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MINING SESSIONS

MINING SAFETY INVOLVEMENT— FROM THE TOP

By R. W. SHILLING
Mines Plant Supt., Kennecott Copper Corp., Hurley, N. M.

The Chino Mines Division of Kennecott Copper Corporation is located in southwestern New Mexico and consists of two major operating plants. The mines plant is located at Santa Rita, and the reduction plant is located approximately nine miles south at Hurley. My comments primarily concern the activities at the mines plant, which is my area of responsibility.

The actual history of the Santa Rita mine dates back to the early 1800's when Spanish soldiers discovered pieces of native copper in surface rocks. Utilizing convict labor loaned from the Mexican government, underground mines were operated intermittently throughout the 1800's, decreasing in production as the copper content of the ore decreased. Some of the earliest copper produced was taken to Mexico by mule train to make Spanish coins.

Since open-pit operations began in 1910, production at Chino has increased to approximately 90,000 tons of material mined daily. Drilling is accomplished with 12-inch rotary drills. The blasting which follows is done by using a patented slurry mix composed basically of ammonium nitrate. Six-yard, eight-yard, and 15-yard shovels load the ore and waste into trucks ranging in size from 65-ton to 100-ton capacity. The ore is taken to an ore reloading station to be loaded into trains and moved by a common carrier railroad to the reduction plant. Approximately 625 employees, including hourly-paid and supervisory, are used in the mining operations.

Even during Chino's early development years, safety was a consideration, of course. With the passage of time, however, there was a growing realization that a more consistent effort was needed to make the work safe and keep it that way. As a result, a special department for safety direction and supervision was established. At that time, the safety engineer carried much of the weight of responsibility for the safety record of the operating organization.

Improvements in technology were accelerating about this time, however, and these demanded additional attention both by the safety man and all levels of supervision—especially the front-line supervisor. As we overcame some of the older safety problems, new ones arose in their places. The safety aspects of using radio-active devices, for example, could not be ignored, nor electronic equipment such as trains controlled by one man who operated a remote control system. So, while our blasting processes became safer, we had other areas to concern us.

I firmly believe that our supervisors have always wanted very much to have their men complete their shifts safely and return home without injury. And I believe that this desire was a powerful force motivating them to learn more about all technical aspects of their work, including safety.

As a result of changing demands in the safety field, we made some changes. The record, as I shall show you a little later, indicates these changes were highly successful.

Of special note has been the improvement in the special relationship between the safety department as a staff function and the supervisor as a representative of the line organization. We reorganized the safety department in 1956. Although it appears the activities of the safety engineer remained much the same as before, the major difference lies in the way these activities are applied. The safety engineer no longer thinks of things to be done by himself but, instead, assists and supports the operating or maintenance supervisor in carrying out a safety program which he can tailor to his own needs. In other words, the operator, not the safety engineer, develops the program. The safety engineer provides the specialized assistance necessary to get the most out of the program.

Merely revising the structure of an organization chart will not reduce severity and frequency rates, and this is not implied. But the lines on an organization chart do delineate the areas of responsibility, and that is where one should start in upgrading the capabilities and performance of the safety organization.

The question of where responsibility for safety should lie has been answered satisfactorily by most managements. Our management considers itself responsible for the safety of each of its employees. The division safety policy reads: "It is the policy of this division to maintain a safe and healthful working environment, and to establish and insist upon safe methods and procedures of work. Accident prevention and property conservation will start with planning and will continue through design, purchasing, operations, and maintenance. Integration of accident prevention measures in all activities is the Chino Mines Division's basic concept of safety."

I believe that this policy has given all our supervisors the proper direction for attainment of their safety goals. Those of you who are in coal, iron, or other types of mining are in business to mine your particular product as efficiently as possible and have established definite goals for your supervisors. The same is true of a supervisor working at the Chino Mines Division of Kennecott. He is charged with the responsibility of efficient mining of ore and reduction of that ore to a marketable product. And he is charged to do it safely.

Each supervisor is responsible within his own work area for production, quality control, industrial relations, costs, and safety. Each supervisor has definite goals to meet in each category. He develops these goals himself in consultation with division management to meet the overall needs of the division. The goals are difficult in many cases, but they represent an agreement between the supervisor and his superiors that they are reasonable and realistic. It is then up to the supervisor to meet these goals. A poor performance in any one of the areas calls for explanation and correction. There is no striking of an average. Top-notch performance in the area of costs, for example, will not offset a sub-par performance in safety. A supervisor who has an outstanding record for getting rock in the box will find this no help to him if he has poor marks in living up to his end of our contracts with the labor unions.

With responsibility, of course, goes authority. The supervisor is free to choose how he is to approach the tasks before him. He has the latitude to decide which areas will receive special emphasis as it may be required.

In attempting to state this program as simply as possible, I may have left the impression that the buck is passed completely to the front-line supervisor who is left then to stew in his own juice. This is not the case. Our method of accountability for job performance calls for total involvement from top to bottom. The supervisor regularly receives reports that tell him how well he is doing in each major area of responsibility. These can be stated in figures, so they are not matters of subjective judgment.

If the supervisor has a problem that calls for outside help, he receives it. He can get help on controlling his costs, improving his relationships with labor, increasing his production, or bettering his safety performance.

Finally, as we move up to each higher level of supervision, the responsibility for coordination and cooperation among the various units increases, so it is not necessary for one front-line supervisor to suffer for the inadequacies of another.

It is imperative that all functions of an efficient, productive organization be a coordinated effort by all those making up that organization. We feel that the foreman or supervisor must be impressed with the fact that safety is not an activity separate and apart from cost control, production control, industrial relations, etc. We want our supervisors to be conscious of costs and the effect his costs have on safety; we want them to be aware of production in their areas of responsibility, but more importantly, to know how to achieve maximum production with maximum safety. Safety must become an integral part of each and every function. It is literally following the National Safety Council slogan: "Schedule Safety Into Every Job."

Placing the responsibility for the safety of his employees on the supervisor has made a remarkable change in the severity and frequency rate at our mines plant. The three-year average frequency rate prior to 1955 was 24.9, and the severity rate was 6,451. In the following three-year period, the frequency rate was 8.6 and severity rate was 165. The downward trend has continued and

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for the period of 1967-1969 the mines plant frequency rate averaged 1.47. There were no injuries in the years 1968 and 1969, and the mines plant at Chino received the signal honor of being awarded the 1969 Sentinels of Safety Award from the American Mining Congress and the Bureau of Mines. This dramatic improvement in safety, I feel, is due to placing the responsibility for safety where it rightfully belongs—with management, especially the front-line supervisor who must tell his men how to work safely and see that they do it.

This does not ignore man's own self-protective instincts and desires but, rather, supplements them. We know the importance of sharpening the individual's instinct for personal safety and the supervisor's attention is directed to the employee's needs.

At one time, we believed that contests were of great assistance in developing our employees' sense of safety awareness, and we placed great emphasis on the safety contest program. Since then, we have de-emphasized the contest approach because we felt the initial impact was lost as our employees became more safety-oriented. They became aware that engineering, education, and enforcement are the real supervisory tools for safety improvement rather than promotion stunts. We still use publicity campaigns effectively but primarily to satisfy the individual need for recognition. Publicity is given to employees when small work sections complete over 2,000 work days without a disabling injury and each employee is given a small gift of appreciation. If such a record is achieved and the workers are not given the recognition, the supervisor soon hears about it. On the other hand, the astute supervisor is one who is encouraging such a record by bringing it to their attention long before the 2,000 days are completed.

Our employees have a voice in our safety program as well. Approximately seven years ago, management on its own initiative established an employees' safety committee composed of employees selected by the represented unions and supervisors. Monthly inspections are made by this committee, which incidentally, is chaired by a mid-management supervisor (our title is work center supervisor) and the plant safety engineer serves as secretary for the group. This committee also investigates all disabling injuries and all accidents having high potential for serious personal injury or equipment damage. The accident and inspection reports are given to the work center supervisor for his use. The committee's recommendations go to the front-line supervisor and he is generally the ultimate judge of whether or not the recommendations should be accepted. We have found these safety committees to be fairly impartial and objective in their judgments and we value this quality highly.

The critical opinions of others, especially those trained in their field, can be of a great deal of help in improving safety. That is why we welcome, rather than oppose, inspection by outside agencies. We have, in New Mexico, a strong, well-managed state office of mine inspection and our properties are inspected frequently. We consider this comparable to the service of an outside auditor in a business. It is another tool to be used by our supervisors.

We are also subject to inspection by the industrial hygiene section of the State Health Department which provides useful recommendations made by professionals. Both state offices also have demonstrated a willingness to offer their ideas and assistance in helping us implement changes in our safety program.

We have our differences with these inspection agencies—which is only natural. But when they recommend an action which appears valid, we take immediate action. If we disagree, we say so and are prepared to appeal if necessary. In most cases, however, we go into the matter with the agency involved more thoroughly and an agreement is reached.

We now are faced with federal inspection as well. In the past, we have found the U. S. Bureau of Mines to be quite helpful in matters of safety training and similar activities, and we are prepared to cooperate to the fullest with the federal people.

All our supervisors were furnished copies of the Federal health and safety standards and meetings were held to permit each one of them to review with members of the safety department any question concerning interpretation. Each supervisor has carefully reviewed his area of responsibility and has, in his opinion, placed his house in order. Management tells the supervisor that the inspection which is to be made by the Federal Bureau of Mines should be looked upon as an additional safety aid.

These three independent inspections made by the safety committee, state mine inspector, and the U. S. Bureau of Mines must be considered by the front-line supervisor to be supplemental to his own daily safety activities. The independent inspections can only assist the supervisor, they cannot be his primary source of awareness of his work area's safety problems—and this must come from his own daily inspections and from his own continual observation of his employees' work procedures. He is the one that is responsible; he is the one that must know.

Safety is an ever-present aspect of our business and yours. Machine manufacturers represented here are invited to have your field representatives contact our operating people and ask for safety suggestions concerning their prototype equipment. Let our supervisors share their safety experience with your engineering design people. Your manufacturing know-how can be used to improve the safety of your equipment. Instruct your salesmen to sell your line of goods because it is equipped with safety devices required by state or federal safety codes. Safety is a good selling point at Chino.

We at the Chino Mines Division of Kennecott Copper Corporation do not claim that ours is the only way to safety, but we do say this—our safety record is good because we make safety a part of every job rather than making safety a separate job.

REHABILITATION OF PHYSICALLY HANDICAPPED ERIE MINING COMPANY EMPLOYEES

By JAMES B. BOWEN
Supervisor of Safety, Erie Mining Co., Hoyt Lakes, Minn.

The mining industry relies on skilled, knowledgeable people to operate its respective properties. These people, in fact, are our most valuable asset. We are all well aware of the cost, time, and energy required to bring a new employee to the competency level of an experienced employee. Considering this fact, plus obvious humanitarian reasons, we have established comprehensive safety and health programs which are directed to the interest and well being of the employees. Medical and hospital benefit plans are furnished by the companies to workers. There is a definite trend to design plants and mining facilities with the health and safety of people in mind. Off the job safety programs are now a common practice with most mining companies. Our training efforts are generally centered around the employee and his physical and emotional health. Much has been accomplished, and more will be done in the future to protect the mining employee in his work environment. Even though positive protective measures have been taken, we have people who for one reason or another become physically handicapped. Mother Nature's degenerative process has not been eliminated. Congenital impairments that remain dormant during the earlier years of a man's life suddenly appear and cause difficulty with advancing age. We continue to have many off the job and some on the job personal injury accidents. These factors combined have produced a significant number of mining employees with physical handicaps. Of course, the conditions I have listed are true to a greater or lesser degree in all industries.

The question is how to arrive at an administrative program that will be consistent and fair to all concerned, and at the same time offer rehabilitative opoprtunities to this group of handicapped workers. We could attempt to ignore the fact that a number or our employees are and will be physically handicapped, or we could react without any great degree of consistency when we consider each case individually. We could also establish a policy requiring each employee to be physically able to perform all aspects of his job without restrictions or conditions. But these approaches leave a great deal to be desired. They may cause a great waste in valuable manpower, as well as social and economic problems for the employees with physical restrictions.

Therefore, we at Erie have chosen to establish a consistent administrative program that will explore all employment possibilities for the physically handicapped worker. Our policy accepts the proposition that some employees will become so severely handicapped that it will be impossible to continue their employment. However, we have found that the vast majority of employees who acquire impairments can be placed in job assignments which allow them to produce full time at a level that is adequate and justifiable. Providing suitable employment for the handicapped worker is the most satisfactory form of rehabilitation.

The cause of the impairment, the degree of impairment, and the response to treatment and rehabilitation will differ with each man. However, the administrative considerations given each case must be the same. Our standard practice procedure to implement the program is entitled the "Employee's Return-to-Work Physical Examination and Reassignment of Physically Restricted Employees." The procedure has been in effect since February 1, 1963. Each employee must have a return-to-work physical examination for any one of the following conditions:

1. Absent from work for 30 calendar days or more.
2. Major surgery.
3. Minor surgery with potential for rehabilitative work restrictions.
4. Private physician's statement recommending work restrictions.
5. Contagious disease.
6. Supervisor's opinion that the man is unable to perform his work.
7. A reported serious non-occupational illness or injury even if employee has no apparent after effects.
8. Occupational injury requiring work restrictions.

The supervisory will not allow the employee to return to work without a medical authorization if any of the conditions above apply. The medical representative on duty at the Erie Plant dispensary determines the type of physical examination required. The doctor may, in addition to his examination, request authority from the employee to obtain medical information from his personal physician by telephone or in writing.

Following the examination, the doctor may specify reasonably insignificant restrictions to be effective for a limited period of time. He would then complete the proper form and have the employee deliver it to his supervisor. If the supervisor understands the limitations and sees no problems with the restrictions, he may return the employee to work after going over the doctor's orders with the man. In the event a supervisor has questions, he may call the safety department for additional information. The examining doctor must forward his report regarding any severe restrictions which are effective for a prolonged period to the supervisor of safety. The employee will be informed by the doctor that his case has been referred to the Return-to-Work Committee, and he will learn the outcome of their meeting in a few days.

The Return-to-Work Committee was created by the previously mentioned standard practice procedure. The committee is composed of the supervisor of safety (chairman), the departmental superintendent (the physically handicapped employee's superintendent), and the supervisor of industrial relations.

The examining physician will be contacted prior to the meeting for the purpose of explaining all aspects of the employee's limitations or he may be asked to attend the meeting. Other supervisory, engineering, or administrative personnel may be called by the committee and asked to attend a meeting if their knowledge or advice could contribute to the outcome.

The supervisor of safety calls a meeting of the committee as quickly as possible after receiving a restriction report from the doctor. The group is varied and sufficiently knowledgeable to consider all aspects of the employee's case. The employee's superintendent explains to the committee the various duties that are required by the employee's regular job assignment. He may also, describe any other available jobs that he feels the employee is qualified to perform. The supervisor of industrial relations views the various employment situations for consistency with past decisions and labor agreements. The examining physician considers the man's health and physical ability to perform the various assignments as they are described or as he knows them to be from observation. The supervisor of safety, in addition to presiding, reviews the various safety aspects of the case considering the potential claims that could develop from occupational aggravation of the pre-existing condition.

The group may approve a job assignment during the initial meeting and make plans for notifying the employee and the supervisors concerned. After approval, the doctor will explain directly to the man involved all aspects of his restrictions and subsequently, the employee's supervisor will go over the restrictions with him to be certain of a mutual understanding. The doctor will inform the group of the follow-up medical care of rehabilitative treatment required, if any. If the case is non-occupational, the employee's personal physician will prescribe the follow-up care, the nature of the treatment, and the amount of time required. The health-care aspects are discussed and considered before any job assignments are made.

Often the Return-to-Work Committee will require a subsequent meeting or meetings, due to a need for additional information, the absence of available jobs in the man's assigned department, or if the doctor determines that the man requires additional time off the job for physical therapy or other other treatment.

In the event a job is not available for which the man is qualified to perform in his department, the supervisor of industrial relations will contact other departmental superintendents to determine what available jobs are open and are worthy of consideration by the committee. If no available jobs are found, the supervisor of safety notifies the general manager of the committee failure to place the employee in a suitable assignment. It then becomes the duty of the supervisor of safety to regularly review the employee's case. The industrial relations department also aids in the continuing search for job assignment possibilities. Every effort is made to find suitable employment as soon as possible for the employee. There have been some very difficult cases where suitable jobs were not available for long periods of time.

For example, an employee suffered a heart attack which resulted in a significant amount of residual damage. Four months following the attack, he presented himself for a return-to-work examination. The examining physician secured a complete report from the man's personal physician and then examined him. This examination resulted in some rather severe work restrictions. To add to the problem, the employee had limited work qualifications and his former job required a great deal of physical effort. The Return-to-Work Committee was unable to locate an available job that would comply with his physical limitations as well as his work qualifications. Six months later a job did become available, the employee was reexamined, and the Return-to-Work Committee made a satisfactory job assignment. The employee continued under doctor's care. After a year following his return to work his heart condition improved substantially, and he was able to work at jobs which offered him more income and responsibility. This individual was not forgotten when the committee was unsuccessful following his original attempt to return. The procedure calls for periodic review of those employees who are not placed in jobs. Without a provision of this nature, it would be very easy to completely forget those handicapped employees who are disqualified for one reason or another.

A review of the program for the year of 1969 and 1970 (to date) will indicate the scope of the Committee's action and the nature of the problems we have faced:

1. A total of 57 cases were reviewed by the Return-to-Work Committee.
2. Twenty-five of the cases reviewed were classified as occupational.
3. Thirty-two of the cases reviewed were classified as non-occupational.
4. Forty-three of the total fifty-seven cases were returned to jobs which were within their physical limitations and for which they were qualified to perform.
5. Ten of the total fifty-seven cases have not been returned to work and are continuing to be reviewed.
6. Four of the total fifty-seven cases appear to have severe physical restrictions that will prevent their return to work.
7. Twenty-six of the total fifty-seven cases were issued permanent work restrictions. (The restrictions were classified as permanent by the examining physician.)
8. Thirty-one of the total fifty-seven cases were issued temporary work restrictions. Of

the thirty-one cases with temporary restrictions, seventeen were of less than six months duration.

9. Thirty-one of the total forty-three cases that resulted in continuing employment were returned to their regular job at their same work location.

10. Eight of the total forty-three cases were returned to their regular job at a different work location.

11. Four of the total forty-three cases were returned to a new work assignment.

12. The nature of the physical impairments reviewed are as follows:

Impairment	Number of Cases
Back	21
Heart	12
Emotional Disorders and Alcoholism	6
Leg and Knee	5
Hand	4
Ulcer	3
Bronchitis	2
Eye	1
Shoulder	1
Hernia	1
Foot	1
Total	57

This program, like any other which attempts to rehabilitate handicapped workers, has its disadvantages along with its advantages. Of the disadvantages, let us consider the following:

1. The possibility of poor morale resulting when a handicapped worker produces less than his healthier counterparts. This will be minimized by properly placing the employee where he is producing a normal day's work.

2. The company's integrity could be challenged by claims of favoritism, if handicapped workers are not provided jobs consistently.

3. The company's integrity may be challenged by claims that the objective of the program is to improve the safety record. This point is not considered valid when non-occupational cases are given the same consideration as occupational cases.

Let us now consider the advantages:

1. The consistency of the program assures proper follow-up medical care and rehabilitative treatment, because the handicapped worker is under the control of the examining physician. If the case is occupational, the examining doctor will directly supervise the treatment. For non-occupational cases, the examining doctor will cooperate with the worker's private physician to assure necessary care.

2. The handicapped worker and his family continue to enjoy the fruits of employment. The worker remains an active member of society not dependent on social welfare programs.

3. The physically handicapped worker is less likely to develop psychological side effects from his impairment if he is employed and active.

4. Overall employee morale is heightened, we believe, by a fair policy of continuing the employment of the handicapped. We feel that most employees are proud of their company for this practice, realizing that they too could have problems in the future.

5. Employees who are properly placed in jobs where they can perform a normal day's work will produce at 100 per cent capacity, and the company retains their knowledge and skills.

Obviously, we support this program because we feel the advantages outweigh the disadvantages. We are convinced that controlled productive work coupled with close medical observation is the most successful form of rehabilitation.

A SYSTEMS SAFETY APPROACH TO MINING

By DAVID V. MacCOLLUM, P. E.
Director of Safety, U. S. Army Strategic Communications Command,
Fort Huachuca, Ariz.

We are in the midst of a consumers revolution and, because of it, safety has taken on a new dimension. As managers, engineers, miners, travelers, homeowners, etc., we all are involved in the role of being a consumer. Whether it be mining machines, construction equipment, or the automobile you drive; the airline you fly in; your wife's automatic washing machine or her electric kitchen appliance, or any household product or tool, you as a consumer are concerned with its ability to perform reliably and safely.

You need only to pick up the evening paper, glance at public interest magazines or look at the TV news reports to become appalled at the number of accidents which are the result of unsafe products or services that were performed in a hazardous manner.

What has happened to cause widespread failure of consumer products and bring about a seemingly national sport of filling our courts with lawsuits arising out of defective and accident-producing products, machines, and systems? We need only to examine the products of our technology to recognize that our progress for creating new things has exceeded our capability of examining our new inventions for all the possible hazards that may be inherent with their use.

As a result of inadequate safety considerations, Ralph Nader has been labeled both as a crusader and as a possible trouble maker. We are often dumbfounded as to the immensities of an "adequate award" obtained by Melvin Belli in accident cases arising from occupational, traffic, or products accidents. Such notoriety has made the public awake, aware, and anxious to do something about protecting themselves from unsafe products. Unfortunately, when a rebellious public confronts our state and national legislators with safety problems, reason often goes out the window in an attempt to right some wrongs, and we become saddled with punitive-type safety laws that do not correct the underlying accident causes.

The broad gap that exists between the consumer's requirements for safety and the designer's specialized knowledge is making safety a recognized branch of engineering. This broad gap is magnified by managers not fully facing up to their safety responsibilities, when they attempt to avoid liability for unsafe features by legal means, rather than establishing a workable policy concerning equipment or product safety. Also, our trade associations have often only talked about safety while actually pursuing a policy of foot dragging.

Today many factors cause things used to be hazardous. Each of you know of mining equipment or processes that are unsafe. We need to examine the basic unsafe factors that exist in the use of almost anything we use, and we will find them to be variables.

To achieve absolute safety, we must consider machine failures, the interface of the machine to man, and allow for safety factors for the man. Unfortunately, most designers' experience and training normally only encompass obvious machine failures, a bit of human factors (in the dimensioning for the configuration of controls; for example, as the relationship of the machine to man), and practically no knowledge of man's behavior, which includes irrational actions that are conducive to creating accident-producing situations.

We can now go one step further and show that machine failure may be induced by environment, failures of the interface of man and machine may be induced by environment, or man failures may be induced by environment. Now we can begin to recognize that the use of almost any product can be considered as a system. For example, this comparison becomes obvious if we relate our daily automobile transportation as a simple system.

The automobile is recognized as the machine, and it is not difficult for us to identify the many types of machine failures that can arise. Next is the relationship of the auto and man, which concerns us with the human factors; these can be related down to just how comfortable the seat of the car is for the driver. The behavior of the man should next be considered, and believe me, when we design an automobile that can sense when the driver is drunk, and has a failsafe device that prevents him from starting the vehicle, we will really have begun to whip one of our biggest accident producers. Last but not least we must consider environment, which encompasses all the many conditions that we may expose the car and the driver to, such as the road, weather, and altitude. With this approach in mind, we are analyzing safety from a systems concept.

We now have the advantage of examining all facets of a particular piece of equipment and being able to relate how a possible insignificant failure of a minor component can be parlayed into a major catastrophe. To do this we need to examine first those events that are considered to be undesirable. Unfortunately, our initial thoughts are often concentrated upon the spectacular, such as the death of an astronaut, a bridge collapse, or other newsworthy accidents which are considered to be the result of a gross hazard, whereas many injuries and deaths of maintenance and operational personnel over a long period of time are often callously viewed as inconsequential.

Little credence has been given to accidents as natural phenomena. Accidents will occur if the proper conditions exist and/or inappropriate behavior is involved. Accident investigations often reveal gross design omissions as the causative factors. This has produced a blame placing syndrome at management level. This management failure has made safety such a disagreeable subject that there has been little incentive for engineers to suggest that logic studies be made on new designs to identify accident-producing events. Further, because of this psychological block on accidents, there is an inadequate information retrieval system to provide a sound basis for avoiding old errors in new designs.

Let us now consider the sequence of undesirable events which might surround the loss of a large passenger aircraft. Included in the design of a new aircraft is a horizontal stabilizer that is taken from the design of an older aircraft of comparable size. The stabilizer is operated by an electric switch controlling a reversible electric motor which turns a worm gear, thereby moving a screw jack that forces the stabilizer down or back to a level position, depending upon the direction in which the worm gear is rotating. There is also a manual trim wheel, located between the pilot's and copilot's seats, which accomplishes the trim via the horizontal stabilizer. It is known that the pilots cannot override the electric motor to the worm gear with the manual trim wheel.

A logic analysis showed a critical hazard existed. It was reasoned that if the electric switch to the motor for the horizontal stabilizer were to fail in the depress mode, the aircraft would be placed in an outside loop and would therefore crash. The sequence would take only one or two minutes. The pilots would have practically no time to save themselves from catastrophe by finding the circuit breaker and throwing it open. The mechanics of this hazard are simple. The surface of the horizontal stabilizer is very large, as compared to elevator surface. The pilots have only a short time to control the aircraft, because the authority of the stabilizer soon exceeds the correction that can be made by the elevator. Therefore, the aircraft is quickly placed in an irreversible outside loop and then is destroyed. The switch is a good example of inadequate safety design. The designers of the horizontal stabilizer of the earlier aircraft only considered failure of the electric motor and provided manual trim as part of the horizontal stabilizer. They did not recognize the consequences of the switch failing in a closed position, thus depressing the horizontal stabilizer, which in reality is the worst possible event. Suppose the accident experience of the earlier aircraft included the loss of two aircraft over the ocean shortly after changing elevation. No investigation of these crashes would be possible to reveal switch failure, because the wreckage could never be recovered.

Now that we have had an example of a probable accident analysis that could result from an undesired event (such as a switch failing in a closed position), we can apply some terminology and develop a fault-tree analysis. Logic symbols are used to adapt the analysis to a graphic presentation. The basic symbols include:

1. And Gate. This describes an operation where all input events must coexist to produce an output event.

2. Or Gate. This describes the operation when an output event occurs if at least one of the input events is present.

There are no restrictions to the number of inputs that can be placed to either type of gate. The other symbols used to graphically represent the analysis are:

1. The rectangle. This describes the fault events that result from the combination of more basic faults that have passed through logic gates.

2. The circle. This describes the basic fault inputs that require no further development. They may include component failures that were identified by testing.

3. The diamond. This describes fault inputs that are not developed.

A simplified fault-tree for the trim system can now be graphically illustrated as shown in Figure 1.

The fault-tree graphically charts the route that an undesirable event can take to cause

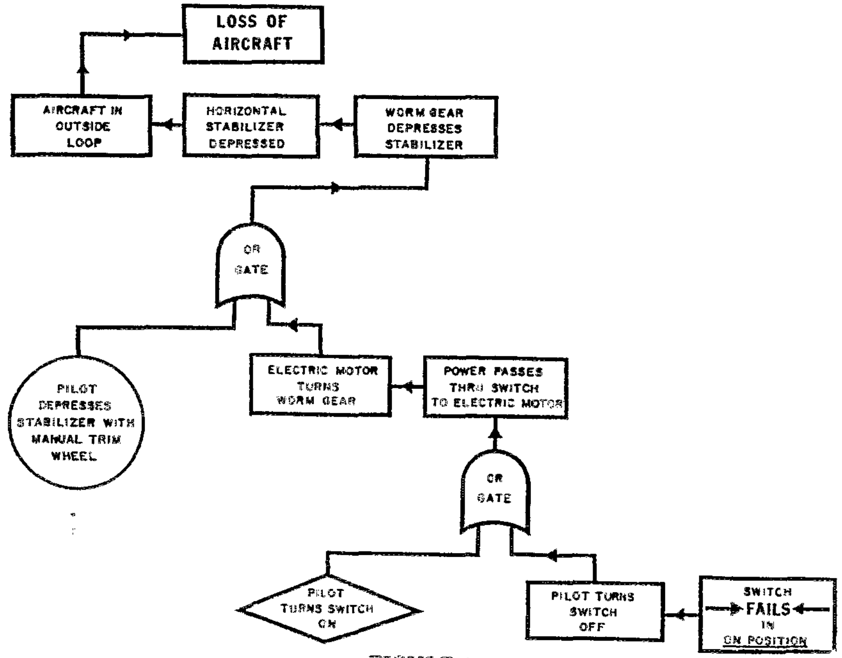

FIGURE 1

a catastrophe. It clearly presents to the designer a number of places where the cycle can be interrupted for the insertion of a safety device to make the system fail-safe. Caution dictates that a new fault-tree be graphed showing the added safety device to assure that no new hazards are introduced into the system.

Assessing Accident Risks

With the sequence of undesirable events schematically portrayed, the risk of accidents can be assessed in meaningful values: i.e., one in a hundred, one in a million, and so forth. The likelihood of the undesired event occurring can be synthesized to determine whether management can live with this risk of failure, or instead can support the cost of design changes necessary to overcome the hazard. A cost-conscious management now can make decisions based on the knowledge of the possible mode of the undesired event, the likelihood of the undesired event occurring, and the cost of eliminating this event with which they feel they cannot live.

The determination of acceptable risks is in itself variable. For example: a picnic is planned for the next Sunday if it doesn't rain. The weatherman predicts that there is a chance of one in a hundred that it will rain on that Sunday. The normal picnic planner considers this an acceptable risk and proceeds to schedule the picnic. However, if we are designing nuclear warheads and the physicists tell us that a design weakness will cause a premature detonation at the rate of one in a thousand, we all recognize that as an unacceptable risk, because of the severe consequences that will result from a nuclear blast.

The ability to assign reliability values of component parts to the fault-tree logic format affords the project engineer an overview of how safe the design is and provides management a basis for determination of an acceptable or unacceptable risk.

Boolean algebra is used to symbolically express the fault-tree in terms of inputs. These algebraic expressions can be simplified to show the combinational effects of these values. For complex equipment, machines, or systems, such as intercontinental rockets, the computing can be done by any desired mathematical refinement or application such as the Monte Carlo or Bayes formulae, which can be mocked up for machine solution by a computer.

A simplified version of determining the chance of accident is shown in Figure 2.

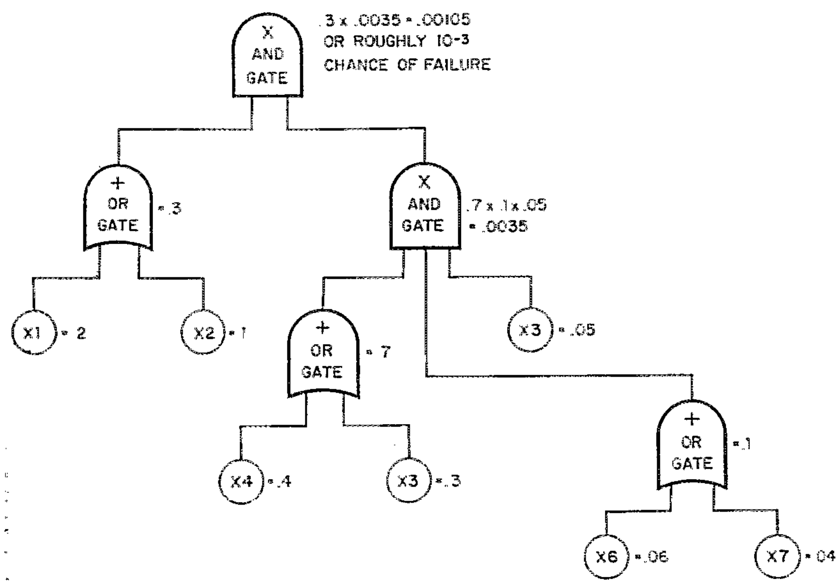

FIGURE 2

The biggest value of this systematized approach is that it affords an engineering department a method of identifying critical hazards during the design period. Cost of corrections made on the drawing table are negligible as compared to costly change orders during the construction or fabrication period. Testing agencies can also make good use of the fault-tree analysis to graphically assess the existence of all possible undesirable events that can result in a serious accident. Testing agencies should develop their own fault-tree graphs and use them as a test of the developer's analysis. A mere review of the developer's fault-tree can lead to prejudiced thinking rather than unbiased logic.

Deductive, intuitive methods

Previous to this symbolized approach to safety engineering analysis, methods had been largely restricted to deductive and intuitive processes to identify hazards. As long as engineers designed simple devices, they were fortuitous in not creating hazards. However, as design becomes involved in more complex mechanisms, the probability of overlooking the latent hazards is a steadily increasing risk. Preliminary hazard studies by safety engineers will give a cut out of the system, and the fault-tree analysis can be applied where detail is required. In areas of severe hazards and risks which have horrendous consequences, the Markov processes can be followed to consider all the effects resulting from the interactions of all possible failures within a complex system or subcomponent.

There are some pitfalls possible when making analyses of this nature, and they can lead to confusion when inadequate mathematical foresight is applied. Consider a machine with 100 components in series, each 99 per cent reliable—the machine is really only 36 per cent reliable. If the machine has 400 components in series, it has only a two per cent reliability. If it ever works at all, it is more luck than anything else. In actual practice, the eventuality of a catastrophic accident is not nearly as inevitable as the example of a machine with 400 series components. The assumptions applied to this circumstance were: first, the failure of any component is independent of any other component's failure. However, a machine with many components is not likely to fail every time any one part fails. The failure of one or more of the parts may only cause reduced levels of performance rather than a complete breakdown of the machine. Therefore, when applying this theory to the impact of the failure of individual parts to a machine, it cannot be treated lightly. It is at this time that the safety engineer, experienced in fault-tree analysis, can provide assistance to the engineering department. He can channel into the fault-tree logic diagram the performance characteristics of the individual parts, as shown by test, and thereby determine the possible hazardous combinational effects.

With this knowledge available and accessible to managers, this technique can be applied to almost any area of construction, mining, or manufacturing. A quick example can be applied to the accidents which have involved heavy earth moving equipment that are diesel-electric powered. Such equipment when used on a straight-away at high speeds functions fine; however, when it is used on steep, curving, winding narrow mountain roads, where low engine speeds are required, the servo-motor systems become less responsive and, therefore, the vehicle becomes less controllable and is now an accident producer. This is just a hint of the many areas where the machine is not properly related to a specific function in our technology of handling of earth which has not been adequately studied for safety efficiency because of a lack of a systems approach.

We are entering a new era whereby a complete safety analysis is needed. The specialized system safety engineer has proven his worth as a member of the design and test field of the aerospace and electronics industries. His talents should be applied in other areas to help bridge the gap that exists between "we" as consumers, and the designers and managers who bring us the benefits of today's technology.

Perhaps some of the concepts are difficult to easily relate to hard-rock mining, but they do. Your rock bolting technique is a system to stabilize your excavations. Your material handling machinery such as hoists, conveyors, and mine trains have become complex, sophisticated, automated equipment, which now demand a system safety analysis to assure they are safe. Human factors, reliability, and maintainability must also be considered as part of the safety requirements. Therefore, we all must consider that as we rely more and more upon machinery to do our back-breaking work, the people who operate and work with machines now depend upon the safe design of the equipment as a major index of their own safety. In short, our safety responsibilities have become tremendously magnified with automation. Management has not fully recognized the change and is attempting to manage the super-automated mine with horse-and-buggy safety concepts.

PROPERTY LOSS PREVENTION AT MINES AND PLANTS

By CONRAD DUNN
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Although loss prevention problems vary with different industries and even with the different mining operations, loss prevention principles are basically the same for mining properties as they would be for paper mills, shoe factories, and electronic plants. It all boils down to the human element—people—and the physical element—fixed and portable protection.

From about the middle of the 19th century until the present time, coal mining, with its inherent gas hazard, accounted for over 14,000 deaths.[1] The cause of these disasters varied but were primarily due to smoking and open flames; blasting and explosives; electrical arcing; flame safety lamps; fires; and friction and sparks, in that order of importance.

During a similar period, in the metal and non-metal mining operations (excluding coal) some 1,305 lives[2] were lost due to mine disasters. Of these, 504 lives were lost due to fires and 399 due to explosions. Other loss of life was due to cave-ins, flooding, etc. Although most of the explosion causes were identified, most of the fire ignition sources were unknown. In the early days many fires were attributed to candles, carbide lamps, and surface fires where products of combustion were drawn into the shafts. One of the major disasters occurred at a copper mine in Montana where 163 persons were killed. This disaster was attributed to the ignition of a power cable by a carbide lamp. Timbers were ignited, and most of the miners were asphyxiated by the products of combustion. There have been several foreign mine disasters where the loss of life has exceeded this. The world's worst disaster was in Manchuria in 1942 where 1,549 workers[3] were killed in a coal mine.

One of the odd things that struck me was the large number of disasters in the early days which were attributed to, "Drawing gasoline by carbide light." I said to myself, "Surely no right thinking person would do such a thing nowadays"—or would they? And then I remembered reading some of our own loss statistics which show that people do things that are unbelievably stupid like throwing lighted cigarets in a tank of naphtha. Would you think people would do this? They do! Thus the human element comes into play.

However—enough of the statistics!

The primary hazards associated with surface installations are fires and explosions. In underground installation the primary hazards are not only fires and explosions but also include flooding, cave-ins, and hoisting accidents.

An effective loss prevention program at any property requires the interest and backing of top management. Any program has to be an active program and not a paper program. There has to be a man in charge with clear channel to top management and on the management staff. His title is immaterial. He could be called Director of Property Conservation, Plant Emergency Chief, or even Chief of Plant Protection. His title doesn't matter as long as he has management's backing and their ear. There should be various departments reporting to him such as the Safety Director, the Fire Chief, and the Security Chief, and under these staff members there will probably be other staff members such as safety inspectors, fire inspectors, plant guards, and others.

There should be an emergency organization and the duties should be in writing. Once organized, the people must be trained and periodic meetings held to keep personnel up to date and drilled in emergency procedures. Each man should know to whom he reports and know his responsibilities.

Don't forget to provide for second and third shifts and for those holidays and vacation shut-downs. Provide alternates for each position in the event of illness or vacations, and keep your organization up to date by replacing those who have been transferred or retired.

Our loss statistics show that for the 50,000 or more locations insured in the Factory Mutual System, there are about 8,000 reportable losses each year. This means that the average plant has one reportable loss about every six years. For each plant that reports two losses a year, one plant has to go twelve years without having a reportable loss. Consequently, it is hard to keep a group on their toes if they will be needed only on an average of once every six years. However, in order to function properly they must be on their toes, and this means training and periodic drills.

If a group is properly trained to act promptly at times of fires or explosions, they will also act promptly in such emergencies as floods, blizzards, tornados, riots, etc. In nearly all disasters reported by the Bureau of Mines and from our own Loss Analysis Section, we find one thing in common—human element failure. We can't eliminate the human element so we must be prepared to control it.

The physical element is much easier to engineer and control but can be somewhat more costly to implement. Most mining operations are basically non-combustible and wet to a certain degree. Why not go as far as possible in making your operation non-combustible by using metal, asbestos, or concrete buildings? Eliminate wood from your shafts and drifts by using concrete and steel. Where wood cannot be eliminated, use sprayed on concrete or similar material to flameproof the wood members.

Where there are store rooms, both above and below ground, it is impossible to eliminate combustibles. Rubber conveyor belts are very common in mining operations today, and process equipment may be rubber lined to cut down on the abrasive action. The only practical answer is automatic sprinkler protection. Automatic sprinklers in mines? Why not? They are reliable, they're always on duty, they are not adversely affected by smoke and heat, they discharge less water than hose streams, and you've eliminated most of the human element.

I'm sure I've heard all the arguments against sprinklers many times, but I don't think they are really valid. The more common arguments why sprinklers cannot or need not be installed are, "The shaft is wet." "The wood won't burn." "Those timbers are too big—you can't set them on fire with a blow torch." "That conveyor belt is covered with ore—how can it burn?"

About two years ago 21 men were killed in a wood lined shaft that was "too wet to burn" but somehow a welding spark ignited the timbers and the shaft did burn.

While it's true you may not be able to burn a large timber with a blow torch, you can ignite it with a welding spark, and you can ignite any size timber with a single match if you have the proper fuel arrangement. A few years ago, there was just such a proper fuel arrangement at an air intake shaft. The timbers were 3x12's, 4x8's and even 12x12's. Even the joints were sealed with gunite. However, the timbers were ignited by a welding spark, resulting in considerable property damage and the loss of one life and four injuries.

One of the more common fires at mining properties today is in the conveyor rubber belt. Even the so-called "fireproof" Approval No. 1 by the National Coal Board or the "fire resistance" U. S. Bureau of Mines 28-1 rated rubber belt burns. We have the losses to prove it. I know of no rubber conveyor belt that does not burn, and they are usually ignited by a welding spark, friction or, occasionally, by hot ore. Rubber belts, like shaft lining, need sprinklers.

So far, we have been talking in terms of loss of life, which is generally uppermost in our minds, but, what about property loss and business interruption? One of the most disastrous losses to occur in modern times was at an iron concentrating plant in Newfoundland. There were six autogenous mills with rubber lined spiral separators and rubber lined launders. A worker repairing a launder ignited the rubber with a cutting torch. The fire went undetected and eventually involved the entire mill. Although the loss was originally estimated at about $17,000,000, it was adjusted at slightly more than $11,000,000, which is still an awful lot of money.

What did all these losses have in common? They lacked sprinkler protection which had

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[1]Humphrey, H. B.: *Historical Summary of Coal Mine Explosions in the United States 1810-1858.* Bulletin 586. Bureau of Mines 1960.

[2]Hyvarinen, John, Leland H. Johnson, and D. O. Kennedy: *Major Disasters at Metal and Non-metal Mines and Quarries in the United States (Excluding Coal Mines).* Bureau of Mines Information Circular 7493 April 1949.

[3]*Chicago Tribunte World Almanac* 1970 Ed.

en installed for one reason or another. st cases, sprinkler protection is prac- ınd can be installed. Without it, the properties are vulnerable to serious fire ossible loss of life, not to mention the ant loss of production and physical e. A number of companies are begin- o realize the value of automatic sprin- and are installing them underground.

losions are a hazard to be reckoned it any property but generally present of a problem in coal mines. Explosions iding the use of explosives) can gen- be categorized into flammable gas, able liquid vapors, and dust explosions. usually do not present too much of lem except at coal and possibly sulphur gilsonite mines. Most mines do have able liquids in them, and there is al- a possibility of a flammable liquid explosion.

same standards pertain to most haz- s materials whether they be gases, va- or dusts, and whether they be above or ground. These are:

Isolate the hazard. Locate it in such a r that a fire or explosion will not e your other operations.

Confine the hazard to the area. This require curbs and drains for flammable s, explosion venting, embankments or resistant walls, and fire walls for the lous materials.

Provide safety ventilation to keep the or flammable liquid vapors at 25 per of the lower explosive limit.

4. Eliminate ignition sources such as matches, open flames, and cutting torches. All electrical equipment should be safe for the occupancy.

5. Provide proper protection in the form of automatic sprinklers with an adequate water supply plus fire extinguishers and fire hose.

6. Train employees to act effectively to sound the alarm and to execute previously *assigned duties.*

These precautions may sound overly simplified and the problems may not be easily solved. However, your insurance carriers have engineers and specialists that are expert in these problems and will be glad to help you set up a loss prevention program.

Loss prevention is human and physical. On the human side, develop a property conservation program that has the backing of top management and is headed by a management staff member. Develop, educate, and train personnel in all conceivable emergency procedures, and keep your organization up to date.

*On the physical side, eliminate all com*bustibles practical by using metal, asbestos, or concrete construction including buildings, shafts, and drifts. Where combustibles cannot be eliminated, provide automatic sprinkler protection plus fire extinguishers and hose. Control the hazardous materials by confining and isolating them.

Property loss prevention is up to you.

FIRE PREVENTION TECHNIQUES FOR A MINERAL OPERATION

By C. R. E. ALLEN
P. Eng., V.P., Marsh & McLennan Ltd., Toronto, Ont.

e waste takes an increasing toll nearly year. Property waste and loss of life ics set new records almost as a matter urse. It leaves many of us who work in ield with the conviction that Murphy's applies to fire protection; that is, if hing can go wrong, it will. To put it clearly into fire protection terms, if hing can catch fire, it eventually will. Over the last twenty years, I have become increasingly convinced of this, and frequently refer to myself as a professional pessimist.

This comes about partly because the fire catastrophes and loss of lives in fire tragedies that occur give one a distinct sense that history is repeating. There is probably no field that receives as much attention where the fundamental lessons are so well known.

To illustrate, it seldom seems that I read anything about a serious fire in a mineral operation where the cause was anything but welding. One would suppose that some method could be developed to control this obvious hazard, but it seems that each individual involved must learn the lesson personally before he really becomes convinced that the trouble of taking precautions is justified.

There are many other illustrations of this nature. Literally hundreds of millions of dollars worth of lessons to be observed, and all now free for the learning! The fact that *these lessons are so continuously* demonstrated and so continuously ignored prompts one to suspect there is some force at work to frustrate man's desire to be safe from fire.

After all, observe the thousands of individuals who read and study the work done by the National Fire Protection Association, and the many hundreds who contribute to this work. Observe how often fire safety subjects are discussed at other meetings such as this one. It is almost a universal statement to deplore wastage of the nation's riches by fire, yet it goes on. One may reasonably come to the conclusion that the answer lies in inherent personality traits.

Many will recall how Parkinson's Law spotlighted some human foibles. Parkinson's description of the directors meeting is a delightful illustration of bumbling in high places which is very amusing, particularly if you do not happen to be a director. In a similar vein, Peter's Principle brings into sharp focus the tendency for many positions to be filled by people incompetent to properly do them. *Perhaps in the writings of such acute* observers, we can find some reason why supposedly responsible intelligent businessmen keep having plants and equipment worth millions of dollars destroyed by fire each year.

This is certainly as true for the mining industry as for any other class of industry. Mining can be made virtually immune from disastrous fire. After all, most of its operations are of very low inherent fire hazard. The fire protection state of the art has progressed to the point that these low hazards can be controlled. Yet serious fires still *occur in the industry.* One occasionally suspects that mining management has a hidden fifth column of members who sabotage the good intentions of others. Before we explore this further, let us cast an eye out for broad lessons from fires in general.

Few lessons available from fire are as dramatic as the one which is probably the world's most widely publicized tragedy. The death of three astronauts in their capsule when fire occurred during a training session shocked the world. According to press reports a tremendous effort was directed to complete review of all *contents of the* capsule and innumerable modifications were made to eliminate burnable materials and possible sources of ignition. While this dramatic occurrence may seem far removed from our humdrum business affairs, it brings out one essential feature: the intense activity directed towards fire safety only came after *the tragedy occurred. Top decision-making* management directed their whole hearted attention to fire safety only after the event.

This story is repeated over and over in the business world. It brings us to fire safety technique number one: top operating management must give clear support and direction to fire safety efforts.

This tragedy has one aspect that is continually thought provoking, even astonishing The space program represents one of the greatest technological achievements of the world's most technological society. Yet this *program suffered* a severe *slowdown from* one of man's earliest perils, fire. One tends to wonder how the array of talent marshalled to the space program could have left an opening for such an occurrence. Those of us who follow more mundane pursuits may be excused an occasional feeling of hopelessness.

On the other hand, perhaps there is something here deserving of thought. Innumerable times I have attempted, and I know other fire protection people have also attempted, to use lessons from a specific loss as an argument why people should adopt some particular fire safety measure. A common response is, "Our operations are different." *Often the differences are very superficial.* A manager will, in effect, tell you that the one that burned was red but his is green, so it can't burn. Usually objections are a little more sensible than this, but often not much.

This aspect of resistance to well recognized fire safety measures is so widespread as to merit emphasis. All of us see ourselves as unique, and our work and our plant as different. However, fire hazards at a vehicle maintenance center are about the same whether the vehicles haul ore from a mine or building supplies to a contractor's work site. Computer and other office operations at a large mine are very much like those at any other large plant. Rubber belt conveyors carrying ore around a mineral operation are very like conveyors carrying commodities to a ship at a port or coal from the yard of an electric generating plant. These few illustrations are enough to make the point. When fire occurs at an industrial operation, it usually has a lesson that is applicable and can be useful to others, even if the others are in something so unique as a mineral operation.

This leads us to fire safety technique number two: learn from the serious fires of others. This fine advice is one of the few areas where one can get something for nothing. All too often people hide behind the fact that they are "different," and therefore ignore the lessons. Perhaps we touch here on the secret of why fires keep happening over and over, even though the same fundamental weaknesses are involved. Of course, it is likely that you may not be familiar with all the fires that have occurred elsewhere. This is where fire protection advisers come to the scene. It is a fairly easy matter, through one's insurance company, through other industries, through the N.F.P.A., and from fire protection seminars, to find someone who will be pleased to draw your attention to examples of fires that have occurred in operations with similar features to your own.

At this point we should consider one major difference between fire safety and most other accident safety. The successful approach in most safety work is bound up in the word prevention. In fire safety work we take the view that most people are prudent and will try to prevent fire, but even the most conscientious not only cannot be certain of success, but are certain to fail. That is, if something can burn, it will eventually catch fire. You can now see where I get the label of professional pessimist.

If one had to pick the most influential single error of judgment behind major fire loss, I believe, it would be that many managers think that fire safety can be achieved by prevention alone. Thus, when the inevitable fire occurs it becomes serious due to the absence of vital fire protection equipment. Fire safety technique number three is: identify what can burn, assume it will catch fire, and answer the question, "How will this fire be most quickly extinguished with minimum damage?"

An interesting thing to observe after a large fire is the fire protection equipment incorporated when the structure is rebuilt. Usually it is found quite possible to do things that were alleged to be impractical or impossible before the fire. These will include such fundamentals as substituting non-burnable construction elements for burnable, and provision of all manner of fire protection devices, such as automatic sprinklers, additional fire pumps, etc. Too, it is interesting to observe the attention given fire protection in other property under the control of the same management. The fire has accomplished getting the true interest of management. Then we can apply fire safety technique number four: consult competent fire safety advisers, and follow their advice.

It is a well demonstrated fact that it is usually easier and less expensive to build fire safety into a project as it is started than to add it as an extra later. Yet, over and over we see fire protection equipment treated as an extra with corresponding resistance by budget-minded management.

Fire safety, indeed safety of all kinds, is one of the many responsibilities of a competent management. That is, operations which are carried on in an unsafe manner are not being properly managed. It is interesting to observe where the responsibility for safety from fire is vested in management. Fire safety technique number one indicated that we must have the strong support of the chief executive. In most companies this is alleged to be true. However, in actual fact it is very often found delegated far down the line without adequate strength in the position. Fire safety technique number five is: Automatically build in good fire protection.

There is an old story about dealing with mules to the effect that step one is to hit them over the head with a 2x4 to get their attention. In fire safety work, it seems that one must have a severe fire to get aggressive management support. It certainly would be interesting to see what would happen if fire safety got the same attention as the work to make modern air transports the safest airplanes ever built. Imagine what might be accomplished if the following quote concerning the 747 applied to fire safety at mineral operations:

"Every component going into this $20 million monster has been approved by something new in airframe manufacturing—a special committee of five hand picked experts. Boeing assigned to this quintet the job of determining the relationship of every part of safety. The five men can overrule any or all of the 2,500 designers working on the 747 project, if any single design raises the slightest safety question."

Throughout my theme of professional pessimism, I have inferred that everyone fails in the field of fire safety. This is of course not quite true. Numerous top management teams are very alert to the damage and waste from fire. They know that lost markets may never be recovered, a work force which has dissipated to other jobs may never be reassembled after a lengthy shutdown, and even when insurance eases the financial burden, it does not create new wealth but is merely a social device for spreading the cost of waste throughout the economy.

We have emphasized that one must be careful not to consider himself unique, and therefore fail to learn valuable lessons from the experiences of others. There is, however, one major aspect of mineral operations that is different from the majority of other industrial operations. This is isolation. A typical mining community is in a remote, relatively inaccessible locale. The management and staff of a mine are very much on their own when it comes to planning and dealing with fire safety matters. There is no handy public fire department to come screaming up on bright red trucks with lots of hose and manpower to do a fire fighting job for the property owner. His own staff must do it. Manpower is often quite limited in the newer operations that are highly automated. For this reason, fire safety technique number six comes into the picture: take advantage of all possible automation of the fire fighting function to minimize manpower requirements and human error.

We have touched on techniques which I believe constitute a practical way to develop virtual immunity from fire. These can be summarized as follows: Management can achieve fire safety by insisting on it. Prevention alone won't work, so must be backed up by protection.

Some may think the foregoing is more theoretical than practical. For those who prefer a check list of steps, here's a simple one: (1) identify any place in your operations with something to burn; (2) install automatic sprinkler protection at that area backed by a reasonable water supply.

Some may still insist that there are many other things for fire safety. So there are. But they're just so many details until you get the sprinklers in. After twenty years in the fire protection trade, that's what I think.

CONTROL OF HEALTH HAZARDS IN METAL MINING

By KENNETH M. MORSE
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We have witnessed over the past eighteen months more Federal occupational health and safety legislation, or administratively promulgated regulations, than has been previously enacted in the history of this country. Industry supported the general objective of this legislation and recognized the need for expanded health and safety programs to control job hazards. Unfortunately, other considerations prevailed and the result has been the most restrictive health and safety regulations that can be found in any nation. Due to these Federal regulations, the mining industry must greatly expand its industrial hygiene programs to comply with the law. Simultaneously, in my opinion, that industry should endeavor to seek relief from those aspects of the law which are unnecessarily restrictive. This effort should not, however, cause a delay in mounting the type of hazard control program which the problem requires.

The standards are an example of the overly restrictive aspect of these laws. The Federal Metal and Nonmetallic Health and Safety Act incorporates by reference, as standards for air contaminants, the "threshold limit values" of the American Conference of Governmental Industrial Hygienists. The preface of the annual publication of these standards states that the limits should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous conditions. Anyone in the industrial hygiene profession knows that even if such fine lines could be developed, inherent errors in the air sampling method and analytical procedures would make their application, as single number values, impractical. I believe that any occupational health legislation should recognize this fact, particularly when there are severe penalties for violations.

Public Law 89-577, which is the Federal Metal and Nonmetallic Mine Health and Safety Act, comprises the first mandatory Federal health and safety regulations. These regulations became effective July 31, 1970. Fortunately for the metal mining industry, it has a long history of sustained accomplishment in the control of its major health hazards—the metal mining industry, which has received more study of its health problems by Federal agencies than any other industrial category. The last study was jointly conducted during 1958-61 by the Public Health Service and the Bureau of Mines. The results, published in 1963[1], stated that, while more remained to be accomplished, the metal mining industry had made considerable progress in the prevention of silicosis and that the industry had instituted or improved many monitoring and dust control systems during the past 25 years, with a marked reduction in dust exposure. During the 10 years since this study, further improvement has taken place. Even so, dust standards are being continually reduced, so that a greater degree of dust control is now required. Furthermore, equal attention is required for such hazards as noise, gas, and radiation. Therefore, an evaluation of past control practices and the institution of new control programs are necessary now to comply with the standards contained in the Federal Metal and Nonmetallic Health and Safety Act.

Potential Health Hazards

It is self-evident that if one is to undertake to control the health hazards inherent in mining, he must be cognizant of the potential hazards. He must also assign to them an order of priority based upon his study of these problems in his own mine and not merely based upon reports in the technical journals. The degree of hazard will depend largely upon (1) the type of ore; (2) the mine layout; (3) the mining method; (4) the mining equipment; (5) the method of haulage and transportation; and (6) the effectiveness of the hazard control program.

The potential health hazards in mining operations may be classified as follows: Dust, Gases, Noise, Ionizing Radiation, and Heat and Humidity.

Dust

Dust is the most pervasive air contaminant in mining. This aerosol exists in all mining operations in varying concentrations, from the breaking of the ore to the final beneficiated stage. The drilling of the blast hole, blasting, the scraping of the ore into piles in roadways or rooms, loading for haulage, and transportation and crushing within the mine are the major dust sources. In the beneficiating plant, crushing, screening, transporting systems, bin loading and unloading, and drying are the major sources to which control measures must be applied.

As previously stated, Federal regulation limits for airborne dust concentrations are those developed by the American Conference of Government Industrial Hygienists. These are constantly being revised on an annual basis.

Industry should be aware that any dust must be controlled, whether it be nuisance dust, high quartz-bearing dust, or any quartz-bearing dust. The standards for total and nuisance dust are stated in gravimetric of mass units. The standard for quartz is stated both in units of particle count and mass. Respirable dust is defined as that fraction which penetrates a size-selector on the air sampling device, which has a stated retention or penetration curve. This is the type of battery-powered personal sampler required for sampling bituminous coal mine dust.

The standards do not state a sampling rate for the air samplers, but, from a practical standpoint, one could safely use that rate required for sampling coal dust, namely two liters per minute, until the Bureau publishes a flow rate for sampling dust in metal and nonmetallic mines.

Gases

The principal gases, from the standpoint of health hazard in metallic and nonmetallic mining, are those arising from diesel-driven equipment used to power vehicles, compressors, or drills, and from explosives used in blasting. In some instances, however, methane may be present, and while this gas is not toxic, its explosibility makes it one requiring effective control. In some instances, hydrogen sulfide may be present. This is a gas of high toxicity; however, it is not commonly found in mine air. The major toxic gases of principal concern are carbon monoxide and nitrogen dioxide.

Noise

Noise is a health problem in mining next in importance to dust. It is almost equally as pervasive as an air pollutant in the mine environment. The mining operations which may produce high noise levels are drilling (particularly with percussion drills), slusher operations, loading operations, ore transport via mobile equipment, crushing, ventilating fans, and rock breakers at grizzles. In ore beneficiating plants, the major noise sources are truck transport to the primary crusher, jaw and cone crushers, screens, ball and rod mills, and fans in dryers or kilns.

The noise standard in the Federal Metal and Nonmetallic Health and Safety Act is exactly the same as in the Walsh-Healey Act. No Federal health standard can be less restrictive than those in the health standards of this Act. These standards are based upon sound levels as measured on the *A*-scale (dB*A*) of an approved sound measuring instrument, on its slow-response setting. The regulation limits a noise exposure over an eight-hour shift to 90 dB*A*. The noise exposure can be increased five dB*A* for each halving of the daily exposure time, which results in limiting the noise level to 95 dB*A* for a four-hour exposure, 100 dB*A* for two hours, etc., with a limit of 115 dB*A* for one-quarter hour or less.

The recent study of Sataloff[2] among metal miners has raised some question on the validity of this standard for individuals having intermittent exposures throughout the day, consisting of short noise bursts with exposure below 90 dB*A* between the noise periods. He indicated that iron miners may, without danger, be exposed to 117 dB*A* noise for 100 minutes during a typical workday, or about eight hours per week. Such a noise exposure is, however, prohibited under the Federal law.

Ionizing Radiation

Few environmental hazards are so misunderstood by the public, because of conflicting views, as that of ionizing radiation. However, the hazard from excessive internal or external exposure to ionizing radiation is severe and well recognized. The problem is one involving uranium mining, but trace quantities of natural radioactive materials are relatively widely found in the earth's crust. A recent study of the West Cumberland iron ore miners in England[3] suggests that they have a lung cancer mortality 70 per cent higher than normal. Evidence suggests that this hazard may be due to radioactivity in the air of the mines, for the average random concentration was 100 pCi/liter, which is equivalent to about 1.0 working level.

The Department of Interior published its radiation standards in the *Federal Register* of January 16, 1969. Until January 1, 1971, 12 WLM (working level months)* of exposure were allowed per year and four WLM thereafter. The standard requires that immediate corrective action shall be taken, or the miners be withdrawn, when the atmospheric concentration of radon daughters exceeds one WL but less than two WL. When the radon concentration exceeds two WL, miners must be withdrawn until corrective action is taken to reduce the concentration to one WL or less.

Heat and Humidity

Heat, together with the high humidity induced from the extensive use of water sprays, particularly in headings, presents a problem in deep underground mines. Gen-

* Working level is derived from the alpha energy released by the total decay of short-lived radon daughter products in equilibrium with 100 picocuries of Radon 222 per liter of air.

erally, this problem is not in the same hazard category as the other environmental contaminants mentioned, but in some cases it can be of considerable importance. Added to the physiologic problem is the mechanical problem of "blinding" cloth filters, when the moisture in the air is high. This results in a high-pressure drop across the filter and a lowering of the ventilation rate through it.

Comfort standards for workers, involving temperature, humidity, and air motion, are a moot subject. Most studies have been done on military personnel or students and cannot be properly extrapolated for a working group with such variables as age, physical condition, and acclimatization, as is true of miners. To the best of my knowledge, no studies have been done on miners. Therefore, one must be guided in controlling heat and humidity by worker response, effect upon productivity, ventilation limitations, and several other factors.

Control of Hazards

The control of the health hazards in mining should consist of the following factors: (1) Comprehensive control as a deeply imbedded operating philosophy; (2) mechanical ventilation (primary ventilation, localized ventilation); (3) water sprays, suppressing dust generation; (4) respiratory protection; (5) noise control (mufflers, acoustic enclosures, ear protection, audiometric testing, purchasing specifications); (6) a testing program; and (7) research.

An Operating Philosophy

Federal and state legislation emphasizes the role that hazard control must now play in daily management decisions. Hazard control should be as inherent in daily decision-making as is quality control, cost control, and productivity. All are inter-related to the successful conduct of any business in the 1970's.

If this concept is accepted, there must be, as a first step, the development of a sound program staffed with competent environmental engineers. Because ventilation is, in my opinion, the most important single hazard control measure, the employment of an experienced contaminant control ventilation engineer with experience in mining hazard control would be a basic requirement. If this experience can be found in an industrial hygiene engineer, such an individual would provide a broader base of effective hazard control. If such an individual cannot be found, which is highly probable because of a shortage of such professional personnel, then the training of a staff engineer who has good ventilation experience could meet the need. Once such an individual is selected, his role in the management organization must be made sufficiently responsible that he will have the authority, for example, to close down an operation if the ventilation system fails or is in need of major maintenance.

Mechanical Ventilation

We have previously indicated that ventilation is the most important single measure in a hazard control program for an underground mine or ore beneficiating plant. It is the principle measure for the control of dust, gases from blasting and diesel engines, and the maintenance of radon daughters within the established standards. In view of the importance of proper ventilation in the control of the hazards in mining, a thorough knowledge of its design principles should be developed by those responsible for the design and maintenance of ventilation systems. Engineering education is notable for the limited attention given to this subject in the curriculum.

The ventilation engineer must obtain a greater knowledge and appreciation of the significance of airway and duct resistance in a ventilation system; the principles of local exhaust ventilation; the need for minimum leakage; and the importance of distribution in any air handling system. It has been correctly stated that resistance to airflow is the most important factor in ventilation design.[4] In a primary ventilation system, multiple intake and return airways and the length of travel appreciably reduce airway resistance. The engineer endeavoring to increase airflow must be fully aware of these factors. In auxiliary exhaust systems which involve ducts, and local systems which involve ducts and enclosures, the many sources of resistance must be appreciated to preclude poor design. In my view, a greater application of local exhaust ventilation systems should be considered to confine the major dust sources and prevent its dispersion into the general air of a working area. For example, haulage transfer points, crushers, chutes, and ore loading are major dust sources

in underground mines where consideration should be given to local exhaust ventilation. Where such systems are employed, it is imperative to duct the exhaust air to the return or to a high efficiency collector. In ore beneficiating plants, local exhaust ventilation is the only method to control the principal dust sources such as ore dumping, crushing, screening, drying, conveyor transfers, and bin loading and load-out. Dilution ventilation is quite impractical for dust control in such plants. Leakage is a major contributing factor to poor ventilation systems. Ducts should be tight, and if leaks occur they should be immediately repaired. This is particularly important in the use of flexible tubing. Stoppings should be tight and resistant to blast damage when used to seal off mined-out rooms.

Finally, the significance of distribution in a ventilation system should be appreciated. The capacity of a system does not, by itself, indicate the adequacy of the system. The system must distribute sufficient air to each work area (slusher drift, stope, heading, sill, etc.) to create an air velocity to remove and reduce the concentration of dust and gas in the breathing zone of the miner to within prescribed limits. The primary ventilation provides the necessary air volume, while the auxiliary and local exhaust system are the methods for utilizing the air to control the contaminants.

The design capacity of a mine ventilation system is dependent upon a number of factors. Such indices as "cfm/ton mined" or "cfm/man underground" are merely averages that, by themselves, do not indicate the adequacy of a system. A high-capacity system is not necessarily a well-designed system, and such indices may result in underestimating or overestimating the capacity of a system for a particular mine. The capacity of a system is the sum of the air volumes required in each working area delivered against the total air resistance from portal to work area. Some mine ventilation engineers employ a method of calculating the air volume required for the maximum number of operations being conducted on the largest shift, with consideration for the type of operations being performed, and checking this against the total number of men on the shift. The system must assure that each room, drift, stope, or other work area has an adequate volume and velocity of air for controllig the dust, to create good visibility, and to control heat and humidity. If diesel equipment is used, the air volume in the area must adequately dilute diesel gases. For this latter purpose, a minimum of 75 cfm/bhp of the diesel engines is generally utilized. Such air should, however, be properly distributed to thoroughly dilute the gases. If a radiation problem may be present from radon daughters, the base ventilation rate may be calculated from the following formula[5]:

$$V_2 = V_1 \left(\frac{WL_1}{WL_2}\right)^{0.56}$$

Where: V_2 = Required cfm of uncontaminated air.

V_1 = CFM of uncontaminated air provided.

WL_1 = Working level of environment.

WL_2 = Desired working level.

However, the adequacy of ventilation for this purpose can be ascertained only by measurements of alpha radiation.

Water Sprays

The effective use of water is a prime element of any dust control program. It is most effective when used to prevent or reduce dust generation. Once the dust becomes airborne, the removal of the respirable dust (5 microns) is not effectively accomplished by water, with or without wetting agents. For optimum effectiveness, the water should be applied as a spray, and not by hosing. The primary objective should be to wet ore before handling and to wet intake airways and passageways to reduce generation of dust.

All mine headings should be equipped with water. Broken ore and ore piles should be wetted before handling and frequently during the work. Chutes, ore passes, and ramp throats should be equipped with sprays. Sprays should be applied at the loadpoints of conveyors and at intervals along its travel. In some instances, shovels and loaders have been equipped with sprays. The value of water sprays in mining can be readily appreciated by shutting off the sprays. Wet drilling will help in dust control, as will the spraying of ore piles in open pit mines before such piles are stirred up by shovel activity.

Respiratory Protective Devices

Respirators of the oral-nasal type, which mechanically filter out the airborne dust from the ambient air, do have a place in a dust control program. This role is not as a substitute for engineering control or the judicious application of water sprays. The respirator's role is in those instances where the work is intermittent and of short duration, where the ventilation system design cannot control short periods of dust in an operation which is not of regular occurrence, or where ventilation system must be repaired or extended while operations are continued.

Oral-nasal respirators are of two general types; one meets the testing schedule of the Bureau of Mines for pneumoconiosis-producing dust and mists and so-called nuisance dusts; the other type does not meet the Bureau's rigid performance tests. The former type has been available for a number of years. The performance tests which they must meet cover such important factors as comfort, leakage, limit of resistance to inhalation, and exhalation and filtering efficiency. These devices were not intended to be worn constantly throughout a full turn, but for the conditions intended they can be worn without much discomfort by most persons provided they are properly maintained. There are some individuals who subconsciously react against any device which covers their nose and throat, even when the device has only a slight resistance to breathing.

The second type of respirator, the "unapproved," can play a useful role in respiratory protection. The unapproved respirator generally affords lower resistance to breathing than the approved types. Therefore, they are more desired by the wearer and are more readily accepted. Some respirators in this group will provide filtration efficiencies as high as 50 per cent. Such efficiency will provide significant protection and may be quite adequate when the dust concentration is no more than 100 per cent in excess of the dust standard.

The foregoing comments do not imply that the present oral-nasal respirators do not have limitations and cannot be improved. Improvements can and are being evaluated to reduce the breathing resistance and the psychological effect of having one's nose and mouth covered. Several groups are evaluating a small battery-powered portable air-supplied respirator. This respirator uses a rechargeable nickel-cadmium battery pack to power a small blower which delivers about five cfm of filtered air to the oral-nasal mask. The power unit weighs only 2½ pounds, which allows it to be readily affixed by a clip that slides over a miner's belt. United States Steel has been testing these air-supplied respirators in non-mining areas, and acceptance has been good. Even those who psychologically react against covering their nose and mouth are responding favorably, as they can feel the air blowing at their face and there is no resistance to breathing. This device, developed under a contract with the American Iron & Steel Institute, would appear to have application in mining and could be further improved if the power could be supplied from the miner's lamp battery. It is my view that an oral-nasal mask is the limit of any face cover of a miner. His type of work, the need for visibility, and an aversion of most persons to a head envelope would appear to preclude acceptance of a helmet-type device.

Hearing Conservation

Noise is a concomitant of mining, ore beneficiating, and maintenance shop operations. However, most of the higher decibel noise is only intermittent; the rest of the time the noise level is low. This is particularly true in underground and open pit mining. In addition, the noise level from the same operation will vary during a day, and will vary for the same operation from mine to mine, due to the variety of mining, loading, and haulage equipment in use and disparities in operating conditions. The highest noise levels are generally associated with pneumatic equipment, particularly percussion drills. Therefore, hearing conservation programs are necessary to protect miners and associated personnel.

A hearing conservation program consists of monitoring noise on a periodic basis; noise control by engineering measures; hearing testing; and ear protective devices.

Monitoring or measurement of noise is necessary to determine compliance with the law, the exposure of mine personnel, and the noise sources which need control, and to ascertain those individuals who should be given periodic hearing tests and those who should be provided ear protection.

Engineering measures for noise control of mining equipment are limited, but more can be done than may appear at first. Noise is generated by noisy equipment, and two general measures can be directed to quieting such equipment. The first is to endeavor to isolate the noise from people, or vice versa, and the second is to design a quieter machine. The latter method is limited, although some progress is being made. For the present, however, reliance must be placed on the former method, which requires the use of sound barriers, sound absorption materials, and vibration dampening. However, until mine operators and mine equipment manufacturers realize that noise control is a mutual responsibility, progress in engineering control will be slow.

Another factor which slows progress is the fact that, in noise control as in ventilation design, engineering personnel are generally on unfamiliar ground, since they have had no acoustic training in their educational background. Further, there is a price attached to noise control, and until this fact is accepted progress will be hindered.

Notwithstanding these factors, a few drill and compressor manufacturers have directed considerable attention to this problem, with some results. One manufacturer is marketing an acoustically housed diesel-driven compressor and related equipment, which, it is claimed, produces 85 dBA at one meter distance from the unit. The same manufacturer claims a reduction of the sound pressure level in a paving breaker with the use of its strap-on muffler weighing only one pound. It is further claimed that operating tests have shown no loss of impact power. Another prominent manufacturer of mining drills has been devoting considerable engineering effort to quieting drill noise. Such drills present three noise sources: vibrating steel drill; vibrating body of the machine; and exhaust air noise.

Most sound attenuating systems depend upon one or a combination of the following: the use of acoustic materials, a muffler of the resonator type to muffle the exhaust air noise, or a diffuser at the exhaust outlet. One manufacturer markets a neoprene rubber-jacketed muffler which makes use of all the above principles, with configurations for stopers, push feed drills, and paving breakers. While these mufflers achieve an appreciable reduction in noise, this manufacturer frankly states that no presently marketed machine achieves sufficient noise control to eliminate the need for ear protection. However, the attenuation required by the ear protector is appreciably less than would be the case without the muffler.

The use of acoustical materials can be applied to control the noise exposure of operators of track mounted drills, trucks, shovels, and other mobile equipment. In beneficiating plants, crusher and mill operators generally spend a significant amount of their time at a control panel or desk. Isolating them in an acoustic enclosure is an example of what can be done to appreciably reduce their exposure time to high noise levels. Noisy equipment can also be isolated from operators in many cases by acoustic enclosures.

As an example of dampening to reduce noise generation, tumbling mills in the foundry industry have been successfully rubber-lined. It would appear that rubber-lining of ball mills and possibly rod mills could be undertaken on an experimental basis.

Hearing tests are vital in any noise control program. The best measure of the adequacy of noise control and hearing protection measures is the hearing of the worker himself. The objective of a noise control program is preservation of hearing. A hearing-testing program involves preemployment and periodic hearing tests. The Federal agency charged with enforcing the Walsh-Healey Act has indicated that where hearing tests demonstrate that hearing impairment has not occurred, even if the noise standard has been exceeded, a hazard does not exist. As standards for exposure to intermittent noise are not well validated, reliance upon competent audiometric data would be the principal method of demonstrating the adequacy or inadequacy of a noise standard.

Finally, equipment should be purchased to conform with an engineering specification containing a requirement for the submission of noise data. Such a noise specification must be realistic and not merely state "conformance with the noise standard of the Walsh-Healey Act." The noise that an installed machine will produce will depend not only on the machine but how well it is installed and the environment in which it is located. Several manufacturers' trade associations, notably the Air Moving and Conditioning

Association, the National Electrical Machinery Association, and the Compressed Air and Gas Institute, have developed test codes for obtaining noise data. Such data should be required in engineering specifications to help the purchaser evaluate equipment from various suppliers.

Testing Program

It should be evident that today it is as necessary for industry periodically to test the quality of the work environment as to test the quality and performance of its product. This will necessitate a monitoring program, with the data recorded on appropriate forms. Such information is essential to demonstrate the existence of a hazard control program, for use in labor relations, to contest inaccurate tests conducted by Federal or state inspectors, for use in medical-legal problems and, most important, to determine the effectiveness of the hazard control program. Today, we are in a "numbers game," unfortunately; therefore, it is essential to obtain and record numbers on the control of health hazards. This includes all tests on air contaminants, noise, ventilation measurements, etc. A test is of no value unless it is recorded.

Research

The breadth and depth of occupational health regulations requires a rethinking of past processes and practices. New methods and techniques will have to be ventured as research projects. Some of this will be necessary on the part of mine operators, since they are in the best position to evaluate the practicability and economy of a new method. However, much of the research necessary to build in controls on equipment must be done initially by the equipment manufacturer. The most effective approach would appear to be a joint effort of the equipment manufacturer working with the mine operator. The ingenuity and technical competence of the American mining industry can meet this challenge as it has met all others.

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TRAINING OF METAL AND NONMETAL MINE INSPECTORS

By THOMAS J. SHEPICH

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The Federal Metal and Nonmetallic Mine Safety Act (Public Law 89-577) has been discussed widely in various forums since its passage in 1966. Its purpose is to promote health and safety in the metal and nonmetallic mineral industries. Among other things, the Act requires that all underground mines shall be inspected by the Bureau of Mines at least annually. The Act also provides for inspections of surface mining operations.

Last year in a progress report on the implementation of Public Law 89-577 made before this group, Henry P. Wheeler outlined the following objective:

"We are recruiting now for mining engineers and for men who have operating experience, to be trained as mine inspectors. We intend to make mine inspection a profession, so that everyone may be assured of the competence of the men who inspect mining operations."

With this objective in mind, the Bureau of Mines has undertaken the selection and training of an inspection staff to meet the requirements of the Federal Metal and Nonmetallic Mine Safety Act.

The Bureau's training of metal and nonmetal mine inspectors consists essentially of on the job development supplemented by formal classroom and other specialized training. This training is designed to meet the needs of the individual and of the Bureau of Mines.

The new inspector will not become authorized to inspect mines subject to the Act until he successfully completes the full course of training.

Before getting into the various aspects of training for metal and nonmetal mine inspectors, I would like to discuss briefly the makeup of our inspection staff. Currently, there are more than 75 mine inspectors operating in six districts, from 14 subdistrict offices. The number of inspectors will be more than doubled over the next 24 months.

In staffing for metal and nonmetal mine inspections, the Bureau has drawn, and will continue to draw, from among persons representing a broad spectrum of experience and education. Included among inspection personnel are persons who were formerly mine superintendents, mining engineers, safety directors, safety engineers, union officials, and mine operating and maintenance supervisors. Their mining experience ranges from a minimum of five years to more than 35 years, and their average age is 42 years. More than half of the inspection staff, including persons presently authorized to inspect mines and persons currently in training, have degrees in mining or related fields. Twelve of the 35 persons hired thus far in 1970 are graduate mining engineers.

Overall training needs vary substantially among the metal and nonmetal mine inspectors because of the wide differences in background and experience. For this reason, total time spent in training is based on individual needs rather than on a fixed timetable, and ranges from four months to more than a year.

Late in 1969, the Bureau of Mines awarded a contract to West Virginia University for development of a formalized training program for Federal mine inspectors. The immediate objective was to satisfy the Bureau's short-term training needs. The long-range goal is establishment of a Mine Safety Academy to develop professional and technical health and safety personnel for all segments of the mining industry. A two-year course leading to an Associate in Arts degree is anticipated. Under terms of the contract, West Virginia University will make recommendations concerning implementation of such a program.

During 1970, two classes of metal and nonmetal mine inspectors completed nine-week training courses at the University. A total of 41 new inspectors completed intensive training in the fundamentals of science, engineering, mining technology, and preparation of reports important to the profession of mine health and safety inspection and investigation. Subjects taught during the nine-week period included safety, English, report writing, explosives, electricity, mine gases, physiological effects of dust, haulage, fires and explosions, mathematics, mining law, mining systems and methods, ventilation, and mechanics of ground control in mines.

For many participants, the West Virginia University training offered new information on subjects germane to metal and nonmetal mine inspection activities. For other participants, the classes served as refresher training in these subjects. In general, the West Virginia University training provided a standard base from which the Bureau of Mines could continue on the job development of metal and nonmetal mine inspectors.

In addition to outside training arrangements, the Bureau also utilizes many of its own courses in the training of metal and nonmetal mine inspection personnel. Included are the basic training courses of first aid, mine rescue, and proper use of the flame safety lamp. Selected inspectors also receive specialized Bureau training in such courses as dust sampling and radiation monitoring.

The Bureau of Mines is currently conducting a nine-week training course for a select group of training coordinators from each metal and nonmetal mine health and safety district. These men will be charged with seeing that Bureau inspectors receive up to date training and information they need, and that Bureau of Mines training for mine inspectors is expanded to include training for company and state mine inspectors and for union safety personnel. The training they will coordinate is the first and most comprehensive course ever formally designed for mine inspectors and safety personnel in the metal and nonmetal mining industries.

Much of the text material for the course is from the *Essentials of Safety and Indus-*

trial Hygiene for Metal and Nonmetal Mines, a comprehensive reference and training manual. The 2,150-page manual, developed by the Bureau of Mines, covers 64 subjects pertinent to metal and nonmetal mine inspections. Instructors for the nine-week course include experts from within the Bureau's inspection force, its Field Health Group, and its Technical Support Group. Other instructors include experts from private industry and from state agencies.

The course provides classroom study in administrative matters important to the inspector and technical study specifically related to application of promulgated Federal metal and nonmetal mine health and safety standards. It will provide much of the basic information needed for the conduct of meaningful and effective mine inspections. This course will also serve as a basis for training state and company mine inspectors.

The most important phase in the overall training of metal and nonmetal mine inspectors is on the job development. During this phase of his training, the new inspector is assigned to accompany several different experienced Bureau of Mines inspectors on mine inspections, fatal investigations, and other special investigations. Under actual field conditions, the new inspector first observes and then participates actively in each phase of an inspection or investigation. He is first assigned to work in smaller mines with subsequent assignments in more complex operations. Responsibility for inspection is increased progressively to a point where he conducts the entire inspection with minimal supervision.

In this manner, the new inspector learns how to conduct effective inspection conferences with management and unions. He learns how to inspect mines for health and safety hazards. The new inspector also learns how to prepare and issue imminent-danger withdrawal orders and notices and other orders pertaining to violations of mandatory standards. Finally, he learns how to prepare effective written reports for distribution to interested persons.

A strong point of this on the job development is that the new inspector travels with several different experienced inspectors. The new inspector is thus able to observe the techniques used by various inspectors in seeking to achieve the same objective. He is then better able to develop an effective technique best suited to him. After each assignment, the experienced inspector provides the prospective new inspector with an objective critique indicating those areas needing further attention. The resulting exchange of ideas is beneficial to both.

The progress of a prospective inspector during on the job development is reported to his supervisor at the conclusion of each field assignment. These reports, together with a field evaluation by the supervisor, form much of the basis for determining when an inspector is ready to conduct inspections and investigations on his own. Other considerations in this determination include the person's background and the amount and type of formal and specialized training received since joining the Bureau.

Upon successful completion of the many phases of his training, the new inspector is authorized by the Director of the Bureau of Mines to conduct inspections and investigations in mines subject to the Federal Metal and Nonmetallic Mine Safety Act.

Training of inspectors does not end when the inspector becomes authorized. Additional training is provided to keep the inspector abreast of changes in policy and technology. The inspector receives general or specialized training on a continuing basis to meet his particular needs and to further his professional development within the Bureau of Mines.

In summary, the Bureau of Mines has responded to the objectives of the Metal and Nonmetallic Mine Safety Act. It has developed a comprehensive formal and on the job training program for Federal mine inspectors to carry out their responsibilities. It has undertaken a monumental task in expanding its force to include professional inspectors, professional educators and trainers, and professional specialists, while extending their services to the metal and nonmetal mining industries to make their mines safe. We believe that mines can be made safe without undue disruption of output and employment. This objective will require trained professionals on all levels—government, industry, and labor. The Federal inspector shall be trained to help as well as criticize in applying the standards he is obligated to administer.

TRAINING THE MINE SUPERVISOR— RESPONSIBILITY AND AUTHORITY

By JAMES A. UNGER
Director of Training, Pickands Mather & Co., Cleveland, Ohio

Pickands Mather & Co. of Cleveland, Ohio, is a unit of Diamond Shamrock Corporation, also of Cleveland. Pickands Mather owns and operates Interlake Steamship Co., Carbon Limestone Co., Milwaukee Solvay Coke Co., and is a leading sales agent for iron ore, coal, pig iron, ferro alloys, and coke. As managing agent, the company operates coal and iron ore docks for railroad companies, as well as a coal mine in Kentucky.

The company also owns and operates the Brooks Coal Mine in Pennsylvania. Our largest role as managing agent concerns the operation of extensive iron ore properties for various steel companies. These iron ore properties are located in Minnesota, Ontario, Quebec, and Labrador in Canada, and in Tasmania, Australia. Pickands Mather produces and ships over 20,000,000 tons of natural ore and iron ore pellets annually, the bulk of shipments being in the form of pellets. We are the fourth largest iron ore tonnage producer in the world. Erie Mining Co., at Hoyt Lakes, Minnesota, is the largest of our iron ore operations, as well as one of the largest single operations of its kind in the world. We operate this property for Bethlehem Steel Corp., Youngstown Sheet & Tube Co., The Steel Company of Canada, Ltd., and Interlake, Inc.

Erie employs about 3,000 people and mines extremely hard low grade taconite rock, which is ground, concentrated and pelletized, with an annual production of over 10,000,000 tons of high grade iron ore pellets. The open pit mining operation uses both rail and truck haulage. For this annual production of pellets we mine about 30,000,000 tons of taconite and move about 20,000,000 tons of waste material.

Such an operation requires that we have extensive shop and maintenance facilities, and we operate a 73-mile railroad which transports the pellets to the modern dock at Taconite Harbor, on Lake Superior. The power plant at the harbor supplies power for the mine, plant, and dock operations.

An operation of this scope presents a real challenge from the standpoint of safety, for all levels of the management team. To aid management to discharge its responsibility, Pickands Mather has developed a safety policy, part of which reads as follows:

"It is the policy of Pickands Mather & Co. to provide safe working conditions for all employees, to provide full instructions covering safe working methods, and to make available, where necessary, special equipment to protect employees against particular hazards.

"There is no such thing as a good mine, shop, or plant operation if it has an unsatisfactory safety record, because safety and efficiency are directly related.

"We expect the management personnel at every mine, shop, or plant to exert every effort to eliminate employee injuries, fires, and property damage accidents. It follows, therefore, that safety performance of management personnel is an important consideration when judging the overall performance of individuals in this group.

"To gain the most efficient control of accidents we must be guided by the following:

1. Management personnel must understand the hazards of the operations, processes, and the practices involved.
2. Insofar as possible, hazards inherent in operations or processes must be corrected through engineering and design.
3. Unsafe practices must be eliminated.
4. Employees' enthusiasm for safety must be stimulated. A sincere desire for safety and prompt handling of safety matters by all levels of supervision is a basic requirement.
5. All statutory requirements for health and safety must be met, and where company standards exceed statutory requirements, as is frequently the case, company standards must be met.

"All management personnel are responsible for carrying out the policy expressed above. Actual responsibility for accident prevention and enforcement of safe practices throughout our operation lies with supervision. Obviously, success or failure in the area of accident prevention must be one measure of supervisory qualifications."

Pickands Mather & Co. has, over the years, compiled an enviable safety record. Formal safety programs in the company began shortly after the turn of the century. The company has zealously applied safety principles to good advantage. For example, since 1930, various of our operations have won the coveted Sentinels of Safety trophy 32 times, the last one in 1968 by Erie Mining Co. This record cannot be equalled by any metal mining company.

The Program

From the time Erie Mining Co. began production in 1957, P.M.'s safety policy has been adhered to and safety training has received a great deal of attention. Although we achieved considerable success in safety, we were still not satisfied. Early in 1963, in meetings with Erie top management, a decision was made to develop a safety training program tailored to Erie's specific safety needs. The result of these discussions was the safety training program which we called "Target Zero."

Target Zero dealt with history, company policy, assigned responsibilities, relationship of safety to production, recognizing accident causes and results, developing proper safety attitudes in employees, planned safety observations and inspections, job safety analysis, accident investigation and report, job safety training, motivating employees to work safely, handling the safety problem employee, and safety meetings and summary. A conference leader's guide was deve.oped for the program.

All members of the safety department received an intensive course in conference leadership techniques, and Target Zero sessions began in 1964 under their leadership. The sessions continued for one hour a month over a period of two years and covered all supervisory and top management personnel. The program stressed the responsibility of supervisors in each of the above areas, but it became apparent to the conference leaders and the administrators of the program that something should be added to make sure each of the conferees had a clear understanding of his personal responsibility and his commensurate authority on safety matters.

To clarify these areas, as well as to ascertain how well Target Zero was achieving its purpose, an evaluation questionnaire was developed covering nine of the most important aspects of Target Zero. This questionnaire was developed in a form similiar to previous responsibility and authority surveys in safety conducted at two of our other operations. The Erie format, however, conformed to the subject matter covered in the Target Zero program. Unfortunately, no pre-Target Zero evaluation was completed. Therefore, pre- and post-comparisons could not be made. When the Target Zero program was completed each participant was asked to write out, in his own words, his concept of his responsibility and authority, as they related to the nine items discussed in the two-year program. His responses were compared to "model" answers, based on the content of Target Zero.

Evaluation

The remainder of our discussion will concentrate on the results of our evaluation survey, and our conclusions. The introduction to the evaluation form reads as follows:

"During the past two years, you have been participating in a safety program, Target Zero, with your conference leaders. Now that this program is completed, we are interested in determining its effectiveness. In relation to the following topics, will you please write a paragraph on what you understand your responsibility and authority to be":

The statments were as follows, with the average grade for all participants (240) listed, based on 10 points for each of the nine statements.

	Average Grade	
	Responsibility	Authority
The recognition and correction of unsafe acts and practices	68	43
The recognition and correction of unsafe conditions	66	61
The conduct of 5-minute safety talks and personal contacts	58	56
The safety observation report	64	54
The development of positive safety attitudes in your employees	58	39
Obtaining and following through on safety recommendations from employees	64	52
Enforcing safety rules and regulations, including the enforcement of discipline where necessary	57	45
Job safety training	72	35
Your specific responsibilities for safety	66	38

The range of 57 to 72 in knowledge of responsibility, and from 35 to 61 in knowledge of authority, as compared to the model answers, revealed two important findings: (1) knowledge of responsibility in safety was not completely understood by everyone; (2) knowledge and use of authority in safety matters required even more training and indoctrination. Moreover, although we already knew this, we were again reminded that instruction in safety principles is never complete—it must be continuous and repetitive; weak areas must be exposed and concentrated on. We also kept a record of average scores for supervisors in each department. These results gave us some further ideas as to where we needed to put forth additional effort in safety training.

The model answers were reviewed with all supervisory personnel in succeeding monthly safety meetings conducted by safety department personnel. These meetings stressed the total responsibility of supervision in all of the areas covered by Target Zero, as well as clarified the authority supervision at Erie has in regard to implementing every aspect of our safety program.

Target Zero laid much stress on the safety observation report as being vital to good supervision in safety, as well as training supervisors to be alert to what to look for and how to correct irregularities.

This survey was completed and summarized by May 1966. After we spent some months reviewing survey results, safety training activities were comprised of routine inspections, the use of the safety observation report, safety contacts, five-minute safety talks, and routine foremen's safety meetings.

During these years, Erie top management watched our safety record very closely. By late 1969, it was noted that our record was not improving as much as we had hoped, or it was remaining constant in some areas, in spite of our previous intensive safety training programs.

Accordingly, we felt that a revival of some formal safety training was in order to ensure continued improvement toward our safety target—zero. Therefore, in November 1969 we revived a portion of Target Zero dealing directly with the supervisors' responsibility and authority. This, too, was a plant-wide program. Beginning in April 1970 each department is responsible for conducting a monthly program for its supervisors on a safety topic selected by the department. Then two months each year, in September and April, the safety department is responsible for conducting plant-wide meetings, using as the topic some review of Target Zero material.

The intensive program of a few years ago, plus the contemporary reinforcement meetings, are again beginning to pay dividends in the form of improved safety experience. The varied attack on accidents makes it impossible to claim any one thing as responsible for success, at least over an extended period. However, we feel that the authority and responsibility survey is a useful tool not only to tell how we are doing in safety training but to point out areas where training is needed.

Thorough safety education, reinforcing of responsibility and authority, plus repetition, appear to be the most satisfactory answer for attaining a satisfactory safety record.

THE USE OF VIDEO TAPE IN SAFETY TRAINING AT MINES AND PLANTS

By H. E. JOHNSON
Safety Engineer, Mines Accident Prevention Association of Ontario

How many companies use the most revolutionary training aid which has become available to us in the past few years? I speak of the great leap forward for the mining industry in training of personnel when they take full advantage of using videotape recording equipment in their training program. It can be as revolutionary as the introduction of tungsten carbide drill bits, the raise borer, or load-haul-dump equipment. We feel confident that there will be an increase in efficiency with a noticeable decrease in accident occurrence when industry puts VTR to work.

What is the history of VTR? It originated with the invention of magnetic sound recording, patented in the U.S. in 1900. The word "television" was coined the same year, although there was no television as we know it. It was in 1927 that an Englishman invented the first technique for recording and playing back a television signal; this was done on a phonograph record rather than on tape. In 1951 video signals were recorded on magnetic tape for the first time. Various types of VTR were produced but it was not until the development of transistors that they entered the low priced portable field.

Whether you realize it or not, you have all seen VTR on TV. For instance, hockey games and football games are recorded on video tape; also, the replays of goals scored or of touch downs are all VTR.

Video tape equipment is available in many shapes and sizes, using magnetic tape from 2 inches wide to one-half inch. We desired portability, and one-half inch equipment offered this advantage. The equipment we first obtained included camera, video tape recorder and playback unit, monitor, portapak, battery charger, lighting equipment, and magnetic tapes.

Possible Uses of VTR Equipment

Supervisory Training. This equipment can be used effectively to train supervisors in the presentation of safety talks and other instructions. Supervisors can give their talk either privately or to a group and play it back for self evaluation or group evaluation.

Job Hazard Analysis. An extensive study of accidents indicates that they generally fall into the same classification of hazard, and quite frequently they occur under the same circumstances. By video taping the conditions and methods used, a study of the hazards can be made either by the department head or by several supervisors. In this way a work situation can be thoroughly analyzed and preventive measures developed.

Proper Job Practices. The establishment of proper job practices is one of the most important phases of any accident prevention program. Video tape can be used to record present practices and, through playback of the tapes, errors and improper actions can be eliminated and correct steps inserted. The final tape of the work method can then be viewed and studied before incorporation as a proper job procedure. Video tapes can also be exchanged between mines so that certain procedures can be standardized throughout the industry.

Conference Leading. Conference leading or "chairing a meeting" is rapidly becoming part of every supervisor's job. The average person finds this task difficult; he should, therefore have some assistance or training in this field. The use of video tape can be helpful in developing confidence and the ability to lead a discussion. A supervisor can learn by observing himself and his fellow supervisors on tape and, with this knowledge, improve his own method of delivery.

Outline for Movie Production. If it is desirable to produce a movie, an outline can be shot using VTR. This would assist considerably as a guide for final script preparation and movie production.

Movies. Movies can be made by reproduction from video tape. Most companies have movie projectors, and small companies may not plan on obtaining VTR equipment for a few years. They can take advantage of VTR by having new video tape productions transferred to movie film.

Video Tape of Movies and Slides. Video tape of movies and slides can also be produced and they can be shortened or edited to suit any requirements; or, movies and slides can be used in conjunction with VTR shooting of actual operations.

Ventilation and Dust Control. All aspects of ventilation such as fan installation, control of dust, and konimeter sampling can be demonstrated.

Indoctrination of Employees. A new employee can be shown video tape of plant operation in general and of his job in detail before he starts work.

Job Instruction Training. Video tape of a job when shown to an employee, whether new or old, will help him grasp the job sooner and remind him of the problems involved.

Other areas where VTR can help are apprentice training, management development, maintenance problem study, and accident investigation.

Considerations Before Obtaining Equipment

What department will operate the equipment? For production of tapes? To show tapes to supervisors and men? A lot will depend on the type and size of the company. It probably would come under the training or safety department, the training department with assistance from the safety department, or vice versa. Considerable study would be necessary before a decision would be made.

How many men will be involved in VTR production? This will depend on the size of the company and the size of the contemplated program. The minimum number of men would be two.

What type and how much equipment should be obtained? The minimum equipment should involve two cameras, switcher, video tape recorder and playback unit, a monitor, portapak, lighting, and tapes.

How will the VTR crew be trained? There are courses given at technical schools and universities on the equipment and training techniques. Our association has reached the stage that we now give a one-week course in VTR to representatives of member mines.

What are the problems which may be encountered in VTR production? There are many in addition to equipment operation. These are script writing, lighting, departmental cooperation, supervisory cooperation, the men's cooperation.

Stages of Advancement in Use

In March, 1969, we rented the most basic set of VTR equipment for a one month trial. We showed the equipment and its operation to mine representatives at Timmins, Cobalt, Kirkland Lake, Elliot Lake, Red Lake, and Thunder Bay.

Like the amateur movie producer, we had problems with focusing and lighting. When we tried to produce a tape our lack of knowledge, particularly in preparation of a script, showed up badly. However, interest in the equipment and the realization that it could be an aid in training was great enough to warrant purchase of equipment.

Since obtaining our own equipment, we have visited many companies at their request to demonstrate it and produce video tapes of various operations and actions.

It was found that we had a lot to learn regarding the equipment and producing a tape to interest and impress the viewers. Two of our staff attended a seminar on VTR at Quetico Center for Continuing Education near Atikokan. After completing this course, we organized a course of our own with the assistance of an experienced former movie producer now associated with a Canadian mining company.

One course for representatives from mining companies was conducted at Elliot Lake in June. After this course, constructive criticism has led to revision of the course for future presentation.

Course in VTR Production

The following is a brief outline of the course for VTR production crews, which lasts five days:

Fifty per cent of the time is devoted to a project to produce a presentable tape on a general problem in the Ontario mining industry; e.g., "The Prevention of Slips and Falls at an Open Pit Operation."

Fifty per cent of the time is devoted to equipment and production problems: script writing; shooting with VTR; job responsibility (director, camera man, lighting, sound); equipment (lighting, stand point of the camera, camera angles, tracking, panning and zooming); editing of tapes; dubbing in sound; and maintenance of equipment.

The main object of the course is to involve the crew with the problems of VTR production, of which script writing is an example. A lot of planning and imagination is necessary to come up with an acceptable, interesting, and impressive production.

Although VTR is still in the infancy stage in Ontario mining, we see a great future for its use as a training aid:

1. It will fill a gap unfilled by a lack of films relative to the mining industry.
2. If all companies use compatible equipment, they will be able to circulate tapes among themselves and we will have a library of tapes from which the companies may draw as they do now with movie films and slides.
3. There will be improved efficiency because VTR will help to train men better and faster than at present. This will reduce cost of training and reduce accidents, because a trained man has fewer accidents.
4. When companies produce their own VTR tape, there will be better employer-employee relations, due to better communications. Also, the men will see tapes of their own operation, themselves or their friends.

FEDERAL INSPECTION PROGRAM FOR METAL AND NONMETALLIC MINES

By ROY G. STOTT
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The mining industries' safety performance has been under attack for some time. A more positive approach to the problems must be found or more stringent legislation can be expected.

During 1969, underground metal and nonmetal mines that voluntarily reported their work injury statistics to the National Safety Council had a disabling injury frequency rate of 31 injuries per million man hours. That was four times the all-industry rate, a relationship that has persisted for more than a decade. On a nationwide basis, mining is rated at the bottom of the list. Bureau of Mines statistics indicate that one mine employee out of every 16 will very likely suffer a lost-time injury on the job, and one out of every 1,400 will lose his life while on the job. Must the industry continue to have such a poor image? Must capable young men from our mining communities continue to seek careers other than mining?

Congress has given us the Metal and Nonmetallic Mine Safety Act with a demand that positive action be taken to make our mines and plants safe. The mandatory standards to implement such action were promulgated July 31, 1969, and February 25, 1970. Both sets of standards became enforceable on July 31, 1970, and Federal inspectors are now in the field applying these standards.

It is important for you to note that these standards incorporate the views and thinking of management, labor, and state inspection agencies. Representatives from each of these groups were appointed to three advisory committees. There was a committee for underground mining, a second one for open pits, and a third one for sand, gravel, and crushed stone operations. Each committee compiled a set of standards for its area of concern and that is the way our standards are organized today.

Based on the work of the three committees, a total of 1,806 standards were published as proposed rulemaking on January 16, 1969. At that time, public comment was invited. There were no comments on 1,023 standards; so they were promulgated on July 31, 1969. Comments and divergent views on another 688 standards were examined and resolved, and these were also promulgated.

On June 24, 1970, a notice was published in the *Federal Register* setting forth proposals to amend, revise, or redesignate 130 standards and introducing a proposed variance clause in lieu of the savings provision proposed January 16, 1969. Very few comments were received regarding the variance clause, which is not subject to public hearings procedures; however, hearings were requested on 76 standards and comments were received concerning clarification of 16 others. No requests for hearings or comments were received concerning the remaining 38 standards published as proposed rulemaking on June 24, 1970. Dates for hearings are now being considered.

The proposed standards published January 16, 1969, which have not appeared since that date in the *Federal Register*, are also subject to consideration at a public hearing as soon as the dates are established.

The main point of this review has been to show you that Federal safety standards on the whole represent recognized good mining practices, and those in effect were agreed to by all parties concerned. Additions and changes will undoubtedly be made from time to time after consultation with advisory committees appointed pursuant to Section 7 of the Act.

The Act recognizes the inadequacy of merely applying penalties for noncompliance with standards. While the Act provides for the establishment of health and safety standards, and for their enforcement through periodic inspections, it goes much further.

The opening words of the Act are significant. In brief, it states, "To promote health and safety . . ." Consistent with the words "To promote," the Act provides for education and training, for technical assistance, for researching safety and health problems, and for gathering and disseminating accident information.

To administer these provisions, the Metal and Nonmetal Mine Health and Safety Activity was established in the United States Department of the Interior under the direction of that Department's Bureau of Mines. The Activity now has 86 mine inspectors in the field operating out of six districts with 14 subdistrict offices. The number of inspectors will be more than doubled in the next 24 months. Also within this activity is a Health Group located in Denver, Colorado, which has the capability of conducting advanced studies of mine environment and other health problems.

Each of our 86 inspectors is a duly authorized representative of the Secretary of the Interior. Over 50 per cent of the inspectors are experienced graduate mining engineers, while the balance are well-seasoned men with many years of supervisory mine experience. All are trained and empowered to enforce the standards.

One important feature of the Act is a provision of any state to submit to the Secretary of the Interior a state plan for the development and enforcement of state health and safety standards which must be substantially as effective as the Federal program. Guidelines for development of such plans and a model state plan agreement were mailed to all state governors in May 1970. Agreements have already been processed and signed with Arizona and Colorado. Twenty-four other states have indicated an interest in entering such agreements. To date, cooperation between the Bureau of Mines and the state inspection agencies has been excellent.

With a state plan agreement in effect, the Bureau of Mines still has the responsibility to see that state regulations are substantially as effective as the Federal standards. Furthermore, the Act requires that all underground mines be inspected by the Bureau of Mines at least once annually. We are presently endeavoring to make these inspections concurrent with the state inspections, whether or not a state plan is in effect. By this means we hope to achieve closer cooperation, a better exchange of knowledge and information, improved communications, uniformity in the application of rules and regulations, and an upgrading of inspector capabilities, both Federal and state.

In any event, the Bureau of Mines has to be responsible to situations of imminent danger which may reasonably be expected to cause death or serious physical harm. Federal inspectors will therefore be required to serve withdrawal orders when and if he finds such situations to exist. This will be done with or without a state plan in effect.

By putting their state plans into effect, the states of Arizona and Colorado have already taken leading positions among the mining states to reduce accidents and occupational illness in the mineral industry.

Industry leadership in safety can be exercised both through enforcement of safe working conditions and through another, often more productive, avenue. That avenue involves the creation of a safety consciousness among workers—a positive attitude for observing safe work practices. Legislatively, that avenue is most difficult to regulate. It is traveled mainly through the constructive persuasion and practical help of professional safety personnel. It frequently takes a professional approach to convince management and labor to play a positive and effective role in accident prevention. Generally speaking, the most successful safety programs can be measured by the degree of management participation.

The Bureau of Mines has undertaken a support program of positive action in the area of health and safety research, training, and the collection, compilation, and analysis of accident statistics. We have undertaken an intensified research program of respirable dust in the mining industry, including definitive measurements of dust to assure proper application of dust standards. It remains to be seen whether or not the gravimetric methods of dust collection as presently used in the coal mining industry can be used as a practical monitoring means for human exposure to airborne dusts in metal and nonmetal mines and plants. We are also conducting a series of noise surveys to assess that problem, and we are concerning ourselves more with the measurement of radiation hazards in underground uranium mines. As part of our broad research program, we are exploring the feasibility of research techniques as the setting of meaningful performance standards for diesel engines used underground.

As a guide for our inspectors, we have developed a 2,150-page reference and training manual covering 64 subjects. Also, we have developed an instruction manual for the conduction of Federal inspections and investigations in mines together with an interim guide concerning the interpretation and application of current standards. No doubt, changes will be made as we gain experience and are able to evaluate better the application and impact of certain standards on the mining industry.

The Bureau is presently in short supply of personnel to conduct training; however, we are accelerating our efforts to obtain and indoctrinate field personnel so that they can assist the states and mine operators in training their inspectors, and help the labor groups which may desire to train their members. The Bureau also intends to sponsor a mine safety academy to develop professional and technical health and safety personnel for all segments of the mining industry. Funds to initiate preliminary studies for this project have already been made available to the Bureau.

The Bureau is employing the most modern automatic data processing systems to handle its collection, compilation, and analysis of accident statistics. Studies have been made by the management firm of Booz-Allen and Hamilton to recommend further means of improving the system and to achieve better use of the data gathered. Current up-to-date information is a vital aid to industry and to the inspector in carrying out his duties. A simple checkoff ledger form to record all injuries, where and how they occur, and other pertinent data has been developed for the use of mine and plant operators. We hope to have the ledger form available soon, and management is urged to adopt this useful aid as a means of pinpointing problem areas as they develop in their operations.

Our estimates indicate that there are 1,500 underground mines, 6,000 to 8,000 open pit mines, and 6,000 to 10,000 sand, gravel and crushed stone operations presently covered by the Act. Our estimates also indicate that these mines employ approximately 34,700 men underground, 114,400 in surface mining operations, and 98,400 in mills for a total of 247,500 persons. The Bureau plans to conduct 3,000 inspections by June 30, 1971. We will include all underground mines and most large and medium-size open pit mines and quarries, plus a representative group of sand and gravel operations. Next year we anticipate having sufficient trained manpower to conduct approximately 8,000 inspections. You can readily see that there is plenty of room and need for state plan participation, and the Bureau will welcome such participation providing proper standards are met.

Between August 1, 1970, and September 21, 1970, the Bureau inspected approximately 300 mines, conducted 13 spot inspections, and

served 1,616 notices of violations of mandatory standards. During this period only two withdrawal orders were issued. In both instances, prompt corrections were made by the companies concerned so that the inspector was able to abate the order before leaving the property. This reflects excellent cooperation by management, labor, and the state mine inspectors who participated actively with the Federal inspectors.

To date, our inspection force is operating with good teamwork, and our inspectors will soon be identified as true professional safety inspectors. The Bureau of Mines is deeply grateful for the cooperation and courtesies extended these men by management and their association, by state inspection agencies, and by labor groups during this critical period of launching a new program. Let us consider, however, what lies ahead.

There will naturally be occasions where differences of opinion will arise and where combinations of circumstances will pose some problems. An operator served a withdrawal order by a Federal inspector may apply for annulment or revision of such order. To handle such problems, the Secretary of the Interior on September 15, 1970 sent to the Senate, for confirmation, the nomination of five persons to a Federal Metal and Nonmetallic Mine Safety Board of Review. Also, the secretary is currently appointing a nine-member advisory committee to develop new standards and review or revise present standards that impose special problems.

Safety is a field in which labor and management must meet on the ground of joint interest. We need an attitude of honesty in the safety business at all levels. We cannot bargain safety.

Those of you who have exceptionally good safety records certainly deserve recognition. Also, recognition should be given those members of labor who have contributed outstanding cooperation in safety. While it may be true that not enough publicity has been given such efforts and achievements in the past, we should recognize that the public too frequently judges the industry's total image and not individual records. Thus, it would be very prudent for those who have established good health and safety programs to encourage and aid their other colleagues to better the mining industry's safety image.

Management, to do its job, must be dynamic, critical, open-minded, adaptable, and just. There are very few accidents in which the supervision is not at least partly at fault in one way or another—especially in failure to impress or communicate. That, too, is a responsibility. If you have picked the right man to be your safety director, he must be in on the planning right from the start. If he is to be listened to by the man at the bottom of the mine, he must be respected as a key staff member by the men at the top.

Labor must also play a more constructive role in your safety program. If you truly want their cooperation, there are ways and means to enlist their participation. Safety records are achieved through teamwork.

The role of the Bureau of Mines is to see that positive action is taken to improve health and safety in metal and nonmetal mines. This necessitates bringing together both management and labor while applying the rules or standards and seeing to it that states apply equivalent standards under state plan agreements.

In performing this responsibility, we have not only an inspectorate force but also a competent technical support group backed up by research personnel and their facilities to evaluate and solve health and safety problems as they arise. Educational personnel are being trained and equipped to bring training, information, and safety promotion to the mines. It is the Bureau's policy to see that mines are made safe, and this must be accomplished with the least possible disruption of production and manpower earnings. We must meet the challenging changes confronting the mining industry with the same energy that we put forth in establishing records in costs and production.

DEVELOPING A STATE MINE SAFETY PLAN

By STEPHEN W. POGSON
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Arizona had its State Mine Safety Plan under the Federal Metal and Nonmetallic Mine Safety Act approved on July 28, 1970. It was the first state to have a plan approved under the Act. The fact that Arizona was the first is the result of three and one-half years of hard work by a lot of people. I would like to first discuss what we in Arizona did. I will then take up the requirements of the Bureau of Mines and discuss them individually, occasionally offering some gratuitous advice as to how to proceed, based on our experiences. In some cases, how we did it and how I would advise someone else to proceed are two different things. In order to have this paper be of any value to people from other states, I think it is important that you get as complete and full a story of our experience as the circumstances permit. As you will no doubt glean from my remarks, we were not always in agreement with the Bureau of Mines and on a number of occasions thought that the Bureau's requirements far exceeded the requirements of the statute. In discussing these areas, it is not my purpose to cast aspersions on the Bureau of Mines. Without its cooperation and assistance, the plan would never have been approved. Failure to discuss these areas of differences with the Bureau would, however, give an incomplete picture.

After the Federal Act was passed in 1966, employers, the mine inspector, and some of the labor organizations representing employees in mines evidenced an interest in updating Arizona's Code so that a state plan could be effectuated. Arizona's Code was originally enacted in 1912. It has always been one of the more stringent codes in the mining states. However, there was uncertainty as to the power of the state mine inspector to make rules and regulations to implement the code and cover areas not covered by the code. At the outset, it was recognized by all concerned that the inspector would have to be empowered with authority to promulgate rules. At this time, we, of course, did not know what the Federal safety standards would be. We did, however, have the benefit of the survey done by the Bureau of Mines under the earlier Act which indicated the various areas of safety it was interested in and indicated whether the state had laws or rules in that area. In May 1967 the Governor of Arizona appointed an eleven person committee to study revisions to the mining Code. Chairman of the committee was our State Mine Inspector. There were four representatives of labor unions, four representatives of employers, and two observers from the legislature. We obtained rules and codes from all large western mining states and relied particularly on those from Colorado and Utah. The committee met from time to time from June 1967 until January 1968. There is no necessity to go into the details of the deliberations of the committee. Suffice it to say that it was recognized by all concerned that the finished product would have to be acceptable to labor and management. After a good deal of deliberation, the suggestions for revisions to the mining code were presented to the legislature in February 1968. I might mention at this juncture that our Arizona Code differs from the Federal in one important respect. In Arizona, the state mine inspector has jurisdiction over smelters. This was done because the Arizona legislature was in the process of setting up an industrial safety department under our Industrial Commission and we did not want two sets of inspectors on our properties.

After the revisions to the Code were agreed on by the legislature, the inspector proceeded to work on rules. He was assisted by a committee of safety engineers from the operators. At this juncture, the unions, particularly the Steelworkers, ceased cooperating, as it was apparent they did not want a state plan. Rules and regulations were promulgated by the inspector in July 1969. At this time, only the first draft of the Federal safety standards was out. In the fall of 1969 it appeared that it would be difficult, if not impossible, for any state to have a plan approved by the Bureau of Mines. In November 1969 we received a rough draft of the State Mine Safety Plan and accompanying documents from the Bureau. In our view, the requirements under this draft were onerous and went far beyond what the Act required. Nevertheless, we entered into discussions with representatives of the Bureau. In January of this year a four-man committee went to Washington to discuss the situation with the Bureau for Metal and Nonmetallic Mine Safety and the Bureau for Mine Safety. We did not know in what form the Bureau wanted our information, so we prepared it in the form of a rather lengthy letter from our mine inspector to the Secretary. We did not at this juncture attempt to cross-reference our safety standards to the Federal. At this meeting, we were assured that a state need not have rule by rule equivalents of the Federal standards. We also discussed a number of other matters relating to state plans and became convinced that we in Arizona could qualify with a plan.

After the publication of the second set of revised standards in February of this year, we awaited the Bureau's revisions to its state plan material. We received it in late May and proceeded to start the onerous job of cross-checking our statutes and rules with the Federal. When this was done, it was sent to Washington, together with other material requested. The same committee of four people then went back to Washington early in July of this year to attempt to get state plan approval. We found that this size committee worked very well and that we complemented each other. A larger group would have been too unwieldy for real deliberations and a smaller group might not have had the expertise that was required to formulate the plan and present it to the Bureau. When we arrived in Washington in July, we found that the Bureau had done its own cross-referencing of our rules and statutes to the Federal standards and found us wanting in some respects. After a good deal of earnest, but always friendly, discussions regarding what the Act required and what is meant by a state having substantially equivalent standards, the Bureau receded from its position that we would have to have standards almost exactly equivalent to the Federal standards. On the other hand, our state mine inspector agreed to promulgate a number of new rules and regulations to cover areas not previously specifically covered by our Code and rules. Previously, the inspector had relied on broad general statutes and rules giving him the power to enforce good safety practices generally. On the other hand, we have always had specific rules and statutes covering such things as underground mining. In any event, our inspector agreed and did proceed to publish revised and expanded rules and regulations. Based on that assurance, the Bureau agreed to accept our state plan. After a few technical revisions were made in the text of the plan, the acting director of the Bureau came to Phoenix on July 28 and the plan was formally executed on that day.

Having discussed how we in Arizona formulated our State Mine Safety Plan, I would now like to turn to the requirements of the Bureau itself and discuss a number of individual items and offer some suggestions as to how to proceed. To my way of thinking, the first order of business is to make sure that your state mine inspection agency has authority to enforce rules and statutes and has authority to promulgate rules. Having to go to a state legislature to obtain amendments to mine safety legislation is a time consuming and often futile procedure. Based on our experience, I suggest that if your agency does not have the power to promulgate rules and regulations, you immediately proceed to attempt to obtain legislation authorizing it to do so. When this is done, it is simply a matter of promulgating rules substantially as effective as the Federal standards and complying with the other requirements of the Bureau and the Act relating to qualifications of inspectors, equipment, etc.

Turning now to the Act, the first and one of the most important requirements is that the agency be the sole agency entrusted with enforcing mine safety and that it have adequate authority to do the job. As I have indicated, this is the first order of business.

The next thing to be taken up is an analysis of the personnel of the state agency. How many people do you have? Do you have enough to make the inspections required by the Act and/or the state plan? Are they under civil service? What are their qualifications? In our case, we prepared a résumé showing the experience of each of the deputy mine inspectors and the mine inspector. We have a mine inspector, a state mine dust engineer and assistant, and six deputy mine inspectors. In the aggregate they have over 130 years experience in mining. We believe that this résumé was helpful in assuring the Bureau that our personnel are well qualified.

The next requirement is that the state agency be adequately funded. We prepared an analysis showing the year by year appropriations to the state mine inspector's office, starting with the year 1945. These appropriations increased substantially during the past several years, showing the Bureau that our state is ready and anxious to live up to its responsibilities in the field of mine safety.

Your state must have adequate laws and other provisions for taking care of fencing or otherwise securing abandoned mines. If your inspector has rule-making authority, this is a relatively simple thing to do. Of course, rules requiring such fencing or securing must be followed up and enforced. This is a very difficult and time consuming responsibility in view of the large numbers of abandoned shafts and prospect holes in most western mining states.

With respect to the number of inspections, the Act requires only that the state inspect underground mines annually. The Bureau's state plan requires that such inspections be made semi-annually. While we had no objections to making this number of inspections and indeed have been inspecting much more often, we believe this is an instance where the Bureau is requiring something that the law does not require. In any event, our Arizona state mine inspector inspects underground mines at least four times a year and in 1969 inspected one prospect shaft 11 times.

The Bureau requires the state agency to have certain equipment and facilities for making tests for ventilation, radon daughters, etc. This is something that is impossible to generalize about, and your committee will have to sit down with the Bureau, discuss the equipment your agency has, and try to come to some sort of agreement. This is a very difficult area because some of the equipment the Bureau would like to have the states have is very expensive and, as a practical matter, cannot be obtained for that reason. After we discussed our situation with the Bureau representatives, we found them cooperative and understanding in this area.

The Act requires certain reports to be transmitted to the Bureau by the state agency. There has been some confusion as a result of the fact that the Bureau sends copies of its inspection reports to labor organizations representing employees at the mine it inspected. While I personally think this is uncalled for, the Bureau has determined as a matter of policy to do this. This does not mean that the state agency has any duty whatsoever to do likewise.

The subject of inspections, both individual and joint, has been the subject of a good deal of discussion between the Bureau and the states. It is the Bureau's philosophy that representatives of labor organizations should be invited to accompany inspectors. It does not, however, have the authority to insist that this be done. If an employer objects to having a union representative accompany inspectors, they will not do so. The federal inspector will notify the union representative that he is in the area and making an inspection of the particular mine. The question of whether or not union representatives should participate in inspections is, of course, a philosophical one which should be resolved on a company by company basis. Some unions representing large numbers of employees in the mining industry have shown a commendable interest in safety at the top level. At the lower levels, "safety" is too often used as an alternate to the grievance procedure. Until such time as local union representatives accept their responsibilities in the field of safety (this includes not trying to defend members of the local who are committing unsafe practices) I see no useful purpose in inviting the unions into the field of safety as a partner. As I have indicated, this is a philosophical issue and I am certainly aware of companies and states that disagree with my opinion.

The most difficult task in getting a state mine safety plan approved is seeing to it that the state statutes and rules are substantially equivalent to the Federal standards. As I have indicated, while the Bureau would like rule by rule equivalents to the Federal standards, it does not insist upon them, and in my opinion, cannot. If you can make a case that a state rule ought not to be as stringent as a Federal rule you might well be able to convince the Bureau. For example, one of the Federal standards relating to hoists in underground mines prohibits the use of hoists driven by belts. Our inspector was able to convince the Bureau that certain types of belt driven hoists with certain safeguards are perfectly safe and that it would be onerous to prohibit their use in

Arizona. On a more general level, a number of the Federal standards are nothing more or less than common sense admonitions, such as a man signalling a truck backing up should be sure to stand clear of the truck. We appreciate the necessity for having such all encompassing rules since they will be in effect all over the country. We did suggest to the Bureau that a number of these rules need not have Arizona equivalents in view of our general prohibitions against unsafe practices directed to employees and employers alike.

We believe that the obvious purpose of allowing state plans was to recognize the reality that mining conditions and problems vary from state to state. For this reason, states ought to be allowed leeway. We believe that we have accomplished that in Arizona and that, despite the great amount of work it took to prepare our state safety plan, the results justify the time and effort.

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