water Ring Construction

The water rings were constructed at depths of approximately 270 feet and 950 feet below the surface. See Appendix G for a detailed discussion of water ring construction. Eight to ten feet above the location of each water ring, the excavated diameter of the shaft rough opening was enlarged to allow clearance for support materials. Wire mesh was installed around the perimeter of the shaft rib and bolted. Rows of angled holes were drilled, loaded with explosives, and shot to create each water ring cavity (approximately 3-1/2 feet deep by 5-1/2 to 7 feet high). Wire mesh was installed against the roof and ribs of each cavity which were then bolted and gunited. Horizontal holes (weep holes) were drilled into the strata at floor level around the perimeter of the water ring cavity to provide drainage into the ring.

After additional mucking was completed to a depth of approximately 26 feet, the first set of 8-foot steel forms (Bottom Ring) was installed and the concrete was poured as described in Appendix F. As a part of this pour, the floor of the water ring was formed and a trough was created in the concrete to allow water drainage. Panning material was placed horizontally and vertically and fastened together to serve as the back wall of the form for the concrete pour (see Appendix G). Once this panning was installed, the water ring cavity located behind the panning would be isolated from the shaft ventilation.

Rebar were installed and a steel mandoor frame was then placed in front of the panning and attached to the rebar. The mandoor frame was installed to allow future access into the water ring. The second and third set of steel forms (middle and top rings), and the closure ring were then installed as described in Appendix F, and were filled with concrete in sequence to complete the cycle.

After removal of the closure, top, and middle rings, four 1.75-inch diameter ventilation holes were drilled opposite the mandoor frame through the concrete shaft lining into the water ring. During construction, these holes were intended to be used to detect the presence of methane and to ventilate the water ring.

EVENTS LEADING TO THE ACCIDENT

On January 11, 2003, construction of the second water ring began (see Appendix H). Between January 11th and January 14th, rows of holes were drilled into the shaft rib at pre-selected angles. The last rows of holes were loaded with explosives and shot on January 15th, creating the water ring cavity. The material was removed as a part of the mucking operation. Sections of wire mesh were attached to the ribs and roof of the water ring cavity, the roof was bolted and gunite was applied to the water ring cavity surfaces by January 17th. On January 18th, panning, rebar, utility pipes and the steel forms for Ring #114 were installed. On January 19th, concrete was poured on the 8:00 a.m. shift. The panning, mandoor frame, C-channels and cables were installed during the following shift. On January 20th, during the 8:00 a.m. shift, additional panning and rebar were installed. At this time, the water ring cavity became isolated from the shaft ventilation system. During this shift, the steel forms for Ring #113 were installed and the concrete was poured. During the 8:00 p.m. shift, the forms for Ring #112 were installed and the concrete pour was started. On January 21st, the 8:00 a.m. crew completed pouring Ring #112. The crew installed the four-piece closure ring and completed pouring the concrete that connected the new concrete pour to the existing concrete shaft lining. The dayshift crew performed work on the surface for the next six hours while the concrete began to cure. Near the end of the shift, the crew re-entered the shaft and began removing pieces of the closure ring.

DESCRIPTION OF THE ACCIDENT

Night Shift Foreman Richard Brumley arrived on site after 7:00 p.m. on January 21, 2003. While preparing for the start of his shift, he met Superintendent Larry Whyte in the office. Whyte discussed the work to be performed, indicating that the dayshift crew had completed pouring concrete and had removed the first two sections of the closure ring. They discussed removing the remaining forms and drilling ventilation holes through the concrete into the top of the water ring. Whyte made a sketch to show Brumley where and how to drill the ventilation holes. They also discussed using an axe to cut an opening in the panning that blocked access into the water ring. Whyte cautioned Brumley about the presence of methane in the water ring and advised him to conduct an examination for methane. In addition, Whyte directed Brumley to use the torch to finish cutting out the panning if methane was not detected. Brumley advised Whyte that he (Brumley) had conducted the preshift examination for his oncoming shift.

Just before 8:00 p.m., the dayshift crew exited the shaft and Lead Miner[1] Paul Price discussed the status of the work that had been completed on his shift with Brumley. Based on previous experience and knowledge about methane, Price also advised Harry Roush, III, oncoming shift Lead Miner, to be careful during his attempt to cut away the panning blocking access to the water ring because there would be methane trapped behind it.

Brumley assigned Drillers Benjamin Bair and Richard Mount to work with Roush III to remove the steel forms. Driller Aaron Meyer was assigned to assist Top Man Jack Cain to clean and oil the forms as they were removed from the shaft. Mechanic David Abel was assigned to perform maintenance on an Eimco mucker since mucking would be performed after all the forms were removed.

Shortly after 8:00 p.m., Roush III, Bair, Mount and Brumley climbed into the bucket. Hoist Operator Denver Jordan lowered the bucket into the shaft and work commenced. After the work of removing the forms began, Brumley exited the shaft and entered the office to perform paperwork. Roush III, Bair, and Mount removed the last two sections of closure ring and patched areas of the shaft wall with concrete. They removed the three pieces of scaffolding used to create the work deck and the jack that supported the top of Ring #112. Roush III, Bair, and Mount then completed the removal of Ring #112.

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[1] Person who directed activities in the shaft in the absence of management personnel.

At approximately 10:00 p.m., Brumley re-entered the shaft with a pneumatic tool to drill four ventilation holes. These holes were drilled through the concrete shaft lining and panning into the top of the water ring. After the holes were drilled, Brumley conducted a methane examination in the shaft at the entrance of the holes using the hand-held CSE 102 detector and then exited the shaft with the pneumatic tool. When Brumley arrived on the surface, Meyer overheard Brumley state that he had taken a methane reading and had detected methane. Meyer recalled hearing Brumley state that he had measured "four"[2] at the ventilation hole(s).

Within the next couple of hours, Roush III, Bair and Mount removed the next set of forms (Ring #113) and had them hoisted out of the shaft. After Abel finished servicing the Eimco mucker, he assisted Meyer and Cain in cleaning and oiling the forms.

At approximately 12:00 a.m., Roush III called from the shaft bottom and requested a pneumatic jack hammer (chipper) and axe. Brumley instructed Cain to load the tools into the bucket. Abel checked the torch cutting assembly and tanks which were also loaded into the bucket. At approximately 12:30 a.m., Brumley, Meyer, and Abel climbed into the bucket and entered the shaft.

Roush III, Meyer, and Bair chipped the concrete from inside the mandoor frame to access the panning. One of the miners used an axe to create an initial opening in the panning. The opening was approximately one-foot long by 3-inches wide and was located towards the right-hand side of the frame. Brumley placed the CSE 102 detector into the opening and measured 0.2%[3] methane. Brumley then instructed Abel to cut the panning. Meyer moved away from the mandoor. Abel assembled and ignited the torch. At approximately 1:00 a.m., an explosion occurred as Abel started cutting through the panning with the torch.

The explosion force exited the water ring through the mandoor frame. Flames shot across the shaft to the opposite wall and continued left and right around the shaft. Meyer, who was positioned to the right side and away from the mandoor, covered his face and dropped to the work deck. When Meyer no longer felt heat, he took his hands away from his face and looked around. He had very limited visibility because of the dust in suspension. Meyer walked toward the center of the shaft and found Brumley who was trying to sit up. Meyer helped Brumley move toward the bucket, however, Brumley was not able to board the bucket due to his injuries.

At the time of the explosion, Cain was in the No. 1 Hoist house with Jordan. They heard the explosion and saw dust rise out of the shaft. The force of the explosion broke a window in the No. 2 Hoist house. Cain ran to the shaft, where he shouted to the miners; however, he did not receive a response.

Believing the fan was off because of the dusty conditions, Meyer located the bell pull cord and signaled Jordan to turn on the fan. According to interview statements of Cain and Jordan, the fan was already operating. Meyer then found the pager phone and instructed Jordan to hoist the

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[2] The MSHA Investigators could not determine whether "four" indicated 4% or 0.4% methane. Meyer only remembered hearing Brumley say "Four". Brumley was advised by counsel during his interview not to discuss any of the activities that took place on the evening of the explosion and the instrument he used to conduct the examination was not able to store data.

[3] Witnesses indicated during their interviews that they were told the morning of the explosion by Meyer that the methane reading was 2.0%. However, during Meyer's interview, he stated that the reading was 0.2% methane.

bucket out of the shaft, empty the bucket, and send Cain back into the shaft to assist him with the injured miners. Meyer asked Jordan to notify him when the bucket was being lowered because he could not see.

Jordan raised the bucket out of the shaft and placed it on the ground. He then entered the office where he and Cain called 911 to report the explosion. After the 911 call was made, Jordan exited the office and observed that the bucket assembly was damaged. He decided to use the No. 2 Hoist and bucket for transporting Meyer and the other injured miners.

Meanwhile, Meyer began looking for the other miners. He again found Brumley who was trying to move toward the center of the shaft. Meyer helped Brumley move to the shaft wall and walked around the shaft searching for the other miners. He found Roush III lying on his back and could not detect a pulse. Meyer located Bair, who was also trying to pull himself toward the center of the shaft. Bair appeared to be in shock and was not responsive to Meyer. After Bair, Meyer found Mount and could not detect a pulse. He was unable to locate Abel.

Jordan notified Meyer that he was lowering the bucket into the shaft. When the bucket was near the bottom, Meyer used the bell pull cord to assist Jordan in placing the bucket on the deck. Meyer tried to help Brumley and Bair enter the bucket but was unsuccessful due to the extent of their injuries. Meyer then climbed into the bucket and signaled Jordan to raise the bucket out of the shaft.

On the surface, Meyer told Cain that Brumley and Bair were injured and needed help. He also told Cain about the status of Roush III and Mount and that he could not locate Abel. Meyer and Cain obtained the backboard, climbed into the bucket and entered the shaft. When they reached the work deck, they were unable to help either Brumley or Bair into the bucket because of the extent of their injuries and Meyer's trauma. Cain and Meyer exited the shaft.

RESCUE AND RECOVERY OPERATIONS

In response to the 911 calls, Marshall County Deputy Sheriffs Brent Wharry and Steven Cook, along with members of area volunteer fire departments and other medical personnel arrived at the shaft site at about 1:40 a.m. Rescue personnel determined that they did not have the proper training to enter the shaft and requested that mine rescue teams be brought to the shaft to recover the injured miners. Discussions took place about the condition of the injured miners and the need to recover them immediately. At about 2:00 a.m., Cain, Wharry, Cook, and Donald Kline, a Tri-State Ambulance Service paramedic, entered the shaft. They assisted Brumley into the bucket, placed Bair on a back board and then placed the back board across the rim of the bucket. They boarded the bucket and were raised to the surface. Bair and Brumley were transported by helicopter to the Mercy Hospital burn unit in Pittsburgh, Pennsylvania. Meyer was transported by ambulance to Reynolds Memorial Hospital in Glendale, West Virginia, where he was treated and released.

At approximately 1:50 a.m., a CONSOL employee who overheard 911 conversations about an explosion on CONSOL property contacted the 911 control center to obtain additional information. CONSOL corporate personnel were informed that an explosion had occurred at the shaft sinking operation of the McElroy Mine resulting in possible casualties and that mine rescue teams were needed. CONSOL corporate safety personnel contacted and mobilized their Enlow Fork and Blacksville #2 mine rescue teams. CONSOL also notified the 911 control center at 2:18 a.m. that these two mine rescue teams had been mobilized.

Due to an ongoing mine fire recovery, the mine rescue teams were located at Mine 84 operated by Eighty-Four Mining Company, a subsidiary of CONSOL located in Eighty Four, Pennsylvania. Charles Pogue, Mine Safety and Health Administration (MSHA) Mine Emergency Unit (MEU) trainer was stationed in the Mine 84 recovery operations command center. CONSOL personnel informed him that an explosion had occurred at the shaft sinking operation at the McElroy Mine and that there were possible casualties. Pogue then notified Ronald Costlow, MSHA MEU Supervisor. At approximately 2:30 a.m., Costlow notified William P. Knepp, Acting District Manager for District 3, who notified MSHA headquarters and other personnel. District 3 personnel were dispatched to the site. MSHA, West Virginia Mine Health, Safety & Training (WVMHS&T), CCD, CONSOL, and United Mine Workers of America (UMWA) representatives, the two mine rescue teams, and various emergency personnel arrived at the site over the next several hours.

At approximately 9:50 a.m., two Industrial Scientific, Model TMX-412 detectors were hung from the bucket and lowered into the shaft to evaluate the shaft atmosphere before personnel were allowed to enter the shaft. When the bucket was returned to the surface, the instruments indicated peak readings of 0.0% methane, 20.9% oxygen and zero parts per million (ppm) carbon monoxide. Therefore, it was determined that mine rescue teams would not be needed to recover the victims.

At approximately 10:00 a.m., Medical Examiner John Carson, Assistant Medical Examiner Mitch Corley, WVMHS&T Inspector Colin Simmons, MSHA District 3 Inspector Ronald Tulanowski, and General Superintendent for CCD Earl Rummel entered the shaft to assess the accident scene and recover the victims. Upon arriving at the work deck, Tulanowski and Simmons exited the bucket to examine the area. Air bottle samples were collected at the center of the shaft and inside the water ring, just beyond the mandoor frame. The results of these bottle samples were 0.02% and 0.31% methane, respectively. After two of the victims were brought to the surface, Whyte replaced Rummel during the recovery of the third victim. By approximately 12:00 p.m., all three victims had been brought to the surface.

INVESTIGATION OF THE ACCIDENT

The Administrator for Coal Mine Safety and Health directed that an investigation be conducted by a team consisting of personnel from MSHA Districts 2 and 8, Education Field Services, Pittsburgh Safety and Health Technology Center, and the Office of the Solicitor. James K. Oakes, MSHA District 8 Manager, was assigned as the accident investigation team leader.

On January 23, 2003, the team assembled at the MSHA St. Clairsville, Ohio Field Office and began the investigation. Preliminary information and records were obtained from MSHA, CCD, and CONSOL. Twenty-one formal interviews were conducted by representatives of the MSHA investigation team and transcripts were prepared. Most of these interviews were conducted in the presence of representatives of CCD, CONSOL, WVMHS&T and the UMWA. Appendix I is a list of persons interviewed on a non-confidential basis and Appendix J lists persons who participated in the investigation. Twelve additional interviews were conducted by MSHA personnel. Other contacts were made and information was obtained from persons having relevant information. Pertinent records were obtained and reviewed during the course of the investigation. Physical evidence was mapped, collected, examined, and/or tested, as necessary (see Appendices K, L and M). Selected photographs are shown in Appendix N.

DISCUSSION

Interaction between Central Cambria Drilling Company and CONSOL

Subsequent to a 1992 shaft explosion involving an independent contractor at its Blacksville No. 2 Mine, CONSOL entered into a cooperative agreement with MSHA in 1996 to improve safety for contractor employees working at CONSOL mines. In this agreement, CONSOL was to more closely review contractor safety background and assign a Site Superintendent to monitor contractor activities at its sites. CONSOL was also to conduct semi-annual safety audits. When the investigation team requested copies of all safety records pertaining to CCD, CONSOL indicated that the only records available were the daily work sheets from CCD. The investigation team obtained copies of the work sheets from CCD during the investigation.

With respect to CONSOL monitoring the shaft construction, CONSOL Project Engineer Michelle O'Neil performed oversight duties at the CCD McElroy Mine, 5 South #2 Airshaft sinking operation. She was supervised by Van Pitman, Manager of Engineering Services. O'Neil was responsible to oversee work performed by CCD to assure it fulfilled its contractual obligation to McElroy Mine in the construction and development of the 5 South #2 Airshaft. O'Neil interacted with Rummel and/or Whyte in matters regarding the development of the shaft. O'Neil determined where both water rings would be installed. She also monitored construction activities and reviewed CCD safety records at the site during periodic visits. However, she did not participate in the day-to-day shift examinations at the site.

Central Cambria Drilling Company Management Structure

The general superintendent had overall responsibility at the shaft site, including but not limited to, planning, purchasing, scheduling, health and safety, training, and interaction with CONSOL. The superintendent reported to the general superintendent and assumed these responsibilities in the absence of the general superintendent. They had direct responsibility over the dayshift crews. The night shift foremen also reported to the general superintendent or the superintendent on their respective work shifts, and had responsibility over the night shift crews. The general superintendent, the superintendent and the night shift foremen were responsible for conducting and recording the required examinations and for complying with the approved Shaft Sinking Plan. A lead miner was assigned to each crew to direct activities inside the shaft and to convey instructions from management. Appendix O depicts the management structure for CCD at the time of the accident.

Injury Incidence Rate History

With respect to the injury history for CCD, Table 2 shows the Non-Fatal Days Lost (NFDL) and All Injury Incidence Rate with the comparable national rates for contractors at coal mines. The All Injury Incidence Rate is a compilation of the Fatal, NFDL, and the No Days Lost (NDL) incidence rates. Preparation plant and office workers are excluded. The table shows the incident rates for the years 2001 and 2002. The accident occurred during the first quarter of 2003.

Table 2 – Incidence Rates for Contractors

Calendar Year	Incidence Rate	Central Cambria Drilling	National
2001	NFDL	5.85	3.90
	All Injury	17.54	5.16
2002	NFDL	10.12	4.21
	All Injury	37.12	5.46

Inspection History

An MSHA Regular Safety and Health Policy Inspection (BAE) of the shaft had been conducted on April 22, 2002. There were no outstanding citations at the time of the accident.

Training

Training required by Title 30, Code of Federal Regulations (CFR), Part 48, does not include shaft-sinking workers. Operators are required by 30 CFR, Section 77.107 to provide a program to train and retrain qualified and certified persons such as hoist operators and persons who conduct examinations for methane and oxygen deficiency. However, CCD did not have an approved training plan as required by 30 CFR, Section 77.107-1. Investigation interviews and available training records indicate that CCD did provide site specific hazard and task training as well as annual refresher training for their employees. Neither the failure of CCD to have an approved training plan nor the training provided to their employees was found to be a contributing factor to the explosion.

Shaft Sinking Plan

The Shaft Sinking Plan (Plan) in effect at the time of the accident was approved by MSHA on January 29, 2002. The shaft was described as a 24-foot inside diameter, round, concrete-lined, two-compartment airshaft of 1,018 vertical feet with a minimum wall thickness of 9 inches. The shaft was to be constructed using conventional shaft sinking methods (drill-shoot-muck), and the estimated construction time was 12 months.

The Plan addressed a variety of requirements, including but not limited to, ventilation, examinations for methane, and burning and welding underground. At least 6,000 cubic feet per minute (cfm) of air was required at the inby (shaft bottom) end of the ventilation ductwork or tubing. The required fan capacity was 7,000 cfm, and the fan could be operated in either a blowing or exhausting mode. The tubing or ductwork was to be maintained within 40 feet of the shaft bottom when operating the fan in a blowing mode. When the fan was operated in an exhausting mode, the tubing or ductwork was to be maintained within 10 feet of the shaft bottom. An examination of the ventilation equipment was required before each shift. The quantity of air in the shaft was to be measured at least once each day by a certified person and the results recorded. The fan was to be operated continuously when miners were underground except while aligning forms, installing or working on ventilation tubing, or plumbing the shaft. During these activities, the fan could be shut off for a maximum of 15 minutes.

The Plan addressed specific requirements for burning and welding in the shaft. All persons who performed burning and welding were required to be trained for such work. No records of this training were required to be maintained nor were any records found. Under the Plan, burning and welding in the shaft were to be performed in fresh air only. A qualified person was required to make an examination for methane before and during burning and welding operations. No burning or welding was allowed when 1.0% or more methane was detected.

In addition, the Plan contained the following provisions:

1. Hoisting equipment included a 250 horsepower (hp) Timberland electric hoist and a 100-hp Timberland emergency hoist.
2. Water rings were to be roof bolted using bolts with a minimum length of 48 inches.
3. Only permissible explosives were to be used when encountering coal seams.
4. Two independent means of signaling were to be provided and each was to be tested daily.
5. A search for smoking materials was to be conducted weekly, on an irregular basis, and the results recorded.

During interviews, CCD management indicated that they understood the various requirements and provisions of the Plan.

Electrical

CONSOL supplied 4,160-volt 3-phase power to the shaft site. Power was distributed through a 750 kilovolt-amperes (kva) load center. The load center provided 480-volt three phase alternating current (ac) and 220/110-volt single phase power for surface facilities and equipment used in the shaft.

A 60-hp, 480-volt fan was used to ventilate the shaft. The remote start/stop switch for the fan was located in the No. 1 Hoist house.

A 220-volt single phase, ¾-hp submersible pump was located in the first water ring. Four single #10 American Wire Gauge (AWG) conductors supplied power to the pump. These conductors entered the shaft through an 8-inch PVC pipe located within the concrete shaft wall and extended to the first water ring. The power conductors to the pump were found disconnected on the surface.

Blasting wires entered the shaft through another 8-inch PVC pipe located within the concrete shaft lining. The wires extended to the bottom of the shaft. The wires were found shunted on the surface and were not in use at the time of the explosion.

A General Electric (GE) 110-volt, Class I, Division I lighting fixture was located in the shaft approximately 35 feet above the work deck. Power was supplied through a #10/3 conductor-type SO cable that originated in the No. 2 Hoist house. This lighting fixture was in service at the time of the explosion.

A Femco-Gulton permissible mine phone was located approximately 42 inches above the work platform. The phone was in service at the time of the explosion. All phones connected to the system were permissible.

Ventilation

The shaft was initially ventilated with a 30-hp Hartzell fan attached to 18-inch diameter, metal ventilation tubing which extended down the shaft. Flexible 18-inch diameter tubing was attached to the end of the metal tubing to meet the ventilation requirements of the Plan. CCD recognized that the ventilation induced by the 30-hp fan was becoming marginal and would not be capable of providing the 6,000 cfm required in the Plan as the depth of the shaft increased. On October 14, 2002, the 30-hp fan was replaced with a 60-hp Hartzell fan, Series 56-33-BU2, operating at 3,500 revolutions per minute (rpm). However, the required air measurements recorded by CCD on October 14th and 15th indicate that the air quantity at the end of the tubing near the bottom of the shaft did not change significantly, increasing from 6,480 cfm to 6,559 cfm.

The depth of the shaft was advanced approximately 350 feet from October 14, 2002 until January 21, 2003. During this period of time additional metal tubing was installed to meet the Plan ventilation requirements. The shaft continued to be ventilated using the 60-hp fan. Between October 12, 2002 and January 21, 2003, inclusive, CCD recorded air quantity measurements that were required to be taken at the inby end of the tubing. The recorded measurements ranged from 6,400 to 9,000 cfm (see Appendix P). There are several factors that affect air quantity measurements, including but not limited to, using proper instruments, taking air quantity measurements at the proper location, maintenance of the ventilation system, length of tubing, and reading the instrument (anemometer) properly. According to interviews, anemometers were used at the proper location. In addition, CCD personnel demonstrated to MSHA personnel that they knew how to use an anemometer properly.

On January 21, 2003, the fan continued to be operated in a blowing mode. CCD records indicate that a quantity of 8,720 cfm was measured at the inby end of the tubing on that date. On

February 5, 2003, measurements were conducted by MSHA personnel to determine if CCD had been in compliance with the Plan ventilation requirements. Air quantity measurements were conducted at three locations. An air quantity of 9,400 cfm was determined in the duct between the fan and the shaft collar. Air quantities measured at the inby end of the metal and flexible tubes were 4,900 cfm and 3,640 cfm, respectively, which did not meet the Plan requirement of 6,000 cfm. Also, a distance of approximately 48 feet was measured between the inby end of the flexible tubing and the shaft bottom below the work platform (top of muck pile). The Plan stipulated a maximum distance between these two points of 40 feet.

After being advised by MSHA investigators that the air quantity measured at the inby end of the tubing did not meet the Plan minimum requirements, CCD requested permission to work on the shaft ventilation system. The 103(k) order was modified on February 11, 2003, to allow them to perform this work. Between February 11th and February 12th, CCD attempted to increase the ventilation quantity to meet the Plan requirements. However, CCD was still unable to obtain the Plan minimum air quantity with the 60-hp fan. On February 12th after CCD's attempts to increase the quantity, MSHA investigators measured 4,810 cfm at the inby end of the metal tubing. At this point, CCD submitted revisions to the Plan to include a 75-hp Hartzell fan, Series 56-48-BV3, designed to operate at 1,780 rpm. On February 13, 2003, after the larger fan was installed, the investigation team measured 6,670 cfm at the inby end of the tubing.

Welding and Cutting

Welding was not performed inside the shaft. If equipment required welding repairs, the equipment was hoisted out of the shaft and repaired on the surface.

Burning or cutting with the torch was performed as needed inside the shaft. The torch was used to cut rebar and to gain access into the water ring after the concrete forms were removed. When torch use was required, the torch and accessories were loaded in the bucket and lowered into the shaft. This welding and cutting equipment was not stored inside the shaft.

The process of burning and cutting inside the shaft, such as the removal of the panning that blocked access into the water ring, required only two persons to perform the operation, one to monitor the atmosphere and the other to perform the cutting operation. If this had been the work practice on the morning of the accident, the number of miners exposed to the hazards would have been reduced.

Just prior to the accident, the mechanic checked the torch before taking it into the shaft. The investigation revealed that the torch cutting assembly, including the valves on both the oxygen and the acetylene tanks, were damaged as a result of the explosion. Portions of the torch were tested by MSHA Approval and Certification Center (A&CC) and the results are contained in Appendix Q.

Search for Smoking Articles

CCD records indicated that searches were being conducted as required in the Plan. While many miners recalled that smoke searches had been conducted, a few miners said they had never been searched. In addition, evidence collected from the bottom of the shaft during the investigation included two pieces of a Camel Ultra Lights® brand cigarette box.

Methane Liberation

On February 5, 2003, air samples were collected to determine the methane liberation in the shaft. A methane liberation rate of 425 cubic feet per day (cfd) was calculated at a location approximately 48 feet from the shaft bottom. Methane samples were also collected in the water ring and showed methane concentrations ranging from 0.0090% to 0.0150% (see Appendix R). These values, along with bottle samples collected after the explosion, show that methane was being liberated in the shaft and in the water ring. The weep holes could have provided a conduit for additional methane to migrate from the strata into the water ring.

Barometric Pressure Readings

Barometric pressures are recorded at various stations throughout the United States. The station closest to the shaft site was identified to be Wheeling, West Virginia. This information is available through several sources and was obtained from an internet source identified as wunderground.com. Data for a 24-hour period, spanning the 12-hour period before and after the time of the explosion was obtained and reviewed. The information indicated that a low pressure weather system had passed through the area which resulted in a barometric pressure drop from approximately 11:30 p.m. on January 21, 2003 to 1:00 a.m. on January 22, 2003 (see Appendix S). The strata gases would have been negligibly affected by this slight pressure drop. Therefore, the barometric pressure drop did not materially contribute to the rate of methane liberation from the adjacent strata into the water ring. However, it would have had some affect on the body of methane confined between the panning and the shaft rib by causing the body of methane to expand.

Effects of Heat of Hydration

As the shaft was constructed, an air space was formed between the panning and the shaft rib. The air space existed the entire length of the shaft and was isolated into three parts: from the hitch point near the collar of the shaft to the floor of the first water ring, from the floor of the first water ring to the floor of the second water ring, and from the floor of the second water ring to the bottom of the concrete shaft lining. Since the shaft had been constructed through three identifiable coal seams and probably other methane bearing strata between the first and second water rings, methane would migrate from the strata into the associated air space between the two water rings. Methane would likely stratify at the high point of each air space because it has a specific gravity of 0.555. As a result, the top of each air space would continuously be filling with methane and the interface between the methane and air would move downward.

When the inby end of the concrete shaft lining was opened to the atmosphere during shaft construction, methane-air mixtures near the bottom of the concrete shaft lining would be flushed out by the passing ventilation currents. Therefore, there would be a gradient of methane content that ranged from nearly100% at the top of the air space to nearly zero at the bottom of the air space, which was open to the bottom of the concrete shaft lining. The air space became a closed system during each concrete pouring cycle. It was isolated from the atmosphere inside the shaft once all the panning was installed for the 25-foot pour and remained isolated until the sand and gravel mix and starter ring were removed. During this isolation period, an increase in total methane would occur in the air space.

The heat of hydration generated from the concrete curing process would create natural ventilating pressure (NVP). The NVP would induce air movement in the air space between the two water rings. This heat would also create convection currents that would mix the warmer air at the bottom with the cooler, methane enriched air above. This would result in a slightly increased methane enriched air mixture that would be circulated back to the water ring. At this point, it would be further heated by the concrete curing and again rise. In addition to being warmed, the air would have a lower specific gravity since it had mixed with methane from above. With the lower specific gravity, the reheated air would displace methane enriched air from a higher point in the air space. This process would continue as long as there was an ambient temperature difference in the air space caused by the concrete curing. Because of this methane and air mixing process, various methane concentrations would be present within the water ring. The quantity of air contained in the second water ring was calculated to be approximately 2,300 cubic feet. The volume of the air space between the two water rings was estimated to be approximately 7,650 cubic feet, over three times the volume of the water ring. Using formulas based on NVP, the period of time to circulate 100% of the water ring air volume was calculated to be less than 10 minutes. Prior to the explosion, the water ring was isolated and unventilated for approximately 26 hours. This provided sufficient time for an explosive methane-air mixture to develop.

Methane in Pipes

Four pipes were installed within the concrete shaft lining and extended from the collar to the shaft bottom (see Appendix C). Three of the pipes were 8-inch diameter PVC pipes and the fourth was a 6-inch diameter steel pipe. These were intended to be used for mine utilities and de-watering. Methane was detected in the pipes on February 5, 2003. Monitoring and testing were conducted to determine the source of the methane. It was determined that methane from the adjacent strata was entering the pipes through openings and cracks in the pipes and concrete shaft lining (see Appendix T).

Methane Detectors

There were three methane detectors on site at the time of the explosion. Two of the detectors were Passport FiveStar Personal Alarm instruments (FiveStar) manufactured by Mine Safety Appliance Company (MSA). Each of the FiveStar instruments was equipped with data storage capability. The third methane detector was a CSE Corporation Model 102 Portable Methane Detector (CSE 102). The CSE 102 detector does not have data storage capability. A FiveStar and the CSE 102 detectors were found among Brumley's personal items during the investigation. The other FiveStar was found in the office located at the shaft site.

A&CC inspected and tested the MSA FiveStar instruments (see Appendix U). It was determined that these units were not manufactured in accordance with their approved design. However, there is no evidence that these discrepancies could have produced conditions that would have provided enough energy to ignite a flammable methane-air mixture.

CCD records indicated that Richard Lewis, Safety Director until November 2002, last calibrated the two FiveStar instruments on October 22, 2002. The data stored in memory showed that the methane sensor in each instrument was last calibrated on October 21, 2002. The data also indicated that the FiveStar found in Brumley's jacket pocket was last activated for less than one minute at 8:11 p.m. on January 21, 2003. Therefore, this instrument was not used to perform the required examinations when the accident occurred.

No record was found that the CSE 102 instrument had been calibrated. The CSE 102 detector was inspected and tested by A&CC (see Appendix U). Several permissibility discrepancies were identified, but were not significant with respect to being an ignition source. No definitive determination on the operating status of the instrument at the time of the accident could be verified because the instrument could not store data. However, interview statements taken during the investigation indicated that this instrument was used to test for methane for the January 21, 2003, 8:00 p.m. preshift and examinations conducted in the shaft during the shift. Tests showed that the instrument was not properly calibrated to detect methane within the limits of accuracy required by the MSHA approval process. When a 2.0% methane-in-air mixture was applied to the instrument, it read 1.6% methane. This equates to a 20% percent error, which would cause the instrument to indicate a lower methane concentration in the atmosphere than what was actually present.

<u>Examinations</u>

CCD had been constructing shafts and slopes since the spring of 1973. The certified supervisory officials had extensive experience constructing shafts through methane bearing strata and they demonstrated knowledge to MSHA of the properties of methane. Preshift and on-shift examinations of the shaft are required under 30 CFR, Section 77.1901. Examinations must be conducted prior to cutting and welding as required by 30 CFR, Section 77.1916(c). These should include tests for methane in all areas that could be affected by these activities, including any location where sparks could travel. CCD certified and/or qualified persons were responsible for conducting these examinations. After the accident, CCD management personnel demonstrated that they knew how to perform examinations for methane.

The Plan required that the ventilation apparatus be examined before each shift, that the air quantity in the shaft be measured daily by a certified person, and that the results be recorded. The quantity of air in the shaft is required, under 30 CFR, Section 77.1911(a), to be measured daily by a certified person and the results of such examinations be recorded in a book. After the accident, CCD management personnel demonstrated that they knew how to properly use airflow measuring equipment.

After conducting air measurements, the investigation team found that the air quantity at the inby end of the ventilation tubing did not meet the Plan requirements, and in fact, was only 61% of the ventilation requirement. The investigation team further determined that the metal duct was intact, the flexible tubing was not damaged by the heat of the explosion, and a 4-inch space between the flexible tubing and the metal duct occurred during installation. In addition, the fan was examined and found not to be damaged by the explosion. As stated previously, CCD was allowed to perform work on the shaft ventilation system on February 11th in an attempt to increase the air quantity, but was unable to increase it to the required 6,000 cfm minimum at the inby end of the tubing. Therefore, the measured quantities obtained during the investigation typified the measured quantities that CCD should have found and recorded. These findings revealed that the air quantities entered in the record books by CCD management personnel did not accurately reflect the air quantities in the shaft prior to the explosion (see Appendix P).

Potential Ignition Sources

An explosion requires the suspension of a fuel within a confined space with sufficient quantities of oxygen present. Also, the fuel must be exposed to significant levels of heat or energy from an ignition source. A determination of the fuel is vital in establishing potential ignition sources because ignition characteristics vary with different fuels. The fuels considered for the explosion that occurred included acetylene, explosives, and methane.

Acetylene from the tank at the bottom of the shaft at the time of the explosion was eliminated as the fuel source for several reasons. The specific gravity of acetylene is 0.908, indicating lighter than air characteristics. Acetylene would not accumulate in the bottom of the shaft because of its tendency to rise in the shaft. The ventilating air would also serve to remove acetylene from the shaft. Acetylene would not be expected to accumulate within the water ring due to its lack of exposure to this confined area. Ignition of a uniform acetylene accumulation would cause similar effects on all individuals within the confines of the shaft. However, the six employees who were working in the shaft at the time of the explosion were subjected to a wide variety of forces, which originated within the water ring. Since the equipment had been checked prior to taking it into the shaft, it should have been in good operating condition and no leakage of acetylene should have occurred.

Explosives were eliminated as the fuel because an evaluation of the work deck and the bottom of the shaft did not reveal any evidence indicating an unplanned detonation of an explosive charge. Explosives were not found during the mapping phase of the investigation. Explosives were not necessary for the work that was being performed at the time of the explosion.

Methane did provide the fuel for the explosion. Evidence indicates that the explosion was initiated within the water ring near the bottom of the shaft. The water ring was separated from the shaft and was not ventilated for a period of approximately 26 hours immediately prior to the explosion. The presence of methane in the water ring was verified through the analysis of bottle samples taken during the recovery of the victims and during the investigation.

Methane explosions can cause pressures resulting in the damages observed during the investigation. The volume of the water ring is sufficient for substantial accumulations of methane to occur within its explosive range. The confinement of the water ring would likely result in pressure piling with its associated increased pressures. The mandoor between the water ring and the shaft allowed directional forces to propagate from the water ring into the shaft.

As methane from the surrounding strata entered and mixed with air trapped within the unventilated water ring, the methane-air mixture eventually entered its explosive range between 5% and 15%. Based on the observed damage caused by the explosion, methane within its explosive range most likely was present in portions of the water ring, including the vicinity of the mandoor frame.

Methane can be ignited by temperatures of about 1,000 degrees Fahrenheit. The minimum ignition energy for methane is about 0.3 millijoule. This amount of energy is only about 1/50 of the static electric charge accumulated by a person walking on a carpeted floor in a dry atmosphere. Potential ignition sources are those sources that have temperatures or energies exceeding the minimum ignition requirements for methane. The potential ignition sources at the bottom of the shaft or in the water ring were as follows:

1. Mine Phone

   MSHA personnel removed the battery from the permissible Femco mine phone during recovery operations. This mine phone was examined and was found to be in safe condition. The battery was reinstalled during the investigation and the phone was operational. The mine phone was eliminated as an ignition source because there was no evidence to indicate that an ignition was caused by its operation and it was not located in close proximity to the mandoor opening into the water ring where the explosion occurred.

2. Striker for Torch

   The striker for igniting the torch was found in the water ring. The striker could ignite methane. However, it would have been used in the fresh air of the shaft and would not have been exposed to explosive concentrations of methane. Statements indicated that the striker was used without incident just prior to the explosion. It was eliminated as an ignition source.

3. Light Fixture

   A light fixture, suspended along the shaft wall approximately 35 feet above the work deck, was used to illuminate the work area at the bottom of the shaft. Explosive methane concentrations would not have occurred at this location due to ventilation in the shaft. The lighting fixture was eliminated as an ignition source.

4. Axe

   The intended function of the axe was to create an opening in the panning covering the mandoor frame. Although there is a remote possibility that this action in itself could ignite methane, the examination and testing conducted by A&CC indicated that it was highly unlikely that the axe striking the panning would create a spark capable of igniting a methane-air mixture. Furthermore, statements revealed that this opening into the panning occurred without incident just prior to the explosion. The axe was eliminated as an ignition source (Appendix U).

5. Electrical Conductors

   There are no indications that electrical conductors provided the ignition source for the explosion.

Examination of the lighting fixture electrical cable revealed no damage. This cable was eliminated as an ignition source.

The electrical wires that supplied power to the ¾-hp pump located in the first water ring were disconnected and were not in use at the time of the explosion. The wires were eliminated as an ignition source.

Blasting wires that were used to detonate explosives during shaft construction were shunted on the surface. The blasting wires were eliminated as an ignition source.

6. Smoking Articles
   Employees of CCD were aware that smoking articles were not permitted in the shaft. Many of the miners involved did not smoke. CCD records indicate that smoking articles were not found on anyone entering the shaft. However, some miners stated that they didn't recall being searched. Two pieces of a cigarette box were found at the bottom of the shaft by the mapping team during the investigation. No physical or interview evidence showed that the explosion was caused by smoking articles or activities. Smoking was eliminated as an ignition source.

7. Pneumatic Chipper
   The pneumatic chipper was used to remove excess concrete from within the mandoor frame. The chipper was not in use at the time of the explosion and was eliminated as an ignition source.

8. Pneumatic Wrench
   The pneumatic wrench was not exposed to the explosive methane concentrations in the water ring. It was eliminated as an ignition source.

9. Cap Lamps
   The cap lamp assemblies were tested by A&CC. Testing indicated that the assemblies were not an ignition source (Appendix U).

10. Gas Detectors
   Gas detectors were tested by A&CC. Testing indicated that the detectors were not an ignition source (Appendix U).

11. Torch
   One function of the torch was to cut through the panning that blocked access into the water ring. Based on the evidence, the flame of the torch, molten metal, or the superheated surface of the panning ignited an explosive methane-air mixture in the water ring (Appendix Q).

Description of Explosion

Before the panning was installed, the water ring cavity was common with the shaft. Methane entering the water ring cavity was being diluted and removed. During the 26-hour period after the panning was installed, the water ring was isolated from the ventilation in the shaft. Additional methane entered the water ring during this time. The methane was not removed because the water ring was unventilated. Bottle samples collected inside the water ring during the investigation confirmed that methane was entering the water ring prior to the explosion.

Four 1.75-inch diameter ventilation holes were drilled into the water ring at a downward angle through the concrete shaft lining opposite the mandoor frame. At the time of the investigation, three of the four holes were found to be obstructed. The ventilation holes did not provide an effective means to ventilate the water ring. The CSE 102 methane detector was held at the drilled ventilation holes and it read "four" according to Meyer's sworn statement, as previously referenced. The methane reading was likely influenced by the shaft ventilation system and was not indicative of the actual methane concentration within the water ring; however, even this reading should have alerted Brumley that methane was present inside the water ring.

The steel forms on the inside of the shaft were removed, exposing the concrete shaft lining. A mandoor frame had been incorporated into the shaft lining to allow access into the water ring. However the panning covered the mandoor opening. The removal of the panning was essential to access and ventilate the water ring.

Initially, an opening was cut through the panning with an axe. Brumley placed a handheld methane detector just inside the opening prior to the explosion and read 0.2% methane. However, this methane reading was not indicative of actual methane concentrations within all portions of the water ring due to the placement of the detector. Brumley did not conduct tests for methane near the top of the water ring. He placed the methane detector approximately three feet from the bottom of the water ring, leaving the top four feet unexamined. Furthermore, the methane reading may have been influenced by fresh air passing through the opening and over the detector. In addition, the testing of the CSE 102 instrument revealed that it was not properly calibrated causing the instrument to indicate a lower methane concentration than was actually present.

As Abel began cutting the panning with the torch, the flame of the torch, molten metal, or the superheated surface of the panning ignited the methane-air mixture in the unventilated water ring (see Appendix U). Heated metal sparks from the cutting process would have likely extended into the water ring well beyond the reach of Brumley during the previous test for methane. An explosion developed within milliseconds, generating flame and excessive pressures.

The maximum overpressure developed during a methane explosion occurs at a concentration of about 10%. Calculations indicated that the volume of the water ring was approximately 2,300 cubic feet. The flame from a methane explosion extends about five times further than the initial methane accumulation. There was no evidence of heat impacting the ventilation tubing, located about 40 feet above the work deck; therefore, it is doubtful that a 10% mixture occurred throughout the entire water ring. Approximately 115 cubic feet of methane entering the water ring would have caused a 10% mixture throughout half the water ring. This total quantity of methane coupled with the confinement of the explosion zone would allow short-duration pressures to exceed 50 pounds per square inch (psi). Based on explosions research, the threshold pressure for a fatality is 35 psi.

The flame of the explosion encompassed the entire water ring, but was directional upon entering the shaft. Flame propagated through the mandoor frame and across the shaft. Upon impacting the opposite side of the shaft lining, the flame split and continued in both directions around the shaft lining. The estimated flame speed exceeded 2,000 feet per second. Considering the diameter of the shaft and the distance around the water ring, the explosion flame lasted approximately 50 milliseconds. Since there was no additional fuel in the shaft, the flame quickly extinguished.

Explosion force was generated by flame. Pressures significantly increased as the flame filled the confined area of the water ring, until the explosion force increased in magnitude to exceed the strength of the panning blocking the mandoor frame opening. Flame and forces shot through the mandoor frame, into and across the shaft. Evidence of the damaged panning indicated pressures exited the water ring into the shaft. As the fuel was consumed, the flame extinguished and pressures deteriorated immediately.

The flame and forces had the greatest impact on workers in direct line with the mandoor frame. Abel most likely experienced fatal injuries instantly because he was located directly in front of the mandoor frame. Mount and Roush III were on the work platform near the center of the shaft and pressures from the explosion also caused their fatal injuries. Brumley and Bair were not in the direct line of the explosion pressures and suffered serious but not fatal injuries. Meyer, who also suffered trauma and injuries, was subjected to the least flame and associated pressure because of his location away from the mandoor frame.

ROOT CAUSE ANALYSIS

A root cause analysis was conducted. Causal factors were identified that, if eliminated, would have averted the accident entirely or mitigated its severity.

Causal Factor: The examination for methane performed by the night shift foreman prior to the explosion was not adequate. An adequate examination would have required testing for methane in all areas that could have been affected by the use of the cutting torch.

Corrective Action: All certified and qualified persons who are required to conduct examinations were retrained by MSHA training specialists in the proper calibration and use of methane detection instruments and in how to properly test for methane, including the use of probes and pumps. Each certified person satisfactorily demonstrated to an MSHA inspector his ability to conduct an adequate examination.

Causal Factor: The water ring was not ventilated to dilute and remove hazardous gases. Proper ventilation of the water ring prior to performing any work would have prevented the accident.

Corrective Action: Water rings should be ventilated throughout the construction process and thereafter to prevent the accumulation of explosive gases.

Causal Factor: The water ring construction method created an unventilated area where methane was able to accumulate. This method also required the use of a cutting torch and other potential methane ignition sources.

Corrective Action: The water ring construction should incorporate a design that assures the continuous ventilation of the water ring during construction and allows access into the water ring without the use of tools that are potential methane ignition sources.

CONCLUSION

During the final stages of water ring construction, the atmosphere inside the water ring became isolated from the air shaft for approximately 26 hours. The water ring became unventilated when metal sheeting (panning) was installed to form the outside wall for a concrete pour. Methane entered the unventilated water ring during this time. The concrete curing process generated heat that caused convection currents inside the water ring to mix methane and air. This process resulted in an explosive methane-air mixture in the water ring at the time of the explosion.

Miners attempted to remove panning that blocked access to the water ring through a mandoor. The panning was partially opened with an axe after which a shift foreman performed an inadequate examination for methane and did not ventilate the water ring area. He then directed the mechanic to cut the panning with a torch. As the cutting occurred, the methane-air mixture inside the water ring ignited, resulting in a methane explosion. Contributing to the severity of the accident was the failure to limit the number of miners inside the shaft to the minimum number necessary to perform cutting and welding.

Standard CCD construction procedures for accessing water rings involved creating an opening in the panning with an axe, performing an examination for methane in the opening, and then cutting the panning with a torch if methane was not detected. Members of CCD management and some shaft miners were aware that methane could be present inside the water ring when it was unventilated and isolated from the shaft. In fact, on the night of the accident, the shaft superintendent cautioned the night shift foreman before the night shift began about the possible presence of methane in the water ring.

Based on the MSHA investigation observations and findings, the January 22, 2003, explosion that occurred at approximately 1:00 a.m. inside the 5 South #2 Airshaft, resulting in three fatal injuries and three serious, non-fatal injuries, could have been prevented. Examination for methane with a properly calibrated methane detector using a probe to evaluate the water ring area for methane would have provided a means to detect hazardous methane levels in areas where torch sparks could travel. Ventilation of the water ring area before any torch cutting was performed would have diluted and rendered harmless any accumulated explosive methane-air mixtures and prevented the explosion.

Moreover, even though conducting an adequate examination for methane and properly ventilating the water ring would have prevented the explosion, it was also practical and feasible to design and construct the water ring with mandoors and ventilation holes in a manner that would not require drilling into an unventilated area, punching through metal sheeting with an axe, nor cutting through metal panning with a torch. This construction method would eliminate the major methane ignition sources, the potential for methane explosions, and minimize the exposure of miners to these deadly hazards.

Approved:

ORIGINAL SIGNED BY
RAY McKINNEY   Date: 11-21-2003
Ray McKinney
Administrator for
Coal Mine Safety and Health

ENFORCEMENT ACTIONS

Section 103(k) Order No. 7119370 was issued on January 22, 2003 to ensure the safety of all persons at the McElroy Mine, 5 South #2 Airshaft construction site until an investigation could be completed and the area made safe. The physical investigation of the site was completed and it was determined that the area was safe for miners to return to work. The 103(k) order was terminated on March 3, 2003.

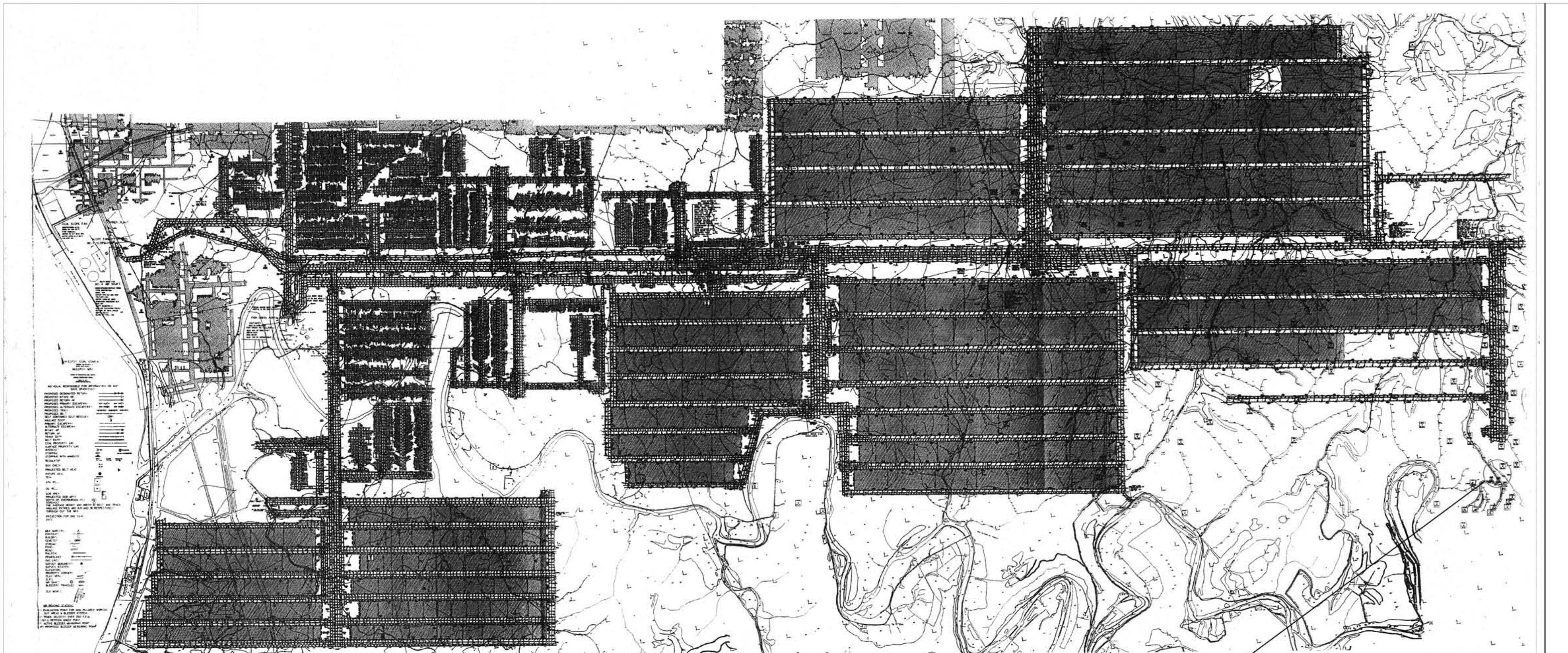
Section 104(d)(1) Citation, 77.1916(c), S&S, High Negligence
On January 22, 2003, an explosion occurred at the McElroy Mine, 5 South #2 Airshaft construction site, resulting in three fatal injuries and three non-fatal injuries. The onsite supervisor, Richard Brumley, conducted an inadequate examination for methane in the shaft immediately before directing a miner to use a cutting torch to gain access into an unventilated water ring containing an explosive methane-air mixture (5% to 15% methane). He did not test for methane near the top of the water ring where methane would most likely accumulate or in other areas within the water ring likely to be affected by the use of the cutting torch. Even though this supervisor had more than twenty years experience with methane gas and understood its characteristics, and had been warned by the supervisor from the previous shift to watch for methane, he directed a miner to operate the cutting torch to gain access to the water ring. Furthermore, this supervisor made no attempt and did not direct anyone to ventilate the water ring before directing the use of the torch to cut the panning covering the mandoor frame. Investigation interviews indicated that no one made an adequate examination for methane when accessing the unventilated water ring.

Section 104(d)(1) Order, 77.1900-1, S&S, Reckless Disregard
On January 22, 2003, an explosion occurred at the McElroy Mine, 5 South #2 Airshaft construction site, resulting in three fatal injuries and three non-fatal injuries. The operator was not in compliance with the approved Shaft Sinking Plan (Part G Ventilation Description, Item 6.). The Plan requires that the quantity and velocity of the current [of] air shall be sufficient to dilute so as to render harmless and to carry away flammable or harmful gasses. The water ring near the shaft bottom was not ventilated to keep the methane concentration at a safe level. An explosive methane-air mixture (5% to 15%) was allowed to accumulate in the water ring. The supervisor on site had more than twenty years experience with methane gas and understood its characteristics, and had been warned by the previous shift supervisor to watch for methane. In spite of his experience and this warning, he directed a miner to operate a cutting torch to gain access into the unventilated water ring containing the explosive methane-air mixture. A compressed air hose was available at the shaft bottom, but not used. Other supervisors stated that they routinely used an air hose to ventilate water rings. This failure to ventilate the water ring contributed to the explosion.

Appendix A - List of Miners on Site At Time of Explosion

Name	Occupation	Location	Nature of Injuries
David W. Abel	Mechanic	Inside shaft	Fatal Injuries
Benjamin L. Bair	Driller	Inside shaft	Multiple Injuries
Richard F. Brumley	Supervisor	Inside shaft	Multiple Injuries
Jack Cain	Top Man	Surface	None
Denver L. Jordan	Hoist Operator	Surface	None
Aaron S. Meyer	Driller	Inside shaft	Multiple Injuries
Richard E. Mount	Driller	Inside shaft	Fatal Injuries
Harry P. Roush, III	Lead Miner	Inside shaft	Fatal Injuries

Appendix B-1
McElroy Mine Map



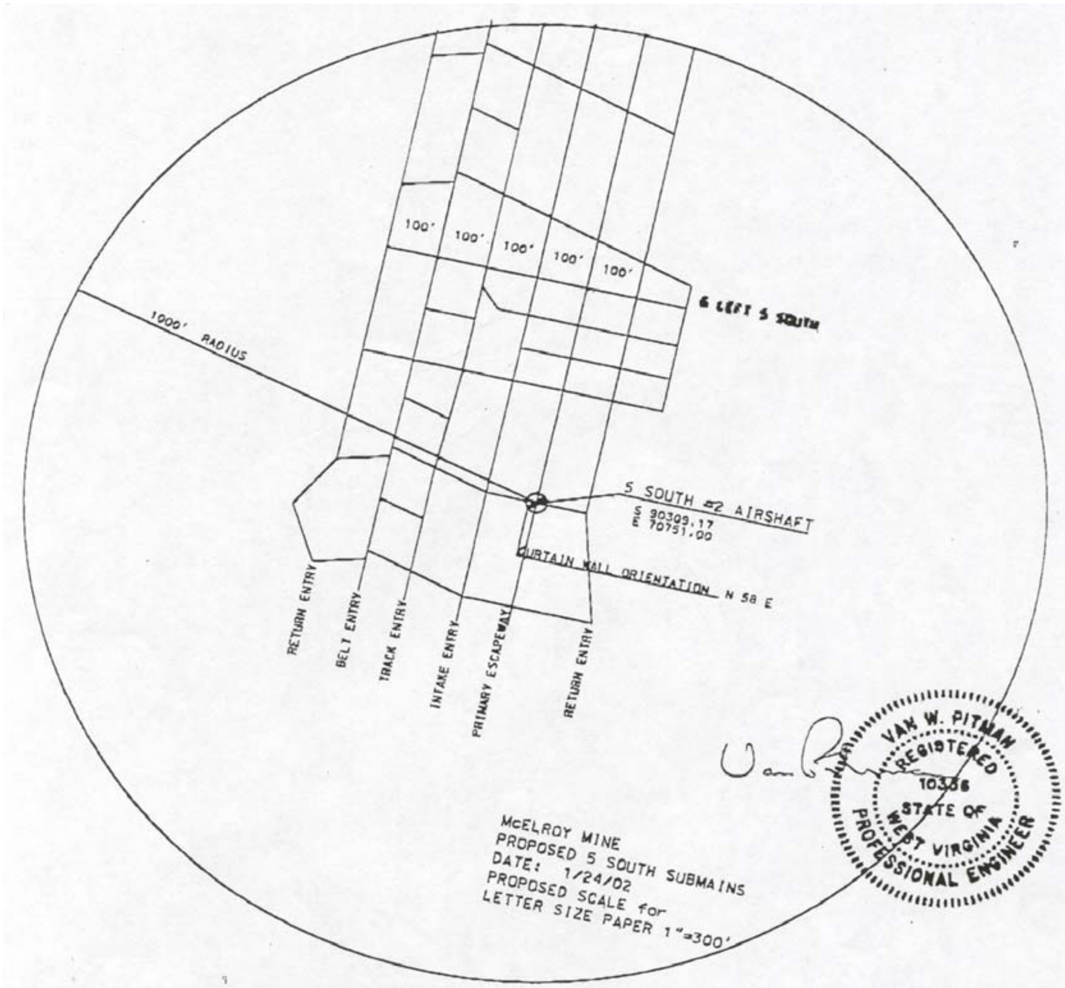
Location of 5 South No. 2 Airshaft

See Appendix B Map 2 of 2
for Detail

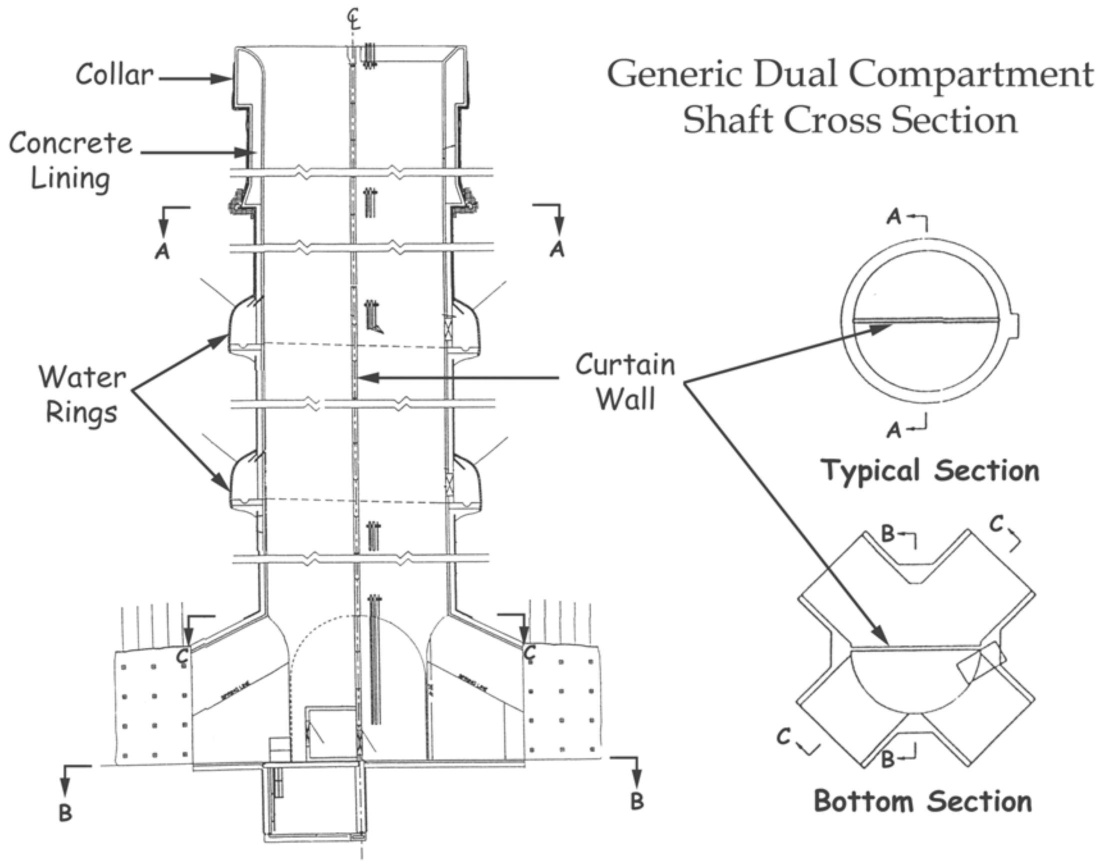
Appendix B

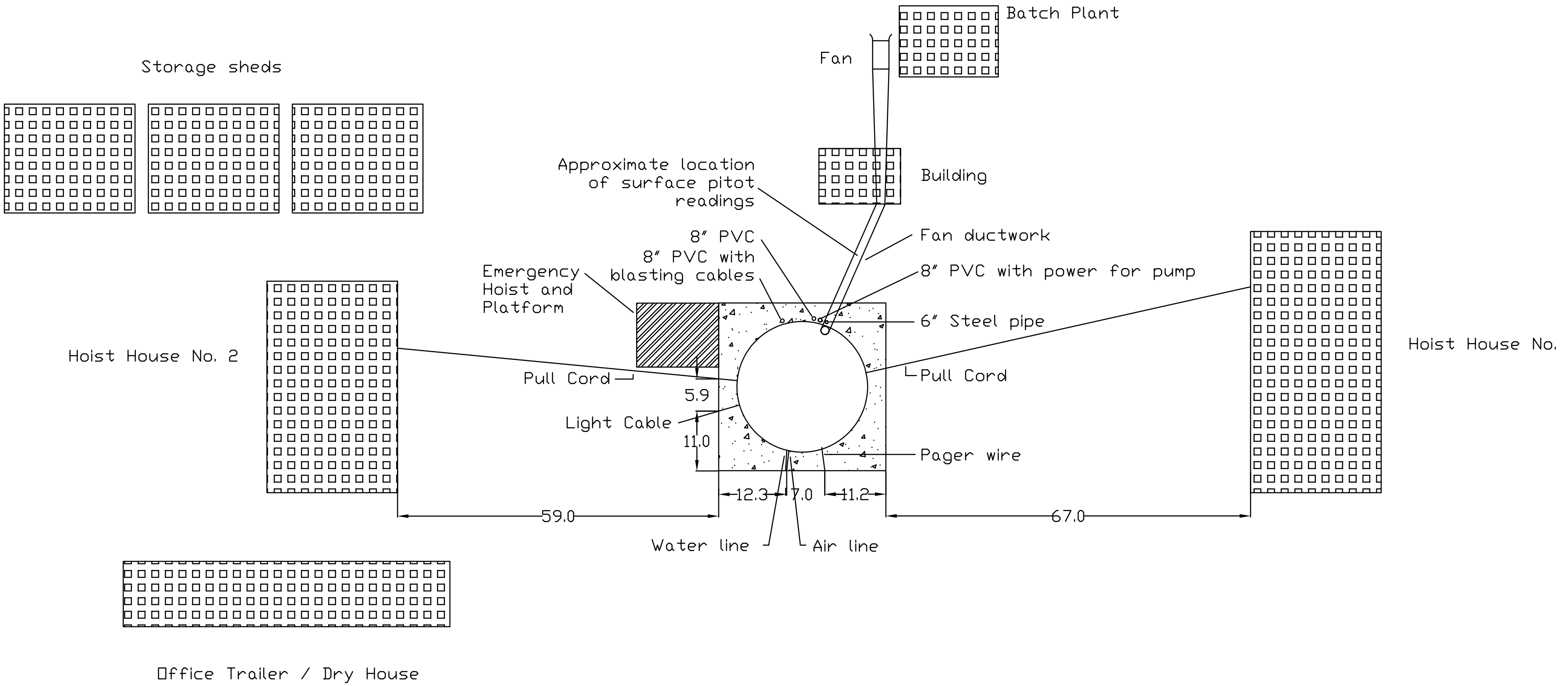
Map 1 of 2
McElroy Mine Map

Appendix B-2 – McElroy Mine Map, Detail
Map 2 of 2



Appendix C – Drawing of Generic Dual Compartment Shaft Cross-Section



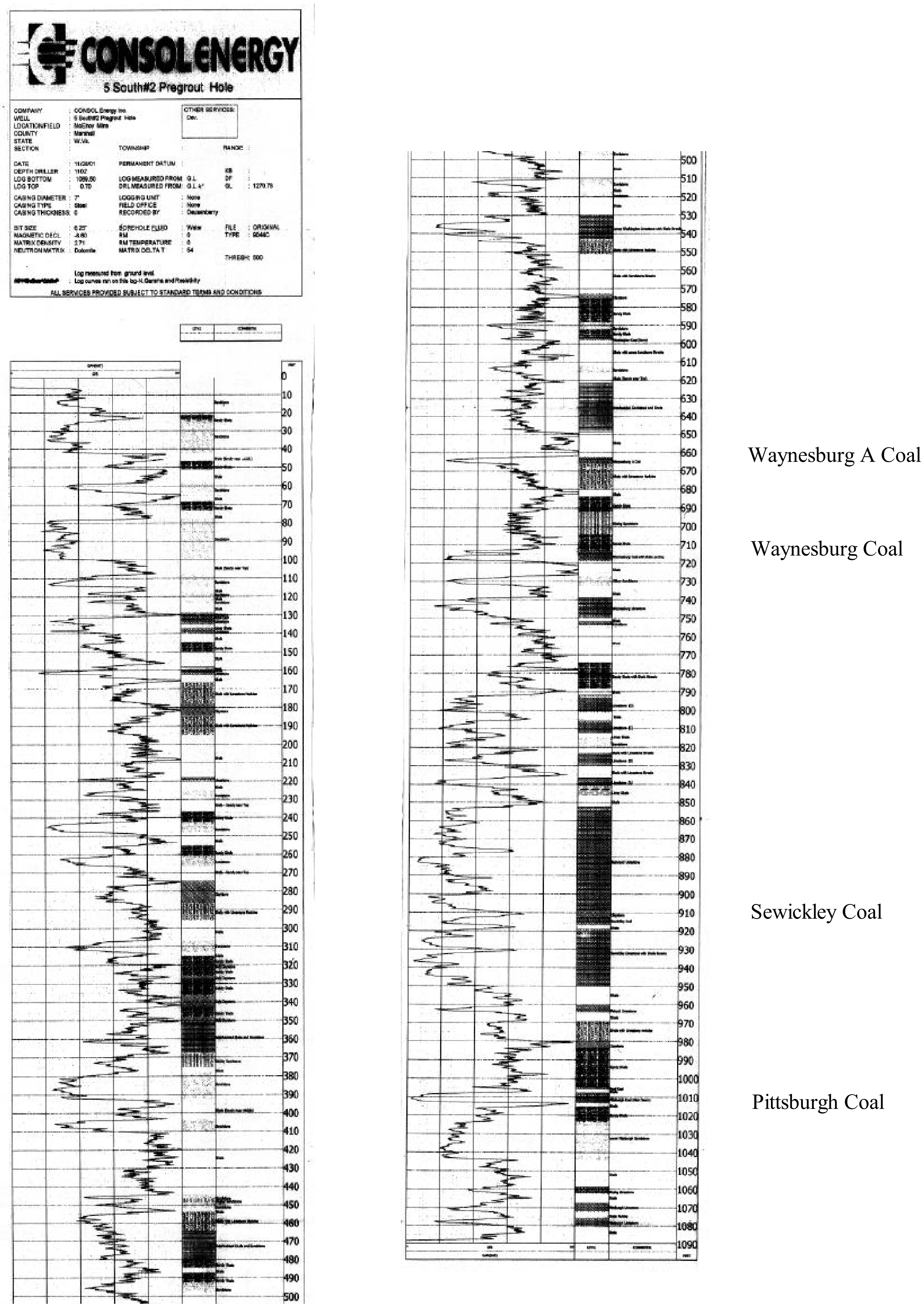


Appendix D

Plan View of Site

Buildings and Platforms Not to Scale

Appendix E
Stratigraphic Chart



Appendix F – Shaft Construction Cycle

The concrete shaft wall lining is poured in 25-foot increments. The shaft construction cycle incorporates all of the activities that take place from the end of one concrete pour to the completion of the next pour.

At the completion of each pour, after all the forms, scaffolding and jacks have been removed from the shaft, four holes are drilled 90 degrees apart at the bottom of the newly poured concrete shaft lining. The Eimco mucking machine (mucker) is lowered into the shaft and five to six feet of loose material is removed to provide clearance to remove the starter ring from the bottom of the concrete shaft lining. The four sections of wood starter ring are then lifted out of the shaft.

Once the starter ring is removed, the remaining loose material is mucked. As more material is removed, the shaft rib is checked for any loose rocks or bad spots. Scaling of the rib is performed using pick hammers. Four plumb lines are hung from wooden plugs inserted into the holes at the bottom of the shaft lining, and measurements are made of the excavated opening to assure there is an adequate clearance to permit the minimum concrete wall thickness. When an area is less than the minimum dimension needed, the jackleg drill is used to drill holes which are loaded with explosives and detonated to provide additional clearance.

When most of the material has been removed, the high-pressure air supply line is used with a "blow" pipe to push the remaining loose material into a pile. This procedure is used to search for misfired detonators from the previous shot. When all of the material has been removed, the shaft bottom is 10-15 feet below the shaft lining, and the mucker is lifted out of the shaft.

The pneumatic four-person Acme Jumbo Drill, Model ASJBH-81, (Jumbo drill) is lowered into the shaft and placed close to the shaft rib. A 10-foot deep hole is drilled at the center of the shaft. This is used as a test hole to determine the quality of the material to be drilled. The Jumbo drill is then centered over this hole. A standard pattern is followed for wet drilling a total of up to 150 holes in the four quadrants. The drill steels are 1.75 inches diameter by 12 feet long; the holes are drilled to a depth of 10 feet. After the holes are drilled, water is removed by pumping it out of the shaft.

The Jumbo drill is raised out of the shaft. Explosives are brought in, the holes are loaded, and the detonator leg wires are connected. Examinations for methane are conducted. The flexible vent tubing, air hose, and water hose are disconnected and removed from the shaft. Miners are brought out of the shaft and the explosives are detonated from the surface. After providing time for the air to clear, an examination for hazardous conditions is conducted and the miners re-enter the shaft. The flexible vent tubing is reinstalled and an air reading is taken. The water and air hoses are reinstalled.

The mucker is brought in, and mucking commences. The miners alternate operating the mucker, helping to position the bucket for loading, communicating with the hoist operator, and keeping hoses from being damaged. After the material is removed, the blow pipe is used as previously described. The drilling, shooting and mucking cycles are repeated several times until the top of the muck pile is 26 to 30 feet from the bottom of the concrete shaft lining. The muck pile is compacted and leveled to the desired depth below the bottom of the shaft lining, using the mucker. At this point, approximately 10-15 feet of muck remains on the bottom.

Sections of panning 3 feet high by 3 feet wide are placed on the muck pile against the shaft rib. The panning is overlapped approximately 12 inches and fastened together at the top and bottom with screws. This is called the “belly band”. It serves to hold the panning to be used for this concrete pour, and to connect the panning which will be installed during the next concrete pour.

Two buckets of sand and gravel mix are spread along the perimeter of the shaft. The mucker is used to compact and level the material to a depth of 26 feet, 2 inches. The material covers the bottom 6-8 inches of the belly band. Twelve wood pads 2 feet x 2 feet x 3 inches are placed around the perimeter of the shaft and leveled to 25 feet, 10 inches below the concrete shaft lining, using a transit. The pads support the four section starter ring. The belly band is located between the starter ring and the shaft rib.

Belly band, rebar, and water seal gasket protruding from concrete shaft lining

The assembled starter ring has several notches to indicate where pipes will be placed. Three 25-foot sections of 8 inch PVC pipe are assembled with a female coupling at one end. The coupling end of each pipe is set on the gravel behind the starter ring in a notch and held in place with sand and gravel. The male ends of the pipes are attached to the female couplings that extend from the bottom of the concrete shaft lining. A 25-foot section of 6 inch steel pipe is similarly installed.

Two PVC and a steel pipe protruding from concrete shaft lining

Twelve 5/8 inch diameter steel reinforcing rods (rebar), 20 feet long are placed through holes in the starter ring. The tops of these rebar are connected to shorter lengths of rebar which are connected to the rebar extending from the bottom of the shaft lining, using Crosby clamps. Additional 20-foot lengths of rebar are placed around the balance of the starter ring. The first 18 inches of each is bent at 90 degrees. The bent end of each rebar is set on the starter ring. The rebar are held in place with nails driven in the wood starter ring. Curved rebar are then installed horizontally and wired to the vertical rebar every 18 inches for the first eight feet above the starter ring. A rubber gasket is nailed in place on top of the starter ring to serve as a water seal between concrete pours.

Two 8-foot high sections of steel forms are placed on the wood pads in front of the starter ring and bolted together. The other two 8-foot high sections are installed in a similar manner. Two 11 inch by 8 feet key plates are set between the two sets of bolted forms and secured. A jack is installed horizontally across the bottom of the shaft and attached to the two key plates. A second jack is installed in the same manner across the top and connected to the key plates. The key plates create the keyway which will be used to install the separation wall. Three sections of metal scaffolding are installed on top of the assembled forms to create the work deck.

An 8-foot high section of steel form

Panning measuring 3 feet by 14 feet is installed vertically behind the forms, between the shaft rib and the belly band. The panning is overlapped approximately 6 inches and the tops are fastened together.

Plumb lines are used to align the assembled form with the existing concrete shaft lining. Four hydraulic jacks are placed between the shaft rib and the assembled form, 90 degrees apart, to stabilize and to reposition the form as necessary. The assembled form is filled with concrete and the concrete is vibrated to eliminate voids. A water seal is installed at the top of the concrete pour. Sections of panning are installed as before with the bottom of the panning being placed between the shaft rib and panning previously installed. The top of each panning section is placed in front of the belly band panning extending from the bottom of the existing concrete shaft lining and fastened to it. Curved rebar are then installed horizontally and wired to the vertical rebar every 18 inches for the next eight feet. Then the process of installing the forms, key plates, jack and scaffolding is repeated and the second assembled form is filled with concrete. A water seal is installed at the top of the concrete pour.

The 18-inch bent rebar extending from the bottom of the existing concrete shaft lining are straightened and wire tied to the rebar extending from the newly poured concrete. The curved horizontal rebar are installed and wired to the vertical rebar every 18 inches to just below the existing concrete shaft lining. The third set of forms, key plates, jack and scaffolding are installed and the concrete is poured.

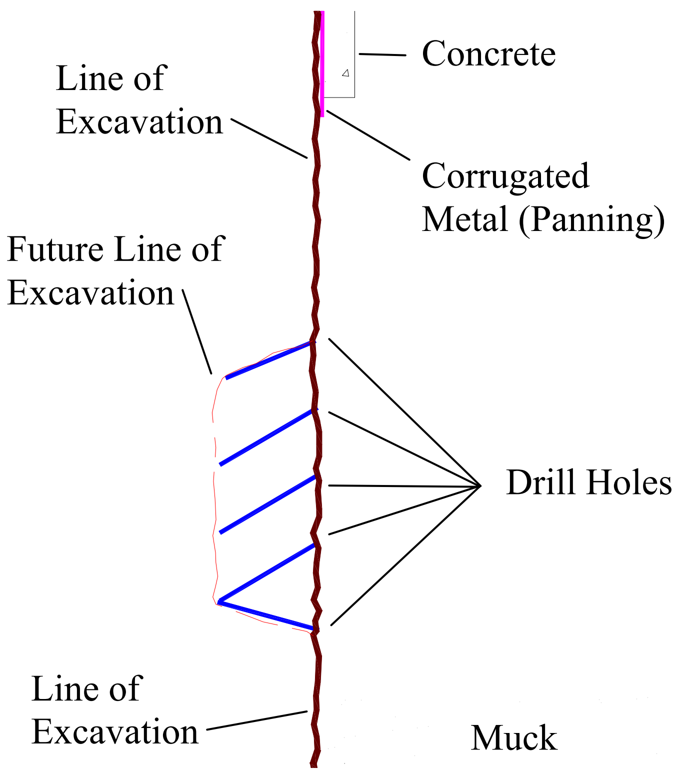
Four sections of 2-foot high steel closure forms are set in place and bolted together. The concrete is poured into the closure form through 12 chute openings as shown in the pictures below. After each area is filled, a steel plate is slid into place and the excess concrete is scraped away. When filled with concrete, these forms connect the existing concrete shaft lining with the newly poured (25-foot) section of concrete. The area is cleaned and while the concrete begins curing, work is performed to prepare panning, rods, and utility pipes for the next cycle.

Views of one segment of a closure ring

After a period of time, the bolts are removed from the closure rings and the sections are removed from the shaft. Any voids in the concrete are patched. The scaffolding and top jack are removed. The bolts are removed and the forms and key plates are hoisted out of the shaft. This is repeated until all three sets of forms, jacks and scaffolding have been removed. Four holes are drilled into the concrete shaft lining near the bottom, 90 degrees apart and plugs are installed. Plumb lines will be hung from these points to plumb the next section of shaft wall concrete lining.

Appendix G – Water Ring Construction

Three sets of 8-foot high steel forms and a closure ring are used for each 25-foot concrete pour. The water ring is designed to be located behind the middle set of forms. The diameter of the shaft opening is excavated to allow a minimum concrete wall thickness of 9 inches. Eight to ten feet above the area where the water ring will be constructed, the shaft diameter is increased one foot to allow clearance for steel C-channels and panning. The rock is drilled, shot, and mucked, as detailed in Appendix F, to this larger diameter. For a distance of approximately 9 feet below the existing concrete shaft lining, wire mesh is installed around the perimeter of the shaft rib using 18-inch bolts. At the bottom of this area, one row of steel straps and steel plates are installed using 4-foot conventional bolts spaced on 4-foot centers to support the shaft rib.



Five rows of holes are drilled 1.75 inches diameter by 4-feet deep. The first row of holes is drilled at a downward angle of 22-degrees on 12-inch centers. The next three rows are drilled 30-inches apart, at a downward angle of 30-degrees, on 18-inch centers. Three feet below, the fifth row is drilled at an upward angle of 15-degrees, on 18-inch centers as shown in the diagram to the left.

Time delay detonators are used to shoot these rows to form the cavity for the water ring that measures approximately 3.5 feet deep by 5.5 to 7 feet high. Nine 1.75-inch diameter holes are drilled 3 to 6 inches deep into the strata approximately every 10 feet at floor level around the perimeter of the water ring. Pieces of 1-inch diameter by 12-inch PVC pipe are inserted and then gunited in place. These holes (weep holes) are intended to allow water to seep into the water ring, preventing water pressure from building up on the gunite lining. Sheets of wire mesh 4 foot by 4 foot are placed against the water ring rib and bolted in place using 18-inch bolts. The wire mesh is bolted to the roof and the roof is supported using 4-foot bolts. A minimum of four inches of gunite is applied to the roof and ribs of the water ring. Panning is attached by screws to the bottom of the belly band that extends from the bottom of the concrete shaft lining. The attached panning is bent along the roof line of the water ring where it ends, permitting water to flow into the water ring.

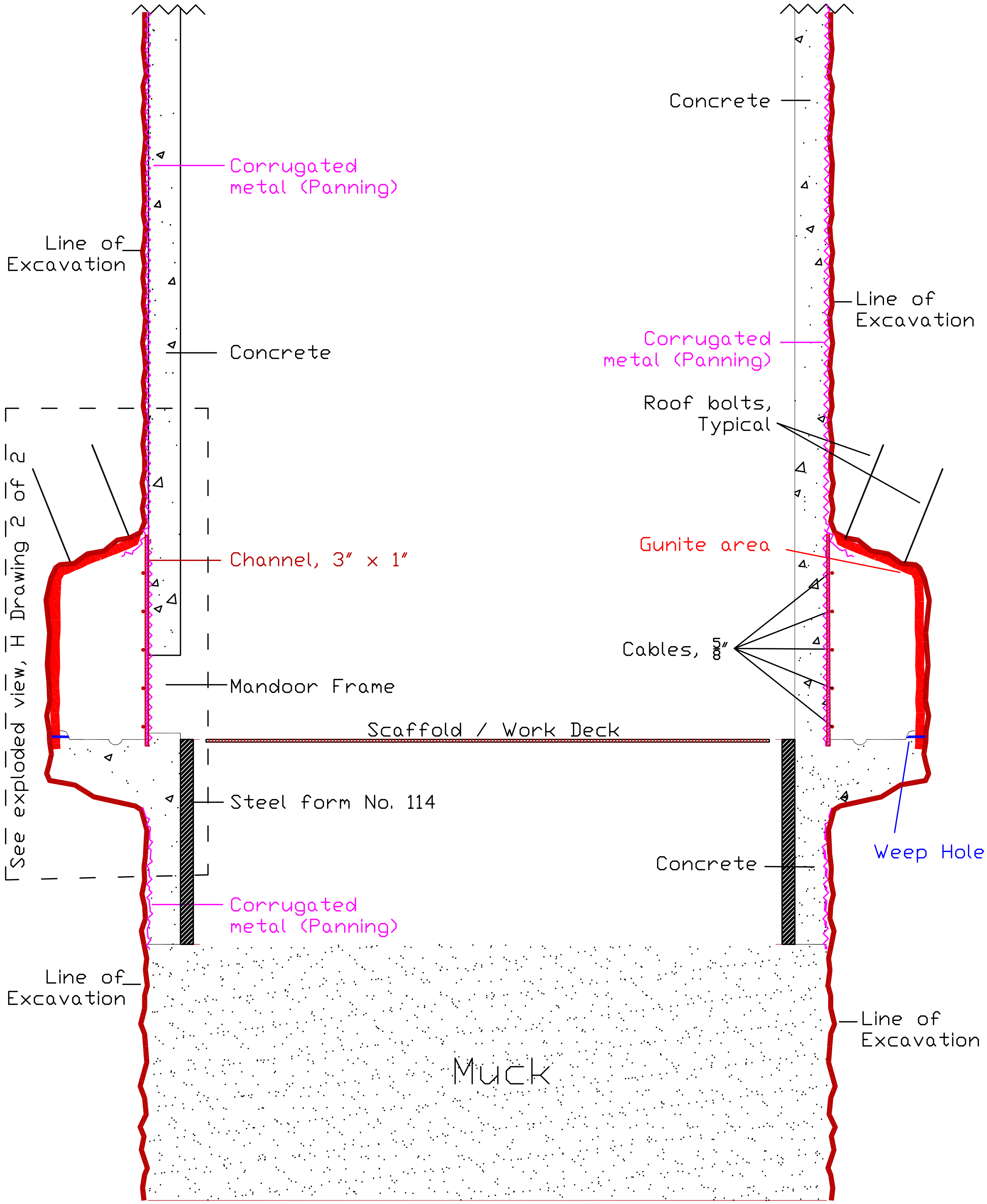
When the mucking is completed to a depth of approximately 26 feet, the area is prepared, and the first set of forms is installed as described in Appendix F. Shorter lengths of rebar are installed and extend 18-24 inches above the top of the first set of forms. The panning extending from the top of the first set of forms is bent in against the floor of the water ring. Concrete is poured to form the floor of the water ring. A trough is shaped in the concrete floor to direct water to the drain. While the concrete is curing, 2 inch by 4 inch by 12 inch blocks are installed 6 inches deep, 14 inches back from the edge of the steel forms, and spaced 14 inches apart around the perimeter of the first set of forms. Where the utility pipes are encountered, the blocks are placed further back to assure that the pipes are enclosed within the concrete.

While the concrete is curing, the blocks are removed from the holes created. Five 0.625 inch diameter steel cables are placed in the water ring behind these holes. Sections of C-channel 1 inch by 3 inch by 11 feet are placed in the holes with the tops against the shaft rib above the water ring. Every fourth C-channel has short sections of rebar welded on the back, beginning six inches from the bottom and spaced on 18-inch centers, which will hold the cables in place.

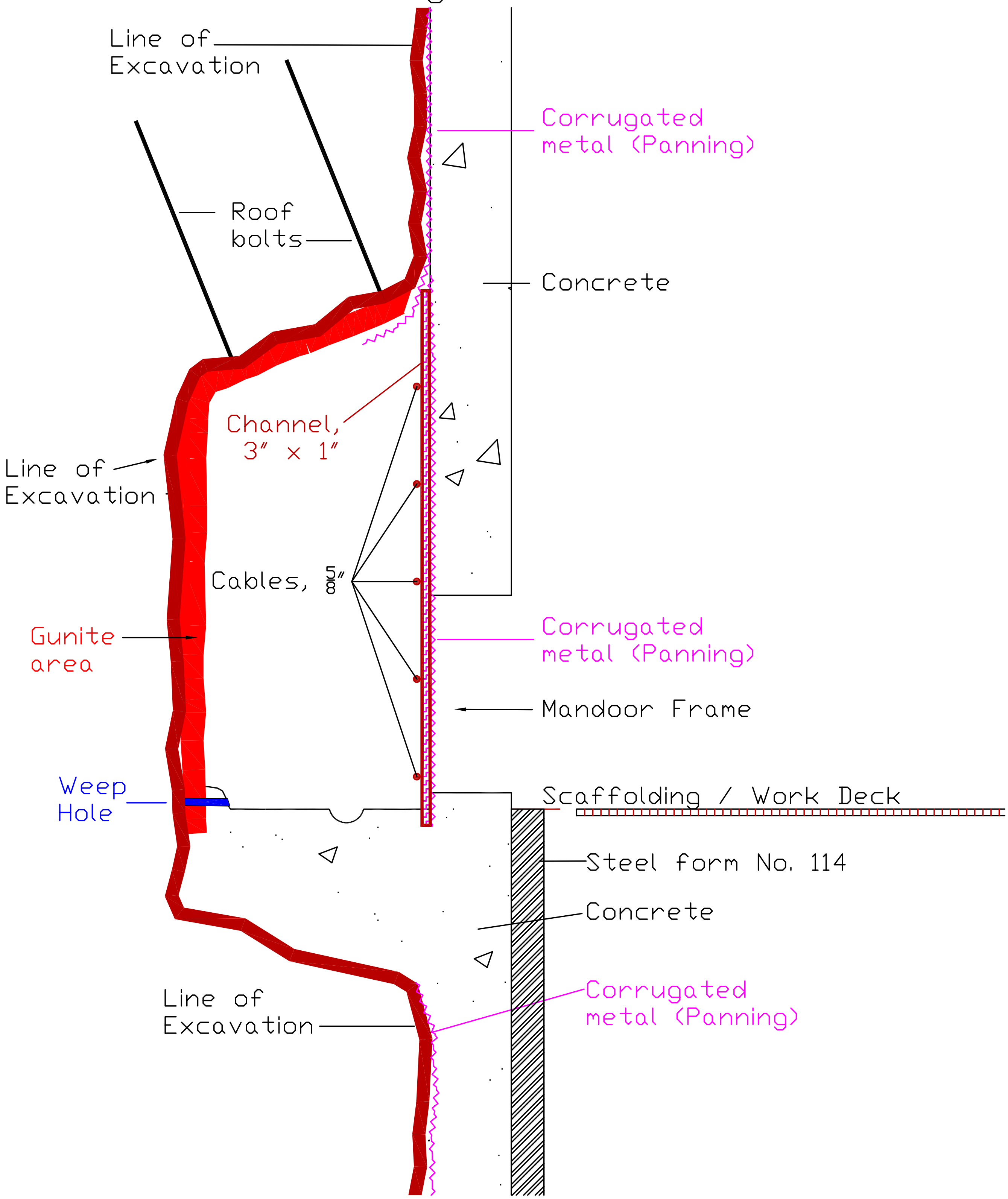
Sections of panning 3-feet high by 10 to12 feet long are placed horizontally and fastened to the C-channels, except for a 3-foot area to provide workers access into the water ring to connect the cables. Additional panning is installed vertically in front of the horizontal panning and fastened, overlapping the width 18 inches to add strength. The five steel cables are hung from the C-channels. The ends of the cables are clamped together at a predetermined length. These cables will help support the C-channels and panning and keep the concrete from pushing the panning apart and flowing into the water ring cavity. Panning is then installed to close the 3-foot opening.

The mandoor frame is placed in front of the panning. The bottom of the frame sets on 12-inch lengths of rebar welded to the frame. Rebar are installed vertically and curved rebar installed horizontally at predetermined vertical spacing and the mandoor frame is attached to the rebar. The 8-foot high steel forms are installed as described in Appendix F and the concrete is poured. A vibrating tool is used to remove air pockets. The third set of 8-foot high steel forms and closure ring are installed and filled with concrete to complete the 25-foot pour. When the forms are removed, the panning behind the mandoor frame must be removed to permit access into the water ring.

Appendix H
Drawing 1 of 2
Shaft and Water Ring Cross-Section



Appendix H
Drawing 2 of 2
Exploded View of Water Ring Cross-Section



APPENDIX I - Persons Who Provided Voluntary (Non-Confidential) Statements[4]

Central Cambria Drilling Company

Name	Title
Benjamin L. Bair	Driller
Daniel C. Baker	Mechanic
Richard F. Brumley	Night Shift Foreman
Jack Cain	Top Man
Joseph D. Chidester	Hoist Operator
Thomas Cunningham	Driller
George Dill	Purchasing Agent
Andy J. Dumm	Lead Miner
Michael A. Dumm	Shop Mechanic
Steve E. Fonner	Driller
Denver L. Jordan	Hoist Operator
Richard C. Lewis	Ex-Safety Director
Douglas E. Luther	Lead Miner
Aaron S. Meyer	Driller
Paul R. Meyer	Top Man
Gary R. Minnear	Ex-Safety Director
Blair L. Neely	Driller
Paul J. Price	Lead Miner
Harry P. Roush, Jr.	Night Shift Foreman
Earl S. Rummel	General Superintendent
Randy L. Rummel	Hoist Operator
Salvatore M. Taranto	Ex-Safety Director
Larry E. Whyte	Superintendent
Shawn R. Whyte	Top Man
Jack W. Williamson	Vice-President
Samuel E. Wilson	Mechanic

CONSOL Energy Inc.

Name	Title
Michelle O'Neil	Project Engineer

West Virginia Mine Health, Safety & Training

Name	Title
Colin Simmons	District Mine Inspector

[4] Other person(s) provided confidential statements.

MSHA District 3

Name	**Title**
Ronald T. Tulanowski	Inspector

Marshall County Sheriff's Department

Name	**Title**
Steven M. Cook	Deputy Sheriff
Brent M. Wharry	Deputy Sheriff

Tri-StateAmbulance

Name	**Title**
Donald M. Kline	Paramedic

Appendix J - Persons Participating in the Investigation

MSHA Investigation Team

Name	Title
James K. Oakes	District Manager, District 8
Joseph S. Tortorea	Assistant District Manager, District 2
Richard T. Stoltz	Supervisory Mining Engineer, Technical Support
Clete R. Stephan	Principal Mining Engineer, Technical Support
Virgil F. Brown	Mine Emergency Unit Specialist, Technical Support
Robert A. Penigar	Coal Mine Safety and Health Inspector – Ventilation, District 2
Jerry W. Vance	Coal Mine Safety and Health Specialist – Training, EFS Morgantown, WV

Office of the Solicitor

Name	Title
James B. Crawford	Attorney
Javier I. Romanach	Attorney

Pittsburgh Safety and Health Technology Center

Name	Title
George N. Aul	Mining Engineer, Ventilation Division
Kim S. Diederich	Mining Engineer, Ventilation Division

Central Cambria Drilling Company

Name	Title
Jack Williamson	Vice-President
William Howe	Legal Counsel
Earl Rummel	General Superintendent
Larry Whyte	Superintendent
Mike Dumm	Maintenance Supervisor

CONSOL Energy Inc.

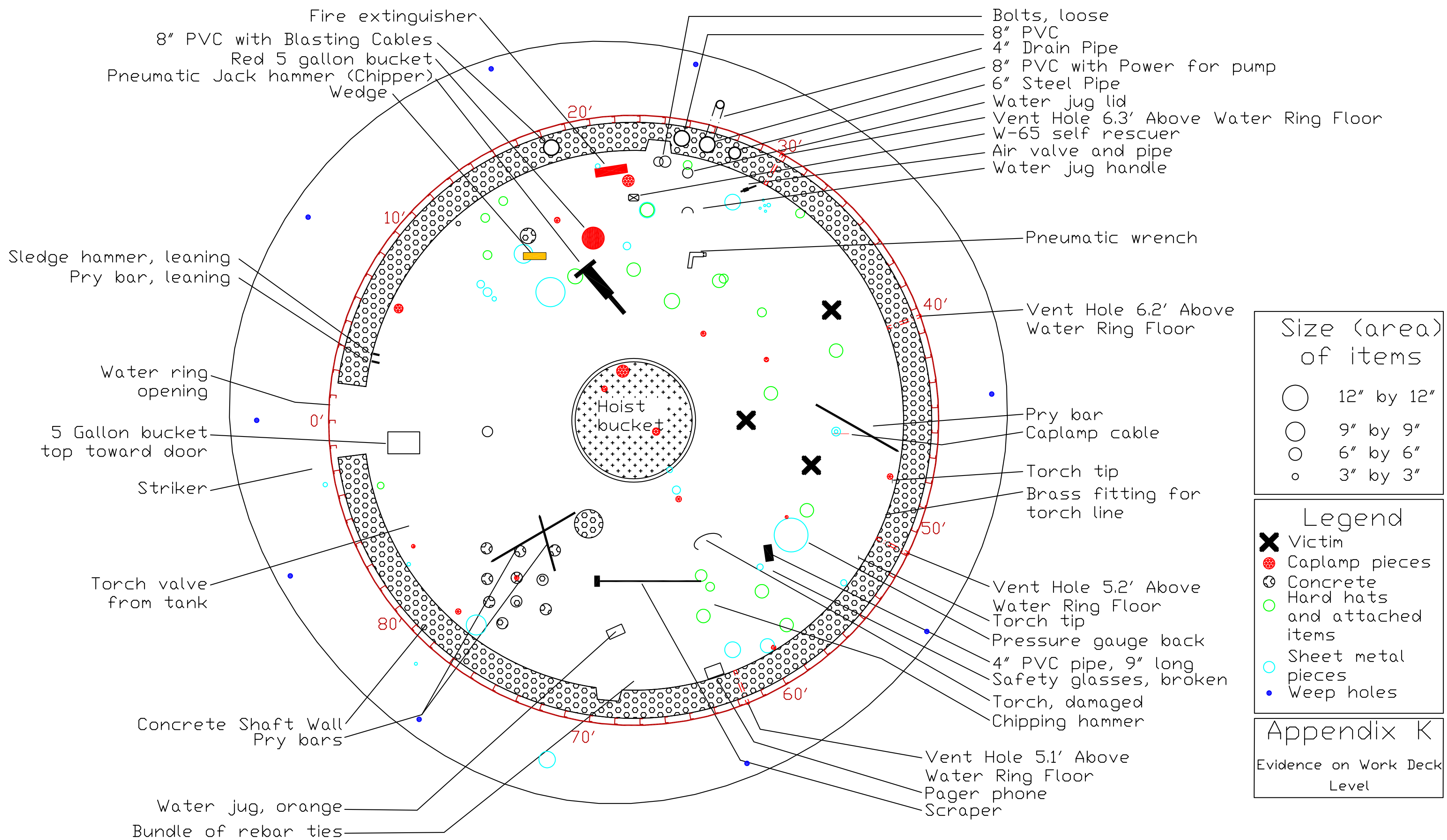
Name	Title
Elizabeth Chamberlain	Manager of Safety
Michelle O’Neil	Project Engineer
C. E. “Spike” Bane	Safety Director, Mining
Don Gibson	Safety Department

West Virginia Office of Miner's Health, Safety & Training

Name	**Title**
Doug Conaway	Director
Terry Farley	Administrator
Brian Mills	Inspector-At-Large
John Larry	Assist. Inspector-At-Large
Colin Simmons	District Mine Inspector
Mike Rutledge	Safety Instructor
Alan Lander	Safety Instructor
Dave Barlow	District Mine Inspector

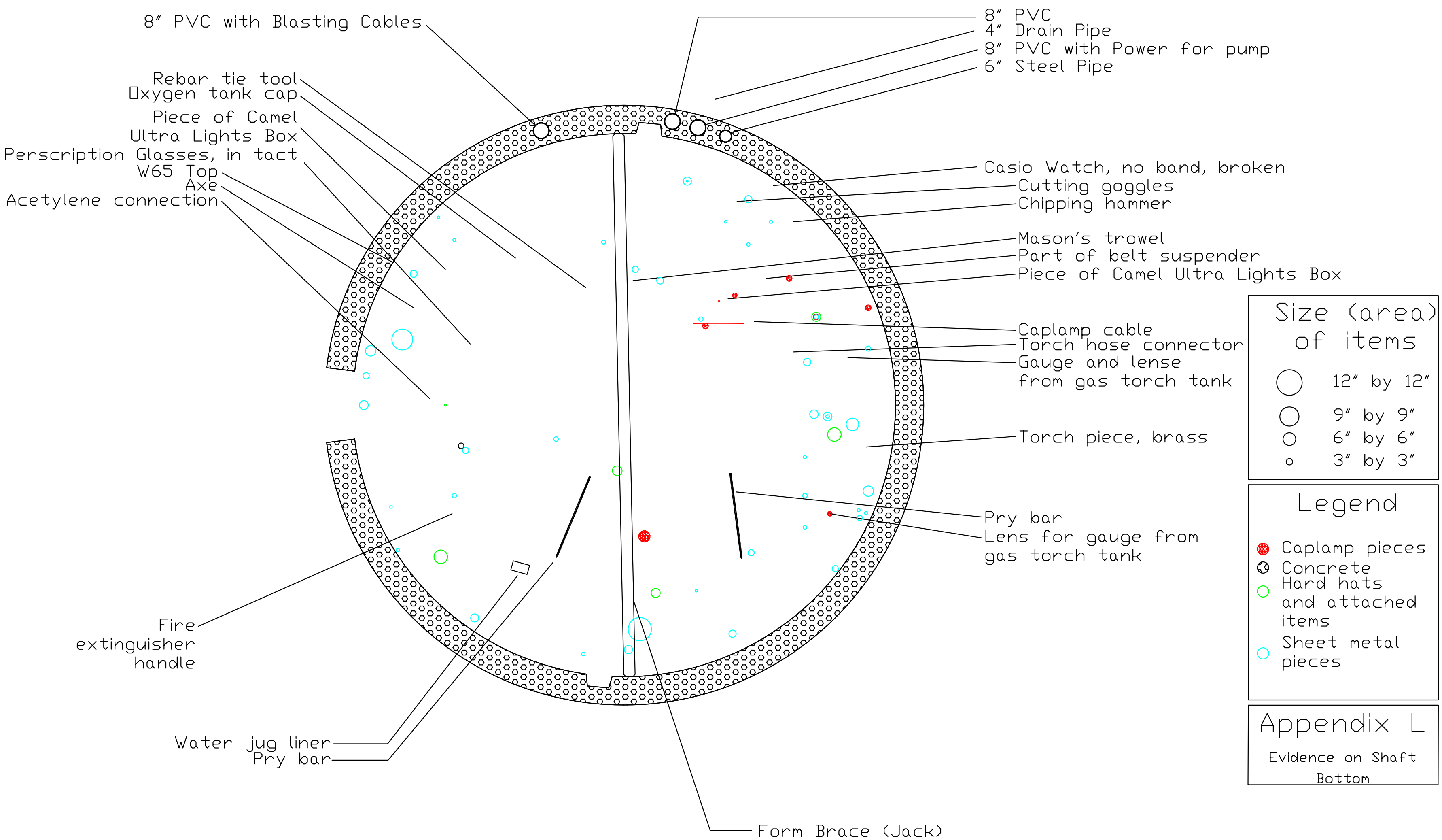
United Mine Workers of America

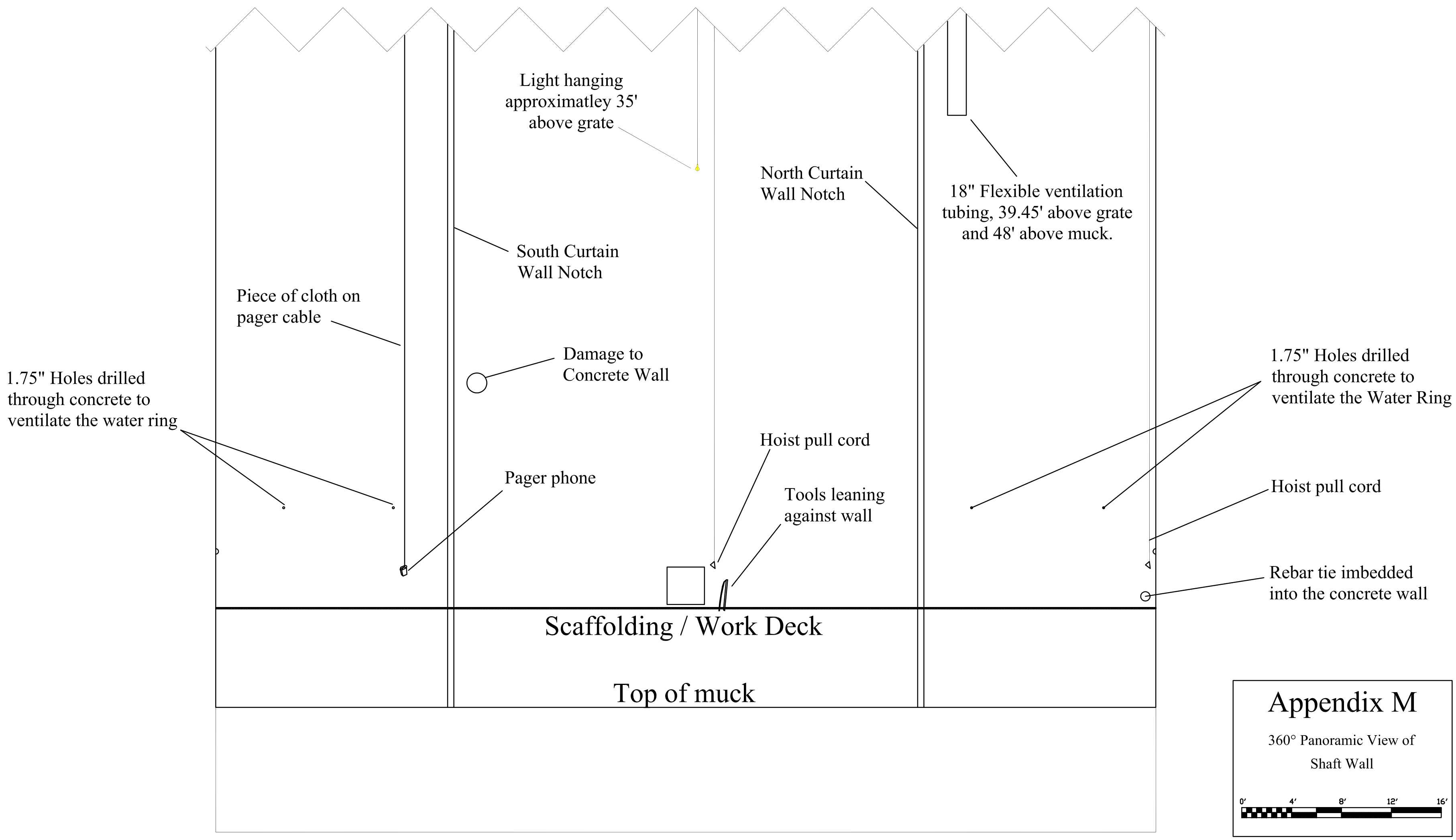
Name	**Title**
Joe Main	Safety Director
Tim Baker	International Safety Inspector
Dennis Odell	International Safety Inspector
Hoya Clemons	President Local 1638
Rick Altman	Vice-President Local 1638



Appendix K

Evidence on Work Deck Level


8" PVC with Blasting Cables
Rebar tie tool
Oxygen tank cap
Piece of Camel
Ultra Lights Box
Perscription Glasses, in tact
W65 Top
Axe
Acetylene connection
8" PVC
4" Drain Pipe
8" PVC with Power for pump
6" Steel Pipe
Casio Watch, no band, broken
Cutting goggles
Chipping hammer
Mason's trowel
Part of belt suspender
Piece of Camel Ultra Lights Box
Caplamp cable
Torch hose connector
Gauge and lense
from gas torch tank
Torch piece, brass
Pry bar
Lens for gauge from
gas torch tank
Fire
extinguisher
handle
Water jug liner
Pry bar
Form Brace (Jack)
Size (area)
of items
12" by 12"
9" by 9"
6" by 6"
3" by 3"
Legend
Caplamp pieces
Concrete
Hard hats
and attached
items
Sheet metal
pieces
Appendix L
Evidence on Shaft
Bottom



Appendix M

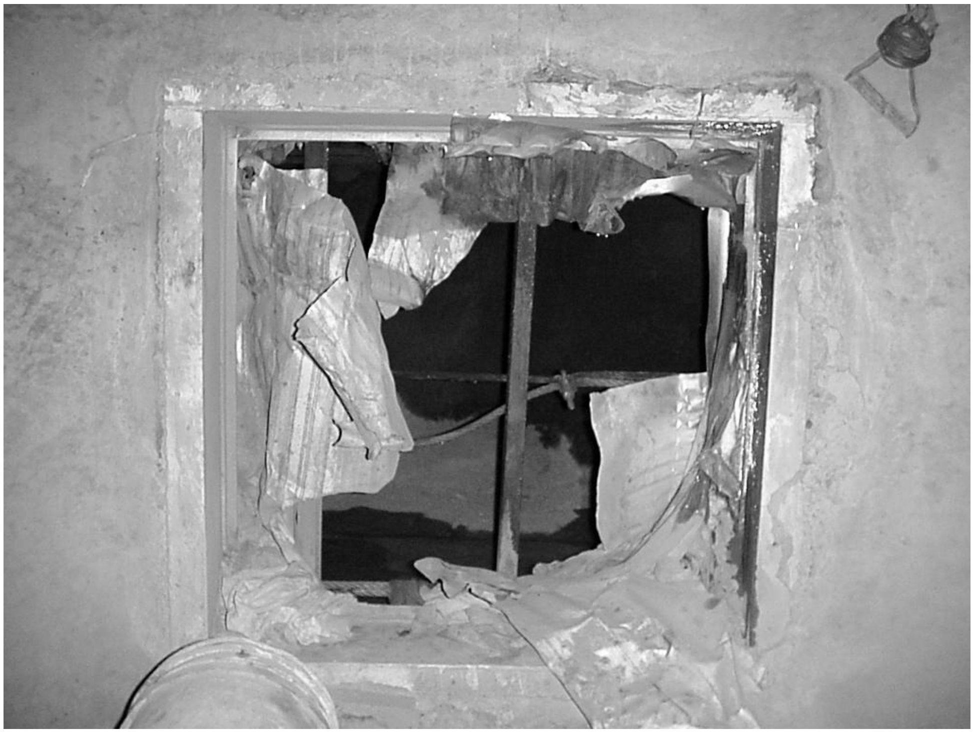
360° Panoramic View of Shaft Wall

Appendix N – Selected Photographs

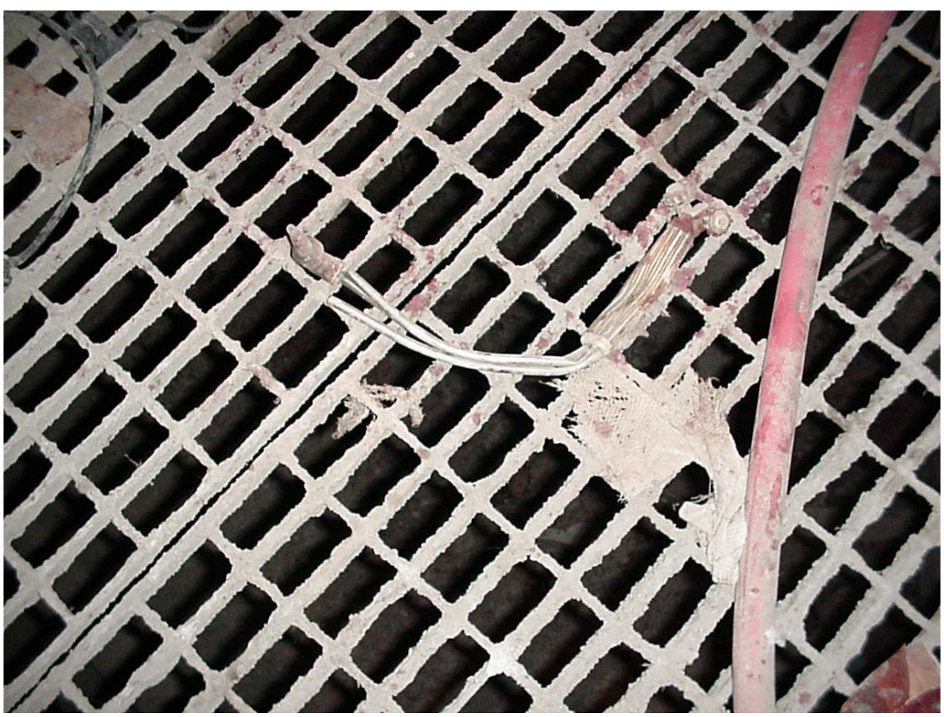
Views of McElroy 5 South #2 Airshaft site

Views of McElroy 5 South #2 Airshaft site

Views of bucket containing oxygen-acetylene tanks
and hoses which were in shaft at time of explosion

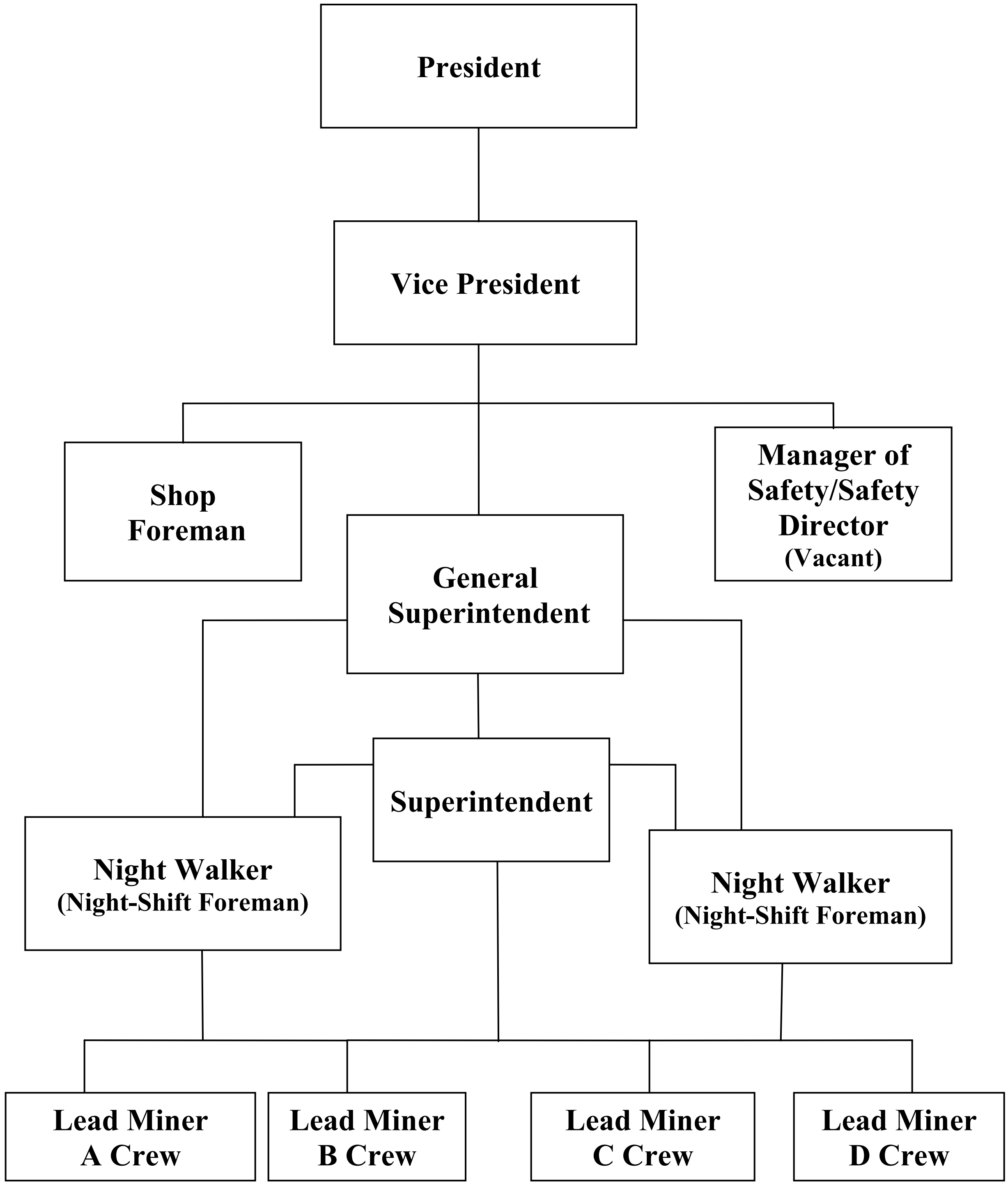


View into water ring through mandoor frame from work deck



View of damaged oxygen-acetylene torch head shown laying on work deck

Appendix O – Management Structure for Central Cambria Drilling Company



The Superintendent and the General Superintendent rotated on steady day shifts, with direct responsibility over day shift crews. Likewise, the two Night Walkers rotated direct responsibility over night shift crews. The crews rotated work schedules through both day and night shifts, independently of the supervisors.

Appendix P – Table of Ventilation Quantity Readings Recorded by Central Cambria Drilling Company

Date and Shift Start Time	Air Quantity (cfm)	Date and Shift Start Time	Air Quantity (cfm)	Date and Shift Start Time	Air Quantity (cfm)
10/12/02 8:00	6,552	11/2/02 8:00	6,750	11/23/02 8:00	7,400
10/12/02 20:00	6,389	11/2/02 20:00	6,750	11/23/02 20:00	7,400
10/13/02 8:00	6,440	11/3/02 8:00	7,650	11/24/02 8:00	7,380
10/13/02 20:00	6,500	11/3/02 20:00	7,483	11/24/02 20:00	7,297
10/14/02 8:00	6,480	11/4/02 8:00	7,280	11/25/02 8:00	7,327
10/14/02 20:00	6,391	11/4/02 20:00	7,541	11/25/02 20:00	7,418
10/15/02 8:00	6,559	11/5/02 8:00	7,190	11/26/02 8:00	9000 <1>
10/15/02 20:00	6,380	11/5/02 20:00	7,318	11/26/02 20:00	8,920
10/16/02 8:00	6,540	11/6/02 8:00	7,220	11/27/02 8:00	8,960
10/16/02 20:00	6,550	11/6/02 20:00	7,531	11/27/02 20:00	8,940
10/17/02 8:00	6,540	11/7/02 8:00	7,600	11/28/02 8:00	<2>
10/17/02 20:00	6,545	11/7/02 20:00	7,590	11/28/02 20:00	<2>
10/18/02 8:00	6,540	11/8/02 8:00	7,600	11/29/02 8:00	8,950
10/18/02 20:00	6,420	11/8/02 20:00	7,600	11/29/02 20:00	8,970
10/19/02 8:00	6,430	11/9/02 8:00	7,580	11/30/02 8:00	8,950
10/19/02 20:00	6,420	11/9/02 20:00	7,560	11/30/02 20:00	8,960
10/20/02 8:00	6,430	11/10/02 8:00	6,870	12/1/02 8:00	<2>
10/20/02 20:00	6,500	11/10/02 20:00	7,590	12/1/02 20:00	<2>
10/21/02 8:00	8,564	11/11/02 8:00	7,485	12/2/02 8:00	8,950
10/21/02 20:00	8,620	11/11/02 20:00	<2>	12/2/02 20:00	8,950
10/22/02 8:00	8,460	11/12/02 8:00	7,520	12/3/02 8:00	8,970
10/22/02 20:00	6,780	11/12/02 20:00	7,480	12/3/02 20:00	8,945
10/23/02 8:00	6,750	11/13/02 8:00	7,468	12/4/02 8:00	9,220
10/23/02 20:00	6,700	11/13/02 20:00	7,450	12/4/02 20:00	8,997
10/24/02 8:00	6,710	11/14/02 8:00	7,500	12/5/02 8:00	8,850
10/24/02 20:00	6,750	11/14/02 20:00	7,480	12/5/02 20:00	8,990
10/25/02 8:00	6,735	11/15/02 8:00	7,500	12/6/02 8:00	8,945
10/25/02 20:00	6,698	11/15/02 20:00	7,500	12/6/02 20:00	8,940
10/26/02 8:00	6,700	11/16/02 8:00	7,500	12/7/02 8:00	8,960
10/26/02 20:00	6,740	11/16/02 20:00	7,490	12/7/02 20:00	8,940
10/27/02 8:00	6,750	11/17/02 8:00	7,506	12/8/02 8:00	8,960
10/27/02 20:00	6,700	11/17/02 20:00	7,451	12/8/02 20:00	8,950
10/28/02 8:00	6,670	11/18/02 8:00	7,440	12/9/02 8:00	8,970
10/28/02 20:00	6,831	11/18/02 20:00	7,460	12/9/02 20:00	8,950
10/29/02 8:00	6,770	11/19/02 8:00	7,470	12/10/02 8:00	8,940
10/29/02 20:00	6,800	11/19/02 20:00	7,480	12/10/02 20:00	8,896
10/30/02 8:00	6,750	11/20/02 8:00	7,500	12/11/02 8:00	8,935
10/30/02 20:00	6,798	11/20/02 20:00	7,480	12/11/02 20:00	8,845
10/31/02 8:00	6,790	11/21/02 8:00	7,500	12/12/02 8:00	8,863
10/31/02 20:00	6,750	11/21/02 20:00	7,490	12/12/02 20:00	8,910
11/1/02 8:00	6,740	11/22/02 8:00	7,495	12/13/02 8:00	8,900
11/1/02 20:00	6,740	11/22/02 20:00	7,450	12/13/02 20:00	8,795
<1> Fixed leak in duct <2> No air quantity listed					

Date and Shift Start Time	Air Quantity (cfm)	Date and Shift Start Time	Air Quantity (cfm)	Date and Shift Start Time	Air Quantity (cfm)
12/14/02 8:00	<2>	12/27/02 8:00	8,920	1/9/03 8:00	8,760
12/14/02 20:00	<2>	12/27/02 20:00	8,798	1/9/03 20:00	8,840
12/15/02 8:00	8,775	12/28/02 8:00	8,810	1/10/03 8:00	8,800
12/15/02 20:00	8,775	12/28/02 20:00	8,870	1/10/03 20:00	8,820
12/16/02 8:00	8,780	12/29/02 8:00	8,880	1/11/03 8:00	8,800
12/16/02 20:00	8,750	12/29/02 20:00	8,790	1/11/03 20:00	8,790
12/17/02 8:00	8,840	12/30/02 8:00	8,800	1/12/03 8:00	8,800
12/17/02 20:00	8,810	12/30/02 20:00	8,780	1/12/03 20:00	8,810
12/18/02 8:00	8,830	12/31/02 8:00	8,760	1/13/03 8:00	8,780
12/18/02 20:00	8,904	12/31/02 20:00	<2>	1/13/03 20:00	8,800
12/19/02 8:00	8,860	1/1/03 8:00	<2>	1/14/03 8:00	8,820
12/19/02 20:00	8,904	1/1/03 20:00	<2>	1/14/03 20:00	8,791
12/20/02 8:00	8,890	1/2/03 8:00	8,700	1/15/03 8:00	8,800
12/20/02 20:00	8,900	1/2/03 20:00	8,724	1/15/03 20:00	8,751
12/21/02 8:00	8,904	1/3/03 8:00	8,760	1/16/03 8:00	8,780
12/21/02 20:00	8,880	1/3/03 20:00	8,889	1/16/03 20:00	8,740
12/22/02 8:00	8,890	1/4/03 8:00	8,880	1/17/03 8:00	8,750
12/22/02 20:00	8,796	1/4/03 20:00	8,767	1/17/03 20:00	8,740
12/23/02 8:00	8,820	1/5/03 8:00	8,840	1/18/03 8:00	8,740
12/23/02 20:00	8,800	1/5/03 20:00	8,800	1/18/03 20:00	8,750
12/24/02 8:00	<2>	1/6/03 8:00	8,740	1/19/03 8:00	8,760
12/24/02 20:00	<2>	1/6/03 20:00	8,790	1/19/03 20:00	8,750
12/25/02 8:00	<2>	1/7/03 8:00	8,740	1/20/03 8:00	8,770
12/25/02 20:00	<2>	1/7/03 20:00	8,750	1/20/03 20:00	8,693
12/26/02 8:00	8,827	1/8/03 8:00	8,735	1/21/03 8:00	8,670
12/26/02 20:00	8,888	1/8/03 20:00	8,756	1/21/03 20:00	8,720
<1> Fixed leak in duct <2> No air quantity listed					

Appendix Q – Approval and Certification Center Report on Torch

September 26, 2003

MEMORANDUM FOR JAMES OAKES
Lead Accident Investigator

FROM: STEVEN J. LUZIK
Chief, Approval and Certification Center

SUBJECT: Executive Summary of Laboratory Investigation of Evidence from the Multiple Fatal Explosion Accident on January 22, 2003, at the Central Cambria Sinking Operation at the McElroy Mine (ID 46-01437)

As requested, a laboratory investigation was conducted at the Approval and Certification Center (A&CC) as part of the subject Central Cambria accident investigation. The evidence examined consisted of 70 numbered items of galvanized sheet steel (including two reference items), 14 numbered items of oxygen/acetylene torch equipment, an axe, and a section of flexible ventilation duct. The referenced items correspond to evidence information received from Joe Tortorea, MSHA Team Investigator. The purpose of this investigation was to examine the sheet metal for evidence of burning or cutting with an oxygen-acetylene torch, the oxygen-acetylene equipment for indications that the equipment may have been in use at the time of the explosion, the axe for the sparking qualities of its head, and to determine the melting point of the plastic material constituting the ventilation duct and whether it was exposed to heat.

Summary of the Evaluation

1. Three pieces of the galvanized sheet steel recovered from the accident site showed burn cuts apparently from an oxygen/acetylene torch. On item P-1, the burned edge is from four to six inches long (See Figures 1 and 2). On item P-4, the burned edge is two inches long (See Figures 3 and 4). A reference sample which has been cut with an acetylene/oxygen torch is also shown in Figure 4 for comparison. On item P-5, the burned edge is one and a half (1.5) inches long (See Figures 5 and 6.). The effects of the burn cuts were observed as a series of bands between the burnt edge and the unaffected material:
   - The burnt edge is a blacked strip that is 1/32-inch to 1/8-inch wide.
   - Next, there are three or four bands where varying degrees of zinc ablation have occurred. Each of these bands is from 1/8-inch to ½-inch across.
   - Behind that is a melted band of galvanized coating that is approximately 1/16 to ½-inch across.
   - Beyond this, the galvanized coating does not appear to have been affected by heat.

This type of banding is visible on each of the items where burn cuts or flame impingement is indicated.

2. On six pieces of the sheet metal, melting of the galvanized (zinc) coating was observed (Items: P-2, P-8, P-9, P-12, P-13, and P-67). The melting point of zinc is reported as 786 ºF.

3. The acetylene valve on the oxygen/acetylene torch (Item P-32) was one quarter (¼) turn open (See Figures 7 and 8). The oxygen valve on the torch was closed. The torch was severely damaged (See Figure 9).

4. Item P-85 is a set of oxygen/acetylene hose and gas pressure regulators. The adjusting screw on the acetylene regulator was down (open). The adjusting screw on the oxygen regulator was approximately 60 percent open. The regulators had been heavily damaged (See Figures 10 and 11).

5. Experiments were conducted with an oxygen/acetylene torch on which the acetylene valve was open one quarter (¼) turn and the oxygen valve was closed. The experiments indicate that the burn cuts and/or melting noted on items P-1, P-2, P-4, P-5, P-8, P-9, P-12, P-13, and P-67 are unlikely to have been caused by brief exposure to an acetylene flame in the reducing mode (i.e. with little or no pre-mixed oxygen). Both the oxygen valve and acetylene valve on the torch head would need to be open about one-quarter turn to obtain a proper flame for cutting purposes. Therefore, when the burn cuts were made, the torch was likely operating with the oxygen valve on the torch head sufficiently open to produce a proper flame. In the experiment, the oxygen/acetylene torch on which the acetylene valve was opened one quarter (¼) turn and the oxygen valve was closed, a persistent, orange flame about one foot long was produced. The temperature of the acetylene diffusion flame was measured as 1550°F.

6. The examination and metallurgical test of the axe head showed it was a standard AISI/SAE 1060 carbon steel. Sparks produced by this type of steel striking galvanized steel sheeting which may ignite methane are highly unlikely. No data was found to confirm such an event could occur.

7. Examination of the ventilation duct showed it was constructed of a yellow film, a white fiber scrim, and a black strip covering outside of the steel spiral. There was no evidence of burning or melting. The softening ranges and a melting point of these polymers was determined as follow:
    - For the yellow film, softening range was from 374°F to 401°F;
    - For the white fiber, the melting point was 482°F;
    - For the black strip, softening range was from 297°F to 356°F.

Significant Findings

Several sections of the sheet metal examined showed burn cuts/flame impingement apparently from an oxygen/acetylene torch flame. The acetylene valve on the oxygen/acetylene torch head was shown to be open one quarter turn. The oxygen valve on the torch head was shown to be in the closed position as found at the site. The oxygen and acetylene valves on the torch head needed to be open and adjusted to obtain a flame that would be sufficient for cutting the metal sheeting. Since the evidence indicates sheet metal was cut by a sufficient flame from the torch, the oxygen valve on the torch head apparently was open, but likely became closed from the torch being thrown around by the dynamic effects of the explosion. The torch was considerably damaged as indicated in Figure 9.

The gas pressure regulator for the acetylene was open. The gas pressure regulator for the oxygen was about 60 percent open.

Comprehensive test results can be obtained from the Chief, A&CC, Box 251, Industrial Park Road, Triadelphia, West Virginia 26059.

Figures 1 through 11

Figure 1 Item P-1, the area of the burn cut is on the right and is designated by the black arrow. The 18-inch rule indicates the size of the item.

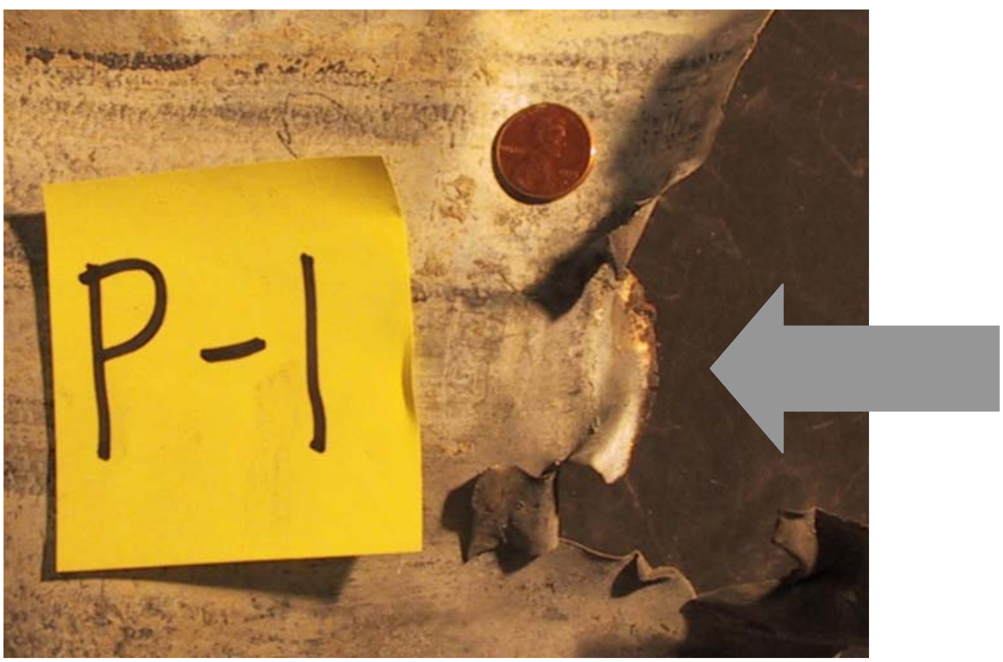


Figure 2 Item P-1, the area of burn cut is indicated by the gray arrow. Part of the burned edge has been torn. The penny is for scale.

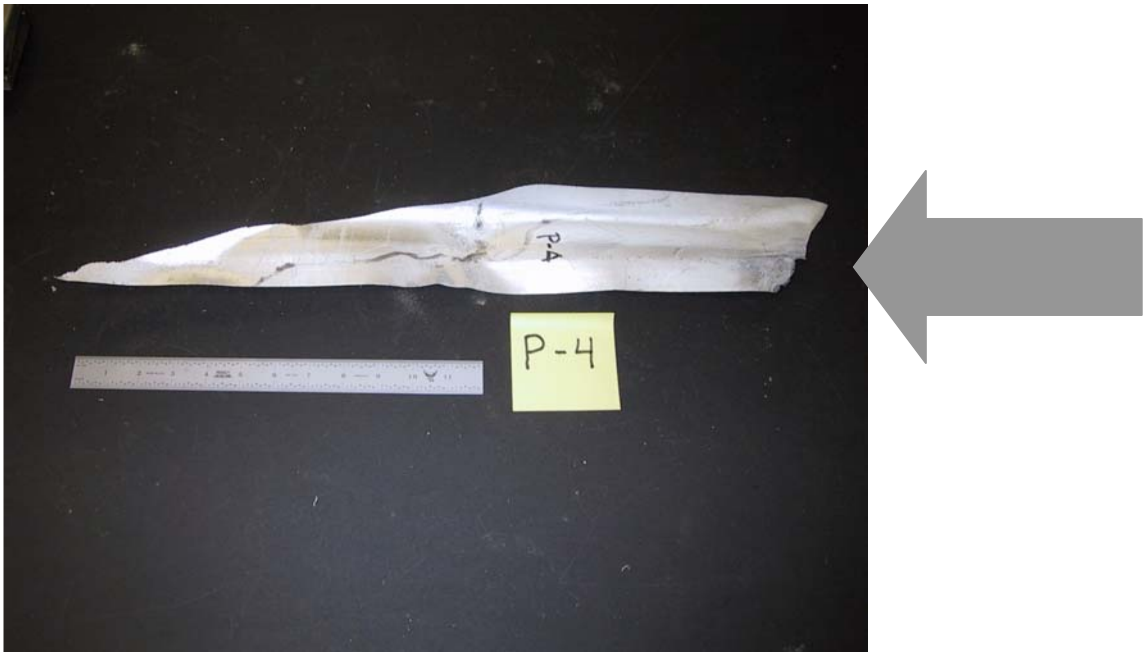


Figure 3 Item P-4, the area of burning is on the bottom right corner and is indicated by the gray arrow. The 12-inch rule indicates the size of the item.

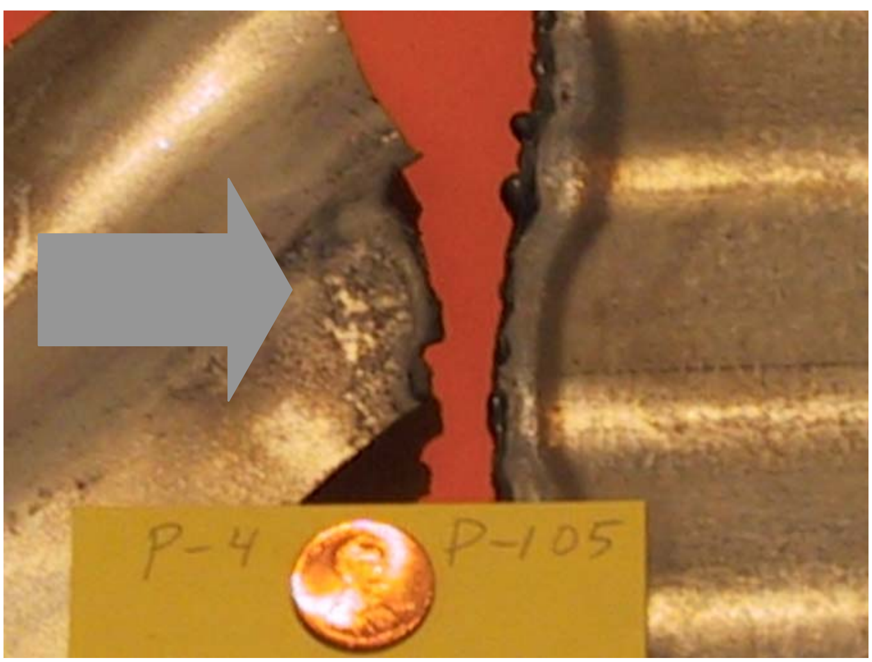


Figure 4 The burned section of item P-4 is on the left. The burn cut edge of item P-105 is on the right. Item P-105 is a reference sample which had been cut with an oxygen/acetylene torch. Banding caused by heat is visible on the surface of both items. The burned edge of item P-4 is indicated by the gray arrow. The penny is for scale.

Figure 5 Item P-5, the burnt area is on the left as indicated by the white arrow. The 12-inch ruler is for scale.

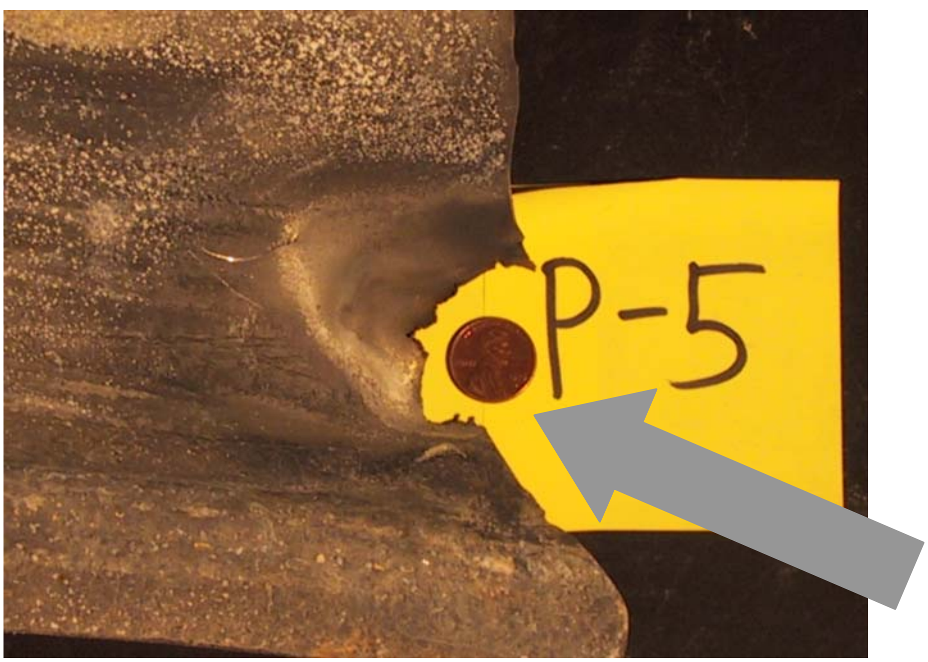


Figure 6 Item P-5, areas where the zinc coating has been melted or ablated are visible. The gray arrow points to the burned edge. The penny is for scale.

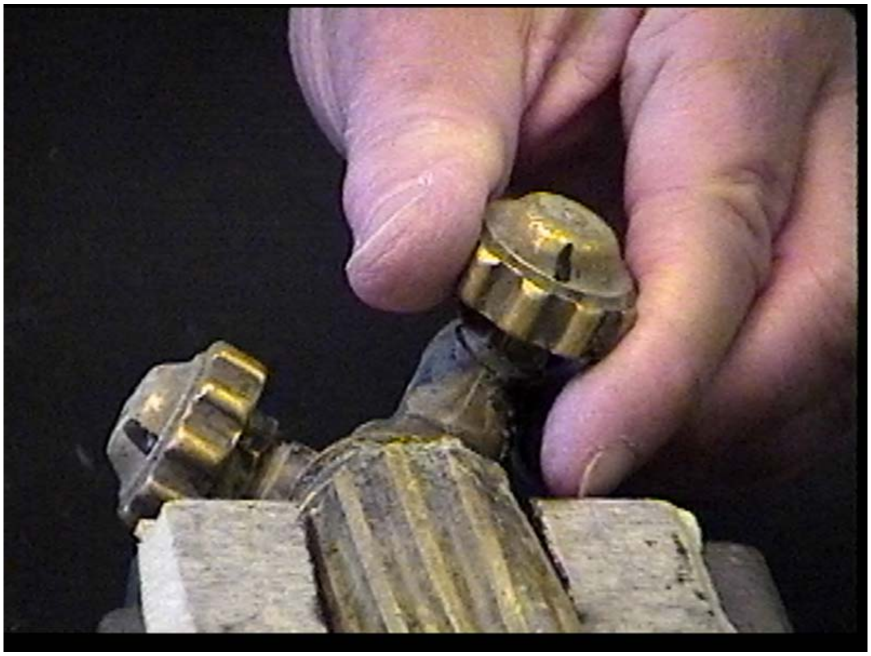


Figure 7 The acetylene valve on the oxygen-acetylene torch (item P-32) is in the position at which it was received and is about to be turned for the first time. The black mark on the front of the knob has been placed there to keep track of valve rotation.

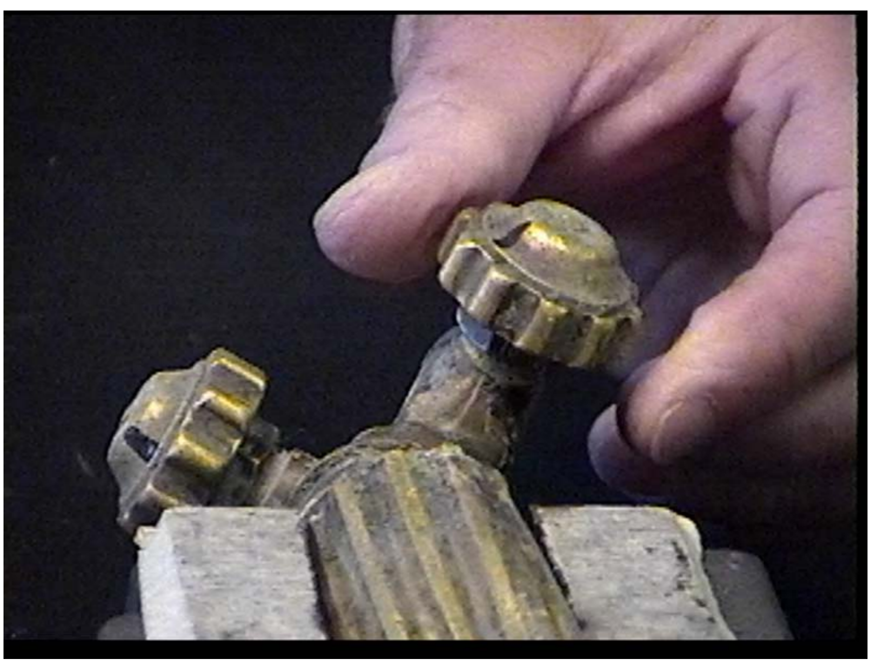


Figure 8 In this image, the acetylene valve on the oxygen-acetylene torch (item P-32) has been turned for the first time. The black mark placed to keep track rotation of the valve knob has moved about one-quarter turn clock-wise, which is the limit of its rotation in that direction. The valve was completely closed after a one quarter turn clock-wise. The acetylene valve was open a quarter turn when received for examination.

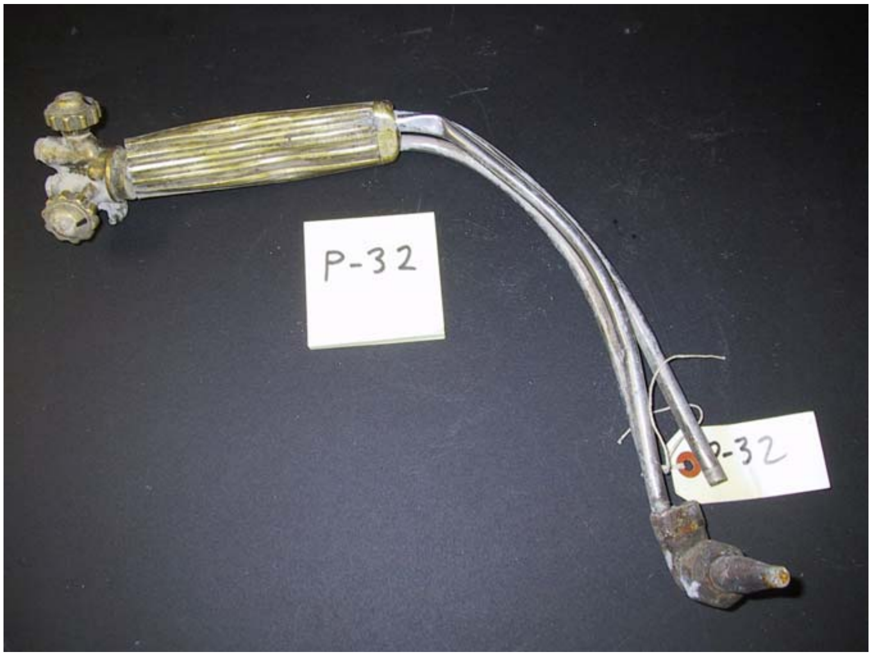


Figure 9 Item P-32 is the oxygen-acetylene torch recovered from the accident site.

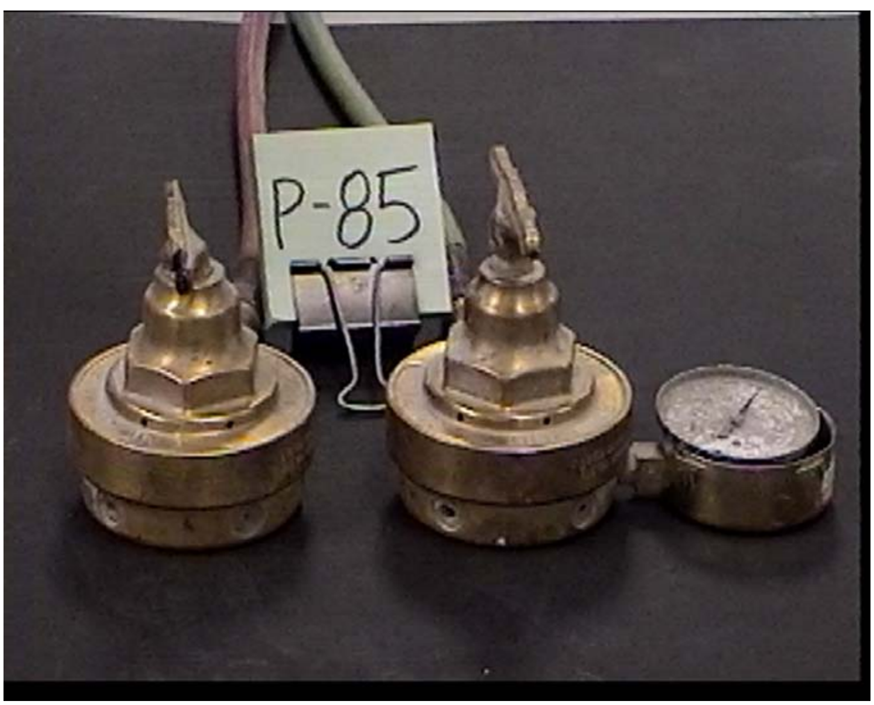


Figure 10 The severely damaged acetylene regulator is on the left. The oxygen regulator is on the right. A black mark on the front of the pressure adjusting handle on the acetylene regulator has been placed there to track rotation of the adjusting screw. The adjustments are in the positions at which they were received for examination.

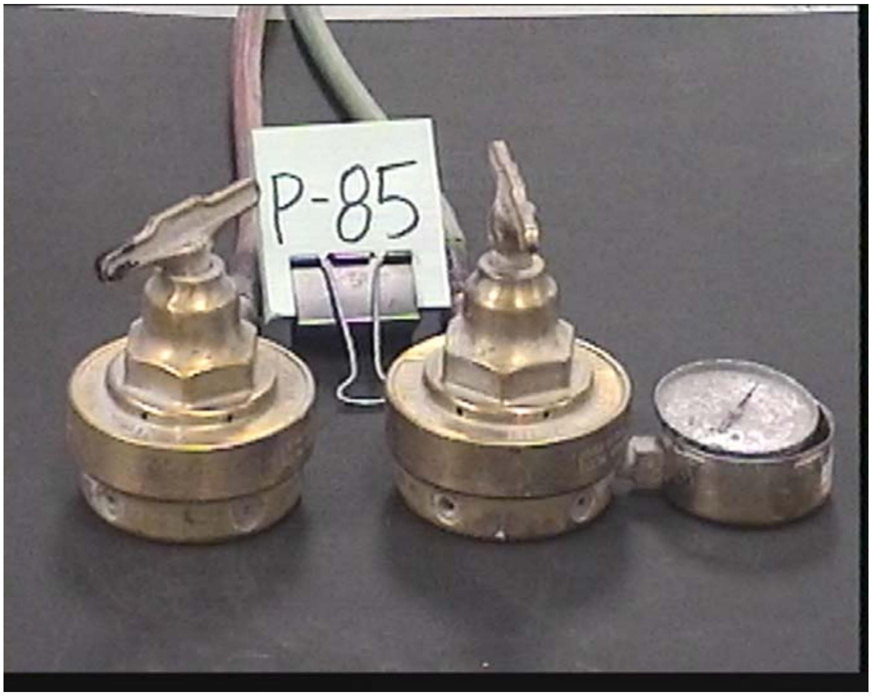


Figure 11 In this image, the pressure adjusting handle on the acetylene regulator has been turned for the first time. The black mark placed to keep track rotation of the screw has moved only one-quarter turn clock-wise (downward), which is the limit of its rotation. This indicates that the acetylene control valve was almost completely open, which would permit the flow of acetylene.

Appendix R – Methane Liberation Study

On February 5, 2003, air samples were collected at the inby end of the flexible ventilation tubing, approximately 48 feet from the shaft bottom, to determine the methane liberation of the shaft. The shaft area was divided into quarters with samples collected in each quarter. The air samples were analyzed and the percent methane in each sample was determined. The results are shown in Table R-1.

Table R-1
Flexible Ventilation Tubing

Sample No.	Quadrant No. 1 % Methane	Quadrant No. 2 % Methane	Quadrant No. 3 % Methane	Quadrant No. 4 % Methane
1	0.0094	0.0086	0.0109	No Sample
2	0.0007	0.0080	0.0099	0.0093

Using an average methane concentration determined from Table R-1 and an air quantity of 3,640 cfm measured at the inby end of the tubing, a shaft methane liberation rate of 425 cfd was calculated.

Additional samples were collected at two locations to determine whether methane could be quantified to a specific zone of the shaft. Samples were collected between the shaft bottom (muck pile) and the work deck. This area was divided into quarters and samples were collected in each quarter. The samples were analyzed and the percent methane in each sample was determined. The results are shown in Table R-2.

Table R-2
Between Shaft Bottom and Work Deck

Sample No.	Quadrant No. 1 % Methane	Quadrant No. 2 % Methane	Quadrant No. 3 % Methane	Quadrant No. 4 % Methane
1	No Analysis	0.0088	0.0081	0.0071
2	0.0082	0.0072	0.0080	0.0060

The sample results indicate that methane was seeping through the muck pile and being liberated into the shaft.

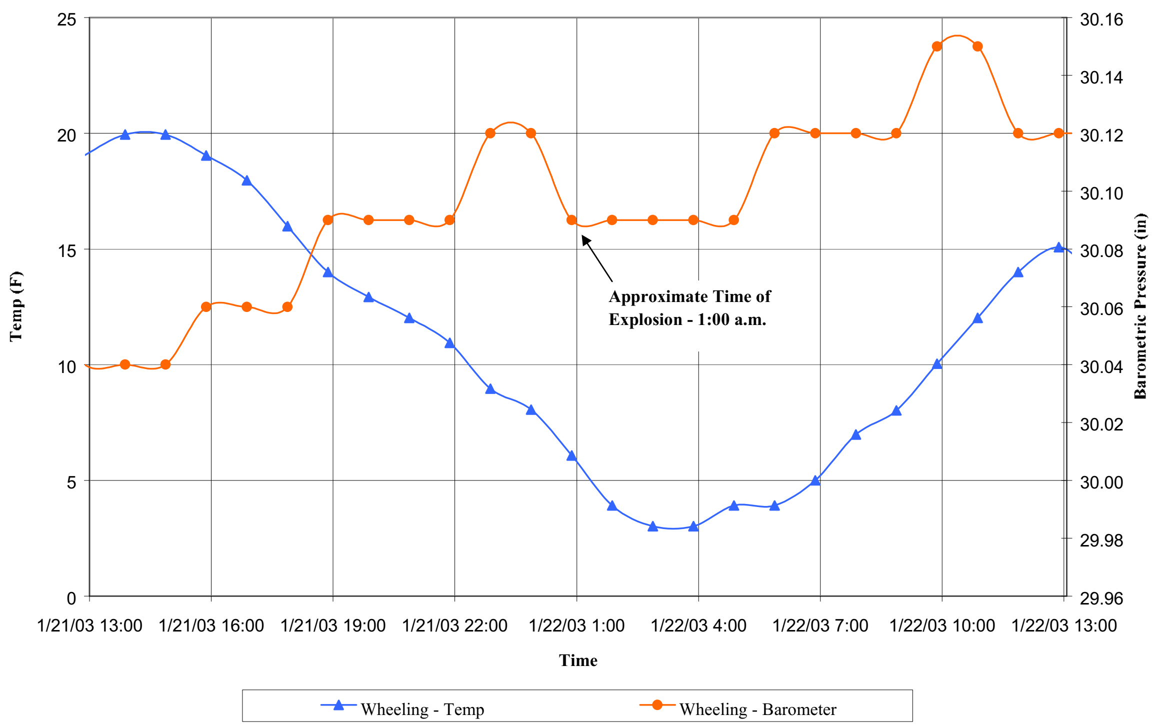
Air samples were also collected in the water ring. These samples were taken at various distances measured clockwise from the mandoor frame (see Appendix K). The methane concentrations found in those samples are shown in Table R-3.

Table R-3
Samples Collected in the Water Ring

	Water Ring @ 12 feet	Water Ring @ 34 feet	Water Ring @ 55 feet	Water Ring @ 87 feet
Methane %	0.0118	0.0150	0.0090	0.0134

A methane liberation rate could not be calculated directly from the air samples collected in the water ring because there were negligible amounts of air movement and methane concentrations found in the water ring. However, the sample results demonstrated that methane was present.

Appendix S – Barometric Pressure and Temperature Data



Appendix T – Methane Readings Measured in Pipes

Four pipes were installed within the shaft wall and extended from the collar to the bottom of the shaft. Three of the pipes were 8-inch diameter PVC pipes and the fourth was a 6-inch diameter steel pipe. These were intended to be used for mine utilities and de-watering. Methane was discovered flowing from the pipes on February 5, 2003. The levels found varied. The dates and levels are provided below.

Date	6-inch Steel (Methane %)	8-inch PVC Water Ring (Methane %)	8-inch PVC (Methane %)	8-inch PVC Blasting Wires (Methane %)
2/05/03	0.4	0	0.4	3.8
2/08/03	0.4 - 0.5	0.8 – 1.2	0.3 - 0.6	3.1 – 4.3
2/10/03	0.15 – 0.6	0.2	0.15 – 0.6	1.4 – 4.5
2/11/03	0 – 0.5	0 – 0.1	0.2 – 0.4	1.1 – 4.4
2/12/03	0	0.1	0	0.2 (6.8[5])
2/13/03	0	0.1	0	0.2
2/14/03	0	0	0	0.2
2/15/03	0	0	0	0
2/19/03	0	0	0	0

It was initially thought that the methane found in the pipes was flowing from the Pittsburgh Coal seam, through the muck pile in which the pipes were buried, and into the uncapped inby ends of the pipes. However, on February 11, 2003, the inby ends of the pipes were dug out by the investigators exposing the end of each pipe and no methane source was found.

Subsequent tests were performed on February 12, 2003, to try to determine the source of the methane. During one test, the end of the PVC pipe liberating the highest detected quantities of methane was capped in the shaft with a plastic seal. A pressure of 1.15 inches was measured across the seal. Methane was measured in the pipe at the top of the shaft. The methane concentration substantially increased to 6.8% after a short period of time. This increase caused the investigation team to believe that the pipe(s) could have been fractured during shaft construction. A down-hole camera was brought to the site on February 13th, and used to film the entire length of the pipe. Openings and cracks in the PVC pipe were found in four places that would have permitted methane to enter the pipe. At a depth of approximately 220 feet, a 1-foot crack was found, at 415 feet, a 2-inch crack, at 505 feet a separation, and at 690 feet, a large crack. It is reasonable to expect that methane entered the other pipes where openings and cracks existed and where the joints were not sealed.

There were four readily identifiable coal seams to be encountered during shaft construction. The coal seams were the Waynesburg A, Waynesburg, Sewickley, and Pittsburgh. All four seams are known to liberate methane. The shaft had been developed through the Waynesburg A,

[5] Maximum concentration measured during the test.

Waynesburg and Sewickley seams. The methane measured in the pipes could have migrated from any or all of those seams.

The PVC pipe containing the blasting wires was of particular concern because measured methane concentrations approached dangerous levels. To eliminate the methane hazard, CCD was required to not cap or plug either end during the completion of the shaft construction.

Appendix U- Report on Examination and Testing of Evidence Conducted by Approval and Certification Center

July 11, 2003

MEMORANDUM FOR JOSEPH TORTOREA, JR.
Supervisory Mine Safety and Health Specialist, Coal Mine Safety and Health, District 2

FROM: STEVEN J. LUZIK
Chief, Approval and Certification Center

SUBJECT: Executive Summary of Investigation of Gas Detectors and of Koehler Cap Lamp Assemblies and Cap Lamp Battery Recovered from the McElroy Mine Explosion

The Approval and Certification Center (A&CC), as requested by Coal Mine Safety and Health, conducted an investigation of two (2) Mine Safety Appliances Company (MSA) Model Passport FiveStar Portable Alarms, one (1) MSA Omega Charging Stand, and one (1) CSE Corporation Model 102 Methane Detector. The purpose of the investigation was to determine if they were maintained according to the approval requirements and to determine their current operational status.

Additionally, the A&CC conducted a laboratory investigation associated with cap lamp assemblies and a cap lamp battery recovered from the same explosion.

Model Passport FiveStar Portable Alarm, Exhibit Number P-88

This MSA Model Passport FiveStar Portable Alarm ("FiveStar Alarm") was noted on the chain of custody form as "found in the pocket of tan work jacket believed to belong to Richard Brumley." The unit was marked as holding MSHA Approval Number 8C-67-0 and had serial number G7-10528-G00. The unit was inspected and compared with approval documentation. Tests were conducted to determine if it or any of its components could have provided enough energy to initiate a flammable methane/air mixture. Operational and performance tests were also conducted.

The investigation identified several permissibility discrepancies that were attributable to improper maintenance or manufacturing discrepancies that deviated from the approved design. Several of the manufacturing discrepancies had a potentially significant impact on the performance of the instrument. There is no evidence that the discrepancies could produce conditions that would have provided enough energy to ignite a flammable methane-air mixture. There was some minor wear to the external components of the unit attributed to normal use. One of the screws securing the sensor cover was missing.

The data stored in memory was downloaded; the last calibration date for the methane sensor was given as 10-21-2002. The last oxygen calibration date was given as 01-21-2003. The time reading from the instrument was approximately 1 hour and 15 minutes ahead of the actual time.

The detector, in the received condition, operated but had low battery charge. A complete test series was not possible without charging the battery. Prior to calibration, the unit detected oxygen within an error of ±0.5% at various concentrations between 13% and 20.9%. However, it did not detect methane within the limits of accuracy required by 30 CFR Part 22. The methane readings were significantly lower than the concentration applied to the instrument. For example, the 1% alarm was not given by the FiveStar Alarm until the mixture applied to the instrument reached 2.90% methane-in-air.

After calibration of the instrument, it detected methane within the limits of accuracy required by 30 CFR Part 22 at mixtures of 3.0% and below. However, with a mixture of 4.03%, the instrument read '4.35', which is above the required limit of accuracy.

No definitive determination of the operating status of the instrument at the time of the accident is possible. However, if the difference between the instrument's clock and real time existed at the time of the accident, it is likely that the unit was not turned on.

No spark ignition testing was conducted or deemed necessary as there was no evidence that there was an internal explosion. When tested to determine if the instrument could have presented a thermal ignition hazard, the methane detection element did not ignite a flammable mixture of methane and air.

It was concluded that there was no evidence that any component of the P-88 FiveStar Alarm would produce conditions that would provide enough energy to ignite a flammable methane-air mixture.

Model Passport FiveStar Portable Alarm, Exhibit Number P-89

This MSA Model Passport FiveStar Portable Alarm ("FiveStar Alarm") was noted on the chain of custody form as "found on shelf in office being charged." The unit was marked as holding MSHA Approval Number 8C-67-0 and had serial number G7-10167-G00. The unit was inspected and compared with approval documentation. Tests were conducted to determine if it or any of its components could have provided enough energy to ignite a flammable methane/air mixture. Operational and performance tests were also conducted.

The investigation identified several permissibility discrepancies that were attributable to improper maintenance or manufacturing discrepancies that deviated from the approved design. Several of the manufacturing discrepancies had a potentially significant impact on the performance of the instrument. There is no evidence however, that the discrepancies could produce conditions that would provide enough energy to ignite a flammable methane-air mixture. There was some minor wear to the external components of the unit attributed to normal use.

The data stored in memory was downloaded; the last calibration date for the methane sensor was given as 10-21-2002. The last oxygen calibration date was given as 01-26-2003. The time reading from the instrument was approximately 1 hour and 15 minutes ahead of the actual time.

The instrument, in the received condition, did not operate due to insufficient battery charge. After battery charging, the instrument operated. As received, the instrument was programmed to display readings in percent LEL, or "lower explosive limit." In the LEL display mode, the instrument does not meet MSHA approval requirements, as it is required to display percent by volume. The measurement mode can be changed, however, by the user when installing a new methane sensor module by following several programming steps.

Prior to calibration, the unit detected oxygen within an error of ±0.2% at various concentrations between 13% and 20.9%. However, it did not detect methane within the limits of accuracy required by 30 CFR Part 22, after conversion of the LEL readings to percent volume readings. The methane readings were significantly lower than the concentration applied to the instrument. For example, the 20% LEL alarm (which corresponds to 1% by volume) was not given by the FiveStar until the mixture applied to the instrument reached 2.90% methane-in-air, which corresponds to 58% LEL.

After calibration of the instrument, it still did not detect methane within the limits of accuracy required by 30 CFR Part 22 at mixtures of 2.0% and above. At these mixtures, it gave readings above the acceptable limits, after conversion of the percent LEL readings to percent volume.

No definitive determination of the operating status of the instrument at the time of the accident is possible. However, if the difference between the instrument's clock and real time existed at the time of the accident, it is likely that the unit was not turned on.

No spark ignition testing was conducted or deemed necessary as there was no evidence that there was an internal explosion. When tested to determine if the instrument could have presented a thermal ignition hazard, the methane detection element did not ignite a flammable mixture of methane and air.

It was concluded that there was no evidence that any component of the P-89 FiveStar Alarm would produce conditions that would provide enough energy to ignite a flammable methane-air mixture.

MSA Omega Charging Stand, Exhibit P-96

This unit, MSA P/N 494716 Rev 4, was used to charge the FiveStar Alarms for the various tests. It operated as expected. The only notable feature was the inclusion of a piece of duct tape at the rear of the instrument well. The tape was most likely used to ensure that the instrument made contact with the charging terminals by forcing the instrument being charged into place.

CSE Corporation Model 102 Portable Methane Detector, Exhibit P-90

One CSE Corporation Model 102 Portable Methane Detector, identified as P-90, was recovered from the mine. The approval marking was noted as 8C-37-7 and the serial number was 79600. It was inspected and compared with approval documentation. Tests were conducted to determine if it or any of its components could have provided enough energy to initiate a flammable methane/air mixture. Operational tests were also conducted.

The investigation identified several permissibility discrepancies that were attributable to improper maintenance or manufacturing discrepancies that deviated from the approved design. None of these discrepancies were significant or could produce conditions that would have provided enough energy to ignite a flammable methane-air mixture.

There was some minor wear and damage to the external components of the unit that were attributed to normal use.

The monitor, in the received condition, did not operate due to insufficient battery charge. After the battery was charged, and prior to calibration, it did not detect methane within the limits of accuracy required by 30 CFR Part 22 at mixtures of 2.0% methane-in-air and above. The methane readings were lower than the concentration applied to the instrument. For example, the instrument read ‘1.6’ in a 2.0% mixture.

After calibration of the instrument, it detected methane within the limits of accuracy required by 30 CFR Part 22 at mixtures of 3.0% and below. However, with a mixture of 4.0%, the instrument read ‘3.5’, which is below the required limit of accuracy.

No definitive determination of the operating status of the instrument at the time of the accident is possible. It has no data storage capabilities.

No spark ignition testing was conducted or deemed necessary as there was no evidence that there was an internal explosion. When tested to determine if it was a thermal ignition hazard, the instrument did not ignite a flammable mixture of methane and air.

It was concluded that there was no evidence that any component of the CSE Model 102 would produce conditions that would provide enough energy to ignite a flammable methane-air mixture.

Koehler Cap Lamp Assemblies and Battery

The following were received for investigation:

1. Exhibit P-39 is a Koehler Model 5100 Cap Lamp with a severely damaged headpiece that is missing the bulb and lens as well as other components.
2. Exhibit P-40 is a Koehler Model 5100 Cap Lamp Assembly that is still operable.
3. Exhibit P-92 is a Koehler Model 5200 Cap Lamp Assembly with a damaged headpiece that is missing the bulb and lens as well as other components.
4. Exhibit P-97 is a Koehler 5000 Series Battery only, with no cord, battery cover, rubber insulator, or headpiece connected.

Each exhibit was photographed and a preliminary inspection was made without disassembling or altering any of the exhibits from their “as received” condition.

Each cap lamp battery was disassembled, photographed, and then decontaminated. After each battery was decontaminated, it was subjected to a flash current test to determine the maximum short-circuit current available from the battery “as received.” The batteries were then recharged and the electrolyte replenished to the “fill” mark on the battery. After each battery was recharged, its open-circuit voltage was measured and the battery was again flash current tested. The battery of Exhibit P-92 recorded the highest short-circuit current and the highest open-circuit voltage was measured on the battery identified as Exhibit P-40. These two batteries were subjected to spark ignition tests and determined not to be a source of ignition of a flammable methane-air atmosphere.

Tests were then conducted on Exhibit P-40 (the only cap lamp that included a lamp bulb) to determine if the surface temperature of the headlamp lens was sufficient to cause the thermal ignition of a layer of coal dust (150 degrees Celsius). The maximum temperature recorded on the outside of the lens directly above the lamp bulb verified that a layer of coal dust would not be ignited by the heat from the lamp bulb. Another temperature test on the lamp bulb envelope inside the headpiece verified that the temperature on the surface of the lamp bulb was not sufficient to ignite a flammable methane-air mixture.

Each exhibit was disassembled, photographed and compared with the drawings on file at MSHA for these approvals. Minor discrepancies were identified between the actual cap lamps and the drawings. None of these discrepancies would affect the safety or performance of the cap lamps.

The operation of the lamp bulb ejection mechanism was verified for each exhibit except P-97. Exhibit P-97 did not include a headpiece. The bulb ejection mechanism disconnects power to the lamp bulb filament if the lamp bulb envelope or headpiece lens is broken to prevent ignition of a methane-air mixture surrounding the exposed lamp bulb filament. This bulb ejection mechanism design was tested and the design approved by MSHA and is documented in the approval records. To the extent possible, we determined that each bulb ejection mechanism functioned properly.

Based on our inspection, tests and evaluation, we conclude the following:

- The cap lamp batteries are not capable of producing a spark that would ignite a flammable methane-air atmosphere;
- The BM-30L lamp bulb used in Exhibit P-40 is not capable of igniting either a coal dust layer or a flammable methane-air atmosphere; and,
- The bulb ejection mechanisms in Exhibits P-39 and P-92 appear to have been operational. The approved design of this bulb ejection mechanism was determined by test in the approval investigation to prevent the ignition of a methane-air mixture if either the lamp bulb envelope or the headpiece lens was broken.

Comprehensive test results can be obtained from the Chief of the A&CC, RR 1, Box 251, Industrial Park Road, Triadelphia, West Virginia 26059.