

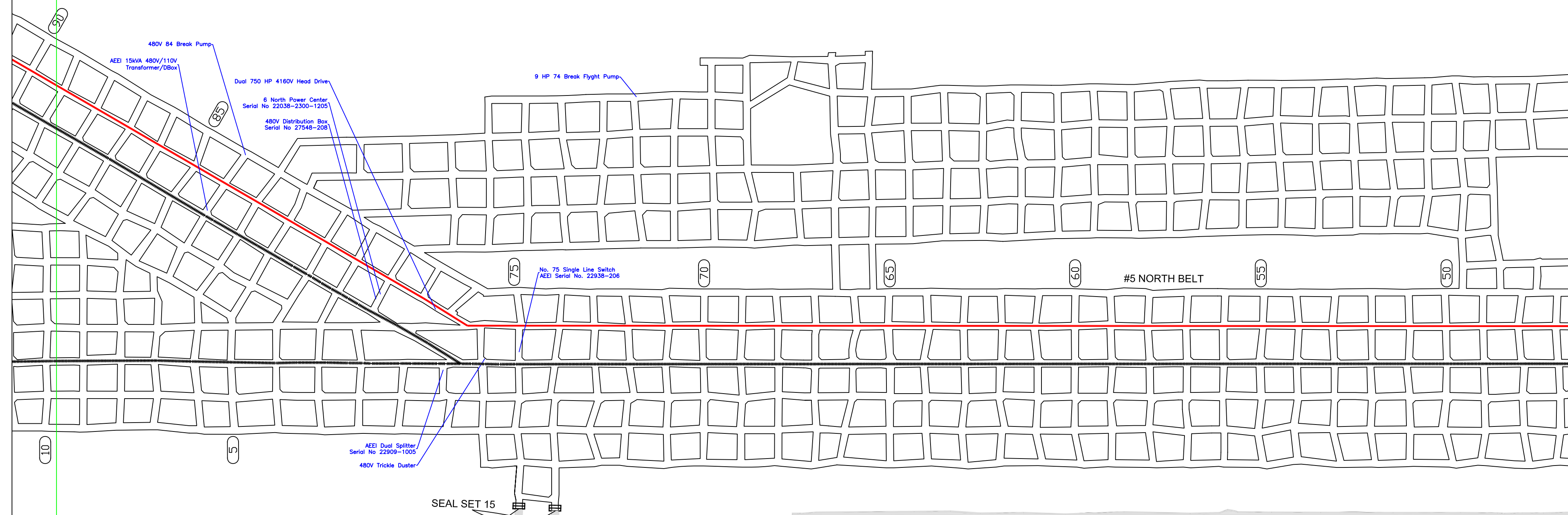
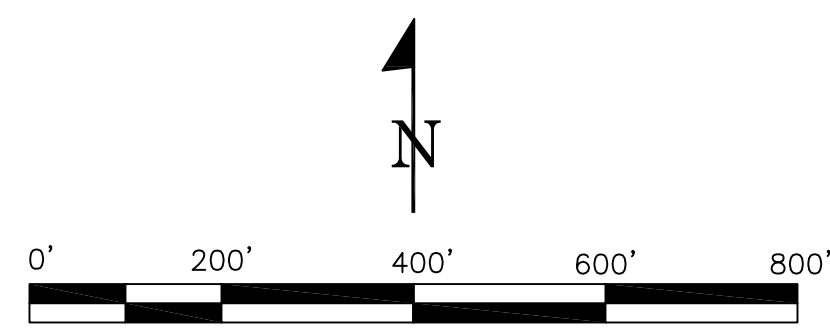
— CONVEYOR BELT
 TRACK

 LEGEND
 Scale 1"=200'

MAPPING NOTES	
MAPPING OF SELECTED ELECTRICAL EQUIPMENT.	

FIGURE T-1
 Map of Electrical System, Equipment,
 and Associated Items
 Upper Big Branch Mine – South
 Performance Coal Company
 MSHA ID No. 46-08436

MATCH TO MAP #1



	CONVEYOR BELT
	TRACK
LEGEND Scale 1"=200'	

MAPPING NOTES

MAPPING OF SELECTED ELECTRICAL EQUIPMENT.

FIGURE T-2
Map of Electrical System, Equipment,
and Associated Items
Upper Big Branch Mine – South
Performance Coal Company
MSHA ID No. 46-08436

Appendix T

Elimination of Electrical Ignition Sources

Lightning

Lightning strikes were eliminated as a possible ignition source of the explosion event. Vaisala's National Lightning Detection Network showed no lightning strikes within a ten mile radius of the mine site between 10:09:42 a.m. and 7:07:02 p.m. (See Vaisala Report 258028 in Appendix V). At the time of the explosion, there was no evidence of power outages related to storms in the area.

Welding and Cutting

There was no evidence of welding or cutting being performed at the time of the explosion, and no cutting equipment was found in the area of the longwall face. However, two electric welders were located near the longwall face in the headgate area. One welder (designated as "DC PTO") was installed inside the third bay of the 480 Vac permissible headgate controller enclosure. This welder was interlocked with the longwall control circuitry, such that it could not be energized while the longwall 4,160 Vac power circuits were energized. Thus, the shearer and this welder could not be energized at the same time. In order to energize the welder through its circuit breaker "CB1," the "DC PTO" switch handle on the outside of the headgate controller must be put in the "DC PTO" position. This switch was found in the "Normal" position, indicating the CB1 circuit breaker and the welder were de-energized. The two individual welding leads, approximately 15 feet long, exited the controller enclosure and were not connected to any other leads.

The other electric welder, which normally hung on the monorail outby the headgate controller, was a portable unit that was found just inby the headgate controller enclosure. The power switch for this welder was found in the "off" position. The cable coupler to the distribution power box was found disconnected, indicating this welder was de-energized at the time of the explosion. No welding leads were connected to this welder when it was found. The only welding leads found in the area of the longwall face were in a flat cable, which was routed from the area of the headgate controller across the longwall face in the face conveyor's (panline) cable handling tray. The end of this flat cable near the headgate enclosure had two male welding connectors, for the face welding leads, and were found disconnected and locked with a chain and padlock in the cable handling tray near the headgate controller. The keys for this padlock were normally kept on top of the headgate controller, and were found on the ground under the controller.

From witness testimony, the last known welding operations in the longwall area was on the midnight maintenance shift prior to the accident. At that time, a welder was used to add additional flights to the face conveyor, and to replace the

shearer head drum cowl blade. Both of these welding tasks were conducted on the headgate side of the longwall face.

Shearer Electrical Components

The Joy Mining Machinery, Model 07LS1A shearer, serial number LSW525C, MSHA Shearer Evaluation No. SE-18630-0, was located at the tailgate end of the longwall. The electrical components on the shearer included explosion-proof enclosures (motors, main controller enclosure, shearer power cable connection enclosure, and solenoid valve enclosure), a methane monitoring system with warning light enclosure, various intrinsically safe circuits, components and sensors, and all associated cables. Electrical cables were examined and no damaged areas were found.

The electrical control components of the shearer were housed in the main controller enclosure, MSHA Certification No. X/P-4161-0. The controller consisted of three bays; access to this single enclosure was provided by three separate covers for the left, middle and right controller bays. There was a small lens on the left cover, and a larger window on the middle cover.

All accessible flame-arresting path surfaces of the permissible explosion-proof enclosures were measured on the shearer, and no excessive openings were found. All unused lead entrances were plugged. A visual inspection of the windows and lenses showed no visible cracking or crazing (network of fine cracks). All fasteners and retainers were in place, and all fasteners were tight.

On the controller enclosure cover, all selector switches and circuit breaker handles were in their normal operating positions. The shearer e-stop mushroom switch, located on the main controller enclosure, was wired properly and functional, and was not activated.

Wiring and components inside the explosion-proof enclosures were examined and checked against the electrical approval documentation, and no deficiencies that would affect shearer operation were found. There was no evidence of abnormal arcing, sparking, or heating of components. No unusual odors were noted, and no abnormal residue was noted on any of the flame-arresting path surfaces.

The JNA event log recorded no protective circuit trip functions or alarms in the hours before the explosion. The last protective device trip was for an overload on the right-hand cutter motor, approximately 7 hours and 10 minutes before the explosion, but evidence indicates that this was not a prolonged shutdown of the machine.

Other mechanical features, including the ranging arm pins and cutter torque shafts, were inspected. Evidence and testimony indicated that the tail ranging

arm “B-Lock” came out when the shearer was at the headgate. No electrical or mechanical deficiencies were found associated with the shearer.

Shearer Remote Control Transmitter

Shearer functions were controlled by two operators with handheld radio remote transmitters (Appendix U-1), designated by the JNA control system as left- and right-hand stations. The left transmitter and receiver operated at a frequency of 458.525 MHz, while the right transmitter and receiver operated at a frequency of 472.100 MHz. The station selector switch on the front panel of the shearer’s main controller was set to “both,” for the JNA control system to receive data from both remote transmitters. Therefore, both remotes must be functioning for the machine to be operational.

The right-hand transmitter, identified by its frequency of 472.100 MHz, was a Matric Limited, Model TX1, Remote Control Transmitter, MSHA Approval No. 9B-220-0, and was found at shield 100. This transmitter was taken to the manufacturer for further examination and testing. The transmitter case and internal components had physical damage consistent with external forces. When attempting to turn the transmitter on, a “stuck button” error occurred. The microcontroller socket had physical damage, and after being replaced by a Matric Limited technician, the transmitter was used to perform functional testing for the shearers’ JNA0 and JNA1 units, without the need for its internal battery to be recharged. Testing found each switch on the remote transmitter to be in operating order. An inspection at A&CC did not identify signs of heating, arcing, or sparking inside or outside the remote transmitter. Evaluation and testing showed that the maximum voltage and current available on any of the external pins of the remote transmitter was intrinsically safe. Therefore, MSHA concluded that this transmitter was not the ignition source.

The left-hand remote control transmitter was never found, but there was no indication that it was not functioning properly. The last record on the JNA event log prior to the explosion showed that the right-hand remote (Exhibit No. PE-0238) caused the shearer to stop.

Automatic Chain Tensioning System

A Joy Automatic Chain Tensioning System (ACTS) was installed at the tailgate area of the face to automatically control the face conveyor chain tension. The ACTS components included: an explosion-proof controller enclosure, a connection enclosure for the intrinsically safe circuits (referred to as a “marshalling box”), and various intrinsically safe transducers, sensors, a display beacon, and solenoids. This intrinsically safe system was accepted under MSHA Evaluation No. IA-18031-0.

All accessible flame-arresting path surfaces of the ACTS controller enclosure were measured, and no excessive openings were found. All unused lead entrances were plugged. An ACTS “PanelView” window display, located on the

front enclosure cover, showed no visible cracking or crazing. All window fasteners and retainers were in place, and all fasteners were tight. All the intrinsically safe components were inspected, and no improper connections or damaged components were observed. None of the fuses in the intrinsically safe barriers, which protect the intrinsically safe circuits, measured “open.” There was no evidence of abnormal arcing, sparking, or heating of components inside the controller enclosure and the marshalling box, and no unusual odors were noted. No abnormal residue was noted on any of the flame-arresting path surfaces.

A communication cable linked the ACTS programmable logic controller (PLC), located in the tailgate controller, to the PLC located in the headgate enclosure. This cable entered both enclosures, but the conductors were not connected to the PLC components in either. The 120 Vac power supply from the headgate was still connected inside both the headgate and the ACTS enclosure, although without communication to the headgate PLC, the ACTS could not operate in automatic mode. The selector switch control was found in the “Auto” position, but longwall employees stated that the ACTS was always operated by manual hand valves, without electrical controls.

The PanelView connected to the PLC was designed to record the last 100 alarms of the ACTS programmable control system. When the alarm history was viewed, there were 100 identical alarms of a tailgate speed sensor fault, recorded within one second of each other, on September 11, 2009. Although the processor clock was off from “real time” by approximately one hour, it was concluded that the ACTS had not been used for many months prior to the accident.

Tail Conveyor Drive Motor

All accessible flame-arresting path surfaces of the enclosure, including the motor connection box, were measured, and no excessive openings were found. All unused lead entrances were plugged.

Wiring and components inside the connection box enclosure were examined and checked against the longwall electrical approval documentation; no deficiencies were found. There was no evidence of abnormal arcing, sparking, or heating of components. No unusual odors were noted, and no abnormal residue was noted on any of the flame-arresting path surfaces. A Fluke 1520 megohmmeter was used to verify that no degradation of the motor insulation had occurred.

Electrical Cables Along the Longwall Face

Electrical cables along the longwall face were located either in the cable handling system of the panline or hung along the longwall shields. The cable handling system consisted of four vertically-stacked sections of a cable trough, accessible from the side of the panline facing the shields. Another cable tray on top of the panline allowed the shearer electrical and water hoses, in its “bretby” handling system, to follow the shearer as it progressed across the face. At shield 88, the

shearer power cable and water hose exited the second section of the cable trough, and entered the cable tray in its “bretby” handling system.

The top section of the trough contained seven electrical cables: 1) flat electrical cable (#2/0 AWG, type W) that contained the welding conductors; 2) blue armored cable for the methane monitor sensor located at the tailgate; 3) yellow communication cable for the ACTS, which was disconnected at both ends, but entered the two enclosures; 4) #6 AWG, 3 conductor, type G-GC cable (previous pump cable disconnected at both ends), which was routed from the headgate area but ended at Shield 86; 5) #6 AWG, 3 conductor, type G-GC cable, (previous pump cable disconnected at both ends), which was routed from the headgate to the tailgate, but was severed, with the ends four feet apart, at shield 115; 6) #14 AWG, 3 conductor, type Remote Control and Drill Cord cable, which was disconnected at both ends, and; 7) #14 AWG, 4 conductor, type Remote Control and Drill Cord cable, which provided 120 Vac to the ACTS controller enclosure. Progressing downward, the second section of the cable trough contained two 4,160 Vac power cables. One was a blue power cable for the tailgate conveyor drive motor. The other was a yellow power cable for the shearer. The third section of the cable trough contained a 1-1/2” hydraulic hose for the shields, 1” hose for the tail conveyor motor drive cooling water, and a hose to the tail drive water coupling. The fourth (bottom) section of the cable trough contained a water hose that supplied the shearer, and a return hydraulic hose for the shield hydraulic system.

Examination of the shearer power cable where it exited the second section of the cable trough at mid-face, and where it entered the shearer, indicated that the bretby handling system containing the hose and cable had sufficient slack. The examination revealed no deficiencies in any cables in the panline cable trough. The shearer cable had been replaced from mid-face to the shearer in mid-March; splices examined at shields 45 and 87 were constructed adequately. Two repairs to the tail face conveyor motor cable, at shields 91 and 105, were found to be constructed adequately.

Insulation Testing of Power Cables (Panline)

The shearer and tail conveyor motor cables were type SHD-GC, with a shield around each of the power conductors, and each conductor shield in contact with the ground conductor. The insulation of the power conductors in both the shearer and tail conveyor motor cables were tested, using an Extech Digital High Voltage Insulation Tester, Model 380395, set at 5,000 volts. For both cables, the tester was placed sequentially between each power conductor and the ground conductor at the respective disconnect enclosures. This tested the insulation of each of the cables’ power conductors for their entire length. The testing showed no degradation in the insulation of any of the power conductors in either cable.

Lighting System Components

The lighting system power cable was a #6 AWG, 3-conductor, type G-GC cable, which provided 120 Vac three-phase power to the lighting power supply, explosion-proof enclosures. The type G-GC cable consisted of three-phase power conductors, an insulated ground-check "pilot" conductor, and two ground conductors. A lighting power supply enclosure was located at shields 3, 23, 43, 63, 83, 103, 123, 143, 163, and 173, each of which housed two intrinsically safe power supplies, accepted under MSHA Evaluation No. IA-13827-0. Each intrinsically safe power supply provided a nominal 12 volts direct current (Vdc) output to power five KH Controls Inc., Model LX1 luminaires (light assembly), located on every other shield. The luminaires were accepted under MSHA Evaluation No. IA-16453-0 and Certification No. X/P-4036-0.

At shield 171, the lighting power cable was damaged, exhibiting a severed ground-check conductor and insulation damage on the black and white phase conductors. The lighting cable is normally zip-tied to the shield water line away from the chock interface unit (CIU). When inspected, the damaged area of the cable was laying on the damaged area of the CIU. The CIU had a bent mounting bracket, deformed enclosure, damaged internal circuit boards, and a damaged face plate. Upon initial inspection, the damage to the lighting cable was determined to have been caused by the same explosive forces, traveling from the tailgate toward the headgate, which damaged the CIU. The damaged section of the cable was recovered and sent to the A&CC for analysis...

The lighting system power cable was protected by an SMC Electrical Products, Inc., Model C54-006, ground wire monitor in the headgate controller. (See Appendix - U-11) This ground wire monitor is designed to trip the lighting circuit breaker when an open or a short in the pilot wire occurs, thus de-energizing the entire longwall lighting circuit. There were no reports of the longwall lights not working and no evidence of maintenance being performed on the lighting circuit. The ground wire monitor circuitry and the pilot wire terminating diode were removed and tested at the A&CC to determine if sufficient energy existed in the pilot wire conductor to ignite an 8.3% methane-in-air mixture. Tests were conducted with and without simulated value of cable inductance. No testing ignited the methane-air mixture. The following protective circuit components were removed from the enclosure; lighting current transformer, lighting relay, ground fault relay, ground wire monitor, and lighting circuit breaker. A&CC performed functional testing of the protective circuitry components and no deficiencies were found.

The lighting power supply explosion-proof enclosures located at shields 163 and 173 were examined. All accessible flame-arresting path surfaces of these enclosures were measured, and no excessive openings were found. There was no evidence of abnormal arcing, sparking, or heating of components in the enclosures (Appendix U-2). No unusual odors were detected, and no abnormal residue was noted on any of the flame-arresting path surfaces.

Various lighting system components were retrieved for further examination and testing at A&CC. The components retrieved were:

Six KH Controls Model ISS1 – 13.0 – 8.10, IA-13827-0 Power Supplies

- Exhibit No. PE-0246-a*, S/N 1034, recovered from shield 173 (written on the front of the supply)
- Exhibit No. PE-0246-b*, S/N 1832, recovered from shield 173 (written on the front of the supply)
- Exhibit No. PE-0247-a**, S/N 2536, recovered from shield 163 (written on the front of the supply)
- Exhibit No. PE-0247-b**, S/N 995, recovered from shield 163 (written on the front of the supply)
- Exhibit No. PE-0248-a***, S/N 2185, recovered from shield 3 (written on the back of the supply)
- Exhibit No. PE-0248-b***, S/N 1295, recovered from shield 3 (written on the back of the supply)

**A case with Exhibit No. PE-0246 was received and contained two power supplies. These two power supplies were assigned the newly generated Exhibit Nos.*

PE-0246-a and PE-0246-b when the case was opened.

***A case with Exhibit No. PE-0247 was received and contained two power supplies. These two power supplies were assigned the newly generated Exhibit Nos.*

PE-0247-a and PE-0247-b when the case was opened.

**** A case with Exhibit No. PE-0248 was received and contained two power supplies. These two power supplies were assigned the newly generated Exhibit Nos. PE-0248-a and PE-0248-b when the case was opened.*

Thirteen KH Controls Model LX1 Luminaire, IA-16453-0, X/P-4036-0

- Exhibit No. PE-0254-a*, S/N 10774, recovered from shield 167
- Exhibit No. PE-0254-b*, S/N unknown (missing approval plate), recovered from shield 124
- Exhibit No. PE-0258-a**, S/N 12483, recovered from the area of shield 62
- Exhibit No. PE-0258-b**, S/N 7791, recovered from the area of shield 66
- Exhibit No. PE-0258-c**, S/N 6712, recovered from the area of shield 89
- Exhibit No. PE-0258-d**, S/N 7353, recovered from the area of shield 173
- Exhibit No. PE-0258-e**, S/N 12535, recovered from the area of shield 64
- Exhibit No. PE-0258-f**, S/N 10437, recovered from the area of shield 139
- Exhibit No. PE-0474, S/N unknown (missing approval plate), recovered from the area of Survey Spad 22567

- Exhibit No. PE-0475, S/N unknown (missing approval plate), recovered from the area of the cross cut adjacent to Survey Spad 22567
- Exhibit No. PE-0476, S/N unknown (missing approval plate), recovered from the area of the tailgate entry at the shearer
- Exhibit No. PE-0477, S/N unknown (missing approval plate), recovered from the area of Shield 175
- Exhibit No. PE-0478, S/N unknown (missing approval plate), recovered from the area of Shield 172

The recovered from location information was obtained from the shield number written on the light, and/or the evidence tag.

**A cardboard box with Exhibit No. PE-0254 was received and contained two KH Controls Model LX1 Luminaire exhibits. These two exhibits were assigned the newly generated Exhibit Nos. PE-0254-a, and PE-0254-b when the box was opened.*

**A cardboard box with Exhibit No. PE-0258 was received and contained six KH Controls Model LX1 Luminaire exhibits. These six exhibits were assigned the newly generated Exhibit Nos. PE-0258-a, PE-0258-b, PE-0258-c, PE-0258-d, PE-0258-e, and PE-0258-f when the box was opened.*

IS Lighting Cable with connectors- Exhibit No. PE-0324, 91 feet of 14AWG, 3/C SOW, recovered from shield 143 to shield 152

Based on technical analysis and inspection of the underground installation, no evidence was found that the lighting system was an electrical ignition source. All lighting power supplies were functional, tested within approved safety settings, and exhibited no sign of internal tampering or damage significant enough to affect the operation. Each recovered luminaire showed effects of explosion-related heat and/or impact damage, which was consistent with all observed luminaires on the face. Luminaires from shields 124 and 66 (Exhibit Nos. PE-0254-b and PE-0258-b) were found in a condition indicating they were not maintained in permissible condition prior to the explosion, but these did not contribute to the explosion. Exhibit No. PE-0254-b had electrical tape wrapped around a significant crack in the connection where the polycarbonate tube, which contained dust and dirt, threaded into the maintenance sleeve. Exhibit No. PE-0258-b had a missing end cap, and the polycarbonate tube, which had electrical tape wrapped around it, was broken off at the threaded end. A crack would defeat the explosion-proof integrity of the assembly. However, these exhibits were not located where the ignition occurred. None of the other damaged luminaires taken as evidence or examined underground had electrical tape covering cracks.

Electrohydraulic Shield System

The Joy MS40 electrohydraulic system, consisting of a Master Supply Unit (MSU) and a Support Control Centre (SCC) at the headgate, controlled the movement of the shields. The intrinsically safe components were accepted under MSHA Evaluation No. IA-408-10. The MSU and SCC were powered by their own intrinsically safe power supplies, (KH Controls, Inc. Model ISSA-13.0-6.8-AL1, accepted under MSHA Evaluation No. IA-13827-0), installed in explosion-proof enclosures, MSHA Certification No. X/P-3929-0. A CIU control enclosure was located on each of the 176 shields along the longwall face. The MSU supplied intrinsically safe, nominal 12 Vdc power for the CIU enclosures via a “roadway” armored cable. On each shield, the CIU controlled six hydraulic solenoid valves, which initiated movement of the shields, and connected to a pressure and a distance transducer.

A dump valve kit, consisting of a solenoid and pressure switch, was designed to release the main system hydraulic pressure to the return line, if any e-stop button was depressed on any face CIU or the MSU, or if the system hydraulic pressure was inadequate. The MSU provided power for the dump valve, and provided monitoring for the e-stop system to protect against solenoid valve short circuit or low voltage conditions.

CIU enclosures were mounted on each shield. Two spare CIU enclosures, missing faceplates and internal printed circuit boards, were found at shields 27 and 77. The CIU enclosures at shields 1, 2, and 6 were damaged, and had several circuit boards missing. CIU circuit boards found in the tailgate area would likely correspond either to CIU enclosures at shields 1, 2, or 6, or from the spare CIU enclosures.

Various components were retrieved for further examination and testing at A&CC, including:

- CIU enclosures from shields 62, 64, 169, 170, 171, 172, 173, 174, 175, and 176. CIU enclosures from shields 169 through 176 were retrieved because they exhibited signs of external heat or physical damage. CIU enclosures from shields 62 and 64 were retrieved because of visible heat damage on the infrared receiver lens.
- The roadway cable between CIU enclosures at shields 169 and 170, which was found disconnected at the headgate side of the CIU enclosure at shield 170.
- The KH Controls, Inc. Model ISSA-13.0-6.8-AL1 power supply for the MSU unit, accepted under MSHA Evaluation No. IA-13827-0.
- The MSU unit.

- The SCC, which was taken to the manufacturer's facility, where engineers and technicians familiar with this equipment attempted to view and recover the event and fault logs. Damage to the SCC and its internal circuitry was too extensive to allow data recovery.
- Six hydraulic solenoid valves recovered from shield 170, and two hydraulic solenoid valves recovered from shield 145.

The intrinsic safety analysis conducted at A&CC examined:

- Output of the intrinsically safe MSU power supply.
- Inductive energy stored in the roadway cable.
- Energy stored in the hydraulic solenoid valves of the shields.
- Energy stored in the total system capacitance of the connected system.
- The possibility of thermal ignition from small-gauge wire strands.

The analysis indicated that no signs of electrical heating, arcing, or sparking were observed on any of the components in the CIU enclosures, solenoids, power supplies, or associated cables. Based on the technical analysis and inspection of the underground installation, the electro-hydraulic shield control system is not considered an electrical ignition source (Appendix U-3).

Control Communication System

The Control longwall face communication/conveyor lock-out system, MSHA Approval No. 9B-71-2, consisted of Longwall Loudmouth Model LM115 phones positioned at the headgate area and typically, every eighth shield. Each phone is powered by its own 12-volt battery. An 18 AWG, 4 conductor, type SOOW cable connected each of the phone enclosures, and was protected by hose conduit up to the in-line connector near the phone. The system was linked to the startup sequence of the longwall face conveyor, through a Model LM1574A start up alarm control receiver, so that an alarm was given over the speakers when the conveyor was about to start. Each phone enclosure was provided with a lockout control capability to prevent the face conveyor from operating.

Investigators noted that some phones were not in their original positions (i.e. mounted on shields). The phone at shield 173, the last in the system, was missing, as was the phone at shield 117. At least four phones were missing on the headgate side of the longwall. Phone circuit boards and enclosure pieces were found at several different locations across the face, as well as in the No. 7 tailgate entry. Electrical investigators that have traveled the face area did not observe any components or cables that showed signs of being an electrical ignition source.

Various system components were retrieved for further examination and testing at A&CC . Worst case tests for intrinsic safety were performed on the power supply, start-up alarm/phone (located near the headgate enclosure), and an equivalent end-of-line termination unit, which was used because the actual termination unit was not located prior to the test, but found later at shield 110 approximately 360 feet from shield 173. This unit was also tested. All tests were performed with a worst case methane-in-air mixture of 8.3%, and indicated that a page transmitted from the headgate enclosure area would not ignite a methane-in-air mixture at the tailgate. A conveyor lockout switch passed the same test.

Five Loudmouth phones and the start-up alarm/phone (from the headgate) were tested at A&CC for functionality. The phone from shield 165 was spark-ignition tested, and did not ignite an 8.3% methane-in-air mixture. Three face phones (shields 85, 109, and 165) and the headgate start-up alarm/phone were fully functional (communication and lock-out functions). Two phones obtained near the crusher and belt conveyor tailpiece had functioning conveyor lock-out switches, but had slight communication issues, in that the tailpiece phone could receive but not transmit, whereas the stageloader/crusher phone could receive, but transmitted a low, audible signal. Two terminating devices and additional Loudmouth phone components found across the longwall face were also sent to AC&C for further examination.

Witness testimony did not indicate any issues with the longwall communication/conveyor lock-out system. The phone at shield 173 has not been found. An electrician that worked the midnight shift prior to the explosion stated that it was working properly. Pieces of telephone components were found around the longwall tailgate area that was possibly from the 173 phone. None of these components showed any signs of arcing and sparking (Appendix U-4).

Multi-Gas Detector

A MSA Solaris multi-gas detector (Exhibit No. B-15-B), carried by Richard Lane, Longwall Section Foreman, was retrieved from mid-face for examination and testing at A&CC. Testing determined that it was in working order. Downloaded data indicated that the device was energized at the time of the explosion and continued operating for several hours thereafter. During thermal ignition testing, the detector did not cause an ignition of a 7.75% methane-in-air mixture when energized (Appendix U-5).

Personal Electrical Items

Various electrical items were removed from six victims found and the longwall face.

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Tracking Tags

Pyott-Boone Model 1980 tracking tag transmitters, MSHA Approval No. 23-A080004-0, were used by the miners. The following tracking tags belonged to victims found on the longwall face:

- Tracking Tag ID 570, belonging to Chris Bell, Exhibit No. PE-0483;
- Tracking Tag ID 584, belonging to Joel Price, Exhibit No. PE-0239;
- Tracking Tag ID 564, belonging to Rick Lane, Exhibit No. B-15-D;
- Tracking Tag ID 547, belonging to Gary Quarles, Exhibit No. B-11-A;
- Tracking Tag ID 540, belonging to Dillard Persinger, Exhibit No. B-10-A; and,
- Tracking Tag ID 546, belonging to Grover Skeens, Exhibit No. B-9-A.

Exhibits PE-0483 and PE-0239 were found near shields 109 and 94-95, respectively. Exhibits B-9-A, B-10-A, B-11-A, and B-15-D were brought out of the mine in the days immediately after the accident. Twenty-four tracking tags, including the six already noted, were retrieved for further examination and testing at A&CC. The examination of the tags indicated that the tracking tag enclosures were not exposed to heat or fire, electrical energy within the tracking tags was not exposed to the mine atmosphere, and that none of the tracking tags represented a thermal or a spark ignition source (Appendix U-6).

Cap Lamps

An assortment of intact cap lamps and components were retrieved. Of these, thirty-three individual items were subjected to further examination and testing at A&CC. Many items exhibited explosion-related damage, i.e. heat, charring, soot, missing pieces or severe physical force. No evidence indicated that any of the cap lamp batteries had sufficient electrical energy to ignite a methane-in-air mixture or enough thermal energy to ignite coal dust (Appendix U-7).

Air-Purifying Helmet Components

Seven components from the air purifying helmets including four batteries, a portion of a battery case, and pieces of the helmet and cable were retrieved for further examination and testing at A&CC. None of the electrical components indicated signs of arcing, sparking or electrical heating. Methane ignition did not occur during a spark ignition test with the highest short circuit current and highest open circuit voltage that was measured from any of the batteries (Appendix U-8).

Watches and Calculators

Several non-permissible electrical items, including six watches and two calculators, were recovered from the longwall face and subjected to examination and testing at A&CC. These items were all disassembled and inspected. Four watches and one calculator were functional and working as expected. None of the items indicated signs of arcing, sparking, or electrical heating, and there is no

evidence that any of these items were a source of spark or thermal ignition (Appendix U-9).

Methane Monitor Sensor Components.

Two CSE Model 140B LD IR methane monitor sensors (Exhibit Nos. PE-0169 and PE-0170) were retrieved from the tailgate area and tested at A&CC. The inspection of these components did not reveal any conditions that would suggest that the components caused an explosion. The sensors did not cause an ignition of a 7.5% methane-in-air mixture when energized in the test gas (Appendix U-10).

See Figures T-1 and T-2 for maps of the Electrical System, Equipment, and Associated Items that shows locations of some of these items and others inspected during the investigation.

APPENDIX U

TESTING RESULTS FOR ALL EQUIPMENT TESTED AT A&CC