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TUESDAY AFTERNOON SESSION

October 3, 1944

Presiding: General Chairman, JOHN TREWEEK, Safety Eng., Homestake Mining Co., Lead, S. D.

Some Sources of Error in Dust Sampling

By A. S. RICHARDSON, J. W. WARREN and W. C. WILLIAMSON
Anaconda Copper Mining Co., Butte, Mont.

In the measurement of the concentrations of dust that are present in air used for the ventilation of mines, or other working places, it is recognized that the dust is not uniformly dispersed in the air. Also that under the same atmospheric conditions widely different results may be obtained by the use of different dust sampling instruments, and by different methods of quantitation. In dust sampling work done by the writers with impingers a number of sources of error have been found to exist, and these are here described for the benefits of others engaged in similar work.

Impinger Sampling in a Flow of Air

In the collection of any volume of air for dust sampling purposes, it is essential that the number of dust particles in the sample volume be the same before and after collection. When the air is not in motion it may perhaps be assumed that this condition exists for sampling with impingers. However, dust sampling in mines is often done in flows of air moving at fairly high velocity, and similar conditions exist in ducts carrying flows of air from dust collection hoods. Although nothing like exact measurement of dust conditions as yet seems possible, it is desirable that the methods of sampling streams of air in motion should be comparable to those taken in still air. Since dust particles carried in a moving current of air possess some definite directional momentum, it is indicated that for uniformity of dust content, the sample volume should be drawn from the air stream without change in the velocity and direction of flow.

In impinger sampling work the flask must necessarily be held in a vertical position and with the tube vertical. This means that air drawn from a horizontally moving air stream must be deflected at right angles to its original direction of flow to enter the tube opening. The momentum of the dust particles would then tend to continue them in motion past the tube opening, and thus reduce the dust content of the sample volume.

To develop the effect of these conditions upon dust sampling results, some tests were made by taking dust samples from air moving horizontally at different velocities simultaneously with two impingers, one having the ordinary vertical tube opening at right angles to the direction of flow, and the other being equipped with an elbow extension to bring the tube in line with the direction of flow. Two samples were also taken with restricted orifices placed at the elbow openings so as to make the velocity of air passing through the orifice the same as that of the main air stream.

Dusty air for this purpose was obtained by allowing a flow of dust, collected at a bag type dust arrester, to fall at a short horizontal distance away from the inlet of a blower. The induced flow of dusty air was then forced through a galvanized iron duct to the sampling position. Compensation for variations in dust collection efficiency of the two impinger instruments used in the test was made by alternating use of the instruments in the two sampling positions.

Geometric mean diameter of the dust particles was 0.65 microns with standard geometric deviation 2.09, as determined by samples taken with an Owens Jet sampler with microscopic work done by micro-projector at a magnification of 10,000 diameters.

Tabulation No. 1

Dust Counts with Impingers Alternated in Two Sampling Positions

Air Velocity Ft. Per Min.	High Concentrations Impinger No. 3 Pos. A	High Concentrations Impinger No. 3 Pos. B	High Concentrations Impinger No. 5 Pos. A	High Concentrations Impinger No. 5 Pos. B	Low Concentrations Impinger No. 3 Pos. A	Low Concentrations Impinger No. 3 Pos. B	Low Concentrations Impinger No. 5 Pos. A	Low Concentrations Impinger No. 5 Pos. B
250	80.2			81.9	29.9			35.2
250		108.0	112.3			27.9	30.3	
250	69.2			80.2	32.0			30.0
250		61.6	68.8			19.3	25.0	
Average	79.8		85.8		27.3		30.1	
Per Cent Variation in Instrument Collection		7.0					9.35	

Tabulation No. 2

Dust counts for Vertical and Parallel Impinger Tube Intakes

Air Velocity Ft. Per Min.	Sample Drawn at Right Angles to Flow Imp. No. 3	Sample Drawn at Right Angles to Flow Imp. No. 5	Samples Drawn Parallel to Flow Imp. No. 3	Samples Drawn Parallel to Flow Imp. No. 5	Per Cent Right Angles to Flow Parallel to Flow
250		64.3	65.4		98.9
500	88.2			92.0	96.0
500		83.6	90.3		92.5
750		37.8	41.3		91.6
750		21.8	22.8		95.6
1000		28.4	46.6		61.0
1000		17.2	27.6		62.2
1000	43.6			56.8	76.8
1250		15.8	22.3		70.9
1250	36.7			51.1	72.0
1500	9.96			33.3	29.9
1500	17.1			74.8	22.9
1500		34.4	74.0		46.4
1500*	51.6			110.8	46.5
1500*		48.3	98.3		49.2

*8.5 mm circular orifices on impinger sampling tubes.

Calibration of Impinger Tubes

In the taking of a number of dust samples at one time with one instrument, it is necessary that a number of impinger tubes be used, and variations in the volumes of air sampled by different tubes under such otherwise identical conditions is a matter of some importance. Variations in sample volume may occur because of differences in size and shape of the tube, particularly the size of the orifice from which the air stream is impinged against the bottom of the flask.

For calibration of the tubes it is, however, necessary to take into account the suction pressure, or vacuum, induced by the pump since in the case of compressed air operated ejectors, it seems impossible to obtain exact uniformity in the size of the ejector orifice and this will cause some variations in the induced vacuum.

In the case of the standard tubes not much variation is shown but in the case of midget impinger tubes, there are appreciable differences. A maximum variation of 23 per cent in the volume of air sampled may be noticed for tubes used in two different midget impingers and this is known to be mainly due to variations in the size of the orifice in the tubes supplied by the manufacturer. Midget impinger number one is equipped with a hand-operated, constant pressure pump and Midget impinger number two is equipped with a hand-operated pump delivering constant volume at constant speed.

Tabulation No. 3

Calibration Comparisons of Midget Impinger Tubes

No. 1 Midget Impinger

Tube No.	Volume Thru Gas Meter Cu. Ft.	Manometer Reading	Vacuum Gauge H_2O	Time Minutes	Volume of Liquid CC	Flow thru Tube C.F.M.
1	1.0	12.1	12.5	9.48	10	0.1058
2	1.0	11.75	12.5	8.40	10	0.1191
3	1.0	11.75	12.5	8.44	10	0.1186
4	1.0	11.80	12.5	7.28	10	0.1374

No. 2 Midget Impinger

Tube No.	Volume Thru Gas Meter Cu. Ft.	Manometer Reading H_2O	Time Minutes	Volume of Liquid CC	Flow thru Tube C.F.M.
5	1.0	10.7	6.36	15	0.1573
6	1.0	13.6	7.50	15	0.1344
7	1.0	13.0	7.68	15	0.1300
8	1.0	10.3	6.70	15	0.1492

Tabulation No. 4

Calibration Comparisons of Standard Impinger Tubes

Tube No.	Volume Thru Gas Meter Cu. Ft.	Manometer H_2O	Time Minutes	Volume Collecting Medium C.C.	Flow thru Tube C.F.M.
		No. 3 Standard Impinger			
1	5.0	37.2	4.74	75	1.055
2	5.0	45.5	4.74	75	1.055
3	5.0	32.5	4.75	75	1.053
4	5.0	38.4	4.745	75	1.054
5	5.0	35.1	4.77	75	1.048
6	5.0	32.6	4.775	75	1.047
7	5.0	38.4	4.74	75	1.055
8	5.0	36.1	4.76	75	1.050
9	5.0	36.0	4.765	75	1.049
10	5.0	39.6	4.72	75	1.058
D	5.0	42.3	4.75	75	1.053
		No. 5 Standard Impinger			
1	5.0	32.2	5.165	75	0.967
2	5.0	40.3	5.15	75	0.971
3	5.0	28.2	5.16	75	0.969
4	5.0	33.0	5.18	75	0.965
5	5.0	30.8	5.145	75	0.972
6	5.0	29.1	5.125	75	0.975
7	5.0	32.9	5.17	75	0.966
8	5.0	31.3	5.17	75	0.966
9	5.0	31.7	5.145	75	0.972
10	5.0	34.5	5.125	75	0.975
D	5.0	36.5	5.19	75	0.963

Effect of Dirty Glassware

While the effect of the presence of dirt on glassware used in dust determination work is so obvious that in most cases no illustration of its importance is needed, it is believed, that there are some fairly common practices in which lack of adequate cleanliness has an appreciable effect upon the results obtained. These are related mainly to the cleaning of the impinger tubes and counting cells.

In the flow of dusty air through an impinger tube, the increased velocity of air motion at the approach to the orifice causes a reduction of pressure which, with the accompanying cooling effect caused by evaporation of the collecting fluid in the flask, causes a lowering in the temperature of the air stream and a consequent deposition of dust on the inside of the tube. Being difficult of access, this inside tube surface is often given only insufficient cleaning as by hand with the use of a pipe cleaner or tapered brush.

The following tabulation shows, for four different samples, the effect upon dust counts of placing a poorly cleaned impinger tube in a flask with the usual quantity of collecting fluid and then briefly shaking the flask by hand.

A method of cleaning the tubes, both standard and midget that has given satisfactory results includes a replaceable fibre brush held in a metal shaft that is rotated by the motor of an electric erasing machine, having a friction grip.

Tabulation No. 5

Data Dirty Impinger Tubes

Description	Midget No. A		Midget No. B		Standard No. A		Standard No. B	
Dust count in 5 Fields before insertion of Impinger tube or Control Count	2	2	2	2	2	2	2	2
Dust count in 5 Fields after insertion of Impinger tube and shaking	38	95	32	56	30	112	38	122
Net increase in Count in 5 Fields	36	93	30	54	28	110	36	120

Depth of Counting Cells and Effect of Settling Time

At the present time a wide variety of cells of different design are used to contain the portion of sample collected for counting. A common defect in the Sedgewick-Rafter type is failure to closely seal the corners of vertical containing strips or walls, with the result that leakage or the evaporation of alcohol causes the formation of air bubbles that interfere with counting. Corners of the cell are also difficult to clean. These defects are well recognized but it is perhaps not so well recognized that appreciable variations in the depth of cells also occur. In the case of 11 cells received from a supply house the variation in depth, as determined by microscope and micrometer was from 0.945 m.m. to 1.195 m.m.

A cell that has been found to give good results is made with the use of a brass ring placed, without any cement, upon a base of non-corrosive glass and covered wtih a coverslip 1 m.m. thick. The brass ring is 38 m.m. outside diameter, 29 m.m. inside diameter and is machined to exactly 1 m.m. in thickness. The glass base is 75 m.m. long, 38 m.m. wide and 3 m.m. thick. The coverslip is 38 m.m. square and 1 m.m. thick. Since all component parts are separated for washing and cleaning, there are no surfaces that are not easily cleaned. An essential piece of equipment for brushing cell surfaces free of air-borne dust before filling with sample fluid is a good camel's hair brush.

An illustration of the effect upon dust counts of variations in the depth of cells is shown in Tabulation number five, which shows the counts obtained from two different portions of the same samples when counted in two different cells. Cell number five had an average depth of 0.87 m.m. and Cell number six had an average depth of 1.13 m.m.

Tabulation No. 6
Variable Cell Depth

Cell No. 5..........0.0344" = 0.87 m.m. Ratio No. 5 to No. 6 = 1 to 1.3
Cell No. 6..........0.0445" = 1.13 m.m. Cell No. 6 = 30% deeper than Cell No. 5

Sample Number	1		2		3		4		Total 1-4	
Cell Number	5	6	5	6	5	6	5	6	5	6
Field Concentration	354	472	308	366	352	401	262	360	1276	1599
Calculated Concentration at 1 m.m. depth	407	417	354	324	404	355	301	318	1467	1415
Ratio Concentration in Cell	1.0	1.33	1.0	1.19	1.0	1.14	1.0	1.37	1.0	1.26
Increase Cell No. 6 over Cell No. 5 in percentage	33		19		14		37		26	

Tabulation number seven, below, shows the counts obtained from different portions of the same sample when counted in five different circular cells of the type previously described.

Tabulation No. 7

Cell No.	1	2	3	4	5	Avg.
Count	376	405	370	386	390	385

When, as is required for accurate results, two counting cells are filled from each sample flask, it is necessary that an interval of time be allowed to elapse between the filling of the first and second cell so that the settling time before the start of the count be the same for both cells. In general, it is well recognized that increased settling time causes a larger count but it may not be so well understood how much the results are affected by this influence.

Tabulation number eight shows the effect upon dust count of allowing the settling time to increase from 25 to 35 minutes.

Tabulation No. 8

Effect of Increasing Settling Time from 25 minutes to 35 minutes

Count at 25 min. Settling	Count at 35 min. Settling	Increase in 10 min.	Increase in 5 min.	% increase in 5 min. from 25 min. settling
14	15	1	.5	3.6
18	23	5	2.5	13.9
33	42	9	4.5	13.6
38	48	10	5.0	13.1
43	52	9	4.5	10.5
54	71	17	8.5	15.8
55	62	7	3.5	6.4
61	75	14	7.0	11.5

Control of Electrical Hazards in Open Pit Mining

By P. L. HENDRICKS
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Electricity, as a source of power and control, was introduced in the open pits approximately twenty-five years ago. A large part of the eighty to ninety million tons of ore now going to our great steel plants each year, has been produced or transported by electric power.

Safety has always been considered of major importance in the mining industry on the Mesaba Range, and has rated an AAA priority in electrical installations. Many important developments for electrical safety, such as "ground-fault protection," "shielded-type shovel cables," and "individual shovel switch-houses," have been among the fruits of the search for safety.

There are certain very definite and positive laws that govern the behavior of electricity. So long as these laws are not violated, electricity in itself, will be more law-abiding than are many human beings.

In electrical installations we are often caught between the economic and physical limitations of low voltage power on one side, handicapped by heavy currents and large conductors, and the hazards of high voltage power on the other, with increased insulation stresses and danger of shock. We have been faced with the necessity of selecting between methods or equipments not of our own choosing, but established by local situations or limitations.

Relatively large quantities of power must be transmitted over sizable distances, both vertical and horizontal. Most of the electrical equipment is portable, and is frequently shifted from one location to another, by reason of ore grading, stripping operations, etc. The increasing depth and reduced area of the pits aggravate congestions and transmission problems, and introduce new problems of pit drainage. Most of the equipment is subjected to hard usage and adverse weather, with seasonal temperature variations up to 140 degrees. Operating labor, especially during the past few years, is often unskilled and careless with equipment.

Iron ore and surface material are loaded out principally by power shovels which, except for the smaller sizes, are electrically operated. The material is usually transported in standard gauge ore and dump cars, or in heavy duty trucks. Railway haulage is powered by steam, electric or diesel-electric locomotives. Heavy duty trucks are propelled by gasoline, diesel, or butane engines. Churn drills are common for blast hole and exploration drilling, and pumps, scraper hoists, tractors, etc., are among the equipment in regular use. On the surface there are an increasingly large number of crushing, washing, jigging, or other ore beneficiation plants, all electrically operated.

Safety Problem

The foremost safety problem concerns the transmission of power to electric shovels. The capacity of the load and the distances involved require voltages relatively high by safety standards, 2,300 or 4,000 volts, depending on local conditions. Because shovels are portable, travel over large working areas on iron ore that is a poor conductor of electricity, and operate on voltages hazardous to life, the importance of adequate grounding of the shovel frames against electric shock cannot be over-emphasized.

There are three principal ways by which a person may receive an electric shock:

(1) Contact with two or more wires of conductors of different voltage or potential.

(2) Contact between a "live" wire and the earth.

(3) Contact between an object charged by accidental contact with a "live" wire, and the earth.

The third condition is responsible for a large percentage of the cases of electric shock. Few persons will knowingly take hold of a wire or electrical conductor unless they have reasonable assurance that it is disconnected from the power. But the frames of equipment are assumed to be insulated from the electrical circuits and safe to touch, and there is no safe, simple method of anticipating "charged" apparatus. Although a flow of slightly more than

1/1000 of one ampere of alternating current through the body produces a perceptible shock, and the quantity of current used by a 10 watt lamp bulb would very likely prove fatal, fortunately the human body is a poor conductor of electricity and offers a high resistance to a passage of current.

Among the human characteristics inherent in electricity is its preference for the paths of least resistance, or short-cuts. This characteristic is the basis for the most important detail of any electrical installation, namely "Grounding." A bypass or short-circuit is maintained between equipment frames and the earth. Any leakage current from defective insulation will take the easier path and follow the ground wire, and the voltage on the frame will be kept within safe limits.

Desirable Factor

Another desirable characteristic of electricity causes electric circuits to interrupt themselves on overloads, short-circuits, or other abnormal conditions. We have utilized this to disconnect instantly any apparatus that develops an insulation breakdown to the earth. If one unit of equipment is to be protected, or if selective tripping is not desired and the entire pit load can be interrupted, the "potential balance" method is satisfactory and lowest in cost. This method consists of a suitable combination of apparatus that acts as a sort of electrical scales, and will be affected by unbalanced neutral voltages created by accidental grounds, and trip out the main oil circuit breaker.

In the larger pits, with several units of equipment in service, it is often desirable that ground-fault tripouts be limited to the defective unit only. Selective tripping not only limits the interruption to the defective unit but greatly simplifies the job of locating and removing the cause of the trouble. Selective ground-fault tripping requires a grounded neutral circuit, and a current-limiting resistor or impedance in the neutral return wire at the source.

The flow of fault current back through the neutral return wire from the point of insulation breakdown, will be limited to from 25 to 65 amperes, depending on the type of equipment. The voltage drop in the return wire with such low current values will not set up any dangerous differences in voltage between equipment frames and the earth, even for the split-second necessary for the circuit breakers to open. The pit neutral wire should not be interconnected with the main substation ground connection, to avoid the possibility of surges from high-voltage insulator flashovers or lightning arrester discharges getting into the neutral wire and backing up to equipment frames. Ground rod resistances are high in iron ore, and the general practice has been to establish the main low resistance earth connection on the surface, and supplement it by a number of ground rod installations distributed along the neutral wire of the power lines. Individual switch-houses are required for each unit of equipment to be protected, installed at the point of attaching the power cable to the power line. The switch-house protecting the defective unit of equipment will trip out instantly by the ground-fault relay, actuated either by unbalance in phase currents due to the fault, or by fault current coming in over the neutral ground conductor from the location of the insulation failure.

One or the other of these types of ground-fault protection is in service in practically every electrified open pit on the Mesaba range, and I do not know of an instance of even slight shock from equipment so protected.

With the selective-tripping type of ground-fault protection the ground or neutral wire becomes a definitive part of the electrical circuit, and a vital link in the protective device. Periodic tests of ground-fault protective installations should be carried out regularly and the results recorded. Such tests are usually done by grounding one or more conductors at a point beyond each switch-house. The individual switch-houses are backed up by a main ground-fault trip located at the sub-station. The ground-fault relay here is given a short time lag to allow the individual switch-houses to clear first. Its purpose is to back up any of the switch-houses if they should fail, and also to protect the power lines, etc., against grounds.

Outlines Switch-Houses

The switch-houses are constructed in several different styles. An oil circuit breaker of ample rupturing capacity is ordinarily included, arranged to open instantly on short circuits and ground-faults, with a time-relay on overloads. Gang-operated disconnect switches simplify the job of cutting off the power for cable changes, repairs, etc. Suitable terminal connections are provided to facilitate the attachment of the incoming and outgoing power cables. Metering installations are also included wherever power consumption records are desired. All of the apparatus is assembled in small, rugged, portable, weatherproof steel enclosures, with dead-front construction. Access to the high-voltage compartment is limited to the electricians. In the pits using railroad haulage the switch-houses are equipped with lifting bails and handled by the locomotive crane. The switch-houses in pits with truck haul are mounted on suitable skids, and moved by tractors or trucks. They are located as near as possible to the point where the shovel cables attach to the power lines.

Equally important to electrical safety is the type of portable high-voltage power cables, used to transmit power in the working areas. The type generally used is the rubber-jacketed, shielded, shovel cable, with one or more internal supplementary ground conductors. Considering the conductor sizes and the operating voltages, these cables are comparatively small, light, flexible, and easy to move about.

Shielded type power cables have decided safety advantages, especially where ground-fault protection is included. The grounded sheath or tube enclosing each individual high-voltage conductor precludes the possibility of current leakage from the conductor to the outside surface of the cable, through cuts or bruises in the insulation. Also, because of the ground sheaths separating the individual conductors from each other, grounds must occur before short-circuits, in instances of cuts or crushing injuries, and the power will be cut off by the ground-fault protection without the flash and burning of heavy power arcs. For the 440 volt power distribution to drills, small pumps, etc., a similar type of cable is commonly used, except that the shielding or ground sheath is omitted. The ground wires in all portable power cables to equipment, regardless of operating voltage, connect to the neutral wire of the distribution system, so that a full metallic ground circuit will be maintained to all equipment.

Proper maintenance of portable high-voltage power cables is important for safety as well as for economic reasons. Normal functioning of the ground-fault protection is contingent upon a continuous, low resistance, ground conductor throughout the length of the cable. *A broken or disconnected ground wire in a cable means that the equipment behind the break is more hazardous than if ground-fault protection were not installed.* Incipient damage to conductor insulation within the cable should be located and repaired before developing into a complete breakdown. Whenever any one conductor of the distribution system is grounded, the insulation on the remaining two conductors throughout the system is subjected to voltage stresses approximately 175% of normal. As a result, if either of these conductors has weakened insulation, just able to hold the normal "neutral voltage" stress the increased electrical pressure or voltage may break down the defective insulation, and a phase to phase short circuit will develop. The ground wire between the location of the two faults will become a part of the short-circuit, and the excessive flow of fault current may build up a dangerous difference in voltage across that section momentarily, until the circuit breaker opens. Periodic high-potential tests of cable conductor insulation are advisable to blow out the weak spots before they fail in service. Cuts and bruises in the outer jackets should be vulcanized as quickly as possible. Otherwise ground water may get inside of the jacket and set up corrosion in the strands of the ground sheath, and penetrate into damaged conductor insulation. Great skill and care are necessary in making cable repairs to preserve the original conductivity and strength of all conductors, and the insulation and watertight qualities of the rubber. Ground wire conductivity and resistance measurements, and high potential tests on conductor insulation are advisable after repairs.

Services Hard

Service conditions for portable power cables are unavoidably severe, but full co-operation from all of the pit operating departments can spare the cables from much unnecessary abuse. Care must be exercised in mines using railroad haulage to protect the cable in crossings under tracks against material falling from the cars, derailments, and hot coals and ashes dropped from passing locomotives. In mines with truck haul the cable crossings over truck roads are usually made by the use of portable cable supports that suspend the cables at a safe height over the roads. Here the service is particularly severe because of the hazard of trucks driving over the cables, or passing under cable crossings with their dump bodies elevated.

Electric power ordinarily is transmitted from the substation to the pit boundaries by overhead power lines, using three power wires and one neutral wire of equal size, mounted on wooden poles. The pit organization should be instructed on the hazards of overhead lines, since guessing the clearance to a "live" wire is as deceptive as guessing the clearance to a buzz-saw, and certainly more serious to the person guessing wrong. Adequate short-circuit protection is important, as well as ground-fault protection, and pole-top sectionalizing switches allow disconnecting branches or sections of the line for additions or repairs. Very few if any of the mines do any "hot-line" work, because of its extreme hazard, and because our men are not specialists in such work.

Another new hazard has been introduced by the rapid increase in the number and size of the ore-treating plants. Automatic control is essential to provide the necessary interlocking between successive units, and the control stations for stopping and starting are usually grouped at central locations. Suitable warning signals for starting are an important safeguard, with provision for return call from the remote point if feasible. Emergency stop stations should be located at strategic points, and arranged so that they can be locked out. Various methods are provided in the control to allow a machine to be locked out of service, such as locking-type pushbutton stations, disconnect switches, etc. Multiple locking by the different individuals or departments working on a given machine is advisable, to be sure that all persons are in the clear before the machine can be restarted. The problem of padlocks may be met to some extent by providing a suitable number of locks and individual keys at each control station. The person placing the lock removes its key and carries it with him. 100% compliance with this lockout rule would have prevented a number of accidents and near accidents.

Records of more than 25 years of experience with electrified open pit operation on the Mesaba Range have convinced us that the subject of electrical safety is not the private property of the mine electrician, but affects to a greater or lesser extent every employee on the job. The electrician is usually trained and more familiar with the proper precautions and procedures. During the past 25 years there have been 10 fatalities from electrical causes in the open pit mines of the Mesaba Range, and a production of approximately one billion long tons of iron ore, plus an equivalent amount of waste material.

The average number of electrical accidents has not been increasing, although the use of electrical power has increased by many hundred per cent. Electrical fatalities represent only a little over 3% of the total from all sources. Achievement of our improved safety record is the summation of the complete cooperation that exists between the electrical departments of the different mining companies, the all-out assistance of the electrical manufacturers, and the liberal financial backing of management, in all matters pertaining to electrical safety.

Hazards Anticipated

The electrical departments endeavor to anticipate possible electrical hazards, and incorporate every reasonable precaution for electrical safety. Every person working where there are any possible electrical hazards should make it his own business to be properly advised about special dangers, and what to do, and what not to do, if any emergency arises. The same is true regarding compliance with rules and regulations, such as locking out controls, use of warning signals, operating equipment without authorization, etc.

No matter how carefully the engineering department may plan the electrical installation, or how sturdy or dependable the apparatus may be built, the continued safe and satisfactory operation is the responsibility of the men who install and maintain the equipment in the mine. I believe many mine electricians fail to realize their opportunities, afforded by the rapid change and expansion. We now have electronic and other modern apparatus in service, the operation of which necessitates some rather involved theoretical knowledge. Many of our men would like to learn more about these new tools, but find it difficult to sweat out the information by themselves. Perhaps our educational facilities could be made available to more men within industry, to help them grow up with their work.

Summarizing, landmarks along the road towards electrical safety were as follows:

1. Introduction of rubber covered, shielded type cables for high voltage power distribution.
2. Development of the individual switch-house, with provisions for automatic fault protection, and switching apparatus.
3. Introduction of "ground-fault protection" to reduce the hazards of accidental grounds and to automatically cut off the defective circuits.
4. Promoting electrical safety in general, by spreading information pertaining to its proper use.

THURSDAY AFTERNOON SESSION

October 5, 1944

Presiding: JOHN TREWEEK, Safety Eng., Homestake Mining Co., Lead, S. D.

Discussion

CHAIRMAN TREWEEK: Before we proceed with the regular program, Mr. Forbes of the National Safety Council will answer questions or hear grievances or anything that you want to put before him.

MR. FORBES: In my brief talk yesterday I suggested, I believe, that the Mining Section should appoint a committee, and I mean a representative group of various types of mines and mining districts to line up a list of titles for industrial data sheets, from two to four pages; those cover specific subjects, and I would like to have just as many phases of mine safety covered as is possible. As I said yesterday, that information must come from men actively engaged in the industry, or from the United States Bureau of Mines, which is the same, as far as I'm concerned.

At the present time the Council has little information on mine safety problems. Mining changes rapidly and methods and conditions vary vastly in the different districts and different types of mines. It's a difficult job to put out information to satisfy the entire mining industry, but if the Council is to be of service to the industry, we must do the best we can to cope with the conditions. It means that perhaps a great many more data sheets will have to be published than may be necessary for some of the other sections in the Council, but I sincerely believe that we should make every effort to cover just as many phases of mine safety as possible.

I'd like to have a committee to prepare the titles for subjects they want covered, and then sincerely try to get men in the industry to prepare the information. As I told you, that information is not just published when it's sent in here; it's gone over and then it is mailed out to many people and committees, to pass on it and criticize and offer suggestions, and it takes a little time to get those things out.

MEMBER: You have a list of about 50 suggested data sheets that we have already presented. What we would like is some information on how to prepare the data sheet.

MEMBER: Isn't it your thought that there should be a source? An operator, for instance, may be doing some new work and he'd like to put in some ladderways that would conform to the best practices. All right; he writes to the National Safety Council and they send him their standard practices on ladderways. That information has to come from the group of men who have been putting in what they consider safe ladderways for a good many years.

MR. FORBES: Exactly.

MEMBER: And if somebody else wants some information, possibly on raising methods or something like that, if he wanted to know the accepted safe practice so he can conform to those general practices, he writes to the mining section or to the clearing house of the Council and it can send to those people accepted information on their particular mine safety problems.

MR. FORBES: That's just exactly what I have in mind. After all, the National Safety Council is only a clearing house for that information. The information must be furnished to the Council.

MEMBER: Mr. Chairman. I have an altogether different idea about this subject. I don't believe we need any of these standards. I believe that there's been enough stuff published in the proceedings of the various mining sections and the Bureau of Mines so that anybody who wants to find out anything about anything that they want to do can find it there. Mining changes every six months or something like that and I think if you had a good library staff and a fellow wrote in you could say "We will give him a big bibliography where he can go and get the stuff"; that suits me all right.

MEMBER: As I understood this, the request has been made and we agreed to comply with it, but because of lack of time we couldn't get into the thing; my thought on it at that time was that what Mr. Forbes wanted was the different ways and means and methods that the different men are employing from time to time in doing certain jobs. Now, when we write a paper we may at that time have a particular method that we are following, whereas within two or three months or even weeks we've done something that's radically different and better than what was written up. I think Mr. Forbes wants to get that type of information together so that it can be passed out to the other members and if they want to use it, all well and good; if they don't, that's all right, too, but there it is. They'll have access to the experience and the practices of their fellow members in the mining industry. Isn't that it, Mr. Forbes?

MR. FORBES: Yes.

MEMBER: The way I look at these safe practice pamphlets they should be something authoritative, isn't that right?

MR. FORBES: Correct.

MEMBER: In other words, it's not just one company's operations; it's in general. I'm going to tell you of an experience we had. We adopted a code of safe practices for handling explosives about a year ago, and we charged some of the safety inspectors with the obligation of putting that thing across, and I believe that it's made their work a lot easier and I think we made more progress in standardizing our explosive practices in the period that set of safe practices has been in effect than we did in any ten years before. I would like to hear the opinion of the fellows using the directives, but it gives us something to fall back on. It's in black and white, and when we say a thing has to be done a certain way all we have to do is say "It's in the code and you fellows know that and you should be doing it this way."

MR. FORBES: If the mining industry is to make satisfactory progress in safety they've certainly got to disseminate information covering every phase of mining safety. That's essential.

THE CHAIRMAN: I believe we're going to be here all afternoon if we don't finish this subject soon. I'm glad to see some of it threshed out.

MR. DAN HARRINGTON: Not that I want to stick my chin out, but I think it can be clarified a little and I think Mr. Forbes has something which may be of use to you people and to the National Safety Council and to all of us. I think that there are two or three things that are involved in this. The data sheets are only one portion. I think that in addition to that there were good points brought out in the discussion by two or three different people. They touched on the fringes of it, at least. If there is some good practice—Anderson spoke about a code of safety in connection with blasting—it doesn't matter whether it's in connection with explosives or setting of timber or taking down a loose roof, no matter what it may be, if there is something that is extremely good that comes out, why don't you people who know about it, who are doing it, who realize that it is official write a short paper and send it in to the National Safety Council and ask them to publish it in the National Safety News. I don't know whether it can be done, but if it can be done it should be done. The papers needn't be very long—maybe a thousand words or thereabouts, and that's not much of a job for anybody to write who knows anything at all about writing. If you people would do that you would be performing a service to yourselves and to the industry as well and I don't believe that involves any codes or anything which is likely to get into legal procedures. It's just merely a matter of getting information from one person to another.

I think that's one thing that all of you can do. We can do it. I think that maybe we in the Bureau of Mines have been a little bit remiss on that; in fact I know we have. We very frequently get papers from some of our men that are hard to handle with the stereotyped procedure we have of issuing them; but we should send them in to the National Safety News and we will. I've laid down a little bit on the job on this thing.

Now about these data sheets. I used to help write them up for the National Safety Council about fifteen or twenty years ago—more than fifteen years, anyway, and my recollection is that they were merely in the form of hints as to what to do, on three-by-five sheets or something like that. You have eight, nine or ten hints of what to do in connection with the preparation of, say, a primer, on the handling of the drilling of a hole or handling of a wet stopper or of a dry drill, which I hope are not in existence now, and a lot of things of that kind. Those things don't necessarily have legal connotations. They can be framed in such a manner as to be strictly suggestions or strictly informative, and it seems to me that that sort of thing can be done, but I don't quite see where the industry can do it. I think that's really a job for the National Safety Council to do. Maybe the thing to do would be for you people to give them suggestions as to what you think about making up a primer. Where? Should it be made on the surface or underground, close to the place it's to be used? Those are matters of controversy. Many times there are good practices and poor practices and the practice which is good in one place may not necessarily be good in another place. We are confronted with that all the time in the Bureau, but I do think there are things of that kind which could be done. Certainly you fellows who know about some good safety procedures, some good safety device, owe it to the industry, owe it to your friends, to write it up, get it out, show the other fellow what you are doing and show him what you think he can do to his advantage.

MEMBER: If I can have just one more word—?

CHAIRMAN TREWEEK: We'll give you one more minute.

MEMBER: All right. I want to tell you men that I consider accident prevention as a profession, just as highly skilled, though perhaps not as highly paid, as the medical profession or the legal profession; but I want to say this: If we straitjacket ourselves with these safe-practice pamphlets and all of that stuff that keeps us down the line we're going to be in a bad way. What's good for Ole and his crowd isn't going to be good for somebody else, and I'm afraid of that if you get too much of that stuff.

MR. FORBES: It was never my intention at any time to set up a standard code for the mining industry. I think I have made it clear that conditions are so diversified that it's quite impossible. But certain essential information pertaining to safe practices in different lines and types of work can be published without harnessing the industry or harming it in any way. It should be most helpful to it. My sincere desire, while I'm with the Council, is to serve the mining industry. I plead with you for your cooperation, for your assistance and for all the information you can give, so that we can disseminate that information and make it helpful from one district to another. As a matter of fact, I would like to see a very active mining section set up in each district, such as the Lake Superior, which is my idea of an ideal mining section. If we had those in each state, I sincerely believe that the safety record of the mining industry would be very, very much improved. Let's see if we can't do that. I have been out in several districts and talked about the necessity for such organizations, and some are under consideration at this time. I think we should have a great many more mining sections similar to the Lake Superior mining section.

Electric Blasting Underground in Metal Mines

LAMAR WEAVER

Superintendent of Mines, Tennessee Copper Company, Ducktown, Tennessee

The mines of the Tennessee Copper Company are in the southeast corner of Polk County, Tennessee. The ore is heavy sulphide consisting principally of chalcopyrite, pyrite, sphalerite and pyrrhotite often containing 95% combined sulphides of iron, copper and zinc. The ore is a good electrical conductor, so much so that only a small percentage of the Direct Current return follows the established bonded rail return path.

Storage of Detonators

The surface detonator magazine is a two room brick building, concrete floor and foundation with 12" brick walls, wood ceiling and corrugated iron roof painted with aluminum paint. One room is for storage of detonators and the other a preparation room where portable boxes are filled for movement to the underground supply magazines and the returned unused detonators are taken from boxes returned from the mines, inspected and hung up for drying.

The storage room carries a maximum of 250,000 electric exploders and is 6 feet wide by 26 feet long.

The preparation room is 14 feet by 20 feet with 12" brick partion wall between rooms. Each have a regulation door to an outside platform of truck height above driveway.

Transportation of Detonators

The detonators are hauled underground once each week.

Light wood boxes are provided for transportation of detonators and two or more are required for each level depending upon the amount needed for a week's requirement. The detonators left in the boxes are brought to the surface magazine where they are sorted, put in special bins to dry and then reissued after a week or more of such treatment.

The carrying box is of convenient size, 21 inches wide by 24 inches high by 11 inches deep with sections for all of the delays used. Detonators are stored in the underground magazine for issue to the miners by a licensed powder-man, who keeps same locked when not in use. On levels using large quantities of detonators they are transported and stored in the original 500 detonator case.

The underground detonator magazine is preferably near the dynamite magazine for convenience of the user and the powder-man.

Detonators are issued to the miners in small wood carrying boxes of a size to carry one 50 detonator box or the equivalent loose. The box has a top and a carrying handle.

Detonators are issued to loading men or trammers (who do block hole blasting throughout the shift) for storage near working place but the stope and development drillers are required to wait until they have drilled out for the day and they know exactly the number of detonators and quantity of dynamite needed. In all cases the unused explosives must be checked back in to the magazine tender at the end of the shift, except dynamite sold to contractors in case lots. Their unused dynamite is stored in a standard wood magazine which must be kept locked.

Blasting Precautions

Grizzly blasting and a small amount of other drilled hole blasting such as a missed hole is done any time during the working shift. However the shots are not heavily charged and are usually few in number as determined by mine Supt., mine Foremen and the State Mine Inspector. (In accordance with the Tenn. law.) The magazine tender is licensed and given authority to see that the explosive act is complied with. A water spray is directed toward all blasts fired during the shift. The sprays are turned on after the shot or shots is connected and is left on until the shot-firer returns after the blast. This spraying minimizes the amount of dust and smoke produced at its source.

Blasting current is obtained from the following sources: 220 volt alternating current, 250 volt direct current trolley wire, and electric blasting machines ranging from 50 shot down to the 10 cap hand twisting machine.

Blasting machines are preferred for development work due to the progressive nature of the work and the 220 volt A.C. power circuit is preferred for more permanent stations such as loading places under stopes and for stope blasting by the drillers.

Where power circuits are used we have found it advisable to have an unusually well protected switch with an air gap of 18" or more not offered in the standard switch. This is due to the moisture and conductivity of the ore dust which will evenutally cause almost any switch to leak. We have substituted a very easily made switch. The firing cable is a duplex rubber covered No. 16 copper wire. This cable, installed on insulators, connects to copper terminals mounted on a V-pointed, 3 foot long wooden paddle known as a "Shooting Paddle." These shooting paddles are located a safe distance from the place to be blasted, and hung so as to prevent contact with ore, rail, pipelines or other conductors. Firing the blast is accomplished by inserting the pointed end of the paddle into what is known as a "Hot Box." The hot box is provided with live alternating current or direct current terminals. The conductors from these boxes connect to the power source. When 220 volt alternating current is used, this circuit is fused and connected in series with an 8 ohm resistor and when 250 volt direct current is used, the current is limited by a 25 ohm resistor.

The other type switch used for firing outside or from points underground near the mine shaft and at a designated firing time, such as stope hole blasting in heavy sulphide ore where the dust is explosive, is the magnetic switch, located about where a paddle switch would be. The magnetic switch is actuated by current over a two wire lead from either a push-down multiple-shot firing unit or from another source of alternating current.

From either power source the current travels over the No. 16 copper wire duplex rubber covered shooting cable to a 2 pole, double throw knife blade switch which is called the safety switch. This switch when thrown in "off" position shunts the portion of firing cable toward the shots that are to be connected. Each working place is provided with an independent firing circuit and paddles and panel switches are plainly marked, for the places to which they are connected. The safety switch is located as near the place to be blasted as safety will permit, usually around the first corner or right angle turn and the shooting line switch back far enough for comfort or safety from a dust explosion.

Where a magnetic switch system is in use it saves material to use a common switchboard near foot of manways, then all these circuits can be energized by one feeder and each place where blasting is desired can be connected to the power line by putting *that* switch in the "on" position.

Maintenance and extension of the shooting line is done by the drill man.

Safety Switches

The safety switch is inspected before entering a working stope or loading place to see that it is in the "off" position before going past it. There are a number of other precautions to take in charging holes before connecting lead wires for blasting; i.e., charge holes by applying pressure with a wood pole, connect leg wires for each round in series or series-parallel then make connection to permanent leads, breaking shunt on one detonator at a time and connect same so as to avoid naked end of wire from becoming grounded. Check wiring to see that everything is in order. It is always advisable to check each round with a circuit tester or galvanometer for circuit, as well as grounded leg-wires, particularly, when blasting in heavy sulphide ore.

Training of all mining personnel in the efficient and safe use of explosives is profitable. In addition to the older man teaching a new man by showing and doing the work, it has been found that aids such as a demonstration board where actual conditions can be approximated, help a foreman and electrician get over ideas better. The film strip and sound is another tool to help get over to all miners the recommended methods.

Discussion

There are inherent hazards with electric detonation in metal mines but it is generally conceded the preferred method of firing shots.

The practice of connecting a number of shots in series involves consideration of the possible hazards of misfires and premature blasts. Abrasion of leg-wire insulation and exposed bare splices between detonators and at lead wire connections give points in the circuit from which the firing current can leak away and cause misfires. There is also the possibility that stray current can enter at these same points before the blasting circuit is closed and thus cause premature blasts.

Experience has shown that measurement of voltage is not the sole criterion of the hazard of premature blast from stray currents because resistance and other factors can limit the current flow to a value below that necessary to fire a detonator.

The minimum current necessary to fire an ordinary electric detonator with certainty is approximately .34 ampere. The resistance of an electric detonator varies according to the length and size of the leg wires used. Therefore the minimum voltage required to cause the minimum firing current to flow will depend upon the total resistance of the detonator, i.e., resistance of the bridge wire plus resistance of the leg wires. A common value used for this minimum voltage is 1½ volts.

Cost of One Electric Blasting Station

Average Length 500 Feet For Stope or Development Work.

28 holes at 50c each	$14.00
24 plugs at 5c	1.20
1 shooting paddle	0.50
1 safety switch (open double-pole double-throw)	0.85
1 safety switch box	0.50
1 hot box	0.50
3 support plugs at 25c	0.75
500 ft. reinforced lamp cord at 1.5c	7.50
3 Nailit knobs at 5c	0.15
Installation by electrician	6.00
Total cost	$31.95

At a Grizzly or Secondary Place

8 holes at 50c	$ 4.00
5 wood plugs at 5c	0.25
1 shooting paddle	0.50
1 safety switch (open-pole double throw)	0.85
1 safety switch box	0.50
1 hot box	0.50
1 25 ohm resistor	0.85
3 support plugs at 25c	0.75
100 ft. reinforced lamp cord at 1.5c	1.50
1 Nailit knob at 0.5c	0.05
Installation by electrician	4.00
Total cost	$13.75

Operating costs for all mines of the blasting materials consumed in mining 1,090,613 tons of ore and 22,815.5 feet of development footage totaled $115,585.70. The dynamite cost was $84,973.00 and the electric blasting supplies was $30,412.70. The electric detonation cost was 26.36% of the total cost and the pounds of dynamite used per electric detonation was 2.30 lbs. or about 6.4 sticks of 1¼x8 dynamite.

Summary details of costs used are:

Dynamite 15,321 cases (766,050 lbs)	$ 84,973.00
Electric caps 332,489	25,992.95
Annunciator (lead wire) wire 9,978 lbs.	3,651.01
Reinforced lamp cord (No. 16 copper wire) 19,865 feet	417.16
Switches 121	105.58
Galvanometers 15	225.00
Blasting Machines 1	21.00
Total	$115,385.70

Recommendations

Electric detonation is recommended in metal mines but necessary precautions must be followed. The safety from stray current would be greatly improved if the D.C. single trolley wire was eliminated. Two pole trolley or battery locomotives have been recommended as offering a possible solution.

Discussion of Paper

MR. DAN HARRINGTON (U. S. Bureau of Mines): In the first place that paper has in it an immense amount of meat. There are in it many things for metal mining people to look at. They have had an explosion down there of metal mine dust, not coal mine, and it was a serious one, and they are using electric blasting. They are using electric blasting in a mine which probably has more stray currents in it than in any other mine in the United States. At any rate we don't know of any mine in the United States that begins to approach the amount of stray currents that they have. Another thing, they are going to ditch the trolley system. Personally I wish every metal mine in the United States and every coal mine in the United States had conditions so they would all have to ditch the trolley system, and the day will come when you're going to ditch the trolley system whether you like it or dislike it. The procedures which they have followed out in connection with their electric blasting are certainly something for you people who are here from other regions to take into consideration. There are a lot of advantages in electric blasting, although many times there are some disadvantages and electric blasting is by no means foolproof. It entails responsibilities and plenty of them.

MR. MORGAN (Hudson Coal Co., Scranton, Pa.): Did you ever have your power cut off the mines and then test for stray currents?

MR. WEAVER: Yes, we spent about a year on tests on off-shifts, Sundays; we did it week after week. We operate three generators, one 100 and one 150, and then we have, about five miles away, the smelting plant. We have 500-volt car locomotives. I was afraid of them. I thought that stuff goes all over the country and probably that was it. So we tested that and we trailed it down definitely, and it was entirely due to our own mine trolley system. With one you'd get circuits in one direction and then operate the other one, you'd get it the other way. We have potential differences on the surface a half mile from the mine of a volt or two volts from the clay, fifty feet of wire over here in the clay to the pipelines; then when the generator is shut down it's all dead.

MR. MORGAN: I know. We shut down but still we find it. We might have a different system on our ground hookups. What I was thinking about was your pipelines in the mines—around those pipelines, probably on the surface some place; that's what I was thinking.

MR. WEAVER: That's right.

MR. VICKERS (Casting Mining Company, New Hampshire): I'd just like to ask Mr. Weaver what method of grounding he uses for return circuits.

MR. WEAVER: We have just the bonds and the rails and in the shaft an independent turn line of four times past the field.

MR. VICKERS: Do you run continuous tests on your rail joints in these bonds? We all know rail bonding joints are a long way from being a good bond system and we have run into experience of stray currents, as well as everybody else in the iron district. We finally came to the conclusion that unless the rails are welded into a continuous return circuit the bonding is a long way from being efficient and because we didn't have continuous welded rails we resorted to carrying an extra copper return circuit alongside the drift and we cut over into our track every hundred feet, tying all our air lines, water lines and this return copper circuit into our rail system and by doing some of those things we have eliminated to a great extent a lot of our stray currents.

MR. WEAVER: I'm sure of that, Mr. Vickers. We have had that same experience and same belief on bonding. We realize that. Every five or six hundred feet we tried to group into the ore body again. We smelted, drilled a hole in to the ore and made connections there and tied up the pipelines. I believe we get about ten per cent coming back through the bonds and we used, just as a check, the ore body; at a thousand feet we used copper wire return. The only way we could get more than ten per cent in power to come back through a copper wire on insulate ore was when we jacked the locomotive up off the track. Ninety per cent would go back through the ore instead of coming back on a copper wire. We ran a test at a thousand feet just to see how much we could get to go back.

MR. VICKERS: It seems to me from what you say that your return circuit there was highly inefficient, because if you had capacity enough that type of circuit, with your locomotive on the rails and cross-connections enough from your rails to the copper, you're certainly going to take it back easier through the copper and the ground; there's no question about that. Years ago I used to think that a pipeline was a good return circuit; I have found out to my sorrow it's not. Every screw joint in the pipeline is a high-resistance joint and it just may be resistance enough to cause a potential difference of half a volt, but if you take a hundred joints you've got quite a voltage built up there. It's going to tend to sneak a lot of your current around and it's going to try to find its way back through other sources, so the thing is to carry a good metallic circuit back and to have it big enough, get enough capacity there, and I'm sure you're going to get away with a lot of your stray currents. In other words, confine those currents to the proper return circuit. They won't take the ground if they can get a good type of circuit back. But I agree with you if they don't have a good copper circuit back they're going to get all off.

MR. ZELAND (Tennessee Copper Company): We've been in this stray currents a lot. There's practically no resistance in our ore. That's on account of the size of this ore body which has been one of our troubles, and we've been into that a long time.

MR. RICKS: We've made quite a study of stray currents and protective blasting systems for a good many years. We started out about twenty years ago with an unfortunate accident and we believe that there are three different steps involved in protection against stray currents. One is that one just under discussion, the matter of reducing the amount of stray currents present. As Vickers said the better your return system is, the less stray currents you're going to have coming back from the ore, or the less difference in voltage you are going to have between the ends of your rail and the adjacent drop, and I mentioned the other day from our experience in mines iron ore is just the opposite from your ore. It has a very high resistance so there is very little by-pass current taking the actual ore path. It doesn't take very much to fire a cap. That makes it particularly important to keep all of the blasting leads insulated from the ground and from the rail return system. That is the first step in protection in stray currents from our experience—to reduce by every means, cross-bond, put in all the return feeders you can, tie all the metal parts together, and have all rail returns, pipelines, tugger cables, machine parts, and everything else all bound together with a good heavy copper conductor.

The next step is keeping the stray currents out of our blasting circuit. Our method has been the use of rubber-covered cables, which have an extra amount of insulation. We use those from the lead wires all the way through just as close to the blasting as possible, and that will depend on the nature of the material. From there to the blasting face we use a heavy weatherproof connecting wire, properly supported. We don't have to worry about stray currents from the ground because of the high resistance. Our ground is an insulate ore, you might say. We have to watch out. We don't beat across any pipes or tugger cables or equipment of any kind.

The last step is the use of blasting switches and type of connections and so on that will make your circuit as safe as possible if stray currents do get in. We have a little different procedure than we ever have used. We have a blasting switch. We have a double-pole switch that we fire the blast with. We don't have to get out of the mine. We have to get back a safe distance from flying material and at that point we have this double-throw switch in the normally open position, which is held open by a spring and by gravity both. The blades are short-circuited similar to yours, but they are short-circuited automatically; you can let go of the handle in any circuit position. That maintains a short circuit on the lead cable. If the lead cable is long you can be a long way away from your noise. Then we put in a supplementary short-circuiting switch on the lead wire somewhat similar to yours, and because the resistance of the lead wires would destroy a great deal of protection, ahead of the blasting switch we have a circuit break that is also normally held open by its spring. Just for the mental satisfaction of the miners we use a removable jumper between the circuit-break and blasting switch that they can carry with them.

It breaks the wiring section from the power line. They can take it in the powder bag or lock it up inside the blasting switch but there's a definite break between the blasting circuit and power supply which they can see and understand and reach. We don't have the cross-conditions so from an electrical standpoint that's unnecessary. It's just for the miners' peace of mind. These switches are locked and they're so locked that this short-circuit condition has to exist before it can be locked.

Hazards Observed in Western Metal Mines

By CARL BELSER

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Introduction

Twenty-four of the 76 coal- and metal-mining engineers appointed as field engineers under Civil Service regulations were assigned to District H, which embraces the 11 Western States and the western parts of South Dakota and Nebraska.

Since August 1942, 741 original inspections were made, and reports were written, as of May 1, 1944, on mines, other than coal, and their associated plants, in District H. Also, 351 reinspections were made of 242 of the more important properties. The total production, in 1943, of the mines inspected amounted to about 116,232,000 tons of metallic ores and 17,176,000 tons of non-metallic ores. The total number of employees at the properties inspected averaged 65,400, of which number 26,360 were employed underground and 39,040 on the surface. The accident-frequency rate in 1943 varied from a high of 237.4 in an underground mine having 260 employees to a low of 2.27 in a large smelter having 1,300 employees. In an underground mine having 1,600 employees, the accident-frequency rate averaged 14.0 over a 5-year period. Several small mines have been operated during the last 5 years without a lost-time injury.

Following the inspections, 7,567 written recommendations were made; 1,108 pertained to the safety of the employees, 4,835 to fire prevention, 1,642 to handling and storing of explosives, and 982 to preventing any interruption or delay in production from sabotage or subversive activities. Several hundred oral recommendations were also made, most of which were adopted during the course of the inspections.

Of the 741 mines and plants inspected, 75 (10 per cent) of the facilities are in a class that employs more than 250 persons; 185 (25 per cent) are in a class that employs 40 to 250 persons; and 481 (65 per cent) are in a class that employs fewer than 40 persons.

Hazards to the Health and Safety of Employees

Accident records were not kept at 9 per cent of the operations. Many operators were unaware of the frequency and the severity of the accidents and were in doubt as to the ability of the various bosses to prevent such accidents. Twenty-one of the smaller mines did not subscribe to any form of compensation insurance. Dust hazards were observed in some dry sections of underground mines, around grinding units in cement plants, and at dry-drilling operations in quarries, pits, and underground mines; and in most instances respirators were not provided.

In 19 mines having extensive and complicated workings, signs had not been posted showing the direction to the escapeways; first-aid supplies were partly or totally lacking at 68 properties; and first-aid training was considered insufficient at 187 (25 per cent) of the operations. A few small mines, situated 50 to 80 miles from the nearest doctor and without telephone or telegraph facilities, had no first-aid supplies, and none of the employees had been trained in first aid.

At a number of properties men were employed in occupations that were hazardous to the eyes and were without the protection of safety goggles. Insufficient guarding and screening of machinery, open stairways, and open grizzlies were noted at 117 plants. At 32 properties company employees did not inspect vital machinery, such as hoists, hoisting ropes, compressors, boilers, and electrical equipment. Proper ladderways were not provided at 32 mines, and at several small mines ladderways consisted of boards nailed to the bottom of bucket skids. Ladders in some mines were leaning backward from the vertical, insecurely fastened, or not maintained in safe condition. In one mine the wooden bucket skids extended down 300 feet along the 65-degree dipping footwall of an open stope. Pieces of 2- by 4-inch lumber, nailed at about 3-foot intervals to the bottom side of the skids, provided the only means of egress. In a large mine a ladder was not available in the lower 200 feet of a vertical shaft being sunk.

Unsanitary latrines, accumulations of garbage and other refuse near the cook house, or polluted drinking water was found at 25 properties. At one small property, 85 miles from the nearest railway, a number of men became "run down" and "all in." Mine dust was suspected as a probable cause, but the state mine inspector found no dust hazard to support this conclusion. The sickness was diagnosed as lead poisoning, and several men were awarded compensation; however, the source of the so-called lead poisoning was traced to a spring that contained arsenic. Manganese poisoning was prevalent at two mines.

Living quarters varied from tents to modern houses, and the living conditions at some properties were not conducive to the proper rest, relaxation, and cleanliness of the employees, resulting in increased unrest and labor turnover.

Men were observed working under loose rock in drifts, stopes, and raises at several mines. Fume hazards from mercury retorts were prevalent at a few mercury plants. Adequate mine rescue equipment was not available at 18 large and medium-size mines. Hard hats were worn by the employees in almost all underground mines, but safety-toe shoes were not as universally worn. Some shaft openings, both on surface and underground, were not provided with safety bars, and some loaded man-cages were handled without the use of safety gates.

The hoisting equipment varied from crude gasoline-engine-driven, friction-clutch hoists to large direct-current-powered hoists, which were equipped with generator-voltage, overwind, overspeed, and loose-brake controls.

Safety organizations were recommended at 16 per cent of the properties. In most cases labor-management safety committees were recommended, and regular safety organizations, supervised by trained safety engineers, were suggested for some of the larger properties. Most of these larger properties now employ safety engineers. At several properties the employees seemed to have no regard for their safety. General safety rules and instructions were lacking at 103 properties. Thirteen small mines and four medium-size mines were found with only one exit.

Timber was found unsafe or inadequate at 35 operations; unguarded trolley wires at crossings where the wire was less than 6½ feet above the top of the rail were noted at 9 mines. Thirty-one mines were inadequately ventilated; however, all operators of medium- and large-size mines were alert to the lost efficiency caused by poor ventilation and were eager to consider any suggestions made by the inspectors.

The following miscellaneous accident hazards were observed at various properties:

1. Miners lacing fuse through explosives; blasting lines closely paralleling power lines; and unlocked blasting switches.

2. Employees in the mine riding on top of locomotives; cars being coupled or uncoupled while in motion; and motormen making "flying" switches and failing to reduce speed and to sound warnings when approaching blind curves.

3. Men in man-trips jostling each other and jumping off the man-trips while the cars were in motion.

4. Cars and loose muck left standing too close to shaft collars.

5. Insufficient clearance for locomotives; inadequate shelter holes; and too much spillage along haulage tracks.

6. Gasoline-powered locomotives used underground.

7. Man-cages not equipped with bonnets or safety dogs; guides, shaft pockets, and shaft timbers in need of repairs; and several shafts equipped with only one method of signaling.

8. Small, tugger-type hoists used for hoisting men.

9. Improper mining methods, such as unfilled stopes, too much ground opened up, and caving banks overhanging power shovels.

10. Unscaled cliffs overhanging bunkhouses, and insecure scaling ropes.

11. Safety belts not provided for men working over unprotected openings.

12. Shaft sinkers without bulkhead protection.

13. Electric equipment and cables not properly grounded.

14. Dangling wires and protruding timber and spikes in drifts, crosscuts, and manways.

15. Proper antidotes not provided where chemicals were being used or processed.

16. Boilers not equipped with a safety valve; a large ventilating fan being operated in such a manner that children at play could be caught in the machinery.

17. No protection provided around the surface openings of caved stopes and abandoned shafts. Holes in floors which might cause a sprained ankle or broken leg.

18. Excessive tailings allowed to accumulate on mill floors and as much as 4 inches of rock dust allowed to accumulate on stairways and runways.

19. Large bunkhouses provided with only one exit, and new company-owned school houses without "panic" exit provisions.

Fire Hazards

Fire-alarm systems were not provided on the surface at 17 per cent of the properties, and emergency alarm systems were not provided in 101 mines. Proper fire doors had not been provided in 83 mines; fire drills were recommended at 252 (34 per cent) of all properties inspected. Operators of small mines were requested to instruct keymen in the use of available equipment, and the operators of large mines were requested to organize fire-fighting crews with an experienced man as chief.

Definite plans of procedure were also recommended in case of underground fires. Some superintendents at large mines had no idea of the type of fire extinguisher to use on each class of fire. The difference in the fire-fighting ability of a well-trained crew and an untrained crew was fully demonstrated at surface fires at three different mines within six weeks. At two fires, trained crews quickly cut their way in and fought the fire at its source, and the fires were subdued with relatively little damage. At the third fire, an untrained crew fought the fire by playing streams of water on the outside of the building. The building, valued at more than $200,000, was completely destroyed. An inspector who investigated all three fires believed that the third fire could have been fought successfully by a trained fire crew.

Gasoline was used for cleaning at 85 mines and plants, and hazardous methods of storing gasoline were noticed at 54 properties.

Waste paper and trash are often burned in piles near buildings. During the inspection of one large mine, a pile of papers was being burned near the frame warehouse, which was not enclosed below the floor line, and a burning paper was blown underneath the warehouse by the wind; the warehouse is now enclosed below the floor line, and a properly screened incinerator has been provided.

The fire-fighting equipment had not been properly maintained at 151 properties, and inspections revealed many unsatisfactory conditions, such as stiff and rotten hose; an inadequate supply of wrenches and nozzles; lost, empty, or broken fire extinguishers; broken hydrants; and stuck doors to hose houses and stuck control valves. The office records and maps of a large mine were recently lost in a fire because a control valve in the fire line stuck.

Hazards in Handling and Storing Explosives

Explosives control embraces proper storage, transportation and handling of explosives. In nearly all the mines inspected, conditions were found to be below the required standards.

A number of small mines were visited at which no provisions had been made for storing explosives. Unprotected explosives create not only a dangerous sabotage hazard but also a serious hazard to children and to people not accustomed to using explosives; each year many children are killed or partly disabled for life while playing with blasting caps.

An underground magazine in a large mine contained 2,260 pounds of dynamite, 45 per cent strength. Seventy-five empty wooden explosive cases and the paper linings from about 150 cases were piled against the wooden front of the magazine.

In contrast, explosives are transported, at a large mine, in special trucks from an isolated magazine to the shaft. The explosives are loaded into wood-lined cars provided with wood-line steel lids. All hoisting of ore and waste is suspended while the explosive cars are being lowered to the various levels. On the levels the explosives cars are coupled to a train consisting of a storage-battery locomotive and three empty cars, and the explosives are then transported to the magazines. The explosives magazines are L-shaped and built in firm ground. In each magazine cases of explosives are stored on a raised concrete shelf covered with 1-inch boards. Near the front end of the "L" is a 12-inch concrete wall containing a doorway fitted with a steel door which is suported by heavy-bolted hinges. Barred ventilation openings, 8 by 12 inches in size, have been left in the concrete wall on each side of the door. Each magazine is ventilated by compressed air, which is blown through small holes in a perforated pipe. Fuse is made up on the surface in a special fuse house, provided with barred windows and fluorescent lights. The capped fuse is transported to the various levels in special containers. The fuse magazines are gunited and have sand floors. Wooden racks are provided to support the capped fuse. Electric detonators are stored in wooden boxes with hinged lids. Some detonator magazines are provided with sprinklers, and hot magazines are cooled with compressed air. A record of the amount of explosives handled and stored during each shift is kept on the printed forms available in each magazine. The count in all 17 underground explosives magazines was found to tally with the actual amount of explosives on hand.

Conclusion

A study of the 242 properties reinspected indicates that 171 of the 2,719 original recommendations were not applicable. After deducting the inapplicable recommendations, 2,052 (80.6 per cent) of the recommendations have been placed in effect.

At many plants the construction of much needed oil houses, the establishment of mine rescue stations, the removal of old and useless frame buildings, and especially a marked improvement in housekeeping, resulted from recommendations which were greatly desired by the local management.

The two tables indicate the number of operations at which each class of hazard was found but do not represent the number of written recommendations. At some operations several hazards of similar type were noted. A single recommendation sometimes embraced several hazards.

HAZARDS TO HEALTH AND SAFETY OF EMPLOYEES IN 741 WESTERN MINES

TYPE OF HAZARD	NO. OF SMALL OPERATIONS	NO. OF MED.-SIZE OPERATIONS	NO. OF LARGE OPERATIONS	TOTAL
1. No Accident Records Kept	29	36	7	72
2. No Compensation Insurance Carried	21	0	0	21
3. Dust Hazards	5	13	2	20
4. No Emergency Exit Signs	7	8	4	19
5. Insufficient or No First-Aid Supplies	57	10	1	68
6. No First-Aid Training	118	57	12	187
7. No Goggles Available	17	11	5	33
8. Screens and Grizzlies Not Guarded	54	45	18	117
9. No Inspection of Machinery	14	12	6	32
10. Improper Ladders	19	9	4	32
11. Improper Sanitation	16	6	3	25
12. Poor Living Conditions	5	7	3	15
13. Working Under Loose Rock	20	9	5	34
14. Exposed to Mercury Fumes	6	2	0	8
15. No Mine Rescue Crews	0	11	7	18
16. No Overwind and Overspeed Control	29	29	2	60
17. No Protective Clothing	14	8	4	26
18. No Safety Bars and Gates at Shafts	8	10	3	21
19. No Safety Organizations	36	63	16	115
20. Safety Consciousness of Employees	4	11	2	17
21. No Printed Safety Rules	59	36	8	103
22. No Second Exit	13	4	0	17
23. Miscellaneous Safety Requirements	82	47	28	157
24. Inadequate Timbering in Mine Workings	21	8	6	35
25. Unguarded Trolley Wires	2	3	4	9
26. Inadequate Ventilation	11	13	7	31
	667	468	157	1,292

EXPLOSIVES HAZARDS

TYPE OF HAZARD	NO. OF SMALL OPERATIONS	NO. OF MED.-SIZE OPERATIONS	NO. OF LARGE OPERATIONS	TOTAL
1. Improper Storing, Transporting, and Handling of Explosives	430	162	67	659
HAZARDS FROM SABOTAGE AND SUBVERSIVE ACTIVITIES				
1. Absenteeism and Labor Turn-over	15	7	11	33
2. Compressors and Fans Not Guarded	22	26	13	61
3. Fences and Gates Not Provided	8	43	19	70
4. Finger Printing Not Required	7	8	21	36
5. No Identification Cards and Badges	0	12	3	15
6. Employees Not Investigated	37	54	37	128
7. Inadequate Illumination on the Surface	27	24	27	78
8. "No Trespassing" Signs	38	17	0	55
9. Vital Machinery Not Protected	10	29	24	63
10. No Control Over Visitors	12	19	18	49
11. No Watchmen or Guards	45	60	37	142
12. Miscellaneous Hazards	15	26	20	61
	236	325	230	791

Discussion of Paper

MR. LARSEN: I think Mr. Belser should certainly be commended on his paper and that you fellows should spend a lot of time in going over that paper, observing the hazards. Most of the hazards are of a mechanical or physical nature that are taken care of principally through management and things like that. They are brought out by observation of safety engineers. In the last part of his paper he said that on rechecks, going back over on the re-inspections that a little better than eighty per cent of the previous hazards listed had been taken care of by the management. That showed definitely that management was in full accord with this inspection as put on by the MPSD of the Federal Bureau of Mines. Originally there were 7,500 recommendations, and boiling them down in his paper he had over eighty hazards listed, and to discuss each hazard or even touch on each hazard would take a couple of weeks to do.

MEMBER: Mr. Belser's paper mentions aluminum dust hazard. Would you enlarge a bit on that, Mr. Belser?

MR. BELSER: On that I'm afraid I'm not very well qualified to speak because those were picked up in California by inspectors there and they had two or three explosions. I personally made no inspection at any plant.

MEMBER: The reason I asked, of course, is that the aluminum dust treatment we are using is probably the finest you can get, and we have absolutely no trouble with aluminum.

MR. HARRINGTON: I can answer you. The answer to it is this: that there are definite hazards and plenty of them in plants processing aluminum, irrespective of anything anybody can tell you about it. We know that.

MEMBER: On that table, on the resume total of operations, would you be able to give us any information on whether or not the operations without safety departments had the greatest number of hazards?

MR. BELSER: In most of the big companies there were very few hazards in comparison with the smaller ones. The small properties have really had a lot of bad things. Some of the big companies with good safety organizations have hazards, and they are aware of most of them and are trying to fix them up as fast as they can, and they are doing a very good job. There are a lot of things, for instance, in a small mine you wouldn't think of recommending —mine rescue equipment with ten or fifteen people. It would be out of the question. In a small mine you wouldn't think of a regular safety committee. You'd think of trying to make a superintendent—if the mine is run sloppily — a little more conscious of those things, and that would be all. I believe that's clear.

MR. HARRINGTON: I might state one thing here in connection with the paper. He mentioned that loose ground was noted in several places. We find in the Lake Superior district over the last four years in our underground iron mines that loose ground has caused approximately twenty per cent of our lost time accidents, and it's caused 47.2% of the time lost through accidents.

Wherever you have loose and underground mining you have the hazards. I just thought I'd bring that one point out. The hazards listed here, as I said, are more of a physical nature and meaning where management can take care of them, and really they only hit about 25% or 30% of our accidents, but it's a big problem. The paper was of extreme interest to me since I am originally from the West. I've worked in some of those mines. I think we can get away from a lot of these hazards through job instruction training and training our men to install equipment safely in the first place and follow up with safety inspection. If there is no more discussion I'll turn the time back to the chairman.

Fundamental Causes of Accidents

(Panel Discussion)

Discussion Leader: J. H. MULCAHY, Supvr., Industrial Relations, Republic Steel Corp., Duluth, Minn.

Participants:

B. G. BEST, Supvr. of Safety, Oliver Iron Mining Co., Duluth, Minn.

DR. JOHNSRUDE, M.D., Mesaba Clinic, Hibbing, Minn.

C. M. FELLMAN, Safety Eng., Montreal Mining Co., Montreal, Wisc.

C. E. HAGER, Range Safety Inspector, Pickands Mather & Co., Hibbing, Minn.

MR. MULCAHY: The first case that we'll discuss is that of an electrician's helper who was burned on both hands and suffered flash burns of both eyes, due to the short-circuiting of the contacts inside an oil switch. He had worked as an electrician's helper at the mine for a year prior to the date of the injury and had previous experience with other employers. At the time of the accident he was inspecting contacts on a live circuit-breaker. He inserted a combination plier-wrench onto the contacts and a flash resulted, spreading hot oil over his face and hands. The oil circuit-breaker was one of several in the plant. Investigation brought out the fact that a few days prior to the date of the accident the chief electrician had given instructions to the electrical crew at the mine, governing several jobs. One job covered by his instructions was the inspection and repair of oil circuit-breakers. It developed that there was a lack of definite understanding of the instructions. The injured helper said he thought they were given to the electrical crew generally. The chief electrician said that he had intended specific jobs and specific instructions for individual members of the crew and certain jobs were to be done by the electrician and the others by the helper. The helper had been doing other jobs around the plant and, apparently having finished them, he turned to the inspection of the oil switch.

I am going to ask Mr. Hager to give us his impression of the fundamental wrong in this case.

MR. HAGER: Mr. Mulcahy, to get this discussion started I could say that this man was just a plain damn' fool, took his life in his hands, and acted very unwisely. Before proceeding I'd like to hear from some of the folks out in the audience to find out what they have to say about this thing.

MR. MULCAHY: I think there may very well be some discussion on this point in a crowd of this size. I'm wondering, though, if you'd care to enlarge a little bit before we open it for general discussion, as to what is your opinion of the fundamental wrong, either with the man's attitude or with his actions.

MR. HAGER: My view of this accident, as far as I'm concerned, indicates that the chief electrician had done a good job of instructing the men two days prior to the date of the accident. That's the way it appeared to me after reading the report of the accident, reading the foremen's report as well as the investigation of the accident. At the time that this was going on there apparently were some job instructions and the only thing that I can see that the foreman didn't do properly was to have the instructions that he gave the individual men repeated.

MR. MULCAHY: You mean spoken back to him?

MR. HAGER: Yes, At that time there were job instructions at this particular property, at the time the accident occurred, the program was well under way. I also found that this particular plant had taken great pains to give instructions in respect to the locking out of switches when men worked on circuits. This information was posted at every panel, posted on the individual switches; locks were provided, keys were there.

MR. MULCAHY: A violation of a definite safety rule was involved in this case, too.

MR. HAGER: It is my opinion that there was a very definite violation of company rulings. Again going back over the record there appears to be some argument, some difference of thought as to whether some responsibility shouldn't have been placed on the foreman, and that's where I suggested that we might have some discussion from the floor.

MR. MULCAHY: I think probably we're in better shape for a little discussion from the floor on that point than we were a little earlier. Instruction sticks out in this case—at least it impresses me that way, that the case should be covered by definite instructions. A method was chosen to instruct; whether or not the method was proper is questionable. Whether the instruction should have been repeated is questionable. I'm wondering, in view of the fact that instructions were given and apparently misunderstood, if someone would like to express an opinion as to what responsibility a foreman does have for the safety of his men.

MEMBER: Mr. Chairman, to me it just appears we're not well enough informed as to what the instructions were that were given the man. Consequently we can't form an opinion of him, as to just why he did this. It does appear that there was a misunderstanding, but as far as a foreman's responsibility is concerned regarding what his man does, I think it's all the foreman's responsibility. The responsibility falls on the foreman if he doesn't give the instructions explicitly enough to know that a subordinate is going to do the job right. I know from personal experience it doesn't make any difference whether you have a new man or a man on the job for years, it just seems involuntarily to creep out of you to say "Be careful that the power is off; see that the disconnects are pulled after the oil switch is open."

MR. MULCAHY: I think we can agree that the instructions, so far as covering the job is concerned, were complete as to the job. Where the difference of opinion arose in the investigation of this accident was whether the instructions were given to the electricians to do this particular job or whether they were broad enough that the helper might have understood that he was to go ahead and do it, too. There was nothing wrong with the instructions as instructions. The error crept in in the difference of opinion that did exist as to whom the instructions were given to.

MEMBER: I didn't mean to infer that, in this particular accident, the responsibility fell on this particular foreman. You might have gotten me wrong. What I maintain is generally that when you say "what responsibility falls on the foreman?" that's what a foreman is for, to assume the responsibility.

MR. MULCAHY: I think I can agree with what you have said. I wonder if anyone else on the panel has anything to add to this one.

There's another question that occurs to me but I'd like to have an expression from any other panel member before we turn to it.

MEMBER: What about this man's immediate foreman? Who told the electrician's helper to do the job? Or did somebody else?

MR. MULCAHY: The only thing I can say in answer to that is that this man had been doing some jobs for several days around the plant and apparently assumed that, after these instructions were given, this was just a continuing job for anybody in the crew. He went on his own, so far as that's concerned; there was a misunderstanding, as long as he was not definitely clear, although he said he was very clear. There was no question but that insofar as he was concerned the instructions were general and anyone in the crew could take these jobs as he had an opportunity to do it. In other words, it was one of the things that had to be done around the plant and anybody could do it as he got time.

MR. HAGER: I can't subscribe to that thought after reading that accident report. It impressed me that this man was well instructed that the three men on the crew were very, very definitely instructed as to the duties. The man involved here, in going back over the record, was to take up motor screws to do other work, and didn't have anything to do with the oil switch job, changing the contact; that was very definitely the job of the plant electrician and as I said before, I think the only mistake that the foreman made there was in not having the man himself or the men in that three-man crew repeat the instructions.

MR. MULCAHY: Then you seem to indicate that the responsibility was very light so far as the foreman was concerned and that the helper probably was trying to educate himself?

MR. HAGER: There should be an answer to that accident. The answer, as I see it, is that the man failed to comply with the company's rules and regulations of locking out that switch.

MR. MULCAHY: That leads to the question I said I still had in mind on this one. Every once in a while you will find some electrician or some mechanic who knows better, failing to lock out moving machinery or electrical switches before he works on it. There may be somebody here, either an electrician or a mechanic or someone in that general line of work who can give us a pretty good slant on why men do that. Why do they take that chance? Is there anybody who would like to answer that question?

MEMBER: Mr. Mulcahey, I think if we could answer that we'd have the accident situation licked.

MR. MULCAHY: Well, we can do it. We've had a good meeting.

MEMBER: It seems to me this particular fellow was going further than his instructions. Very likely he went beyond the instructions for his particular work and in so doing encountered this accident to himself. If he is that type of fellow and he hasn't learned a lesson by it—he'd better change his profession, because electricity is something that you want to know what you're doing before you start. I think in this case it was definitely the man's fault. I think he was probably a little overambitious or overenthusiastic and started something which he didn't know the ins and outs of.

MEMBER: Mr. Chairman, I wonder if the foreman knew this man and the man knew the foreman. It would seem to me this man was in the electrical game, was supposed to have certain knowledge of electricity which he probably didn't have, and it would seem to me that it would have been the foreman's business to know just exactly if that man knew what he was to do and if he should have drawn that out by having him repeat the instructions.

Sometimes there is such a thing as overinstruction. You take a man who is thoroughly experienced and you know he is, and you don't tell him the details of his job; but if the foreman didn't know the capacities of this worker then I think the foreman definitely was at fault in not finding out exactly whether the man understood what his instructions were.

MEMBER: I'd like to ask one question. If there was a standing order that no hot work should be done, if the foreman observed his men from time to time to see that they were obeying that rule? Is this an isolated case of a man working on hot wires?

MR. HAGER: That's a very general rule in the plant, that nobody is to work on any hot wires or hot circuit.

MEMBER: Did the foreman see that the rule was obeyed or did he neglect it and thereby create a habit in the mind of the helper, which caught him on this particular occasion?

MR. MULCAHY: Of course I suppose you will never establish whether these things are habit or whether they're not. My experience has been that the accident that caused the injury is the first one of its kind that ever took place, regardless of where it happened. We never had that happen before. That's always the answer. I think that we can probably agree that we've discussed this thing from the two sides that should be discussed—whether the blame is entirely on the part of the individual hurt, which is an old-fashioned idea, I think, or whether it is entirely on the forces of supervision or whether it might be divided and it appears to me that in this case there was probably some division of responsibility, some division of blame. Instructions were given. The point comes up, were the instructions understood, and in the final analysis it's a question, of education, education properly given, instruction properly understood and a definite regard for safety rules. If those things are done we've at least gone part way in whipping some of the fundamental causes of accidents.

If there's no further discussion on that we've got another one that's interesting, too, probably a little bit from the same angle.

This one is where there was a new level being opened in an underground mine. The ore body was wet, so that the temporary fuse and cap magazine had not been moved from its original location near the shaft and this was about 3,000 feet from the working places. Capped fuses were placed in carrying cans, each holding 50 to 75 fuses, and were carried by the miners to a convenient location in the working area where the cans were used for storage.

A gang of three miners driving a crosscut loaded 19 holes, each provided with a seven-foot fuse. Two of the miners started lighting the fuses. The men working at the right side could not light one fuse. The third man in the crew, who had been standing nearby, stepped forward, cut off the end of the fuse and then split the new end. By this time the first man's fuse lights had burned out, and he used his carbide light to light the remaining fuses on his side of the cut. He then helped his partner whose light had also burned out. They were lighting the fuse in the lower left-hand corner when one of the upper holes exploded. The men ran to safety. Two of them escaped injury, but the third, who had been struck by flying chunks from the first explosion, sustained injuries in the chest and legs.

MR. BEST: You might call this a beautiful accident. There was only one man hurt when three might have been killed. The one man that was injured lost some 280 days.

Now, these fuse cans that carried from 50 to 75 fuses were not individual contract cans. They were cans that were carried in to be used by all the miners or any of the miners in that particular area. Another thing to be brought out is that the fuse lighters were also used as timers, and there was a standing safety rule that as soon as the first fuse lighter burned out the men were supposed to leave the place. In reviewing this it seems the direct cause, that is, the unsafe act that actually caused the accident, was the violation of this safety rule requiring the men to leave when the fuse lighter burned out. There are several fundamental causes, to my mind, that caused the unsafe act. In other words, why did these miners violate the rules? It wasn't ignorance of the rule. It wasn't ignorance of the danger. It was a desire to take a chance and not spoil their blast.

To correct that you have the matter of penalties. These men were all penalized; even the fellow that was hurt was penalized when he came back, but perhaps more important than that is the matter of supervision. This happened once, where the fellows got caught; God knows how many times it happened when they didn't get caught. It would seem that the shift bosses, the local foremen, possibly didn't know what was going on in the working places. In one mine that I know of the foreman issued the powder for every blast. They know conditions before the blast, and they issue the proper amount of explosives, and also twice each week they had to inspect the blasting operations in some contract and make a report on it. I don't think that that method was handled in this particular mine. If the method described had been used I doubt—well, I could say that the chances of this accident happening would have been very much lessened.

A second cause was the damp fuses. If the fuses hadn't been damp, of course, they wouldn't have had any trouble lighting them. If the fuse station had been moved closer to the working places it's probable that the men wouldn't have carried in such fuses or possibly would have gone to the fuse station to get them when needed. The fuse would have been issued in smaller amounts. Incidentally, this accident happened several years ago, before the well-known Federal Explosives Act went into effect. Since the accident, the corrective action taken was the building of a fuse house closer to the working places, the installation in that fuse station of a drying apparatus for fuse that had become damp, and the issuing of fuse in smaller amounts, the amount necessary for each day, and individual contract cans.

One might reasonably ask "why did not the supervisory force anticipate their condition?" Here you had a fuse station located at considerable distance from the working places. You were carrying in fuses in generous amounts, leaving them there for a day, possibly two days. Should your supervisory force have anticipated that these fuses would have become damp and had they inspected them at different times to see what the condition of the fuses was? I don't want to say aye, yes or no on that, except that possibly a little more intensive training of foremen might have taken care of this angle.

MR. MULCAHY: I think that the instruction angle of the mining industry is a very poor one. I think instruction to the foremen as well as supervision and through the foremen to the workmen is extremely important. This accident indicates to some extent at least that there wasn't a great deal of difference in the type of thinking, type of action that was peculiar to the miners, the man who was hurt, and that of supervision. It seems to me they were both willing to take a chance and probably as long as we're willing to take chances we're going to run across these accidents and as we get them we're going to throw together an investigating committee which probably, nine times out of ten, will not be composed of any better brains or any different brains than we had on the job regularly day by day, and that investigating committee is very likely going to find some better way of doing the job and a safer way of doing the job. The point that I would like to make is that it seems sad, to say the least, that we have to wait until someone is hurt before we put into effect better methods and safer methods. If somebody disagrees with that I'm not thin-skinned at all. I have a pretty strong feeling that a great responsibility rests with supervision and after all supervision is in the saddle as far as making necessary changes in mining operations.

I'm perfectly willing to listen to any different opinions on that score, however.

MEMBER: Were the men who were doing the blasting working contract, and were the foremen who supervised the job sharing in the production if a certain thing was reached?

MR. BEST: The men were working contract, but the foremen were on a daily-wage basis.

MEMBER: I can understand why the men failed, but it would seem to me there would be some system of checking the lighting as far as the issuing of the lighters was concerned. You run into that right along. Our neighbors had an accident where they weren't sure how many lighters were lit, and I can see why men in their effort to make more money are going to take chances when it comes to blasting a place where they're having a little trouble with water. I don't know what can be done about it unless you can supervise the number of lighters that are used in a place. We use a nine-inch lighter. We instruct our men if one man can do the lighting with one nine-inch lighter, okay; if he can't do the lighting with one nine-inch lighter then there must be two men with lighters, both lighting simultaneously, and when the lighter goes out the men go out with it, but I'm not saying that that's going to solve the problem.

MR. BEST: Those are the same instructions these men had.

THE CHAIRMAN: How many holes were they lighting?

MR. MULCAHY: I think there were nineteen holes.

THE CHAIRMAN: And a seven-foot fuse, and the fuse had been stored in the mine for a period?

MR. BEST: A couple of days.

THE CHAIRMAN: Was it very wet?

MR. BEST: It was damp.

THE CHAIRMAN: Just ordinarily?

MR. BEST: Yes.

THE CHAIRMAN: We had something like that ourselves. Our two men got killed, however. We weren't quite as fortunate as you were. After the thing was all over we shoveled out this drift rock and we found where they had trimmed the fuses twice—took their first trimming on eight inches and on the second trim, because they were getting close to quitting time, they trimmed it down again. They were contractors, too. I had pieces of fuse 21 inches long.

MR. BEST: I think this third man cut off a couple of feet instead of inches.

MEMBER: How about electric blasting and getting rid of the fuse?

MR. BEST: These fellows were more proficient in cap-and-fuse blasting than they were in electric blasting. That's something to be considered.

THE CHAIRMAN: Another thing we found in our case. We use carbide lamps for all of our lighting fuses but they are supposed to use a safety fuse. In other words, if they're using a seven-foot fuse, they cut it in half and light that. When the detonator goes off they're supposed to go out. We found the carbide lamp in the mudpile with the carbide in and no water, but they had used the Spitz fuse. You all know what that is; take a piece of fuse and notch it. Instead of notching it close they had notches further apart and that's where they lost their time.

MR. MULCAHY: Doesn't all this indicate that they're still taking chances and a lot of education should be done? It's the only way you're going to clip it.

THE CHAIRMAN: In order to settle it all, regardless of new men or old men, we went to electric blasting in all of our drifts; almost everything is electric blasting now. That taught us a lesson.

MEMBER: We had an accident almost identical to that. We, too, weren't quite as fortunate. One man was killed and one wasn't. In checking up on that accident we found a great deal of carelessness on the part of the men. I think that a great deal was due in that accident to the fact that we had two men not knowing what the burning rate of fuse was. We have told them fuse burns between 30 and 40 seconds a foot. In checking up afterwards I found that in every mine there was at least one man, and sometimes more—old time miners that had been working from 15 to 25 years in a mine—that had the idea that a fuse burned at the rate of a foot a minute; one fellow even said it burned a foot in a minute and a half. I think that was one thing that really caused our accidents. The fellow that was killed in that particular case had been working in our main drifts for over 15 years, continuous work in main drifts. That just shows that experience isn't always the thing. I think experience quite often leads to carelessness.

Just a short while back I happened to come into a drift and see some fellows making up explosives, and here was a man fixing his primer cartridge and doing everything right, except that while he was fixing it he had a cigaret burning in his mouth. That, to me, showed that carelessness was very prevalent among our old-time miners.

Just to get around and give these old-time miners a knowledge of actual burning rate of fuse we took ten-foot lengths of fuse and with a couple of stop-watches and several of their own men running the stop-watches we timed the burning rate of fuse. I think now all of our men know that fuse burns faster than one minute a foot. I think some of you might check and find about the same situation that we found.

MR. BEST: I'd like to bear out everything that was just said. One standard question that I ask every new employee coming into the mine is how fast does fuse burn. Since I started asking that question there have been over a thousand men hired. I've got four answers that were right.

MEMBER: What do they say?

MR. BEST: The 996 plus told me fuse burned one minute to a foot, and in our country it burns 40 seconds to a foot. There's the answer we're getting day after day. I think a lot of trouble comes in blasting accidents from that fact. I got hold of the powder up in Canada Industries, Ltd. They didn't know what was occurring and had no idea that the condition existed. This summer they have surveyed the situation just as I have done and right now they're driving that home in every way they can. The fuse that they make burns 40 seconds to the foot. I'll tell you another thing that's coming in now. We're getting a few men back from the Army. I don't know about the Army. When we get these fellows back from the Army Engineers and ask them that question they say "A minute to the foot; that's what the Army tells us." I don't know what you're going to do with those engineers back in your mines with 40-second fuse.

MEMBER: Mr. Chairman, I don't think that we should be so concerned about the time of fuse burning any more. I don't think that had anything to do with that accident. The thing that was basically wrong there possibly was the fact that there was no follow-up.

I can relate experiences along that line. We all talk about supervision, more supervision, which is absolutely right, and follow-up on the training. I have told men, the same as any other safety man has told them, how fast fuse burns, and I also told them that when that lighter burns out, you get out. If you can't light all of it with one lighter, two lighters should be lit at the same time, and when they go out, you get out. After a year one gang, because they were missed in the checkup, were asked how they lit their round. They answered "When one lighter burns halfway down and we have a lot of holes we light another one." Right there it proves that had the thing been followed up religiously and often enough we probably would have gotten rid of that lighting the second lighter when the first one burned half way. Fortunately we didn't get into an accident but it shows we could have.

Now, the time element is there. It's been figured out by somebody else and put on the market, given to the man to use and it's our job to make him use it and use it properly.

MR. MULCAHY: I think the discussion seems to boil itself down to either no education or not enough education or no follow up of the education.

MEMBER: There's one thing that we're losing sight of, and I don't think it's been brought out already. I don't think there's a man in this room that can take a piece of seven-foot fuse and light it and tell you when that fuse is going to go through, even if he knows the exact burning time per foot per minute. I don't think there's anybody here capable of judging time that way. If you sit down in a movie five minutes is no time at all; if you're waiting for your wife to get ready to go to that meeting, five minutes is half an hour. There's nobody who can do that. Men say, "I judge the time." There's nobody who can judge time unless he has a watch or time device, and that's the thing we have to impress on these men—you can't judge the time!

We give you a nine-inch lighter or a six-inch lighter and the rule is when that burns out you go out. That's the thing we have to insist upon. You have to set up a standard of time and after that has elapsed, those men have to leave the place.

MR. MULCAHY: Isn't the rest of the answer that when these fellows have worked with powder or anything else for years, they naturally prove the old saying that familiarity breeds contempt, and that's the thing you have to recognize and guard against.

THE CHAIRMAN: What alibi did the men have? Fast fuse?

MR. BEST: No, I don't think the men had any alibi except to say they took a chance. I know these three fellows.

THE CHAIRMAN: That's usually the alibi; "I had a fast fuse." Out of every carload of fuse we get we take so many rolls out of each box—one every carload—and we cut that in three-, six-, eight-, and twelve-foot lengths and we time that fuse—the burning speed of that fuse. We take the average of that, make a note of it and put it in each one of our magazines. I've seen that fuse go from 38 seconds a foot up as high as 52 on the same carload of fuse and same conditions.

MR. BEST: We test our fuse the same way, and this fuse that we left in the can was tested following the accident and burned at the regular rate after we cut off an inch and a half; and the timers burned at the regular rate. In some other mines with contract box cans there's a sign "The fuse you use burns at the rate of 40 seconds a foot."

MR. MULCAHY: We have another accident. To show we don't pick all the serious ones we picked some that resulted in less serious disability, but just to indicate what might happen to such things we throw them in once in a while.

Two miners were moving a scraper past a timber air hoist on a sub-level. As one of the men stooped over to remove a cable from under the scraper the air hose connection on the hoist gave way. The hose lashed out and the coupling attached to the end of it struck the man in the face.

Investigation showed that the air hose serving the hoist was also used for other purposes from time to time and that when it was rushed to the hoist after one of its other uses care had not been exercised in tightening the connections.

This is an example of an accident and injury resulting to one workman through the negligence of another. In all probability the accident would not have happened if the one who had last used the air hose had connected it securely when he lashed it to the hoist.

Mr. Fellman, I wonder if you will develop this a little bit.

MR. FELLMAN: This is a fairly simple accident to analyze. There are three fundamental causes, all related.

First of all, of course, is the one of supervision. This air hose had been used for other purposes. The miners had taken it off of that air tugger when they were short of hose. They'd use it and return it. That obviously is poor supervision, to allow a thing like that to go on.

Secondly, the carelessness of the workman who put the hose back and didn't see that that coupling was tight. That's obviously negligence on the part of another workman.

Thirdly, the fact that there was no safety chain on that hose. In other words, we come around to the third cause; the failure to provide the guard. If the guard had been there very likely the hose would not have lashed out far enough to have struck this man.

So here we have an accident which seems to me is a combination of just about everything that we've been talking about and should not do. Supervision failed, carelessness on the part of the workmen, the guard was not in place; that's all I have to say.

MR. MULCAHY: We have tried for about 45 minutes here to get down to what we call the fundamental causes of accidents, and as I started out to say the only way we could hit on what might give some idea of what they are was to take individual cases.

We're all concerned with preventing accidents, but we're all having accidents, and we're all providing the doctors with more work than they'd like to have just at this particular time.

I'm going to ask Dr. Johnsrude to discuss, from his experience in the Mesabi Clinic, some of the things that might and should be done in the way of first aid cases, to run the gamut of these things and give a pretty good overall picture of some of the things that are done that shouldn't be done, and some of the things that should be done that are sometimes forgotten in the way of first aid; just his general impression of what laymen, which we all are, can do to aid the fellow who is unfortunate enough to get himself hurt on the job.

DR. JOHNSRUDE: I think most first aid consists of overtreatment. That is, the fellow workers tend to try to do too much to help or alleviate the pain of the injured worker. First aid consists of leaving the patient or the individual alone and getting adequate medical help or care.

The first case we will discuss will be that of a burn. Now, burns may either be very severe, involving a large part of the body surface, or they may be relatively minor and involve only a small part of the body surface. Regardless of whether they're severe or minor, the best first aid that can be rendered is to see that the individual gets medical care. If it's a severe burn, the best care you can give him in the meantime is to leave him alone, keep him warm, and keep him comfortable. People that die quickly of burns die from shock. The treatment there would be simply treatment of shock. Don't try to treat the burn itself. Don't try to apply ointment. If the burn is very extensive and it's cold you can put on a simple dry, sterile dressing. The treatment the physician will use will vary and frequently the various greases will interfere with his treatment of the burn, so the best treatment of burns is to keep the patient quiet and see that he gets medical aid as soon as possible.

That also holds pretty well for first aid treatment of other conditions, as for instance injury to a leg or arm. If there is considerable pain in the extremity and it appears fairly obvious that there is a fracture, there is a case where you can do little more than simply leave the patient alone and attempt to splint it. I won't go into detail. Splint it either by tying the extremity to something solid, like a board, or use special splints for that purpose.

I think I should say that there are a few other things one should do in first aid. That is, determine whether or not a man is bleeding badly. Of course, if an individual is bleeding you have to stop it if you want him to stay alive. The best way, I think, is simply a tight pressure bandage on the bleeding area. They teach the use of tourniquets in first aid classes, stopping of arterial bleeding, but I have never yet seen a tourniquet applied correctly. I believe the best treatment is simply a tight pressure bandage over the bleeding itself. If necessary hold it with your hands because you can always get aid within fifteen minutes.

You should see that the injured man is breathing. If he's not breathing you must start artificial respiration.

To sum it up, I would say that first aid should consist first of all of stopping any hemorrhage, keeping your patient breathing, or starting breathing if he's not doing so, and leaving him alone. Keep him warm, comfortable, and wait for medical care.

THE CHAIRMAN: We train our employees in first aid and the fact of the matter it that I've seen lots of tourniquets applied correctly. I've had cases in our mine where we couldn't stop it with a tourniquet; the man was holding the pressure point and the doctor came out and couldn't stop the bleeding. I don't believe that they don't know how to put on a tourniquet. I'll say for our men they do, and we encourage them to do all first aid. I've seen a lot underdone but not overdone.

MR. MULCAHY: I think there might be something in this underground operation that you don't encounter in an open pit operation, where more than keeping a man at rest is indicated. I think there that the Bureau of Mines is doing a fine job in their instructions and that by and large the rescue crews and so forth are fairly competent in the handling of men.

MEMBER: I was rather surprised to hear your remarks. Thirty years ago the medical profession objected very strenuously to first aid in mine operation. I don't believe that the standard of first aid is as high as it should be. I may be incorrect but I don't believe you have run into the type of first aid work that you should have run into. Our doctors swear by it. I don't know whether you're acquainted with Dr. Ilsingil, the orthopedic specialist, or not. He was called into a case where a man had a fractured tibia just below the knee joint. The knee joint was involved. Two of the arteries were severed. Dr. Ilsingil made this examination of the limb and saw his X-rays. He was surprised that it was possible to bring a man out of an underground mine and get him into the hospital without that third artery being severed, and he wanted to know from our local doctor how that could be. You see, we have to carry them down through ladderways and things of that sort. We have to give the man first aid in the working place. We have to control bleeding. We have to apply splints and then we have to put him on a stretcher that will protect him while we take him down through these various openings and out and up from the mine into our hopsital. It takes sometimes as long as 45 minutes. I have known cases where they have had to dig men out where it's run longer, and first aid had to be administered while they're partly confined.

I appreciate your remarks, but here's old Dan Harrington—they've been hammering on this thing for years and I would hate to think our first aid was so poor that our doctors would have to say "Just let the man alone." Take in your case of burn. What produces the shock in the case of the burn? Isn't it the pain that the man is suffering?

DR. JOHNSRUDE: That's part of it; not all of it.

MEMBER: Then the nervous reaction and one thing and another, but it would seem to me a properly formulated burn treatment ought to relieve that pain, at least. Maybe I'm misinformed there, but my understanding is that there are good ones and bad ones.

DR. JOHNSRUDE: I think you have misunderstood me. I am not condemning first aid treatment. I did say that fractured extremities should be splinted, and I did say that you should see that they're breathing and see that any bleeding is stopped.

MEMBER: I'd like to ask the doctor if there isn't a time element in there that makes first aid very important when the injured man can't get to a doctor right away. We are underground some places over 2,000 feet and to bring a man out takes time. At other times we can get him out in a few minutes, and I've had a doctor say he would rather we didn't put on any iodine or mercurochrome if that is the case, but when it's a matter of time we should take care of him. He's seen too much overdone first aid where a fellow could be gotten to a doctor in fifteen or twenty minutes, and he was so painted up with iodine or mercurochrome that the doctor could hardly tell what was wrong with him.

MEMBER: I'd like to ask you a question in connection with the first case that we had. I happen to know that foil was administered there and the man was in the hospital fifteen minutes after the accident occurred. Should we have used foil? Foil and sterile bandages—he was burned pretty badly.

DR. JOHNSRUDE: The point is if you start with foil a physician will have to continue with it. Now, a physician may or may not want to use that particular type of treatment. If he wants to do something else he's going to have to do a pretty thorough scrubbing job to get rid of the foil.

MR. BEST: I think it's possible, too, that our first aid and medical departments are too widely separated. The medical department ought to have a whole lot to do with the type of first aid we teach and practice, so the two are working together. That would prevent us from getting all mixed up if, when a man is burned, the doctor wants to use foil and somebody starts using something else.

DR. JOHNSRUDE: I think that's a good suggestion. Possibly from where I come these people get medical care so quickly that a lot of elaborate first aid is not necessary.

MR. MULCAHY: I think that's why the men who represent underground operations here, Doctor, have taken exception to your remarks. By and large your experience has been with open pits, where it's a relatively short space of time that's required to get a man to a doctor.

There's another question that I think is interesting in connection with all cases, and

I believe the doctor can answer it: I have a notion that a man's mental attitude, about things not related to his job, has a bearing on his performance on the job and possibly can influence him either as a safe or unsafe workman.

DR. JOHNSRUDE: I think definitely a man that's well, both physically and mentally, a man that isn't worrying about either finances or his family's health, is less of a hazard than a man who is worrying about a wife who may have TB or a little girl who he is not sure might have to have a dangerous operation or something of that sort; he can't keep his mind on his work like the man who has no particular worries at home.

We've endeavored to give these families themselves the best of medical care as well as the worker.

MR. MULCAHY: I think that what prompted me to ask that question was a statement that was made to me just the other day by another doctor. He said he could show records that he had kept over the past years indicating that in the weeks immediately prior to Christmas, or the weeks immediately after Christmas the greatest number of accidents occurred.

He said that before Christmas they're wondering what kind of Christmas they're going to have and what Christmas present they want to buy, and after Christmas they wonder how they're going to pay the bills.

From my own experience I can't say that we have had a greater frequency of accidents prior to Christmas or after Christmas; I haven't any such record as that. I think you wouldn't have it so much in the open pit operations, where your operations during the Christmas holidays are practically nil, but I think there might be something interesting to develop there from other parts of the industry; underground mining may show something of that sort, and mills may show something of it.

MR. FELLMAN: It might be an interesting investigation but that's an old, old story about the mental attitude of the man on the job. What have we ever done and what can we do about it, as far as his home conditions are concerned?

MR. MULCAHY: I don't know what can be done about the actual home conditions, but I think there is something indicated that should be done. We go back to the old theme song—instruction; education. The foreman not only knowing the job to be done but the men to do the job. I think the foreman who can know every man and know as much about him as possible is a very valuable foreman, not only to the company but to the men. He may be able to place them in jobs that are more suited to their particular mental attitude at the time. It's a very tough proposition and I think everybody is beginning to realize, if they don't by now, that education of the workman is very definitely in the picture and is going to stay.

MR. FELLMAN: I wasn't questioning that, but take the doctor's example of a man with a tubercular wife and a child who needs an operation. Most any of us would worry about that. What can the company do in that case or in similar cases of which there are any number of variations of that same theme?

DR. JOHNSRUDE: I might add that in our setup the employee pays so much a month for complete medical care of himself and his family, so extra medical care is no added burden to him whether it touches himself or his family.

MEMBER: I don't think they do it as much now as they did probably ten years ago. Some of the companies, however, still maintain home nursing, that is, the industrial nurse, and I believe if you can get a girl that fully understands her responsibilities she can do as much toward cutting down your accidents, I would say, as anyone in your safety organization.