FINAL REPORT, EXPLOSION, WILLOW GROVE NO. 10 MINE, HANNA COAL COMPANY OF OHIO, NEFFS, OHIO, MARCH 16, 1940

By J. J. Forbes, G. W. Grove, W. J. Fene, and M. J. Ankeny

INTRODUCTION

An explosion occurred in the Willow Grove No. 10 mine of the Hanna Coal Company of Ohio, Neffs, Richland Township, Belmont County, Ohio, at about 11:05 a.m., March 16, 1940. Seventy-two men were killed as a result of this explosion, of which number 66 were killed outright by burns and violence, 3 were killed by burns and afterdamp, 2 were asphyxiated, and 1 died 6 days later from the effects of carbon monoxide poisoning. One additional man was severely burned and injured by the explosion and two others were severely injured by a rock fall while engaged in recovery work 11 days after the explosion. Twenty-two others were overcome by afterdamp, rescued, taken to the surface, and revived, and 79 uninjured men were temporarily imprisoned and 5 hours later led to the surface through the air shaft by rescue parties. Two uninjured men escaped to the outside unaided. A total of 176 men were in the mine at the time of the explosion. The explosion was not general throughout the mine but traversed the entire 22 south section and a short distance inby and outby 22 south on the main west haulage entries. The investigation disclosed two possible points of origin; however, after a careful study, the writers believe that the explosion was caused by the firing of a shot charged with black (pellet) powder near the face of 8 west off 22 south entry.

No water was used in this mine for allaying the coal dust and the mine was not rock-dusted except that some rock dust had been applied to the main west haulage entry outby 22 south.

The Bureau of Mines at Pittsburgh was advised of the explosion by the Associated Press at about 2:00 p.m. As it was Saturday afternoon no employee of the Safety Division was on duty. Members of the Safety Division were reached at their homes by telephone and they left Pittsburgh about 3:15 p.m. by automobile, together with a truck and rescue equipment. This crew consisted of Messrs. G. W. Grove, W. J. Fene, C. W. Owings, and H. J. Rietodt, with Messrs. H. R. Burdelsky and E. L. Christensen on the truck. They arrived at the mine about 5:30 p.m. Later in the evening Messrs. R. D. Leitch and J. W. Pero arrived. Messrs. J. J. Forbes and M. J. Ankeny, who were en route to Clarksburg, West Virginia, at the time of the explosion, were notified by telegram and arrived at the mine about 8:00 p.m. Mr. F. E. Griffith, who could not be reached at the time the other men left, arrived at the mine later during the evening.

GENERAL INFORMATION

Location and Operating Officials

The Willow Grove No. 10 mine is located on the Baltimore and Ohio and the Wheeling and Lake Erie Railroads at Neffs, Belmont County, Ohio, and is owned by the Southeastern Coal Company. The mine is operated under lease by the Hanna Coal Company of Ohio. The officials of the company are as follows:

President	R. L. Ireland, Jr.	1300 Leader Building, Cleveland, Ohio
General Manager	R. V. Clay	St. Clairsville, Ohio
Chief Engineer	John Hartley	St. Clairsville, Ohio
Superintendent	J. H. Richards	(Deceased)
Safety Engineer	John Davis	St. Clairsville, Ohio
Mine Foreman	C. L. Carroll	(Deceased)

Employees and Production

The mine operates three 7-hour shifts per day, 6 days per week, and has a total of 711 employees, including a "floating" shift. The regular employment is as follows:

Underground	Day shift	215 men per shift
Underground	Afternoon shift	144 men per shift
Underground	Night shift	144 men per shift
Surface	Day shift	67 men per shift
Surface	Afternoon shift	24 men per shift
Surface	Night shift	24 men per shift

The tipple operates 21 hours per day and the mine has a daily production of about 4,300 tons.

Openings

The mine is opened by two drift entries and these openings are supplemented by two air shafts. The old ventilating shaft located at the face of 12 north entries is out of service but serves as an upcast airway. The new ventilation and escapeway shaft, located on the 23 north entries, is a double-compartment shaft, one compartment serving as an upcast, having been provided with stairs, and the other compartment serving as the main air intake for the mine. This new shaft, which was put into service February 11, 1940, is 156 feet deep.

Nature of the Coal Bed

The Willow Grove No. 10 mine is operating in the Pittsburgh No. 8 coal bed, which dips southeast about 30 feet to the mile. The coal bed averages about 5 feet in thickness and is overlain by from 10 to 14 inches of draw slate, 1 to 12 inches of roof coal, 5-1/2 to 6 feet of fire clay (locally called "soapstone"), and 10 to 40 feet of limestone. The draw slate is taken down during normal operations, and at places where the roof coal falls and exposes the fire clay it readily disintegrates and begins to fall. The roof conditions in the Willow Grove No. 10 mine are extremely bad and are difficult to control. The floor is a hard, smooth fireclay.

Three face samples of coal were collected during the investigation, the analyses of which are shown in table 1.

Table 1.- Analysis of coal, Willow Grove No. 10 mine, Hanna Coal Company of Ohio, Neffs, Ohio, March 27 and 29, 1940

Labor-atory No.	Location in mine	Coal--as received, Percent: Mois-ture	Vol. matter	Fixed carbon	Ash	Sul-phur	B.t.u.	Coal--moisture- and ash-free, Percent: Vol. matter	Fixed carbon	Sul-phur	B.t.u.
B-50817	Face of room 4, 6 north face	3.3	38.5	49.6	8.6	3.3	13,050	43.7	56.3	3.7	14,790
B-50893	300 ft. inby main west butts on C north face	3.2	38.7	47.9	10.2	3.6	12,780	44.7	56.3	4.1	14,760
B-50894	7 west, 60 ft. inby last chute, 10 south face entry	3.6	37.5	48.3	10.6	3.3	12,690	43.7	56.3	3.8	14,790

These analyses of the Pittsburgh No. 8 coal at the Willow Grove mine show the volatile matter to average 38.2 percent and the average fixed carbon is 48.6 percent. The volatile combustible ratio of this coal, which is an index of the explosibility of the coal dust, is shown by the formula:

$$\text{Volatile ratio} = \frac{\text{Volatile matter}}{\text{Volatile matter + fixed carbon}} = 0.44$$

Experiments have shown that coal dust having a volatile combustible ratio in excess of 0.12 is explosive. The explosibility of coal dust increases as the volatile combustible ratio increases. It is therefore obvious that the coal dust in the Willow Grove No. 10 mine is highly explosive.

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

Method of Mining

The panel room-and-pillar method of mining is used in which only the entry pillars are recovered. The main entries consist generally of a set of four entries driven to the westward on the butts of the coal from which are turned the main face entries to the north and south at intervals of about 3,000 feet. Present development of main face entries is in sets of four; however, some face entries previously developed have been opened by sets of three entries. Butt or development entries are driven in pairs from the main face entries at intervals of about 600 feet to the east and west from the main face entries, and rooms are turned at an angle of 60° from both entries of each pair of butts. The rooms are driven about 22 feet wide on 30-foot centers, leaving a room pillar of about 8 feet. The rooms are driven about 300 feet deep and are not cut through to rooms of adjacent butt entries. A semi-retreat system of mining is used in which the butt entries are turned and developed from the main face entries as they advance, but the butt entries are driven to their limits before any rooms are turned. When butt entries reach their limits, rooms are turned in blocks of 12, starting at the inby end of the butt entries, and are opened in blocks of 12 as needed. A 80-foot pillar is left between each block of six rooms. The driving of entries is known as "narrow work" and the driving of rooms is known as "wide work".

The coal is generally undercut and sheared with Oldroyd arcwall mining machines, except that one Goodman shortwall mining machine is in use. Drilling of coal is done by means of 20 electric power drills; 8 rock drills are used also. The coal and draw slate is loaded mechanically by means of Myers-Whaley No. 3 Automat coal loading machines into 5-ton cars. Machine crews working in entries consist of 6 men each and are known as "narrow crews". Machine crews working in rooms consist of 17 men each and are known as "wide crews". Each crew prepares the face, cuts and shears the coal, drills, blasts, loads, and delivers the coal to the side track. In entries the coal is undercut and sheared on one side, except in 7 and 8 west off 22 south where the coal is undercut only. The entry crews start room necks at regular intervals as the entries advance. In rooms the coal is undercut and sheared in the center. In all instances the undercutting and shearing is about 8-1/2 feet deep.

Due to the extremely tender roof, extensive timbering is necessary in entries and rooms. In entries, supporting consists of 60- and 65-pound steel rails used as crossbars, generally set at about 3-foot centers in tender roof but at varying centers in ordinary roof. These crossbars are supported in some instances by wooden posts or legs not recessed in the ribs. In other instances the crossbars are supported by wooden posts on one end and by a short wooden block recessed in the rib on the other end. In rooms the roof is supported by a double row of posts on each side of the track, leaving a clearance of 6 inches between the side of the car and the row of posts on one side and a clearance of 14 inches on the other side. The row of posts adjacent to the track is set on 3-foot centers and the row of posts adjacent to the rib is set on 6-foot centers. The line of rib posts is 18 inches from the line of track posts and they are set in a staggered position with reference to the track posts. Prepared cap pieces are provided, but wedges are made underground. Additional timbers are set whenever required by unusual conditions of the roof. A definite timbering system is used in rooms and timbering rules have been formulated which are enforced strictly.

<u>Ventilation and Gases</u>

The mine is ventilated by means of an 8- by 5-foot Robinson centrifugal fan driven by a 100-horsepower motor. It is of the nonreversible type and is operated as a force fan. The fan is placed almost directly over the downcast compartment of a two-compartment air shaft about 3 miles from the main drift entrance to the mine and is reported to circulate a total of 85,000 to 89,000 cubic feet of air per minute at a water gage of about 4-1/2 inches. Explosion doors are provided in the fan casing, but the fan is not sufficiently offset from the air shaft. No reserve power is provided for use in case of failure of the regular source of power and no auxiliary fan has been installed for use in case of damage or failure of the regular ventilating fan.

It is extremely important that all mine fans be so constructed and installed that the air current can readily be reversed in case of an emergency such as a mine fire or explosion if such action is deemed necessary. In addition to explosion doors in the fan casing to release the pressure in case of an explosion, the fan should be offset from the mine opening at least 20 feet, and in no case should the fan be mounted in direct line with the mine opening. A reserve source of power, such as a separate and independent service line or an auxiliary power unit, should be provided for use in case of failure of the regular source of power. A signal system should be installed which will give both a visual and audible warning in case of slowing down or complete stoppage of the fan. These signals should be so installed at a place or places where someone is in attendance at all times, so that the proper official may be notified promptly if the fan is not operating normally. In addition to being provided with signaling devices, the fan should also be equipped with an electric relay system which will automatically cut all power off from the mine in the event the fan slows down or stops.

The map of the mine, included in the appendix of this report, shows by arrows the coursing of air through the mine prior to the explosion. The entire ventilating current is forced into the mine through the shaft located on 26 north face entry. The air current splits at the intersection of 26 north face entry and a small split of air is taken inby on the main west entries, through L and M north face entries, and returns on the main west haulage and the left parallel main west entries. This return current mixes with the intake at 21 north face entry. A small amount of leakage from this split and from the main intake returns through the upcast compartment of the shaft. While the major air current travels outby on the main west entries, a portion of the air is deflected into 23, 24, 25, and 26 south face entries and is circulated in a continuous current in 7 west, out 8 west; in 24 south, out 23 south; in 22 south, out 21 south; in 6 east, out 5 east; in 4 east, out 3 east. The air then travels out 21 south face and 22 south face (the haulage road) to the main west intersection where it mixes with the main intake air current. The full volume of air for the mine travels outby on the main west entries, including the main haulage road to 19 south and 19 north where it is split. One split in a continuous circuit ventilates all butt entries and other workings in the 19 north section, and the other split in a continuous circuit ventilates all butt entries and other workings in the 19 south section. The returns from these two splits are brought together again just outby 19 north and 19 south on the main west haulage, and the entire return of the mine is conducted through the main haulage of the mine to the drift mouth, except for some leakage to the surface from the 19 north section through the old air shaft located near the end of the 11 north face entries and the leakage as hereinbefore mentioned through the upcast compartment of the new shaft.

Ventilation is controlled by a system of doors, which are installed singly and are provided with latches. They are, however, provided with bumper bars and need not be latched open while a trip is passing through. Stoppings in the main and face entries are constructed of concrete blocks, and stoppings on butt entries are constructed of wood. No stoppings are used in room crosscuts.

The maximum distance between break-throughs on entries is 120 feet; however, many break-throughs are driven at closer intervals. Blower fans with vent tube are being used at faces of entries for the purpose of quickly removing the smoke after blasting.

The installation of haulage roads on intake air is a strongly recommended safety practice, especially where hauling is done by trolley locomotives. Intake air on the haulage roads not only lessens the danger of electrical ignitions of methane, but it greatly expedites rescue and recovery operations in the event of mine fires and explosions. The fact that the haulage in the Willow Grove mine was on return air was responsible for the death of 8 men and endangered the lives of 104 others.

The best system of ventilation for the Willow Grove No. 10 mine would be to place all haulage roads on pure intake air by providing primary splits of air for each set of main face entries and secondary splits of air for each set of butt entries. Such a procedure in the Willow Grove No. 10 mine, however, would require more main airway capacity than exists at the present time. In lieu of the above method, it is strongly urged that the management give careful consideration to the proposal to place the main haulage road and all haulage roads in main face entries on pure intake air and to provide separate and independent splits of air for each set of main face entries, so that the return from each set of main face entries can be conducted directly to the main returns leading from the mine.

To effectively carry out the suggestion outlined in the foregoing paragraph, the following steps are deemed necessary:

1. Seal off, by means of strong fireproof stoppings, all accessible entrances to abandoned and worked-out areas to the right and left along the main haulage entries between 19 south and the drift mouth.

2. Provide an exhaust fan to be connected to the upcast compartment of the air shaft at 26 north face.

3. Admit sufficient air at the main drift opening to ventilate 19 north and 19 south. This air should be conducted through the main butts west and split at 19 north and 19 south. The return air from 19 north and 19 south should be conducted directly to the upcast shaft through the two right-hand parallel entries of the main butts west and 21, 22, and 23 north face entries.

4. Admit the balance of the air into the mine through the downcast compartment of the air shaft. Conduct the air to the main butts west through 24, 25, and 26 north face entries. Split the air at the intersection of the main butts west. Carry one split of air to the face of the main butts west, from there through O and N north face entries, thence through M and L north face entries, and thence

to the main return at 21, 22, and 23 north face entries. Conduct the other split to 21 and 22 south face through the main haulage, thence into 21 and 22 south face; in 3 east, out 4 east, in 5 east, out 6 east; to the face of 21, 22, 23, and 24 south; in 8 west out 7 west and return through 23 and 24 south face to the main return.

5. The use of doors should be avoided insofar as possible by the installation of overcasts, but where the use of doors cannot be avoided, they should be installed in pairs so as to form an air lock.

6. In the interest of safety, blower fans should not be used in coal mines. In gassy mines, line brattices should be used from the last open crosscut to the face. The danger in the use of blower fans is that firedamp may accumulate by recirculation of the air and may be ignited by an electric spark from the fan motor or from some other source; moreover, blower fans are often operated intermittently, which practice may permit an accumulation of gas during the times when the fan is stopped.

7. All entries, rooms, panels, or sections that cannot be kept well ventilated throughout or cannot be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, should be sealed by strong fire-proof stoppings.

The mine is classed as nongassy by the Ohio Division of Mines. No fire bosses are employed, but section foremen carry flame safety lamps and are supposed to test all working places for gas. Testimony given at the hearing conducted by the Ohio Department of

Industrial Relations indicated that foremen are lax in their inspections for gas. Explosive gas was found in at least one place during the recovery work following the explosion, and testimony at the hearing indicated that gas had been ignited on several occasions previous to the explosion, at least once in the 19 north section and once in the 22 south section.

Numerous gas and oil wells penetrate the coal bed in which the Willow Grove mine is operating, some of which are on record but not located, thus constituting a possible source of danger.

Several air samples were collected in the mine during the investigation, analyses of which are shown in the following table. Inasmuch as the ventilating system has been changed since the explosion, the quantities of air shown in the table are not representative of the conditions prevailing previous to the explosion.

Table 2.- Air analysis, Willow Grove No. 10 mine, Hanna Coal Company of Ohio, Neffs, Ohio, March 1940

Laboratory No.	Location in mine	Percent Carbon dioxide	Percent Oxygen	Percent Carbon monoxide	Percent Methane	Percent Nitrogen	Quantity of air, cu. ft. per min.	Methane liberated in 24 hours, cu. ft.
65497	Face of room 25, 5 east, 22 south	0.10	20.85	0.00	0.02	79.03	No vel.	
	Last crosscut, 5 and 6 east, 22 south						11,229	
65491	Face of 23 south	0.09	20.87	0.00	0.02	79.02	No vel.	
65492	Face of 8 west, 22 south	0.14	20.72	0.00	0.33	78.81	No vel.	
	Last crosscut between 7 and 8 west, 22 south						13,680	
65493	Face of 7 west, 22 south; cave in roof	0.25	20.16	0.00	2.46	77.13	No vel.	
65494	7 west, 10 ft. inby 24 south, return of 22 south section active workings	0.06	20.88	0.00	0.04	79.02	14,147	8,148
65495	23 north face entry, 150 ft. inby	0.05	20.85	0.00	0.07	79.03)	19,365	19,510
65496	Upcast shaft; return from most of mine	0.05	20.82	0.00	0.06	79.07)		
65498	10 ft. inby drift mouth, part of	0.20	18.97	0.00	0.24	80.63)	5,920	30,828
65499	Full mine return	0.27	18.88	0.00	0.24	80.61)	8,920	

It will be observed from this table that samples of air collected in the face of room 26, 3 east off 22 south, and at the face of 23 south entry contained 0.02 percent methane in each sample. A sample collected at the face of 8 west, 10 days after the explosion, contained 0.33 percent methane, with 13,880 cubic feet of air per minute passing through the last break-through, which was 106 feet back from the face; while a sample taken in a high place in the roof at the face of 7 west contained 2.46 percent methane. A sample collected in 7 west, 10 feet inby from 24 south, which includes the entire present return from the 22 south section, contained 0.04 percent methane in 14,147 cubic feet of air. This means that the entire 22 south section on the day that the sample was collected was producing 8,148 cubic feet of pure methane per 24 hours. This amount of methane, if mixed with air in the highest explosive proportions, would make 81,480 cubic feet of explosive mixture, or enough explosive gas to fill an entry 60 square feet in area a distance of 1,358 feet in 24 hours, or twice this length of entry with minimum explosive mixture, if the ventilation were cut off during this period.

Duplicate samples collected on 23 north face entry, 150 feet inby from the upcast shaft, consisting of the entire return from the 22 south and main west sections, contained 0.07 and 0.06 percent methane, respectively, in 19,356 cubic feet of air. At this rate these two sections produce 19,510 cubic feet of methane per 24 hours. Another set of duplicate samples collected 10 feet inby the drift mouth, consisting of the return from 19 north and 19 south sections and considerable area of old "works", contained 0.24 percent of methane in

8,920 cubic feet of air. This represents a liberation of methane at the rate of 30,828 cubic feet per day. Accordingly, the mine was producing at least a total of 80,330 cubic feet of methane each 24 hours. These samples were collected 10 days after operations were suspended due to the explosion. It is reasonable to believe that a somewhat higher quantity of methane would be liberated in the mine during normal operations, particularly in view of the rapid advancement of working faces resulting from a mechanical method of mining. Moreover, the return air upcasting at the 12 north shaft was not measured or sampled and is therefore not included in the total return.

From the analysis of these samples it is apparent that a considerable amount of explosive gas is being liberated in the mine, and that a dangerous condition might result should the ventilating current be short-circuited from the working faces for any length of time. In view of the amount of methane being liberated, it is the opinion of the writers that this mine should be classed as a gassy mine and be operated accordingly.

To detect accumulations of gas which may occur, preshift examinations should be made by fire bosses and the result of their findings recorded in a book provided for that purpose; frequent tests for gas should also be made during the working shift by the section foremen, by operators of electrical equipment before being taken beyond the last open break-through and frequently while such equipment is being operated, and before and after firing each shot.

Other precautions which are necessary in the safe operation of a gassy mine are discussed in other parts of this report.

Haulage

All underground haulage is by electric locomotives, trolley-pole locomotives being used on main-line and secondary haulage; cable-reel locomotives are used for gathering. Coal cars of steel, side-dump construction are equipped with eight wheels and automatic couplings and are of 5-ton capacity. The track gage is 42 inches, with 60-pound welded rail used on main entry, 40-pound rail used in side entries, and 30-pound rail used in rooms. Clearance generally is inadequate in entries and rooms to provide safe passage of persons by trips, and no shelter holes are provided. All haulage in main and face entries is on return air. Haulage equipment which is not operated on pure intake air should be of permissible type. No trolley-wire guarding was observed underground.

The main haulageway has been arched and gunited, and a well-ballasted track of heavy steel permits of rapid transportation. Two 16-ton "streamlined" trolley locomotives equipped with air brakes are used for main-line haulage. Haulage is controlled by a dispatcher and an electric block system.

Lighting

While the Willow Grove No. 10 mine is rated as nongassy and is considered as such by the management, portable permissible electric cap lamps have been supplied and are used by the employees because of the superior illumination afforded. The mine foreman, the safety inspector, and all section foremen carry Koehler-type permissible flame safety lamps for testing for oxygen deficiency and possible liberation of methane. Fixed lights have been installed on the trolley circuit at frequent intervals and at track switches along the main haulage roads, at the butt-entry switches, in the underground machine shop, and at other permanent electrical installations underground. These fixed incandescent lights are not guarded.

Machinery Underground

All machinery underground is operated electrically by 250-volt direct-current circuits. This machinery is all of the nonpermissible type and includes locomotives, loaders, coal-cutting machines, drills, pumps, and machine-shop equipment.

Transmission lines, carrying 4,000-volt alternating current, are taken into the mine through the air shaft and mine drift to the portable mercury rectifiers and transformers. These transmission lines are buried a foot in the floor. The transmission lines are sectionalized by means of automatic tie-in breakers and feed-line switches. The trolley wire into each section is sectionalized through cut-out switches and automatic reclosing circuit breakers.

Explosives and Blasting Practices

Black blasting powder in pellet form is used for blasting both coal and rock. The powder is brought into the mine in a well-designed and constructed insulated powder car 2 days of every week, during a working shift, on a special locomotive supply trip. The powder is delivered in the original containers to storage boxes, which hold between 500 and 600 pounds of powder and are placed in specially prepared and cleaned break-throughs near the entrance to a butt entry. The storage boxes are of steel construction, 3 feet 5 inches by 2 feet 7-1/2 inches by 2 feet 8 inches in size, and are lined inside with a layer of wood next to the steel, then a layer of asbestos board and a layer of fiber board. The lid is hinged and provided with a hasp, but no lock. Each storage box serves two entry crews or one wide crew and an entry crew. The shot firer, who is either a driller or a cutting machine man, obtains enough powder from this storage box for his shift. The powder is carried from the storage box to the face in either micarta boxes or insulated bags. Electric squibs are used to fire the shots, which are fired from an attachment on the cap-lamp battery at any time during the shift. Electric squibs are stored in a supply shanty located in each working section and are issued to the shot firers by the section foreman.

The coal is undercut 6-1/2 feet and shot holes are drilled 8 feet deep. It is reported that an average of three sticks (1-1/2 pounds) of pellet powder is used in each hole, but it is believed that in excess of this amount is sometimes used. In rooms the coal is undercut and sheared in the middle, and four holes are drilled, one on each side of the shear and one on each side of the rib. In entries the coal is undercut and sheared on one side and two shot holes are drilled. In 7 and 8 west off 22 south, a shortwall mining machine is used and only an undercut is made and three shot holes are drilled. "Bug dust" in paper dummies is used for stemming and is tamped with a copper-tipped steel bar.

When misfired shots occur, the shot firer notifies the section foreman, and another hole is drilled not closer than 12 inches from the misfired shot.

It is reported that on several occasions the use of black powder has resulted in the ignition of coal dust.

In the interest of safety, permissible explosives, fired electrically should be exclusively used. Conditions of "permissibility" of explosives for use in coal mines are: (1) Not more than 1-1/2 pounds shall be used in any one shot; (2) the explosive shall be fired only by use of electric detonators of standard make and proper strength; (3) shots shall not be fired on the solid; and (4) use only incombustible stemming material tightly tamped to the collar of the hole.

Nonpermissible explosives, such as black powder, including pellet powder, dynamite, and special explosives that will not pass the Bureau's tests for "permissibility", readily ignite gas and coal dust and have been the cause of numerous explosions. It is claimed that in some coal beds blasting with permissible explosives makes somewhat more screenings than if black powder is used; even if the claim should be correct for special conditions, the Bureau believes that no coal-mine operator is justified in taking the chances of an explosion disaster by using a nonpermissible explosive, particularly when the working shift is in the mine.

In addition to the above, competent shot firers should be employed to fire all shots and they should be required to make tests for gas with permissible flame safety lamps before and after firing a shot.

Drainage

The mine is naturally dry and dusty throughout. The nature of the mining operations at the faces is conducive to excessively dusty conditions of the atmosphere and the deposition of fine dust throughout the mine. Three water pumps are in operation at the mine and are located near the drift entrance on the main bottom, at the bottom of the 11 north shaft, and at the bottom of the new air shaft.

Coal Dust

Considerable coal dust is "made" during the operations of blasting, cutting, shearing, drilling, and loading. Roadways are kept fairly clean, but much of the fine dust caused by mining operations is picked up by the ventilating current and deposited on ribs, timbers, etc. No water is used for allaying the dust.

To lessen the coal-dust explosion hazard:

(1) Machine coal cuttings should be wetted as the cutting is being done.

(2) The face regions should be wetted before and after blasting.

(3) Water should be sprayed on the coal pile while it is being loaded mechanically.

(4) The coal face, and the working place 40 feet therefrom, should be kept free of coal dust by the use of water.

(5) The coal should be so loaded that it will not shake off in haulage.

(6) The empty cars and loads should be so sprayed as to prevent dust being distributed along the haulageway.

The above practices are aimed at wetting, as much as possible, the dust at the point of its formation in the working places and elsewhere, and thus preventing it from rising, as dry dust will, into the air and being carried and spread widely by the air current. The use of water at the working face can best be effected by having water lines extend to each face and watering by hose, each face region being kept supplied with suitable hose. The installation of sprinklers along haulageways will prevent the blowing of dust from the tops of fast-moving trips, which is largely responsible for the wide distribution of coal dust.

Moreover, coal dust in the air materially decreases visibility, and this increases the hazard to the mine worker through not seeing a threatening fall of roof or coal, or in the handling of machinery, or in haulage and other hazards in the working place, which lead to many individual accidents in mines.

Rock Dust

The main west haulageway, which is gunited, was rock-dusted during April and October 1939. No other parts of the mine have been rock-dusted.

To prevent the propagation of mine explosions, rock-dusting should be done in all coal mines, except anthracite mines, in every part, whether in damp or dry condition.

Rock-dusting a mine is likely to be of little or no value in preventing the propagation of an explosion unless it is thoroughly done and well maintained.

The dust to be used should not contain more than 5 percent of combustible matter nor more than 25 percent of quartz or free silica; all the dust should pass through a sieve having 20 meshes per linear inch and 60 percent or more should pass through a sieve having 200 meshes per linear inch; the dust should not absorb moisture from the air to such an extent as to cake and destroy its effectiveness as a dry dust.

The first step in the adequate rock-dusting of a mine should be thorough cleaning by washing down of all passageways and loading out of as much loose and gobbed material as practical. Producing entries should generally be the first entries dusted, and should be dusted from the face outby, and rock-dusting advanced as the faces advance. All crosscuts, rooms, pillar workings, and entries should be kept rock-dusted to within 40 feet of the face or the last crosscut. All entries or workings from which track is to be removed should receive a heavy coating of rock dust on ribs, roof, and floor before the track is removed. Air courses and other places having no track may be dusted by means of tubing carried from a high-pressure rock-dusting machine on the entry through doors or holes in stoppings and along the air course to be dusted.

The amount of dust to be applied depends on the character of the coal, the amount of incombustible matter already present in the mine road and rib dust, as well as the practices likely to cause deposition of coal dust day by day. The ratio of the volatile combustible matter in a coal dust to the total combustible is an index of the explosibility of a particular dust; the higher the volatile combustible matter, the more explosive the dust.

Analyses of samples of the Pittsburgh No. 8 coal bed at the Willow Grove mine indicate the volatile ratio to be 0.44. Coal dust of this ratio requires admixture of approximately 60 percent of incombustible to prevent propagation of an explosion.

Seventy-seven samples of dust were collected in the Willow Grove mine during the investigation, the analyses of which are shown in table 3.

Table 3.- Analysis of dust samples collected in Willow Grove No. 10 mine, Hanna Coal Company of Ohio, Neffs, Ohio, March 26 to 29, 1940

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Percent: Through 20-mesh	Cumulative 100 percent through 20-mesh, Percent through: 40-mesh	100-mesh	200-mesh	Remarks
50818	8 west 10 ft. inby last chute, 22 south	Rib	70.1	29.9	71.0	66.5	42.1	23.1	In explosion area
50819	8 west 10 ft. inby last chute, 22 south	Road	80.2	19.8	66.3	56.6	34.7	22.2	do.
50820	7 west, 22 south, 50 ft. outby face	Rib	70.3	29.7	61.2				do.
50821	7 west, 22 south, 50 ft. outby face	Road	81.3	18.7	57.7	57.5	38.1	24.6	do.
50822	Room 25, 3 east, 22 south	Rib & Roof	73.6	26.4	68.4				
50823	Room 25, 3 east, 22 south	Road	79.5	20.5	64.0	50.9	37.1	23.5	do.
50824	L north face at room 4	Rib & Roof	77.8	22.2	62.2	58.8	34.8	25.1	At edge of explosion area on main west inby
50825	L north face at room 4	Road	74.0	26.0	64.3	52.7	29.1	18.6	
50826	M north face at room 2	Rib & Roof	66.1	33.9	74.7	70.0	46.8	29.3	
50827	M north face at room 2	Road	54.7	45.3	64.7	51.9	30.2	19.4	do.
50828	Main west haulage at 26 north face	Road	1.0	99.0	32.1	22.4	9.2	7.1	do.
50829	No. 2 main west at 26 north face	Rib & Roof & X-bar	54.4	45.6	71.0	69.4	48.9	34.2	do.
50830	No. 2 main west at 26 north face	Road	34.2	65.8	66.1	44.9	24.2	16.0	do.
50831	No. 4 main west at station 148 between 25 and 26 north	Rib & Roof	46.3	53.7	66.7	65.5	40.4	26.4	do.
50832	No. 4 main west at 26 north face between 25 and 26 north at station 148	Road	70.8	29.2	68.3	59.8	37.8	23.4	do.

Table 3 - contd.

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Percent: Through 20-mesh	Cumulative, 100 percent through 20-mesh, Percent through: 48-mesh	100-mesh	200-mesh	Remarks
50833	No. 5 main west between 24 and 25 north faces	Road	61.0	39.0	84.4	58.3	29.2	16.9	At edge of explosion area on main west inby
50834	No. 6 main west between 25 and 26 north faces	Road	66.9	33.1	80.8	42.4	22.0	12.7	
50835	No. 2 main west inby 1st slant inby substation	Rib & Roof	62.8	37.2	73.0	70.8	50.4	35.3	At edge of explosion area on main west outby
50836	No. 2 main west inby 1st slant inby substation	Road	57.4	42.6	57.8	48.6	25.8	15.9	
50837	Main west haulage 50 ft. inby 1st slant inby substation	Crossbar	19.5	80.5	84.3	65.8	44.9	28.3	do.
50838	Main west haulage 50 ft. inby 1st slant inby substation	Road	10.6	89.4	66.1	45.4	28.0	19.9	do.
50839	No. 4 main west 40 ft. outby 23 north	Road	70.1	29.9	71.6	58.0	32.6	10.6	Inby from explosion area
50840	No. 5 main west 40 ft. outby 23 north	Road	28.3	71.7	72.1	61.8	41.7	28.6	do.
50841	Main west haulage at station 126 (outby C north)	Timber	15.9	84.1	87.6	72.7	65.7	56.2	
50842	Main west haulage at station 126	Road	4.2	95.8	76.8	21.0	10.4	7.3	
50843	No. 2 main west in passway opposite station 126	Crossbar	24.7	75.3	89.9	80.6	73.4	66.1	
50844	No. 2 main west passway opposite station 126	Road	3.0	97.0	73.7	22.0	8.5	5.1	
50845	Room 4, 65 ft. inby 19 east, 19 south	Rib & Cob	73.7	26.3	81.4	55.9	32.7	20.5	Unaffected portion of mine

Table 3 - contd.

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Percent: Through 20-mesh	Cumulative 100 percent through 20-mesh, Percent through: 48-mesh	100-mesh	200-mesh	Remarks
50846	Room 4, 45 ft. inby 19 east, 19 south	Road	77.4	22.6	67.7	61.1	39.5	25.5	Unaffected portion of mine
50847	Room 1, 19 east, 19 south	Rib & crossbars	47.0	53.0	60.0	50.1	32.9	19.3	do.
50848	Room 1, 19 east, 19 south	Road	53.3	46.7	60.4	55.0	26.0	21.1	do.
50849	17 west inby rib of room 1, 19 south	Rib & crossbars	67.0	33.0	74.0	55.1	38.1	23.6	do.
50850	19 south, 19 east at inby rib of room 1	Road	60.0	40.0	67.5	59.2	36.6	21.6	do.
50851	19 south, 20 west, 10 ft. outby room 1	Rib & Roof	73.6	26.4	72.6	67.3	44.4	26.8	do.
50852	19 south, 20 west, 10 ft. outby room 1	Road	62.7	37.3	60.9	54.0	31.1	18.4	do.
50853	19 south, 15 east, room 46, 20 ft. outby face	Rib & Roof	85.3	14.7	61.0	55.9	32.0	20.6	do.
50854	19 south, 15 east, room 46, 20 ft. outby face	Road	81.7	18.3	64.1	58.7	36.6	24.2	do.
50855	19 south, 15 east between rooms 1 and 2	Rib & Roof	75.7	24.3	54.7	25.1	9.1	4.8	do.
50856	19 south, 15 east between rooms 1 and 2	Road	56.2	43.8	59.3	45.3	19.1	10.4	do.
50857	19 south, 15 east between 1st and 2nd chute	Rib & crossbars	69.6	30.4	60.2	47.7	17.0	7.3	do.
50858	19 south, 15 east between 1st and 2nd chute	Road	49.5	50.5	65.0	42.6	17.2	6.0	do.
50859	19 south at 15 east switch	Rib & crossbars	27.0	73.0	60.8	37.2	18.4	11.8	do.
50860	19 south at 15 east switch	Road	17.9	82.1	70.5	32.9	13.4	7.0	do.

Table 3 - contd.

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Through 20-mesh	Cumulative 100 percent through 20-mesh, Percent through: 40-mesh	100-mesh	200-mesh	Remarks
50861	19 south, 11 west, between 4 and 5 rooms	Rib & Roof	78.5	21.5	65.9	66.1	43.4	28.3	Unaffected portion of mine
50862	19 south, 11 west, between 4 and 5 rooms	Road	74.1	25.9	67.6	58.2	35.2	24.1	do.
50863	19 south, 12 west between 4 and 5 rooms	Rib & Roof	81.4	18.6	61.2	59.3	34.5	23.3	do.
50864	19 south, 12 west between 4 and 5 rooms	Road	68.2	31.8	74.2	61.7	42.0	20.6	do.
50865	19 south, 75 ft. outby 11 west	Rib & crossbars	69.6	30.4	82.0	73.1	52.5	37.8	do.
50866	19 south, 75 ft. outby 11 west	Road	34.9	65.1	75.4	44.3	26.8	10.9	do.
50867	1 east between 9 and 10 rooms, 19 south	Rib & Roof	81.5	18.5	56.0	58.0	31.2	19.0	do.
50868	1 east between 9 and 10 rooms, 19 south	Road	77.4	22.6	69.5	54.6	20.4	13.4	do.
50869	19 south, 1 east, room 1 opposite room 9	Rib & Cob	79.7	20.3	65.5	56.5	31.9	21.6	do.
50870	19 south, 1 east, room 1 opposite room 9	Road	77.7	22.3	69.7	61.4	41.5	27.6	do.
50871	19 south, 1 east entry, room 2 opposite room 9	Rib & Cob	81.3	18.7	65.5	56.0	35.7	22.5	do.
50872	19 south, 1 east entry, room 2 opposite room 9	Road	77.7	22.3	72.4	59.6	37.7	23.2	do.
50873	19 south, 50 ft. outby 1 east	Rib & crossbars	52.3	47.7	77.4	61.0	40.6	28.4	do.
50874	19 south, 50 ft. outby 1 east	Road	48.2	51.8	79.1	62.9	52.5	25.8	do.

Table 3 - contd.

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Through 20-mesh	Cumulative 100 percent through 20-mesh, Percent through: 48-mesh	100-mesh	200-mesh	Remarks
50875	Main west haulage 200 ft. outby 19 north	Rib & Roof	17.5	82.5	97.6	96.6	94.3	91.4	Unaffected portion of mine
50876	Main west haulage 200 ft. outby 19 north	Road	9.3	90.7	89.1	47.9	29.0	22.2	do.
50877	Main west passway 200 ft. outby 19 north	Rib & Roof	40.3	59.7	87.5	78.4	65.4	56.6	do.
50878	Main west passway 200 ft. outby 19 north	Road	27.3	72.7	76.5	43.5	25.9	19.8	do.
50879	Main west at station 87	Rib & Roof	10.8	89.2	98.7	99.3	98.5	97.1	do.
50880	Main west at station 87	Road	58.2	41.8	74.0	65.5	40.5	33.5	do.
50881	2 main west opposite station 87	Rib	40.5	59.5	76.5	70.0	62.6	50.7	do.
50882	2 main west opposite station 87	Road	41.5	58.5	36.7	51.3	27.5	17.9	do.
50883	Main west haulage at station 82	Rib & crossbars	15.3	84.7	98.8	97.3	96.0	95.1	do.
50884	Main west haulage at station 82	Road	48.2	51.8	86.8	66.1	49.2	36.6	do.
50885	Main west haulage at station 70	Rib & crossbars	18.7	81.3	95.9	93.9	92.8	91.1	do.
50886	Main west haulage at station 70	Road	49.5	50.5	77.9	73.2	59.7	48.5	do.
50887	No. 2 main west opposite station 70	Rib & Gob	52.7	47.3	85.9	73.3	56.4	40.9	do.
50888	No. 2 main west opposite station 70	Road	52.9	47.1	86.9	80.5	70.7	55.4	do.
50889	Main west haulage at station 50	Rib & crossbars	21.7	78.3	95.7	93.1	91.1	88.7	do.

Table 3 - contd.

Laboratory No.	Location in mine	Kind of sample	Percent: Combustible, V.+ F.C.	Percent: Incombustible, moisture + ash	Through 20-mesh	Cumulative 100 percent through 20-mesh, Percent through: 48-mesh	100-mesh	200-mesh	Remarks
50890	Main west haulage at station 50	Road	68.3	31.7	74.9	73.4	57.5	44.3	Unaffected portion of mine
50891	No. 2 main west opposite station 50	Rib & Timber	48.8	51.2	70.9	82.4	69.5	61.9	do.
50892	No. 2 main west opposite station 50	Road	58.8	41.2	98.3	98.5	95.9	92.6	do.
51040	30 ft. from face 7 west, 22 south	Roof	72.6	27.4					Not rock-dusted; large amount of coke present
51041	12 ft. outby face 8 west, 22 south	Roof	69.6	30.4					do.

A study of the analyses of these samples shows:

1. The incombustible content of the rib and roof dust samples collected along the main west haulageway ranges from 59.7 to 89.2 percent, with an average of 79.4 percent. The road-dust samples range from 31.7 to 99.0 percent, with an average of 72.1 percent, incombustible. The incombustible content of the dust along the main west haulageway falls well within the quantity necessary to prevent propagation of flame.

2. The incombustible content of rib and roof samples collected along the face entry haulageways ranges from 28.5 to 73.0 percent, with an average of 41.5 percent. The incombustible content of road-dust samples in face entries ranges from 26.0 to 82.1 percent, with an average of 54.1 percent.

3. The incombustible content of rib and roof dust samples collected along butt entry haulageways ranges from 18.5 to 39.4 percent, with an average of 23.7 percent. The road-dust samples range from 18.7 to 50.5 percent, with an average of 29.5 percent, incombustible.

4. The incombustible content of rib and roof dust samples collected in rooms ranges from 14.7 to 53.0 percent, with an average of 39.3 percent. The road-dust samples collected in rooms range from 16.3 to 46.7 percent, with an average of 31.9 percent, incombustible.

5. The incombustible content of rib and roof dust samples collected in air-course entries ranges from 37.2 to 53.7 percent, with an average of 46.1 percent. The road-dust samples collected in air-course entries range from 29.2 to 65.8 percent, with an average of 46.8 percent, incombustible.

6. Samples of rib and roof dust collected near face regions showed a range of incombustible content of from 18.7 to 29.9 percent, with an average of 26.2 percent. Road-dust samples ranged from 18.7 to 22.6 percent, with an average of 20.8 percent, incombustible. This shows that the coal dust near face regions contains but little incombustible and will readily propagate an explosion.

7. The high incombustible content of the dust along the main west haulageway and to a lesser extent along 22 south face entries was probably a large factor in preventing further propagation, and materially reduced the violence of the explosion.

The incombustible content of all the samples collected is somewhat higher than would be expected in the average non-rock-dusted mine. This may be accounted for by the fact that the roof is constantly scaling, which roof rock weathers and mixes with the coal dust, thereby increasing the incombustible content.

The analyses indicate that the addition of comparatively small amounts of rock dust will bring the incombustible content up to that required to prevent propagation.

8. The size of coal dust in a mine is a factor governing the propagation of an explosion; the finer the dust the more readily it will enter into the propagation. Experiments have shown that any coal dust that will pass through a 20-mesh screen (400 openings to the square inch) will enter into an explosion. Experiments have also shown that an explosion can be propagated with as little as 0.08 ounce of typical mine-size dust (all through 20-mesh and 20 percent through 200-mesh) per cubic foot of space. This is a very small amount and

is equivalent to 4.8 ounces per linear foot in an entry 60 square feet in cross-section. Such an amount of coal dust distributed over all the surfaces could be detected only by careful examination, and it is evident that no coal mine can be so clean that propagation of a coal-dust explosion is impossible.

Sizing tests of all dust samples were also made. These tests show that an average of 73.8 percent of the rib dust and 70.2 percent of the road dust is less than 20-mesh size, and that an average of 30.9 percent of the rib dust and 24.0 percent of the road dust is less than 200-mesh size. This indicates that 70 to 73 percent of the dust present in this mine is of such size that it will enter into the propagation of an explosion, and that the relatively high amount of very fine dust (200-mesh) will greatly add to its explosibility.

FIRST AID AND MINE RESCUE

About 10 percent of the employees have received the American Red Cross course in first-aid training and there is no regular program of retraining. The first-aid training has been conducted by the safety inspector at the mine who is an authorized Red Cross first-aid instructor. First-aid material is kept available in the working sections of the mine and a first-aid dressing station is maintained on the surface, with a nurse in charge.

There are no self-contained oxygen breathing apparatus at the mine or at any nearby mine, and no mine-rescue teams have been organized or trained at the mine. The State of Ohio maintains several rescue trucks, one of which is stationed in this district. Two gas masks are available for fire-fighting purposes and these masks are in safe operating condition.

SAFETY ORGANIZATION

A safety inspector is employed at the mine. His duties are to make inspections of the mine for substandard conditions and practices, conduct safety educational activities, instruct men in first-aid methods, and foster and develop the general safety organization plan.

Three employees' safety committees have been organized, one for each of the working shifts. These committees are composed of one member from each crew elected by the crew. They are encouraged to report any substandard condition or practice that they have observed or that has been called to their attention and to make recommendations for the correction of unsafe conditions and practices.

A general safety committee composed of all mine officials has also been organized and holds its meetings regularly.

General safety meetings of all employees are held quarterly, at which time prizes are awarded for outstanding safety records. About $250 each month is distributed in the form of safety prizes to the employees of the four mines of the company. Employees must be free from accidents during the month in order to participate in the drawing.

A bonus system for supervisory mine officials is also in effect wherein the section foreman or other supervisory official is awarded $10 for the best safety record for any month, $50 for the best record covering a 6-month period, and $100 for the best record over a period of one year. To be eligible for the bonus, however, the section in charge of the foreman must be up to a certain standard with regard to physical condition as determined by the company mine inspector.

It is evident that the attitude of the management toward the general problems of safety has been exceedingly favorable and probably as much has been done to safeguard the employees against ordinary mine accidents at this mine as at any other mine in Ohio.

The Hanna Coal Company has actively engaged in safety work since 1927, when the present safety organization was instituted, and a steady improvement in accident reduction has been experienced. The records show that in 1927 this company experienced 1.726 accidents per 1,000 days worked, while in 1937 only 0.444 accident per 1,000 days occurred; in 1927, 2,236 tons of coal were produced per accident, while in 1937, 13,191 tons were mined per accident; in 1927, 108,166 tons were produced for each fatal injury, while in 1937, 639,779 tons were produced per fatality. In 1927 the rate of premium to the Workmen's Compensation Fund was based on a 40-percent penalty, while in 1937, due to much better accident rates, the premium was based on a 66-percent credit.

The Ohio State Department of Safety and Hygiene conducts a State-wide safety campaign based on the accident records from each mine. These campaigns are conducted on the basis of 6-month periods of experience. In 1936 the Willow Grove mine took ninth place for the first 6-month period and first place for the second period; in 1937, first place for the first period and third place for the second period; in 1938, first place for the first period and fifth place for the second period; in 1939, second place for the first period and fifth place for the second period. The above figures are quoted to show that the accident records at the Willow Grove mine compare favorably with other mines in the State.

The accident records for the Willow Grove mine for last year, 1939, are considerably better than for other mines of the same company and are considerably above the average. During last year the Willow Grove mine produced 1,475,637 tons of coal with 165,545 man-days of labor; 59 accidents, of which only 29 were compensable, occurred during the year.

The following table compares the accidents at the Willow Grove mine with other mines of the company for 1939.

	No. of accidents per 1,000 man-days	Tons mined per accident
Willow Grove	0.356	25,010
Dun Glen	.638	10,701
Piney Fork	.520	9,286

The accident experience of the Willow Grove mine from 1934 through 1939 is indicated by the following table.

Year	No. of accidents per 1,000 man-days	Tons mined per accident	Tons mined per fatal
1934	0.320	14,904	417,336
1935	.267	18,919	No fatals 2/
1/ 1936	.273	23,181	811,334
1937	.368	23,161	682,972
1938	.372	23,276	1,326,744
1939	.356	25,010	491,879

1/ Year mine became mechanized.
2/ 510,613 tons produced.

SUPERVISION AND DISCIPLINE

It is evident that the supervision of the mine is both thorough and competent. The competency of the mine foreman, his assistants, and all section foremen has been certified to by the Ohio Division of Mines, and personal contact with the survivors of the official force at this mine indicates that they are above the average in essential qualifications. That the supervision has been thorough is indicated by the fact that not more than 34 employees come under the supervision of any one section foreman at any time. In view of the fact that the work is concentrated, this number is not excessive, and it is probable that almost continuous supervision is given to the working forces.

A complete set of safety rules and regulations to supplement the mining laws has been adopted by the company and it is believed that, with few exceptions, these rules have been carefully obeyed.

FIRE-FIGHTING

No fire-fighting organization is maintained. Fire hydrants are located at convenient points on the surface and hose is available for use in case of fire on the surface. A water tank (1,000-gallon capacity) mounted on a truck and provided with an electric pump is provided for use underground in case of fire. Rock dust and portable fire extinguishers are provided for fire use at all underground electrical installations.

MINE CONDITIONS IMMEDIATELY PRIOR TO EXPLOSION

The mine was operating normally and no unusual conditions had been observed during the day of the explosion. The weather was clear and cold and the barometer readings taken at St. Clairsville, made to secure the immediate service of the State Department of Mines, medical aid, and all the available outside help. I was then told that Richards and Sanders, the superintendent and outside foreman, had started into the pit mouth. I also found Steve Olexa at the office. Olexa was the one who had come out on the so-called runaway trip. Upon questioning him, found that he had left the 19 north and south junction at about ten minutes after eleven in a cloud of dust and smoke and started for the outside, with a loaded trip. Somewhere along the mains west haulageway he lost consciousness and had come out on the outside loop at full speed, the trolley pole flying off the wire on the outside but the momentum of the locomotive carried the trip back into the mine as far as the lower end of the pit mouth passway. This distance is approximately 900 feet back into the mine. He said that Richards and Sanders, together with two other outside men, had gone into the mine and had taken him off the motor. Richards and Sanders remained at the mine telephone located at this point while the two outside men brought Olexa and the trip back on the outside. Olexa's trip was brought back on the outside at about 11:30 a.m. I also found in the outside office two mechanics who had worked in the 19 north and south machine shop. These men stated that they were the last two to leave the machine shop and proceeded to the dispatcher's shanty at the 19 north and south junction and upon finding a rather disorganized group there, they had taken it upon themselves to slip by the dispatcher and started walking and running out of the mains west motor road. These men spoke to Richards while he was telephoning at the bottom and had been told by him to go on outside. They reached the outside at approximately 11:45 a.m. and were in excellent shape and aided in the rescue work at the air shaft immediately after.

I went over to the pit mouth with John Davis, safety engineer, to see if Richards and Sanders could be located, at approximately 12:10 or 12:15 p.m. The pit mouth was completely filled with dust clouds and foul air, making it impossible for anyone to go into the pit mouth without rescue equipment. I pounded on the wire going into the pit mouth in hopes that we might receive some answer. Then I left Davis at the pit mouth with the instructions to organize a rescue crew to go after Richards and Sanders.

Before this time, I had called into the junction at 19 north and south and talked to Harry Ruehl, our chief inside electrician. I told him in detail what I had found in 22 south and that they had better abandon their position at the dispatcher's shanty and return up into 19 north and south. Later investigation showed that Ruehl had remembered nothing of this conversation since the men who were making the telephone calls in the dispatcher's shanty were overcome with fumes so rapidly that they were no longer coherent.

John Davis related later that he had organized a rescue crew at the pit mouth and at about 12:30 p.m. the air had cleared sufficiently so that without any other equipment, other than a safety lamp, they were able to go into the pit mouth at least 100 feet or more to reach the bodies of Richards and Sanders. Richards and Sanders were brought out and given artificial respiration and inhalators were used but they were not revived.

I sent a group of about six men back up to the air shaft in my car to help Hartley get the injured man out of the air shaft. I then organized all the men available on the outside and with trucks, filled with stretchers, gas masks, brattice boards, and other material and supplies, we went to the air shaft. The first six men reached from "C" and "D" entries and the brattice man were outside and out of danger about noon.

Upon reaching Hartley at the bottom of the air shaft, we found that he had Polocy all ready to come up the shaft. Hartley had already taken steps to open the air lock doors between 24 north air intake entry and 23 north, the return air so as to insure fresh air down to the mains west. Hartley and myself donned gas masks and organized all the available men to carry brattice material down the 23 north return air course to which junction point is at the mains west.

We then proceeded with masks and safety lamps to go down the mains west and try to get into the 22 south. We were only able to penetrate to a point slightly above the third break-through on 22 south before meeting such large quantities of afterdamp. We then returned to the bottom of the air shaft and after consultation among ourselves, decided that, if anyone were alive in 22 south, they would make an attempt to reach the air shaft through the intake air entries. So it was decided to explore these entries as far up into 24 south as possible.

We were able to reach a point in 24 south approximately the same distance as we had by going into 22 south before encountering afterdamp again and found no men or no traces of anyone having attempted to come through the air course. We found that the overcast across the 23 north air course had been slightly damaged and proceeded to extend this damage to the roof of the overcast, allowing more fresh air to blow out on the mains west entry.

About this time, Charles Neff, mine electrician, and Domenic Stanchini, mine foreman, arrived. With the assistance of these two men and the outside men who were available, we started to brattice off the 22 south entries. These men informed me that Mr. Clay was coming down the air shaft and wanted to see me. Mr. Clay, after having been advised of the conditions we had found and that we believed no one was alive in 22 south--while some 70 odd men were still living in 19 north and south entries with 20 odd men attempting to go out on the motor road--gave me authority to take charge of the rescue work and proceeded to seal off 22 south until such time that the men had been rescued from the other areas and the district mine inspector, Richard McGee, should arrive on the scene. Mr. Clay informed me at this time that he had been successful in contacting the deputy mine inspector and that he was on his way to the scene.

With the arrival of four more of our section bosses and a group of inside workers, I left John Hartley in charge of the 22 south area and brattice work at this point. I took Stanchini and J. C. Lukasko on down the mains west in an attempt to contact the men at 19 north and south. Upon reaching the first door across the mains west entry, which was still intact, we left J. C. Lukasko at this point and proceeded down the mains west, arriving at the junction. We contacted the men who were in 19 north and found that they had adequate air supply and instructed them that we were going to send more fresh air up to them by closing the door across the mains west motor road inby 19 north and south.

After definitely establishing this new air circulation and having it confirmed by telephone by the men in 19 north, we started up to meet them. These 69 men were escorted by their foremen down 19 north and up the mains west motor road and out the air shaft, arriving at the top of the air shaft at about 3:00 p.m. After establishing telephone communication to Mr. Ireland on the outside of the mine and advising him of the work that had been done, we formulated a plan at that time. As soon as adequate men arrived on the scene, we started a searching party out on the mains west motor road and a searching party up 19 south. Before any parties were organized, we received a call at the junction from three men who were working at 19 north 17 and 18 west. These men had no knowledge of any explosion and were in fresh air and had started out of 17 and 18 west toward 11 west from which point they had telephoned the junction, it being approximately their quitting time.

I instructed them to proceed down the junction and they arrived there without any assistance. Two of these men were sent on up to the air shaft and arrived on the outside at 5:00 p.m. At this time, McGee arrived on the outside. After advising him of the information we had gotten from the men who were taken out of 19 north, it was thought the best policy to start a searching party out of the mains west and to thoroughly search 19 south in case the information received from the 19 north group was not absolutely correct. This plan was adopted because it was of the opinion of all that if any attempt was made to air 22 south, the remaining men who were alive on the motor road would be in danger. McGee's party arrived at 19 north and south junction at approximately 3:15 p.m.

The party, organized to go out the motor road, consisted of Tom Gettings, Mine Safety Appliances Company, and Carl Clipp, section foreman. These two men proceeded on foot, testing the air. Behind them, another crew of five men with cars was sent to pick any bodies found along the motor road. At 5:15 p.m. I received word from Carl Clipp over the telephone that this party had reached the bottom telephone and had found 23 men, all of whom were down but breathing. This party of rescue workers reached the outside at 8:20 p.m. Twenty-three men were found between 12 north and 6 north, a distance of about 3,000 feet along the main haulageway. The man closest to the outside was approximately 4,600 feet from the pit mouth.

The story of Domenic Stanchini is as follows:

The first thing I did, I came to the mine about one o'clock and I went over to the pit mouth and found out that they were working on John Richards as he had passed out from fumes and that there was no way of getting into the mine from this end. I got my lamp and got into my car and went to the shaft. I met Mr. Clay at the top of the shaft and he told me what had happened. He said that Nailler and Hartley had entered the mine ahead of the men. Mr. Clay also said, "When you get down there, get in touch with Nailler and tell him I want to talk with him." I went to the bottom of the shaft and from there I went down to 23 north. I met Nailler and Hartley. A timber had been blown out at 23 north overcast and they were trying to put the timber back in to reestablish the ventilation. I explained to them that it was not necessary to rebuild the overcast as all the air would go down the main entry way. They told me that the overcast from 22 south was all right. We proceeded from this point on down the mains west to where 22 south turns off the mains west. When we reached the junction of 22 south, as near as I can remember, we were joined by a group of other section foremen and we decided to close 22 south off.

After 22 south had been closed off we continued going down the main entry. Upon reaching 19 south and north junction, we got in communication by telephone with Steve

Hobart, section boss, in 19 north. We told him to stand by as we were going to close the door at the junction in order to put all fresh air in 19 north. After we had closed the door, we told them to stand by as we would come out where they were before they started out. Then after we got there, Mailler and I started into 19 north and we met Steve Hobart in 5 east on 19 north. Upon reaching Steve, I asked him if he had all the north men with him. He said he had. Then I asked him if he had all the south men with him. He said he didn't. They had all but 27. I asked Steve how the south men got into the north. He said he had called the south men by telephone and told them to go into the north. I asked him if he had the south section boss there and he said he did. I asked him if all the men were accounted for and he said he didn't think so, that some of them went out the motor road. I explained to the men that they were all ready to go outside, for them not to be afraid but walk slowly and that the air had been re-established and that they were safe.

I took the lead and led the men down the mains west junction. Then after that group of men were out, we decided to explore 19 south as we did not know how many men were left in the south. Upon reaching 19 north junction at the mains west, I explained to Hobart that they were to go out the new air shaft at 23 north and for him to take all his men out that way.

Before starting into 19 south, some Rail & River men had come and we had a group of nine men. Just as we started into 19 south, we met three men coming out of 19 south and they told us that they had been working in 17 and 18 west, 19 south, and that they didn't know anything had happened only that there was no power on the line and that there was no man-trip running. We asked them if they knew of any other men working in 19 south. They did not know of any. We asked them if they would be able to go back and two of them said they would be glad to go back to see if any more men were left in there, but as one of these men didn't look so good, we decided to leave them go out and take one fellow back with us.

The men that were taken back told us that on the way down they saw that the 11 west door was left open. We decided that before we explored the south, we had better go down and close the 11 west door to reestablish the air in that part of the mine. J. C. Lukasko went down by himself to 11 west with the instructions to close the door and stay on the fresh air side of the door after he had closed it and wait there for at least 5 minutes on that side of the door and then come out with his safety lamp and make a test of the air on the return at 19 south and he was to report to us if it was clear enough for us to come to him. After that was done, he called us by telephone and told us that everything was O.K. up to that point.

Then I took the group of men that had joined us at that time and went to 11 west in the south. After reaching 11 west and meeting up with Lukasko, again we organized groups to explore 23 west, 19 east, 15 and 16 east, 11 and 12 west, and 1 and 2 east. I told Lukasko that he would have charge of that group of men for that inspection as I was returning to the junction to see what was happening to the men that were on the motor road.

Upon returning to the junction, I was informed by Nailler that a group of men had gone by him going towards the outside to rescue anyone who was on the motor road. After we had received a complete report by telephone from the exploring crews in 19 south, they all returned back to the junction until we had a report from the outside that all men on the motor road were out.

After we were assured that all the men had started out on the motor road were outside and when the exploring party came back from 19 south, the power from the outside to the junction was shut off on the outside. Along with Dick McGee and Jerome Watson, who had joined the party at that time, we closed the door at 19 south junction and went back up the mains west towards 22 south. When we reached 22 south junction, we decided to build temporary stoppings and put the full force of the air into the 22 south area.

An attempt was made to restore ventilation in the affected area through 23 and 24 south air course, which was extremely difficult due to extensive falls and dangerous roof conditions; however, the work was carried on until it was no longer possible to advance with the amount of air available.

The entire 22 south section contained extensive and numerous falls under which approximately 50 of the 69 men who were killed by the explosion in this section were buried.

After the ventilation had been changed to permit electrical equipment to be operated on intake air on 22 south, a loading machine was put in operation cleaning up falls on this entry. After the falls had been cleaned to the junction of 3 east, the 3 and 4 east entries were ventilated and explored. The work of ventilating and exploring 5 and 6 east and rooms off 6 east, the 21, 22, 23, and 24 south face entries, and 7 and 8 west entries was continuously carried on until completed about 2:00 p.m., March 21. In the meantime, as the cleaning of falls progressed, additional loading machines were put in operation on the 3 east and 4 east, 5 east and 6 east, 22 south, and 7 and 8 west. This work was continued to March 28, when the last body was recovered.

The personnel of the Bureau of Mines, under the direction of J. J. Forbes, supervising engineer of the Safety Division, participated in the recovery operations with one or more men actively on duty underground from 8:00 p.m., March 16, to 7:00 p.m., March 28, when the last body was recovered. The Bureau of Mines' participation in the recovery work consisted of consultations with the management and inspectors of the Division of Mines, Ohio Department of Industrial Relations, regarding proper and safe procedure; supervision and direction of the working forces in the reventilation of the mine; and protection of the brattice crews, labor crews, and loading-machine crews against poisonous gas, roof falls, and other hazards incidental to recovery operations. The closest possible cooperation existed between the Ohio Division of Mines, officials of the mining company, and the Bureau of Mines during the recovery operations. The recovery work was organized into three 7-hour shifts, and at least two Bureau representatives were assigned to each shift.

investigators are of the opinion that the explosion was initiated at a black (pellet) powder storage box located on 24 south between 7 and 8 west; however, in the opinion of the Bureau of Mines investigators the evidence here is not convincing.

Evidence upon which opinion is based that the explosion originated at the face of 8 west is as follows:

1. From the condition of the face and the location of the bodies, it is indicated that a shot was fired in the left rib in starting a room neck, near the face of 8 west, immediately prior to the explosion. This is indicated by the fact that the shot-firing cable was strung from the face outby and because the body of the shot firer was found at the outby end of the shot-firing cable.

2. Analyses of the scrapings in this rib shot hole and also from the rock shot hole at the face of 8 west, made by the Explosives Section of the Bureau of Mines, show definitely that black powder was shot in these holes.

3. Evidence indicates that an excessive amount of black powder was used for the burden to be brought down, and that the coal was thrown, due to the angle of the shot, against the face and ricocheted against the right rib. This violent blasting and movement of the coal, in addition to the "bug dust" stemming in the hole, doubtless threw considerable coal dust into the air, and this dust, together with dust raised by the preceding rock shot, probably formed a sufficiently dense cloud of dust to be ignited by the flame of the black blasting powder.

4. The absence of violence at the faces of 7 and 8 west is additional evidence that the explosion originated at this point. In

hundreds of explosion tests at the Bureau's experimental mine it is found that virtually no violence is manifested at the point of origin of explosions, ~~including those started by~~ when started by blown-out shots of black blasting powder; this fact is further borne out by personal observations following numerous explosions investigated by Bureau engineers. The three men found near the face of 8 west were not severely injured or seriously burned and were probably killed by carbon monoxide. All other men in the explosion area were killed almost instantly by violence or burns, or both; this further indicates the lack of violence at the faces of 7 and 8 west and gives ground for the conclusion that the ignition of dust (possibly including some gas) occurred here.

5. There was plenty of evidence of intense heat inby the last open crosscut of 7 west, as shown by heavy deposition of coke of silver-grey color on ribs, roof, and timbers. This heavy coking leads the investigators to believe that an accumulation of gas was present with relatively slow burning of this gas. The presence of gas in 7 west may have been due to the liberation of gas by the shots which were fired in this entry a short time before the explosion. The accumulation may have resulted from a derangement of ventilation through a door or doors having been left open, thereby "shorting" the air from the faces of 7 and 8 west. If gas was present in either 7 or 8 west or both, even in small percentages (from 0.5 to 2.0 percent), it would add materially to the explosibility of the coal dust. Since gas has been found at both 7 and 8 west faces since the explosion, it is reasonable to believe that gas was being liberated prior to the explosion. This is further substantiated by finding an explosive mixture of gas

in the face of 7 west before ventilation was restored and by analysis of samples collected after ventilation was restored, which showed 0.33 percent of methane at the face of 8 west and 2.46 percent in 7 west. Gas was also detected by flame safety lamp several times after ventilation was restored. It is therefore strongly suspected that methane gas was a factor in initiating the explosion.

6. It is believed by Bureau investigators that, after the ignition of coal dust at the face of 8 west, the explosion was propagated outby by the coal dust which was raised into the air by the pioneer pressure wave that preceded the flame of the explosion. By the time the explosion reached the junction of 7 and 8 west with the south face entries, it was apparently traveling at a high rate of speed and had developed considerable pressure. It is also believed that the powder box, which was almost directly in the path of the explosion, was violently moved by the advance pressure wave and the powder was ignited by the following flame.

CORONER'S INQUEST

C. C. Hardesty, coroner, Belmont County, St. Clairsville, Ohio, advises that no special inquiry was held on the Willow Grove mine disaster other than that he or his staff officially examined all of the bodies that were recovered from the Willow Grove mine and took testimony from 12 persons at the mine during the recovery of these bodies. He stated that he based his conclusions that the death of 69 men in the affected region was caused by burns on the fact that all bodies showed evidence of third-degree burns and that at the time of his investigation the cause of the explosion in the Willow Grove mine, which occurred on March 16, 1940, was unknown.

PRESS RELEASE BY DEPARTMENT OF INDUSTRIAL RELATIONS OF OHIO

The following is a press release issued on April 12, 1940, by the Director, Department of Industrial Relations of Ohio, on the Willow Grove mine disaster:

> After a careful and extensive investigation of the mine explosion which occurred March 16 at Willow Grove mine in Belmont County which included the physical examination of the mine immediately following the removal of the last body, and the taking of testimony of company officials, powder experts, one member of the Federal Bureau of Mines, miners, representatives of the United Mine Workers Union, and of State mine inspectors, the following conclusions are made:
>
> 1. The seat of the explosion was confined within the limits of 7 and 8 west entries and that portion of 24 south between the junction of 7 and 8 west.
>
> 2. The severity and wide extent of the explosion were the result of a propagated dust explosion.
>
> 3. The evidence obtained does not support presence of gas as the probable cause of the explosion.
>
> 4. At the face of 8 west there was evidence that there may have been an overcharged shot fired which could have been capable of causing an explosion.
>
> 5. At the junction of 7 and 8 west with 24 south a destroyed steel powder magazine which was located on 24 south between 7 and 8 west gave evidence that a terrific explosion had occurred at this point which was capable of propagating a dust explosion.
>
> My opinion from the preponderance of evidence places the seat of the explosion on 24 south between the junction of 7 and 8 west, and the probable cause of the primary explosion was the explosion of the powder magazine, the cause of which is unknown.

PROBABLE CAUSE OF THE EXPLOSION

After carefully considering observations made during recovery operations, evidence and information obtained throughout the investigation, the results of analyses of dust and air samples collected in the mine, and the careful weighing of testimony presented during hearings conducted by the Department of Industrial Relations of Ohio, the Bureau investigators are of the opinion that this explosion originated in the face of 8 west entry off 22 south; that the explosion was caused by the firing of a shot of black pellet powder stemmed with "bug dust" which ignited a cloud of coal dust, in which gas may or may not have been present; and that the explosion was propagated throughout the affected area by coal dust which was raised in suspension by the initial explosion.

LESSONS LEARNED FROM THE CONDITIONS AS THEY RELATE TO THIS EXPLOSION

In the opinion of the writers, there are six outstanding lessons learned from this explosion, as follows:

1. The use of black blasting powder is a hazard in any coal mine. While there is a difference of opinion as to the point of origin of this explosion, the investigators are in agreement that black blasting powder initiated the explosion. The fact that black blasting powder, in either granular or pellet form, can be easily ignited by flame, and the fact that it produces a long, hot flame when fired, renders it much more hazardous to handle and to use than permissible explosives. Many explosions and the loss of many hundreds of lives have resulted from the use of black powder. Because of the danger in the use of black powder, some States prohibit its use in any coal mine and many States prohibit its use in gassy coal mines, and the Bureau of Mines, since shortly after its organization, has recommended the use of permissible explosives (with exclusion of dynamite and black blasting powder) for blasting purposes in coal mines.

This explosion is one of four very bad disasters which have occurred in the last 4 years in bituminous mines in the United States in connection with blasting in mechanized mines. Unquestionably blasting in mechanically operated mines requires much more safeguarding than it now has.

2. This explosion forcibly demonstrates the hazard of haulageways being used as return airways. Had the main west haulage been on intake air, at least three lives would have been saved, the men who escaped the violence of the explosion could have left the mine immediately in safety, and rescue and recovery operations would not have been delayed. Additional reasons for placing the haulageways on intake air are contained in the body of this report.

3. If this mine had been properly rock-dusted, it is almost a certainty that only a few lives would have been lost rather than 72.

4. Another lesson has been developed as a result of analysis of mine air samples. These show that at least 50,000 cubic feet of methane per day is being liberated. This mine has been considered to be nongassy and has been operated on that basis and, while the amount of methane is not as large as for some gassy mines, it does serve as a warning that a dangerous condition might readily be encountered. Moreover, because of the fact that development in connection with mechanical operation is progressing at a rapid rate, and that the mine is rapidly going below drainage and consequently more cover, it is reasonable to expect that more gas will be encountered in the future than there has been in the past. In fact, this explosion in a so-called nongassy mine is merely a repetition of the fact which has been proven

by scores of explosions that no mine can be considered nongassy if explosive gas can be found in it at all. Most of the very destructive coal-mine explosions in the United States have occurred in the so-called nongassy mines which give off a little gas or possibly in mines which are termed slightly gassy.

5. There was considerable difficulty in identifying the bodies recovered because of the checking-in-and-out system which was being used. This system was based on check numbers placed on the batteries of the electric cap lamps. In some instances it was found that the victims had changed lamps and consequently check numbers, and in other instances the batteries were torn from the men by the force of the explosion. It is believed that a system using two checks, one of which is always on the body of the man and a duplicate thereof placed on a check board when he enters the mine and taken off when he leaves the mine, would afford a more reliable method of identification and checking in and out of the mine.

6. The lack of knowledge of the properties and physiological effects of mine gases and the lack of proper equipment and trained men probably resulted in the loss of the lives of the two men who were killed a short distance inside the mine portal. Sufficient protective and detective equipment should be provided and men trained in its use and in methods of rescue and recovery operations, so that men and equipment may be available for such emergencies.

COMMENDABLE SAFETY PRACTICES

The Hanna Coal Company of Ohio has instituted many commendable safety practices at its Willow Grove mine, some of which are:

1. High type of supervisory officials and the practice of placing a foreman over a small section, which permits frequent inspections of each working place.

2. The past good accident record of the mine reflects the attitude of the company toward safety, and that good cooperation between workers and officials is obtained.

3. The safety organization and safety committee set-up of workers has, without doubt, been a large factor in maintaining a good safety record. It is understood that the Willow Grove mine had the lowest compensation rate of all mines in the State.

4. The modern and progressive methods used in the mining, transportation, and treatment of coal are commendable. This has caused the Willow Grove mine to be known as a "model mine".

5. The publication of the "Hanna News" in printed form in which it is issued is unique in coal mining, and serves to knit closer cooperation between men and management.

6. The use of permissible electric cap lamps and permissible flame safety lamps for testing for gas and the use of safety hats, safety goggles, and safety shoes are commendable practices.

7. The establishment of the new air shaft is a decidedly commendable procedure, giving as it does a much better opportunity to ventilate the face regions and also providing another escapeway. Its worthwhileness was amply proven for both purposes during the recent disaster.

RECOMMENDATIONS

The following recommendations are made with the belief that their adoption will materially lessen the chances of an explosion occurring in this mine in the future.

Ventilation and Gas

1. In view of the fact that the mine liberates an appreciable quantity of methane and because of the possibility that larger quantities may be encountered, it is recommended that this mine be operated on a gassy-mine basis.

(a) Fire bosses should be employed to make preshift examinations and make a record of their findings.

(b) Section foremen should make frequent tests for gas throughout the shift.

(c) Mining machine and loading machine crews should also make frequent tests for gas.

2. The ventilating fan should be of a reversible type, should be offset at least 25 feet from the mine opening, and should be provided with adequate explosion doors.

3. An auxiliary source of power should be provided in the event of failure of the regular source of power.

4. A warning device that will give both visual and audible warning and a relay switch to cut off the electric power from the mine in the event of stopping or slowing down of the fan should be provided on the fan.

5. The ventilating system should provide an adequate amount of fresh air in face regions to dilute and render harmless any explo-

sive or noxious gases formed or liberated, and it should be arranged so as to put all haulageways on intake air.

6. The ventilating circuit should be split so that not more than one set of face entries will be on one split of air in accordance with suggestions made in the body of this report.

7. Break-throughs should be made promptly and at a distance not to exceed 60 feet.

8. Falls should be removed or leveled, and approaches to overcasts should be graded to obtain greater ventilating efficiency and an increased quantity of air.

9. The use of doors should be eliminated so far as possible by the use of overcasts, but where it is necessary to use doors they should be installed in pairs to form an air lock.

10. Latches should not be installed on doors to hold them open, and doors should be hung in such manner as to insure positive self-closing.

11. All stoppings should be constructed of incombustible material.

12. The use of blower fans in this mine should be discontinued and line curtains used instead to force fresh air from the break-throughs to the faces.

13. Abandoned or worked-out sections of the mine that cannot be thoroughly ventilated and inspected should be sealed with tight incombustible stoppings.

Explosives

1. The use of black blasting powder in any form should be discontinued, and only permissible explosives used in a permissible manner should be used.

2. The conditions of use of such explosives to comply with permissibility are:

(a) That not more than 1-1/2 pounds be used in any one hole.

(b) That electric detonators of not less than No. 6 strength be used.

(c) That holes shall not be drilled on the solid or that the shot have a burden so heavy that it is likely to blow out.

(d) That the explosive be tamped with incombustible stemming to the collar of the hole.

(e) That the shots be fired with a permissible battery or other permissible firing device.

(f) That not more than one shot is fired at a time and that no shot is fired in the presence of a dangerous percentage of explosive gas.

3. Competent shot firers should be employed to do all shooting of coal and rock, and they should make tests for gas before and after firing each shot.

4. No more explosives should be taken into the mine or stored in any underground distributing magazine or box than is necessary for one day's operation.

6. Consideration should be given the use of sheathed permissible explosives, a new type of extra-safe permissible explosive for use in coal mines.

Allaying Coal Dust

1. Water should be used on mining machines, loading machines, before and after blasting, and on loaded and empty cars to allay coal dust.

2. All working places should be thoroughly wetted in the face regions for at least 40 feet back from the face.

Rock Dust

1. Accumulations of loose coal and coal dust should be cleaned up and loaded out preparatory to rock-dusting.

2. Rock dust should be applied to the surface of all openings, airways, entries, haulageways, rooms, and crosscuts to within at least 40 feet of the working faces in sufficient amount so that the incombustible content will be at least 65 percent.

3. If gas is present in the air current, the incombustible content should be increased about 1 percent for every 1/10 percent of gas present.

4. Samples of rock dust should be collected frequently in various places throughout the mine and, when analyses of such samples disclose that there is less than 65 percent incombustible present in any portion of the mine, redusting should be done immediately so the required amount or more of incombustible will be present at all times.

Electricity

1. All electrical equipment used at or near the face of workings should be of the permissible type and should be maintained in a permissible manner.

2. Trolley or cable-reel locomotives should not be operated except on pure intake air (containing not less than 20 percent of oxygen and not over 0.05 percent of inflammable gas), and in no event should they be operated beyond the last open break-through.

3. Trolley and bare power lines should be adequately guarded wherever they are less than 6-1/2 feet above the rail.

Miscellaneous

1. A more positive check-in and -out system should be employed, as suggested in the body of this report.

2. No smoking or smokers' articles should be permitted in the mine, and a systematic search should be made at frequent intervals to assure that smokers' articles or matches are not being taken underground by employees.

3. A mine-rescue station containing at least 10 sets of oxygen breathing apparatus, gas masks, and gas-detecting devices should be provided at the mine or be readily available for emergency use.

4. A number of selected employees should be given a course of instructions in the use and care of oxygen breathing apparatus and in rescue and recovery operations. Employees trained in this work should be given additional training periodically.

ACKNOWLEDGMENT

The writers wish to acknowledge the courtesies extended and the help given by the officials of the Hanna Coal Company. All information requested from the company in connection with this investigation was given without reservation. The cooperation of the Ohio Department of Industrial Relations and the Division of Mines is also gratefully acknowledged.

Respectfully submitted

J. J. FORBES
Supervising Engineer
Safety Division

G. W. GROVE
Senior Mining Engineer

H. J. FENE
Mining Engineer

M. J. ANKENY
Mining Engineer

Approved:

D. HARRINGTON
Chief, Health and Safety Branch

APPENDIX A

APPENDIX D

6-139

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

G—COAL-ANALYSIS REPORT

Test No. ____________ Lab. No. B-50893

Sample of High Volatile A Bituminous Coal (57.-145)-CF. Can No. W-04

Operator Hanna Coal Company Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 300' inby main West butts on C north Face

Method of sampling Standard Gross weight, lbs. 78.88 Net weight, grams 1046.0

Date of sampling 3/29/40 Date of Lab. sampling 3/31/40 Date of analysis ____________

B. of M. or U. S. G. S. section B. of M. Collector J. W. Pero

	Air-dry Loss 1.3	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.9	3.2		
	Volatile matter	39.2	38.7	40.0	44.7
	Fixed carbon	48.6	47.9	49.5	55.3
	Ash	10.3	10.2	10.5	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon				
	Nitrogen				
	Oxygen				
	Sulphur	3.6	3.6	3.7	4.1
	Ash				
	British thermal units	12960	12780	13210	14760
	Softening temperature of ash	° F.			

Date April 3, 1940 (Signed) H. M. Cooper
Chemist.

U. S. GOVERNMENT PRINTING OFFICE 6—8404

Form 6—138

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Can No. W-04

F—SAMPLING REPORT

Lab. No. B-50893

(1) State Ohio (2) County Belmont (3) Town Neffs (Post office) (4) Mine Willow Grove

(5) Sample of High Vol A Bit Coal - (57.-145)-CF (6) Analysis desired Prox., S., B.t.u.

(7) Method of sampling Standard (Describe if other than standard)

(8) Location in mine 300' inby main West butts on C north face (Distance and direction from opening. Locate with respect to rib, room, pillar, aircourse, entry, etc.)

(9) Date 3/29/40, 19 (Of sampling)

(10) Coal, dry or moist Dry (11) Gross wt., lbs. 78.88 (Sample cut) (12) Net wt., lbs. 3 lbs. (Sample mailed)

(13) Sample from fresh or weathered coal Fresh

(14) Roof Soapstone (Kind and quality)

(15) Draw slate or roof coal (Description and thickness)

(16) Floor Gray slate, hard, smooth (Kind, soft or hard, smooth or rough)

(17) Vertical depth from surface to point of sampling, feet 150'

No.	Section of Bed	Ft.	Ins.	No.	Section of Bed	Ft.	Ins.
x1	Bone		2	10	Coal		4
2	Coal	2	2	x11	Slaty coal		3
x3	Sulfur		1	12			
4	Coal		2	13			
x5	Bone		4	14			
6	Coal	1	8	15			
x7	Slate and bone		2	16			
8	Coal		4		Total thickness of bed	5	10
x9	Slate and bone		2		Thickness in sample	4	8

(18) Excluded from sample, marked X, section Nos. 1, 3, 5, 7, 9, and 11

(19) Send analysis to J. J. Forbes (20) Collector J. W. Pero (21) Office Pittsburgh, Pa.

Above information copied from B card by FEH on April 3, 1940, 19

U. S. GOVERNMENT PRINTING OFFICE 6—6098

6-139

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

G—COAL-ANALYSIS REPORT

Test No. ____ Lab. No. B-50894

Sample of High Volatile A Bituminous Coal (58.-144)-CG. Can No. M-25

Operator Hanna Coal Company Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 7 West, 60' inby last chute -- 19 South face entry

Method of sampling Standard Gross weight, lbs. 102.93 Net weight, grams 1017.0

Date of sampling 3/29/40 Date of Lab. sampling 3/31/40 Date of analysis 4/1/40

B. of M. or U. S. G. S. section B. of M. Collector J. W. Pero

	Air-dry Loss 1.7	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	2.0	3.6		
	Volatile matter	38.1	37.5	38.9	43.7
	Fixed carbon	49.2	48.3	50.1	56.3
	Ash	10.7	10.6	11.0	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon				
	Nitrogen				
	Oxygen				
	Sulphur	3.3	3.3	3.4	3.8
	Ash				
	British thermal units	12910	12690	13170	14790
	Softening temperature of ash	° F.			

Date April 3, 1940 (Signed) H. M. Cooper
Chemist.

U. S. GOVERNMENT PRINTING OFFICE 6—8404

Form 6—138

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Can No. M-25

F—SAMPLING REPORT

Lab. No. B-50894

(1) State Ohio (2) County Belmont (3) Town Neffs (Post office) (4) Mine Willow Grove

(5) Sample of High Vol A Bit Coal - (58.-144)-CG (6) Analysis desired Prox., S., and B.t.u.

(7) Method of sampling Standard (Describe if other than standard)

(8) Location in mine 7 West, 60' inby last chute -- 19 South face entry (Distance and direction from opening. Locate with respect to rib, room, pillar, aircourse, entry, etc.)

(9) Date 3/29/40, 19 (Of sampling)

(10) Coal, dry or moist Dry (11) Gross wt., lbs. 102.93 (Sample cut) (12) Net wt., lbs. 3 lbs. (Sample mailed)

(13) Sample from fresh or weathered coal Fresh

(14) Roof Weak soapstone (Kind and quality)

(15) Draw slate or roof coal (Description and thickness)

(16) Floor Hard, smooth gray slate (Kind, soft or hard, smooth or rough)

(17) Vertical depth from surface to point of sampling, feet 150' ±

No.	Section of Bed	Ft.	Ins.	No.	Section of Bed	Ft.	Ins.
1	Coal	2	0	10			
x2	Sulfur - trace			11			
x3	Bone		4	12			
4	Coal		10	13			
x5	Sulfur		2	14			
6	Coal	1	8	15			
7				16			
8					Total thickness of bed	5	0
9					Thickness in sample	4	6

(18) Excluded from sample, marked X, section Nos. 2, 3, and 5

(19) Send analysis to J. J. Forbes (20) Collector J. W. Pero (21) Office Pittsburgh, Pa.

Above information copied from B card by FEH on April 3, 1940, 19

U.S. GOVERNMENT PRINTING OFFICE 6—6098

6-139

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

G—COAL-ANALYSIS REPORT

Test No. ____ Lab. No. B-50817

Sample of High Volatile A Bituminous Coal (57.-145)-CG. Can No. R-264

Operator Hanna Coal Company Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine Face of room 4, L north face

Method of sampling Channel Gross weight, lbs. 60 Net weight, grams 1094.0

Date of sampling 3/27/40 Date of Lab. sampling 3/31/40 Date of analysis 4/1/40

B. of M. or U. S. G. S. section B. of M. Collector C. W. Owings

		Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Air-dry Loss 1.4					
Proximate Analysis	Moisture	1.9	3.3		
	Volatile matter	39.0	38.5	39.8	43.7
	Fixed carbon	50.4	49.6	51.3	56.3
	Ash	8.7	8.6	8.9	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon				
	Nitrogen				
	Oxygen				
	Sulphur	3.4	3.3	3.4	3.7
	Ash				
British thermal units		13210	13030	13470	14790
Softening temperature of ash		° F.			

Date April 3, 1940 (Signed) H. M. Cooper
Chemist.

U. S. GOVERNMENT PRINTING OFFICE 6—8404

Form 6—138

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Can No. R-264

F—SAMPLING REPORT

Lab. No. B-50817

(1) State Ohio (2) County Belmont (3) Town Neffs (Post office) (4) Mine Willow Grove

(5) Sample of High Vol A Bit Coal - (57.-145)-CG. (6) Analysis desired Prox., S., and B.t.u.

(7) Method of sampling Channel (Describe if other than standard)

(8) Location in mine Face of room 4, L north face (Distance and direction from opening. Locate with respect to rib, room, pillar, aircourse, entry, etc.)

(9) Date 3/27/40, 19 (Of sampling)

(10) Coal, dry or moist Dry (11) Gross wt., lbs. 60 (Sample cut) (12) Net wt., lbs. 3 (Sample mailed)

(13) Sample from fresh or weathered coal Fresh

(14) Roof Coal (Kind and quality)

(15) Draw slate or roof coal Soft, 12 in. (Description and thickness)

(16) Floor Hard, smooth slate (Kind, soft or hard, smooth or rough)

(17) Vertical depth from surface to point of sampling, feet 200'

No.	Section of Bed	Ft.	Ins.	No.	Section of Bed	Ft.	Ins.
x 1	Bony coal		1-1/2	10	Coal	1	0
2	Coal		11-1/2	11			
x 3	Sulfur streak		1	12			
4	Coal	1	1-1/2	13			
x 5	Bearing in band		1/2	14			
6	Coal		2	15			
x 7	Bearing in band		1	16			
8	Coal	1	6		Total thickness of bed	5	2
x 9	Sulfur band		1		Thickness in sample	4	9

(18) Excluded from sample, marked X, section Nos. 1, 3, 5, 7, and 9

(19) Send analysis to J. J. Forbes (20) Collector C. W. Owings (21) Office Pittsburgh, Pa.

Above information copied from B card by FEH on April 3, 1940, 19

U. S. GOVERNMENT PRINTING OFFICE 6—6098

A P P E N D I X   B

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 701 Laboratory No. 65491

Sample of mine air after explosion

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine Face of 25 South

Method of sampling Vac. Date sampled 3-26-40 Hour 8:35 a.m.

Velocity air still Area ______ Quantity ______

Pressure on seal ______ Barometer: Inside 29+ Outside ______

Temperature: Wet bulb ______ °F. Dry bulb ______ °F. Humidity ______

Mailed ______ Received 4-1-40

Collector C. W. Owings
(Name and title)

Laboratory No.	65491		Ethane (C_2H_6)		
Bottle No.	701				
Carbon dioxide (CO_2)	0.09		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.87		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)			Sulphur dioxide (SO_2)		
Carbon monoxide (CO)	0.00				
Methane (CH_4)	0.02				
Nitrogen (N_2)	79.02				
Total	100.00				

Remarks: ______

Date 4-2-40 (Signed) H. H. Schrenk.
Chemist.

6—8409

U.S. GOVERNMENT PRINTING OFFICE

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 702 Laboratory No. 65492

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine Face of 8 West, [illegible] no.

Method of sampling Vac. Date sampled 3-26-40 Hour 9:05 a.m.

Velocity air still Area Quantity

Pressure on seal Barometer: Inside Outside

Temperature: Wet bulb °F. Dry bulb °F. Humidity

Mailed Received 4-1-40

Collector C. W. Owings
(Name and title)

Laboratory No.	65492		Ethane (C_2H_6)			
Bottle No.	702					
Carbon dioxide (CO_2)	0.14		Hydrogen sulphide (H_2S)			
Oxygen (O_2)	20.72		Unsaturated hydrocarbons (C_2H_4, etc.).			
Hydrogen (H_2)			Sulphur dioxide (SO_2)			
Carbon monoxide (CO)	0.00					
Methane (CH_4)	0.33					
Nitrogen (N_2)	78.81					
Total	100.00					

Remarks:

This report is CONFIDENTIAL NOT FOR PUB[illegible] OR CIRCULATION without special permi[illegible] from [illegible] Director of the Bureau of Mines. Not to b[illegible] in litigation or in the exploitation of any [illegible] ess or product.

Date 4-2-40 (Signed) H. H. Schrenk.
Chemist.

6—8409 U.S. GOVERNMENT PRINTING OFFICE

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 703 Laboratory No. 65493

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine Face of 7 West, 22 So. in cave in roof

Method of sampling vac. Date sampled 3-26-40 Hour 10:00 a.m.

Velocity air still Area Quantity

Pressure on seal Barometer: Inside Outside

Temperature: Wet bulb °F. Dry bulb °F. Humidity

Mailed Received 4-1-40

Collector C. W. Owings (Name and title)

Laboratory No.	65493		Ethane (C_2H_6)		
Bottle No.	703				
Carbon dioxide (CO_2)	0.25		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.16		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)			Sulphur dioxide (SO_2)		
Carbon monoxide (CO)	0.00				
Methane (CH_4)	2.46				
Nitrogen (N_2)	77.13				
Total	100.00				

Remarks:

Date 4-2-40 (Signed) H. H. Schrenk. *Chemist.*

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 704 Laboratory No. 65494

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine 7 West 10 feet inby 24 south. Return of 22 south section.

Method of sampling Vac. Date sampled 3-26-40 Hour 10:55 a.m.

Velocity air 301 Area 47 Quantity 14,147

Pressure on seal Barometer: Inside Outside

Temperature: Wet bulb °F. Dry bulb °F. Humidity

Mailed Received 4-1-40

Collector C. W. Owings (Name and title)

Laboratory No.	65494		Ethane (C_2H_6)		
Bottle No.	704				
Carbon dioxide (CO_2)	0.05		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.88		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)			Sulphur dioxide (SO_2)		
Carbon monoxide (CO)	0.00				
Methane (CH_4)	0.04				
Nitrogen (N_2)	79.03				
Total	100.00				

Remarks:

Date 4-2-40 (Signed) H. H. Schrenk. Chemist.

6—8409 U.S. GOVERNMENT PRINTING OFFICE

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 705 - 708 Laboratory No. 65495 65496

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine No. 25 north face entry 150 feet inby upcast shaft, most of mine return

Method of sampling vac. Date sampled 3-28-40 Hour 2:00 p.m.

Velocity air 395 Area 49 Quantity 19,355

Pressure on seal ______ Barometer: Inside ______ Outside ______

Temperature: Wet bulb 47-1/2 °F. Dry bulb 51 °F. Humidity ______

Mailed ______ Received 4-1-40

Collector C. W. Owings
(Name and title)

Laboratory No.	65495	65496	Ethane (C_2H_6)		
Bottle No.	705	708			
Carbon dioxide (CO_2)	0.05	0.05	Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.85	20.82	Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)			Sulphur dioxide (SO_2)		
Carbon monoxide (CO)	0.00	0.00			
Methane (CH_4)	0.07	0.06			
Nitrogen (N_2)	79.03	79.07			
Total	100.00	100.00			

Remarks:

Date 4-3-40 (Signed) H. H. Schrenk.
Chemist.

6—8409 U. S. GOVERNMENT PRINTING OFFICE

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 706 Laboratory No. 65497

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine Face x room 25, 3 east, 29 south

Method of sampling vac. Date sampled 3-26-40 Hour 11:50 a.m.

Velocity air still Area Quantity

Pressure on seal Barometer: Inside Outside

Temperature: Wet bulb °F. Dry bulb °F. Humidity

Mailed Received 4-1-40

Collector C. W. Owings (Name and title)

Laboratory No.	65497		Ethane (C_2H_6)			
Bottle No.	706					
Carbon dioxide (CO_2)	0.10		Hydrogen sulphide (H_2S)			
Oxygen (O_2)	20.85		Unsaturated hydrocarbons (C_2H_4, etc.).			
Hydrogen (H_2)			Sulphur dioxide (SO_2)			
Carbon monoxide (CO)	0.00					
Methane (CH_4)	0.02					
Nitrogen (N_2)	79.03					
Total	100.00					

This report is CONFIDENTIAL NOT FOR PUBLICATION OR CIRCULATION without special permit from the Director of the Bureau of Mines. Not to be used in litigation or in the exploitation of any process or product.

Remarks:

Date 4-3-40 (Signed) H. H. Schrenk. *Chemist.*

6—8409

U.S. GOVERNMENT PRINTING OFFICE

A P P E N D I X F

6-213

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 707 - 709 Laboratory No. 65498 / 65499

Sample of mine air

Mine Willow Grove No. 10 Operator Hanna Coal Co.

State Ohio County Belmont

Town Neffs Name of coal bed Pittsburgh (No. 8)

Location in mine 10 ft. inby drift mouth. Part of full mine return

Method of sampling vac. Date sampled 3-29-40 Hour 11:55 a.m.

Velocity air 223 Area 40 Quantity 8,920

Pressure on seal Barometer: Inside 29½ Outside 29½

Temperature: Wet bulb 59 °F. Dry bulb 62 °F. Humidity

Mailed Received 4-1-40

Collector C.W.Owings
(Name and title)

Laboratory No.	65498	65499	Ethane (C_2H_6)			
Bottle No.	707	709				
Carbon dioxide (CO_2)	0.26	0.27	Hydrogen sulphide (H_2S)			
Oxygen (O_2)	18.97	18.98	Unsaturated hydrocarbons (C_2H_4, etc.).			
Hydrogen (H_2)			Sulphur dioxide (SO_2)			
Carbon monoxide (CO)	0.00	0.00				
Methane (CH_4)	0.24	0.24				
Nitrogen (N_2)	80.53	80.51				
Total	100.00	100.00				

Remarks:

Date 4-2-40 (Signed) H. H. Schrenk. *Chemist.*

6—8409 U. S. GOVERNMENT PRINTING OFFICE

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ______ Lab. No. B-50818

Sample of Rib dust (through 20-mesh screen). Can No. 190

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 8 West 10 ft. inby last chute 22 Rol

Method of sampling Standard Gross weight, lbs. ______ Net weight, gms 63.3

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis ______

For B. of M. section Mine Accident Collector C. W. Owings

Air-dry Loss .8	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis				
Moisture	1.7	2.5		
Volatile matter	19.2	19.0	19.5	27.1 [a]
Fixed carbon	51.5	51.1	52.4	72.9
Ash	27.6	27.4	28.1	
	100.0	100.0	100.0	100.0
Ultimate Analysis				
Hydrogen				
Carbon		GRAMS	PERCENT	
Nitrogen On 20-Mesh		25.8	29.0	
Oxygen Through 20-Mesh		63.3	71.0	
Sulphur Total wt. of sample		89.1	100.0	
Ash				
Calorific value determined				
Calories	Not rock dusted.			
British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	65.5
through 100 mesh	42.1
through 200 mesh	23.1
Area from which sample was taken (sq. ft.)	

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ____ Lab. No. B-50819

Sample of Road dust (through 20-mesh screen). Can No. 185

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 10 ft. inby last chute 8 west, 22 So.

Method of sampling Standard Gross weight, lbs. ____ Net weight, gms. 120.2

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis ____

For B. of M. section Mine Accident Collector C. W. Owings

	Air-dry Loss .8	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.5	2.4		
	Volatile matter	31.4	31.1	31.9	38.8 (a)
	Fixed carbon	49.6	49.1	50.3	61.2
	Ash	17.5	17.4	17.8	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		61.0	33.7	
	Oxygen Through 20-Mesh		120.2	66.3	
	Sulphur Total wt. of sample		181.2	100.0	
	Ash				
Calorific value determined	Calories	Not rock dusted.			
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	56.6
through 100 mesh	34.7
through 200 mesh	22.2

Area from which sample was taken (sq. ft.) ____

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ________ Lab. No. B-50820

Sample of Rib dust (through 20-mesh screen). Can No. 151

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 7 West, 22 South, 50 Ft. outby face.

Method of sampling Standard Gross weight, lbs. ________ Net weight, gms. 34.3

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis ________

For B. of M. section Mine Accident Collector C. W. Owings.

Air-dry Loss 1.5		Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.6	3.1		
	Volatile matter	25.8	25.5	26.3	36.2 (a)
	Fixed carbon	45.6	44.8	46.3	63.8
	Ash	27.0	26.6	27.4	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		21.7	38.8	
	Oxygen Through 20-Mesh		34.3	61.2	
	Sulphur Total wt. of sample		56.0	100.0	
	Ash				
Calorific value determined	Calories	Not rock dusted.			
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	
through 100 mesh	
through 200 mesh	
Area from which sample was taken (sq. ft.)	

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Lab. No. B-50821

Test No.

Can No. 179

Sample of Road dust (through 20-mesh screen).

Operator Hanna Coal Company

Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine 7 West, 22 South, 50' outby face.

Method of sampling Gross weight, lbs. Net weight, gms. 151.9

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis

For B. of M. section Mine Accident Collector C. W. Owings

	Air-dry Loss 1.5	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.5	3.0		
	Volatile matter	33.6	33.1	34.1	40.7 [a]
	Fixed carbon	49.0	48.2	49.8	59.3
	Ash	15.9	15.7	16.1	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen		GRAMS	PERCENT	
	Carbon	~~On 20-mesh~~	111.3	42.3	
	Nitrogen	~~Through 20-mesh~~	151.9	57.7	
	Oxygen	~~Total wt. of sample~~	263.2	100.0	
	Sulphur				
	Ash				
		NOT ROCK DUSTED.			
Calorific value determined	Calories				
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	57.5
through 100 mesh	38.1
through 200 mesh	24.6

Area from which sample was taken (sq. ft.)

Date, April 3, 1940. (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ____ Lab. No. B-50822

Sample of Rib & Roof dust (through 20-mesh screen). Can No. 160

Operator Hanna Coal Company Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine Room 25 at 3 east, 22 South.

Method of sampling Standard Gross weight, lbs. ____ Net weight, gms. 50.0

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis ____

For B. of M. section Mine Accident Collector C. W. Owings

	Air-dry Loss .4	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.7	2.1		
	Volatile matter	25.1	25.0	25.6	34.0 (a)
	Fixed carbon	48.8	48.6	49.5	66.0
	Ash	24.4	24.3	24.9	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen		GRAMS	PERCENT	
	Carbon	On 20-mesh	26.4	34.6	
	Nitrogen	Through 20-mesh	50.0	65.4	
	Oxygen	Total wt. of sample	76.4	100.0	
	Sulphur				
	Ash				
		NOT ROCK DUSTED.			
Calorific value determined	Calories				
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	
through 100 mesh	NO SIZE
through 200 mesh	

Area from which sample was taken (sq. ft.) ____

Date, April 3, 1940. (Signed) H. M. Cooper., *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ________ Lab. No. B-50823

Sample of Road dust (through 20-mesh screen). Can No. 168

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine Room 25 at 3 East 22 South

Method of sampling Standard Gross weight, lbs. ________ Net weight, gms. 148.9

Date of sampling 3/26/40 Date of Lab. sampling 4/1/40 Date of analysis ________

For B. of M. section Mine Accident Collector C.W.Owings

	Air-dry Loss .7	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.4	2.0		
	Volatile matter	33.0	32.8	33.5	41.3 (a)
	Fixed carbon	46.9	46.7	47.6	58.7
	Ash	18.7	18.5	18.9	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		83.6	36.0	
	Oxygen Through 20-Mesh		148.9	64.0	
	Sulphur Total wt. of sample		232.5	100.0	
	Ash				
Calorific value determined	Calories	Not rock dusted.			
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	59.9
through 100 mesh	37.1
through 200 mesh	23.5

Area from which sample was taken (sq. ft.) ________

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ______ Lab. No. B-50824

Sample of Rib & Roof dust (through 20-mesh screen). Can No. 189

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine L North face at room 4

Method of sampling Standard Gross weight, lbs. ______ Net weight, gms. 130.6

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis ______

For B. of M. section Mine Accident Collector C.W.Owings.

Air-dry Loss 1.0	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis				
Moisture	2.1	3.1		
Volatile matter	33.5	33.2	34.2	42.8 [a]
Fixed carbon	44.8	44.3	45.8	57.2
Ash	19.6	19.4	20.0	
	100.0	100.0	100.0	100.0
Ultimate Analysis				
Hydrogen				
Carbon		GRAMS	PERCENT	
Nitrogen: On 20-Mesh		79.5	37.8	
Oxygen: Through 20-Mesh		130.6	62.2	
Sulphur: Total wt.	of sample	210.1	100.0	
Ash				
Calorific value determined				
Calories	Not	rock dusted.		
British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	58.0
through 100 mesh	34.5
through 200 mesh	23.1
Area from which sample was taken (sq. ft.)	

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ______ Lab. No. B-50825

Sample of Road dust (through 20-mesh screen). Can No. 159

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine L North face, at room 4

Method of sampling Standard Gross weight, lbs. ______ Net weight, gms. 120.0

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis ______

For B. of M. section Mine Accident Collector C. W. Owings

	Air-dry Loss	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture		2.1		
	Volatile matter		31.4	32.1	42.4 (a)
	Fixed carbon		42.6	43.5	57.6
	Ash		23.9	24.4	
			100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		66.5	35.7	
	Oxygen Through 20-Mesh		120.0	64.3	
	Sulphur Total wt. of sample		186.5	100.0	
	Ash				
		Not rock dusted.			
Calorific value determined	Calories				
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	52.7
through 100 mesh	29.1
through 200 mesh	18.6

Area from which sample was taken (sq. ft.) ______

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

(a) This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ______ Lab. No. B-50826

Sample of Rib & Roof dust (through 20-mesh screen). Can No. 158

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine M North Face at room 2

Method of sampling Standard Gross weight, lbs. ______ Net weight, gms 93.5

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis ______

For B. of M. section Mine Accident Collector C. W. Owings

	Air-dry loss 3.6	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	2.4	5.9		
	Volatile matter	30.7	29.6	31.5	44.8 (a)
	Fixed carbon	37.9	36.5	38.8	55.2
	Ash	29.0	28.0	29.7	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		31.6	25.3	
	Oxygen Through 20-Mesh		93.5	74.7	
	Sulphur Total wt. of sample		125.1	100.0	
	Ash				
		Not rock dusted.			
Calorific value determined	Calories				
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	70.0
through 100 mesh	46.8
through 200 mesh	29.3
Area from which sample was taken (sq. ft.)	

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. ______ Lab. No. B-50827

Sample of Road dust (through 20-mesh screen). Can No. 164

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine M North face at room 2

Method of sampling Standard Gross weight, lbs. ______ Net weight, gms. 110.3

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis ______

For B. of M. section Mine Accident Collector C.W.Owings

Air-dry Loss .9	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis				
Moisture	1.2	2.1		
Volatile matter	23.8	23.6	24.1	43.0 (a)
Fixed carbon	31.5	31.1	31.8	57.0
Ash	43.5	43.2	44.1	
	100.0	100.0	100.0	100.0
Ultimate Analysis				
Hydrogen				
Carbon		GRAMS	PERCENT	
Nitrogen	On 20-Mesh	60.1	35.3	
Oxygen	Through 20-Mesh	110.3	64.7	
Sulphur	Total wt. of sample	170.4	100.0	
Ash				
Calorific value determined				
Calories		Not rock dusted.		
British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	51.9
through 100 mesh	30.2
through 200 mesh	19.4

Area from which sample was taken (sq. ft.) ______

Date, April 2, 1940 (Signed) H. M. Cooper, *Chemist.*

a This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Test No.

DUST-ANALYSIS REPORT

Sample of Road dust (through 20-mesh screen). Lab. No. B-50828

Operator Hanna Coal Company Can No. 178

State Ohio County Belmont Mine Willow Grove

Town Neffs Bed Pittsburgh

Location in mine Main West butts haulage at 26 N. face

Method of sampling Standard Gross weight, lbs. Net weight, gms. 412.0

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis

For B. of M. section Mine Accident Collector C. W. Owings

Air-dry Loss .8	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis				
Moisture	.7	1.5		
Volatile matter				(a)
~~Fixed carbon~~ XXXXXXXXX Comb.	1.1	1.0	1.1	
Ash	98.2	97.5	98.9	
	100.0	100.0	100.0	
Ultimate Analysis				
Hydrogen				
Carbon		GRAMS	PERCENT	
Nitrogen On 20-mesh		90.1	17.9	
Oxygen Through 20-mesh		412.0	82.1	
Sulphur Total wt. of sample		502.1	100.0	
Ash				
	Coked particles present:		Trace.	
Calorific value determined Calories	NOT ROCK DUSTED BUT MOSTLY ALL SAND GUNITED.			
British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	22.4
through 100 mesh	9.2
through 200 mesh	7.1
Area from which sample was taken (sq. ft.)	

Date, April 3, 1940. (Signed) H. M. Cooper., *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

6-261

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. A-Crossbar Lab. No. B-50829

Sample of Rib, Roof, dust (through 20-mesh screen). Can No. 187

Operator Hanna Coal Co. Mine Willow Grove

State Ohio County Belmont Bed Pittsburgh

Town Neffs

Location in mine No. 2 Main West at 26 N. Face.

Method of sampling Standard Gross weight, lbs. Net weight, gms. 79.0

Date of sampling 3/27/40 Date of Lab. sampling 4/1/40 Date of analysis

For B. of M. section Mine Accident Collector C. W. Owings.

	Air-dry Loss .5	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	3.1	3.6		
	Volatile matter	26.8	26.7	27.7	49.1 [a]
	Fixed carbon	27.9	27.7	28.7	50.9
	Ash	42.2	42.0	43.6	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen				
	Carbon		GRAMS	PERCENT	
	Nitrogen On 20-Mesh		32.3	29.0	
	Oxygen Through 20-Mesh		79.0	71.0	
	Sulphur Total wt. of sample		111.3	100.0	
	Ash				
		Not rock dusted.			
Calorific value determined	Calories	Coked Particles Present NONE			
	British thermal units				

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	69.4
through 100 mesh	48.9
through 200 mesh	34.2

Area from which sample was taken (sq. ft.)

Date, April 2, 1940 (Signed) E. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.