

Report of Investigation Underground Coal Mine Explosion



U.S. Department of Labor
Mine Safety and Health Administration
1990

**Pyro No. 9 Slope
William Station Mine
I.D. No. 15-13881
Pyro Mining Company
Sullivan,
Union County,
Kentucky**

September 13, 1989

United States
Department of Labor
Mine Safety and Health Administration
Office of the Administrator
Coal Mine Safety and Health

REPORT OF INVESTIGATION
UNDERGROUND COAL MINE EXPLOSION
PYRO NO. 9 SLOPE, WILLIAM STATION MINE - I.D. NO. 15-13881
PYRO MINING COMPANY
SULLIVAN, UNION COUNTY, KENTUCKY

SEPTEMBER 13, 1989

by

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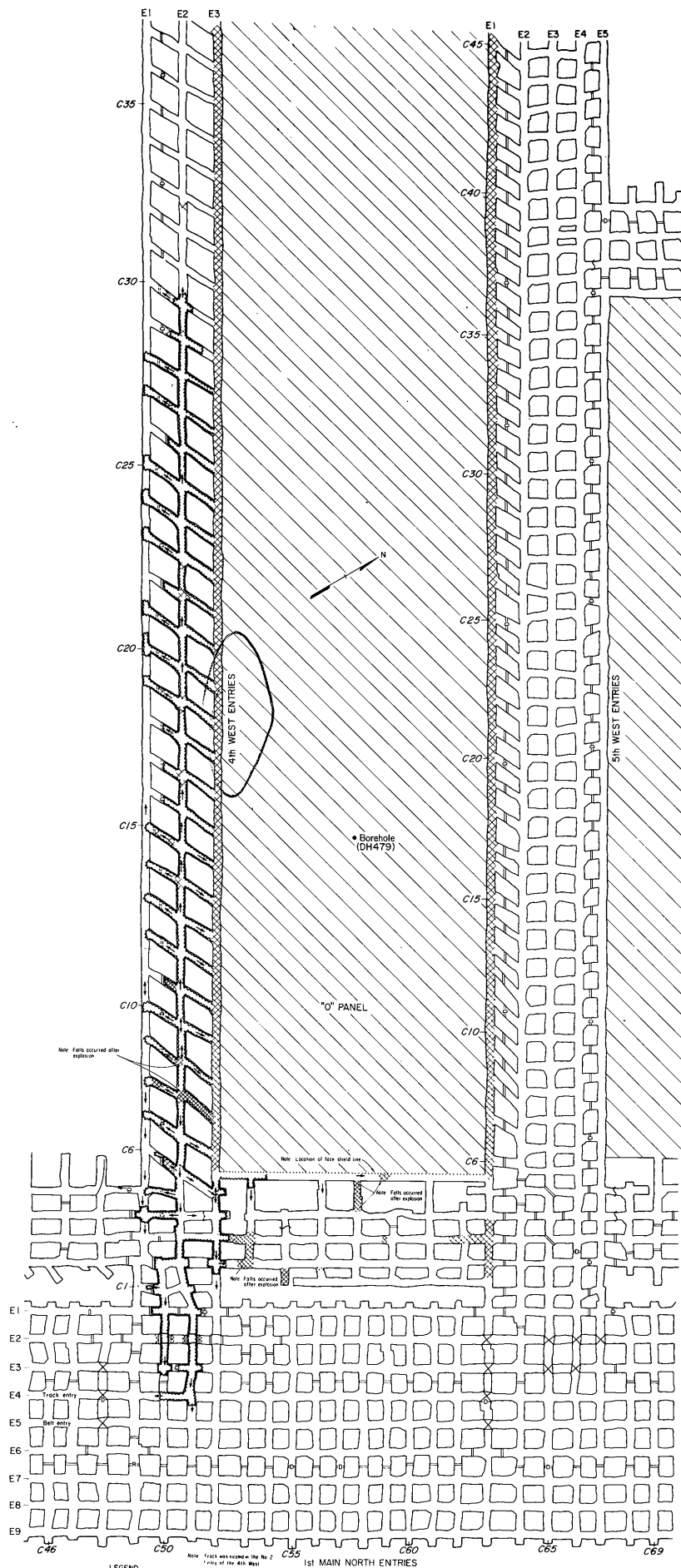
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- LEGEND
- I—Stopping intact
 - I—Stopping partially out
 - I—Stopping out
 - FD—Stopping with door
 - P—Stopping with door out
 - R—Regulator
 - bn Overcast
 - bn Gob
 - C9 Crosscut
 - E9 Entry
 - Extent of flame
 - Direction of force
 - Check curtain
 - Roof fall
 - Arched roof support
 - Check curtain out

APPENDIX Z - MINE MAP (Affected Area)

PYRO NO. 9 SLOPE,
WILLIAM STATION MINE, ID NO. 15-13881
PYRO MINING COMPANY

Direction and extent of forces, extent of flame, and information gathered during the investigation.

Scale, ft

100 200



Authority—This report is based on an investigation made pursuant to the Federal Mine Safety and Health Act of 1977, Public Law 91-173, as amended by Public Law 95-164.

Section A—Identification Data

1. Title of investigation: Underground Coal Mine Explosion
 2. Date MSHA investigation started: September 22, 1989
 3. Report release date: May 8, 1990
 4. Mine: Pyro No. 9 Slope, William Station
 5. Mine ID number: 15-13881
 6. Company: Pyro Mining Company
 7. Town, County, State: Sullivan, Union County, Kentucky
 8. Author(s): M. Childers, R. Elam, M. Eslinger, S. Kattenbraker, R. Phillips, E. Ritchie

Section B—Mine Information

9. Daily production: 10,500 tons
 10. Surface employment: 7
 11. Underground employment: 360
 12. Name of coalbed: Kentucky No. 9
 13. Thickness of coalbed: 55"

Section C—Last Quarter Injury Frequency Rate (HSAC) for:

14. Industry: 12.06
 15. This operation: 12.61
 16. Training program approved: Yes
 17. Mine Profile Rating: n/a

Section D—Originating Office

18. Mine Safety and Health Administration Office of the
 Coal Mine Health and Safety District No. : Administrator
 Address: 4015 Wilson Boulevard
Arlington, Virginia 22203

Section E—Abstract

At about 9:13 a.m., September 13, 1989, an explosion occurred on Longwall Panel "0", between the 4th and 5th West Entries off the 1st Main North Entries, of Pyro Mining Company's Pyro No. 9 Slope, William Station Mine. Fourteen miners were present in the longwall recovery area at the time of the explosion. Ten of the miners died as a result of the explosion. Four of the miners escaped, despite being exposed to high concentrations of carbon monoxide and smoke. The names of the miners in the longwall recovery area are listed in Appendix A and victim/survivor data is listed in Appendix B.

Changes had occurred during the mining of Longwall Panel "0" in the 4th and 5th West Entries and in the longwall bleeder system that caused a fragile balance of air flows to exist in the longwall bleeder ventilation system. This fragile balance was affected when changes were made to the ventilation controls in the 4th West Entries and the longwall recovery area. The combination of changes significantly decreased the air flow across the longwall face and reduced the air flow in the 4th West Entries. The combination of changes also permitted methane to migrate from the gob and to accumulate in the No. 2 Entry of the 4th West Entries in by the No. 6 Crosscut and near the longwall headgate.

The removal of the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries disrupted the separation between the 2nd Main North Entries ventilation system and the longwall bleeder system. This action caused an explosive methane-air mixture to flow toward and into the longwall recovery area where it was ignited by one of the five probable sources identified in this report.

Section F—Mine Organization

Company officials:	Name	Address
19. President:	P. Ron Siler	P.O. Box 267 Sturgis, Kentucky 42459
20. Superintendent:	H. Michael McDowell	P.O. Box 267 Sturgis, Kentucky 42459
21. Safety Director:	P. Bruce Hill	P.O. Box 267 Sturgis, Kentucky 42459
22. Principle officer—H&S:	David L. Steele	P.O. Box 267 Sturgis, Kentucky 42459
23. Labor Organization:		
24. Chairman—H&S Committee:		

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GENERAL INFORMATION

The Pyro No. 9 Slope, William Station Mine, I.D. No. 15-13881, located near Sullivan, Union County, Kentucky, is operated by Pyro Mining Company. Pyro Mining Company is in partnership with Costain Mining (Pyro) Inc. and WKY Mining (Pyro) Inc.

The principal management officers of Pyro Mining Company and Pyro No. 9 Slope, William Station Mine at the time of the explosion were:

Pyro Mining Company Mine

P. Ron Siler	President
Steven R. Whitsell	Director of Surface Operations and Support
David L. Steele	General Superintendent
P. Bruce Hill	Director of Safety & Human Resources

Pyro No. 9 Slope, William Station Mine

H. Michael McDowell	Superintendent
Frank G. Head	Mine Manager
Roger K. Clifford (victim)	Director of Longwall Operations
Roy J. Head	Director of Maintenance
Donald R. Ramsey	Production Support Director

Pyro No. 9 Slope, William Station Mine is interconnected with Pyro No. 11 Mine. Pyro No. 11 Mine, I.D. No. 15-10339, was developed as a drift mine into the Kentucky No. 11 Coal Seam and began active status on April 13, 1977. Pyro No. 11 Mine entered inactive status on May 6, 1983.

Pyro No. 9 Slope, William Station Mine was opened into the Kentucky No. 9 Coal Seam by three shafts and a slope. An intake shaft, 486 feet deep, and a return shaft, 857 feet deep, were developed from the surface. An 800 foot long slope and a 164 foot deep return shaft were developed from Pyro No. 11 Mine, down to the Kentucky No. 9 Coal Seam. In the longwall mining area of the mine, the Kentucky No. 9 Coal Seam averaged 55 inches in thickness.

Pyro No. 9 Slope, William Station Mine, at an elevation of about 361 feet above sea level, entered active status on January 11, 1983. The mine extends over an area of approximately five square miles. A map of the entire mine is in Appendix Y.

At the time of the explosion, the mine employed 372 miners on three shifts per day. The mine had three different work crews, the Blue Crew, the White Crew, and the Weekly Crew. The Blue and White Crews were primarily the production crews and normally worked 10-hour shifts on four consecutive days and usually a fifth 10-hour shift. The Weekly Crew was the support crew and normally worked 10-hour shifts on five consecutive days. Production averaged 10,500 tons of coal per day.

Mining Methods

A block system of mining was employed. Mining was conducted using longwall, continuous, and conventional mining methods. Continuous mining equipment was used to develop longwall mining panels and conventional mining equipment was used to develop main entries. Main entries, rooms, and crosscuts were normally developed 18-20 feet wide. The longwall panels utilized retreat mining methods using two single-drum shearers in conjunction with shield-type roof supports. The entries and rooms are numbered for identification from left to right.

The longwall, continuous mining, and conventional mining units produced coal on two 10-hour shifts with one staggered shift for maintenance.

At the time of the accident, there were two active continuous mining units and two active conventional mining units. Also, there was one set of longwall mining equipment that was in the process of being recovered from Longwall Panel "O" and moved to Longwall Panel "P". Longwall Panel "O" (between 4th and 5th West Entries) had finished production and was in the equipment recovery stage. Longwall Panel "P" (between the 3rd and 4th West Entries) was in the equipment set-up stage.

Longwall Panel "O" was developed 3,730 feet in depth with a face width of 670 feet. Longwall Panel "P" was developed 4,980 feet in depth with a face width of 535 feet.

The type of mining performed on each of the active units/panels was as follows:

<u>Active Units/Panels</u>	<u>Location</u>	<u>Mining Type</u>
Panel "O"	Between 4th and 5th West Entries off 1st Main North Entries	Longwall Mining (Recovery)
Panel "P"	Between 3rd and 4th West Entries off 1st Main North Entries	Longwall Mining (Set-up)
No. 1 Unit	2nd West Entries off 1st Main North Entries	Continuous Mining
No. 2 Unit	9th Main North Entries off 2nd East Entries	Conventional Mining
No. 3 Unit	3rd North Entries off 1st Main West Entries	Conventional Mining
No. 4 Unit	2nd West Entries off 2nd Main North Entries	Continuous Mining

Federal Mine Inspections

A complete MSHA Safety and Health Inspection (AAA) of the entire Pyro No. 9 Slope, William Station Mine was conducted from June 6, 1989, through July 5, 1989. During the inspection, 23 citations and five orders were issued.

Another MSHA Safety and Health Inspection (AAA) began on August 8, 1989, and at the time of the explosion was nearly complete. A total of 35 citations and one order were issued. During the day shift on September 13, 1989, two federal inspectors were on the surface at the mine preparing to perform inspection activities when the explosion occurred. This last Safety and Health Inspection (AAA) was terminated on September 13, 1989 because of the explosion.

Pyro No. 9 Slope, William Station Mine was under a 5-day, 103(i) inspection program, based upon two previous explosions within the last five years.

Roof Support

The roof control plan in effect for the mine was approved by the MSHA District Manager on July 20, 1989.

Generally, the immediate roof over the coalbed consisted of three feet of black shale. The main roof consisted of 20 feet of gray shale. The roof was supported throughout the mine with various types of roof bolts.

Conventional roof bolts, resin roof bolts, Double Lock roof bolts, #7 tension rebar roof bolts, and High-Tech roof bolts were all used in the mine. Six-foot resin roof bolts, installed on 5-foot centers, were the most commonly used type of roof support in the mine. Supplemental roof support materials consisted of wooden posts, timbers, and cribs. Also, steel straps and truss bolts were used. In certain instances, steel arches were installed in lieu of roof bolts.

On the longwall sections, two-leg, 595-ton shields were used to support the roof on the longwall face, and 40-ton hydraulic jacks were used at the headgate and stageloader. Also, wooden cribs were installed as additional roof support for the bleeder entries and headgate entries that would serve as future tailgate entries.

Ventilation / Examinations

There were four openings into the mine, three shafts and one slope. Ventilation was induced by three main fans located on the surface. An exhaust fan was located at the top of the Mitchell Station shaft and a blowing fan was located at the top of the William Station Portal, a double-compartment shaft. Another exhaust fan was

located at a drift opening of the Pyro No. 11 Mine and utilized the shaft between the two mines to exhaust air from Pyro No. 9 Slope, William Station Mine. These fans provided ventilation utilizing a push-pull system. The exhaust fan installations included automatic-closing and explosion-relief doors.

The exhaust fan located at Mitchell Station shaft was a Joy Axivane Model M96-58DS direct-drive fan operated at 1,180 rpm by a 1,000-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 22-degree blade position, at a negative pressure of 13.80 inches of water. An air measurement made during the investigation indicated 339,000 cubic feet per minute (cfm) was being exhausted from the Mitchell Station shaft.

The intake fan located at William Station Portal was a Joy Axivane Model M84-50 direct-drive fan operated at 1,180 rpm by an 800-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 32-degree blade position, at a positive pressure of 6.60 inches of water. An air measurement made during the investigation indicated 364,000 cfm was being forced into the mine.

The exhaust fan located at Pyro No. 11 Mine drift opening was a Jeffrey Model 8HU-84 Aerodyne, belt-driven fan operated at 1,180 rpm by a 700-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 1B-1S blade position, at a negative pressure of 6.16 inches of water. An air measurement made during the investigation indicated 194,000 cfm was being exhausted from the drift opening.

The methane liberation was 1.73 million cubic feet per 24-hour period as measured during the last MSHA Safety and Health Inspection (AAA) prior to the explosion.

Permanent stoppings, overcasts, and undercasts were used to provide the required separation between the various aircourses. All were constructed of incombustible materials. Most stoppings were constructed of concrete blocks, dry-stacked and sealed.

The ventilation plan in effect at the mine was approved by the MSHA District Manager on March 13, 1989. The plan required a minimum of 4,000 cfm of air to be maintained at each working face where coal was being cut, mined or loaded. When a continuous mining machine was operated, the plan required a minimum of 5,000 cfm of air to be maintained at the end of a blowing line curtain. On longwall sections, the plan required a minimum of 15,000 cfm of air to be directed across the face.

Respirable dust created by mining in the face areas was controlled by water sprays on the equipment, including the longwall equipment, and by the use of ventilation directed to the working faces by line curtains.

A wrap-around type bleeder system was developed around the block of coal being mined by the longwall. The ventilation plan required that the maximum allowable concentration of methane anywhere in the bleeder system shall not exceed 2 percent. Methane drainage boreholes equipped with surface mounted pumps were also used to drain methane from longwall gob areas.

Preshift, onshift, and weekly examinations were to be made by certified persons. The results of these examinations were to be recorded in approved record books on the surface.

Combustible Material / Rock Dusting

The operator established a program to prevent the accumulation of loose coal, coal dust, float coal dust, and other combustible materials in the active workings and on electric equipment.

The application of rock dust was the primary means used for inerting coal dust. Rock dust was applied to the underground areas of the mine including all working places within 40 feet of the face and all crosscuts less than 40 feet from the working faces. Rock dust machines were used to apply rock dust in outby areas and on the working sections.

Water lines and sufficient hose to reach each working face was provided on each working section. Coal dust created by mining in the face areas was controlled by water sprays on the equipment, including the longwall equipment, and by the use of ventilation directed to the working faces by line curtains. The continuous mining machines were also equipped with wet-bed scrubbers to control generated dust. Dust at conveyor belt transfer points was controlled by water sprays.

Electricity

Electric power was purchased from the Henderson-Union Rural Electrical Cooperative at 69,000 volts alternating current (AC) and transmitted to surface substations located at the Mitchell Station Fan and the William Station Portal. The 69,000 volts AC was reduced to 7,200-volt, AC three-phase power at the Mitchell Station Fan by a 5,000 kVA delta-wye connected three-phase transformer and three, 1,000 kVA delta-delta connected single-phase transformers. These transformers supplied two underground circuits that entered the mine through a borehole adjacent to the substation.

The 5,000 kVA transformer secondary neutral was properly grounded through a 25-ampere, current-limiting resistor to a safety ground field. A zig-zag grounding transformer provided a secondary neutral for the three, 1,000 kVA single-phase transformers and was properly grounded through a 25-ampere, current-limiting resistor to a safety ground field.

Both underground high-voltage circuits were protected by an individual 1,200-ampere, oil circuit breaker. Each circuit breaker was equipped with a ground-check monitor and relays designed to provide overcurrent, short-circuit, grounded-phase, and undervoltage protection for the circuit.

The 7,200-volt, three-phase power was further reduced to 4,160-volt, AC three-phase power by a 1,500 kVA wye-wye connected three-phase transformer that supplied the Mitchell Station Fan. The fan circuit was protected by an individual 600-ampere, oil circuit recloser located in the substation.

The 69,000 volts AC circuit at the William Station Portal was reduced to 4,160-volt, three-phase power by a 1,000 kVA delta-wye connected three-phase transformer and supplied power for the fan and surface area. The fan circuit was protected by an individual 1,200-ampere, oil circuit recloser located in the substation.

Each recloser was equipped with relays to provide short-circuit and overcurrent protection for the circuits. Each fan circuit extended from the substations by means of overhead power lines to the fan installations.

Sets of single-pole, knife-blade switches were installed in the surface substations to provide visual evidence that the phase conductors of each surface and underground high-voltage circuit originating in the substations were disconnected when the knife blades were opened.

One underground circuit supplied three section power centers, 19 portable power centers, six vacuum circuit breakers and one oil circuit breaker, located in the 1st Main West Entries, 2nd Main North Entries, No. 3 Unit, No. 4 Unit, 8th Main North Parallels, 1st Main East Entries, 3rd East Entries, and the No. 2 Unit. The section power centers reduced the 7,200-volt, three-phase power to the utilization voltages of the equipment on the active units. The portable power centers reduced the 7,200-volt, three-phase power to 480-volt, AC three-phase power for utilization by conveyor belt drive units, pumps, and battery chargers. Since this high-voltage circuit did not extend into the explosion area, it will not be described in detail in this report.

The other underground, high-voltage circuit supplied three section power centers, five portable power centers, two oil circuit breakers and three vacuum circuit breakers, located in the 1st Main West Entries, 1st Main North Entries, 2nd West, 3rd West and 4th West Entries. The section power centers reduced the 7,200-volt, three-phase power to the utilization voltages of the equipment on the active units. The portable power centers reduced the 7,200-volt three-phase power to 480-volt, three-phase power for utilization by conveyor belt drive units, pumps, and battery chargers.

The high-voltage circuit that extended to the explosion area contained approximately 11,500 feet of shielded, three-conductor,

8 KV, mine power cable. The phase conductors in the mine power cable were No. 4/0 AWG copper except for 400 feet of No. 1/0 AWG copper mine power cable. A dual vacuum circuit breaker was installed in the high-voltage circuit near the bottom of the borehole. In addition, a vacuum circuit breaker or oil circuit breaker was installed at the beginning of each underground branch circuit.

Each vacuum or oil circuit breaker was equipped with a ground-check monitor and relays designed to provide overcurrent, short-circuit, grounded-phase, and undervoltage protection for the branch circuit. Each vacuum and oil circuit breaker also contained a three-phase, visible disconnect switch for the circuit breaker.

The section power center for Longwall Panel "O" reduced the 7,200-volt, three-phase power to 995-volt, and 480-volt, AC three-phase power for utilization by the electric equipment on the panel. The portable power center on the panel reduced the 7,200-volt power circuit to 480-volt for utilization by a roof bolter, welder, loading machine, and battery chargers. The low- and medium-voltage, secondary circuits of the section power centers and portable power centers were resistance grounded. A three-pole, molded-case circuit breaker was provided for each low- and medium-voltage power circuit originating at a section power center or portable power center. Each circuit breaker was equipped with a ground-check monitor and devices to provide overcurrent, grounded-phase, and undervoltage protection for the circuit. A cable coupler was provided for each low- and medium-voltage power circuit originating at a section power center or portable power center to provide visual evidence that the power was disconnected when the cable plug was withdrawn from the receptacle.

The electric face equipment was of a permissible type and according to mine record books, was examined weekly. Records of these examinations were kept in books at the mine office.

Fire Protection / Emergency Procedures

The operator's program of instruction, which includes the fire-fighting and the evacuation plans, was approved by the MSHA District Manager on November 17, 1987. This program also included instruction and training for mine employees in the location and use of firefighting equipment, location of escapeways, exits and routes of travel to the surface, proper evacuation procedures to follow in the event of an emergency and proper use of filter-type self-rescuers and self-contained self-rescuers (SCSR).

All underground electric face equipment was equipped with a fire suppression system that could be activated by the equipment operator. These systems contained powdered dry chemicals, except for the continuous miners, which used a water deluge system. The main water line located at the section belt tailpiece was equipped with a fire hose outlet. All belt conveyor lines were provided with fire hose outlets at 300-foot intervals and at each conveyor

drive end tailpiece. Fire hose was provided at or near each conveyor drive and tail piece. Portable fire extinguishers were located at or near all electrical installations, oil storage stations, diesel fueling stations, and on all mantrips.

The approved program also included procedures for firefighting in outby areas of working sections, on the surface, on the longwall panels, as well as firefighting on a conventional unit and on a continuous miner unit.

Firedrills were conducted so that miners were aware of the designated escapeways. The designated escapeways were maintained continuously to the surface. The two designated escapeways in the conventional and continuous miner sections from the working sections to the surface were the intake entries and track entries. The primary escapeway for the longwall was the intake entry and the secondary escapeway was either the belt entry or return entry. The escapeways were separated by concrete block stoppings. The results of escapeway examinations conducted by certified persons were recorded in a book kept on the surface. A map indicating the escapeways, exits and routes of travel to the surface was submitted with the ventilation plan every six months.

Pyro Mining Company was granted a Petition for Modification of 30 CFR 75.1103-4(a), pursuant to Section 101(c) of the Federal Mine Safety and Health Act of 1977, on November 4, 1987, to install a carbon monoxide detection system in Pyro No. 9 Slope, William Station Mine and Pyro Mine No. 11. This system was to be used in lieu of a point-type fire warning system along the belt conveyors, with the petition permitting the system to provide identification of a fire within an area rather than within each belt flight.

Explosives

Supplies of permissible type explosives and electric detonators were stored in a surface storage magazine about 1000 feet from the drift openings. Explosives and detonators were transported into the mine in closed containers. Explosives were also stored underground at various locations in substantially constructed magazines. Explosives were used on the conventional mining units in the production of coal, and were used occasionally on the longwall face and in outby areas for construction work. A magazine was not provided on Longwall Panel "O".

Transportation and Haulage

Personnel were transported into the mine by an automatic elevator located at the William Station Portal. Supplies were transported into the mine by means of rail cars through the drift openings in the Pyro No. 11 Mine.

Personnel were transported from the elevator by mobile rubber-tired, battery-powered personnel carriers, rubber-tired, diesel-

powered personnel carriers, and battery-powered track-mounted personnel carriers.

Materials were transported from the slope bottom by battery-powered and diesel-powered, track-mounted rail equipment and rubber-tired battery-powered scoop tractors.

On continuous mining units and conventional mining units, coal was loaded at the face into shuttle cars and transported to the section loading point where it was discharged onto the conveyor belt system. On the longwall mining panels, coal was loaded onto a chain conveyor system and transported to the section loading point where it was discharged onto the conveyor belt system. The conveyor belt system transported the coal to a preparation plant. After being cleaned and processed, the coal was loaded into railroad cars.

Communications

Two-way voice communication was provided by a telephone system containing pager telephones located on the surface, on the automatic elevator, at the elevator shaft bottom, at the slope shaft bottom, on the working units, and at other appropriate locations underground. Permissible pocket phones were used in conjunction with the two-way system to provide communication from remote locations.

On the longwall panels, a permissible telephone system supplied with the longwall controls was used for communication across the longwall face. However, the mine telephone system found on the longwall face during the investigation was of a nonpermissible type.

Oil Wells and Gas Wells

There were 27 oil wells and gas wells located on the mine property. However, none were located in the Longwall Panel "O" area. Pyro Mining Company was granted a Petition for Modification of 30 CFR 75.1700 on May 25, 1989, for cleaning out and plugging oil and gas wells, prior to mining through them. Three oil wells and gas wells have been mined through.

Smoking

The smoking search program to prevent smoking articles from being taken underground was approved on February 3, 1983, by the MSHA District Manager. The plan required that a systematic search be conducted of all persons entering the mine at least weekly at irregular intervals. Additionally, spot searches were to be conducted when necessary to ensure that the program was being followed. The program required that records of the searches be kept, and that "No Smoking" signs would be prominently displayed at mine entrances.

Mine Rescue and Self-Rescuers

Pyro Mining Company maintained a trained mine rescue team equipped with four-hour, self-contained breathing apparatuses. The mine rescue team, made up of Pyro employees from different mines, served each Pyro Mining Company area mine. The Pyro No. 9 Slope, William Station Mine, also had an agreement with the Kentucky Department of Mines and Minerals State Mine Rescue Team to provide service if necessary. The State Mine Rescue Team was located in Madisonville, Kentucky, within 60 minutes driving time from the mine.

At the time of the explosion, Pyro Mining Company's Mine Rescue Team was in Louisville, Kentucky competing in the National Mine Rescue and First-Aid Contest. The State Mine Rescue Team was the first mine rescue team to arrive at the mine after the accident.

Filter-type self-rescuers and SCSRs were provided for underground employees. Each employee had been trained in the use of each type of self-rescuer. Each underground employee carried the filter-type self-rescuers while underground. SCSRs were stored at accessible locations throughout the mine.

Methane Monitors and Detectors

Pyro No. 9 Slope, William Station Mine used portable methane detectors and equipment-mounted methane monitors. Portable detectors used were CSE Corporation, Model No. 102 and Industrial Scientific Corporation, Model Nos. CD210, CD212, MX240, and CMX270. Portable detectors were issued to most management personnel, face equipment personnel, firebosses, and mechanics. The safety managers conducted a monthly calibration program for the portable methane detectors.

Equipment-mounted methane monitors were mounted on continuous mining machines, loading machines and cutting machines. The types of equipment-mounted methane monitors included models manufactured by General Monitor, Appalachian Electronic, and Mine Safety Appliance. A weekly calibration program was carried out by the 3rd shift maintenance crew.

When operating, the longwall equipment had a methane monitor provided by Appalachian Electronics. This monitor was located on the panline conveyor near the tailgate. Weekly calibration checks were provided by the 3rd shift maintenance crew. However, at the time of the explosion, the methane monitors had been removed along with the equipment they were mounted upon.

Identification Check System

A check-in and check-out system was provided at the mine consisting of a check board with brass tags corresponding to similar tags worn by the miners when underground.

Illumination

Permissible electrical cap lamps were worn by all persons in the mine for portable illumination. Permissible light fixtures were installed on the electric face equipment to provide illumination while the equipment was being operated in the working places in the mine. In various outby locations that were ventilated by intake air, nonpermissible light fixtures were used to provide area illumination.

Training Program

The training and retraining plan that met the requirements of 30 CFR Part 48 was approved by the MSHA District Manager on January 12, 1988. The program for training and retraining of certified and qualified persons and for training and retraining of selected supervisors in first aid, mine rescue, gas detecting devices, self-rescuers, ventilation, roof and rib control, and the Federal Mine Safety and Health Act of 1977 was approved on January 12, 1988.

Emergency Medical Assistance

The operator had made arrangements with Union County Hospital in Morganfield, Kentucky for emergency medical assistance for injured employees at the mine. Emergency transportation for injured mine personnel was provided by the Union County Ambulance Service. Receipt of the emergency medical assistance plan was acknowledged by the MSHA District Manager on February 1, 1983.

Mine Drainage System

Mine water was pumped with various sized electric pumps into one of two major underground sumps. These sumps were located at the bottom of the intake shaft at William Station Portal and at the bottom of the exhaust shaft at Mitchell Station. Water from these two sumps was pumped to the surface at the rate of 50 gallons per minute (gpm) and 150 gpm, respectively, on an as needed basis. A third sump was located at the intersection of the 8th West Entries and the 2nd Main North Bleeder Entries. This sump, located at the lowest elevation in the area, was fed with mine water by gravity. Water was pumped to the surface from this sump through a borehole at the rate of 75 gpm.

EXPLOSION, RECOVERY, AND INVESTIGATION

Explosion

The following narrative description of the explosion and the events before and after the explosion was developed from interviews with the survivors of the accident, and with those involved in the initial recovery of the victims. Also, additional information was obtained during the accident investigation.

On September 13, 1989, on the 7:00 a.m. to 5:00 p.m. shift, coal production was scheduled for the two continuous mining units and the two conventional units. The No. 1 Unit and the No. 4 Unit were continuous mining units developing the 2nd West Entries from opposite directions. The 2nd West Entries being developed were the headgate entries for Longwall Panel "Q", a future longwall panel.

Work was also scheduled on this shift for Longwall Panels "O" and "P", which were adjacent to each other. Longwall Panel "O", located between the 4th and 5th West Entries, had "cut-out" or finished mining coal on September 6, 1989 and was in the equipment recovery stage. Longwall Panel "P", located between the 3rd and 4th West Entries, was in the equipment set-up stage.

Since Longwall Panel "O" had finished production, work had progressed steadily to dismantle and recover the longwall mining equipment. As the equipment was recovered, it was transported to Longwall Panel "P", where it was being reassembled at the new face. The longwall production crews and maintenance personnel were responsible for the dismantling, transporting and reassembling of the longwall equipment. The new set-up in Longwall Panel "P" was scheduled to be complete and ready for initial coal production on September 17, 1989.

By the morning of September 13, the shearers, stageloader and tailgate equipment had been dismantled and removed. All but six sections of the panline conveyor had been separated and removed. Fifty-four of the 139 shields used on the Longwall Panel "O" face had been removed. In addition, all of the conveyor belt and associated hardware in the 4th West Entries had been removed. Only the conveyor belt headframe and take-up framework remained. Most of the dismantled longwall equipment had already been transported to the new longwall face, approximately 5,000 feet away. The longwall shields and other large pieces of equipment were loaded on rail-mounted flatcars and transported through the main entries to the new longwall panel. However, some of the equipment was transported by scoop tractor through the 3rd West Entries.

Start of Day Shift - September 13, 1989

At 6:45 a.m., September 13, 1989, the Blue Crew and Weekly Crew, entered the mine at the William Station Portal and proceeded to their respective working sections. The longwall recovery and set-up crew, under the supervision of Curtis W. Scott, Longwall Foreman, traveled to the recovery area in Longwall Panel "O" by a diesel-powered mantrip and golf carts. The crew that day consisted of eleven members of the Blue Crew, three members of the White Crew, and one member of the Weekly Crew.

At about 7:30 a.m., the crew arrived at the track entry of the 4th West Entries near the longwall recovery area. Roger K. Clifford, Director of Longwall Operations, Kenneth E. Reed, Longwall Coordinator - Blue Crew, and Mark S. Hedges, Shift Maintenance Foreman - Longwall, were also on the longwall panel to oversee the recovery operations.

Scott assigned Rickie D. Furgerson, Shield Operator, to load shields on flatcars with a scoop tractor in the 4th West Track Entry. Lynn A. Ashmore, Master Controller, and Anthony T. McElroy, Shield Operator, were assigned to remove the remaining sections of the panline conveyor from the longwall face. Phillip R. Blanford, Longwall Mechanic, Larry Pennington, Longwall Mechanic (White Crew), Sharon Scott, Shield Operator (White Crew - wife of Curtis Scott), Michael L. Whitsell, Master Controller (White Crew), and Paul Harvey, Electro-Hydraulic Mechanic (Weekly Crew) were all assigned to work on the new face. The remaining crew members were to work on the old face removing and transporting shields.

Furgerson remained near the track entry to begin loading shields with a scoop tractor. Ashmore and McElroy proceeded to the old longwall face near the headgate. The mechanics proceeded to their tool boxes located in the 4th West Track Entry, just a few cross-cuts outby the longwall face. They gathered their tools and proceeded to their various assigned work locations. Blanford and Pennington traveled from the 4th West Entries to the new face area by golf cart. Joseph W. Thompson, Longwall Mechanic, walked through the recovery rooms to the No. 3 Recovery Chute and to the face. Scott and the rest of the miners proceeded to the old face where the last shields had been removed. To get to the face, they walked from the track entry through the No. 3 Recovery Room and the No. 3 Recovery Chute. This was the easiest, most direct route of travel to that area of the longwall face. This route was also the route used by the scoop tractors conveying shields from the face to the 4th West Track Entry.

At the headgate, Ashmore and McElroy were assigned to remove the remaining sections of the panline conveyor. These six remaining sections extended inby from the headgate. The conveyor flight chain had been removed, and all that remained was to separate the sections of panline into two groups. Each group consisting of three sections would then be dragged by a scoop tractor to the track entry for transporting. The sections of panline were held

together on each side by a heavy steel connecting link, known as a "dogbone". The dogbones were held in place by steel set screws. During the course of mining, the set screws became heavily rusted and were difficult to loosen with hand tools. Under these conditions, an oxygen/acetylene torch was used to cut away the set screws.

A set of four recovery rooms and four recovery chutes were previously developed to permit recovery of the equipment upon completion of mining in Longwall Panel "O". However, adverse roof conditions and previous roof falls had limited travel through certain areas of the recovery rooms. Also, a large roof fall had blocked access to the No. 1 Recovery Chute and the No. 2 Recovery Room. Due to this roof fall, travel from the headgate entries into the recovery rooms was only possible through the No. 3 Recovery Room. A loading machine and a roof bolting machine were located at the mouth of the No. 2 Recovery Room where rock had been loaded from this roof fall. However, on the morning of the accident, no one had been assigned to work at this location (Appendix BB).

Arriving at the old longwall face, Scott and the other miners began removal of the next shield. Shields were removed by a crawler-mounted piece of electric equipment referred to as a "mule". The mule pulled the collapsed shields from their location to the nearest recovery chute. After each shield was removed, wooden cribs were constructed to support the immediate roof. A scoop tractor would pick up the shield and transport it through the recovery chute and recovery rooms to a storage area near the track entry. Another scoop tractor loaded the shields onto rail-mounted flatcars in the track entry of the 4th West Entries. From there, the shields were transported by rail through the main entries to the new longwall face in Longwall Panel "P".

Account of Thompson

At the beginning of the shift, Scott assigned Thompson to unhose the shields. This job involved disconnecting the various hydraulic hoses which interconnected each shield. Thompson unhosed five or six shields and was about ten shields ahead of the crew that was removing the shields. At that time, Clifford, who had just arrived at the longwall face, came to him with a different assignment. Clifford told Thompson that a scoop tractor needed repair near the 4th West Track Entry. Clifford instructed Thompson to assist Furgerson, who was operating the scoop tractor loading shields onto railcars.

As Thompson started to leave the area, Scott told him that they had just lost hydraulic pressure on the longwall shields. This usually indicated that the longwall emulsion pump, located in the 4th West Track Entry, had run out of emulsion oil and shut down. Without hydraulic pressure, the shields on the longwall face could not be pressurized to raise or lower them. Scott told Thompson to check the emulsion pump. Until the pump could be restarted and hydraulic

pressure restored, work removing the shields from the face stopped. Thompson left the face and walked out the No. 3 Recovery Chute to the No. 3 Recovery Room.

As Thompson proceeded through the No. 3 Recovery Room, he noticed Furgerson's scoop tractor stopped ahead. The scoop tractor was parked in the intersection of the No. 3 Entry (4th West Entries) and the No. 3 Recovery Room. The rear headlights were lit and Thompson could hear the scoop tractor running. According to the investigation interviews, when he got close enough to communicate, Thompson called out to Furgerson, asking what was wrong with the tractor. Furgerson, who was out of the cab of the scoop tractor, replied that nothing was wrong. Furgerson appeared to be unhooking the scoop-mounted winch from a shield he was transporting. At that time, Thompson was within 10-15 feet of the rear of the scoop tractor.

The next instant, at about 9:13 a.m., an explosion occurred on the longwall panel.

Escape of Thompson

A gush or blast of air and dust came toward Thompson from the direction of the scoop tractor. Thompson was spun around and knocked to the mine floor by the blast. Before he could react, a huge fireball passed over the top of the scoop tractor and Thompson. In his interview, Thompson recalled that the whole area seemed to glow a bright fluorescent orange for a few seconds. Thompson, realizing that some type of explosion had occurred, quickly put on his filter-type self-rescuer, which he carried on his belt. At that time, Furgerson called back to Thompson to see if he was alright. Thompson acknowledged that he was okay, and inquired about Furgerson. Furgerson called out that he was badly hurt. There was no further response from Furgerson.

Thompson, in the intense heat, began to crawl. He did not know in which direction he was going and there was no visibility due to the dense smoke which completely filled the entry. After crawling a short distance, Thompson sensed cooler air hitting him in the face. He continued in the same direction and ran into a piece of equipment that he thought was the stageloader. (This piece of equipment was later found to be the pump control box by the investigation team). Thompson then realized he was in the intake entry of the 4th West Entries, across from the mouth of the No. 3 Recovery Room. According to Thompson, the smoke in this area was much lighter and there was fair visibility.

At the Mule at the time of the Explosion

At the time of explosion, the following persons were working at the longwall face area, between the Nos. 78-85 Shields in the vicinity of the mule. Scott and Bobby L. Short, Shearer Operator, were

located on the inby side of the mule boom where they had been repairing a hydraulic hose on one of the shields prior to its removal. Wayne D. Whitledge, Shearer Operator, and Ralph E. Plunkett, Shield Operator, were located beside the mule on the outby side where Whitledge had been lowering the shields prior to their removal by the mule. Paul T. Harris, Shield Operator, was seated in the operator's cab of the mule and had been operating the mule, pulling shields from the face. James A. Tinsley, Shield Operator, was at the scoop tractor in the No. 3 Recovery Chute, waiting to transport the next shield. Clifford had just arrived and was positioned with Whitledge and Plunkett beside the mule. Ernest W. Stewart, Main Gate Operator, was located at a scoop tractor in the recovery rooms, just outby the No. 2 Recovery Chute.

While waiting for Thompson to restart the emulsion pump, all work removing shields had temporarily stopped.

At approximately 9:13 a.m., the miners working at the mule were struck by a large blast of air carrying small rocks, dirt and debris. According to Plunkett, the tremendous rush of air, traveling from the direction of the headgate, knocked everyone to the mine floor. However, there was no visible flame. At once, Clifford cried out that they had to leave. Everyone realized that there had been an explosion, but they didn't know where it had originated. Immediately, they all ran from the face out the No. 3 Recovery Chute toward the recovery rooms. As they ran, they began to encounter smoke and someone yelled to put on their self-rescuers. At the intersection of the No. 3 Recovery Chute and the No. 3 Recovery Room, everyone stopped to don their filter-type self-rescuers. They were joined there by Stewart, who had come from the scoop tractor, located one crosscut outby.

Due to the uncertainty of what had happened and the thickness of the approaching smoke, several of the miners experienced difficulties donning their self-rescuers. According to the investigation interviews, after everyone had their self-rescuers on, the group started to advance into the heavy smoke. They proceeded along the No. 3 Recovery Room toward the 4th West Entries. Some of the miners were holding hands to keep from getting separated. However, not everyone stayed together and interview statements of Plunkett and Whitledge indicated that there were obvious attempts made to verbally communicate with each other.

After traveling about one crosscut, the group stopped near the rear of a scoop tractor. According to the investigation interviews, some of the miners were somewhat confused and overwhelmed with intense heat and dense smoke which offered no visibility. Some of the miners advanced on their own. Others were overheard attempting to communicate with their self-rescuers out of their mouths.

Whitledge, Short, and Plunkett proceeded on their own without removing their self-rescuers or attempting to communicate. They did not travel together and each was uncertain about the direction in which he was traveling.

Escape of Whitledge and Short

Whitledge wandered around the scoop tractor, somewhat disoriented, before he turned and started out the No. 3 Recovery Room. As he neared the track entry, he began to feel cooler air on his face. Whitledge realized he was going in the right direction. When he reached a point near Furgerson's scoop tractor, visibility had improved slightly. There he stopped and removed his self-rescuer from his mouth and called out for anyone. Scott called back and asked where he was. Whitledge answered Scott, despite not being certain where he was. Short then emerged from the dense smoke heading toward Whitledge. Together, Whitledge and Short proceeded in the direction of the cooler air and the improving visibility. Ahead of them, they heard someone else shouting.

While still in the intake entry, Thompson heard someone call from the direction of the No. 3 Recovery Room. Thompson momentarily removed his self-rescuer and responded. He soon recognized Whitledge and Short as they crossed the track entry and approached through the slowly clearing smoke. Thompson, Whitledge and Short decided that the intake entry would be their best route of escape since the track entry was still full of smoke. Together, they climbed around the equipment and started out the intake entry. They traveled in the intake entry until they came to a mandoor, which opened into the 4th West Track Entry. Finding clear air, Thompson and Short exited through a mandoor. Whitledge, however, continued in the intake entry. He exited through the next mandoor into the 1st Main North Track Entry. Thompson went to a nearby mine telephone at the mouth of the 4th West Entries and called for help and reported the explosion. Whitledge rejoined Thompson at the mine telephone and Short proceeded back into the 4th West Entries to help in the initial recovery.

Escape of Plunkett

Plunkett stated during his interview that he thought he knew where he was and in which direction he was traveling. However, wandering in the heat and smoke which offered no visibility, he got turned around and separated from the group. Without attempting to communicate, Plunkett passed a scoop tractor. He thought he was heading toward the 4th West Entries, however, he was proceeding toward the longwall face. As Plunkett started through the No. 2 Recovery Chute, he became confused about his location. Soon he heard voices yelling in a distance. Plunkett reversed his direction and proceeded toward the voices.

The first persons Plunkett encountered were Scott and Tinsley. They were attempting to help Harris who was lying on the mine floor. Scott and Tinsley tried to get Harris' self-rescuer back in his mouth which he had apparently removed to communicate. Stewart called for help a short distance away. Plunkett went to Stewart who was attempting to help Clifford. Clifford was also lying on the mine floor with his self-rescuer out of his mouth.

Clifford was having difficulty breathing and Stewart could not get his self-rescuer back into Clifford's mouth.

Realizing that Harris and Clifford could not survive much longer, Plunkett took a deep breath and removed his self-rescuer. He called to the others to start pulling Harris and Clifford out of the smoke, before replacing his self-rescuer. Stewart and Plunkett began dragging Clifford. Simultaneously, Scott and Tinsley began dragging Harris. According to the interview of Plunkett, after a short distance, everyone became fatigued and stopped.

Plunkett knew that they were fairly close to the storage location of several SCSRs. He remembered their location, having passed by them on several previous days. Plunkett told Scott he was going for the SCSRs. Scott acknowledged by nodding his head and pointing straight out the entry in which they were traveling. At that point, Plunkett left the others and crawled toward the 4th West Track Entry. Plunkett, however, was not convinced that Scott had pointed in the proper direction for escape. He was sure that he had to make one more right turn. At the first crosscut that he came to, Plunkett turned right and proceeded. A short distance ahead, he crawled over a track which he recognized as the track in the No. 2 Recovery Room. Plunkett then realized that he was going in the wrong direction and that Scott had been right.

Plunkett reversed his direction and crawled back to where he had turned. He heard Scott call out to him as he approached. Scott and Tinsley had left the others and were attempting to crawl toward the 4th West Track Entry. When Plunkett got to Scott, he was kneeling with his self-rescuer out of his mouth and in a daze. Plunkett replaced Scott's self-rescuer in his mouth and told him that he would be right back with the SCSRs. As he again started crawling toward the SCSRs, he found the mule trailing cable on the mine floor. Plunkett followed the cable, knowing that this would lead to the power center in the 4th West Track Entry. As he proceeded toward the track entry, the air started feeling cooler.

When Plunkett reached the track entry, he found the SCSRs storage area along the inby rib. He quickly activated an SCSR and started to don it when lights approached him from the outby direction of the track. Voices called out to Plunkett telling him that they were in fresh air. Plunkett quickly proceeded toward the voices.

Outby, in the track entry, he met Larry J. Griffin, Crew Manager, and T. Larry Keith, Assistant Mine Foreman. About the same time, Blanford and Pennington arrived with Ricky B. Taylor, Belt Mechanic.

Upon reaching fresh air, Plunkett told those that had arrived about the other men he had just left inby in the No. 3 Recovery Room. He explained there were five men down and three of them could not survive much longer without SCSRs. Blanford, Pennington, and Taylor donned SCSRs, while Griffin and Keith started to re-establish ventilation and set up communications with the surface.

Initial Rescue and Recovery

Griffin and Keith were in the No. 1 Unit, about 1600 feet outby the 4th West Entries, when the explosion occurred. They came in response to an urgent mine telephone call received from Dean Morrow, Belt Walker. Morrow had been working in the vicinity of the belt head of the 3rd West Entries when the explosion occurred. When she went to investigate what had happened, Morrow encountered smoke in the 1st Main North Entries outby the 4th West Entries. She immediately went to a nearby mine telephone and began to call for help. After a few minutes, Morrow was joined by Thompson and Short as they emerged from a nearby mandoor.

Blanford and Pennington were a few crosscuts outby the Longwall Panel "P" Face when they felt a concussion, quickly followed by several large gusts of dust-laden air. They went to the mine telephone and heard Morrow's call for help. According to their investigation interviews, Blanford and Pennington left immediately on their golf cart for the 4th West Entries.

Taylor was at the belt head of 1st Main North Entries near a mine telephone when he heard Morrow's call for help. He immediately responded and left for the 4th West Entries. Taylor stopped at several belt heads along the 1st Main North Entries to pick up all the SCSRs he could find.

The air at that time was relatively clear of smoke where the 4th West Track Entry switches off the 1st Main North Track Entry. The rescue and recovery attempts were initiated from this location.

Recovery of the No. 3 Recovery Room

Blanford, Pennington and Taylor accompanied Plunkett into the smoke. They crawled from the 4th West Track Entry into the mouth of the No. 3 Recovery Room, using the mule trailing cable as a guide. They attempted to stay as low to the mine floor as possible because the air there contained less smoke and visibility was slightly improved.

The first person Plunkett and Taylor found was Scott. Scott was slumped over with his self-rescuer laying beside him. They checked his vital signs, but none were found. Plunkett and Taylor then crawled about 10 feet to Tinsley. Blanford and Pennington, however, stayed with Scott and attempted to revive him. Blanford removed his SCSR from his mouth and placed it in Scott's mouth. He then squeezed the air bag, in an attempt to give Scott air. However, Scott did not respond. After a few unsuccessful attempts, Blanford and Pennington left Scott and crawled further inby.

When checked by Taylor, Tinsley was not breathing, but a faint heartbeat was detected. Taylor immediately began Cardio-Pulmonary Resuscitation (CPR). After about 30 seconds, Tinsley responded with a regular pulse, but he was still not breathing. Taylor then

took a few deep breaths and removed the hose of his SCSR from his mouth and began to administer mouth-to-mouth resuscitation to Tinsley. After a short while, Tinsley began to gasp for breath. At that point, Taylor put his SCSR in Tinsley's mouth. Taylor, however, had become light-headed and dizzy apparently from breathing the contaminated atmosphere. As he held his breath, Taylor activated another SCSR that he had brought with him. When he had managed to revive himself, Taylor called out to the others to go for a stretcher for Tinsley.

As they continued crawling in the No. 3 Recovery Room, Blanford and Pennington located Stewart. Plunkett joined them there, after leaving Taylor with Tinsley. According to the investigation interviews, Blanford, finding no vital signs, attempted to force air from his SCSR into Stewart without effect. Harris and Clifford were then located just inby Stewart. Finding no signs of life in either Harris or Clifford, the three retreated to Taylor, who had been calling for a stretcher. Taylor and Plunkett remained with Tinsley while Blanford and Pennington returned to fresh air for a stretcher.

When Blanford and Pennington returned to the track entry, other mine personnel had arrived to join in the rescue and recovery attempts. Blanford and several of the miners returned into the smoke-filled No. 3 Recovery Room, carrying a stretcher. Each rescuer was wearing an SCSR. Tinsley was put on the stretcher and carried to the track entry and fresh air. Tinsley, however, had stopped breathing when they arrived at the track entry. CPR was immediately begun and continued as Tinsley was transported out of the mine. Tinsley was pronounced dead when he arrived on the surface.

The investigation interviews indicated that ventilation of the No. 3 Recovery Room was re-established by hanging a brattice curtain across the 4th West Track Entry, just inby the mouth of the room. Also, after the victims had been located, curtains were installed in the crosscut between the No. 2 and the No. 3 Recovery Rooms. This slowly began improving the visibility and air quality in the recovery rooms.

When Blanford returned to the track entry, he met with Thompson. Thompson explained to Blanford that, at the time of the explosion, he was located close to Furgerson and the scoop tractor he had been operating. Blanford, however, did not recall seeing Furgerson during the initial explorations of the No. 3 Recovery Room.

Blanford, accompanied by Short, returned to the No. 3 Recovery Room. At that time, other rescuers began recovering the previously discovered victims. At the first intersection inby the track entry, Blanford and Short discovered the scoop tractor as described by Thompson. This scoop tractor had been unnoticed in the thick smoke during the early explorations in the recovery room.

Blanford and Short quickly located Furgerson's body lying against

the inby rib beside the operator's cab of the scoop tractor. Furgerson had no signs of life, and unlike the other victims discovered in the recovery room, he was burned.

Throughout the initial rescue and recovery attempts in the recovery rooms, there were no signs of Ashmore and McElroy. Also, the location of Reed and Hedges was not known. On previous days, Reed and Hedges had been traveling between the two longwall faces as work of dismantling and assembling the longwall equipment took place.

On the Surface at the Time of the Explosion

At the time of the explosion, H. Michael McDowell, Superintendent, was on the surface meeting with Harold L. Gamblin and Ted D. Smith, Coal Mine Safety and Health Inspectors (MSHA). Shortly after 9:00 a.m., a telephone call was received on the surface from the No. 1 Unit, stating that the unit had lost power and there had been a large unusual gush of air underground. When told of this, McDowell started calling the other underground units to see if they had also lost power. Every unit except the longwall recovery panel responded. While trying to determine the cause of the problem, Morrow's call for help broke in on the mine telephone. Morrow stated that there had been an explosion on the longwall.

McDowell immediately organized the notification and evacuation of the other working units of the mine. A call was made to David L. Steele, General Superintendent, located at the company office a few miles away. After notifying Gamblin and Smith of the occurrence, McDowell made arrangements for the notification of the Kentucky Department of Mines and Minerals. Also, McDowell made arrangements for ambulances and established a check-in and check-out system to be used by anyone entering or leaving the mine.

Within minutes of being called, Steele and David R. Canning, Production Engineer, arrived at the mine. Steele and Canning joined McDowell and Roy J. Head, Director of Maintenance, and proceeded underground. When they arrived at the longwall recovery area, they quickly donned SCSRs and joined in the rescue and recovery operations, already in progress. Steele immediately began to direct ventilation efforts in the No. 3 Recovery Room, while McDowell and Canning assisted in the recovery of the victims. Head was directed to establish and maintain open communications with the surface.

Recovery of the Longwall Face

As the bodies of the victims found in the No. 3 Recovery Room were being removed, the other accessible areas of the recovery rooms were explored. Also, attempts to enter the longwall face were made through the No. 2 Recovery Chute. Steele entered the longwall face through the No. 2 Recovery Chute and proceeded toward the longwall

headgate, where Ashmore and McElroy were believed to have been working. However, after traveling a short distance, he heard the pump motor of a scoop tractor running on the longwall face. Steele took a methane reading which indicated 2.8 percent and a carbon-monoxide (CO) reading which indicated 700 to 800 parts per million (ppm). Steele then retreated and decided to enter the longwall face from the headgate entries.

When the victims had been removed from the No. 3 Recovery Room, ventilation in the 4th West Track Entry was advanced by hanging line curtains. These curtains were used to direct fresh uncontaminated air further inby in the track entry and to the headgate end of the longwall face. When methane and CO levels were sufficiently reduced in the headgate entries, exploration of the longwall face began.

Steele led the first group into the longwall face area from the headgate. As Steele entered this area, he saw, through light smoke, a headlight shining toward him from inby on the longwall face. Also, he again heard the pump motor running. The headlight and pump motor were on the scoop tractor that was used to remove the sections of panline. As they entered the longwall face area, they located the bodies of Reed and Hedges, one on either side of the panline. It appeared that Reed and Hedges had been working to remove the dogbone links between the panline sections at the time of the explosion.

An oxygen/acetylene torch was laying in the panline near where the dogbones were being removed. Also, a set of oxygen and acetylene tanks were laying beside the panline. Reportedly, the valves on the torch and the valve on the oxygen tank were in the off or closed position. However, the valve on the acetylene tank was slightly open and not seated. The dogbone set screws on the shield side of the panline at the No. 8 Shield had been recently cut away with the torch, but the dogbone had not been removed. Also, a small area of gob had been dug away to expose the opposite dogbone and set screws on the face side of the panline, as if to begin removal of the dogbone. However, no cutting had been done in this area.

The bodies of Ashmore and McElroy were discovered at the scoop tractor, just inby the last section of panline. After numerous checks for methane were made on all sides, the scoop tractor was deenergized. All four victims located in the longwall face area were burned by the explosion. The bodies of the four men were then removed from the longwall face.

At that point, all rescue and recovery efforts of the victims were complete (Appendices A and B). Most of the persons involved in the rescue and recovery of the victims left the mine (Appendix C). However, several members of management remained at the mouth of the 4th West Entries to accompany the Kentucky Department of Mines and Minerals's Mine Rescue Team, who had arrived at the mine to assist in the rescue and recovery operations.

Activities of MSHA and State Personnel

On September 13, 1989, at about 7:00 a.m., Gamblin and Smith arrived at the Pyro No. 9 Slope, William Station Mine to conduct a regular Mine Health and Safety Inspection (AAA).

Prior to going underground, Gamblin and Smith held a violation conference with management personnel. After the conference, Gamblin and Smith changed clothes and prepared to enter the mine to continue their inspection. Before they entered the mine, McDowell told them that there had been an explosion in the longwall recovery area and that nine men were missing. Gamblin immediately went to the nearby monitoring room and saw that the CO sensor, located in the 4th West Belt Entry off the 1st Main North Entries, was flashing a warning. The monitor showed a reading of 50 ppm, its upper limit.

Gamblin called the MSHA Madisonville District Office at 9:30 a.m. and informed Richard L. Reynolds, Assistant District Manager, of the occurrence. Reynolds dispatched David L. Whitcomb, Supervisory Mine Safety and Health Specialist (Electrical), to the mine site and instituted Mine Emergency Operations (MEO) procedures by contacting Rexford Music, District Manager. At the time, Music was in Louisville, Kentucky at the National Mine Rescue and First-Aid Contest.

Gamblin and Smith began to organize emergency procedures. They established the location of the explosion and a list of those miners unaccounted for. They organized a list of all mining personnel working underground and in the longwall recovery area. Also, they made sure that all mining personnel underground had been notified and ordered to evacuate the mine. Gamblin and Smith then issued Section 103(k) orders to Pyro No. 9 Slope, William Station Mine and Pyro No. 11 Mine, respectively. Whitcomb was briefed by Gamblin and Smith when he arrived at the mine at 10:20 a.m. Whitcomb sent Gamblin and Smith underground to assist in the rescue and recovery operations. As other MSHA personnel arrived at the mine, they were assigned to various mine openings to monitor the mine atmosphere leaving the mine and to record all activities and readings (Appendix F).

The Kentucky Department of Mines and Minerals Mine Rescue Team was dispatched to Pyro No. 9, William Station Mine when notified of the explosion. The State Mine Rescue Team consisted of the following persons:

Captain	Douglas R. Monroe	-	Mine Inspector
No. 2 Man	Elmer Giffin	-	Mine Inspector
No. 3 Man	John Franklin	-	Mine Inspector
No. 4 Man	Bill D. Perkins	-	Electrical Inspector
No. 5 Man	Billy C. Smith	-	Mine Inspector
No. 6 Man	Oscar Summers	-	Mine Safety Analyst

The team was equipped with self-contained breathing apparatuses, suitable for mine rescue operations. At 12:23 p.m., after organizing on the surface, the team proceeded underground, accompanied by Gamblin and Smith. The MSHA inspectors were only equipped with SCSRs, and did not have available the proper apparatus for mine rescue activities.

When the State Mine Rescue Team and the MSHA inspectors arrived underground, they were informed that six victims had been recovered from the No. 3 Recovery Room. However, four persons, believed to be in the longwall face area, were still missing. They were also told that high levels of methane and CO were measured at the longwall face where a scoop tractor was energized.

The MSHA inspectors, according to their investigation interviews, decided to exit the mine because they did not have the proper equipment or training and they were concerned about the reports of high levels of methane and CO present in the recovery area where the scoop tractor was still energized.

The State Mine Rescue Team proceeded to the 4th West Entries, longwall recovery area. When they arrived, they were briefed by Steele and McDowell. By that time, all of the victims had been recovered and ventilation had been established across the longwall face and in the recovery rooms. Steele and McDowell accompanied the State team through the remaining areas of the longwall face that had not been previously explored. All explorations were done bare-faced due to the established ventilation which had improved the air quality. After all areas were explored, a map of the affected area was made indicating the location where each victim had been recovered. Chalk markings were also made on the mine roof at each such location. After receiving permission from MSHA on the surface, the headgate area of the longwall face was wet down with fire hoses to prevent a fire from occurring.

The State Mine Rescue Team and remaining mine personnel exited the mine about 3:30 p.m. Thomas E. Hughes, Safety Manager, and Mark Bartkoski, Production Engineer, remained in the mine to monitor conditions in the area of the explosion.

Music, Jennings D. Breedon, District Manager, District No. 2 (Former District Manager of District 10), and Fred T. Casteel, Chief of Engineering Services, arrived at the mine later at 4:30 p.m. After a briefing about the explosion and recovery, it was decided by MSHA, with the concurrence of the State, to remove the remaining two persons from the mine until the next morning when the recovery of the mine could begin. MSHA personnel remained at the mine to continuously monitor the atmosphere leaving the mine from each mine opening.

Mine Emergency Operations (MEO)

To initiate Mine Emergency Operations (MEO), Reynolds contacted Music at about 9:50 a.m., concerning the explosion. Music immediately notified Jerry L. Spicer, Administrator, and Robert G. Peluso, Chief, Pittsburgh Health Technology Center, who were also in Louisville, Kentucky. Peluso then notified Jeffrey Kravitz, Chief, MEO, and Edward J. Miller, Chief, Ventilation Division, Pittsburgh Health Technology Center. Promptly, after initiating MEO, Music and Casteel left Louisville and returned to Madisonville. Breedon also left Louisville and traveled to Madisonville.

The MEO emergency equipment and personnel were put on standby, awaiting further instructions as needed. On September 20, 1989, a support trailer, dispatched from the Pittsburgh MEO, arrived at the mine site. The trailer functioned as a communications center for MSHA personnel, a ventilation survey coordinating center, and a location for storage of maps and materials brought out of the mine. The support trailer remained on site until October 16, 1989.

Mine Recovery and Establishment of Ventilation

During the rescue and recovery operations that began on September 13, 1989, personnel from MSHA District 10 established a surface control center in the mine office (Appendix F). MSHA personnel operated this center continuously. The control center had both underground and outside phone capability, which permitted the coordinator to communicate with personnel in the mine and at District 10 Headquarters in Madisonville, Kentucky. The control center coordinator maintained a positive check-in and check-out system and logged the activities at the mine. The William Station Portal was the access point to underground workings for rescue and recovery operations.

Pyro Mining Company officials disconnected power to the mine. MSHA personnel attended the Mitchell Station and Pyro No. 11 Highwall Mine fans and made periodic tests of the air exhausting from the mine and records of these tests were kept. MSHA approved each step of the recovery plan and modified the Section 103(k) order to permit ventilation evaluations, electric power to be restored, and other work to make the mine safe for investigation. Personnel assigned to explore or work in the mine were instructed not to disturb anything in the explosion area. The personnel who entered the mine were informed about the possibility of high methane concentrations, low oxygen concentrations, and the presence of CO. MSHA coordinated the recovery of the mine in consultation with the Kentucky Department of Mines and Minerals.

Maurice S. Childers, District Manager, District 8, arrived at District 10 Headquarters at about 11 a.m. on September 14, 1989.

Mike Sakovich, Subdistrict Manager, District 8, and Mark O. Eslinger, Supervisory Mining Engineer, District 8, also arrived to assist in the recovery and prepare for the investigation. Kevin G. Stricklin, Mining Engineer, and John E. Urosek, Supervisory Mining Engineer, Pittsburgh Health Technology Center, departed the National Mine Rescue and First-Aid Contest and arrived at District 10 Headquarters. Robert A. Elam, Acting District Manager, District 9, arrived on September 15, 1989, to provide assistance in the mine recovery. A list of the persons who participated in the mine recovery and establishment of ventilation is located in Appendix D.

During the initial rescue and recovery operation on September 13, 1989, Pyro made many ventilation changes. Pyro installed brattice cloth curtains in the 4th West Entries and in the longwall recovery rooms to ventilate these areas and the longwall face. The exact locations of all of these curtains could not be determined from investigation interviews because maps were not made of these changes by the recovery personnel. Pyro removed or changed these curtains during mine recovery attempts between September 15, 1989, and September 19, 1989, with approval from the State and MSHA.

Also, during the initial rescue and recovery operations on September 13, 1989, Pyro installed a framed curtain in the No. 1 Cut-through Entry. The No. 1 Cut-through Entry was one of four cut-through entries that connected the 4th and 5th West Entries in the 2nd Main North Entries. Prior to the explosion, the Nos. 1 and 4 Entries had concrete block stoppings with metal manddoors, and the Nos. 2 and 3 Entries had concrete block stoppings without manddoors. These stoppings separated the 2nd Main North ventilation system from the longwall bleeder ventilation system. The stopping in the No. 1 Cut-through Entry was being dismantled by Don R. Ramsey, Production Support Director, and Joe E. Jones, Bratticeman, at the time of the explosion. They finished dismantling the stopping after the explosion and left the entry without a ventilation control device.

Interviews of Ramsey and Jones revealed that they did not know that the sound and gush of air they heard and felt was the explosion. Also, during the time the stopping was being dismantled and before the explosion, Ramsey told Larry S. Hunt, Fireboss, to open the manddoor in the stopping in the No. 4 Entry. Hunt stated in an interview that he opened the manddoor and continued his examination duties. Steele ordered the installation of the brattice cloth stopping in the No. 1 Cut-through Entry while he was underground during the rescue and recovery operation. Steele reported that he had methane "coming back in on him" so he asked if there had been any changes made that morning. Steele said he was informed about the stopping removal. Steele stated that he did not know if the concrete block stopping removal had anything to do with the air direction and methane, so he ordered the brattice cloth stopping to be installed. Ramsey returned to the cut-through entries with Danny R. Griffin, Mine Manager, and installed the curtain in the No. 1 Cut-through Entry and closed the manddoor in the No. 4 Cut-through Entry.

On September 14, 1989, at about 11:10 a.m., State and MSHA personnel met in District 10 Headquarters to discuss the explosion and conditions in the mine. Monroe described the conditions encountered during exploration of the accident area on September 13, 1989. Information received at this meeting aided State and MSHA personnel in formulating a tentative plan to evaluate the mine later that day. At about 11:50 a.m., Hill and Whitsell joined the meeting. The tentative plan for evaluating the mine was explained to and coordinated with the Pyro officials. Pyro discussed its intentions to restore ventilation in the accident area to the status in the ventilation plan approved prior to the explosion. Plans for the mine evaluation were finalized following these discussions and personnel left for the mine.

September 14, 1989

At approximately 3:00 p.m. on September 14, 1989, evaluation teams consisting of Pyro, State, and MSHA personnel entered the mine to evaluate conditions in the mine (Appendix E-1). Three teams examined the Nos. 1, 2, and 3 Units and found these areas unaffected by the explosion.

At the same time, the evaluation team of Bruce W. Morris, Section Foreman, Thomas W. Johnson, State Mine Inspector, and Louis W. Stanley, MSHA Specialist (Ventilation), entered the mine and traveled to the 2nd Main North Entries. They examined the No. 4 Unit and the new longwall set-up area. The team continued their exploration by traveling to the cut-through entries and found the framed curtain, which was installed during the rescue and recovery of the victims, in the No. 1 Entry. They detected air leaking through this curtain from the 2nd Main North Entries to the No. 1 Entry of the 5th West Entries. The team discovered that air in the 5th West Entries split and moved slowly east toward the 1st Main North Entries and slowly west toward the 2nd Main North Bleeder Entries. The team examined the No. 4 Entry and found the mandoor closed in the stopping.

The team proceeded through the 5th West Entries to the 2nd North Bleeder Entries to the accumulation of water located at the No. 93 Crosscut in the 2nd Main North Bleeder Entries. Air quality measurements in the 2nd Main North Bleeder Entries showed 0.4 percent methane, 20.1 percent oxygen, and 7 ppm CO. The team detected only a slight movement of air toward the water in the bleeder entries. They observed no evidence of the explosion at any point of these explorations. The team retreated and joined the other teams and returned to the surface at about 8:30 p.m. on September 14, 1989.

The accumulation of water at the junction of the 2nd Main North Bleeder Entries and the 8th West Entries blocked air from flowing to the 8th West Entries from the 2nd Main North Entries. Canning reported that Pyro had been pumping water from this area through the No. 4 Borehole to the surface since July 11, 1989.

An additional three teams and James H. Hackney, III, MSHA Supervisory Inspector, entered the mine at 3:00 p.m. on September 14, 1989, and traveled to the 1st Main North 4th West Track Switch. Hackney set up an underground communication station at the track switch and advised the surface control center of this established station. Hackney operated the communication station while the three teams examined their assigned areas. The team of Eslinger, Ricky L. Bowles, Longwall Coordinator, and T. Smith, examined the 4th West Entries inby the old longwall face. The team of L. Griffin, Monroe, and James E. Wolfe, MSHA Specialist (Ventilation), examined the longwall face and recovery area. Thomas E. Hughes, Safety Manager, and Keith G. Ryan, MSHA Inspector, examined the 1st Main North Entries inby the track switch and the 8th West Bleeder Entries.

The 4th West Entries and the longwall recovery area teams proceeded together up the track entry of the 4th West Entries to the No. 6 Crosscut. The No. 6 Crosscut provided access to the Longwall Panel "O" face and was the crosscut through which intake air entered the face before and after the explosion. As the teams prepared to separate, they made air quality measurements in the opening of a partial check curtain between the Nos. 6 and 7 Crosscuts. Steele stated in his interview that he constructed this check curtain during the rescue and recovery effort. The measurements showed 3.0 percent methane, 17.5 percent oxygen, and 60 ppm CO. The teams detected a perceptible movement of air in the outby direction toward the No. 6 Crosscut. This air joined intake air from the 1st Main North Entries flowing up the 4th West Track Entry at the No. 6 Crosscut. The combined splits of air flowed through the No. 6 Crosscut toward the No. 3 Entry of the 4th West Entries.

The teams decided to remain together and proceeded inby the curtain to a roof fall at the No. 8 Crosscut in the No. 2 Entry. The roof fall appeared to have happened after the explosion and prevented travel up the No. 2 Entry. Monroe reported that a large roof fall occurred at about 1:15 p.m. on September 13, 1989, while the State Mine Rescue Team was examining the longwall face. He stated that Pyro personnel monitoring air near the No. 6 Crosscut in the No. 2 Entry for the rescue team heard a fall in the 4th West Entries inby their position. The teams measured the air quality near the roof fall and found 4.0 percent methane, 18.0 percent oxygen, and 60 ppm CO. The teams retreated to the No. 7 Crosscut. Bowles and Monroe traveled through the No. 7 Crosscut to the No. 1 Entry. Bowles advanced to the No. 8 Crosscut and made air quality measurements. The measurements showed 5.0 percent methane, 16.5 percent oxygen, and 120 ppm CO. Bowles and Monroe rejoined the others and the teams retreated to the No. 6 Crosscut. The teams decided that because of the air quality it was unsafe to explore the 4th West Entries inby the No. 8 Crosscut.

Both teams proceeded through the No. 6 Crosscut to the No. 3 Entry, up the No. 3 Entry, and onto the Longwall Panel "O" face. The teams found air from the No. 6 Crosscut flowing up the No. 3 Entry to and across the longwall face. The air flowing across the face

contained 0.7 percent methane, 20.5 percent oxygen, and 2 ppm CO. The personnel traveled across the longwall face to the No. 3 Recovery Chute and through the chute to the No. 3 Recovery Room and toward the 4th West Entries. They continued on to the No. 2 Entry of the 4th West Entries and back to the communication station.

The teams found soot in the 1st Main North Entries, the 4th West Entries, and in the face area. The forces of the explosion became more evident the further the teams traveled up the 4th West Entries. The teams observed heavier soot, damaged equipment, evidence of heat, and blown-out stoppings. The teams found soot and debris in the No. 6 Crosscut and the No. 3 Entry leading to the longwall face area. They observed soot and evidence of heat on the face, but the explosion evidence diminished on the face the farther away from the headgate the teams traveled. The evidence of flame was non-existent beyond the No. 1 Recovery Chute. The forces were not evident beyond the No. 3 Recovery Chute, which is located approximately 400 feet down the longwall face toward the No. 1 Entry of the 5th West Entries. The teams found little evidence of the explosion in the recovery rooms (Appendix Z).

The roof in the 4th West Entries and in the recovery rooms showed signs of normal frontal abutment pressure. The teams saw bent roof-bolt plates, crushed cribs and header boards, and encountered falls during the exploration. Bowles expressed concern for mining equipment in the area and asked to move a scoop tractor in the No. 3 Recovery Chute to prevent loss or damage. MSHA denied the request in order to maintain the accident area until it could be inspected by investigation teams. The teams ended this portion of their exploration at about 5:45 p.m. Hackney reported the findings to the surface control center.

While at the communication station, Wolfe measured a quantity of 60,000 cubic feet per minute (cfm) of air flowing in the track entry between the Nos. 51 and 52 Crosscuts of the 1st Main North Entries. The measurement was made only in the track entry of the 1st Main North Entries and Hackney reported the air measurement to the surface control center.

Upon receiving the air measurement report, Whitcomb, stationed on the surface, requested a check of the quantity and quality of the air flowing out of the 5th West Entries. Bowles, Eslinger, and Smith traveled to the 5th West Overcasts in the 1st Main North Entries. They measured 34,000 cfm of air flowing out of the 5th West Entries that contained 0.6 percent methane, 20.6 percent oxygen, and 7 ppm CO. The team retreated to the communications station and reported the findings to the control center at about 7:05 p.m.

At about 8:00 p.m., Whitcomb requested another check of air quality in the No. 6 Crosscut in the 4th West Entries. Bowles, Monroe, and Wolfe returned to the No. 7 Crosscut in the No. 1 Entry and found 5.9 percent methane, 16.0 percent oxygen, and 100 ppm CO. They retreated to the communications station and reported their findings.

The team of Hughes and Ryan walked to the 8th West Entries by traveling in the 1st Main North Track Entry. They proceeded up the 8th West Entries approximately half the distance to the 2nd Main North Entries. At this location, Hughes and Ryan detected very little air movement. They measured approximately 2.6 percent methane, 18.4 percent oxygen, and 100 ppm CO. The team retreated to the communications station arriving at 8:40 p.m. The team did not reach the water accumulation at the junction of the 2nd Main North Bleeder Entries and the 8th West Entries. The team found no evidence of the explosion except concentrations of CO. Hackney reported their findings to the surface control center. The three teams and Hackney returned to the surface at about 9:15 p.m.

September 15, 1989

The following day, September 15, 1989, at 8:15 a.m., the State and MSHA met in the District 10 Headquarters. Members of the teams that had explored the mine on September 14, 1989, briefed the personnel on their findings. MSHA called Pyro and requested a recovery plan to make the mine safe for investigation and scheduled a meeting for later that morning.

At 11:50 a.m., MSHA met with the State and Pyro officials in District 10 Headquarters. Hill presented a plan to explore the mine and to re-establish ventilation. The plan detailed provisions to explore the 4th West Entries by accessing these entries through the 2nd Main North Entries. If no fires or hot spots were found, Pyro proposed to re-establish ventilation in the 4th West Entries. Pyro planned for air to flow from the 1st Main North Entries to the 2nd Main North Entries. This was the direction that Pyro stated the air was moving prior to the explosion. The State and MSHA approved the plan. MSHA modified imminent danger Order No. 3418308 to reflect a methane concentration of 5.9 percent and an oxygen concentration of 16.5 percent found during the exploration on September 14, 1989. The affected area described in the order included the entire mine.

At about 3:00 p.m., September 15, 1989, the No. 1 evaluation team entered the mine and traveled to the top of the 3rd West Entries (Appendix E-2). The team traveled across the new longwall set-up to the 4th West Entries. The team traveled down the No. 1 Entry and encountered a stopping between the Nos. 50 and 51 Crosscuts. This stopping was one of the two stoppings in the 4th West Entries that separated the 2nd Main North Entries ventilation system from the longwall bleeder system. A mandoor provided access to the longwall bleeder entries. Prior to opening the mandoor, air quality checks near the stopping revealed 0.4 percent methane, 20.3 percent oxygen, and 3 ppm CO. Upon opening the mandoor, a distinct movement of air from the 2nd Main North Entries toward the 1st Main North Entries occurred. The team closed the door and checked the quality of air in the bleeder system. The air quality did not change.

The team proceeded down the No. 1 Entry of the 4th West Entries where they observed evidence of the explosion. They found a stopping destroyed by the explosion in the No. 30 Crosscut. The team proceeded from the No. 30 Crosscut toward the longwall recovery area at the No. 6 Crosscut. Within the 24 crosscut area, 19 concrete block stoppings were destroyed between the Nos. 1 and 2 Entries. The explosion force was apparent from the No. 2 Entry toward the No. 1 Entry. The teams found concrete blocks and wooden crib blocks against the rib of the No. 1 Entry. The No. 1 Entry had been cribbed the entire length in preparation for mining the adjacent Longwall Panel "P". Only the cribs in the intersection were dislodged by the explosion. The air quality deteriorated slowly as the team advanced toward the longwall recovery area. An air quality check showed 3.5 percent methane, 18.0 percent oxygen, and 17 ppm CO near the No. 11 Crosscut. The highest concentrations of methane and lowest concentrations of oxygen found were detected near the No. 11 Crosscut. The air flowed slowly toward the longwall recovery area. Air quality had improved slightly since September 14, 1989, with the concentrations of CO showing a significant drop from over 100 ppm to under 20 ppm.

Also, at about 3:00 p.m. on September 15, 1989, the No. 2 evaluation team entered the mine and traveled to the 1st Main North 4th West Track Switch (Appendix E-2). The team explored the longwall recovery area and found that a roof fall had occurred in the No. 3 Recovery Chute covering a scoop tractor. The team examined the 4th West Entries and stopped at the No. 11 Crosscut. Here they detected slight air movement in the outby direction. At about 5:20 p.m., the No. 1 team arrived. Neither team found fires or hot spots. The teams found roof falls in the No. 2 Entry of the 4th West Entries. The absence of roof falls in the No. 1 Entry was attributed to the installation of cribs along the entry. Both teams proceeded to the communications station at the 1st Main North 4th West Track Switch. Here, they reported results of the examination to the surface control center. The teams returned to the surface at about 6:45 p.m.

On September 15, 1989, Pyro, State, and MSHA officials met in the mine office at 7:00 p.m. Pyro officials proposed a plan to establish ventilation controls that would cause air to flow from the 1st Main North Entries through the 4th West Entries to the 2nd Main North Bleeder Entries. The plan provided for tightening ventilation controls by covering stoppings with plastic brattice cloth in the cut-through entries and in the 4th West Entries between the Nos. 50 and 51 Crosscuts. The plan also required installation of brattice cloth stoppings in the 1st Main North Entries to course air into the 4th West Entries. The State and MSHA approved the proposal.

On September 15, 1989, at 8:00 p.m., a ventilation crew (Appendix E-3) entered the mine to make the proposed ventilation changes. The crew gathered supplies and traveled to the cut-through entries. The crew found the framed brattice cloth stopping in the No. 1 Cut-through Entry leaking air from the 2nd Main North Entries to the

5th West Entries. The crew added an additional brattice cloth to this stopping and added brattice cloth to the stoppings in the Nos. 3 and 4 Entries. The crew placed no cloth on the stopping in the No. 2 Entry, because the outby side of the stopping was inaccessible due to a roof fall.

After installing these curtains, the crew traveled to the stopping between the Nos. 50 and 51 Crosscuts in the No. 1 Entry of the 4th West Entries. The crew opened the mandoor, which measured 33 inches by 33 inches, and measured 11,000 cfm of air flowing toward the 1st Main North Entries. The crew closed the mandoor and covered the stopping with brattice cloth on both sides. The crew also added brattice cloth to stoppings in the Nos. 2 and 3 Entries of the 4th West Entries. These stoppings were later discovered not to be the stoppings separating the 2nd Main North Entries ventilation system from the longwall bleeder system. These stoppings had been used to direct air in the set-up entries between the 4th and 5th West Entries.

At 8:55 p.m. on September 15, 1989, another ventilation crew (Appendix E-4) entered the mine and went to the longwall recovery area. The crew began its assignment and was later joined by the other crew at about 12:20 a.m. on September 16, 1989. The crews completed the brattice cloth stopping installations and made an evaluation of the airflow direction inby the No. 6 Crosscut in the 4th West Entries. They found the air still flowing in the outby direction. The ventilation adjustments contributed little toward improving the ventilation system. The water restriction at the junction of the 2nd Main North Bleeder Entries and the 8th West Entries continued to be a factor contributing to this condition. The crews returned to the surface at about 3:00 a.m.

September 16, 1989

Pyro, State, and MSHA officials met on September 16, 1989, at District 10 Headquarters. Pyro proposed additional ventilation changes to make air flow up the 4th West Entries from the 1st Main North Entries to the 2nd Main North Bleeder Entries. The plan involved constructing and removing stoppings in the 2nd Main North Entries and removing the curtains in the No. 1 Cut-through Entry. This would add the Nos. 2 and 3 Entries of the 4th West Entries above the Longwall Panel "O" Set-up Entries and the cut-through entries into the longwall bleeder system. They also proposed adding and removing curtains in the longwall recovery area and restarting the pump on the No. DH477 degasification borehole in Longwall Panel "O" to drain methane from the gob (Appendix FF). The State and MSHA approved the changes. During subsequent exploration, the No. 3 Entry of the 4th West Entries was found not to be mined through from the No. 50 to No. 51 Crosscuts. Only the Nos. 1 and 2 Entries were connected. The degasification pump on the No. DH477 borehole was restarted about 6:30 p.m.

Two crews of Pyro employees with observers from the State and MSHA entered the mine between 5:30 p.m. and 6:00 p.m. on September 16, 1989 (Appendix E-5). The crews completed the assigned work and returned to the surface about 2:00 a.m. on September 17, 1989. The changes failed to reverse the direction or improve the quality of air flow in the 4th West Entries inby the No. 6 Crosscut. A measurement near the No. 7 Crosscut showed 3.4 percent methane, 18.8 percent oxygen, and 13 ppm CO. The change increased from 6 to 17 the number of stoppings separating the 2nd Main North Entries ventilation system from the longwall bleeder system. These stoppings provided additional leakage paths. Examinations of the air flowing out of the 5th, 6th, 7th, and 8th West Entries in the 1st Main North Entries detected methane concentrations as high as 2.3 percent and oxygen as low as 18.8 percent.

September 17-18, 1989

Pyro officials immediately proposed building and removing additional stoppings and curtains in the longwall recovery area. The State and MSHA approved the changes and at 3:00 a.m. on September 17, 1989, another ventilation crew of personnel from Pyro and observers from MSHA proceeded underground (Appendix E-6). The crew made changes and evaluated the ventilation. The changes failed to reverse the direction of airflow in the 4th West Entries inby the No. 6 Crosscut. The crew measured approximately 4,000 cfm of air still flowing in the outby direction toward the No. 6 Crosscut. Air quality measurements near the No. 7 Crosscut and the roof fall in the track entry showed methane less than 2 percent and oxygen above 19.5 percent. The ventilation crew returned to the surface at 8:50 a.m.

On September 17, 1989, MSHA officials made a decision to re-examine the 2nd Main North Bleeder Entries and the 1st Main North Entries to evaluate the feasibility of starting the accident investigation. Part of the plan was to establish a series of air quality check stations (Appendix FF) to track trends in air quality at specific locations. At about noon, evaluation teams entered the mine and proceeded to set up check points and test air quality in assigned areas (Appendix E-7). The teams completed their evaluations and returned to the surface before 5:00 p.m. The team in the 1st Main North Entries found 6.5 percent methane and 15.2 percent of oxygen at the No. 6 Station in the 1st Main North Entries. The team in the 2nd Main North Entries measured methane concentrations below 1.0 percent and oxygen above 19.5 percent. Because of the high methane level found, MSHA decided not to start the investigation at that time. Pyro, State, and MSHA officials convened at 5:15 p.m. in the mine office to formulate more ventilation adjustments to reduce methane levels in the 1st Main North Entries. Pyro proposed to install additional brattice cloth stoppings in the longwall recovery area and to partially close a regulator in the 1st Main West Entries. Decreasing the size of the regulator in the 1st Main West Entries would cause more air to flow into the 1st Main North Entries. The State and MSHA approved the changes.

At about 8:00 p.m. on September 17, 1989, a ventilation crew of personnel from Pyro with State and MSHA observers entered the mine and began making the proposed changes (Appendix E-8). At about 9:00 p.m., additional personnel went into the mine to assist in adjusting the ventilation (Appendix E-9). All personnel returned to the surface by 2:00 a.m. on September 18, 1989. No additional ventilation work or exploration was done on September 18, 1989. A Pyro contractor began drilling Borehole No. 5 from the surface to the water accumulation at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries on September 18, 1989. This borehole was installed to provide additional water pumping capability.

September 19, 1989

On September 19, 1989, at 9:30 a.m., State and MSHA officials met in District 10 Headquarters. The officials discussed the ineffectiveness of the ventilation work done through September 18, 1989. They also discussed the possibility of inaccurate measurements due to the high velocities of air sampled at the Mitchell Station fan. A new sampling procedure was begun on September 18, 1989, at the Mitchell Station fan by Stricklin and Urosek to alleviate the problem. At about 2:00 p.m. they installed a pump to draw a sample from air exhausted by the Mitchell Station fan to a remote sampling point. Pyro officials joined the meeting. They stated that the return air methane readings at the Mitchell Station fan had dropped to 0.3 percent. They proposed evaluating the longwall ventilation system using three teams. The State and MSHA approved the proposal.

At 2:00 p.m. on September 19, 1989, the three teams entered the mine (Appendix E-10). The teams made their evaluations and called out the results. The team in the 1st Main North Entries measured 6.0 percent methane, 14.2 percent oxygen, and 7 ppm CO at the No. 5 Station near the 7th West Entries. The teams in the 2nd Main North Entries and in the longwall recovery area found less than 0.4 percent methane and 3 ppm CO and more than 20.0 percent oxygen at all locations checked. The three teams retreated to the 9A Header (belt conveyor drive), which is located at the intersection of the 1st Main West Entries and 1st Main North Entries, and waited for instructions from the control center.

Pyro, State, and MSHA officials conferred on the surface. Pyro proposed a plan of additional changes that the State and MSHA accepted. At 8:11 p.m., the control center sent a map underground to the personnel waiting at the 9A Header to show exactly what changes to make. The changes involved decreasing the air to the No. 1 Unit in the 2nd West Entries and decreasing the air to the 1st Main West Entries. The size of openings in the regulators for the 2nd West Entries and the 1st Main West Entries would be decreased. These changes would increase the volume of air flowing in the 1st Main North Entries in by the 2nd West Entries. The teams completed the changes and made ventilation checks. The checks

revealed that air was continuing to flow in the outby direction in the 4th West Entries. The teams returned to the surface at 10:25 p.m.

September 20, 1989

On September 20, 1989, the State and MSHA re-approved the evaluation plan used on September 19, 1989, with an additional stipulation. The teams would only proceed until 2.0 percent methane was detected. This same plan was used in subsequent evaluations. Three teams entered the mine at 2:35 p.m. (Appendix E-11). The teams in the 2nd North Entries and in the longwall recovery area found methane concentrations less than 0.8 percent, oxygen above 20.5 percent and less than 7 ppm of CO. The team examining the 1st Main North Entries found a methane reading of 2 percent at the No. 4 Station near the 6th West Entries and did not proceed to the other sampling stations. The teams returned to the surface at about 5:00 p.m.

At 5:10 p.m., Pyro personnel with observers from MSHA went underground to install a continuous recording methane sensor in the 1st Main North Entries at the No. 63 Crosscut in the No. 9 Entry (Appendix E-12). The personnel installed the sensor and returned to the surface at about 9:00 p.m. The sensor became a part of the environmental monitoring system in use at the mine. The sensor continuously measured methane in return air of the 1st Main North Entries inby the No. 63 Crosscut. This sensor replaced the sensor monitoring return air near the Mitchell Station shaft so that only return air from the longwall bleeder system would be monitored.

September 21, 1989

On September 21, 1989, three evaluation teams (Teams A, B, and C) went underground, made their examinations, and returned to the surface (Appendix E-13). Teams A and C found methane concentrations less than 1.0 percent, oxygen concentrations above 19.5 percent, and CO concentrations less than 3 ppm. Team B found 2.2 percent methane, 18.1 percent oxygen, and 10 ppm CO at the No. 17 Station. Team A traveled to the water accumulation in the 2nd Main North Bleeder Entries. They found the water had receded since the examination on September 14, 1989. The water was still roofed and prevented air from flowing to the 8th West Entries. Canning reported that Pyro had pumped continuously before and after the explosion, except from 11:00 p.m. on September 14, 1989, to 10:00 a.m. on September 15, 1989, when the pump was down for repairs. Drilling continued on the No. 5 Borehole.

At 4:00 p.m. on September 21, 1989, Pyro and MSHA officials met in the mine office and discussed the improvement in air quality. The pattern of airflow in the 4th West Entries remained the same. The water restriction at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries continued to be a factor preventing the air from flowing from the 1st Main North Entries to the 2nd

Main North Bleeder Entries. Brattice cloth stoppings installed in the No. 6 Crosscut blocked air from flowing directly to the longwall face. Air flowed through the Nos. 7 and 8 Crosscuts and across the front of the gob or leaked through the shields onto the face and coursed across the face to the 5th West Entries. Air in the 5th West Entries flowed to the return air courses of the 1st Main North Entries. Intake air also moved in the 1st Main North Entries inby the 5th West Entries. MSHA scheduled another evaluation for the next day.

September 22, 1989

At 7:30 a.m. on September 22, 1989, teams A, B, and C, entered the mine, made their evaluations, and reported the results by 12:15 p.m. (Appendix E-14). Team A traveled to the water accumulation in the 2nd Main North Bleeder Entries. They found the water had receded approximately one-half inch since September 21, 1989. The teams found no methane reading greater than 2.0 percent or oxygen less than 18.2 percent at any of the air quality check stations. The teams found no methane readings above 1.0 percent or oxygen less than 19.5 percent in the accident area or any area where the investigators would work or travel. MSHA made the decision to begin the investigation that day.

At about 1:00 p.m. on September 22, 1989, the underground investigation began. The investigation team for the initial day consisted of MSHA personnel with observers from the State and Pyro. Two Pyro officials were used to monitor air quality and check for ventilation reversals. One monitor was located near the No. 14 Crosscut in the 4th West Entries and the other monitor was located in the 1st Main North Entries at the 5th West Entries. These monitors remained at their stations while the accident investigators worked in the 4th West Entries and longwall recovery area.

Each day, prior to investigators entering the mine, teams of personnel from Pyro and MSHA examined work areas and made air quality checks at the stations as shown on the map in Appendix FF. While investigators worked, Pyro officials monitored the atmosphere in the 4th West Entries and 1st Main North Entries.

Investigation of the Explosion

The investigation of the explosion area was commenced on September 22, 1989, after all areas where the investigation would be conducted were determined to be safe. Persons were stationed at strategic locations to continuously monitor air quality and direction from the bleeder system. The investigation was conducted jointly by MSHA and the Kentucky Department of Mines and Minerals along with the members of management and employees of Pyro Mining Company, as well as representatives of the miners from the Pyro No.

9 Slope, William Station Mine. Childers was appointed the Investigation Manager. Elam and Sakovich served as Technical Advisors. A list of those persons that participated in the investigation can be found in Appendix H.

A plan for the systematic exploration of the affected areas was established and reviewed with the various investigative teams prior to entering the mine. The area affected by the explosion was divided into three separate sections for investigation. The longwall face was the first area to be investigated, followed by the recovery rooms and then the 4th West Entries. This sequence of investigation was followed because of the deteriorating roof conditions on the longwall face and the recovery rooms which required additional roof support to be installed. Since the time of the explosion, several large roof falls had occurred in the recovery rooms due to the adverse roof conditions present. These roof falls completely covered a scoop tractor in the No. 3 Recovery Chute and a roof bolting machine at the mouth of the No. 2 Recovery Room. These two areas and pieces of equipment were inaccessible during the investigation.

The investigation was conducted by organized teams consisting of representatives from each participating organization, with one individual designated as the Team Leader. The "Photo and Collection of Evidence" team was designated as the first group to enter the various areas to be investigated, followed by the "Ventilation and Mapping / Flames and Forces" team. After these teams completed their work in a given area, the "Electrical" team and the "Inspection and Dust Survey" team followed. A list of MSHA personnel and their assignments can be found in Appendix G. Numerous other Pyro Mining Company personnel participated during the underground investigation. These personnel continually monitored the air quantity and quality throughout the longwall bleeder system, provided transportation, maintained communications, and provided assistance to the investigative teams when required.

The Photo and Collection of Evidence Team took 143 photographs of various scenes depicting explosion force-damaged equipment and heat-damaged materials in the areas explored. Selected photographs and their descriptions are in Appendix U. Also, 18 items of evidence were collected, photographed, tagged and identified, and receipted. Most of the items were heat-damaged materials collected for laboratory analysis. Several components of the methane and CO sensor system were also collected as evidence. These items and their laboratory analyses are listed in Appendices R and T.

The Ventilation and Mapping Team explored and mapped each area affected by the explosion. Ventilation controls and explosion damage, as well as the location of the victims and the equipment, were plotted on the maps. The maps created are located in Appendices Z, AA, BB, CC, and EE. Also, the team monitored and evaluated the Longwall Panel "O" ventilation during the investigation.

The Flames and Forces Team evaluated all areas affected by the explosion, in an attempt to determine the possible cause and origin of the ignition, the magnitude and direction of explosion forces, as well as the extent and path of flames. Also, a channel sample of coal was collected near the affected explosion area for analysis to determine the volatile ratio of the coal. The channel sample analysis is outlined in the Coal Dust section of the report.

The Electrical Team examined and tested all electric circuitry and equipment found in the affected area, in an attempt to find the origin of the ignition. Detailed inspections of all power circuits and all electric and mechanical components of the electric equipment were also conducted. The results of the examinations and tests are included in the Electric Circuits and Equipment and Mechanical and Miscellaneous Devices sections of the report. A detailed Computer-Aided-Design (CAD) drawing of the electric circuits and equipment in the affected area is contained in Appendix X, and a single-line diagram of the high-voltage circuits is included in Appendix W.

The Inspection and Dust Survey Team collected mine dust samples in three survey areas; the 1st Main North Entries, the longwall recovery room entries and the 4th West Entries. A total of 186 samples were collected and submitted for laboratory analysis to determine the percent of incombustible content and the presence of coke. The analysis of the mine dust samples are summarized in the Coal Dust section of the report and listed in Appendix Q.

The underground investigation was conducted in all accessible locations affected by the explosion. All existing conditions were evaluated and recorded on maps and notebooks by team members.

An Absolute Mine Ventilation Pressure - Air Quantity Distribution Investigation of the entire mine was conducted by MSHA on September 25-30, 1989. The results of this survey are listed in Appendix J.

Beginning on October 11, 1989, MSHA conducted 26 voluntary interviews with the survivors and persons involved with the initial rescue and recovery. People with knowledge of the events or conditions prior to the explosion were also interviewed. The interviews were conducted at the MSHA District Office in Madisonville, Kentucky. Each interview was recorded and transcribed, and copies were made available to each interested party. The transcripts were released to the general public on October 30, 1989. Those persons interviewed are listed in Appendix I.

DISCUSSION AND EVALUATIONS

Ventilation History of Longwall Panels "M", "N", and "O"

Longwall Panels "M", "N", and "O", were part of an area of longwall mining bounded by the 1st Main North, 8th West, 2nd Main North, and 1st Main West Entries. Longwall Panel "M" was the first longwall panel in this particular system and was located between the 6th West and 7th West Entries. Initial development for Longwall Panel "M" utilized three working sections, one each in the 6th West, 7th West, and 8th West Entries. Five entries were developed in the 6th West Entries, six in the 7th West Entries, and seven in the 8th West Entries. The 8th West Entries were connected to the 2nd Main North Bleeder Entries during August 1988, with these entries serving as the bleeder entries for Longwall Panel "M" and subsequent longwall panels. Set-up entries for Longwall Panel "M" were developed in a northerly direction and were then turned East to join the 7th West Entries. Longwall Panel "M" was ready to begin production as soon as the 7th West Entries were connected. By mid September, 1988, Longwall Panel "M" was ready to begin operation, but the 7th West Entries were not connected. Pyro decided to connect only the No. 1 Entry, or tailgate entry, of the 7th West Entries. The remaining entries were left separated by a distance of approximately 150 feet. According to Steele, the failure to connect these entries was not considered critical because the 2nd Main North Bleeder Entries and the 8th West Entries were functioning properly. However, the failure to connect the 7th West Entries reduced air flow through these entries and along the edge of the worked out areas of Longwall Panel "M". It also eliminated the potential use of the 7th West Entries as bleeder entries in the event the primary bleeder entries became ineffective due to water accumulations or roof falls. Since the 7th West Entries were projected to be connected to the 2nd Main North Bleeder Entries, a Section 104(a) citation had been issued on January 27, 1989, for failure to follow mining projections.

Longwall Panel "M"

Longwall Panel "M" began production during September 1988. Primary intake ventilation was coursed up the tailgate entry, the No. 1 Entry of the 7th West Entries, and across the active longwall face. Intake air was coursed up the Nos. 2, 3, and 4 Entries of the 6th West Entries with the belt air in the No. 5 Entry also directed toward the headgate. At the headgate, air coursed up the 6th West Entries, including the belt air in the No. 5 Entry, joined the return air from the longwall face and was directed inby toward the 2nd Main North Bleeder Entries. A portion of this return air traveled through the 2nd Main North Bleeder Entries and the 8th West Entries before entering the return aircourses of the 1st Main North Entries. The remaining portion of this return air was

directed from the 2nd Main North Bleeder Entries back down the No. 1 Entry of the 6th West Entries. This system of ventilation remained in effect for the duration of Longwall Panel "M".

The bleeder system for Longwall Panel "M" functioned properly until January 4, 1989, when MSHA inspectors from the Madisonville District Office issued two Section 104(a) citations for accumulations of methane. Methane concentrations of 2.5 percent and 3.0 percent were found in the connecting entries between the 2nd Main North Bleeder Entries and the 7th West Entries. (Analysis of bottle samples taken revealed 3.40 percent and 4.92 percent respectively.) One of the citations also stated that no air movement could be detected in these connecting entries. On January 5, 1989, MSHA inspectors from the Morganfield Field Office issued a Section 107(a) imminent danger order along with a Section 104(a) citation for a violation of the approved ventilation plan when 4.8 percent methane (analysis of bottle samples revealed 4.11 percent) was found in this same general area of the bleeders. Specifically, the methane was detected at the junction of the No. 1 Entry of the 8th West Entries and the No. 6 Entry of the 2nd Main North Bleeder Entries. When methane levels were reduced to 2.5 percent, the Section 107(a) imminent danger order was modified to allow production to resume as long as methane checks were made in the affected area at designated time intervals.

On January 27, 1989, ventilation specialists from the District 10 MSHA Office took pressure and quantity readings in the Longwall Panel "M" bleeder system. These measurements were made to evaluate the system and determine what effect the failure to connect the 7th West Entries had on the performance of the bleeder system. From the mouth of the 7th West Entries to the junction of the 2nd Main North Bleeder Entries, a pressure drop of 0.9 inch was measured. Although air flow in the 7th West Entries was considerably restricted due to the unconnected entries, the pressure drop across this area was in the proper direction.

Methane readings taken during this January 27th inspection revealed that methane concentrations from 2.1 percent to 3.4 percent (analysis of bottle samples revealed 3.19 percent) were present in the side bleeder, or No. 1 Entry of the 6th West Entries. A Section 104(a) citation was issued for methane readings exceeding the 2.0 percent limit imposed by the ventilation plan. Roof conditions in the No. 1 Entry of the 6th West Entries were extremely poor in by the longwall face and were restricting ventilation in this particular entry. Adjustments were made to reduce methane levels in this entry, and by February 3, 1989, the Section 107(a) imminent danger order as modified and all Section 104(a) citations still in effect on the bleeder system were terminated when methane levels were reduced to less than 1.4 percent. On February 4, 1989, production in Longwall Panel "M" was completed and the process of moving the longwall equipment began.

Longwall Panel "N"

Longwall Panel "N" was projected to be the same depth and width as Longwall Panel "M". Set-up entries were driven and connections from the 5th West Entries to the 2nd Main North Bleeder Entries completed. However, as Longwall Panel "M" retreated, roof conditions in the 6th West Entries deteriorated and Pyro was forced to change mining plans for Longwall Panel "N". New set-up entries were driven, which reduced the panel depth from approximately 5,000 feet to 2,170 feet. This change in projection, along with a change in the ventilation plan for Longwall Panel "N", was approved by the MSHA District Manager on February 16, 1989. Primary intake ventilation was coursed up the No. 1 Entry of the 5th West Entries and directed into Entries No. 2 and No. 3 as it neared the longwall headgate. From here, the intake air traveled through the headgate area and across the longwall face. Air used to ventilate the Nos. 2, 3, and 4 Entries of the 5th West Entries was directed inby toward the longwall headgate where it was regulated into the belt entry and traveled in an outby direction. In the five 5th West Entries inby the active longwall face, air was flowing toward the 2nd Main North Bleeder Entries. Return air from the longwall face split at the tailgate with some air traveling toward the 2nd Main North Bleeder Entries and the remaining air returning out the No. 1 Entry of the 6th West. Longwall Panel "N" started production in late February 1989, and used this system of ventilation until the longwall cut out in mid April 1989.

Longwall Panel "O"

The shortened Longwall Panel "N" resulted in Longwall Panel "O" being reduced in depth. Three-entry development of the 4th West Entries was stopped approximately 1,300 feet short of original plans in order to establish set-up entries for the longwall equipment being moved from the worked out Longwall Panel "N". Intake air for Longwall Panel "O" was coursed up the No. 2 Entry of the 4th West Entries, to and across the longwall face. The approved ventilation plan required a minimum of 15,000 cfm of air to be directed across the longwall face. The No. 1 Entry of the 4th West Entries served as a partial return from the inby end of the 4th West Entries and air flow in the No. 3 Entry, or belt entry, was directed outby where it joined the belt and haulage entries of the 1st Main North Entries. Intake air was also coursed up the tailgate entry, or the No. 1 Entry of the 5th West Entries. This ventilation system was in effect until sometime during June 1989, when the direction of air flow in the tailgate entry, or the No. 1 Entry of the 5th West Entries, was reversed. According to the approved ventilation plan, intake air was to be coursed up the tailgate entry of the 5th West Entries, join the return air from the active longwall face, and return up the 5th West Entries toward the 2nd Main North Bleeder Entries. During June 1989, Pyro changed the tailgate entry from an intake aircourse to a return aircourse. On July 1, 1989, MSHA issued a Section 104(d)(2) order for the unauthorized change. Pyro's decision to initiate the air reversal

was prompted by two conditions which disrupted air flow in the entire bleeder system. As Longwall Panel "O" approached the worked out areas of Longwall Panel "N", poor roof and squeeze conditions in the tailgate entries restricted return air flow up the 5th West Entries. Water also began to accumulate in the bleeder entries at the junction of the 2nd Main North Bleeder Entries and the 8th West Entries. The water accumulation blocked air flow through the bleeder system which forced the majority of the return air from the longwall face to return down the No. 1 Entry of the 5th West Entries and only perceptible air movement in an inby direction was present at the tailgate.

On June 29, 1989, MSHA Inspector Smith found 6.8 percent methane (analysis of bottle samples revealed 9.96 percent) at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries. Smith issued a Section 107(a) imminent danger order for the accumulation of methane and he issued two other Section 104(a) citations for violations of the approved ventilation plan. (Smith's violations identify the location of the methane as the No. 51 Crosscut. The crosscut and entry numbering scheme established during the investigation differs from the crosscut and numbering system commonly used by Pyro.) One citation stated that an effective bleeder system was not maintained, while the other cited 30 CFR 75.316 for methane in excess of the 2.0 percent limit mandated by the ventilation plan. Later that day, MSHA inspectors from the Morganfield Field Office, Madisonville District Office, and Pyro officials began traveling the bleeder entries and approaches to the worked out areas to determine the extent and cause of the methane accumulation. At the intersection of the set-up entries for Longwall Panel "O" and the 5th West Entries, 3.5 percent methane and 19.8 percent oxygen were detected. Exploration in the 8th West Entries revealed areas where the oxygen content was less than 19.5 percent. Due to the oxygen and methane readings in both of these areas, the water accumulation at the junction of the 2nd Main North Bleeder Entries and the 8th West Entries was believed to be the cause of the bleeder system failure. McDowell traveled to the water in the 2nd Main North Bleeder Entries on the evening of June 29, 1989, and entered his findings in the record book for weekly examinations of the bleeder system. McDowell noted that, "Water has accumulated in the northern most corner of the longwall bleeder, thus restricting the ventilation flow." He further stated that, "Efforts are underway to install a surface pump to lower the water, so that ventilation will be established."

On June 30, 1989, MSHA inspectors detected 5.0 percent methane and 17.1 percent oxygen in the 5th West Entries between the set-up entries for Longwall Panel "O" and the 2nd Main North Bleeder Entries. Additional methane readings were taken in the bleeder entries and in the return from the worked out areas at the mouth of the 5th West, 6th West, and 7th West Entries. Since concentrations of methane from 2.0 percent to 6.0 percent were still present in these areas, the Section 107(a) imminent danger order was modified to close the entire mine instead of only Longwall Panel "O". During this time, adjustments to the bleeder and ventilation

system were being made by Pyro officials to counter the effects of the water blockage. These changes included tightening existing ventilation controls, installing additional controls across the belt and haulage entries of the 1st Main North Entries, and opening the return regulators located at the mouth of the 5th West, 6th West, and 7th West Entries. Ventilation was also changed to course return air through the No. 1 Entry of the 2nd Main North Bleeder Entries to the water accumulation. Changes at the mouth of the 8th West Entries directed air flow through the No. 1 and No. 2 Entries of the 8th West Entries up to the water, and returned down the Nos. 6, 7, and 8 Entries of the 8th West Entries.

By July 1, 1989, the changes made to the bleeder and ventilation system were reducing methane levels in the 4th West and 5th West Entries. At 8:00 p.m. on July 1, 1989, the Section 107(a) imminent danger order was modified to allow Longwall Panel "O" to resume production as long as certain stipulations were followed. Continuous monitoring for methane and oxygen content was required one crosscut outby the tailgate in the No. 1 Entry of the 5th West Entries. Continuous monitoring for methane and oxygen content was also required at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries. The ventilation changes which were successful in reducing methane levels were submitted to the MSHA District Manager on July 2, 1989, and approved as a revision to the mine ventilation plan on July 3, 1989. These changes included the air reversal in the tailgate entry which resulted in the issuance of a Section 104(d)(2) order on July 1, 1989. This order was modified on July 1, 1989, to allow an evaluation of the bleeder system. Also on July 3, 1989, the Section 107(a) imminent danger order was modified to clarify requirements for methane and oxygen monitoring. Continuous monitoring for both methane and oxygen levels was still required at the tailgate with the additional requirement that the results be recorded. Monitoring of methane and oxygen at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries was to be conducted every 3 hours and the results also recorded. During July, monitoring by MSHA showed perceptible air movement toward the 2nd Main North Bleeder Entries in the 4th West Entries. Monitoring in the 5th West Entries at Spad 41+85 indicated airflow ranging perceptible to 5000 cfm toward the 2nd Main North Bleeder Entries. Air quality tests in the 4th West and 5th West Entries indicated oxygen concentrations above 19.5 percent and methane levels below 2.0 percent. The Section 104(d)(2) order was terminated on September 11, 1989, after the longwall had cut out.

The ventilation plan supplement approved July 3, 1989, showed airflow traveling in the No. 2 Entry of the 4th West Entries toward the set-up rooms and returning in the No. 1 Entry of the 4th West Entries. Air also traveled through the set-up rooms to the 5th West Entries. The investigators were unable to determine when this method of ventilation in the 4th West Entries was discontinued. MSHA developed numerous computer ventilation simulations during the investigation. These simulations are included in Appendix K and are discussed in more detail later in this report. Computer simulations of this method of ventilation were developed. The

simulations showed that if a regulator in the No. 49 Crosscut between Nos. 6 and 7 Entries of the 1st Main North Entries was fully open, the air would flow in the inby direction inby the No. 6 Crosscut in the No. 2 Entry of the 4th West Entries. This ventilation scheme provided the greatest quantity of airflow toward the 2nd Main North Entries in the No. 2 Entry of the 4th West Entries of all simulations analyzed. This regulator was found completely closed at the time of the investigation.

Ventilation plan supplements approved July 12, 1989, and July 21, 1989, outlined projections and procedures for connecting entries from the 2nd Main North Entries to the 2nd Main North Bleeder Entries. These entries were offset from the main entries due to adverse roof conditions in the 2nd Main North Entries. The connections were made on July 22, 1989, and a methane monitor was installed at the No. 74 Crosscut in the No. 1 Entry of the 5th West Entries on July 29, 1989. The methane monitor and an air flow monitoring device were connected to the mine-wide monitoring system.

The separation of the 2nd Main North Entries ventilation system and the longwall bleeder ventilation system in the cut-through entries was important. On July 24, 1989, Smith reported no movement of air in the 4th West Entries inby Crosscut No. 30 and in the 5th West Entries inby the set-up rooms. On July 27, 1989, Stanley and Ramsey found that when they opened the door in the No. 4 Cut-through Entry, the air would flow through the door toward the longwall. When they opened the mandoor in the No. 1 Cut-through Entry, that air would flow through the mandoor and split in the No. 1 Entry of the 5th West Entries. The air flowed toward the 2nd Main North Bleeder Entries and toward the longwall. On July 30, 1989, Roy J. O'Leary, CMS&H Inspector and Howard Meadows, Surface Safety Manager, traveled from the 2nd Main North Entries through the cut-through entries to the newly installed methane monitor in the 5th West Entries. O'Leary found a mandoor propped open in the stopping line installed in these cut-through entries, and issued a Section 104(a) citation for a violation of the ventilation plan. According to the citation, the stopping line separated the No. 4 Unit return from the longwall bleeders which contained the methane monitor. With the mandoor open, return air from No. 4 Unit traveled through the door toward the longwall face. Ramsey closed the mandoor and the citation was abated. O'Leary talked to McDowell on the surface and told him to be very careful about leaving the mandoores open. McDowell acknowledged the fact that leaving the mandoores open would short circuit the air toward the longwall. These occurrences indicated the importance of the separation of the 2nd Main North Entries ventilation system and the longwall bleeder ventilation system in the cut-through entries. The condition of the ventilation controls used to make that separation would affect the air flow in the longwall bleeder ventilation system.

On August 22, 1989, a supplement to the ventilation plan was approved by the MSHA District Manager which described the proce-

dures for connecting the 4th West Entries to the 2nd Main North Entries. By making these connections, the tailgate entries for the next longwall, Longwall Panel "P", were established. The condition of the ventilation controls used to make the separation between the 2nd Main North Entries ventilation system and the longwall bleeder ventilation system in the 4th West would also affect the airflow in the longwall bleeder ventilation system.

Longwall Panel "O" cut out on September 6, 1989. After the cut-out and up to the time of the explosion on September 13, 1989, changes in the ventilation controls were being made in order to facilitate removal of the longwall equipment and prepare for the new longwall face. During this period after the cut-out, methane accumulations were encountered on the longwall face, at the tailgate, and in the recovery chutes. According to the interviews conducted as part of the investigation, methane concentrations up to 2.0 percent were detected on the longwall face after the cut-out into the No. 3 and No. 4 Recovery Chutes. On Saturday, September 9, 1989, two workmen preparing to cut a sprocket retaining pin on the shearer found up to 6.5 percent methane near the No. 20 Shield. At approximately the same time on Saturday, September 9, methane concentrations from 1.0 to 2.0 percent were detected at the tailgate. Bowles helped Gary E. Johnson, Section Foreman, install curtains in the recovery entries to direct more air to the longwall face. Meanwhile, Jerry O. Hedgepath, Longwall Section Mechanic, and Pennington, who detected the 6.5 percent methane, were installing a line curtain at the headgate to direct more air to the area where the methane was found. Three foremen were on the longwall face during or immediately after the methane was detected, but no record was made in the on-shift or daily reports to indicate the presence of methane. Consequently, neither McDowell nor Steele, according to their statements in the investigation interviews, was aware of the methane accumulations until after the accident. Several miners who were not in the longwall recovery area when the methane was detected stated they were made aware of the methane accumulation and cautioned by their fellow workers. Once the methane was cleared from the immediate work site, no action was taken by mine management to determine the reason for the methane accumulations, other than to repair the damaged curtains in the recovery entries. Bowles stated during the interviews that after the longwall cut out, methane accumulations were normally not a problem and that it was unusual to encounter the methane readings they were finding. He further stated that he and Johnson assumed a roof fall had forced methane into the headgate area, but management did not travel in by the headgate area in the 4th West Entries to determine if this was the case or if methane was present.

Methane accumulations on Longwall Panel "O" were not limited to the time after the cut-out. Miners indicated during the investigation interviews that encounters with methane were common after the water accumulation blocked the bleeder entries during June 1989. Ronald W. Howton, Longwall Mechanic, stated that after the water appeared in the bleeders, "the gas was always right behind the shields."

He also stated "if you didn't have real good air, well, you always had a gas problem." According to Howton, methane levels would at times reach 6 to 7 percent at the tailgate. Several workers stated that it was common for the methane monitor on the longwall face to deenergize the longwall equipment due to methane accumulations on the face. Production delays due to methane accumulations on the longwall face were normally documented in the longwall section foreman's daily production reports. From June 5, 1989, through August 13, 1989, only 19 shift reports were available for review. This review showed that production was delayed or stopped on 50 occasions due to excessive methane levels. Thirty-three of these occasions reviewed occurred between June 5, 1989, and June 28, 1989. Only four production shifts were available for review for the month of July and three production shifts for the month of August. During this time period after June 28, production was delayed on 17 occasions due to excessive methane levels. Methane concentrations ranged from 2.0 percent to 3.1 percent and delayed production from 2 to 23 minutes.

Since production had ceased, the Section 107(a) imminent danger order issued was modified on September 11, 1989, to eliminate monitoring at the longwall tailgate and at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries. Continuous monitoring through the use of the methane monitor installed in the 5th West Entries was still required until a ventilation plan was approved for the operation of Longwall Panel "P".

Water Accumulations in the Bleeder System

The Kentucky No. 9 Coal Seam strike and dip was such in the Pyro No. 9 Slope, William Station Mine, that the intersection of the 2nd Main North Entries and the 8th West Entries was expected to be the area of the bleeder system with the lowest elevation. Coal seam elevations at this junction were 670 feet below mean sea level. In comparison, elevations at the mouth of the 4th West Entries were 520 feet below mean sea level. According to Canning, water accumulation in the northwest corner of the bleeders was expected and plans were made to provide pumping facilities at this location prior to the start-up of the first longwall, Longwall Panel "M". A borehole from the surface was started on July 27, 1988, to intersect the underground workings at the junction of the 2nd Main North Bleeder Entries and 8th West Entries. This borehole missed the underground workings as did a second borehole which was drilled during August 1988. A third borehole was started on September 1, 1988, but this hole was abandoned when the drill bit used to enlarge the diameter of the borehole became lodged in the hole. The fourth borehole was started on October 26, 1988, and finished on February 11, 1989. A 6-inch submersible pump was installed in the borehole on March 15, 1989, but was not energized since no water was present at the pump inlet.

During May 1989, Hunt reported to Pyro management that water was accumulating in the bleeder entries. On June 8, 1989, Hunt traveled through the area and noted in the weekly examination records that the water accumulation was approximately 1,000 feet long and 2 feet deep. Hunt stated during the interviews that on this date he declared that portion of the bleeders unsafe for travel and made subsequent examinations to the edge of the water. By the end of June 1989, water levels had risen further and completely blocked the bleeder entries at the intersection of the 2nd Main North Bleeder Entries and 8th West Entries. This was verified on June 29, 1989, when a Section 107(a) imminent danger order was issued for methane accumulations in the 4th West Entries. Canning estimated the initial water accumulation contained 8 million gallons and inflow was approximately 34 gallons per minute (gpm).

The submersible pump installed in March 1989, was energized on June 2, 1989, but this pump failed to pump any water. According to Canning, there was insufficient water at the pump suction inlet and the pump motor overheated. A second submersible pump was installed in the borehole on June 30, 1989, but this pump was defective and required repair. Efforts to reinstall the pump failed as did the installation of two 2-inch submersible pumps. On July 10, 1989, a 4-inch oil-well sucker-rod pump was installed, which started pumping 64 gpm on July 11, 1989. On July 17, 1989, adjustments were made to the pump which increased the flow rate to 75 gpm. This pumping rate continued until the time of the accident on September 13, 1989.

A fifth borehole was started on September 18, 1989, and a 4-inch oil-well sucker-rod pump was installed on the borehole on September 27, 1989. The combined output of both pumps was approximately 135 gpm. This pumping rate was effective in lowering the water level so that by the first week in October 1989, air was flowing over the water and through the area.

Ventilation During Longwall Recovery

During the recovery phase of Longwall Panel "O", Pyro made numerous changes to ventilation controls in the 4th West Entries and the recovery area of Longwall Panel "O". These changes were made to facilitate the removal of the longwall equipment. The changes included removal of the track doors, stoppings and curtains, and the installation of curtains at various locations. Near the end of mining in Longwall Panel "O", Pyro mined past the regulator that controlled air to the longwall panel.

Changes were also necessary in the 2nd Main North Entries area of the mine to prepare Longwall Panel "P" for mining operations. The changes involved incorporating Longwall Panel "P" into the bleeder

system that encompassed Longwall Panels "M", "N" and "O". Several stoppings were built and some were removed, and a track door was moved to separate the longwall bleeder system from the ventilation system in the 2nd Main North Entries. Some of the changes were completed prior to the explosion and others were underway at the time of the explosion.

In order to evaluate these changes in greater depth, MSHA conducted an Absolute Mine Ventilation Pressure - Air Quantity Investigation of the mine ventilation system on September 25-30, 1989. A report on the results of this investigation is contained in Appendix J. Information gathered during this investigation also provided a data base for MSHA to construct computer simulations of the various changes in the mine ventilation system. MSHA used the computer simulations to assist in analyzing how changes to different ventilation controls could affect the mine ventilation system. Assumptions necessary for these simulations were based on information received from company officials and from theoretical calculations. A report on the results of these simulations is contained in Appendix K.

Mining Past the Longwall Panel "O" Regulator

During the latter part of mining on Longwall Panel "O", Pyro maintained a regulator in the No. 1 Entry of the 5th West Entries between the Nos. 6 and 7 Crosscuts. The purpose of the regulator was to control the amount of air flowing across the longwall face and to maintain pressure against the gob. The longwall mined past the regulator sometime between August 31, 1989 and September 2, 1989. The exact time could not be determined from the investigation interviews and was not recorded in the Preshift-Onshift and Daily Report books. An examination of these books revealed that the quantities of air that were reported did not change significantly after the regulator was removed.

During the investigation, MSHA found that the No. 1 Entry in the 5th West Entries from the tailgate of the longwall to the return entries of the 1st Main North Entries had a high resistance to airflow. This was partially caused by the condition of the four overcasts in the 1st North Main Entries. The areas over the top of these overcasts were small and the approaches to the overcasts were abrupt. The investigators discovered roof falls in the No. 1 Entry of the 5th West Entries between the longwall tailgate and the No. 1 Entry of the 1st Main North Entries. These conditions had the same effect as a regulator and limited the quantity of air returning from the longwall to the 1st Main North Entries.

The cutting out of the regulator had a minimal effect on the ventilation of Longwall Panel "O" and the gob areas. Although the removal of the regulator was not critical to ventilation of the area in this instance, Pyro management failed to ensure that the location of the regulator was such that it would not be damaged by

mining without management's knowledge and assessment of the effects. The regulator could have been placed outby the recovery rooms for its protection. Additionally, management was unaware that the regulator was cut out.

Mining into Recovery Chutes

On September 6, 1989, the longwall mined into the recovery chutes. The recovery chutes were connected to and driven from the recovery rooms before the longwall began retreating. The investigation interviews revealed that curtains were installed in the recovery chutes between the face and the No. 1 Recovery Room in order to maintain air flow across the longwall face during mining. Once the longwall mined into the recovery chutes, air no longer flowed just across the face. Air could leak into and flow across the recovery rooms to the No. 1 Entry of the 5th West Entries. Shortly after the longwall cut into the recovery chutes, mining in Longwall Panel "O" ceased and Pyro began dismantling and moving the longwall equipment. The equipment was reassembled in the set-up entries for Longwall Panel "P", located between the 3rd West and the 4th West Entries near the 2nd Main North Entries.

Removal of Track Doors

After the longwall completed mining, Pyro dismantled and moved the metal doors installed across the track entry for the 4th West Entries. These doors had been installed in pairs to form an air-lock and were electrically operated. One door was located between the Nos. 2 and 3 Entries in the No. 51 Crosscut of the 1st Main North Entries. The other door was located in the 4th West Track Entry between the No. 1 Entry of the 1st Main North Entries and the No. 1 Crosscut of the 4th West Entries. While mining was in progress in Longwall Panel "O", the doors separated the air in the belt and haulage entries from the air in the intake entries. Some Pyro personnel stated in the investigation interviews that these doors prevented intake air from coursing into the 1st Main North Belt and Haulage Entries. During mining, it was normal for miners and equipment to pass through these doors to travel from the 1st Main North Track Entry to the intake entry for the longwall. McDowell stated in his investigation interview that the doors were taken to and assembled at the mouth of the No. 1 Unit. This unit began mining in the 2nd West Entries at about the time mining ceased in Longwall Panel "O".

MSHA computer simulations (Appendix K) indicated that the removal of these doors had a minimal effect on the ventilation across the longwall face or in the 4th West Entries inby the longwall face. The volume and direction of air on the longwall face and in the 4th West Entries remained about the same when the doors were removed.

Removal of Stoppings in the 4th West Entries

After the longwall cut out, Pyro removed concrete block stoppings from the Nos. 2 and 3 Crosscuts between the Nos. 2 and 3 Entries of the 4th West Entries. They also removed concrete block stoppings from between the No. 3 Entry and Nos. 2 and 3 Recovery Rooms. Pyro dismantled and removed the belt conveyor from the No. 3 Entry of the 4th West Entries at this time. The removal of the stoppings and the belt conveyor permitted equipment to pass into and out of the recovery rooms. Personnel interviewed during the investigation stated that brattice cloth curtains were installed in the crosscuts between the Nos. 2 and 3 Entries to direct intake air up the No. 2 Entry of the 4th West Entries. These interviews revealed that these curtains were often torn down from equipment passing through them and were not always immediately replaced. Interviewees stated that when the high concentrations of methane were detected at the face during the longwall recovery, these curtains were replaced or repaired to properly course the air and clear the methane. Without the curtains in place in the Nos. 2 and 3 Crosscuts, the intake air would course directly into the No. 3 Entry of the 4th West Entries and into the recovery rooms, leaving the intake entry with very little air flow. After the explosion, rescuers installed curtains in these areas to course air up the No. 2 Entry to clear the smoke so they could search for missing miners on the longwall face. During mine recovery, it was also necessary to maintain these curtains to course air up the No. 2 Entry.

Howton stated in his investigation interview that when he left the longwall recovery area at about 8:10 a.m. on September 13, 1989, a curtain was not installed in the No. 2 Crosscut between the Nos. 2 and 3 Entries in the 4th West Entries. He stated that there was a curtain in the No. 3 Crosscut. He further stated that there was "a lot of air" in the recovery rooms. He said a partial curtain was in place across two-thirds of the No. 2 Entry at the right inby rib of the No. 6 Crosscut. He also stated that there was a brattice cloth curtain across the No. 3 Entry from the left outby corner of the No. 6 Crosscut to the right inby corner of a room stub. This curtain prevented air from flowing back down the No. 3 Entry from the No. 6 Crosscut.

Recovery Room Curtains

During the investigation interviews, some personnel stated that brattice cloth curtains were installed in the recovery rooms to keep air flowing at the longwall face. MSHA attempted to establish the locations of these curtains but the exact locations could not be definitively established from the interviews. The most probable locations are shown on a map in Appendix DD. Failure to install curtains in the recovery rooms would permit most of the air to flow through the No. 3 and No. 4 Recovery Rooms directly to the No. 1 Entry of the 5th West Entries. Bowles stated that when high concentrations of methane were found during the longwall recovery, recovery room curtains were replaced or repaired. These curtains

were placed in addition to the curtains between the Nos. 2 and 3 Entries of the 4th West Entries. Edens stated that a curtain was also installed under the first few shields to direct air across the face. Bowles reported that the installation of the curtains in the recovery rooms dissipated the methane that accumulated in the longwall face and at the longwall tailgate. Steele stated in his investigation interview that he installed curtains in the recovery rooms to improve air quality in their search for the missing miners. During the mine recovery, MSHA personnel found it necessary to maintain curtains in the recovery rooms to have adequate ventilation across the face. When the curtains were not maintained, MSHA personnel found that air escaped through the recovery chutes into the recovery rooms.

MSHA computer simulations indicated that the failure to maintain the recovery room curtains significantly decreased the airflow across the longwall face. The simulations also showed that failure to maintain curtains in the recovery rooms affected the air flow in the 4th West Entries inby the No. 6 Crosscut. Although the total amount of the changes was small, their effect contributed to the reduction of airflow in the 4th West Entries. Management's failure to maintain the curtains in the 4th West Entries and in the recovery rooms after the longwall cut out, significantly reduced the quantity of air traveling across the longwall face. This considerably reduced the capability to dilute methane that migrated to the face area.

Ventilation Plan Requirements

The approved mine ventilation plan, under a section entitled "Longwall Mining Plan", required that a "minimum of 15,000 cfm of air will be directed across the face of the longwall". The required quality and quantity of air necessary during longwall recovery were specified in 30 CFR 75.301. The last date a quantity measurement was entered into the Preshift-Onshift and Daily Report book was September 7, 1989, when Blair Lamb, Longwall Foreman, called out a reading of 21,000 cfm. Russell A. Faulk, Jr., Section Foreman, recorded 22,300 cfm on September 7, 1989. The preshift records indicated these were intake measurements, although the exact location where these readings were taken was not determined.

The ventilation plan also required that the air flow in the inby direction inby the longwall face in the No. 2 Entry of the 4th West Entries. After the issuance of the Section 107(a) imminent danger order on June 29, 1989, Pyro officials frequently monitored the air flow direction and quality in this entry. Bowles stated that he always detected a slight movement in the inby direction when he made his evaluations.

During the investigation interviews, MSHA attempted to determine if examinations of the airflow direction and quality inby the No. 6 Crosscut were made after the longwall ceased mining. The

management officials and firebosses interviewed, who were responsible for these examinations, indicated that these examinations were not conducted. Management failed to conduct examinations in the 4th West Entries inby the No. 6 Crosscut, after the longwall ceased mining, and therefore failed to find the accumulation of methane that led to the subsequent explosion.

Underground evaluations of the mine ventilation system made by MSHA on September 14 and 15, 1989, revealed that air inby the No. 6 Crosscut in the 4th West Entries drifted slowly outby to the No. 6 Crosscut. At the time of these evaluations, there was a framed brattice cloth curtain in the No. 1 Cut-through Entry. There were also curtains between the Nos. 2 and 3 Entries of the 4th West Entries and curtains in the recovery rooms. The installation of these curtains during the rescue attempt returned the air flow pattern to one similar to that prior to the explosion. The controls that separated the 2nd Main North Entries ventilation system from the bleeder system were not damaged by the explosion. During mine recovery from September 15-20, 1989, Pyro installed and changed various ventilation controls to re-establish the ventilation system. They changed controls in the 4th West Entries, the Longwall Panel "O" face, the recovery rooms, the 1st Main North Entries, the 1st Main West Entries, the 2nd Main North Entries, and the cut-through entries. These numerous measures failed to reverse the air flow pattern in the 4th West Entries inby the No. 6 Crosscut. At various times during the re-establishment of the ventilation system, methane accumulations were found in the 4th West Entries and in the 1st Main North Entries at the 6th, 7th and 8th West Entries bleeder returns.

Methane Migration

The headgate corner of Longwall Panel "O" was the highest elevation point in the longwall bleeder system. The coal seam dipped from this corner toward the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries. This made the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries the lowest elevation point and was where the water accumulated in the bleeder system. Methane is lighter than air and migrates to and accumulates in the cavities above the gob. When a very small or no pressure drop exists across the gob, and methane continues to accumulate, it migrates out at the highest elevation point. Pyro failed to maintain the proper pressure differential across the Longwall Panel "O" gob. Methane migrated out of the gob and accumulated in the No. 2 Entry of the 4th West Entries and near the longwall headgate.

Longwall Panel "P"

Longwall Panel "P" was planned as the fourth longwall panel on the bleeder system. To assemble longwall equipment in the set-up entries, Pyro transported equipment to these entries through the

2nd Main North Entries. Sometimes Pyro transported equipment and personnel through the 3rd West Entries off the 1st Main North Entries to the set-up entries. At the top of the 3rd West Entries, just outby the set-up entries, concrete block stoppings separated these entries from the 3rd West Entries. Air leaked from the set-up entries through these stoppings into the 3rd West Entries and flowed to the 1st Main North Entries. A mandoor in the stopping in the No. 2 Entry provided access to these entries.

The No. 4 Unit was developing in the 2nd West Entries, approximately 500 feet off the 2nd Main North Entries. This was a continuous miner section, driving three gate entries east for the subsequent longwall panel and had been mining only a brief period.

Pyro ventilated the Longwall Panel "P" Set-up Entries and where the longwall equipment was being assembled with return air from the No. 4 Unit. The return air from the unit flowed back to the No. 9 Entry of the 2nd Main North Entries and inby to the No. 1 Entry of the 3rd West Entries. The air coursed through the 3rd West Entries and across the set-up entries to the 4th West Entries and back to the 2nd Main North Entries. Concrete block stoppings installed between the Nos. 50 and 51 Crosscuts in the 4th West Entries prevented the air in the 2nd Main North Entries from entering the bleeder system. Concrete block stoppings in the Nos. 1 through No. 4 Cut-through Entries also prevented the air in the 2nd Main North Entries from entering the bleeder system. However, air leaked through the stoppings and provided a significant portion of the air flow in the western regions of the bleeder system. MSHA computer simulations (Appendix L) indicated that leakage through these six stoppings did have an impact on the ventilation in the bleeder system.

Pyro officials had previously scheduled a meeting with MSHA officials on Friday, September 15, 1989 to obtain approval of the ventilation plan before mining in Longwall Panel "P". Pyro projected that mining would begin in Longwall Panel "P" on Sunday, September 17, 1989. Numerous changes had to be made to the ventilation controls in the 2nd Main North Entries of the mine prior to beginning mining operations in Longwall Panel "P". Pyro intended to make the necessary changes and to evaluate the effect of the changes by making air quantity measurements before meeting with MSHA.

Steele indicated that McDowell scheduled a meeting on September 11, 1989, with Pyro officials to discuss the needed changes. Steele volunteered to attend the meeting, but McDowell did not think his presence was necessary. The meeting on September 11, 1989, failed to occur. When Steele met McDowell and Clifford underground on Tuesday, September 12, 1989, he found out that the meeting had not been held and instructed McDowell to have the meeting. Steele, McDowell, Clifford, and Ramsey discussed the ventilation changes while underground. They returned to the surface and met in McDowell's office late Tuesday afternoon, September 12, 1989. Steele, McDowell, Griffin, Keith, Canning and Ramsey

attended the meeting and discussed the ventilation of Longwall Panel "P". The ventilation would be similar to the ventilation of Longwall Panels "M", "N", and "O" and the bleeder system would encompass those four panels. The officials discussed the changes to be made to the various ventilation controls including the construction and removal of several stoppings in the 2nd Main North Entries. Ramsey assigned Jesse O'Rourke, Assistant Mine Foreman, to complete the changes during the 2nd shift on September 12, 1989. Steele and Canning planned to evaluate the changes and make air quantity measurements to record on a map during the day shift on September 13, 1989.

Ramsey instructed O'Rourke to make the following ventilation changes: construct two stoppings at the mouth of the 3rd West Entries; rebuild a concrete block stopping between the Nos. 1 and 2 Entries near the No. 15 Crosscut in the 3rd West Entries; build stoppings across the Nos. 2 and 3 Entries between the No. 8 Entry of the 2nd Main North Entries and the No. 63 Crosscut of the 3rd West Entries; move a track door from the No. 35 Crosscut between the Nos. 5 and 6 Entries of the 2nd Main North Entries to the No. 1 Entry of the 3rd West Entries between the No. 8 Entry of the 2nd Main North Entries and the No. 63 Crosscut of the 3rd West Entries; knock out a stopping in the No. 8 Entry of the 2nd Main North Entries between the Nos. 38 and 39 Crosscuts; and, build a stopping in the No. 46 Crosscut between the Nos. 6 and 7 Entries of the 2nd Main North Entries. Ramsey listed these changes in the investigation interviews and stated that the purpose of the changes was to isolate the No. 4 Unit return from the new face line.

O'Rourke directed personnel on the 2nd shift to make the changes. The changes were not completed on the 2nd shift, so O'Rourke stayed through the 3rd shift to direct the work. When O'Rourke came to the surface on the morning of September 13, 1989, he discussed the changes made with Ramsey. He told Ramsey about a stopping that needed to be built which had not been included in his assignment. This stopping was needed in the No. 47 Crosscut between the Nos. 6 and 7 Entries of the 2nd Main North Entries.

Removal of the Stopping

During the meeting of September 12, 1989, Pyro officials discussed the removal of the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries. It was decided that Ramsey would have the stopping removed on the morning of September 13, 1989. The removal of the stopping in the cut-through would permit air to travel from Longwall Panel "P" into the bleeder system. During the discussion about the effects of removing the stopping, Ramsey asked what direction the air would flow when the stopping was removed. Canning stated that the air from the cut-through entries would flow toward the water located at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries. Canning thought that the manddoors in the stoppings of the Nos. 1 and 4 Cut-through Entries were propped open. Hunt stated in the investigation interviews

that he regularly traveled the area and that the doors were always closed. Ramsey stated that when he was in the area, he traveled through the door in the stopping located in the No. 4 Cut-through Entry and it was always closed. O'Leary found the mandoor open on July 30, 1989, and issued a Section 104(a) citation for a violation of 30 CFR 75.316 and the door was closed.

MSHA computer simulations showed that for all ventilation schemes analyzed, that when the stopping was being dismantled, air would flow in the 4th West Entries toward the longwall recovery area (Appendix K). These findings were critical because methane had accumulated in the No. 2 Entry of the 4th West Entries inby the No. 6 Crosscut. Air flow toward the No. 6 Crosscut would push methane that had accumulated to the longwall face. The effects of the stopping being one-half and totally removed were simulated. There was little difference found between either simulation. This showed that by the time the stopping was one-half removed that the separation between the 2nd Main North Entries ventilation system and the longwall bleeder ventilation system was destroyed. During the recovery and the investigation, the separation of these systems was maintained by stoppings. At all times during the mine recovery and the investigation, air flowed toward the longwall recovery area in the 4th West Entries.

On the morning of September 13, 1989, Ramsey returned to the mine between 5:00 a.m. and 5:30 a.m. and routinely reviewed work sheets to determine the progress of various assignments. Prior to going underground, he briefly discussed with Steele the removal of the stopping located in the No. 1 Cut-through Entry. Ramsey told Steele that he would remove the stopping. Steele told Ramsey to complete the ventilation work in that area by 10:30 a.m., so Steele and Canning could make air measurements for the scheduled meeting with MSHA. After discussion with O'Rourke, Ramsey assigned personnel to meet him near the end of the 2nd Main North Entries. When Ramsey arrived there, he met Hunt, and Hunt informed him that water was building up in the No. 48 Crosscut of the 2nd Main North Entries and asked if the stopping line could be moved back one crosscut. This would permit Hunt to travel through the area to make his examinations without having to travel in the water. This change would necessitate the building of two stoppings instead of one. These two stoppings would be built in the Nos. 5 and 6 Entries between the Nos. 46 and 47 Crosscuts. Ramsey instructed personnel to build the stoppings in those locations and took Jones with him to the No. 1 Cut-through Entry.

When Ramsey and Jones arrived at the stopping in the No. 1 Cut-through Entry, they found the mandoor closed. After Ramsey instructed Jones to start knocking down the stopping, he went through the mandoor. He told Jones he was going to open the door in the stopping in the No. 4 Cut-through Entry. He met Hunt and after a brief discussion, Hunt stated he would open the door. Ramsey returned to the location where Jones was working. Hunt opened the door and traveled to the water accumulations in the 2nd North Bleeder Entries.

While Jones was removing the stopping, the explosion occurred. Ramsey and Jones reported that they did not know it was an explosion. There was a sudden gush of air through the No. 1 Entry of the 5th West Entries. Ramsey reported that at that time, there was "around half of it, maybe a little more" of the stopping removed. Ramsey thought the gush of air was caused by a rock fall. When they finished removing the stopping, Ramsey took an air measurement and found 19,000 cfm flowing through the entry. Ramsey did not evaluate which direction the air flowed after it intersected the No. 1 Entry of the 5th West Entries.

Ramsey sent Jones to help the other personnel build the stoppings. Ramsey went to the new longwall tailgate to check air flow at a stopping there. When he arrived, someone informed him that something serious had happened on the old longwall. Ramsey went to his crew and told them he was going to a phone. On his way to the phone, Ramsey met Gary F. Browning, Utilityman, and was informed by Browning that everyone was to evacuate the mine. Ramsey returned to his personnel and instructed them to depart the mine. He then located Hunt near where the stopping was removed and told him to leave the mine. Ramsey helped evacuate other people from the mine and then traveled to the accident area.

Summary

Pyro changed the longwall bleeder ventilation system after an accumulation of water at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries blocked air flow in the bleeder system. On July 22, 1989, Pyro completed mining the Cut-through Entries between 2nd Main North Entries and the 5th West Entries. In late August 1989, Pyro completed mining the 4th West Entries between the 2nd Main North Entries and the set-up rooms. The combination of the change in the longwall bleeder ventilation system and the connections with the 2nd Main North Entries caused a fragile balance to exist in the longwall bleeder ventilation system.

Pyro made a series of changes to ventilation controls in the 4th West Entries and in the longwall recovery area prior to the explosion. These changes significantly reduced the airflow across the longwall face and affected the fragile balance in the longwall bleeder ventilation system. The ventilation changes and their effects were as follows:

Mining Past the Regulator - The cutting out of the regulator had a minimal effect on the ventilation of Longwall Panel "O" primarily due to the high resistance to air flow in the No. 1 Entry of the 5th West Entries;

Mining Into Recovery Chutes - Once the longwall mined into the recovery chutes, it became more difficult to maintain air flow on the longwall face and pressure against the gob. The installation of curtains in the recovery chutes became crit-

ical to the ventilation of the longwall face, the gob, and recovery area;

Removal of Track Doors - The removal of these doors had a minimal effect on the ventilation across the longwall face or in the 4th West Entries inby the longwall face;

Removal of Stoppings in the 4th West Entries - The failure to maintain curtains in the 4th West Entries where stoppings had been removed greatly reduced the air flow to the No. 6 Crosscut and across the longwall face; and,

Recovery Room Curtains - The failure to maintain curtains in the recovery rooms significantly decreased the air flow across the longwall face and contributed to the reduction of air flow in the 4th West Entries. This considerably reduced the capability to dilute methane that migrated to the face area.

The combination of the above described ventilation changes and connections in the 4th and 5th West Entries permitted methane to migrate from the gob and to accumulate in the No. 2 Entry of the 4th West Entries inby the No. 6 Crosscut and near the longwall headgate. The ventilation changes and connections were contributing factors to the cause of the accident.

Examinations

Preshift examinations for the active longwall section and other producing units were conducted by a certified foreman on the unit and results of the examinations were called to the surface where the examination record books were kept. The oncoming foreman for each respective unit received the call and documented the report in the preshift books. The foreman making the examination signed the books when he reached the surface. Outby areas requiring preshift examinations or those sections which were idle prior to an oncoming shift were examined by a designated fireboss.

A review of longwall preshift records kept prior to the accident revealed inadequacies in the method of recording the examinations. Longwall preshift records from September 3, 1989, to the time of the accident on September 13, 1989, failed to show the actual time of the examinations in that shift times, such as 11:00 p.m. to 9:00 a.m. or 7:00 a.m. to 5:00 p.m., were recorded instead of the actual examination time. The books also consistently failed to indicate the time the examination was reported to someone on the surface. Once the longwall cut out and began moving, confusion existed over the requirements of preshift regulations. Several management personnel responsible for preshift examinations indicated during the investigation interviews that they believed a preshift examination was not required while the longwall was moving. Consequently,

preshift books reflected this misconception and failed to show required information. The records showed shift hours worked instead of the actual times of the preshift examination, and for six shifts during the period of September 7, 1989, through September 10, 1989, no examination times were recorded. Also, the examination books failed to indicate that a preshift examination was conducted in the longwall recovery area prior to the midnight shifts of September 7 and 9, 1989.

Two foremen were assigned to the longwall recovery unit for the midnight shift on September 13, 1989. Jerry Corbin, Shield Operator, who was substituting as a section foreman, worked the regular midnight shift, 11:00 p.m. to 9:00 a.m. Faulk (Section Foreman) was working an extra shift, or "fifth" day, and was assigned to work from 1:00 a.m. to 5:00 a.m. Faulk stated during the investigation interviews that he made an examination of the Longwall Panel "O" face at approximately 2:30 a.m. to 3:00 a.m. and detected 0.3 percent methane at the tailgate and 0.6 percent at the headgate. He further stated that he made the examination for his own purposes, that is, he wanted to "see what was there," and was not conducting a preshift examination for the oncoming day shift. From the longwall recovery area, Faulk traveled to the new longwall set-up and did not return to the recovery area for the remainder of his shift. Corbin split his time between the longwall recovery area and the new longwall face, with the majority of his time spent in the recovery area. At the beginning of his shift, Corbin made methane checks on the Longwall Panel "O" face near the No. 2 Recovery Chute and at the headgate. At both places he found 0.1 percent methane. At approximately 5:30 a.m., Corbin phoned the surface to report his progress to Reed (Victim - Longwall Coordinator) and to discuss his plans for the remainder of his shift. According to Corbin's statements during the investigation interviews, this phone call did not constitute the call-out for the preshift examination. Corbin remained in the recovery area until the day shift crew arrived. He left the area some time after 8:00 a.m. on September 13, 1989.

Preshift records for the midnight shift of September 13, 1989, contain the entry "Idle-Moving", but show no time of examination and do not indicate when the examination was reported to the outside or who received the call. Both Faulk and Corbin made examinations of the longwall recovery area at various times during their shift, but neither foreman conducted a preshift examination of the longwall recovery for the oncoming day shift of September 13, 1989. The examinations made by Faulk and Corbin were also not complete, in that approaches to abandoned areas were not examined. The immediate area inby No. 6 Crosscut in the 4th West Entries was not examined to determine whether the air was traveling in its proper course and normal volume.

Deficiencies in the preshift records indicated mine management failed to ensure that personnel responsible for the preshift examinations were aware of the record keeping requirements of 30 CFR 75.303. Mine management also failed to ensure that examination

requirements of 30 CFR 75.303 were followed in the longwall recovery area. Foremen responsible for the preshift examinations were generally unaware that a preshift was required after the cut-out, when the examination was to be made, and what areas had to be examined.

On-shift examinations on working sections and the active longwall unit were conducted by the section foreman. Records of the longwall on-shift examinations from September 3 through 6, 1989, showed normal conditions were present and methane readings were all less than 1.0 percent. Beginning on September 7, 1989, after the longwall cut out, and continuing to the shift of the explosion, the on-shift and daily records typically showed the longwall as "Idle-Moving", and contained little if any other information. With the exception of a roof fall noted on September 7, 1989, the on-shift and daily report records indicated no hazardous conditions were present and none were reported to the foreman who signed the books. During interviews conducted as part of the accident investigation, miners stated that at various times methane levels in excess of 2.0 percent had been detected along the longwall face, tailgate, and in the recovery chutes. Specifically, methane in concentrations from 6.5 to 9.0 percent were reportedly found on the longwall face on Saturday, September 9, 1989. Foremen in the recovery area were aware of this concentration and participated in the ventilation changes to remove the methane from the face. Daily reports by the mine foreman and his assistants required by 30 CFR Section 75.324 failed to record this hazardous condition or show the action taken to correct the condition. This failure by management to record the methane accumulations corresponds with statements made by management personnel during the investigation interviews, that it was not a practice to document high methane readings. In addition, the mine foreman and his assistants did not make a daily report for the longwall recovery area on the midnight shifts of September 8, 9, and 10, and on the day shift of September 12, 1989.

Weekly examinations for hazardous conditions and weekly ventilation examinations as required by 30 CFR Sections 75.305 and 75.306, were the responsibility of Hunt. Hunt was also required to examine the longwall bleeders on a weekly basis. According to Hunt, he first notified management in May 1989, that water was accumulating in the longwall bleeder system. His weekly records show that on June 6, 1989, water was at the upper end of the bleeders approximately 1,000 feet long and 2 feet deep. After this date, Hunt stated that the water was too deep to safely travel, and he would only examine to the edge of the water.

Weekly records from June 8 through September 7, 1989, inconsistently note the existence of water. Records of longwall bleeder examinations conducted on June 15, June 22, August 10, and August 17, 1989, failed to note the presence of any water. In addition, although the records do not indicate a change, the route of examination was altered after June 8, 1989, due to the water obstruction at the intersection of the 2nd Main North Bleeder Entries and the

8th West Entries. Hunt would usually approach the water from the 2nd Main North Entries and return by the same route. The route up the 8th West Entries to the water was traveled occasionally by Hunt, but not on a weekly basis. On one of his trips to this area, he detected over 2.0 percent methane, less than 19.5 percent oxygen, and very little, if any, air movement at the water. The specific date of these readings was not entered in the weekly books nor was the fact that the 8th West Entries was examined. During this time, only one reference was made to the 8th West Entries. This reference was made on July 1, 1989, when a foreman traveled to the water and made minor changes in stoppings to increase the amount of ventilation sweeping the edge of the water.

Methane Drainage Boreholes

The mine ventilation plan approved the use of methane pumps installed on the boreholes to aid in the control of methane in longwall pillared areas. Pyro drilled boreholes from the surface to the coalbed in advance of retreating longwall panels and installed pumps on the boreholes. The boreholes were encased in steel to within approximately 125 feet above the coalbed. The pumps were started after the longwall retreated past the borehole. The methane gas was pumped to the surface and exhausted to the atmosphere. The pumps were fueled by the methane exhausting from the boreholes.

The boreholes were located about midway across each longwall block to be mined. Longwall Panels "M" and "N" each had one 5-inch borehole located near the top of the respective coalblocks. Longwall Panel "O" had two 5-inch boreholes, No. DH477 near the top of the panel and No. DH479 near the bottom of the panel. Borehole No. DH479 was located across from the No. 15 Crosscut of the 4th West Entries. This borehole was nearest the accident area.

The methane pumps in use at the Pyro No. 9 Slope, William Station Mine were skid-mounted units consisting of a positive displacement exhauster connected by a V-belt to a 2- or 4-cylinder internal combustion engine. The pumps in use at the time of the explosion were Peabody Holmes Models HR 80/23 and HR 80/21. The nominal operating parameters are 1,500 revolutions per minute (rpm), 120 inches water gage (wg) vacuum on the well with the pumps exhausting 200 to 250 cfm of methane through the well.

The concentrations of methane pumped decreases over time from an initial value of 80 to 95 percent methane down to about 40 percent methane. When the concentration of methane drops to about 40 percent, there is insufficient methane to operate the engine. When this occurs, a check valve in the borehole allows the hole to vent by natural pressure. During the investigation interviews, Canning confirmed that the boreholes continue to vent by natural pressure even after the pumps stop. He stated that this venting exists

though there is a negative ventilation pressure in the mine due to the main mine fan. He also stated that about one half of the pumps can be restarted after reaching the starve point. The methane concentration rises in the area penetrated by the borehole, enabling the pump to be restarted. The methane concentration in the air exhausting from the hole must be above 45 percent in order to restart the pump. A full-flow flame arrestor is installed at the well head to prevent any accidental methane ignitions from propagating into the mine.

A log of the methane pump history was kept for Longwall Panels "M" through "O". The log showed that the pump on Longwall Panel "M" started on January 5, 1989, and ran about 50 percent of the time until it finally stopped on March 7, 1989. The last methane level recorded was 48 percent on February 2, 1989. The pump operated only 50 percent of the time due to problems with the pump. The pump of Longwall Panel "N" was started on March 28, 1989, and ran about 90 percent of the time until it stopped on May 30, 1989. The last methane level recorded was 52 percent on May 24, 1989.

The pump on Borehole No. DH477, near the top of Longwall Panel "O", was started on May 28, 1989, and ran approximately 75 percent of the time until it stopped on August 26, 1989. The methane concentration was checked on August 28, 1989, and found to be 40 percent. The pump on Borehole No. DH477 was restarted on September 16, 1989, and ran continuously during the mine recovery and investigation. The methane level on September 20, 1989, was recorded as 75 percent. The pump on Borehole No. DH479, near the bottom of Longwall Panel "O", never operated satisfactorily. Canning reported that each time the pump was started, it would run until it reached the limits of its operating capabilities and would then stop. Canning stated that this would occur quickly after starting the pump and attributed this problem to too much resistance in the hole.

Environmental Monitoring System

On November 4, 1987, a Section 101(c) Petition for Modification (PFM) for the application of 30 CFR 75.1103-4(a) was granted for the Pyro No. 9 Slope, William Station Mine. This petition permitted the mine to use a low level CO monitoring system in lieu of point-type heat sensors for its automatic fire sensor and warning device system required on the belt conveyor systems. A copy of this PFM is included in Appendix L.

Continuous Monitoring System

The company utilized a Conspec Model 200 continuous monitoring system installed to comply with the provisions of the PFM. A total

of 29 CO sensors were installed throughout the belt entries. Pyro also installed other types of sensors to obtain additional information for their own use. These included two methane sensors, one velocity sensor and numerous other sensors to monitor various conveyor belt functions, main fan functions, and the longwall emulsion system functions. The surface control system was equipped with a computer that employed trending and graphic options, audible and visual alarms, a color monitor and a printer for obtaining a hard copy of any data.

A map showing the locations of the CO, methane and velocity sensors is shown in Appendix L. The CO sensors were located to continuously monitor the air at each belt drive, each belt tailpiece and at intervals not to exceed 2,000 feet along each conveyor belt entry. One methane sensor (M-19) was located in the No. 1 Entry between the Nos. 73 and 74 Crosscuts of the 5th West Entries. The other methane sensor (M-22) was located in the return entry adjacent to the Mitchell Station Shaft. The air velocity sensor (F-23) was located at the same location as the methane sensor (M-19) in the 5th West Entries.

Sensor Calibration and Examination

The PFM required that the CO sensors were to be visually examined at least once each coal-producing shift and tested for functional operation every seven days. The sensors were to be calibrated with known concentrations of CO at intervals not exceeding 30 days. Since the methane and velocity sensors were not required by Federal regulations or the PFM, the examination and calibration of these sensors was not required by MSHA. According to records, the CO sensor at the mouth of the 4th West Entries (CO-13), which was the CO sensor nearest to the explosion area, was calibrated on August 21, 1989. The methane sensors located in the 5th West Entries (M-19) and in the return entry adjacent to the Mitchell Station Shaft (M-22) were calibrated on August 30, 1989. Records indicated that these sensors were operating properly.

Installation of Sensors in the 5th West Entries

On July 29, 1989, approximately one month after a Section 107(a) imminent danger order was issued for accumulations of methane in the 4th West Entries, a methane sensor (M-19) and a velocity sensor (F-23) were installed in the No. 1 Entry between the Nos. 73 and 74 Crosscuts of the 5th West Entries. These sensors remained in operation until after the explosion.

During the investigation, a nonpermissible outstation power supply box (blue outstation) was found in the No. 1 Entry of the 5th West Entries near the sensors. Although the blue outstation was equipped with the appropriate barriers that permit it to be connected to sensors that were installed in areas where permissible equipment

is required, the outstation was not permissible. Additionally, the velocity sensor found in the No. 1 Entry of the 5th West Entries was not approved as permissible.

Response of Methane and Velocity Sensors

From 12:00 a.m. until 8:56 a.m. on September 13, 1989, the methane sensor (M-19) located in the No. 1 Entry of the 5th West Entries indicated that the methane concentration varied between 0.59 and 0.62 percent. At 8:56 a.m., the methane concentration began to drop quickly. By 9:20 a.m., the methane concentration leveled off at 0.16 percent (Appendix L). The change in the methane concentration corresponds to the time that the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries was being removed. Computer ventilation simulations (Appendix K) indicate that the air in the 5th West Entries in by the set-up rooms would flow towards the 2nd Main North Entries prior to the removal of the stopping in the No. 1 Cut-through Entry. The simulations also indicate that the air would reverse in the 5th West Entries in by the set-up rooms and would flow away from the 2nd Main North Entries toward the longwall tailgate after the removal of the stopping in the No. 1 Cut-through Entry. The air entering the 5th West Entries from the No. 1 Cut-through Entry contained less methane than was present in the 5th West Entries. This air would flow away from the 2nd Main North Entries and would pass over the sensor causing a reduction in the methane. Therefore, it was concluded that the methane sensor in the 5th West Entries responded to changes in the ventilation system caused by the removal of the stopping in the No. 1 Cut-through Entry.

Stewart, in his investigation interview, stated that the velocity sensor (F-23), which was located at the same location as the M-19 methane sensor in the 5th West Entries, was not operating correctly at the time of the explosion. Therefore, the velocity sensor readings from this location did not provide any useful information during the investigation.

The methane sensor (M-22) located in the return entry adjacent to the Mitchell Station Shaft was not operating properly from 12:00 a.m. on September 13, 1989 until the time of the explosion. Therefore, the methane sensor readings did not provide any useful information during the investigation.

Response of the CO Sensors

At 9:13 a.m., the CO sensor at the mouth of the 4th West Entries (CO-13) indicated that the CO concentration increased from 6 ppm to a maximum reading of 50 ppm (Appendix L). This was the time immediately following the explosion when the CO sensor was saturated with CO. Because the sensor reads CO in a range of 0 to 50 ppm, the actual concentration could not be determined. The CO

sensor (CO-44) located at the mouth of the 3rd West Entries in the 1st Main North Entries was not affected by the CO given off after the explosion.

After the Explosion

At 9:40 a.m., the remaining mine power was deenergized and the battery back-up power system for the monitoring system was activated. It was required to provide a minimum of four hours of operating time. At 10:03 a.m., the 4th West Entries CO sensor (CO-13) suddenly dropped to zero. The sensor had become saturated with the higher concentrations of CO and failed. The system continued to operate until 4:06 p.m. when the battery back-up power system deenergized.

Self-Rescuers

Each underground employee at Pyro No. 9 Slope, William Station Mine, was provided with a filter-type self-rescuer, which they carried with them. The filter-type self-rescuers provided were MSA Model W-65 and Drager Model 910. A calibration program was in effect utilizing a 90-day schedule for weighing.

Nine W-65 self-rescuers were used during the initial escape attempts after the explosion. Each of the four survivors used a W-65 self-rescuer in his escape. From the survivors' accounts, some of the victims encountered trouble donning the filter-type self-rescuers. According to the survivors, several of the victims removed their self-rescuers in an attempt to communicate verbally with each other.

Drager OXY-SR60B self-contained self-rescuers (SCSRs) were provided for underground employees at various underground storage locations. A storage plan was in effect, providing SCSRs at various locations throughout the mine. These locations included storage on the working sections, conveyor belt-heads, and on mantrips. Storage on the longwall panels consisted of 12 SCSRs at both the headgate and the tailgate. However, at the time of the explosion, the SCSRs at the tailgate had been removed with the tailgate equipment and the SCSRs at the headgate had been moved to the 4th West Track Entry.

Only SCSRs were used for the rescue and recovery attempts. During this time, several problems occurred while using the SCSRs. The problems included crimping of the hoses and the SCSR becoming too hot to wear. Also, there were a few unexplainable instances of the loss of breathable air by the SCSR user.

Atmospheric Pressure

Atmospheric pressures recorded by the National Weather Service at Evansville, Indiana, and Paducah, Kentucky, from September 5, 1989 to September 13, 1989, were as follows:

<u>Date</u>	<u>Time</u>	<u>Atmospheric Pressure</u>	
		<u>Evansville</u>	<u>Paducah</u>
September 5	9:00 a.m.	29.770	29.770
September 6	9:00 a.m.	29.720	29.735
September 7	9:00 a.m.	29.670	29.685
September 8	9:00 a.m.	29.600	29.615
September 9	9:00 a.m.	29.485	29.485
September 10	9:00 a.m.	29.570	29.605
September 11	9:00 a.m.	29.650	29.665
September 12	9:00 a.m.	29.730	29.725
September 12	9:00 p.m.	29.705	29.695
September 13	12:00 a.m.	29.700	29.685
September 13	3:00 a.m.	29.660	29.640
September 13	6:00 a.m.	29.660	29.655
September 13	7:00 a.m.	29.660	29.665
September 13	8:00 a.m.	29.660	29.675
September 13	9:00 a.m.	29.680	29.685
September 13	10:00 a.m.	29.670	29.685
September 13	11:00 a.m.	29.660	29.665
September 13	12:00 p.m.	29.640	29.655

It was the consensus of the those involved in the investigation that the slight fluctuations of the atmospheric pressure had no bearing on the occurrence of the explosion.

Coal Dust

During the investigation, one standard channel sample of coal was taken by MSHA. This sample was collected at the 0 + 300 ft. mark in the coal pillar between the No. 1 and No. 2 Entries of the 4th West on September 25, 1989. The location of the sample is shown on the map in Appendix GG.

A proximate analysis is performed on the channel sample, which identifies the percentage of moisture, volatile matter, fixed carbon, and ash present in the sample. The volatile matter and fixed carbon are then used to determine the volatile ratio. From this analysis, the classification of coal can also be determined. A channel sample of coal was taken from the mine in the explosion zone on September 26, 1989. This sample was tested by the MSHA

Industrial Safety Division (ISD) laboratory. The laboratory reports are included in Appendix R. The proximate analysis is as follows:

<u>Ingredient</u>	<u>Composition %</u>
Moisture	1.47
Volatile Matter	35.46
Fixed Carbon	52.73
Ash	<u>10.34</u>
	100.00

Volatile Ratio (calculated).....0.40

The volatile ratio is a value established by the Bureau of Mines to evaluate the explosibility of U.S. coals based on large-scale tests in the Experimental Coal Mine at Bruceton, Pennsylvania.

The volatile ratio (VR) of coal is defined as the ratio of its volatile matter (VM) to the sum of its volatile matter and fixed carbon (FC) contents or $VR = VM / (VM + FC)$. This method for calculating the volatile ratio produces a value independent of the natural and added incombustible in the coal. It has been established that all U.S. coals, having a volatile ratio in excess of 0.12, are considered to present an explosion hazard.

If the volatile ratio of the coal exceeds 0.12, it must be inerted according to Title 30, Code of Federal Regulations, Part 75, Mandatory Safety Standards - Underground Coal Mines, Section 75.400.

The test results indicate that this coal would be classified as a high-volatile bituminous coal.

During the investigation, MSHA also conducted a mine dust survey in the 1st Main North Entries, the Longwall Recovery Rooms, and the 4th West Entries. A total of 186 rock dust samples were collected. A breakdown of survey activities is as follows:

1. The Nos. 7 through 9 Entries of the 1st Main North Entries were surveyed on September 22, 1989;
2. The Nos. 1 through 6 Entries of the 1st Main North Entries were surveyed on September 23, 1989;
3. The Nos. 1A through 3 Longwall Recovery Rooms were surveyed on September 24, 1989, and
4. The No. 1 and No. 2 Entries of the 4th West Entries were surveyed on September 25, 1989.

No samples were collected in the No. 4 Entry of the 1st Main North Entries nor the No. 4 Recovery Room due to a combination of roof

falls, bad roof conditions and gob storage. All samples collected were analyzed for incombustible content and the presence of coke. The results of the analyses and a map showing the locations of these samples are in Appendices Q and GG.

Coke was present in 93 percent of the samples collected in the two 4th West Entries. A breakdown of the incombustible content and comparative amount of coke (extra large, large, small, trace, and none) in the mine dust samples follows.

<u>Location</u>	<u>No. Of Samples</u>	<u>Avg. Incomb. Content</u>	<u>Samples Below</u> <u>65% 80%</u> <u>(Intake) (Return)</u>		<u>No. of Samples with Coke</u>	<u>Coke in Samples</u> <u>XL L S T</u>			
1st Main North Entries									
No. 9 Entry (Return)	11	74.2%	-	3	0	0	0	0	0
No. 8 Entry (Return)	12	69.8%	-	9	0	0	0	0	0
No. 7 Entry (Return)	7	68.3%	-	5	0	0	0	0	0
No. 6 Entry (Belt Intake)	17	77.7%	4	-	0	0	0	0	0
No. 5 Entry (Intake)	20	82.8%	-	-	6	0	0	1	5
No. 3 Entry (Intake)	10	73.9%	3	-	4	0	1	1	2
No. 2 Entry (Intake)	2	71.7%	-	-	1	0	0	1	0
No. 1 Entry (Intake)	<u>1</u> 80	<u>54.0%</u> 75.6%	<u>1</u> 8	<u>-</u> 17	<u>0</u> 11	<u>0</u> 0	<u>0</u> 1	<u>0</u> 3	<u>0</u> 7
Longwall Recovery Rooms									
No. 3 Recovery Room (Intake)	15	62.5%	8	-	6	1	2	1	2
No. 2 Recovery Room (Intake)	13	56.9%	10	-	0	0	0	0	0
No. 1 Recovery Room (Intake)	11	53.6%	8	-	3	0	1	2	0
No. 1A Recovery Room (Intake)	<u>7</u> 46	<u>55.3%</u> 57.7%	<u>6</u> 32	<u>-</u> -	<u>3</u> 12	<u>0</u> 1	<u>0</u> 3	<u>1</u> 4	<u>2</u> 4
4th West Entries									
No. 1 Entry (Intake)	28	69.9%	8	-	25	0	2	6	17
No. 2 Entry (Intake)	<u>15</u> 43	<u>69.5%</u> 69.7%	<u>6</u> 14	<u>-</u> -	<u>15</u> 40	<u>5</u> 5	<u>7</u> 9	<u>2</u> 8	<u>1</u> 18

Presence of Drugs in Victims

Autopsies were performed on the ten victims by a county medical examiner; the presence of marijuana was reported in one victim, and the presence of marijuana and cocaine was reported in another victim. Three other victims exhibited evidence of certain prescription drugs commonly associated with therapeutic uses.

At MSHA's request the autopsy results were further reviewed for the Agency by the United States Department of Defense Armed Forces Institute of Pathology. MSHA requested an opinion from the Armed Forces Institute of Pathology which would address the medical use of the drugs found, screening and confirming methods used to test for the drug's presence, and a determination of possible impairment of the victims based on drug levels found. Based on the opinion of the Armed Forces Institute of Pathology, it was concluded that no relationship can be established between the presence of drugs in the victims and the mine accident.

In two victims, Kenneth E. Reed and Anthony T. McElroy, the presence of cannabinoids (marijuana) in urine was detected by use of screening tests. According to the examiner from the Armed Forces Institute of Pathology, a positive screening test combined with a positive confirming test would indicate exposure to marijuana. No confirming tests, however, were performed for either of these victims. Therefore, according to the autopsy reviewer, no statement can be made about the presence of marijuana that is scientifically defensible. Based on the screening test and scientific knowledge about the effects of marijuana, the autopsy reviewer could not make a statement concerning impairment of the victims, or other pharmacologic effects of the exposure, even if an amount was known. Therefore, there is no basis to conclude that there was any impairment of the victims due to marijuana, according to the Armed Forces Institute of Pathology reviewer.

McElroy, in addition to testing positive for marijuana, tested positive for cocaine metabolite in urine. The presence of cocaine was determined to be present based on two tests, the results of which indicated exposure to cocaine. However, no quantitation of the cocaine metabolite in urine was performed, and even if the amount in the urine had been quantitated, no conclusions about impairment or other pharmacologic effects could be made, according to the autopsy reviewer. The autopsy reviewer noted that a blood cocaine concentration might provide that information, however, no such test was performed as part of the autopsy. Therefore, there is no basis upon which to conclude that there was any impairment of the victim due to the presence of cocaine.

Four other drugs were found in the three other victims. Ernest W. Stewart was found to have quinidine in his system. According to the Armed Forces Institute of Pathology reviewer, this drug is used to treat heart conditions. The amount found in the victim's blood was consistent with therapeutic use.

Ricky D. Furgerson was found to have amitriptyline in his urine. This drug is commonly used to treat depression, but may also be used for the treatment of chronic pain, neuralgias, or migraines. According to the autopsy reviewer, the presence of this drug in the urine indicated prior use of the drug.

James A. Tinsley exhibited evidence of lidocaine, which is a drug frequently administered during resuscitation efforts, and chlorpheniramine which is an antihistamine for the treatment of cold or allergy symptoms. The autopsy reviewer noted that the quantitative presence of that drug (chlorpheniramine) in the victim's blood indicated use.

Based on the autopsy review performed by the Armed Forces Institute of Pathology, it was concluded that there was no evidence which showed that impairment of the victims was a cause of the accident.

Extent of Flame and Forces

A close examination, during the investigation, of the extent of flame and forces helped reveal the severity of the explosion and account for the potential ignition sources within the explosion zone.

Flame

Evidence accumulated during the post-explosion underground investigation helped determine the extent of flame. This evidence included melted plastic brattice cloth, burned rock dust bags, accumulations of coke on cribs, and results of laboratory analyses of dust and other various items collected after the explosion. The examination and interpretation of materials taken from a fire or explosion for evidence of heat and fire damage requires an understanding of thermodynamic principles and material properties. These principles are explained in Appendix R along with the results of testing on items delivered to MSHA's ISD.

The extent of flame during a methane explosion is dependent upon the total volume of methane in the initial gas body, and on any localized accumulations of methane within the explosion zone. Greatest flame extension is obtained with a 12 percent methane-air mixture, where flame distances can extend up to five times the distance of the initial gas zone.

Research has shown that there are five factors which limit flame propagation: (1) oxygen deficiency; (2) excess fuel; (3) insufficient fuel; (4) pressure release, and (5) dispersed inert material. Any one or a combination of these factors can arrest flame propagation.

Visual observations can only detect the most obvious signs of flame after an explosion. However, analysis of dust samples can provide a determination of coking throughout the explosion zone. Research on coke formation and deposition in experimental explosions has proven that coke indicates the passage of flame. Also, coke is produced by a relatively slow-moving flame and is not formed where the dust contains more than 50 percent incombustible. It is important to note that coke and soot is deposited in and beyond the area traversed by flame, however, deposits are generally thicker in the explosion area.

Since the temperature of the explosion flame can exceed 3,000°F, coal dust may coke during an explosion. The involvement of burning coal dust in an air-rich burning methane flame can cause temperatures and pressures to be increased, can extend the flame, and can change the color of the flame from light blue to orange.

During underground coal mine explosions, the area affected by the explosion forces is larger than the area traversed by the flame of the explosion. In evaluating the direction of force that occurred, a general transition zone was seen from which propagation occurred in all directions.

The underground investigation showed that such a transition zone existed in the 4th West Entries. Specifically, the area between and including the Nos. 9 and 10 Crosscuts in the No. 2 Entry of the 4th West Entries was the location where the primary forces originated. The map of the explosion zone is contained in Appendix Z and includes arrows to show the direction of the explosion forces.

Extent of Flame in the 4th West Entries Inby the No. 10 Crosscut

A close examination of the explosion zone leads to the conclusion that the greatest flame extension occurred in the No. 2 Entry of the 4th West Entries, where propagation occurred to a point just inby the No. 30 Crosscut (Appendix Z). This conclusion was verified by observations of materials underground that were affected by the flame of the explosion and also by a coking analysis of the mine dust sampled after the explosion. Large and extra-large quantities of coke were found throughout the area affected by the explosion flame. The greatest amount of coke was found along the No. 2 Entry and occurred to a point just inby the No. 28 Crosscut. It is believed that the flame of the explosion traveled about 200 additional feet beyond this point before dissipating.

Previously, factors limiting flame propagation were discussed. The configuration of the 4th West Entries does not change between the No. 10 Crosscut and the No. 30 Crosscut, thus eliminating pressure release as a limiting factor. It is doubtful that an excess of fuel existed because explosion pressures were relatively low and excess quantities of float coal dust were not observed in the explosion zone. The No. 1 Entry did not contain significant quantities of methane prior to the explosion, otherwise propagation

of an explosion flame throughout the length of the No. 1 Entry would have been evident. Although flame appears to have traveled into each crosscut between and including the Nos. 10 through 30 Crosscuts, only short distances of the No. 1 Entry were actually exposed to any explosion flame. Coke samples have indicated that the flame of the explosion did not travel any great length within the No. 1 Entry. Evidence indicated that an oxygen deficiency did not exist inby the No. 28 Crosscut.

After eliminating the factors of pressure release, excess fuel, and oxygen deficiency, only the encountering of sufficient inert material or a reduction in fuel would have limited flame propagation. Research from the U.S. Bureau of Mines has shown that rock dust is not effective in extinguishing a propagating methane explosion. Therefore, the encountering of sufficient inert material did not play a significant role in reducing and extinguishing the explosion flame, although the presence of rock dust reduced the involvement of coal dust in the explosion. A reduction in the amount of methane available for continued propagation kept the flame of the explosion from propagating further inby in the 4th West Entries.

The flame of the explosion propagated to the gob at each crosscut between the Nos. 10 and 28 Crosscuts. Inby the No. 28 Crosscut, the flame was short and quickly died out. It is doubtful that flame would propagate into the gob at any location because it would encounter conditions where the oxygen is greatly reduced and the methane content increases substantially beyond its maximum explosive concentration of 15 percent.

Extent of Flame in the Nos. 9 and 10 Crosscuts

The flame characteristics affecting this area are very similar to the inby areas of the 4th West Entries. The No. 2 Entry was engulfed in flame during the explosion. Also, the crosscuts were exposed to the flame of the explosion. A sample of dust taken from the gob side of a crib in the No. 10 Crosscut was shown to have a large quantity of coke, indicating that flame from the explosion passed through this area. The flame propagated toward the No. 1 Entry, however, propagation did not occur in the No. 1 Entry as shown in Appendix Z.

Extent of Flame in the 4th West Entries Outby the No. 9 Crosscut

The explosion flame propagated outby from the No. 9 Crosscut toward the 1st Main North Entries, especially along the No. 2 Entry of the 4th West Entries. As the flame of the explosion traveled along the No. 2 Entry, it split into the crosscuts and traveled both toward the No. 1 Entry and the No. 3 Entry. For the most part, the flame traveling toward the No. 1 Entry did not propagate along any substantial length of the No. 1 Entry. This conclusion is evidenced by the fact that the analysis of dust samples taken after

the explosion revealed no significant coking in the No. 1 Entry. The flame traveled between the No. 2 Entry and the gob in the Nos. 8 and 7 Crosscuts. As the flame traveled through the No. 6 Crosscut and into the No. 3 Entry, it split. Part of the initial flame continued to propagate toward and across a portion of the longwall face. Also, the flame continued to propagate outby the No. 6 Crosscut in the No. 3 Entry for approximately an additional 325 feet to a point just outby the No. 2 Crosscut.

The No. 3 Crosscut was the last outby crosscut that the flame traveled between the No. 2 Entry and the No. 3 Entry. The flame propagated approximately an additional 600 feet along the No. 2 Entry until it dissipated about four entries into the 1st Main North Entries. The flame propagated into the No. 1 Entry and traveled about 500 additional feet toward and into the 1st Main North Entries.

The investigation revealed that a reduction of available fuel and pressure release were responsible for eliminating additional propagation as the flame traveled out of the 4th West Entries and into the 1st Main North Entries. The original methane accumulation did not extend into the 1st Main North Entries. The original methane body was restricted to an area inby the No. 6 Crosscut in the 4th West Entries, and across a short distance of the longwall face near the headgate entries. This determination was based on analyzing the extent of flame and the direction and magnitude of explosion forces.

Extent of Flame at the Longwall Face

As previously stated, the flame propagated from the No. 2 Entry toward the No. 3 Entry in the No. 6 Crosscut and a split occurred. The flame continued to travel outby to the No. 2 Crosscut. Also, the flame traveled inby and turned to travel across the longwall face. If the explosion originated in the No. 2 Entry of the 4th West Entries, this would be the first exposure of miners and equipment at the longwall face to the explosion flame. If the explosion originated at the longwall face, the flame in the face area would have consumed the available methane and oxygen as it burned toward the transition zone. A transition zone is an area from which explosion forces propagate in all directions. As the flame propagated out of the transition zone it would have traveled toward the longwall face. However, significant flame propagation across the longwall face would have been prevented by the lack of methane and oxygen, but the temperatures of the gases would have been sufficiently high to burn the victims. The four victims found in the vicinity of the headgate were found to have burns on their bodies and clothing.

Also, the autopsy reports show a measurable amount of methane in three of the four victims found at the longwall face after the explosion. Scientific data is not currently available to quantify this measurable amount or draw a conclusive inference about its

significance. The finding of this methane is substantially different from finding carbon monoxide intoxication in the victims after an explosion. Typically, ambient levels of carbon monoxide are low and miners are not affected by such levels prior to an explosion. After an explosion, the carbon monoxide levels in the explosion area are significantly increased. Victims who expire quickly due to the force of the explosion stop breathing and are not affected by the higher levels of carbon monoxide that follow. Victims who expire after the explosion flame has passed may breathe a short time, thus allowing the carbon monoxide intoxication to occur, resulting in death. On the other hand, research has shown that nearly all the available methane is burned during a methane-air explosion. The presence of methane in these victims may indicate that they were exposed to methane concentrations prior to the explosion. A quantification of these methane concentrations is not possible. It was concluded that methane concentrations occurred at the longwall face area prior to the explosion.

Based on the observed evidence, the flame appears to have died out at a point just past the first recovery chute. Very little flame projected into this first chute. Various materials scattered across the longwall face area and the condition of the surviving miners, who were in the face area, indicated that flame did not propagate any further than indicated in Appendix Z.

Forces

The development of explosion forces is related to the same characteristics that influence the extent of flame travel. Both the concentration of methane and the total volume of the methane-air mixture play important roles in determining the magnitude of pressure during an explosion. Factors including the degree of mixing of the methane-air concentration, type and strength of ignition source, location of ignition source within the mixture, and location of the gas body within the mine also affect the explosion flame and pressure development. Pressure development is caused by the heating of the atmosphere during the combustion process.

Methane is explosive between 5 and 15 percent when mixed with air. The forces generated during an explosion gradually increase from a low magnitude at 5 percent to its greatest magnitude at about 10 percent. With additional increases in original methane concentrations above 10 percent, the magnitude of the explosion forces gradually decreases. Forces that occur from an explosion are similar in magnitude when ignition occurs either near the upper or lower explosive limits. For example, 6 and 14 percent methane-air mixtures develop about half of the explosion pressure that a 10 percent methane-air mixture develops. However, the extent of flame can assist in determining the original concentration of methane. Flame propagation is shortest near the lower explosive limit and gradually increases as the original methane concentration increases to about 12 percent. The extent of flame travel at 12 percent is

about five times the distance affected by the original methane accumulation. Further increases in a methane concentration above 12 percent result in a reduction in the flame propagation.

The amount of mixing of a methane-air concentration affects the length of flame and magnitude of forces. The most violent explosion develops with a homogenous mixture; the least violent occurs when methane is liberated just below the roof. Flame velocities and pressures decrease when the point of ignition within a gas body is moved from the face toward the outby end of the mixture. As the strength or size of the ignition source increases, the most readily ignited concentration decreases.

Based on the extent of flame and the magnitude of explosion forces in the explosion zone, it was concluded that the methane concentration prior to the explosion was on the order of 5.5 to 6.0 percent.

Perceptible pressures of 1.0 pound per square inch gauge (psig) are not evident until appreciable flame develops. Research has shown that there is a distinct relationship between the flame speed of an explosion and the static pressure that is developed during the explosion. For example, flame speeds of 400, 800, 1,200, and 1,600 feet per second correspond to static pressures of approximately 7, 15, 23, and 30 psig. Furthermore, tests by researchers on the physiological effects of blast pressure have shown that a peak overpressure of about 1 pound per square inch (psi) will knock a person down, 5 psi will cause rupture of eardrums, 15 psi results in lung damage, 35 psi is the threshold for fatalities, 50 psi results in 50 percent fatalities, and 65 psi causes 99 percent fatalities.

After a methane body ignites, and a fireball begins to form, damage is caused by both dynamic and static pressures. The dynamic pressures exhibited in this explosion had the greatest effect on mine equipment in the No. 2 Entry of 4th West Entries, such as the damage to the batteries for the scoop tractor and the battery charging unit. This fact does not necessarily mean that the greatest explosion forces would be concentrated in a particular entry. Forces from a methane explosion can increase, decrease, or remain constant throughout the explosion zone, depending on whether additional fuel is contributing to the explosion as previously discussed. Static pressure would exert an equal force in all directions, causing the destruction of stoppings in the crosscuts. The extent of flame and the direction of the explosion forces indicated that the primary methane body was located in close proximity to the gob. This would place methane accumulations throughout the No. 2 Entry of the 4th West Entries, in the cross-cuts between the Nos. 2 and 3 Entries, and in the face area prior to the explosion.

Extent of Forces in the 4th West Entries Inby the No. 10 Crosscut

In the 4th West Entries at the No. 10 Crosscut, the forces were heading toward the longwall gob and also toward the No. 1 Entry. At this location, the dynamic forces are propagating inby along the

No. 2 Entry and, at each inby crosscut, the forces are again heading away from the No. 2 Entry.

Between the No. 2 Entry and the No. 3 Entry (longwall gob), there was evidence in the form of coal dust, damaged cribs, and loose materials blown toward the No. 3 Entry that indicate forces heading toward the longwall gob. This effect was seen from the No. 10 Crosscut to the No. 30 Crosscut. The further inby that the investigation team traveled, the lower the forces in the crosscuts appeared to have been. At the No. 10 Crosscut, suspected flame speeds of less than 600 feet per second accounted for a pressure of less than 10 psig. This pressure was evidenced by the destruction of stoppings and the damage to cribs. It was doubtful that any locations in the explosion zone were subjected to pressures exceeding 10 psig. As the explosion propagated inby in the No. 2 Entry, the forces diminished over the length of the entry until, at the No. 30 Crosscut, the magnitude of the dynamic explosion forces were less than 2 psig. Accordingly, forces in the crosscuts between the Nos. 2 and 3 Entries were even less as the static pressure is only about 50 percent of the dynamic pressure experienced in the No. 2 Entry. At the No. 10 Crosscut, the magnitude of static forces heading toward the gob would have been less than 5 psig and, at the No. 30 Crosscut, the magnitude of static forces heading toward the gob would have been less than 1 psig. Between the No. 2 Entry and the No. 1 Entry, there was evidence in the form of coal dust, damaged cribs, blown-out and partially-damaged stoppings, and loose materials blown toward the No. 1 Entry that indicated forces headed from the No. 2 Entry to the No. 1 Entry.

In the No. 2 Entry, there was evidence that cribs along the length of the entry were subjected to forces heading in the inby direction. Many cribs remained intact along the length of the No. 2 Entry. Substantial weight from the roof was being supported by these cribs. There were also many damaged cribs along the entry, which appear to be falling away from the source of the explosion as they were exposed to forces heading inby. Many of the intersections along the No. 2 Entry had the remains of cribs laying on the mine floor. These cribs probably were not subjected to the same amount of loading from the weight of the roof as those between the intersections. These intersections were also truss bolted in addition to having cribs, which helped keep the roof from sagging and, therefore, eliminated severe loading on these cribs.

Heading inby from the No. 10 Crosscut, stoppings between the No. 2 Entry and the No. 1 Entry were blown away from the No. 2 Entry in many crosscuts. Research has shown that a typical block stopping with mortared joints fails near 4 psig and drywall stoppings with plastered faces fail at about 2 psig. However, these values increase if the stopping is bearing any load from the roof.

As previously stated, the forces generated during an explosion can increase, decrease, or remain constant throughout the explosion zone depending on whether additional fuel becomes available. This fact could account for several intact stoppings occurring randomly

throughout the 4th West Entries. The loading from the roof may have been great enough to hold the stoppings in place when subjected to the low magnitude static pressure. Also, gob or roof falls in some crosscuts prevented the forces from destroying the stoppings.

Extent of Forces in Nos. 9 and 10 Crosscuts of the 4th West Entries

The transition zone from which the primary explosion forces propagated was located in the area of the 4th West Entries, including the Nos. 9 and 10 Crosscuts. More specifically, the center of the zone appeared to be located in the No. 2 Entry. Stoppings in these crosscuts, located between the Nos. 1 and 2 Entry, were blown out toward the No. 1 Entry. Evidence indicated that the explosion forces also propagated from the No. 2 Entry toward the longwall gob in both the No. 9 Crosscut and the No. 10 Crosscut.

For example, in the No. 10 Crosscut, a dust sample was taken from the gob side of cribs located in the crosscut between the No. 2 Entry and the longwall gob. Laboratory testing has shown that this sample was comprised of coke that occurred as the flame of the explosion propagated through the area. The results of this laboratory testing are contained in Appendix R. Research has shown that coke accumulations occur on materials and equipment underground on the side opposite to the direction of force when pressures are high. Actually, coke deposits occur around the entire crib, but the force of the explosion removes the coke accumulation from the side facing the oncoming pressure wave, thus leaving the coke deposited on the opposite side as was the case in the No. 10 Crosscut. Other evidence of force heading from the No. 2 Entry toward the gob in these crosscuts includes coal dust and loose dust accumulations, and obvious forces exerted on the cribs.

Extent of Forces in the 4th West Entries Outby the No. 9 Crosscut

Outby the No. 9 Crosscut, it appears that the primary dynamic explosion forces propagated along the No. 2 Entry toward the 1st Main North Entries. Between the Nos. 1 and 2 Entries, evidence including damaged and destroyed stoppings indicates that the static force of the explosion traveled from the No. 2 Entry toward the No. 1 Entry. The dynamic force along the No. 2 Entry diminished from about 10 psig at the No. 9 Crosscut to about 2 psig at the No. 1 Crosscut. The static force exerted about 5 psig on stoppings near the No. 9 Crosscut and only about 1 psig on stoppings near the No. 1 Crosscut.

Although flame was not believed to have propagated outby in the No. 1 Entry, the forces of the explosion appeared to be heading outby in the No. 1 Entry from about the No. 8 Crosscut to about the No. 2 Crosscut. An offset in the entry at the No. 2 Crosscut prevented the force from continuing outby at the magnitude it had been traveling.

Between the No. 2 Entry and the longwall gob, forces propagated

toward the gob in the No. 7 Crosscut. Between the No. 2 Entry and the longwall gob, the No. 8 Crosscut was inaccessible during the investigation. From the Nos. 1 to 6 Crosscuts, forces propagated from the No. 2 Entry toward the No. 3 Entry. The No. 2 Entry was open throughout this location, however, inby the No. 6 Crosscut, the No. 3 Entry was a part of the gob because mining had proceeded to that point. After splitting off of the No. 2 Entry, the explosion forces continued toward the longwall recovery rooms and outby toward the 1st Main North Entries.

After entering the No. 3 Entry at the No. 6 Crosscut, the forces apparently split, with some force traveling to and across the face and the remaining force traveling outby in the No. 3 Entry. With approximately 5 psig exerted in the No. 6 Crosscut, about 2.5 psig would have been propagating outby in the No. 3 Entry. After traveling several additional crosscuts, the propagating flame and force came into contact with one of the eventual victims, who apparently was partially located in the No. 3 Entry at the No. 2 Crosscut. The autopsy report indicated that the cause of death was smoke and soot inhalation. There was no evidence of pressure induced damage to the lungs or ear drums. This information led investigators to believe that the victim at this location was subjected to less than 5 psig.

Forces continued to propagate outby until sufficient relief area was encountered, which tended to reduce and eventually eliminate the pressure wave.

Electric Circuits and Equipment

The flames and forces of the explosion were present where electric circuits and equipment were found in the 4th West Entries, Longwall Panel "O" face, recovery rooms, and 1st Main North Entries. MSHA investigators examined and tested the circuits and equipment for evidence of the ignition source. MSHA was assisted by personnel from the Kentucky Department of Mines and Minerals, officials and employees of Pyro Mining Company and miners' representatives of Pyro No. 9 Slope, William Station Mine.

A detailed description of the examinations and tests follow:

Electric Circuits and Electric Equipment

- 1. Vacuum Circuit Breaker, Line Power Manufacturing Company, Model No. VCB-1, Serial No. 11387**

A vacuum circuit breaker was found in the 1st Main North Entries at the mouth of the No. 2 Entry of the 4th West Entries. This circuit breaker received 7,200-volt, AC three-phase power from an oil circuit breaker located in the surface substation at the

Mitchell Station fan. Investigation interviews revealed that the high-voltage circuit was energized at the time of the explosion and that the surface oil circuit breaker, and vacuum circuit breaker tripped (opened) when the explosion occurred.

Visual indicators (mechanical targets) were found on the grounded-phase relay trip unit and two instantaneous overcurrent trip units at the surface oil circuit breaker. In addition, a target was found on the grounded-phase relay at the underground vacuum circuit breaker. These targets indicated that a ground-fault condition and a phase to phase short-circuit condition had occurred in the high-voltage system. However, the investigators did not find any evidence that a phase to phase short-circuit condition existed in the high-voltage system that supplied AC power to the 4th West Entries. The targets on the surface instantaneous trip units resulted from a circuit breaker trip that occurred before the explosion or a mechanical vibration created by the circuit breaker opening at the time of the explosion.

Information gathered during the investigation revealed that the vacuum circuit breaker contained a manually operated, visible disconnect switch, ground-check monitor, and relays designed to provide overcurrent, grounded-phase, and undervoltage protection for the high-voltage circuit. Further examination revealed that the manually operated, visible disconnect switch was in the closed (on) position and the ground-check monitor would trip (open) the circuit breaker when the ground-check circuit was interrupted. The overcurrent, grounded-phase, and undervoltage relays were operative and the vacuum circuit breaker was in the open (off) position. The ground-check monitor and undervoltage relays were not provided with visual indicators. Targets were provided for the overcurrent and grounded-phase relays.

The targets on the grounded-phase relays indicated the circuit breakers tripped as a result of a grounded-phase condition. This investigation revealed that a grounded-phase condition was created by the explosion forces. A top cover lid of the 300-kVA portable power center sheared a 3/8-inch bolt used to connect a high-voltage phase conductor to the high-voltage buss in the power center.

The transition zone of the explosion forces was located inby the vacuum circuit breaker and the direction of damaging forces also indicated the explosion originated outside of the vacuum circuit breaker. The investigators did not find any evidence of an ignition in the vacuum circuit breaker. Based on these facts, the vacuum circuit breaker did not provide the ignition source for the explosion.

- 2. Approximately 400 Feet of Mine Power Cable, Type SHD-GC, No. 1/0 AWG Copper, 8 KV, Rome Cable Company, P-105 MSHA, with ADALET-PLM, Catalog No. OPML415, 15 KV, 500 Ampere Cable Couplers Attached**

Approximately 400 feet of mine power cable originated at the vacuum

circuit breaker and extended to a 1,750 kVA section power center located in the No. 4 Crosscut between the No. 1 and No. 2 Entries of the 4th West Entries. This cable was supported with cable hangers from a messenger wire installed on the left side of the No. 2 Entry and had five vulcanized splices. The cable was torn down from the No. 3 Crosscut to the power center by the explosion forces. Insulation resistance measurements revealed that the high-voltage cable, and PLM cable couplers were free from a ground-fault or short-circuit condition. Information gathered during the investigation revealed that the mine power cable was energized when the explosion occurred.

The transition zone of the explosion forces was located in by the cable and the direction of damaging forces also indicated the explosion originated in by the cable. Investigators did not find any evidence that the mine power cable or PLM cable couplers provided the ignition source for the explosion. Based on these facts, neither the mine power cable nor the PLM cable couplers provided the ignition source for the explosion.

3. 1,750 kVA Section Power Center, Line Power Manufacturing Company, Serial No. P9809-1

A nonpermissible 1,750 kVA, section power center was found in the No. 4 Crosscut between the No. 1 and No. 2 Entries of the 4th West Entries. The power center reduced 7,200-volt, AC three-phase power to 995-volt, and 480-volt, AC three-phase power for operation of the longwall face equipment, emulsion pumps, roof bolter, loading machine, welder and battery chargers.

1,750-kVA Section Power Center: High-Voltage Portion Findings

- (a) The high-voltage portion of the power center was energized when the explosion occurred;
- (b) The high-voltage feed-through receptacle was connected to approximately 25 feet of mine power cable that supplied 7,200-volt, AC three-phase power to the 300 kVA portable power center;
- (c) The manually-operated high-voltage disconnect switch was in the closed (on) position;
- (d) All three high-voltage fuses were intact;
- (e) The emergency-stop switch was in the closed (on) position;
- (f) Evidence of high-voltage arcing was not found in the high-voltage portion of the power center;
- (g) Insulation resistance measurements revealed that the high-voltage portion of the power center was free from a fault condition; and,

- (h) The power center was provided with 14 interlock switches, nine under the top covers, and five behind the side covers. Tests indicated that all of the interlock switches were bypassed and not properly connected in series with the incoming ground-check conductor so that removal of a cover would interrupt the incoming ground-check circuit and cause the vacuum circuit breaker to trip (open).

The damage observed by the investigators included the following:

- (a) All of the top covers were torn off the section power center. The bolts were pulled through the bolt holes in the top covers;
- (b) One glass observation window for the high-voltage disconnect switch was broken and blown into the power center;
- (c) Two of the arcing contacts on the high-voltage disconnect were bent and all of the insulating barriers were broken;
- (d) Two insulators on the low-voltage buss, one on the top buss and one on the bottom buss, were broken;
- (e) One insulator that supported a high-voltage fuse holder was broken;
- (f) The outside brace on the low-voltage end of the power center was bent about 2 inches near the top of the brace;
- (g) Two top center braces over the transformer had welds that were broken; and,
- (h) The power center was severely damaged by the explosion (Appendix U).

1750-kVA Section Power Center: Low- and Medium-Voltage
Portion - Findings

The power center contained six, 995-volt, three-phase receptacles: two receptacles for the No. 1 longwall starter assembly; two receptacles for the No. 2 longwall starter assembly spare; one receptacle for the No. 3 pump circuit, and one receptacle for the No. 4 pump circuit spare.

The power center contained two, 480-volt, three-phase receptacles for the No. 1 and No. 2 auxiliary circuits, two, 240-volt, single-phase receptacles, and two, 120-volt, single-phase, duplex receptacles. All receptacles were properly identified.

The power center contained four, three-pole, molded-case circuit breakers for the 995-volt, three-phase, secondary circuits and two,

three-pole, molded-case circuit breakers for the 480-volt, three-phase, secondary circuits. The circuit breakers were equipped with ground-check monitors and devices to provide overcurrent, grounded-phase, and undervoltage protection for these circuits. All circuit breakers were in the tripped position when the investigators examined the power center.

The power center was not permissible and was located within 150 feet of pillar workings. Arcing caused by a fault condition or by a manual or automatic operation of one of the circuit breakers, relays, or switches in the power center could have released sufficient energy to ignite an explosive methane-air mixture. The investigators found no evidence of a short-circuit or ground-fault condition in the low- or medium-voltage portion of the power center. The location of the miners on the longwall face and recovery rooms indicated that the miners were not in a position to operate any circuit breakers or switches when the explosion occurred. Insulation resistance measurements revealed that the high-voltage portion of the power center was free from a ground-fault or short-circuit condition.

The direction of damaging forces in by the section power center indicated the explosion originated outside the power center. The investigators did not find any evidence that the power center provided the ignition source for the explosion. Based on these facts, neither the high-voltage portion nor the low- and medium-voltage portions of the section power center provided the ignition source for the explosion.

1,750 kVA Section Power Center: Low- and Medium-Voltage Circuits - Findings

One medium-voltage, AC circuit originated at the section power center and supplied 995-volt, AC power to a portable pump station consisting of a portable pump starter assembly, and two, portable 150-horsepower electric motors, located in the No. 4 Crosscut between the No. 2 and No. 3 Entries of the 4th West Entries.

The pump starter assembly supplied 995-volt, AC power to two 150-horsepower motors installed next to the emulsion tank located in the same crosscut.

Examination of approximately 30 feet of No. 4/0 AWG, portable power cable, that supplied AC power from the power center to the pump starter assembly, revealed that the power cable was not provided with metallic drain shields around each power conductor nor was there a metallic shield around the assembly. In addition, the ground conductor was reduced in size by severing eight of the 14 strands from one ground conductor. Examination of the pump starter assembly revealed an opening in excess of 0.004 inch between the panel cover of the enclosure, and the fluid level control switch was bypassed.

Approximately 30 feet of No. 1 AWG, AC portable power cable that

supplied power to the No. 1 emulsion pump motor and 30 feet of No. 1 AWG portable power cable that supplied AC power to the No. 2 emulsion pump motor were examined. This examination revealed that the metallic drain shields provided in the cable were removed for approximately 4 inches inside each cable coupler and the metallic drain shields were not attached to the ground conductors.

One permanent splice was found in the No. 1 AWG, power cable between the pump starter assembly and the No. 2 emulsion pump motor. This splice was not made according to the manufacturer's specifications. The power conductors and the ground conductors were connected with mechanical connectors that were beat flat. Both pump motors were examined and found to be maintained in a permissible condition.

A No. 12 AWG, SO portable power cable was used to replace the fluid level control circuit that was bypassed in the pump starter enclosure. This power cable supplied 120-volt, single-phase power from a duplex receptacle located on the section power center to the liquid level switch and a two-way solenoid coil. Examination of this cable revealed a splice approximately 24 inches from the liquid level switch that was made without mechanical connectors. The liquid level switch was not of an approved type and was installed within 150 feet of pillar workings.

Insulation resistance measurements revealed that the starter assembly, both pump motors, all AC power cables, and control circuits were free from a short-circuit or ground-fault condition. Both emulsion pumps were examined for mechanical defects and were found to be properly maintained.

Investigation interviews revealed that a problem had occurred with the hydraulic emulsion system before the explosion. Investigators could not conclude whether the AC circuits supplying the pump starter assembly, emulsion pump motors, and liquid level control circuits were energized when the explosion occurred.

The direction of damaging forces in by the portable pump station indicated that the explosion occurred outside the station. Investigators did not find any ignition source for the explosion in any of the electric circuits or equipment installed in the portable pumping station. Based on these facts, neither the AC power circuits, control circuits, pump starter assembly, emulsion pumps, nor the pump motors provided the ignition source for the explosion.

Two low-voltage, AC power circuits originated at the section power center. The first circuit supplied 480-volt, AC power to a battery charger located in the No. 3 Crosscut between the No. 1 and No. 2 Entries of the 4th West Entries. The second circuit supplied power to a roof bolter located under a fall in the No. 2 Recovery Room. Investigation interviews revealed that the roof bolter was not in use when the explosion occurred. The No. 6 AWG, trailing cable and cable coupler were examined and tested up to the edge of the fall. This examination revealed eight permanent splices that were

mechanically sound and well insulated. Insulation resistance measurements revealed that the cable was free from a short-circuit or ground-fault condition.

The battery charger was supplied AC power by approximately 125 feet of No. 6 AWG, portable power cable that extended from the power center. Examination of the cable, battery charger, battery charging cables and batteries revealed that the cable ground-check circuit was connected to the ground conductor in a permanent splice. This splice was approximately 25 feet from the power center and a proper fitting was not provided where the cable entered the frame of the charger.

Insulation was removed from the direct-current battery charging cables where they entered one battery charging plug exposing the power conductors for approximately 1 inch. There was visible evidence of arcing (melted copper) on both conductors. The metal battery charging plugs were not provided with a frame ground. Evidence of electrical arcing was not present on the battery-cell terminals, or intercell connections on the batteries. Insulation resistance measurements revealed that the cables were free from a ground-fault or short-circuit condition. The battery charging station was not installed in a fire-proof structure or area and was not ventilated directly into the return. The charger was free of a fault condition and did not receive any physical damage from the explosion forces. However, the inside and outside surfaces of the charger were heavily coated with dust. It was concluded that the power circuit supplying the battery charging installation was energized when the explosion occurred and that the batteries were being charged.

The transition zone of the explosion forces was located in by the battery charging station and the direction of the damaging forces also indicated that the explosion originated outside the battery charging station. Investigators did not find any evidence that the electric circuits or the equipment installed in the battery charging station provided the ignition source for the explosion. Based on these facts, neither the AC power circuit, battery charger, direct-current power circuit, nor the batteries provided the ignition source for the explosion.

A single-phase, 120-volt, AC circuit originated at a duplex receptacle on the power center and extended approximately 600 feet to a utility receptacle located in front of the No. 57 Shield.

Power was supplied to the utility receptacle by a No. 12 AWG, SO portable power cable. Two nonpermissible 1/2-horsepower AC water pumps were found on the longwall face. One pump was located at the No. 44 Shield and was not connected to a power source. The other water pump was located approximately 15 feet in front of the No. 58 Shield and was connected to the utility receptacle. Examination of the portable power cable, utility receptacle, water pumps, and pump cables revealed that mechanical connectors were not used in eight splices in the portable power cable. The portable

power cable was not installed on insulators and was laying within 2 feet of the cutting torch assembly that was being used to disassemble the longwall panline. An effective ground was not provided for the metallic frame of the water pump located at the No. 58 Shield. Fire-clay mud had insulated the ground in the utility receptacle from the ground prong attached to the pump cable.

Investigators could not determine conclusively if the power cable, utility receptacle, and water pump found at the No. 58 Shield were energized when the explosion occurred. However, investigation interviews of mine personnel revealed that the power circuit and water pumps were used on the shift prior to the explosion. The water pumps and duplex receptacle were not permissible and were installed within 150 feet of pillar workings. The investigators examined and tested the power circuit, utility receptacle, water pumps, and pump cables to determine if they provided the ignition source for the explosion.

The water pumps with cables attached, and duplex receptacle, were found beyond the extent of the flames on the longwall face and the investigators did not find any evidence that the water pumps, pump cables, or duplex receptacle provided the ignition source for the explosion.

Based on these facts, neither the duplex receptacle, water pumps, nor the cables attached to the water pumps provided the ignition source for the explosion.

The portable power cable was found next to the cutting torch assembly. However, the investigators did not find evidence that a fault condition had occurred in the portable power cable.

Based on these facts, the portable power cable did not provide the ignition source for the explosion.

4. Approximately 25 Feet of Mine Power Cable, Type SHD-GC, No. 4/0 AWG Copper, 8 KV, Hatfield Cable Company, P-124-22 MSHA, with ADALET-PLM, Catalog No. OPML415, 15KV, 500 Ampere Cable Couplers Attached

This cable originated at the feed-through receptacle on the 1,750-kVA section power center and supplied 7,200-volt, AC three-phase power to a 300-kVA portable power center located in the same crosscut. Insulation resistance measurements revealed that the high-voltage cable, and PLM cable couplers were free from any fault conditions. Investigation interviews revealed that the mine power cable was energized when the explosion occurred.

The direction of damaging forces indicated that the explosion occurred inby the mine power cable. The investigators did not find any evidence that the high-voltage circuit or PLM cable couplers provided the source for the explosion. Based on these facts, neither the mine power cable nor the PLM cable couplers provided the ignition source for the explosion.

5. 300 kVA Portable Power Center, Pemco Manufacturing Company, Serial No. A522173, Model No. K-300

300-kVA Portable Power Center: High-Voltage Portion Findings

A nonpermissible portable power center was found in the No. 4 Crosscut between the No. 1 Entry and No. 2 Entry of the 4th West Entries. The power center reduced 7,200-volt, AC three-phase power to 480-volt, AC three-phase power for operation of the roof bolter, loading machine, welder, and battery chargers.

- (a) The mine power cable from the feed-through on the section power center was energized;
- (b) The high-voltage feed-through receptacle on the power center was capped;
- (c) The high-voltage disconnect switch was in the closed (on) position;
- (d) All three high-voltage fuses were intact;
- (e) The emergency-stop switch was in the closed (on) position;
- (f) Evidence of a short-circuit condition was not found in the high-voltage portion of the power center;
- (g) Insulation resistance measurements revealed that the high-voltage portion of the power center was free from any fault condition; and,
- (h) The power center was provided with 10 interlock switches, six under the top covers, and four behind the side covers. Tests indicated all interlock switches were bypassed and not properly connected in series with the ground-check conductor, so that removal of any cover would interrupt the incoming ground-check circuit, causing the vacuum circuit breaker to trip (open).

The damage observed by the investigators included the following:

- (a) All of the top covers were torn off the power center. The fastener bolts for the top covers were pulled through the bolt holes in the side of the power center;
- (b) One glass observation window for the high-voltage disconnect switch was broken and blown into the power center;
- (c) The insulating barriers for the high-voltage disconnect switch were broken when a SCSR was blown into the top of the power center by the explosion forces;

- (d) Two top braces on the high-voltage end of the power center were damaged. One brace was bent about 2 inches over the top of the power transformer and the welds on both of the braces were broken. One of the braces was blown out of alignment approximately 14 inches from its original position;
- (e) One side cover was ripped and blown inside the low-voltage end of the power center. The side brace was bent about 1 inch when a piece of slate rock was blown through the side cover by the explosion forces;
- (f) One low-voltage circuit receptacle panel was bent approximately 3 inches on the low-voltage end of the power center;
- (g) Two ground-check monitor access doors and one ground-check monitor panel were blown from the frame of the power center;
- (h) Two insulators between the high-voltage buss bars were broken;
- (i) A portable welder was blown into the low-voltage end of the power center (Appendix U);
- (j) A ground-fault condition was created when one of the top covers was blown into the power center shearing a 3/8-inch bolt used to connect a high-voltage phase conductor to the high-voltage buss inside the power center; and,
- (k) The power center was severely damaged by the explosion forces (Appendix U).

300-kVA Portable Power Center: Low-Voltage Portion
Findings

The portable power center contained four, 480-volt, three-phase receptacles, two, 240-volt, single-phase receptacles, and one, 120-volt, single-phase, duplex receptacle. All receptacles were properly identified. The power center contained four, three-pole, molded-case circuit breakers. All circuit breakers were equipped with ground-check monitors and devices to provide overcurrent, grounded-phase, and undervoltage protection. All circuit breakers were in the tripped position when the investigators examined the power center.

The direction of damaging forces in by the power center indicated that the ignition occurred outside of the power center. The investigators did not find any evidence that the low-voltage portion of the power center provided the ignition source for the explosion. Based on these facts, neither the high-voltage portion nor the low-voltage portion of the power center provided the ignition source for the explosion.

300-kVA Portable Power Center: Low-Voltage Circuits Findings

One low-voltage, AC power circuit originated at the portable power center and supplied 480-volt, three-phase power to a battery charger located between the No. 5 and No. 6 Crosscuts in the No. 2 Entry of the 4th West Entries. Examination of the AC power circuit, battery charger, direct-current charging circuits, and batteries revealed that the No. 6 AWG, power cable was dislodged from the cable hangers at the power center to the battery charger by the explosion forces. This cable was originally supported from the messenger line installed on the left side of the No. 2 Entry. A proper fitting was not provided for the cable where the cable entered the frame of the charger.

The top cover of the charger was blown off by the explosion forces and was found approximately 15 feet outby the charger. Two bolts were pulled through the fasteners in the frame of the charger and were found with the top cover. Two bolts were pulled through the bolt holes in the top cover and were found in the frame of the charger. The left corner of the top cover was bent down approximately 10 inches, forming a crease that extended diagonally from the left corner, to approximately 36 inches inby the right corner. The top cover was also bent approximately 10 inches in the middle (Appendix U).

Inside the charger, the power cable connections were pulled from the pressure connectors on the fuse block by the explosion forces (Appendix U). The ground-check conductor and ground conductors were connected to the frame of the charger under the same connector.

Both access doors for the charger were blown open by the explosion forces and the timer switch control knobs located on the outside surface of the doors were broken. The ground monitor phase-filter connecting leads were not properly attached with suitable connectors (Appendix U). All fuses inside the charger were intact. Bushings were not provided for four No. 2/0 AWG, direct-current power conductors that supplied power from the charger to the batteries, and two No. 2/0 AWG, single ground conductors that extended from the frame of the charger to the battery connector plugs.

The battery cover lids were torn off by the explosion forces and were found approximately 5 feet outby the batteries. Insulation resistance measurements revealed that the AC power circuit, battery charger, direct-current power circuits, batteries and charging circuits were free from any fault conditions. The battery charging station was not installed in a fire-proof enclosure or area and was not ventilated directly into the return.

The charger was not permissible and was installed within 150 feet of pillar workings. Arcing caused by a fault condition or by a manual or automatic operation of one of the relays or switches in the charger could have released sufficient energy to ignite an explosive methane-air mixture. The locations of the miners

indicated that they were not in a position to manually operate the charger switches. It was concluded that the power circuit to the battery charging station was energized and that the batteries were being charged when the explosion occurred.

The direction of damaging forces indicated the explosion occurred inby the battery charging station. The investigators did not find any evidence to indicate that the battery charging station equipment provided the ignition source for the explosion. Based on these facts, neither the AC power circuit, battery charger, direct-current power circuits, nor the batteries provided the ignition source for the explosion.

A single-phase, 120-volt, AC power circuit originated at a duplex receptacle on the power center and extended approximately 15 feet to a nonpermissible battery charger installed on a nonpermissible battery-powered golf cart, located in the No. 2 Entry at the No. 4 Crosscut. The 120-volt, single-phase, battery charger was supplied power by a No. 12 AWG, portable power cable that was approximately 35 feet long. The charger reduced the 120-volt, AC power to 12-volts, direct-current power that was utilized to charge the golf cart batteries.

Examination of the No. 12 AWG, power cable, charger, and battery-powered golf cart revealed three splices in the power cable that were not provided with mechanical connectors. Two splices in the No. 16 AWG, direct-current light-circuit conductors, one approximately 13 inches and one approximately 5 inches from the front headlight assembly, were not provided with mechanical connectors. All fuses were intact in the charger.

Overcurrent protection was not provided for the traction motor on the golf cart. Investigators did not find evidence of electrical arcing on the battery-cell terminals, or intercell connections. Insulation resistance measurements revealed that the cable, battery charger, and personnel carrier were free from a fault condition. The golf cart and charger were not of a permissible type and were located within 150 feet of pillar workings.

The golf cart was blown approximately 15 feet from where it was positioned for charging and the main frame was bent approximately 2 inches by the explosion forces. The 2-inch foam padding for the operator's seat was burned off, exposing the metal underneath. The top rear cover was blown around approximately 8 inches on the operator's side (Appendix U). It was concluded that the AC power circuit, battery charger, and battery charging circuits were energized when the explosion occurred.

The direction of the damaging forces indicated the explosion occurred inby the golf cart. The investigators did not find any evidence that the AC power circuit, battery charger, battery charging circuit nor the golf cart provided the ignition source for the explosion. Based on these facts, neither the AC power circuit, battery charger, battery charging circuit nor the golf

cart provided the ignition source for the explosion.

Two low-voltage, AC power circuits originated at the power center and supplied 480-volt, three-phase power to a loading machine located in the intersection of the No. 3 Entry and the No. 2 Recovery Room and a nonpermissible welder. The welder was originally located approximately 15 feet in by the power center in the No. 2 Entry.

Examination of the portable power cable, welder, and welding leads revealed that the cable coupler and all but 6 feet of the No. 6 AWG, cable were removed from the welder. After the initial examination and tests, the welder was transported to the surface for further examination and testing. The examination and tests revealed that one side of the metal cover for the welder was bent in approximately 2 inches, contacting the insulating board and transformer inside the welder. All fuses inside the welder were intact. The welder was not of a permissible type and was located within 150 feet of pillar workings. Insulation resistance measurements revealed that the cable and welder were free from a fault condition.

Two single-conductor No. 1/0 AWG, welding leads originally supported by plastic tie wraps from the messenger line installed along the No. 2 Entry to the No. 6 Crosscut were torn down by the explosion forces. Both welding leads were torn apart at the intersection of the No. 6 Crosscut and the No. 2 Entry. The welding leads extended through the No. 6 Crosscut into the No. 3 Entry, where one welding lead was attached to the frame of the panline by a ground clamp. The other welding lead continued to the No. 20 Shield where the welding circuit ended. Two welding stingers, not attached to the welding circuit, were also found. There were numerous damaged places and splices were made without mechanical connectors throughout the circuit. The welding leads were not installed on insulators through the No. 6 Crosscut and across the longwall face (Appendix X).

The investigation interviews revealed that the welder and welding leads were not energized at the time of the explosion. Based on this fact, it was concluded that neither the portable welder nor the welding circuit provided the ignition source for the explosion.

Due to the number of permanent splices found in the loading machine trailing cable, the investigators had the cable transported to the surface for examination and testing. Examination and testing of the cable revealed 36 permanent splices that were not made in accordance with the manufacturer's specifications. Insulation resistance measurements revealed four of the 36 splices were not free of ground faults. Two of these splices had inner insulation failure with evidence of carbon tracking between the phase conductors and ground. All four of the splices had moisture inside of the splices. The outer jacket and inner insulated power conductors were torn in five places exposing bare phase conductors. In addition, 20 taped repair places were found where the cable was damaged before the explosion. One taped place supported from roof

bolt plates installed across the No. 3 Entry had visible evidence of heat and flame damage from the explosion.

Examination and testing of the loading machine revealed the following:

- (a) The tram control levers on the loading machine were not provided with a self-centering safety device;
- (b) The operator's side tram motor junction connection box cover had an opening in excess of 0.025 inch and the back right corner bolt was missing. The other three bolts in the cover were not tight;
- (c) There was an opening in excess of 0.010 inch between the tram motor junction box and the end plate of the motor;
- (d) The packing gland entrance sleeve was split and broken and the packing gland was not provided with a means to secure it in place;
- (e) The methane monitor power conductors were torn from the sensor unit and the sensor unit was not attached to the frame of the loader;
- (f) A 10-ampere control fuse in the main panel was bridged across with approximately two wraps of No. 18 copper wire;
- (g) A ground was not provided for the 120-volt, single-phase lighting circuit that originated from the secondary side of the lighting transformer inside the main panel;
- (h) The cable entrance gland for the off side conveyor motor was broken out of the motor;
- (i) The main contactor panel had an opening in excess of 0.005 inch;
- (j) The methane monitor read-out unit had a cable entrance gland that was broken;
- (k) The pump start reset switch would not return to the run position when the switch was activated;
- (l) The tram control station had four openings in excess of 0.005 inch;
- (m) The pump motor and hydraulic tank had accumulations of oil-soaked coal and coal dust that were approximately 1 1/2-inch in depth;
- (n) The right front head light mounting bracket was torn from the loader frame and the head light lens cover was not secured; and,

- (o) The activator button was missing from the offside emergency fire suppression actuator cylinder.

Damage observed on the loading machine showed that the rear offside tri-plane light lens was broken and blown into the light fixture by the explosion forces.

Investigation interviews revealed that the AC power circuit supplying the loading machine was not energized at the time of the explosion. Based on this fact, neither the trailing cable nor the loading machine provided the ignition source for the explosion.

- 6. Approximately 25 Feet of Mine Power Cable, Type SHD-GC, No. 4/0 AWG Copper, 8 KV, Hatfield Cable Company, P-120 MSHA, with ADALET-PLM, Catalog No. OPML415, 15 KV, 500 Ampere Cable Couplers Attached**

The cable originated at the feed-through on the vacuum circuit breaker and supplied 7,200-volt, AC three-phase power to the 1,750-kVA portable power center located between the 1st Main North Track and Belt Entries at the mouth of the No. 2 Entry of the 4th West Entries. Insulation resistance measurements revealed that the mine power cable and couplers were free from a ground-fault or short-circuit condition. Investigation interviews revealed that the mine power cable was energized when the explosion occurred.

The direction of damaging forces indicated that the explosion originated in by the mine power cable. The investigators did not find any evidence that the mine power cable or PLM cable connectors provided the ignition source for the explosion. Based on these facts, neither the mine power cable nor the PLM cable couplers provided the ignition source for the explosion.

- 7. 1,750-kVA Portable Power Center, Line Power Manufacturing Company, Serial No. 9125**

1750-kVA Portable Power Center: High-Voltage Portion Findings

The portable power center was found in the 1st Main North Entries at the mouth of the No. 2 Entry of the 4th West Entries and reduced 7,200-volt, AC three-phase power to 995-volt, and 480-volt, AC three-phase power for operation of the longwall shield retriever (mule), longwall belt drive, rope hoist for the belt take-up unit, and battery charger.

The investigators determined that:

- (a) The mine power cable from the feed-through on the vacuum circuit breaker was energized;
- (b) The feed-through on the power center was capped and the three high-voltage phase conductors were disconnected inside the power center;

- (c) The high-voltage disconnect switch was in the closed (on) position;
- (d) All three high-voltage fuses were intact;
- (e) The emergency-stop switch was in the closed (on) position;
- (f) Evidence of electrical arcing was not found inside the high-voltage portion of the power center;
- (g) Insulation resistance measurements revealed that the high-voltage portion of the power center was free from a ground-fault or short-circuit condition;
- (h) The power center was provided with 14 interlock switches, nine under the top covers and five behind the side covers. Tests indicated all of the interlock switches were bypassed and were not properly connected in series with the incoming ground-check conductor so that removal of a cover would cause interruption of the incoming ground-check circuit and trip (open) the vacuum circuit breaker; and,
- (i) The power center was not damaged by the force of the explosion. However, the inside and outside surfaces were heavily coated with dust.

1750-kVA Portable Power Center: Low- and Medium-Voltage
Portion - Findings

The power center contained six, 995-volt, three-phase receptacles: two receptacles for the No. 1 longwall starter assembly; two receptacles for the No. 2 longwall starter assembly spare; one receptacle for the No. 3 pump circuit, and one receptacle for the No. 4 pump circuit spare.

The power center contained two, 480-volt, three-phase receptacles for the No. 1 and No. 2 auxiliary circuits. The power center also contained two, 240-volt, single-phase receptacles, and two, 120-volt, duplex single-phase receptacles. All receptacles were properly identified.

The power center contained four, three-pole, molded-case circuit breakers for the 995-volt, three-phase, secondary circuits. The power center also contained five, three-pole, molded-case circuit breakers for the 480-volt, three-phase, secondary circuits.

All circuit breakers were equipped with ground-check monitors and devices to provide overcurrent, grounded-phase, and undervoltage protection for these circuits.

All circuit breakers were in the tripped position when the investigators examined the power center. Evidence of a short-

circuit or ground-fault condition was not found in the low- or medium-voltage portion of the section power center.

The transition zone of the explosion forces was located in by the portable power center and the direction of damaging forces also indicated that the explosion occurred outside of the power center. The investigators did not find any evidence that the power center provided the ignition source for the explosion. Based on these facts, neither the low-voltage portion nor the medium-voltage portion of the power center provided the ignition source for the explosion.

1,750-kVA Portable Power Center: Low- and Medium-Voltage
Circuits - Findings

Medium-voltage circuits were not used on the power center. Two low-voltage circuits originated at the power center and supplied 480-volt, AC power to a battery charger and the mule.

One low-voltage AC circuit originated at the power center and extended to a direct-current battery charger located in the 1st Main North Track Entry between the No. 2 and No. 3 Entries of the 4th West Entries. The charger was powered by a No. 6 AWG, portable power cable.

Tests and examinations revealed the following:

- (a) The cable was not installed on insulators;
- (b) The instantaneous trip units protecting the cable were set at 650-amperes;
- (c) There was one permanent mechanical splice in the cable;
- (d) The ground-check conductor and the ground conductors of the cable were attached to the frame of the charger under the same connector;
- (e) The metal cable coupler for the cable was not provided with a frame ground;
- (f) Insulation resistance measurements revealed that the cable coupler, cable, and battery charger were free from a fault condition;
- (g) All fuses were intact inside the charger; and,
- (h) The charger was not damaged by the explosion forces. However, the inside and outside surfaces of the charger were coated with dust.

It was concluded that the AC power circuit to the charger was energized when the explosion occurred. However, the charger was not energized to charge batteries.

The transition zone of the explosion forces was located inby the charger and the direction of the damaging forces also indicated the explosion occurred inby the charger. Evidence was not found that indicated the charger provided the ignition source for the explosion. Based on these facts, neither the AC power circuit nor the battery charger provided the ignition source for the explosion.

The other low-voltage AC power circuit originated at the power center and extended approximately 1,700 feet to the mule that was in the process of removing the No. 85 Shield when the explosion occurred. The trailing cable was made from four different size cables. The first portion of the cable was a No. 6 AWG, cable that originated at the power center and was installed on the right side of the No. 2 Entry of the 4th West Entries. The cable extended through the crosscut between the Nos. 2 and 3 Entries of the 4th West Entries into the No. 3 Recovery Room. The cable was approximately 600 feet long.

The second portion of the cable was a No. 4/0 AWG, cable that originated at the splice located approximately 20 feet inby the No. 1 Recovery Room to the No. 3 Recovery Chute. The cable looped across the intersection of the No. 3 Recovery Room and the No. 3 Recovery Chute then continued back along the left side of the No. 3 Recovery Room and into the No. 2 Recovery Chute to a splice. The cable was approximately 375 feet in length.

The third portion of the cable was a No. 4 AWG, cable that originated at the splice located on the right side of the No. 2 Recovery Chute and extended approximately 32 feet to a permanent splice located in the intersection of the No. 2 Recovery Room and the No. 2 Recovery Chute.

The final portion of the cable was a No. 2 AWG, cable that originated at the splice located in the intersection of the No. 2 Recovery Room and the No. 2 Recovery Chute. The cable extended along the No. 2 Recovery Chute to the longwall face and across the longwall face to the mule. The cable was approximately 700 feet in length. It was determined that:

- (a) The AC cable was energized when the explosion occurred;
- (b) The mule was energized when the explosion occurred;
- (c) Insulation resistance measurements revealed that the cable and mule were free from a short-circuit or ground-fault condition;
- (d) The cable had seven permanent splices;
- (e) The mule was approved by MSHA as permissible but was not maintained in a permissible condition due to the length of the trailing cable; and,
- (f) The cable coupler for the mule was connected to a receptacle that was identified as the roof bolter receptacle.

Survivors were present on the longwall face at the mule when the explosion occurred. An ignition source was not found on the mule or on the cable extending to the mule. Based on these facts, neither the cable nor the mule provided the ignition source for the explosion. A short-circuit study was conducted on the high-voltage system and cable. A summary of the results of this study is in Appendix O.

A 120-volt, single-phase, AC power circuit originated at a duplex receptacle on the power center and extended to a nonpermissible lighting system installed for the 4th West Belt Drive. The lighting circuit was supplied power by a No. 14, AWG, portable power cable. The power cable was protected by a 15-ampere circuit breaker. Insulation resistance measurements revealed that the power cable, metal connection box, and nonpermissible light fixtures were free from a fault condition. It was concluded that the lighting circuit was energized when the explosion occurred.

The transition zone of the explosion forces was located in by the lighting system and the direction of damaging forces also indicated that the explosion occurred in by the lighting system. Evidence was not found that indicated the lighting system provided the ignition source for the explosion. Based on these facts, neither the AC power circuit nor any portion of the lighting system provided the ignition source for the explosion.

One other 120-volt, single-phase AC power circuit originated at the power center and extended to a metal safety disconnect switch box located in the 1st Main North Track Entry between the No. 2 and No. 3 Entries. The switch box was supplied power by a No. 10 AWG, portable power cable that was installed on insulators and protected by a 30-ampere circuit breaker. The power cable had two splices that were not provided with mechanical connectors and the outer jacket of the cable was torn off in one location, exposing approximately 5 inches of the inner insulated power conductors. The proper fitting for entering the power cable into the switch box was not installed to prevent strain on the power conductors and one fuse inside the switch box was bypassed with a No. 18 AWG, copper conductor. A power circuit was not connected to the load side of the switch box.

The AC power circuit was not energized when the explosion occurred and neither the AC power circuit, cable, nor the safety disconnect switch box provided the ignition source for the explosion.

Battery-Powered Equipment

The battery-powered equipment found in the 4th West Entries and 4th West recovery area after the explosion consisted of three MSHA approved scoop tractors, three nonpermissible golf carts, four permissible methane detectors, five permissible electric cap lamps, and two nonpermissible mine pager phones.

During the recovery, one MSHA approved scoop tractor, Company No. R038, was found in the intersection of the No. 3 Entry and the No. 3 Recovery Room. The investigators examined and tested the scoop tractor to determine if the scoop tractor or any of its components provided the ignition source for the explosion. Examination and tests revealed the following:

- (a) Locking devices were not provided for the battery plug connectors;
- (b) Two battery cover lids were not provided with a means to secure them in a closed position;
- (c) Three packing gland nuts on the main contactor panel enclosure were not provided with a means to secure them against loosening;
- (d) Adequate short-circuit protection was not provided for the control circuits that extended from the main contactor panel. The 10-ampere fuses approved for the control circuits were replaced with 30-ampere fuses;
- (e) One cable entrance gland on the main circuit breaker enclosure was not properly packed;
- (f) One cable entrance gland on the main contactor panel enclosure was not properly packed;
- (g) The approved specified circuit breaker settings for the power circuit that extended from the main circuit breaker enclosure to the main contactor enclosure were not maintained;
- (h) The micro-interlock switch was bypassed;
- (i) The shunt trip coil for the main circuit breaker was disconnected;
- (j) The scoop tractor did not have an attached approval plate that identified the machine as being permissible;
- (k) Insulation resistance measurements revealed that the traction and pump motors, contactor panel, solid state panel, power, control and light circuits on the scoop tractor were free from a ground-fault condition;
- (l) Evidence of electrical arcing was not present on the battery-tray covers, battery-cell terminals, or intercell connections; and,
- (m) Evidence of an internal methane-air ignition was not present in any of the electric enclosures.

Based on the investigation interviews, it was concluded that the scoop tractor was energized and used to retrieve shields from the longwall face when the explosion occurred. The direction of the damaging forces indicated that the explosion occurred in by the scoop tractor. An ignition source was not found on the scoop tractor. Based on these facts, the scoop tractor did not provide the ignition source for the explosion.

An MSHA approved scoop tractor, Company No. R039, was found next to the Nos. 13 and 18 Shields (Appendix U). Investigators examined and tested the scoop tractor to determine if the scoop tractor or any of its components provided the ignition source for the explosion. Examination and tests revealed the following:

- (a) The control panel enclosure in the operator's compartment had one fastener bolt missing from the top right corner of the panel cover. The first fastener bolt to the right of the top left corner fastener bolt was loose. There was an opening in excess of 0.005 inch where the fastener bolt was missing. The pump motor "on" switch was removed from the control panel cover leaving a 1/2-inch opening where the switch shaft had originally been. Mechanical connectors were not used to splice two control circuit conductors that were removed from the "on" switch. With the control circuit for the "on" switch bypassed, the pump motor for the scoop tractor was started and shut-off by using the emergency stop (panic bar) lever. The control circuits for the tram motor were also controlled by the panic bar lever;
- (b) The main circuit breaker enclosure had the operator's side battery cable packing gland missing, allowing an opening of approximately 1 inch from the interior to the exterior of the enclosure. One fastener bolt was loose in the panel cover for the enclosure. The packing nuts for all cable entrance glands entering the enclosure were not secured against loosening. The ground conductors provided for the enclosure were not attached to the frame of the enclosure. The operator's side battery negative power conductor was grounded (welded) to the metal frame of the enclosure. The approved specified circuit breaker settings for the power circuit that extended from the main circuit breaker enclosure to the main contactor enclosure were not maintained. Short-circuit protection was not provided for the main circuit-breaker solenoid trip coil circuit that extended from the enclosure to the contactor panel enclosure (Photo-Appendix U);
- (c) The main contactor panel enclosure had two panel cover fastener bolts that were loose. There was an opening in excess of 0.005 inch on the right side of the panel cover. Adequate short-circuit protection was not provided for the control and light circuits that extended from the enclosure. The micro-interlock switch was

bypassed. The packing gland for the pump motor cable was not properly packed. A bushing that reduces the inside diameter of the stuffing box to accommodate the cable was missing;

- (d) The front headlight assembly on the operator's side had a lens cover that was not secured against loosening and two packing glands were not properly packed;
- (e) The rear head light assembly opposite the operator had one packing gland that was not properly packed. Two splices inside the rear head light were made without mechanical connectors. The frame-ground conductor provided for the rear head light was not attached to the metal frame of the enclosure;
- (f) A frame-ground conductor was not provided from the left rear head light enclosure to the right rear head light enclosure;
- (g) The traction motor cable entrance packing gland was not secured against loosening;
- (h) The battery plug connectors were not provided with padlocks. The battery-box cover lids for the operator's side battery were not provided with a means to secure them in a closed position;
- (i) The 2-inch flame-resistant hose conduit that provided mechanical protection for the power cable that extended from the main circuit breaker enclosure to the main panel enclosure had an unacceptable taped repair splice;
- (j) Insulation resistance measurements taken after the battery negative lead was removed from contacting the frame of the circuit breaker enclosure revealed that the motors, contactor panel, solid state panel, power, control, and light circuits on the scoop tractor were free from a fault condition;
- (k) The scoop tractor did not have an attached approval plate that identified the machine as being permissible; and,
- (l) Evidence of electrical arcing was not found on the inside of the battery-tray covers, battery-cell terminals, or intercell connections on the batteries.

Investigation interviews revealed that the scoop tractor was energized when the explosion occurred and the pump motor on this scoop tractor was still operating after the explosion. The pump motor was deenergized by mine personnel who were recovering the victims. The negative lead from the operator's side battery was found grounded (welded) to the frame of the circuit-breaker enclosure with evidence of arcing that could provide a source of

ignition. Openings existed in the circuit breaker enclosure that would allow flames to escape to the surrounding atmosphere. Based on these facts, the operation of this scoop tractor in an explosive methane-air mixture could provide an ignition source for the explosion.

One MSHA approved scoop tractor, Company No. R006, was found in the No. 2 Recovery Chute, between the No. 2 and No. 3 Recovery Rooms. Investigators examined and tested the scoop tractor to determine if the scoop tractor or any of its components provided the ignition source for the explosion.

Examination and tests revealed the following:

- (a) The power-take-off (PTO) circuit-breaker enclosure located in the operator's compartment had an opening in excess of 0.005 inch and the solenoid trip coil for the PTO circuit breaker was defective;
- (b) The master control panel enclosure located in the operator's compartment had three packing gland nuts that were not secured against loosening. One fastener bolt was missing from the control panel cover and the panel cover had an opening in excess of 0.005 inch. Two cable entrance openings were closed by welding 1/8 inch metal plates to the end of packing nuts;
- (c) The main contactor panel had an opening in excess of 0.005 inch and the pump motor cable entrance gland was not properly packed. The front tram motor cable entrance gland was not properly packed. Adequate short-circuit protection was not provided for the control and solid state logic circuits that extended from the contactor panel. The micro-interlock switch was bypassed. Six packing gland nuts for cables that enter the main contactor panel were not provided with a means to secure them against loosening;
- (d) The main circuit breaker enclosure had one cable entrance gland that was not properly packed. Short-circuit protection was not provided for the circuit-breaker solenoid trip coil circuit that extended from the circuit breaker enclosure;
- (e) The battery plug connectors were not provided with a locking device;
- (f) The operator's side rear headlight had two splices inside the enclosure that were made without mechanical connectors. The ground conductor for the headlight enclosure was not attached to the frame of the headlight enclosure;
- (g) Insulation resistance measurements revealed that the motors, contactor panel, solid state panel, power,

control and light circuits on the scoop tractor were free from a fault condition;

- (h) Evidence of electrical arcing was not found on the inside of the battery-tray covers, battery-cell terminals, or intercell connections on the batteries;
- (i) The scoop tractor did not have an attached approval plate that identified the machine as being permissible; and,
- (j) Evidence of an internal methane-air ignition was not found in any of the electric enclosures.

Investigation interviews revealed that the scoop tractor was used to supply roof support materials to the longwall face when the explosion occurred. The scoop tractor was found out of the area affected by the flames of the explosion. Evidence was not found that indicated the scoop tractor provided the ignition source for the explosion. Based on these facts, the scoop tractor did not provide the ignition source for the explosion.

One nonpermissible battery-powered golf cart was found one crosscut inby the 1st Main North Track Entry between the No. 2 and No. 3 Entries of the 4th West Entries. A nonpermissible battery charger mounted on the golf cart had approximately 30 feet of No. 12 AWG, three-conductor, SO portable power cable that supplied 120-volt, single-phase, AC power to the battery charger.

Examination and tests of the cable, battery charger, and golf cart revealed the following:

- (a) All fuses in the battery charger were intact;
- (b) The direct-current traction motor was not provided with overcurrent protection;
- (c) The golf cart was not damaged by the explosion forces;
- (d) Insulation resistance measurements revealed that the cable, battery charger, and wiring of the golf cart were free from a fault condition; and,
- (e) Evidence of electrical arcing was not found on the battery-cell terminals, or intercell connections.

The forces generated by the explosion damaged electric equipment and circuits inby the golf cart. Evidence was not found that indicated the golf cart provided the ignition source for the explosion. Based on these facts, it was concluded that the golf cart was parked in the crosscut and turned off before the explosion and did not provide the ignition source for the explosion.

One nonpermissible battery-powered golf cart was found between the No. 2 and No. 3 Entries of the 4th West Entries in the 1st Main

North Track Entry. A nonpermissible battery charger mounted on the golf cart had approximately 30 feet of No. 12 AWG, three-conductor, SO portable power cable that supplied 120-volt, single-phase, AC power to the battery charger.

Investigation interviews revealed that this golf cart was driven to this location after the explosion and remained there until the investigation was completed. Based on this fact, the golf cart did not provide the ignition source for the explosion.

A twin 250-horsepower belt drive with two, 250-horsepower motors, was found in the No. 3 Entry of the 4th West Entries at the intersection of the 1st Main North Belt Entry. The starter assembly for the belt drive was removed, but the No. 4/0 AWG, and 350 MCM AWG, motor cables were still connected to the motors. One 480-volt, three-phase, rope hoist was found in the No. 3 Entry two crosscuts inby the 1st Main North Belt Entry. The belt drive, rope hoist, and cables were not connected to any source of AC power. Based on these facts, they did not provide the ignition source for the explosion.

A battery-powered pager phone circuit originated at a nonpermissible mine pager phone located at the mouth of the No. 2 Entry of the 4th West Entries and extended to a nonpermissible mine pager phone located between the foot pads of the Nos. 79 and 80 Shields. The two pager phones were interconnected by approximately 1,700 feet of No. 16 AWG, two-conductor phone cable.

One nonpermissible pager phone was installed within 150 feet of pillar workings. Arcing from an automatic or manual operation of a relay or switch in the pager phone could have released sufficient energy to ignite an explosive methane-air mixture. Investigators examined and tested the mine pager phones and mine phone cable to determine if the pager phones or cable could have provided the ignition source for the explosion.

Survivors were present at the pager phone on the longwall face when the explosion occurred. Forces generated by the explosion damaged electric equipment and circuits inby the pager phone at the mouth of the No. 2 Entry. Evidence was not found that indicated the nonpermissible pager phones or the phone circuit provided the ignition source for the explosion.

Diesel-Powered Equipment

One diesel-powered scoop tractor was located under a fall in the No. 3 Recovery Chute. Since the scoop tractor could not be examined or tested and was in an area not affected by the flames from the explosion, it was concluded that the scoop tractor did not provide the ignition source for the explosion.

Cap Lamps and Methane Detectors

Fourteen permissible cap lamps were used in the 4th West Entries and recovery area when the explosion occurred. Four of the cap lamps were worn to the surface by survivors, five of the cap lamps were removed with the victims, and five cap lamps were found during the investigation. All the permissible cap lamps used the morning of the explosion could not be conclusively identified, so the investigators visually examined all cap lamps at the mine.

The examination revealed that the cap lamps were being maintained in a permissible condition. Investigators found no evidence that the cap lamps provided the ignition source for the explosion.

Four permissible methane detectors were recovered by the investigators. These detectors were sent to the MSHA Approval and Certification Center for testing and evaluation to determine if one of the devices could have provided the ignition source. A summary of the results of the testing and evaluation of these devices is in Appendix T. Based upon the results of these tests and examinations, the methane detectors did not provide the ignition source for the explosion.

Stray Currents

The investigators also eliminated any likelihood that stray currents acted as an ignition source for the explosion. During the investigation, tests were conducted to determine if stray currents may have existed with sufficient energy to ignite methane or detonate electric blasting caps in the explosion zone. To verify whether or not stray currents did exist and to establish their intensity, MSHA's Mine Electrical Systems Division (MESD) was requested to assist in the investigation. During subsequent trips underground by the MESD engineers to the 4th West Entries, stray currents of sufficient energy to ignite methane or blasting caps were not found.

Therefore, the probability of stray currents acting as the ignition source is unlikely. The results of the stray current study are in Appendix O.

Environmental Monitoring System

A nonpermissible power supply box (outstation), air velocity sensor (F-23), and a methane sensor (M-19) were recovered from the No. 1 Entry of the 5th West Bleeder Entries. Also, two CO sensors were recovered. CO sensor (CO-48) was recovered from the return aircourse near the bottom of the Mithcell Station return air shaft, and CO sensor (CO-13) was recovered from the intersection of the 1st Main North Track Entry and the No. 3 Entry of the 4th West Entries. All of these devices were sent to the MSHA Approval and Certification Center for testing and evaluation.

Evaluation of the Conspec P1400 CO sensors (CO-13 and CO-48) recovered from the mine showed that the sensors had various component changes. These changes did not involve increases in the total capacitance or induction or decreases in the resistance values. Even with these component value differences the classified sensors remained safe when connected to a classified Class G Barrier.

A summary of the results of the testing and evaluation of all these devices is in Appendix T. Due to the physical location and the test results of these devices, it was concluded that they did not provide the ignition source for the explosion.

Electric Blasting Caps

During the investigation, an electric blasting cap was found in the No. 15 Crosscut of the No. 2 Entry of the 4th West Entries. Three electric blasting caps of the same type and manufacturer were found stored in the No. 22 Shield. These blasting devices were recovered by investigators and sent to the U.S. Department of Interior, Bureau of Mines, Explosives Group for testing and evaluation. An additional 100 duplicate blasting devices were sent for testing and evaluation to determine if the devices could provide the ignition source for the explosion. A summary of the results of the testing and evaluation of these detonators is in Appendix S.

Since blasting caps were found, it indicated that other caps could have been left in the 4th West Entries, longwall face, or gob area. Based on these facts, a blasting cap could have detonated when impacted between hard surfaces, and provided the ignition source for the explosion.

Mechanical and Miscellaneous Devices

The flames and forces of the explosion were also present where other mechanical and miscellaneous devices were found. In addition to examining the previously described electrical circuits and equipment, MSHA examined and tested these mechanical and miscellaneous devices for evidence of the ignition source. A detailed description of these examinations and tests follow.

Cutting Torch Assembly

One cutting torch assembly consisting of one oxygen bottle and one acetylene bottle, a cutting torch, cutting torch hoses, and two pressure regulators was found in front of the No. 11 Shield. Investigation interviews revealed that a cutting torch was frequently

used to remove the set screws that held the dogbone connecting link in place on the sides of the panline. The investigators determined that the set screws on the shield side of the panline were cut with a torch and loose material was cleaned away from the dogbone connecting link on the opposite side of the panline, so the set screws holding that connecting link could be removed.

The cutting torch was found in the center of the panline at the No. 7 Shield with both the oxygen and acetylene shut-off valves in the closed position. The shut-off valves on the oxygen and acetylene bottles were also found in the closed position. Investigation interviews revealed that mine personnel recovering the victims checked the oxygen bottle's shut-off valve and reportedly found it in a closed position, and found the acetylene shut-off valve opened approximately 5 degrees. These interviews revealed that earlier in the shift one of the survivors saw the flame and smelled smoke from the cutting operation. It appeared at least one cutting operation (cutting of set screws) was performed during the morning of the explosion. Based on these facts, the cutting torch or hot slag created by the cutting operation could provide an ignition source for the explosion.

The cutting torch assembly was recovered by the investigators and sent to the MSHA Bruceton Safety Technology Center for testing and evaluation to determine if one of the devices could have provided the ignition source for the explosion. A summary of the results of the testing and evaluation of these devices is in Appendix R.

Torch Ignitor

One torch ignitor was found between the foot pads of the Nos. 20 and 21 Shields. The torch ignitor was capable of producing a spark that could ignite an explosive methane-air mixture. The location of the torch ignitor and the location of the victims indicated that the torch ignitor was either thrown or placed there by one of the victims, or was blown to this location by the explosion forces. Based on these facts, the torch ignitor could provide an ignition source for the explosion.

Messenger Wire

Investigators found steel messenger wire installed along the No. 2 Entry of the 4th West Entries. This messenger wire was found in by the No. 6 Crosscut under falls of roof material that pulled the wire extremely taut. The wire was found pulled apart near the location where bi-directional explosion forces originated in the No. 2 Entry. A portion of the messenger wire was recovered by investigators and sent to the MSHA Bruceton Safety Technology Center for testing and evaluation to determine if steel messenger wire could have provided the ignition source for the explosion.

Past research indicates that, under certain specific conditions, tensile failure of steel wire similar in size to the messenger wire

found could generate sufficient energy to ignite methane. Based on these facts, the steel messenger wire could provide an ignition source for the explosion.

Sledgehammer

A sledgehammer was found beside the panline in front of the battery-powered scoop tractor. If this sledgehammer was used to strike a metal object, enough energy could be generated to ignite a methane-air mixture. Investigators did not find any evidence that the sledgehammer was used the morning of the accident. Based on this fact, the sledgehammer did not provide the ignition source for the explosion.

Smoking Materials

Evidence from the investigation did not indicate that smoking was the ignition source for the explosion. Experiments have shown that the temperatures generated by a lit cigarette are on the order of 800-850°F. These values are less than the approximate 1,100°F required for ignition of methane. The flame of a match or a cigarette lighter provide temperatures in excess of 1,200°F and can easily ignite methane. None of the victims were present in the transition zone of the 4th West Entries and, therefore, the only potential for an ignition to occur from smoking would be at the longwall face. After the explosion, no smoking articles were found on the victims. However, the investigators did find one cigarette butt in the No. 6 Crosscut of the No. 2 Entry in the 4th West Entries. Although this fact tends to verify that smoking may have occurred underground, the investigators did not observe any evidence that indicated smoking occurred on the day of the explosion within the explosion zone. Based on the facts that a burning cigarette alone would not have a sufficient temperature to ignite methane, and that none of the victims were found in the transition zone and that no smoking articles were found on the victims, it is concluded that the use of smoking materials did not provide the ignition source for the explosion.

Potential Ignition Sources

After evaluating all of the evidence and based on the observation and tests conducted during the investigation, the investigation determined that several potential ignition sources existed. The existence of these potential ignition sources was determined by examining several factors.

An underground coal mine explosion can occur when an ignition source of sufficient heat or energy ignites a fuel, typically

methane or coal dust. An explosion zone develops as the explosion propagates. This zone can be identified on mine maps showing the extent of flame and direction of primary forces. Ignition sources are those that exist within the boundaries identified by the extent of flame. However, it is typical for an explosion to propagate in all directions away from the source of ignition. Identifying the direction of primary explosion forces is a major factor in eliminating many of the ignition sources within the explosion zone. Thus, a large number of ignition sources can be reduced to a few potential ignition sources. Appendix Z shows the extent of flame and direction of forces within the explosion zone at the Pyro No. 9 Slope, William Station Mine.

A transition zone in the 4th West Entries was identified as the area between and including the Nos. 9 and 10 Crosscuts in the No. 2 Entry. This area would be considered the area where the explosion began to violently propagate. A low-magnitude methane explosion could have propagated into this area and then escalated. This condition could have existed from an ignition of methane either at the face or within the outer regions of the gob.

Ignition sources such as electrical equipment located away from the transition zone and longwall face are considered to be of low probability, either due to the direction of explosion forces or the likelihood of the source causing a spark of sufficient incendivity. For example, the sledgehammer found at the longwall face would be unlikely to provide the source of ignition.

After carefully examining the entire explosion zone and identifying all of the forces that occurred during the explosion, a list of potential ignition sources was compiled. This list of potential ignition sources is taken from those ignition sources within the transition zone or the longwall face area. These sources are:

1. Operation or the attempted lighting of a cutting torch;
2. Operation of a scoop tractor;
3. Detonation of blasting cap;
4. Roof fall; and,
5. Tensile failure of messenger wire.

The following review of each potential ignition source gives an analysis of each source examined in relation to the flames and forces found by the investigation, and in relation to other evidence.

Operation or the Attempted Lighting of a Cutting Torch

The operation or the attempted lighting of a torch in the longwall face area may have caused the explosion. Although this equipment was located a substantial distance from the transition zone, consideration must be given to the torch as a potential source of the explosion. An historical summary of underground coal mine explosions shows that most explosions are initiated through the actions

of one or more of the victims. Evidence in the vicinity of the victims, such as the torch and ignitor, is closely evaluated in all explosion investigations.

The extent of flame and the direction of forces shown in Appendix Z indicated that the primary explosion occurred in the transition zone of the 4th West Entries. In order for the torch or the ignitor to be the ignition source, methane must have accumulated in one of two ways:

- (1) An accumulation must have existed at or near the location of the torch, through the shields, along the perimeter of the gob, and into the 4th West Entries; or,
- (2) A methane layer must have accumulated behind the shields, along the perimeter of the gob, and extend into the 4th West Entries.

In the No. 1 scenario, the regular activities of miners working in the longwall face area would prevent methane from layering in the immediate face area near the headgate shields. If a small methane-air mixture were ignited in the face area, it could propagate to a methane accumulation behind the shields, and then along the perimeter of the gob to the transition zone in the No. 2 Entry. In addition, for the torch to be a potential ignition source, the torch must have been in operation or an attempt to light the torch must have been made.

In the No. 2 scenario, since the torch is not a fixed piece of equipment, it can be repositioned in many ways. The torch could be swung into contact with a methane layer, or a hot particle may project into the methane layer or accumulation behind the shields from the area where cutting was being done. An ignition of methane could occur and burn along the perimeter of the gob in the No. 3 Entry until it reached a methane-laden path into the transition zone. Here, the explosion could reach its maximum flame speed and pressure, resulting in the extent of flame and forces shown in Appendix Z.

The operation of the torch requires open acetylene and oxygen regulators on the tanks. Acetylene and oxygen valves must also be open on the torch. In order to light the torch, only the acetylene valve on the torch needs to be open while the oxygen valve remains closed. The torch was found by investigators with both valves in the closed position. It could not be verified exactly when these valves were placed in the off position, or even if they were both off at the time of the accident. Based on this evidence, it could not be assumed that the torch was off or inoperable at the time of the explosion. Examination of the cutting torch, regulators, and hoses was conducted by MSHA ISD after the explosion. The results of all testing are contained in Appendix R. The operation or the attempted lighting of the torch remain as potential sources of the ignition.

Operation of the Scoop Tractor

The only scoop tractor that was a potential source of ignition for this explosion was located near the headgate on the longwall face. This scoop tractor was not maintained in permissible condition as evidenced by the numerous violations found during the investigation. These conditions are discussed in the Electric Circuits and Equipment section of this report. If this scoop tractor was the ignition source, a methane accumulation would have existed from the face area, along the perimeter of the gob, and into the 4th West Entries. The normal movement of miners in the longwall face area would have prevented methane layering in front of the longwall shields. A low concentration methane mixture could have occurred at the longwall face. However, methane layering behind the shields was possible. Energizing electric components not maintained in a permissible condition in an explosive methane-air mixture could result in an explosion at the face. The limited quantity of methane may have prevented the explosion from propagating in any direction except into the gob. This ignition could result in the slow burning of a methane layer along the perimeter of the gob. Eventually, this methane layer would burn along a methane-laden path into the transition zone. Here, the explosion could reach its maximum flame speed and pressure resulting in the extent of flame and forces shown in Appendix Z. Operation of the nonpermissible scoop tractor remains as a potential source of the ignition.

Detonation of a Blasting Cap

A blasting cap could have detonated in the transition zone of the 4th West Entries or in the longwall face area. Investigators found a live blasting cap in the No. 15 Crosscut of the 4th West Entries. This blasting cap was not detonated and is not considered as the source of ignition for the explosion. However, it does indicate that other blasting caps may have been left in the 4th West Entries, the longwall face or the gob. Tests conducted by the U.S. Bureau of Mines (USBM) revealed that a blasting cap could detonate when impacted between hard surfaces such as existed in the mine (Appendix S). The detonation of a blasting cap remains as a potential source of the ignition.

A Roof Fall

Since roof falls existed in the 4th West Entries and the gob area of the longwall, the explosion could have been the result of a roof fall. Documented methane ignitions have occurred as a result of roof falls. Frictional contact can occur between hard rock surfaces, which results in a hot streak with temperatures exceeding 1100°F, or as crystals break apart in the rock with energies exceeding 0.3 millijoule. This phenomena is known as a piezoelectric discharge. Frictional ignitions during roof falls are usually limited to those areas with a thick sandstone roof. The hard sandstone allows friction to buildup heat, unlike shales where

excess pressure and friction cause the shale to break apart.

Throughout the explosion zone, the roof is primarily comprised of shales, which do not become involved in frictional heating during a roof fall. Many pyritic inclusions in the roof/coal seam interface existed in this area of the mine. Pyritic inclusions may release sufficient energy when splitting to ignite methane accumulations in the explosive range. One split pyritic inclusion was found by the investigators at the No. 13 Crosscut in the No. 2 Entry of the 4th West Entries. This location was too far in by the transition zone to be considered as the source of the explosion. However, a roof fall between the Nos. 8 and 11 Crosscuts in the No. 2 Entry is a possibility which could have resulted in the explosion.

Roof falls occurred prior and subsequent to the explosion within or near the transition zone. For example, major falls were observed at the Nos. 8, 9 and 11 Crosscuts in the No. 2 Entry of the 4th West Entries. Between the Nos. 2 and 3 Entries, the No. 8 Crosscut was inaccessible and no force arrows are shown at this location in Appendix Z. Also, there are no force arrows shown in the No. 11 Crosscut. Investigators were not able to determine the direction of forces in the No. 11 Crosscut because roof falls made the area inaccessible. For these reasons, a roof fall near the edge of the gob cannot be eliminated as a possible ignition source. A roof fall would have had to develop a spark of sufficient incendivity within an explosive methane-air mixture.

A roof fall in the interior of the gob could have resulted in the explosion. This scenario is unlikely based on the magnitude of the dynamic and static pressures experienced throughout the explosion zone. If an explosion were propagating away from the gob, it would push methane accumulations into the No. 1 Entry, where a propagating flame front would have been expected. Evidence of flame along the No. 1 Entry was not observed by the investigators, thus eliminating a roof fall ignition in the gob as the cause of this explosion. However, a roof fall in the transition zone or near the perimeter of the gob remains as a potential source of the ignition.

Tensile Failure of the Messenger Wire

The possibility existed that sufficient energy to ignite methane could occur if a tensile failure of the messenger wire occurred. This messenger wire was installed along the length of the No. 2 Entry in the 4th West Entries. It was originally installed as a support wire for the high voltage cable that was used in the 4th West Entries during development. The explosion investigation revealed that this wire was stretched tightly in many places and it ran under several roof falls, preventing the investigators from examining its entire length. The pulling apart of this wire, inducing a tensile failure, could create sufficient energy to ignite methane. Because of the difficulty in performing a laboratory experiment to show this, a literature search was

undertaken. Past research indicates that, for steel wire similar in size to the messenger wire found along the 4th West Entries, sufficient energy would exist in such a tensile failure under certain specific conditions to ignite methane. Therefore, the tensile failure of the messenger wire remains as a potential source of ignition.

Probable Point of Origin

In attempting to determine the probable point of origin of the explosion, MSHA investigators carefully evaluated the following factors:

1. The effects on the longwall bleeder ventilation system created by the following:
 - (a) Accumulation of water at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries that blocked air flow in the bleeder system;
 - (b) Completion of mining in the Cut-through Entries between 2nd Main North Entries and the 5th West Entries;
 - (c) Completion of mining in the 4th West Entries between the 2nd Main North Entries and the Set-up Rooms;
2. The effects on the ventilation of the 4th West Entries, 5th West Entries, longwall face, and recovery rooms created by the following:
 - (a) Removal of the Longwall Panel "O" regulator located in the No. 1 Entry of the 5th West Entries;
 - (b) Removal of the air-lock doors located in the track entry of the 4th West Entries;
 - (c) Removal of permanent stoppings located between the recovery rooms and the 4th West Entries;
 - (d) Installation and maintenance of check curtains installed in the recovery chutes, recovery rooms and the 4th West Entries;
 - (e) Removal of the concrete block stopping located in the No. 1 Cut-through Entry between the 4th West and 5th West Entries;
3. The extent of flame in the 4th West Entries, longwall face, and 1st Main North Entries;

4. The magnitude and direction of forces in the 4th West Entries, longwall face, recovery rooms and the 1st Main North Entries; and,
5. The locations of the potential ignition sources.

After evaluating these factors, it was concluded that the explosion originated either on the longwall face or in the No. 2 Entry of the 4th West Entries between and including the Nos. 8 and 11 Crosscuts.

The actual ignition source could not be definitely identified. The explosive methane-air mixture was ignited by one of the following probable ignition sources:

1. Operation or the attempted lighting of a cutting torch;
2. Operation of the scoop tractor;
3. Detonation of a blasting cap;
4. A roof fall; and,
5. Tensile failure of the messenger wire.

FINDINGS OF FACT

Findings

1. At about 9:13 a.m., September 13, 1989, an explosion occurred in the 4th West Entries, longwall recovery area, of Pyro Mining Company's, Pyro No. 9 Slope, William Station Mine, near Sullivan, Union County, Kentucky.
2. Fourteen miners were present in the longwall recovery area at the time of the explosion. Ten of the miners in the area died as a direct result of the explosion. Four of the miners were exposed to heat, smoke, dust and the forces of the explosion, but survived uninjured.
3. Five of the victims were recovered from the No. 3 Recovery Room where they had been overcome by smoke and four of the victims were recovered from the longwall face near the headgate where they had been burned and overcome by smoke and CO. One of the victims was recovered from the intersection of the No. 3 Recovery Room and the 4th West Belt Entry where he had been burned and overcome by smoke and CO. All victims were transported to the surface at the William Station Portal.
4. The medical examiner's reports indicated all of the victims died as a result of smoke, soot and/or toxic fume inhalation.
5. An MSHA Safety and Health Inspection (AAA) was in progress at the time of the explosion. The inspection began on August 8, 1989, and was terminated on September 13, 1989 because of the explosion. A total of 35 citations and one order were issued during this inspection.
6. During the day shift on September 13, 1989, two federal inspectors were on the surface at the mine preparing to perform inspection activities when the explosion occurred.
7. Pyro No. 9 Slope, William Station Mine is interconnected with Pyro No. 11 Mine. Pyro No. 11 Mine, ID No. 15-10339, was developed as a drift mine into the Kentucky No. 11 coal seam and began active status on April 13, 1977. Pyro No. 11 Mine entered inactive status on May 6, 1983.
8. Pyro No. 9 Slope, William Station Mine was opened into the Kentucky No. 9 coal seam by three shafts and a slope. An intake shaft, 486 feet deep, and a return shaft, 857 feet deep, were developed from the surface. An 800 feet long slope and a 164 feet deep return shaft were developed from Pyro No. 11 Mine, down to the Kentucky No. 9 coal seam.
9. Ventilation was induced by three main fans located on the surface. These fans provided ventilation utilizing a push-

pull system. The exhaust fan installations included automatic-closing and explosion-relief doors.

10. The exhaust fan located at Mitchell Station shaft was a Joy Axivane Model M96-58DS direct-drive fan operated at 1,180 rpm by a 1,000-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 22-degree blade position, at a negative pressure of 13.80 inches of water. An air measurement made during the investigation indicated 339,000 cubic feet per minute (cfm) was being exhausted from the Mitchell Station shaft.
11. The intake fan located at William Station Portal was a Joy Axivane Model M84-50 direct-drive fan operated at 1,180 rpm by an 800-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 32-degree blade position, at a positive pressure of 6.60 inches of water. An air measurement made during the investigation indicated 364,000 cfm was being forced into the mine.
12. The exhaust fan located at Pyro No. 11 Mine drift opening was a Jeffrey Model 8HU-84 Aerodyne, belt-driven fan operated at 1,180 rpm by a 700-horsepower electric motor. Pressure and air quantity measurements made at this fan during the investigation indicated the fan was operating in the 1B-1S blade position, at a negative pressure of 6.16 inches of water. An air measurement made during the investigation indicated 194,000 cfm was being exhausted from the drift opening.
13. The methane liberation was 1.73 million cubic feet per 24-hour period as measured during the last MSHA Safety and Health Inspection (AAA) prior to the explosion.
14. At the time of the accident, there were two active continuous mining units and two active conventional mining units. Also, there was one set of longwall mining equipment that was in the process of being recovered from Longwall Panel "O" and moved to Longwall Panel "P".
15. Longwall Panels "M", "N", and "O", were part of an area of longwall mining bounded by the 1st Main North, 8th West, 2nd Main North, and 1st Main West Entries.
16. The 8th West Entries were connected to the 2nd Main North Bleeder Entries during August 1988, with these entries serving as the bleeder entries for Longwall Panel "M" and subsequent longwall panels.
17. By mid September 1988, Longwall Panel "M" was ready to begin operation, but the 7th West Entries were not connected. Only the No. 1 Entry, or tailgate entry, of the 7th West Entries was connected; the remaining four entries were left separated by approximately 150 feet.

18. On January 4, 1989, methane concentrations of 2.5 percent and 3.0 percent were found in the connecting entries between the 2nd Main North Bleeder Entries and the 7th West Entries. On January 5, 1989, 4.8 percent methane was found in the same general area of the bleeders.
19. On January 27, 1989, methane concentrations from 2.1 percent to 3.4 percent were detected in the side bleeder of Longwall Panel "M", or the No. 1 Entry of the 6th West Entries.
20. The shortened Longwall Panel "N" resulted in Longwall Panel "O" being reduced in depth. Development of the 4th West Entries was stopped approximately 1,300 feet short of original plans in order to establish set-up entries for the longwall equipment being moved from the worked out Longwall Panel "N". Longwall Panel "O" was 3,730 feet in depth with a face width of 670 feet.
21. During June 1989, Pyro changed the tailgate entry of Longwall Panel "O" from an intake aircourse to a return aircourse. This change was prompted by poor roof conditions in the tailgate entries inby the longwall face along with an accumulation of water at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries.
22. The lowest elevation in the mine was at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries. According to David R. Canning, Production Engineer, plans were made to provide water pumping facilities at this location prior to the start-up of the first longwall, Longwall Panel "M".
23. Three attempts to drill boreholes into the bleeder entries for water removal were unsuccessful. The fourth and successful borehole was finished on February 11, 1989. A 4-inch oil-well sucker-rod pump was installed on the borehole and began pumping at the rate of 64 gpm on July 11, 1989. The pumping rate was increased to 75 gpm on July 17, 1989, and continued at this rate up to the time of the explosion.
24. During May, 1989, Larry S. Hunt, Fireboss, reported to Pyro management that water was accumulating in the bleeder entries. By the end of June, 1989, water levels had risen further and completely blocked the air flow through the bleeders at the intersection of the 2nd Main North Bleeder Entries and the 8th West Entries.
25. On June 29, 1989, Ted D. Smith, Coal Mine Safety and Health Inspector (MSHA), found 6.8 percent methane (analysis of bottle samples revealed 9.96 percent) at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries. Smith issued a Section 107(a) imminent danger order for the accumulation of methane and he issued two other Section 104(a) citations for violations of the approved ventilation plan.

26. After changes were made, the Section 107(a) imminent danger order was modified to allow Longwall Panel "O" to resume production, on July 1, 1989, as long as continuous monitoring for methane and oxygen concentration was conducted at the tailgate and at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries.
27. During July, monitoring by MSHA showed perceptible movement toward the 2nd Main North bleeder Entries in the 4th West Entries. Monitoring in the 5th West Entries at Spad 41+85 indicated airflow ranging from movement to 5000 cfm toward the 2nd Main North Bleeder Entries. Air quality tests in the 4th and 5th West Entries indicated oxygen concentrations above 19.5 and methane concentrations below 2.0 percent.
28. On July 22, 1989, Pyro completed mining the Cut-through Entries between the 2nd Main North Entries and the 5th West Entries. In late August of 1989, Pyro completed mining in the 4th West Entries between the 2nd Main North Entries and the Set-up Rooms. The combination of the change made in the longwall bleeder ventilation system after the water blockage occurred and the connections with the 2nd Main North Entries caused a fragile balance to exist in the longwall bleeder ventilation system.
29. On July 29, 1989, approximately one month after a Section 107(a) imminent danger order was issued for accumulations of methane in the 4th West Entries, a methane sensor (M-19) and a velocity sensor (F-23) were installed in the No. 1 Entry between the Nos. 73 and 74 Crosscuts of the 5th West Entries. These sensors remained in operation until after the explosion.
30. On July 30, 1989, Roy J. O'Leary, Jr., Coal Mine Safety and Health Inspector (MSHA), issued a Section 104(a) citation when he found a mandoor propped open in the stopping line located in the cut-through entries. Ramsey closed the mandoor and the citation was abated. O'Leary talked to McDowell and told him to be very careful about leaving the mandoores open. McDowell acknowledged the fact that leaving the mandoores open would short circuit the air toward the longwall.
31. The headgate corner of Longwall Panel "O" was the highest elevation point in the longwall bleeder system. Methane migrated out of the gob near this point and accumulated in the No. 2 Entry of the 4th West Entries.
32. Sometime between August 31, 1989, and September 2, 1989, Longwall Panel "O" mined past the regulator located in the No. 1 Entry of the 5th West Entries. The cutting out of the regulator had a minimal effect on the ventilation of Longwall Panel "O", primarily due to the high resistance to air flow in the No. 1 Entry of the 5th West Entries.
33. Longwall Panel "O" cut out into the recovery chutes on September 6, 1989. The installation of curtains in the

recovery chutes became critical to the ventilation of the longwall face, the gob and recovery area.

34. During longwall recovery, Pyro dismantled and moved the metal doors installed across the track entry for the 4th West Entries. The volume and direction of air on the longwall face and in the 4th West Entries remained about the same when the track doors were removed.
35. During longwall recovery, Pyro removed concrete block stoppings in the 4th West Entries to facilitate removal of the longwall equipment. The failure to maintain curtains where these stoppings had been removed greatly reduced the air flow to the No. 6 Crosscut and across the longwall face.
36. During longwall recovery, curtains installed in the recovery rooms were frequently damaged from equipment passing through them, and were not immediately replaced. The failure to maintain curtains in the recovery rooms significantly decreased the air flow across the longwall face and contributed to the reduction of air flow in the 4th West Entries.
37. Ricky L. Bowles, Longwall Coordinator, stated that when high concentrations of methane were found during the longwall recovery, recovery room curtains were replaced or repaired. He reported that the installation of the curtains in the recovery rooms dissipated the methane that accumulated in the longwall face and at the tailgate.
38. Changes had occurred during the mining of Longwall Panel "O" in the 4th and 5th West Entries and in the longwall bleeder system that caused a fragile balance of air flows to exist in the longwall bleeder ventilation system. This fragile balance was affected when changes were made to the ventilation controls in the 4th West Entries and the longwall recovery area. The combination of changes significantly decreased the air flow across the longwall face and reduced the air flow in the 4th West Entries. The combination of changes also permitted methane to migrate from the gob and to accumulate in the No. 2 Entry of the 4th West Entries, in by the No. 6 Crosscut and near the longwall headgate.
39. Since production had ceased, the Section 107(a) imminent danger order issued was modified on September 11, 1989, to eliminate monitoring at the longwall tailgate and at the No. 48 Crosscut in the No. 2 Entry of the 4th West Entries. Continuous monitoring through the use of the methane monitor installed in the 5th West Entries was still required.
41. Pyro projected that mining would begin in Longwall Panel "P" on Sunday, September 17, 1989.
42. On September 12, 1989, David L. Steele, General Superintendent, H. Michael McDowell, Superintendent, Danny Griffin, Mine

Manager, T. Larry Keith, Assistant Mine Foreman, Donald R. Ramsey, Production Support Director, and Canning met to discuss the ventilation of Longwall Panel "P". They discussed the changes to be made to various ventilation controls and the removal of the stopping in the No. 1 Cut-through Entry. Canning stated that the air from the Cut-through Entries would flow toward the water accumulation when the stopping was removed.

43. On the morning of September 13, 1989, Ramsey told Steele that he would remove the stopping located in the No. 1 Cut-through Entry. Steele told Ramsey to complete the ventilation work by 10:30 a.m.
44. The stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries was being dismantled on the morning of September 13, 1989, and was approximately one-half dismantled when the explosion occurred.
45. The removal of the stopping in the No. 1 Cut-through Entry disrupted the separation between the 2nd Main North Entries ventilation and the longwall bleeder system. This action caused the explosive methane-air mixture that had accumulated in the No. 2 Entry of the 4th West Entries to flow toward and into the longwall recovery area.
46. Air readings taken after the stopping was removed revealed that 19,000 cfm was traveling through the No. 1 Cut-through Entry from the 2nd Main North Entries into the bleeder system for Longwall Panel "O".
47. MSHA computer simulations showed that for all ventilation schemes analyzed, air would flow in the 4th West Entries toward the longwall recovery area when the stopping was being dismantled. Investigators observed during the mine recovery and investigation that air always flowed toward the longwall recovery area in the 4th West Entries.
48. Adequate precautions were not taken prior to removing the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries.
49. Changes in ventilation which materially affected the split of air used to ventilate Longwall Panel "O" and which affected the safety of miners were made while the mine was producing coal. Power circuits in Longwall Panel "O" were energized and miners were working to move the longwall equipment while the stopping in the No. 1 Cut-through Entry was being removed.
50. From 12:00 a.m. until 8:56 a.m. on September 13, 1989, the methane sensor (M-19) located in the No. 1 Entry of the 5th West Entries indicated that the methane concentration varied between 0.59 and 0.62 percent. At 8:56 a.m., the methane concentration began to drop quickly. By 9:20 a.m., the

methane concentration leveled off at 0.16 percent. The change in the methane concentration corresponds to the time that the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries was being removed.

51. Ronald W. Howton, Longwall Mechanic, stated that when he left the longwall recovery area at about 8:10 a.m. on September 13, 1989, a curtain was not installed in the No. 2 Crosscut between the Nos. 2 and 3 Entries in the 4th West Entries.
52. By the morning of September 13, 1989, the shearers, stage-loader and tailgate equipment had been dismantled and removed. All but six sections of the panline conveyor had been separated and removed. Fifty-four of the 139 shields used on the longwall face had been removed.
53. After the explosion, nine of the 14 miners attempted to escape from the longwall face and recovery rooms using Mine Safety Appliance (MSA), Model No. W-65, filter-type self-rescuers. Each of the four survivors escaped to fresh air using only the filter type self-rescuers.
54. At 9:13 a.m. on September 13, 1989, the CO sensor at the mouth of the 4th West Entries (CO-13) indicated that the CO concentration increased from 6 ppm to a maximum reading of 50 ppm. Because the sensor reads CO in a range of 0 to 50 ppm, the actual concentration could not be determined.
55. All rescue and recovery operations used National Mine Service, Drager Model No. OXY-SR60B self-contained self-rescuers (SCSR).
56. During the rescue and recovery operations on September 13, 1989, Ramsey and D. Griffin installed a framed brattice cloth stopping in the No. 1 Cut-through Entry, where the stopping had been removed.
57. During mine recovery, evaluation teams detected a perceptible movement of air flowing in the 4th West Entries inby the face toward the No. 6 Crosscut. This air joined intake air from the 1st Main North Entries flowing up the 4th West Track Entry at the No. 6 Crosscut. The combined splits of air flowed through the No. 6 Crosscut toward the No. 3 Entry of the 4th West Entries and up the No. 3 Entry and onto the longwall face.
58. Underground evaluations of the mine ventilation system made by MSHA on September 14 and 15, 1989, revealed that air inby the No. 6 Crosscut in the 4th West Entries drifted slowly outby to the No. 6 Crosscut.
59. Pyro made numerous ventilation changes during the mine recovery attempts from September 15 to 20, 1989. These changes failed to reverse the air flow pattern in the 4th West Entries inby the No. 6 Crosscut.

60. The explosion was primarily a methane gas explosion. The original methane body was restricted to an area inby the No. 6 Crosscut in the 4th West Entries, and across a short distance of the longwall face near the headgate entries. The methane concentration prior to the explosion was on the order of 5.5 to 6.0 percent.
61. The explosion flame propagated inby from the No. 9 crosscut towards the 2nd Main North Entries. The greatest flame extension occurred in the No. 2 Entry of the 4th West Entries, where propagation occurred to a point just inby the No. 30 Crosscut. Inby the No. 28 Crosscut, the flame was short and quickly died out. As the flame of the explosion traveled along the No. 2 Entry, it split into the crosscuts and traveled both toward the No. 1 Entry and the No. 3 Entry. The flame of the explosion propagated to the gob at each crosscut between the Nos. 10 and 28 Crosscuts.
62. The explosion flame propagated outby from the No. 9 Crosscut toward the 1st Main North Entries, especially along the No. 2 Entry of the 4th West Entries. The flame traveled between the No. 2 Entry and the gob in the Nos. 8 and 7 Crosscuts.
63. As the flame traveled through the No. 6 Crosscut and into the No. 3 Entry, it split. Part of the initial flame continued to propagate toward and across a portion of the longwall face. The flame died out at a point just past the first recovery chute. Very little flame projected into this first chute.
64. The flame continued to propagate outby the No. 6 Crosscut in the No. 3 Entry for approximately an additional 325 feet to a point just outby the No. 2 Crosscut. The No. 3 Crosscut was the last outby crosscut that the flame traveled between the Nos. 2 and 3 Entry. The flame propagated approximately an additional 600 feet along the No. 2 Entry until it dissipated about four entries into the 1st Main North Entries. The flame propagated into the No. 1 Entry and traveled about 500 additional feet toward and into the 1st Main North Entries.
65. A transition zone of the forces existed in the 4th West Entries. Specifically, the area between and including the Nos. 9 and 10 Crosscuts in the No. 2 Entry of the 4th West Entries was the location where the primary forces originated.
66. The dynamic forces propagated inby along the No. 2 Entry and, at each inby crosscut, the forces headed away from the No. 2 Entry. The forces diminished over the length of the entry until the No. 30 Crosscut, where the magnitude of the dynamic explosion forces diminished.
67. Inby from the No. 10 Crosscut, stoppings between the No. 2 Entry and the No. 1 Entry were blown away from the No. 2 Entry in many crosscuts.

68. Outby the No. 9 Crosscut, it appeared that the primary dynamic explosion forces propagated along the No. 2 Entry toward the 1st Main North Entries. The forces of the explosion continued outby in the No. 1 Entry from about the No. 8 Crosscut to about the No. 2 Crosscut.
69. Between the No. 2 Entry and the longwall gob, forces propagated toward the gob in the No. 7 Crosscut. Between the No. 2 Entry and the longwall gob, the No. 8 Crosscut was inaccessible during the investigation. From the Nos. 1 to 6 Crosscuts, forces propagated from the No. 2 Entry toward the No. 3 Entry. After entering the No. 3 Entry at the No. 6 Crosscut, the forces split, with some force traveling to and across the longwall face. A slight pressure would have continued along the longwall face to the area of the third chute into the recovery rooms.
70. Only minor pressure pulses traveled into the recovery rooms from the face area with the highest of these pressures traveling into the first recovery chute. The remaining force traveled outby in the No. 3 Entry. The explosion forces continued toward the longwall recovery rooms and outby toward the 1st Main North Entries.
71. One torch ignitor and one cutting torch assembly were present on the Longwall Panel "O" face when the explosion occurred. The cutting torch was used to assist in disassembling the panline on the longwall face. The torch ignitor was found between the Nos. 20 and 21 Shields. The cutting torch was found in the center of the panline at the No. 5 Shield. The torch was found by investigators with both valves on the torch in the closed position. It could not be verified exactly when these valves were placed in the off position, or even if they were both off at the time of the accident. Based on this evidence, it could not be assumed that the torch was off or inoperable at the time of the explosion.
72. The dogbone set screws on the shield side of the panline at the No. 8 Shield had been recently cut away with the torch, but the dogbone had not been removed. Also, a small area of gob had been dug away to expose the opposite dogbone and set screws on the face side of the panline. However, no cutting had been done in this area.
73. A battery-powered scoop tractor was present on the Longwall Panel "O" face at the time of the explosion. During the investigation, 24 permissibility deficiencies were found on the Eimco Elkhorn battery-powered scoop tractor.
74. During the investigation, an electric blasting cap was found in the No. 15 Crosscut of the No. 2 Entry of the 4th West Entries. Three electric blasting caps of the same type and manufacturer were found stored in the top portion of No. 22 Shield. These blasting caps were not detonated and are not

considered as the source of ignition for the explosion. However, it does indicate that other blasting caps may have been left in the 4th West Entries, the longwall face or the gob area. A magazine for explosives storage was not provided on Longwall Panel "O".

75. Roof falls occurred prior and subsequent to the explosion within or near the explosion transition zone. Major falls were observed at the Nos. 8, 9 and 11 Crosscuts in the No. 2 Entry of the 4th West Entries. Between the Nos. 2 and 3 Entries, the No. 8 Crosscut was inaccessible. Investigators were not able to determine the direction of forces in the No. 11 Crosscut because roof falls made the area inaccessible.
76. A 1/4-inch steel messenger wire was present along the length of the No. 2 Entry of the 4th West Entries. It was found stretched tightly in many places in by the No. 6 Crosscut by roof falls and was pulled apart near the transition zone in the No. 2 Entry. Past research indicates that, under certain specific conditions, tensile failure of steel wire similar in size to the messenger wire found, could generate sufficient energy to ignite methane and provide an ignition source for the mine explosion.
77. A review of longwall preshift examination records kept prior to the accident revealed inadequacies in the method of recording the examinations. Deficiencies in these records indicated mine management failed to ensure that personnel responsible for preshift examinations were aware of the record keeping requirements of 30 CFR 75.303.
78. Once the longwall cut out and was being moved to a new location, confusion existed over the requirements of preshift regulations. Several management personnel responsible for preshift examinations indicated during the investigation interviews that they believed a preshift was not required while the longwall was being moved.
79. Mine management failed to ensure that examination requirements of 30 CFR 75.303 were followed in the longwall recovery area. Both Russell A. Faulk, Jr., and Jerry L. Corbin, Shield Operator, made examinations of the longwall recovery area at various times during their shift, but neither foreman conducted a preshift examination of the longwall recovery for the oncoming day shift of September 13, 1989.
80. Methane in concentrations to 6.5 percent were reportedly found on the longwall face, near the No. 20 Shield, on Saturday, September 9, 1989. Foremen in the recovery area were aware of this concentration and participated in the ventilation changes to remove the methane from the face. Daily reports by the mine foreman and his assistants failed to record this hazardous condition or show the action taken to correct the condition. The failure to record the methane accumulations

prevented management officials and other interested persons from learning of the hazardous condition and initiating corrective action.

81. The direction of air flow in the No. 2 Entry of the 4th West Entries, inby the No. 6 Crosscut, was not in accordance with the approved mine ventilation plan. A series of changes to ventilation controls was made in the longwall recovery area prior to the explosion that caused the air in the No. 2 Entry to flow in an outby direction. Air flow in this direction did not direct methane-air mixtures away from the active workings of the longwall recovery area.
82. A fragile balance existed throughout the bleeder system after the water accumulated in June 1989. Management failed to recognize the sensitivity of the bleeder system and the effects of the ventilation changes made prior to the explosion.
83. Management failed to determine whether the bleeder system was functioning to continuously move methane-air mixtures from the gob, away from the active workings, and deliver such mixtures to the return aircourses.
84. Management failed to maintain a sufficient volume and velocity of air in the proper direction in the 4th West Entries and longwall face to render harmless, and carry away methane accumulations.

Contributing Violations

Ten of the conditions and practices noted in the Findings of Fact contributed to the explosion and constituted violations of the Federal Mine Safety and Health Act of 1977 and the mandatory standards contained in 30 CFR Part 75. The explosion occurred on September 13, 1989, and resulted in the deaths of 10 miners.

30 CFR 75.301

The volume and velocity of air ventilating the 4th West Entries and the Longwall Panel "O" recovery area were not sufficient to dilute, render harmless, and carry away methane that was liberated.

30 CFR 75.303

A preshift examination of Longwall Panel "O" recovery area was not conducted for the day shift crew (7:00 a.m. to 5:00 p.m.) of September 13, 1989. A preshift examination was required in this area between 4:00 a.m. and 7:00 a.m. on September 13, 1989.

30 CFR 75.316

The approved ventilation system and methane and dust control plan for this mine was not being followed in the 4th West Entries and bleeder system for Longwall Panel "O". The direction of air flow in the No. 2 Entry of the 4th West Entries, inby No. 6 Crosscut, was in an outby direction, which was not in accordance with the approved plan. A supplement to the ventilation plan that was approved on July 3, 1989, required air flow in the No. 2 Entry to travel in an inby direction toward the 2nd Main North Bleeder Entries.

Changes had occurred during the mining of Longwall Panel "O" in the 4th and 5th West Entries and in the longwall bleeder system that caused a fragile balance of air flows to exist in the longwall bleeder ventilation system. This fragile balance was affected when changes were made to the ventilation controls in the 4th West Entries and the longwall recovery area. The combination of changes significantly decreased the air flow across the longwall face and reduced the air flow in the 4th West Entries. The combination of changes also permitted methane to migrate from the gob and to accumulate in the No. 2 Entry of the 4th West Entries inby the No. 6 Crosscut and near the longwall headgate.

The removal of the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries disrupted the separation between 2nd Main North Entries ventilation system and the longwall bleeder system. This action caused the explosive methane-air mixture in the No. 2 Entry of the 4th West Entries to flow toward and into the longwall recovery area.

30 CFR 75.322

Changes in ventilation which materially affected the split of air used to ventilate Longwall Panel "O" and which affected the safety of miners were made while the mine was producing coal. Power circuits in Longwall Panel "O" were energized and miners were working to move the longwall equipment while the ventilation changes were made. A stopping located in the No. 1 Cut-through Entry between the 4th West and 5th West Entries was being removed on the morning of September 13, 1989, when the explosion occurred. The removal of this stopping disrupted the separation between the 2nd Main North Entries ventilation system and the longwall bleeder system. ~~This action caused an explosive methane-air mixture that had accumulated in the No. 2 Entry of the 4th West Entries to flow toward and into the longwall face.~~ Air readings taken after this stopping was removed revealed 19,000 cfm was traveling through the No. 1 Cut-through Entry from the 2nd Main North Entries into the bleeder system of Longwall Panel "O".

30 CFR 75.324

Methane concentrations of up to 6.5 percent were detected on the face of Longwall Panel "O" on the day shift of Saturday, September 9, 1989. Foremen in the recovery area were aware of these concentrations and helped install curtains to remove the methane, but no examination was conducted to determine the source and cause of the methane accumulations. Reports by the mine foremen for this shift failed to record the presence of these hazardous accumulations of methane or show the action taken to correct the condition. The failure to record the methane accumulations in the approved record books prevented management officials and other interested persons from learning of the hazardous condition and initiating corrective action. This condition was determined during the investigation interviews about the explosion on September 13, 1989, which resulted in the deaths of 10 miners.

30 CFR 75.324

A methane concentration of up to 9 percent was detected on the face of Longwall Panel "O" on the afternoon shift of Saturday, September 9, 1989. A foreman in the recovery area was aware of this concentration and helped install curtains to remove the methane, but no examination was conducted to determine the source and cause of the methane accumulation. Reports by the mine foreman for this shift failed to record the presence of this hazardous accumulation of methane or show the action taken to correct the condition. The failure to record the methane accumulation in the approved record books prevented management officials and other interested persons from learning of the hazardous condition and initiating corrective action. This condition was determined during the investigation interviews about the explosion on September 13, 1989, which resulted in the deaths of 10 miners.

30 CFR 75.1002-1

The Eimco Elkhorn Manufacturing Company scoop tractor, Serial No. 582-2065, Approval No. 2G-2641-8, Model No. 582, and Company No. R039, was not maintained in a permissible condition. This scoop was found next to Nos. 13 through 18 roof support shields on the Longwall Panel "O" face within 150 feet of pillar workings and was inspected during an investigation of a mine explosion that occurred on September 13, 1989, which resulted in the deaths of 10 miners. The inspection revealed the following permissibility violations¹ on the operator's compartment control panel enclosure:

¹ These permissibility deficiencies could have been the source of the explosion if the point of origin was at the scoop tractor. As indicated previously, investigators were not able to definitely identify the actual ignition source among the probable ignition sources found.

- (a) The top right corner panel cover fastener bolt was missing;
- (b) The first panel cover fastener bolt to the right of the top left corner fastener bolt was loose;
- (c) An opening in excess of 0.004-inch was determined by inserting a 0.005-inch feeler gage along the flame path between the panel enclosure and panel cover where the top right corner bolt was missing. The maximum allowable opening for a plane flange joint on an enclosure with more than 124 cubic inches internal volume is 0.004-inch; and,
- (d) The pump motor "on" switch was removed from the control panel cover leaving an opening of approximately 1/2-inch where the switch had originally been.

30 CFR 75.1002-1

The Eimco Elkhorn Manufacturing Company scoop tractor, Serial No. 582-2065, Approval No. 2G-2641-8, Model No. 582, and Company No. R039, was not maintained in a permissible condition. This scoop was found next to Nos. 13 through 18 roof support shields on the Longwall Panel "O" face within 150 feet of pillar workings and was inspected during an investigation of a mine explosion that occurred on September 13, 1989, which resulted in the deaths of 10 miners.

The inspection revealed the following permissibility violations ² on the operator's side front headlight assembly:

- (a) The device for securing the headlight lens cover was missing from the front headlight assembly; and,
- (b) Two cable entrance glands for the direct current (dc) power cables that entered the front headlight assembly were not properly packed, in that, the packing gland nuts were tightened flush against the headlight enclosure and the power cables could be pulled freely through the entrance glands.

² These permissibility deficiencies could have been the source of the explosion if the point of origin was at the scoop tractor. As indicated previously, investigators were not able to definitely identify the actual ignition source among the probable ignition sources found.

30 CFR 75.1002-1

The Eimco Elkhorn Manufacturing Company scoop tractor, Serial No. 582-2065, Approval No. 2G-2641-8, Model No. 582, and Company No. R039, was not maintained in a permissible condition. This scoop was found next to Nos. 13 through 18 roof support shields on the Longwall Panel "O" face within 150 feet of pillar workings and was inspected during an investigation of a mine explosion that occurred on September 13, 1989, which resulted in the deaths of 10 miners.

The inspection revealed the following permissibility violations ³ on the main circuit breaker enclosure:

- (a) The cable entrance gland for the battery cable on the operator's side of the scoop was missing allowing an opening of approximately one inch from the exterior to the interior of the enclosure;
- (b) The second fastener bolt to the left of the top right corner fastener bolt was loose;
- (c) The packing nuts for all cable entrance glands entering the enclosure were not secured against loosening;
- (d) The specified circuit breaker setting for adequate short-circuit protection of the direct current (dc) power conductors that extended from the main circuit breaker enclosure to the main contactor panel was not maintained, in that, the instantaneous settings were adjusted to 3,000-amperes. The specified setting is 1,600-ampere +/- 10 percent as indicated on the wiring diagram for this scoop; and,
- (e) Short-circuit protection was not provided for the direct current (dc) circuit breaker trip coil power conductors that extend from the main circuit breaker enclosure to the main contactor panel. The 10-ampere fuses that were specified as adequate short-circuit protection were removed (bypassed) from the circuit and the trip coil conductors were connected directly to the power conductors at the circuit breaker.

³ These permissibility deficiencies could have been the source of the explosion if the point of origin was at the scoop tractor. As indicated previously, investigators were not able to definitely identify the actual ignition source among the probable ignition sources found.

30 CFR 75.1002-1

The Eimco Elkhorn Manufacturing Company scoop tractor, Serial No. 582-2065, Approval No. 2G-2641-8, Model No. 582, and Company No. R039, was not maintained in a permissible condition. This scoop was found next to Nos. 13 through 18 roof support shields on the Longwall Panel "O" face within 150 feet of pillar workings and was inspected during an investigation of a mine explosion that occurred on September 13, 1989, which resulted in the deaths of 10 miners.

The inspection revealed the following permissibility violations ⁴ on the main contactor panel enclosure:

- (a) Two fastener bolts for the main contactor panel cover were loose. The first fastener bolt under the top right corner fastener bolt and the first fastener bolt to the left of the bottom right corner fastener bolt were not tightened securely;
- (b) An opening in excess of 0.004-inch was determined by inserting a 0.005-inch feeler gage along the flame path between the panel cover and the main contactor panel enclosure. There was excessive build up of corrosion on the plain flange joint between the panel cover and enclosure on the right side of the contactor panel. The maximum allowable opening for a plane flange joint on an enclosure with more than 124 cubic inches internal volume is 0.004-inch;
- (c) The 10-ampere fuses that were specified as adequate short-circuit protection for the direct current (dc) control and light power conductors that extend from the main contactor enclosure were not maintained, in that, the 10-ampere fuses were replaced with 30-ampere fuses; and,
- (d) The cable entrance gland for No. 2 AWG, pump motor cable was not properly packed, in that, a bushing that is required to reduce the inside diameter (I.D.) of the entrance gland stuffing box from 1.812-inch to 1.5-inch to accomodate this specific size cable was missing.

⁴ These permissibility deficiencies could have been the source of the explosion if the point of origin was at the scoop tractor. As indicated previously, investigators were not able to definitely identify the actual ignition source among the probable ignition sources found.

Conclusions

The failure to maintain air flow in its proper course, volume, and direction in the 4th West Entries and across the longwall face to dilute, render harmless, and carry away explosive gases allowed the accumulation of an explosive methane-air mixture. Changes had occurred during the mining of Longwall Panel "O" in the 4th and 5th West Entries and in the longwall bleeder system that caused a fragile balance of air flows to exist in the longwall bleeder ventilation system. This fragile balance was affected when changes were made to the ventilation controls in the 4th West Entries and the longwall recovery area. The combination of changes significantly decreased the air flow across the longwall face and reduced the air flow in the 4th West Entries. The combination of changes also permitted methane to migrate from the gob and to accumulate in the No. 2 Entry of the 4th West Entries inby the No. 6 Crosscut and near the longwall headgate.

The removal of the stopping in the No. 1 Cut-through Entry between the 4th West and 5th West Entries disrupted the separation between the 2nd Main North Entries ventilation system and the longwall bleeder system. This action caused the explosive methane-air mixture that had accumulated in the No. 2 Entry of the 4th West Entries to flow toward and into the longwall recovery area where it was ignited by one of the following sources:

1. Operation or attempted lighting of a cutting torch;
2. Operation of a scoop tractor;
3. Detonation of a blasting cap;
4. A roof fall; and,
5. Tensile failure of the messenger wire.

The primary cause of the explosion was the failure of Pyro to maintain a sufficient volume and velocity of air in the proper direction in the 4th West Entries and longwall face to dilute, render harmless, and carry away methane accumulations. The following factors contributed to the occurrence of the explosion:

1. The failure to maintain adequate air flow in the proper volume and direction in the No. 2 Entry, of the 4th West Entries inby the No. 6 Crosscut and the failure to maintain the proper pressure differential across the Longwall Panel "O" gob in accordance with the approved mine ventilation plan;
2. The failure to recognize the sensitivity of the bleeder system and the effects of the numerous ventilation changes;
3. The failure to determine whether the bleeder system was functioning to continuously move methane-air mixtures from the gob, away from the active workings, and deliver such mixtures to the return aircourses;

4. The failure to maintain curtains in the recovery rooms and in the 4th West Entries where permanent stoppings were removed;
5. The failure to ensure that a preshift examination was conducted in the Longwall Panel "O" recovery area prior to the day shift of September 13, 1989;
6. The failure to initiate corrective action to determine the source and cause of methane accumulations when explosive concentrations were detected on the longwall face on Saturday, September 9, 1989;
7. The failure to take adequate precautions prior to removing the stopping in the No. 1 Cut-through Entry between the 4th and 5th West Entries. The stopping was removed during an active shift with miners in the mine.

Respectfully submitted,

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