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UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION

Underground Coal Mine

Fatal Electrical Accident
July 19, 2003

Upper Big Branch Mine-South
Performance Coal Company
Naoma, Raleigh County, West Virginia
I.D. No. 46-08436

Accident Investigators

Roger D. Richmond
Coal Mine Safety and Health Inspector/Accident Investigator

Marcus Smith
Electrical Engineer

Originating Office
Mine Safety and Health Administration
District 4
100 Bluestone Road
Mt. Hope, West Virginia 25880
John Pyles, Acting District Manager
Release Date: February 2, 2004

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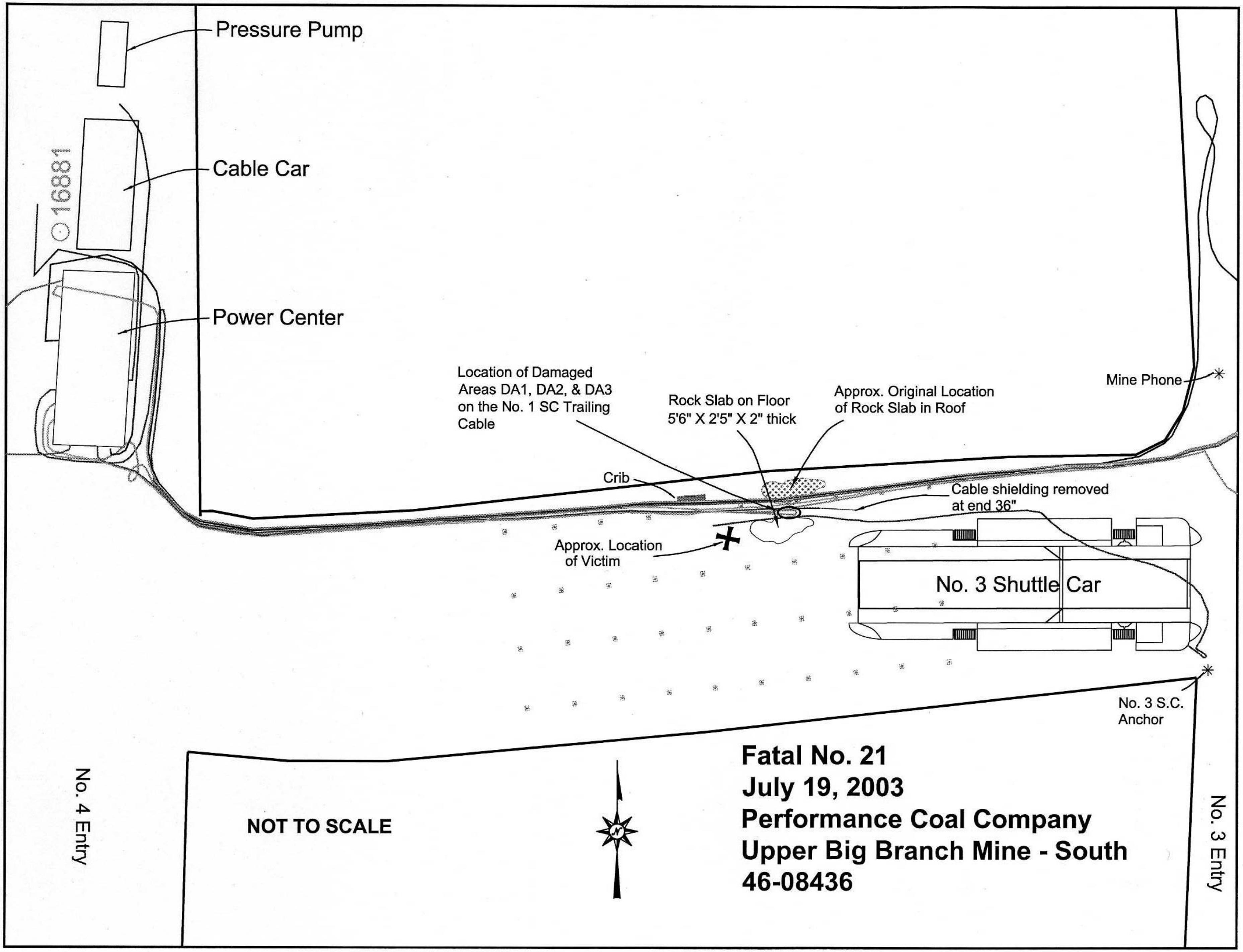
Pressure Pump
Cable Car
⊙16881
Power Center
Location of Damaged Areas DA1, DA2, & DA3 on the No. 1 SC Trailing Cable
Rock Slab on Floor 5'6" X 2'5" X 2" thick
Approx. Original Location of Rock Slab in Roof
Mine Phone
Crib
Cable shielding removed at end 36"
Approx. Location of Victim
No. 3 Shuttle Car
No. 3 S.C. Anchor
No. 4 Entry
NOT TO SCALE
Fatal No. 21
July 19, 2003
Performance Coal Company
Upper Big Branch Mine - South
46-08436
No. 3 Entry

OVERVIEW

On Saturday, July 19, 2003, at approximately 5:15 p.m., Rodney Alan Scurlock, a 27-year old electrician, was fatally injured while repairing a shuttle car trailing cable at the Performance Coal Company, Upper Big Branch Mine-South. The accident occurred in a crosscut between the No. 3 and No. 4 entries on the No. 17 headgate section. There were five additional trailing cables lying on the mine floor in the area where the victim was working; one of which was damaged. Two energized 480 VAC phase conductors were exposed on the damaged trailing cable, which was lying in mud and water in the area where the victim was working. The victim was electrocuted when he came in contact with the power emitted by the damaged trailing cable.

GENERAL INFORMATION

Massey Energy's Performance Coal Company, Upper Big Branch Mine-South, I.D. No. 46-08436, is located near Naoma, Raleigh County, West Virginia. The mine is accessed by 19 drift openings and two shafts into the Eagle Coal Seam. The coal seam averages 65 inches in thickness, with a total mining height of approximately 88 inches at the accident site.

The mine employs 171 underground and 6 surface employees. An average of 10,000 tons of coal is produced daily by three continuous mining machine units and one longwall unit. The mine produces coal two shifts per day, seven days per week. Coal is transported from the continuous mining machine units to the section loading point with shuttle cars. Belt conveyors transport coal from the sections to the surface. A track haulage system is used to transport supplies, materials, equipment and employees into and out of the mine.

The mine is ventilated by two main mine fans (one blowing and one exhausting). The mine liberates approximately 2,000,000 cubic feet of methane every 24 hours. During development, face areas are ventilated using both blowing and exhausting line curtain configurations and continuous mining machines equipped with scrubbers.

The roof control plan in effect at the time of the accident was approved by the Mine Safety and Health Administration on September 25, 2002. The immediate mine roof consists of gray shale and sandstone. The main roof is 40 to 50 feet of sandstone.

The principal officers for Upper Big Branch Mine-South are:

President..Bill Potter
Vice President/Superintendent of Operations........................Homer Wallace
Safety Director..George Nelson

MSHA completed its last regular inspection of this mine, prior to the accident, on June 24, 2003. The Non-Fatal Days Lost, (NFDL), incident rate during the previous quarter was 6.98 for underground mines nationwide and 9.62 for this mine.

DESCRIPTION OF THE ACCIDENT

On Saturday, July 19, 2003, at approximately 4:00 p.m., the nine-man evening shift crew for the No. 17 Headgate Section, under the supervision of Richard C. Kim, Section Foreman, entered the mine via the track drift opening located at the Upper Big Branch Mine-South portal and traveled to the Headgate No.17 Section (MMU 009) to produce coal.

Upon arrival at the working section, Kim gave a safety talk and assigned work duties to the crew. Bryan Scurlock, continuous mining machine operator, was directed to begin mining in the No. 3 face. Randall Kirk, No. 2 shuttle car operator, and Bobby Kirk, No. 3 shuttle car operator, began hauling coal from No. 3 face to the section feeder. Kenneth Chapman and Earl Waddell, roof bolting machine operators, started bolting the roof in the No.1 face. Lawrence Deal, scoop operator, and Joel Price, utility man, were performing other duties on the section.

B. Kirk noticed that the No. 3 shuttle car wasn't tramming correctly. After determining that the shuttle car needed hydraulic oil, he located two cans of oil in the No. 4 entry, which he put into the shuttle car. He then returned to hauling coal from the No. 3 face. When he pulled onto the section feeder with his third load, the No. 3 shuttle car lost power. The inoperative shuttle car blocked the No. 2 shuttle car, driven by R. Kirk, from dumping coal on the feeder.

After the shuttle cars did not return to the face for loading, B. Scurlock walked toward the feeder. B. Kirk went to the power center, where he summoned electrician, Rodney Scurlock (victim), to see if the breaker for the No. 3 shuttle car had opened. R. Scurlock tried setting up the breaker two or three times, but it would not stay in. B. Kirk and R. Scurlock began looking for damage in the No. 3 shuttle car cable as they walked from the power center along the left rib, where the trailing cables were lying on the mine floor. They found a 2-inch thick rock, measuring 5-½ feet by 2-½ feet, lying on both shuttle car trailing cables, approximately 4-½ inches from the inoperative No. 3 shuttle car. B. Kirk and R. Scurlock flipped the rock off of the cables and observed an area in the No. 3 shuttle car cable, which appeared to be swollen. They did not detect damage to the outer insulation in this portion of the cable.

R. Scurlock returned to the power center, where he unplugged and locked out the visible disconnect for the No. 3 shuttle car cable. He then went back to the area where the cable was swollen, cut the cable open, and found that two phase conductors were severed. In order to move the shuttle car off of the feeder so that production could continue, R. Scurlock made a temporary splice in the cable. Once the temporary splice was finished, he went back to the power center, attached the plug to the receptacle, and energized the breaker. The lights functioned; however, the shuttle car tram motors remained inoperative.

Kim instructed the miners to use the No. 2 shuttle car to pull the No. 3 shuttle car off the feeder in order to resume production. The shuttle car was pulled approximately ten feet away from the feeder. B. Kirk asked Kim if he wanted him to stay and assist R. Scurlock to find the problem with the No. 3 shuttle car. Kim, however, instructed B. Kirk to run the No. 1 left side shuttle car. B. Kirk and R. Kirk continued hauling from the No. 3 face until the cut was finished. During this time, Kim returned to the face to check B. Scurlock's progress in the cut. Finding that B. Scurlock was nearly finished in No. 3, Kim positioned the left side continuous miner in the face of the No. 2 left crosscut, the next place to be mined. When B. Scurlock finished mining in the No. 3 face, he walked to the area where R. Scurlock was working on the shuttle car cable to see how the repairs were going. He observed the victim pulling cable off of the No. 3 shuttle car reel and throwing it over the discharge end of the shuttle car. B. Scurlock then headed back towards the face of the No. 2 left crosscut where mining would resume. While en route, he met Chapman in the No. 2 right crosscut. Chapman was in need of oil for his roof bolting machine and asked B. Scurlock if he had seen any. B. Scurlock replied that he had not, so Chapman continued walking toward the power center. He noticed a light shining against the mine roof in the crosscut between No. 3 and No. 4 entries, approximately ten feet outby the No. 3 shuttle car (which had been pulled off of the feeder). As Chapman walked toward the light, he saw R. Scurlock lying on the mine floor, with the No. 3 shuttle car trailing cable he had been repairing lying across his body.

Chapman immediately went to get help and ran into B. Scurlock. The two men returned to the accident site. Chapman told B. Scurlock not to touch the victim because the cable lying on top of him could have power on it. B. Scurlock kicked the cable out of the victim's right hand, while Chapman ran up the No. 3 entry and summoned Waddell. Chapman went to the 3 left crosscut, where he summoned B. Kirk and Kim. When Chapman, Waddell, B. Kirk, and Kim arrived at the accident scene, B. Scurlock and R. Kirk were performing cardiopulmonary resuscitation (CPR) on the victim. R. Kirk called outside to inform them that a serious accident had occurred and asked them to clear the track. Kim instructed the crew to get the first aid equipment located on the power center.

R. Kirk and Kim relieved Scurlock in performing CPR. Kim checked for vital signs, but could not detect any. Kim then instructed the crew to prepare the victim for transport. Kim instructed Waddell to contact someone on the surface to give them a description of the victim's condition, so that this information could be passed on to the ambulance attendants.

R. Kirk informed Kim that he was going to de-energize the power center that supplied electricity to the trailing cables because he had felt a tingling sensation, which he believed to be caused by electricity, as he was getting up from the mine floor. He then de-energized the power center. Kim instructed the crew on the route of travel and the crew transported the victim by carrying him to the mantrip. Price, also an Emergency Medical Technician (EMT), helped perform CPR. Because there wasn't room for everyone on the mantrip, Deal, Chapman, and Waddell remained on the section until Ben Dulan, longwall face foreman, could come to the No. 17 headgate section to pick them up.

Rodney Scurlock was transported to Raleigh General Hospital, Beckley, West Virginia, by the Whitesville Ambulance Service, and later transported to the Medical Examiner's Office in Charleston, West Virginia, where he was pronounced dead by the Deputy Chief Medical Examiner at 8:20 p.m., on July 19, 2003.

INVESTIGATION OF THE ACCIDENT

The Mine Safety and Health Administration (MSHA) was notified at 7:58 p.m., on July 19, 2003, that a serious accident had occurred. MSHA accident investigator Roger Richmond and electrical specialist Marcus Smith were dispatched to the mine. A 103(k) Order was issued to insure the safety of the miners until the accident investigation could be conducted. MSHA and West Virginia Office of Miners Health, Safety, and Training (WVMHST) personnel conducted a pre-investigation conference with mine officials and miners upon arrival at the Upper Big Branch Mine-South. Preliminary interviews with persons who had knowledge of the accident were conducted.

Representatives of MSHA, WVMHST, and the operator traveled to the underground accident scene, where a thorough investigation of physical conditions at the accident scene was conducted. Photographs, video recordings, relevant measurements were taken, a sketch was made of the accident scene, and electrical cables were thoroughly inspected. During the course of the investigation, damage to the No. 1 shuttle car cable was observed in the area of the accident. A 10-foot length of the No. 1 shuttle car cable containing the damaged area was removed to allow for a detailed examination by the MSHA Approval and Certification Center (A&CC). Wayne Colley, Electrical Engineer, and Donald Peiffer, Physical Scientist, examined the cable at the A&CC laboratory, Triadelphia, West Virginia, on August 18, 2003. Results of that examination are summarized in Appendix B.

The underground portion of the investigation included a complete and thorough inspection of all trailing cables on the section, from the visual disconnects to the individual machines. In addition to the violation that contributed to the accident, 15 non-contributory violations of mandatory standards were observed during inspection of these cables. Non-contributory enforcement actions were issued under a spot inspection, which was conducted concurrent to the accident investigation.

Formal interviews were conducted with persons who had knowledge of the accident on July 21, 29, and 31, 2003 in the conference room of the Performance Training Center located at Montcoal, West Virginia. Persons who were present and/or participated in the investigation are listed in Appendix A. The on-site physical portion of the investigation was completed on July 22, 2003, and the 103(k) Order was terminated.

DISCUSSION

The victim had made a temporary splice in the No. 3 shuttle car cable. However, the shuttle car would still not operate. He pulled cable off of the cable reel, routing the cable across the center of the shuttle car, to position the cable to make a permanent splice. Cuts in the separated leads of the No. 3 shuttle car cable suggested that the victim was attempting to find other areas of damage before starting the permanent splice. The portion of the cable extending from the section power center was lying near the No. 3 shuttle car. The outer jacket had been removed for approximately two feet, and the insulated leads had been separated. The portion of the cable extending from the No. 3 shuttle car was found in the victim's right hand and lying diagonally across his body. This end was cut so that all conductors were flush and an empty outer jacket extended approximately six inches past the end of the conductors.

Cable cutters were not found at the accident scene, which indicated that the victim was not severing the cable at the time of the accident. The victim was found lying on his back, approximately ten feet from the end of the No. 3 shuttle car. One point of contact with the electrical energy was specified in the autopsy report as an "electrocution burn on the right 2nd finger." Other points of contact could not be determined.

All cables receiving power from the section power center were inspected. As a result of this inspection, 13 citations and two orders were issued as non-contributing violations. Evidence indicated that inadequate electrical examinations were performed and recorded. One such example of this is that the No. 2 shuttle car cable contained an area damaged by heat for a distance of 150 feet. This hazardous condition was known by examiners, but not reported or corrected. The last recorded electrical examination for the No. 1 shuttle car cable was performed on July 13, 2003. This examination did not list any hazardous conditions and there was no evidence indicating that the damaged areas existed at the time of the examination.

Six electrical cables and a water line were routed along the coal rib in the No. 4 left crosscut (accident site) on the mine floor. Five of the electrical cables, including the damaged No. 1 shuttle car cable, were energized. The No. 3 shuttle car cable, which the victim was working on, was not energized. The No. 3 shuttle car trailing cable's visual disconnect was unplugged and locked out when the accident occurred. Tags indicating that equipment was locked out were not in place. The key on the victim's mining belt would not open the lock on the No. 3 shuttle car cable's visual disconnect, however, a key lying on the section power center would open the lock.

Inspection of the cables in No. 4 left crosscut revealed three damaged areas in the No. 1 shuttle car cable, each exposing an energized 480 VAC conductor, as detailed in appendix B. These damaged areas were discovered in a 32-½-inch span of the cable located one to four feet from the victim. The victim was performing electrical work on the damaged area of the No. 3 shuttle car cable when the accident occurred. The position in which he was found indicated that he fell on his back after receiving the electrical shock.

The electrical work was being performed in an area of wet and muddy conditions. The mine floor in this area was saturated with mud and two to three inches of standing water. The energized, electrical cables, including the damaged No. 1 shuttle car cable, were laying in the mud and water.

While in the process of examining the No. 3 shuttle car cable for damage, B. Kirk and R. Scurlock found a 2-inch thick rock, measuring 5-½ feet by 2-½ feet, lying on several trailing cables approximately 4 feet, 5 inches from the No. 3 shuttle car. They flipped the rock off of the cables and noticed a swollen area on the No. 3 shuttle car cable. However, they did not examine the other cables for possible damaged areas. This indicates that the miners did not consider the possible damaging affects of rock falling on cables other than that associated with known operational problems.

ROOT CAUSE ANALYSIS

A root cause analysis was performed using evidence obtained during the accident investigation. The following causal factors were identified:

Causal Factor: Electrical work was being performed in wet and muddy conditions and in close proximity to energized electrical cables.

Corrective Action: When a damaged portion of a cable is lying in the immediate vicinity of other energized cables, certified electricians should de-energize all of the cables or move the damaged portion of the cable a substantial distance from the energized cables, to a dry area if possible, before repairs are made.

Causal Factor: The No. 1 shuttle car cable was laying in mud and water and contained three undetected damaged areas; exposing two energized 480 VAC phase conductors. Stray electrical energy originated from these damaged areas.

Corrective Action: The examination of trailing cables covered with mud and water makes detection of damaged areas of the cable more difficult. Personnel performing such examinations should take appropriate measures to ensure that a complete and thorough examination is performed.

Causal Factor: The accident resulted from failure to protect cables from damage. Several damaged cables were discovered during the investigation. In addition to the damaged No. 1 shuttle car cable, other damaged equipment or inadequately spliced cables were found on the following equipment: No. 2 shuttle car, No. 3 shuttle car, No. 2 roof bolting machine, No. 1 continuous mining machine, and the coal feeder.

Corrective Action: The first line of defense in protecting personnel from the hazards of damaged power cables is to prevent the damage from occurring. Procedures should be implemented to protect the cables from potential sources of damage.

CONCLUSION

Rodney Scurlock was electrocuted when he came into contact with stray electrical energy released by the damaged trailing cable that was supplying power to the No. 1 shuttle car. The stray electrical current resulted from undetected damage to the No. 1 shuttle car cable which exposed two energized 480 VAC phase conductors. The root cause of the accident was mine management's failure to ensure that proper precautions were taken when conducting electrical work in wet and muddy conditions. Failure to adequately protect electrical cables from damage also contributed to the accident.

ENFORCEMENT ACTIONS

A 103(k) order, No. 4639865, was issued to ensure the safety of all persons of the No. 17 Headgate Section, MMU 009, until an investigation could be completed and the area deemed safe for entry.

A 104(a) citation, No. 7224607, was issued for a violation of 30 CFR 75.517, stating that the No. 2 AWG trailing cable, which supplies 480 (VAC) power to the No. 1 shuttle car, is not insulated adequately nor fully protected. There are four damaged areas in the cable causing two energized power conductors and one grounding conductor to be exposed. The damaged cable was located on the No. 17 Head Gate section, and the damaged areas were discovered in the crosscut between the No. 4 section power center entry and the No. 3 coal feeder entry. The section power center is located close to surveyor spad No. 16881. This violative condition is a contributing factor to the fatal accident that occurred on July 19, 2003.

Approved by:

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John M. Pyles
Acting District Manager

Appendix A

Listed below are persons furnishing information and/or present during the investigation:

Massey Coal Services/Performance Coal Company

Bill Potter	President
David Hardy	Attorney
George Nelson	Safety Director
Frank Foster	Safety Director, Massey Coal Services
Wendell Wills	Mine Foreman
* Richard Kim	Section Foreman
Darvin Spencer	Electrical Engineer
Paul Thompson	Chief Maintenance Supervisor
John Henline	Chief Electrician
Barry Hale	Massey Coal Services
Dean Jones	Block Superintendent
Keith Hainer	Massey Coal Services
John Rinehart	Consultant for Massey Coal Services
Darvin Spencer	Massey Coal Services

Upper Big Branch Mine–South Employees

* Randall Kirk	Shuttle Car Operator
* Joel Price	Utility Man
* Lawrence Deal	Scoop Operator
* Bobby Kirk	Shuttle Car Operator
* Bryan Scurlock	Continuous Miner Operator
* Earl Waddell	Roof Bolt Machine Operator
Joe Marcum	Continuous Miner Operator
Frank Ratcliff	Roof Bolt Machine Operator
Robert Adkins	General Inside Laborer
Robert Cox	Shuttle Car Operator
Kenneth Chapman	Roof Bolt Machine Operator

* Persons Interviewed

West Virginia Office of Miners Health, Safety, and Training

Terry Farley	Administrator
Gary Snyder	Supervisor
William Tucker	Supervisor
Clark Gillian	District Inspector
Robert Cozart	District Inspector
C. A. Phillips	Deputy Director
Tom Harmon	District Electrical Inspector
Bob Thornbury	District Electrical Inspector
Mike Rutledge	District Inspector

Mine Safety and Health Administration

Roger Richmond	Accident Investigator/Coal Mine Safety and Health Inspector
Marcus Smith	Coal Mine Safety and Health Electrical Engineer
Jim Beha	Accident Investigation Coordinator
Larry Cook	Coal Mine Safety and Health Electrical Supervisor
Terry Willis	Coal Mine Safety and Health Electrical Inspector
Fred Wills	Coal Mine Safety and Health Inspector
Wayne Colley	Electrical Engineer, A&CC
Donald Peiffer	Physical Scientist, A&CC

Scurlock Family

Rodney Scurlock	Father
Pamela Scurlock	Mother
Brian Scurlock	Brother
Stacie Scurlock Scott	Sister
Jared Scurlock Scott	Nephew
Doug Spencer	Attorney
Sandra Harrah	Attorney
Matthew Balmer	Forensic Electrical Engineer

Amercable

Mark Fuller	Senior Applications Engineer

Appendix B

EQUIPMENT RELATED
PHYSICAL FACTORS

DATE OF LABORATORY INVESTIGATION: August 18, 2003.

INVESTIGATORS:
Wayne Colley, Electrical Engineer, Electrical Safety Division
Donald Peiffer, Physical Scientist, Quality Assurance & Materials Testing Division.

PURPOSE OF INVESTIGATION:
1) To photograph and document the damaged areas of cable outer jacket, conductor insulation and conductors.
2) Identify which conductors are affected by the damage.
3) Assess the condition of the splice made in the cable for exposed phase conductors and approved (compatible) splice kit components.

EQUIPMENT:
AmerCable, Tiger Brand, flat #2 AWG, 4 conductor cable, 600/2000 volt, Type W, MSHA Acceptance # 184-41-MSHA, identified as "UBB-1". The cable was a 10' segment cut out of the cable connected from the section power center at Head Gate No. 17 to the No. 1 shuttle car. The measured major and minor diameters of the cable were approximately, 2-2/8 inches and 7/8 inches, respectively.

PHYSICAL FACTORS:

Trailing Cable Orientation

The subject trailing cable was marked "UBB-1." The UBB-1 mark was painted on the cable by MSHA investigators for identification. Areas of cable damage under examination are designated as DA1, DA2 and DA3 shown in Photographs # 1, # 2, # 3, and # 4. The section power center was located in the direction leading toward the damaged area DA2. The No. 3 shuttle car was located in the direction leading toward the damaged areas DA1 and DA3.

The distance between DA1 and DA2 was approximately 32-½ inches. In between DA1 and DA2 was an area covered with tape from a splice kit. The measured distance from DA1 to the nearest splice kit tape was approximately 10-7/8 inches. The distance measured from DA2 to the nearest splice kit tape was approximately 1-3/8 inches. The measured length of the splice kit components along the cable was approximately 20-½ inches.

Damaged Area DA1

The damaged area designated as DA1 is a teardrop-shaped hole in the cable jacket, located on the flat surface of the cable. The DA1 hole was located approximately one inch from the edge of the cable containing the black insulated conductor. The location of DA1 was directly over the white insulated conductor in the cable. The length and width of DA1 was measured to be approximately 13/32 inch and 7/32 inch, respectively. The narrow end of the teardrop shape pointed toward the power center end of the trailing cable, and the rounded end of the teardrop shape pointed toward the shuttle car end of the cable.

The white conductor insulation at DA1 was not visible from the exterior of the cable jacket and there were no visible conductors protruding through the cable jacket, as shown in Photograph #5.

The hole at DA1 was partially filled with charred material. A particle of the charred material in the hole measured approximately 2/32 inch by 2/32 inch by 2/32 inch. A fine strand of white insulation approximately 1/64 inch in diameter anchored the particle of material to the white insulation. The walls of the hole through the cable jacket were charred. The thickness of the cable jacket was approximately 0.119 inch, near damaged area DA1. The cable jacket thickness for a cable of this type, according to International Cable Engineers Association (ICEA) Standard No. WC-58-1991, S-75-381, is 0.95 inch. The measured depth of the hole into the cable jacket at DA1 was approximately 5/32 inch (0.156 inch).

The white conductor insulation directly beneath the hole in the cable jacket at DA1 contained a charred oval hole that measured 12/64 inch by 8/64 inch. The hole was partially filled with charred material. Exposed strands of the multi-stranded #2 AWG conductor were visible through the damaged white conductor insulation. Stereoscopic Photograph #6 shows the exposed conductor strands.

The electrical continuity between the exposed conductor strands and an end of the insulated white conductor was established. The electrical resistance between a single strand of 10 mil tungsten filament inserted into the charred material at DA1 and the end of the white insulated #2 AWG conductor was measured to establish continuity. The resistance measured was 0.4 ohms. The ohmmeter's closed circuit continuity resistance was also 0.4 ohms.

The strands of conductor directly beneath the hole in the white insulation at DA1 were electrically undamaged but discolored with a residue of charred material. Stereoscopic Photograph #7 shows the discolored conductor strands.

Damaged Area DA3

The damaged area designated as DA3 is a crescent-shaped indentation in the cable jacket located on the flat surface of the cable. The DA3 indentation was located approximately 11/16 inch to 15/16 inch from the edge of the cable containing the black insulated conductor. The crescent shape of DA3 was angled away from the teardrop shape of DA1 and was located approximately 1/8 inch from the edge of the DA1 hole. The location of the DA3 crescent-shaped damage was directly over the white insulated conductor in the cable. The length and width of DA3 was measured to be approximately 28/64 inch and 2/64 inch, respectively. The crescent-shaped indentation was a hole that penetrated the cable jacket and the white conductor insulation. The white conductor insulation was not visible from the exterior of the cable jacket at DA3. No conductors were protruding through the cable jacket at DA3, as shown in Photograph #8.

The white conductor insulation directly beneath the indentation in the cable jacket at DA3 contained a crescent-shaped hole that measured approximately 24/64 inch by 1/64 inch. The hole was partially plugged with a rigid, non-conductive, granular chip of debris that measured approximately 13/64 inch by 8/64 inch by 3/64 inch. After removal of the rigid chip of debris from the hole in the insulation, other granular particles partially filled the hole. No conductors were protruding through the white insulation at DA3. The hole through the white insulation at DA3 extended to the conductor. Particles of granular debris had migrated through the hole and had accumulated under the white conductor insulation. Exposed strands of conductor were not visible through the damaged white conductor insulation.

Six conductor strands on the outer layer of the multi-stranded #2 AWG conductor, directly beneath the crescent-shaped hole in the insulation, were severed, as shown in Stereoscopic Photograph #9. The severed strands of conductor are indicative of a mechanical cutting due to shear forces, as opposed to an elongation rupture due to tension forces.

The electrical continuity between the conductor strands and an end of the insulated white conductor was established. The electrical resistance between a single strand of 10 mil tungsten filament inserted into the crescent-shaped hole and the end of the white insulated #2 AWG conductor was measured, to establish continuity. The resistance measured was 0.4 ohms. The ohmmeter's closed circuit continuity resistance measurement was also 0.4 ohms.

Damaged Area DA2

The damaged area designated as DA2 consisted of two cuts through the cable jacket and black conductor insulation at the edge of the cable. The cuts were perpendicular to the length of the cable. One cut was located where the rounded cable edge transitions into the flat side of the cable. The other cut was located where the rounded cable edge transitions into the opposite flat side of the cable. The two cuts were oriented approximately 170^{o} from each another.

One of the cuts measured approximately 24/32 inch in length and the other cut measured approximately 23/32 inch in length. With the cable laid straight, the width of the cuts measured approximately 4/32 inch and 1/32 inch, as shown in Photograph #10. When the cable was forced into an arced position to create tension in the black insulated conductor, both cuts could be opened to a width greater than ¼ inch. On the extreme edge of the cable, a short section of uncut cable jacket existed between the two cuts. This section of uncut cable jacket measured approximately 7/32 inch.

In both cuts at DA2, strands of the black insulated conductor were exposed and visible from the exterior of the cable jacket. Debris from the mine was not found in either cut at DA2. The severed strands of conductor in both cuts at DA2 are shown in Stereoscopic Photograph #11. The severed strands of the conductor are indicative of mechanical cutting due to shear forces, as opposed to an elongation rupture due to tension forces.

The electrical continuity between the conductor strands and an end of the insulated black conductor was established. The electrical resistance was measured by touching the probes of an ohmmeter to the accessible conductors at DA2 and the end of the black insulated #2 AWG conductor to establish continuity. The resistance measured was 0.4 ohms. The ohmmeter's closed circuit continuity resistance measurement was also 0.4 ohms.

Cable Splice Kit and Cable Repair

The tape splice kit components were assembled on the cable between the damaged areas DA1/DA3 and DA2 as described above. The splice kit's PVC tape was marked with MSHA Approval No. 153-MSHA and the Jacket Wrap tape was marked with the MSHA Approval No. 7K-SK-153082-1-MSHA. Both approval numbers identified Plymouth Rubber Company as the manufacturer of the Tape Splice Kit. The tape splice kit, as approved, is rated for 600V/2KV up to #2 AWG cables.

Removal of the splice kit tape revealed that the conductors were not spliced, which indicated that the tape splice kit was used for a cable repair. The insulation on the four conductors was intact, but damaged in one localized area of the cable. The white and black conductor insulations each contained cuts approximately ¾ inch in length, in the center of the insulation running along the length of the cable. The cuts in the white and black conductors' insulation were to the depth of the conductors. Conductor strands were protruding through the cut in the black insulation. The conductors were visible through the white insulation. The red conductor insulation contained a cut across the width of the insulation that penetrated to the conductor. The green conductor insulation was cut, but the cut did not extend through to the conductor beneath. The insulation cuts in all four insulated conductors were wrapped in at least five layers of the PVC tape marked with MSHA Approval No. 153-MSHA. No conductor strands were visible when the PVC tape was covering the cut areas as shown in Photograph #12. The "PlyTuff" PVC tape, according to a Plymouth Rubber Specification sheet, has a dielectric strength of 7000 volt per layer, when tested according to ASTM D-1000.

The PVC tape was used to bind the insulated conductors together. Many wraps of PVC tape were used to fill the space to the level of the original cable jacket. The splice kit's Jacket Wrap was used in the cable repair. The Jacket Wrap overlapped the original cable jacket at the beginning and end of the cable repair by approximately three inches, and a layer of the PVC tape was applied over both the beginning and end of the Jacket Wrap, consistent with the Plymouth Rubber splice kit assembly instructions. The Jacket Wrap securely adhered to the original cable jacket and adhesive residue was evident on both the original cable jacket and the Jacket wrap.

SUMMARY FINDINGS:

1. The cable damage area designated as DA1 exhibited charring of the cable jacket and conductor insulation directly above the conductor due to heat.

2. The cable damage area designated as DA2 exhibited a severed cable jacket, severed black insulation and severed conductor strands due to external shear forces applied to the cable.

3. The cable damage area designated as DA3 exhibited a punctured cable jacket, punctured white insulation and severed conductor strands due to external shear forces applied to the cable. A chip of rigid, non-metallic, granular material was embedded in the white insulation and granular debris was found between the white insulation and the conductor.

4. Electrical continuity was established between the accessible conductors in the damaged areas designated as DA1, DA2, and DA3 and the end of the conductor segment under examination.

5. The splice kit components were used for a cable repair. The components were compatible components manufactured as an MSHA approved splice kit. The assembly of the splice kit provided an adequate degree of insulation at the repaired section of cable.