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METAL AND NONMETALLIC MINE SAFETY ACT

By ROY G. STOTT

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The Bureau of Mines was created by Act of Congress in 1910 to improve the safety and health of miners and to conserve mineral resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries. Thus a close interrelationship of health and safety activities and research on mining technology was established. Today the Metal and Non-metallic Mine Safety Act of 1966 (P.L. 89-577) covers uranium, oil shale, gilsonite, and asphaltic tar mines as well as nonfuel mines; coal mines are covered by the Coal Mine Safety Act of 1969 (P.L. 91-173.) The diverse nature and complexity of mining technology applicable to the noncoal fuel mines and other mines covered under the Metal and Nonmetallic Mine Safety Act has prompted the Bureau of Mines to staff its metal and nonmetal mine inspection force heavily (50 per cent) with mining engineers and to conduct a rather thorough professional level training program for all mine inspectors.

The Metal and Nonmetallic Mine Safety Act of 1966 places the following responsibilities on the Secretary of the Interior who in turn has delegated them to the Bureau of Mines:

1. To make inspections and investigations for the purpose of obtaining, utilizing, and disseminating information relating to health and safety conditions in mines, causes of accidents involving injury or loss of life, and causes of occupational diseases; determining whether or not there is compliance with a health and safety standard issued under this Act; and evaluating the manner in which a State Plan approved under the Act is being carried out. Each underground mine shall be inspected by a Federal inspector at least once each calendar year.

2. To develop, revise (after consultation with advisory committees), and promulgate health and safety standards for mines for the purposes of protection of life, promotion of health and safety, and prevention of accidents.

3. To issue withdrawal orders debarring all persons not necessary to correct the hazard from imminent danger areas. (Imminent danger means where danger exists which could reasonably be expected to cause death or serious physical harm immediately or before the imminence of such danger can be eliminated.

4. To issue notices where there is failure to comply with a mandatory standard and fix a reasonable time for abatement of the violation.

5. To issue withdrawal order for failure to abate a violation of mandatory standard after time has expired on a notice and no reasonable justification exists for extension of time.

The Act requires operators of mines to provide, as prescribed by the Secretary of the Interior, reports of accidents, injuries, occupational diseases, and related data. The Secretary shall compile, analyze, and publish the information obtained. All information, reports, orders or findings shall be made available for public inspection.

The Act requires development of expanded programs for the education and training of employers and employees in recognition, avoidance, and prevention of accidents or unsafe or unhealthful working conditions in mines. It also requires Federal cooperation with state mine inspection or safety agencies and for the development and approval of a state plan whereby the state may carry out inspections of mines and enforcement of state standards that are substantially equivalent to Federal standards.

It designates that the major responsibility for administering the provisions of the Act shall be vested in the Bureau of Mines, and requires annual reports by the Secretary to the Congress on the administration of his functions under the Act, together with such findings, comments, and recommendations for legislative action as he may deem proper.

According to the Metal and Nonmetallic Mine Safety Act of 1966, the term "mine" means: (1) an area of land from which minerals other than coal or lignite are extracted in nonliquid form, or if in liquid form, are extracted with workers underground; (2) private ways and roads appurtenant to such areas, and; (3) land, excavations, underground passageways and workings, structures, facilities, equipment, machines, tools or other property, on the surface or underground, used in the work of extracting such minerals.

of the Interior has informed the Bureau of Mines that the Act applies "beyond mining only in the narrow and ordinary sense of the term, to the next sequential stage to that of the related milling operation" and does not apply beyond the point where milling ends and where smelting, refining, or manufacturing begins. He has also ruled that "The Department is obliged to construe the Act in a manner which will best accomplish the purpose of the Act—to protect life, promote health and safety and prevent accidents.... Therefore, the Bureau must enforce the Act in each metal and nonmetal mine, regardless of its size and the use to which its production is ultimately applied."

The following penalties are provided by the 1966 Act:

1. Temporary or permanent injunction or restraining order or other order for refusing to permit inspections to be carried out, hindering or interfering with inspectors, refusing to comply with notices or orders, or refusing to furnish information requested by the Secretary.

2. Fines of not less than $100 or more than $3,000, or imprisonment not to exceed 60 days, or both, for refusing to comply with orders issued that involve imminent dangers. Corporate officers or their authorized representative who knowingly permit such offenses are subject to the same penalties.

The Act provides operators with provisions for applying for annulment or revision of orders served upon them and for judicial review of decisions made on such orders upon petition by any aggrieved person. Basically, the initial appeal can be directed to the Secretary of the Interior or to the Federal Metal and Nonmetallic Mine Safety Board of Review or both. The procedure is spelled out in the Act and, being of legal nature, will not be discussed herein.

Although they are not provided for by the Metal and Nonmetallic Mine Safety Act of 1966, the following developments should be of interest:

Internal Revenue Service. A letter of agreement has been signed between the Department of the Interior and Treasury Department for the Bureau of Mines to perform on behalf of the Alcohol, Tobacco, and Firearms Division of the Internal Revenue Service inspections at mines for compliance with explosive-storage requirements of Title XI of the Organized Crime Control Act of 1970. These inspections will cover all explosives storage in mining operations. It has also been agreed that the Bureau of Mines and the Alcohol, Tobacco, and Firearms Division will attempt to develop common standards for explosives storage on mining properties. Bureau inspectors have been indoctrinated and supplied with required forms. They are currently making these inspections.

Department of Labor. Discussions are currently underway to avoid duplication and to develop a clear line of demarcation between the inspection activities of the Labor Department under the Occupational Safety and Health Act of 1970 and those of the Bureau of Mines under the Federal Metal and Nonmetallic Mine Safety Act of 1966. Of particular interest are gypsum board plants, brick plants, ceramic plants, kiln products, retorting, heat expansion plants, asphalt mixing, sintering, pelletizing, concrete and ready mix plants, underground storage and warehousing facilities, smelters, and refineries.

Department of Transportation. Trucks that operate in open pits, quarries, and sand and gravel operations also travel over highways and onto construction sites. The question arises as to whose standards will be applied to such transportation and as to the role of the Bureau of Mines. This area has yet to be explored.

Summary

The foregoing presentation is intended as a briefing for your information and guidance.

In closing, I wish to point out that although the Bureau of Mines has the know-how to carry out inspection of an entire mining operation through all plant facilities including kilns, furnaces, board plants, batching plants, and refining processes, our present funds do not cover such overlapping programs and cannot be spent legally outside of inspections conducted under the Metal and Nonmetallic Mine Safety Act. However, some of these facilities will be covered by the Occupational Safety and Health Act and the standards developed for implementing that Act, and whether or not the Bureau of Mines will ultimately conduct inspections of those facilities depends on forthcoming interagency decisions and agreements and the appropriation of funds earmarked for that purpose.

COMMERCE IN EXPLOSIVES REGULATIONS

By REX D. DAVIS
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The Alcohol, Tobacco, and Firearms Division, referred to as "ATF," is part of the Internal Revenue Service, which is in the Department of the Treasury. ATF has two principal areas of responsibility. One is federal regulation of the legal alcohol, tobacco, firearms, and explosives industries; the other is enforcement of the federal criminal statutes relating to illicit liquor, firearms, and explosives.

In the regulatory area, which we call revenue control, we are interested in such things as the elimination of unfair trade practices, consumer protection, issuance of federal permits, and the collection of taxes. It might interest you to know that the federal revenue from excise taxes on alcohol and tobacco products amounted to $7 billion during the past fiscal year.

In our law enforcement program, we have over 1,600 criminal investigators stationed at 230 posts of duty throughout the United States. During the past fiscal year, ATF arrested over 5,400 persons for violations of the federal laws relating to illicit liquor, firearms, and explosives. We consider one of our primary missions to be the rendering of assistance to state and local law enforcement officers in their fight against crime and violence.

You might well ask: "What is ATF doing on a program sponsored by the National Safety Council?" Or, to put the question more specifically, "How did ATF get into the explosives safety picture?" The Alcohol, Tobacco, and Firearms Division has been in the federal gun control business since 1934. But it was not until 1968 that a strengthened Gun Control Act included "destructive devices" among those types of weapons that had to be registered with the ATF Division. Basically, the term "destructive devices" includes a wide range of articles such as mortars, mines, rockets, and cannons. The term also includes home-made bombs and molotov cocktails. ATF has been investigating bombings since the passage of the Gun Control Act in 1968.

In October of 1970, the President signed the Organized Crime Control Act of 1970. Title XI of this Act was concerned with the regulation of explosives, with primary emphasis on controlling the criminal misuse of explosives.

Because the provisions of Title XI were quite similar to the provisions of the Gun Control Act of 1968 and because of our experience in the investigation of bombings, ATF was given responsibility for administering the new law.

Title XI provides for the licensing of importers, manufacturers, and dealers in explosive materials. It also requires that a user of explosive materials obtain a permit if he acquires the explosives in interstate commerce. The statute makes it unlawful for certain categories of individuals such as felons, fugitives, and narcotic addicts to acquire or possess explosives. It also requires the reporting of the theft of explosives within 24 hours of the discovery of the theft and provides criminal penalties for several unlawful acts involving explosives.

As you can see, Title XI is primarily aimed at the criminal misuse of explosives. But the opening sentence of Title XI stated the purpose of the title: "The Congress hereby declares that the purpose of this title is to protect interstate and foreign commerce against interference and interruption by reducing the hazard to persons and property arising from misuse and unsafe or insecure storage of explosive materials." As a result, the Title provides for regulation of the storage of explosive materials within the United States, and we have promulgated regulations in this area. In addition, the law charges us with the responsibility for investigating the site of any accident or fire in which there is reason to believe that explosive materials were involved to determine precautions which may be taken to prevent similar accidents from occurring. As a result of this law, ATF is concerned with the safe storage of explosive materials and the investigation of accidental explosions.

As taxpayers in general and users of explosives in particular, you have a legitimate concern regarding overlapping of jurisdiction and duplication of effort on the part of federal agencies charged with responsibilities in the safety area. All of us share your concern and our purpose is to report the progress we are making in eliminating misunderstanding and wasted effort. This, then, is the picture as I see it from the viewpoint of ATF.

Department of Interior. Upon enactment of Title XI of the Organized Crime Control Act of 1970, it became apparent immediately that there could be a duplication of effort between ATF and the Bureau of Mines. As a result of exploratory meetings, a memorandum of understanding has been entered into between the two departments. Essentially, the understanding provides that Bureau of Mines personnel will carry out the requirements of Title XI in mines under its jurisdiction. This arrangement is well underway and should eliminate duplication and confusion. In addition, the two agencies are working towards common standards of storage of explosives under the applicable laws they administer.

Department of Transportation. There are no overlapping jurisdictional areas between the Department of the Treasury and the Department of Transportation. We fully recognize their responsibility for regulation of the interstate transportation of explosives. In the few borderline situations which have arisen, we have worked with DOT to resolve the problem. We will look forward to continuing this cooperation on any future problem areas. We have initiated action with DOT which we believe will result in an understanding that DOT will investigate accidental explosions on interstate carriers. This will avoid simultaneous investigations of the same accident by DOT and Treasury.

Department of Labor. Apparently, the only problem area existing between Labor and Treasury is found in the explosives storage regulations issued for the construction industry by Labor. Since these conflict in some areas with storage regulations issued by ATF, we will initiate action with Labor to iron out the differences.

Department of Justice. While ATF has overall responsibility for the regulation of explosives, Title XI gave concurrent jurisdiction to ATF and the FBI over criminal acts in six sections of the law. In order to avoid duplication of law enforcement effort, we have entered into an understanding with the FBI as to who has primary responsibility for each section.

MOTOR CARRIER SAFETY REGULATIONS

By ARTHUR R. McANDREW, Jr.
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The Department of Transportation has many functions and regulations in the area of transportation safety. However, I am going to confine my comments to those which would apply to operators of motor vehicles transporting property.

The statutory authority under which we in the Bureau of Motor Carrier Safety of the Federal Highway Administration work comes from what is sometimes known as the Motor Carrier Act of 1935, now Part II of the Interstate Commerce Act, and from what is known as the Explosives and Other Dangerous Articles Act. Both of these Acts have been in existence for a good many years, and over those years have undergone some changes. However, the regulatory concept and the bulk of the Acts are the same as they were originally many years ago.

To determine who is subject to the regulations promulgated under these Acts, certain basic elements must be considered, and because they vary somewhat, I will take the two Acts separately. With respect to the Interstate Commerce Act, the initial consideration is that there must be transportation by motor vehicles—transportation more specifically, in this case, of property; second, that transportation must be over the public highways; and third, the transportation must be in interstate commerce. In other words, if you operate trucks but those trucks never operate on the highway, you are not subject to our jurisdiction. If you operate trucks and those trucks operate on the public highways, but are not performing any interstate transportation, then you and those trucks and their drivers are not subject to our regulations. But if your trucks do transport property over the public highways in interstate commerce, then those trucks and drivers are subject to the Motor Carrier Safety Regulations which have been promulgated under the Interstate Commerce Act.

With respect to the Explosive and Other Dangerous Articles Act, certain of the elements would be the same. You must be transporting property—specifically, explosives or other hazardous materials—over the public highway by motor vehicle, and you must be an interstate carrier.

As I use the word "carrier," I do not mean a for-hire carrier. As we use the term it would include common carriers and contract carriers, whether or not they are regulated by the Interstate Commerce Commission, and also private carriers. A private carrier is one who transports merchandise which he owns or holds under lease, bailment, or some similar arrangement when the transportation is in connection with a commercial enterprise.

Note here the subtle difference in the terms I have used with respect to interstate commerce. In considering the transportation of non-explosive or dangerous commodities, the Motor Carrier Safety Regulations apply only to those vehicles and drivers who are actually engaged in transportation of a commodity which is moving from a point in one state to a point in another state. On the other hand, with respect to hazardous materials, if you conduct any transportation in interstate or foreign commerce, then, when your vehicle is transporting explosives or other dangerous commodities, the vehicle and the driver are subject to the Motor Carrier Safety Regulations, and they and you as the carrier are subject to those regulations peculiar to hazardous materials whether or not the vehicle is at that time operating in interstate commerce. Thus, if you have dump trucks which haul gravel in interstate commerce and you send a pickup truck to town to pick up some explosives, that pickup truck and its driver who bring the explosives from town back to the quarry only a couple of miles away are fully subject to both the Motor Carrier Safety Regulations and the Hazardous Materials Regulations.

I have used the term interstate commerce several times, and I should therefore explain a little further what we mean when we say that a driver or a vehicle must be operating in interstate commerce or that you as the carrier must transport property in interstate commerce.

There have been many interpretations and court cases dealing with this subject as it applies to the Acts under which we work. A shipment is in interstate commerce from the time it leaves a point of origin in one state until it reaches an intended destination in some other state, or perhaps a foreign country. Any vehicle which performs any portion of that transportation is said to be operating in interstate or foreign commerce, even though it may perhaps never leave the state in which it started or even the city in which it started. Thus, if you do not have a rail siding, and your dump truck takes gravel from the quarry and hauls it to a public rail siding four or five miles away where the gravel is dumped into a railroad car for a journey to a point in another state, that transportation by the dump truck is in interstate commerce.

These situations are not always so cut and dried, but over the nearly one hundred years that the Interstate Commerce Act has existed, there have been many, many determination cases, and we can find a parallel for most any circumstance that you come up with if you have questions as to whether or not your operation would be in interstate commerce.

I'll touch briefly on our regulations. They consist of rules applicable to the vehicle and the driver, and additionally include certain record keeping requirements. The first and one of the most important sections deals with qualifications of drivers. Before being hired and placed in interstate commerce, driver's backgrounds must be checked, their driving ability must be tested, their knowledge of the regulations must be tested, and they must meet certain physical requirements. They must periodically be re-examined as to physical fitness, and you must keep certain personnel records.

The second section deals with driving rules. For the most part these rules bear a similarity to state laws and are mostly nothing more than common sense.

The third section deals with requirements as to vehicle parts and accessories, and to emergency equipment which must be carried on the vehicle.

The fourth part relates to the reporting of accidents. At the present time private carriers do not have to report accidents unless they involved explosives or other dangerous articles, but this rule will undoubtedly be changed in the near future to include private carriers within the reporting requirement.

The regulations prescribe limitations on the number of hours that drivers may drive and the number of hours that drivers may be on duty. There are limitations both in terms of daily driving time and daily on-duty time as well as weekly on-duty time. This section also requires drivers, other than short haul drivers meeting certain requirements, to prepare a daily log, and for the carrier to retain copies of that log.

The regulations also include a section dealing with requirements as to inspection and maintenance of vehicles. Briefly, they require that you have a systematic program for inspection and maintenance of your motor vehicles and that you have the records that are needed to have and control such a program.

If you as a carrier transport explosives or other dangerous articles, or if you as a shipper ship by any mode of transportation explosives or other dangerous articles, you will then be concerned with regulations relating to the packaging of the commodity, labeling of the container, the loading and unloading of the vehicle, the loading arrangements of the vehicles, placarding of the vehicles, shipping papers and information contained on those shipping papers and, lastly, with certain rules governing the storage of the commodities while they are in transit, particularly the storage of explosives while they are in transit.

What I have outlined here is, of course, only a thumbnail sketch of the area of our responsibility. If you have questions, we have 77 detached offices around the country, including nine regional offices. If there is no office in your town, contact any interstate for-hire carrier in your town and I'm sure they can tell you where the nearest office is or, write to me in Washington.

ROCK BLASTING INITIATION SYSTEMS

By RICHARD L. JOHNSON
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The power provided by commercial explosives and blasting agents is still one of the most useful and convenient forms of energy available to man today because of its many applications to mining and quarrying. The safe and efficient use of this energy depends, to a large degree, on how explosives are initiated. As such, recent developments and trends in products that are used to initiate explosives are matters of interest to all of us here today. A definition of the blast initiation system is that part of the entire blast that (1) provides a signal transmission and sufficient energy impulse to the main charge, and (2) provides, when required, a sequential delay between adjacent charges. This signal transmission and energy impulse can be one and the same, or they can be two completely separate and distinct functions.

In this presentation, I will be discussing four initiation systems; cap and fuse, electric blasting caps, Primacord-type detonating cord and a relatively new system, namely, precise non-electric delays. As I stated, the signal transmission and energy impulse can be the same or distinctly separate functions. In the case of cap and fuse initiation, the fuse provides the signal transmission, and the cap provides the energy impulse. For electric blasting caps, the leg wires transmit the signal, and the cap provides the energy impulse. In detonating cord, we have the system wherein the two functions are one and the same. That is, the cord not only transmits the signal but also provides the energy impulse all along its length. This is a linear function, as opposed to the caps of other systems being point application of energy impulse. Non-category, as the detonating cord in this case (being of very small explosive coreload) only transmits the signal and the cap again provides the energy impulse.

As you all know, in the past fifteen years we have witnessed major technological changes in the explosives industry. These changes have had widespread effects on blasting as practiced by mining and quarrying industries. In fact, it is safe to say that the discovery in 1955 that ammonium nitrate sensitized with a carbonaceous fuel produces an effective low-cost blasting agent, revolutionized the explosives industry.

This revolution has had, in addition to the technological advances, some important side effects. "The name of the game" in any business is profit. All important to profit are costs. Such costs have been climbing at a fantastic pace; however, the cost of chemical explosives to break a given quantity of rock has actually been reduced. But more important, as we discuss these things, we see that in addition to the economic and technological gains in blasting practices we have a third aspect that has come into play, namely, that of safety.

The safety aspect of commercial blasting has far outpaced both the technological and economic advances. In short, the sensitivity, the handling methods, the accuracy, the control, not only of energy but of excess-energy (that shows up as air-blast and seismic shock), have been so improved that practical production blasting as we see it today is hardly recognizable through 1950 eyes. Nevertheless, we must not overlook the fact that regardless of how much safer blasting is today as compared to fifteen or twenty years ago, explosives and blasting agents are designed to release incredible amounts of energy and as such remain a serious safety hazard when not properly managed. Putting the energy to useful work in the most efficient (which is, incidentally, the safest) manner, will be a never ending concern of safety conscious operators. This revolution is still going on, and it is anybody's guess when the many new products and technical concepts will be fully evaluated.

By and large, the mining, quarrying, and explosive industries have focused their attention and activities on what new blasting agents or explosives can best be used to achieve optimum blasting performance at lowest possible cost. A relative few are aware that significant developments and changes have taken place in blast initiation products which are fundamental to safe and efficient blasting.

Before delving into specifics, I will briefly review three general fundamentals so that subsequent comments will fall quickly and logically into place:

1. All methods of initiation must release enough energy, or punch, to reliably initiate some larger explosive mass. A simple example would be a blasting cap to a charge of cap-sensitive dynamite. A second would be a line of Primacord (detonating cord) to a blasting agent primer, to a larger charge of, say, ANFO. In all instances, the initiating strength of the first must be capable of detonating the second, etc.

2. For obvious safety reasons, the first release of energy in any blast must be timed to take place after all personnel, mobile equipment, etc., are removed from the scene of the blast. Further, for ultimate safety, the system must be insulated from external influences that would either prematurely trigger the reaction or impede it in any way. Time, then, is a basic factor.

3. In many blasting applications, ultimate performance can only be achieved if time becomes a factor in yet another way; that is, to provide delay firing for multiple shot blasts.

Now let's take an objective look at cap and fuse, electric blasting caps, detonating cord, and non-electric delay units, to see how they satisfy the three criteria for the initiation system just reviewed; that is, (1) signal transmission and explosive energy, (2) time for safe evacuation and performance through delay firing.

In deference to age, let's first consider cap and fuse. This method of initiation remains the oldest and still the most widely used system in the world today.

The initiating energy is satisfied by a blasting cap which is sensitive to fire as provided by the fuse. Expressed in a different way, the fuse is simply a means of transmitting a signal from one point to another by a time-controlled burning media. The length of the fuse provides the time required for safety. Varying the length of individual fuses in multiple-shot blasts is one of two ways of providing sequential delay. The system has inherent limitations as regards delay timing, and unless the blast design can tolerate delay intervals of one second or more, cap and fuse can be ruled out. Cap and fuse has a high degree of safety from prematures as a result of outside influences and handling.

The use of ANFO mixtures introduced: first, oil as a possible contaminant; second, static electricity if holes are charged with pneumatic loaders; and third, blasting agent charges that are not sensitive to the energy output of a No. 6 cap. New fuse structures which have an impervious plastic jacket adequately dispose of the problems that could conceivably stem from oil or static electricity.

The use of a primer—generally dynamite—provides the necessary punch to reliably detonate the main charge of ANFO or blasting agents. There is, however, a decided trend in such countries as Canada, South Africa, Australia, and the United States, to double, triple, or further increase the strength of the blasting cap so as to preclude the use of a separate primer.

Now let's turn to electric blasting caps. Like the cap and fuse system, the energy impulse is provided by a cap, and the leg wires carry the signal transmission. Unlike cap and fuse, the fire or heat is conveyed to the cap in the form of electical energy which is converted to heat within the confines of the cap. The time factor required for safety—to remove personnel, et cet.—is normally controllable as electrical circuits to convey the triggering signal from a point of safety. Time increments for delay blasting are built into the cap with accuracy and timing intervals which are completely beyond the scope of cap and fuse. If precise, short interval delay is required because of the blast design, the use of electrical blasting caps is required rather than cap and fuse systems.

One of the major disadvantages of electrical initiation is that the caps are activated by relatively small quanties of electric current. Extraneous electricity, whether generated by nature or man, is common and insidious. To

isolate electrical circuits from undesired extraneous electricity defies definitive resolution at this time. There is a lesser problem which is just the reverse. That is to retain the desired electricity in the circuitry when it is applied so as to preclude current leakage and subsequent misfires. This is particularly true when blasting in conductive ground. Unfortunately, conductive ground and current leakage are also insidious factors which are difficult to control.

Over the years, the crispness (accuracy) and range of delay timing have been significantly improved and extended. Work is continually in progress to improve the system against the two electrical problems. It is questionable, however, if advancing technology will ever disclose a practical way to build an electrical system which will accept and retain only desired electrical energy.

The introduction of ammonium nitrate, particularly in small diameter, underground blasting, and the subsequent use of pneumatic loading equipment, have brought with them hazards in the form of static electricity. While there has been an effort to design electric blasting caps so they would be reasonably immune to this type of energy, most work has been directed towards resolving the problem by the use of specially designed and maintained equipment in conjunction with specific handling procedures during loading. A great deal of work has been done on this problem, and if industry recommendations are maintained and followed, electric blasting with ammonium nitrate can be carried on with a relatively high degree of safety.

This brings us to detonating cord. Detonating cord cannot be directly compared to either cap and fuse or electric blasting caps. It is simply a cord with a center core of explosives which, when initiated by a blasting cap, detonates at approximately 20,000 feet per second and has the initiating energy of a cap along its entire length. That is, signal transmission and initiation energy are one and the same. This permits the use of an explosive (PETN) which has a high order of chemical and physical stability with consequent advantages of safety, reliability, and performance.

With detonating cord, the time factor for safety is satisfied in that the activating energy required (either cap and fuse or an electric blasting cap) need not be introduced into the system until just prior to blast time. Excellent control can be maintained at all times.

The time factor incidental to performance is limited as, for all practical purposes, detonating cord lends itself only to instantaneous shooting or millisecond applications where delay units can be tied into a surface hookup.

There have been many changes in Primacord-type detonating cords during the past ten years. Some are the result of changing field needs, while others have been the outgrowth of technical breakthroughs. Changes to meet field needs include the use of a tough, impervious, inner-plastic jacket which, with textiles and other materials, protects the explosive core from contamination as well as providing tensile strength, durability, and handling features necessary in the field.

Technical breakthroughs plus new and improved processing techniques have made it possible to manufacture reliable detonating cords from as little as one to more than 400 grains of explosives per foot (1 lb./7M ft. to 1 lb./20 ft.).

Because of the low sensitivity of many of the blasting agents now being used, a detonating cord with a high initiation punch was desired in a number of applications. This requirement has been filled by the large coreload products. The most significant developments, however, lie in the other direction; that is, lower coreload products. The breakthrough that made it possible to produce safe, dependable, high-performing cords with less than 45 grains per foot has made it possible to lower costs and reduce prices without sacrificing any of the qualities or practical performance features that are essential in the field. At this time, Primacord-type detonating cord with reduced coreloads is being successfully used for many blasting applications. The trend is toward further developments in this direction.

So much for the three most common initiation schemes in use today. You will recall that two are nonelectric, both having limitations in sophistication delay time. The third system, electric blasting caps, provides the ultimate in delay timing but has inherent disadvantages because safety and performance depend on the vagaries of electricity. As such, all three systems have disadvantages, advantages, and limitations. In other words, there has been a void in initiation systems which if filled would satisfy many blasting requirements which are now accomplished with products which fall short of the ultimate in safety or performance.

The desirability of and need for a precise, nonelectric delay to fill this void has been recognized for many years. The problem was how to transmit the signal. The feasibility of using the inherent advantages of detonating cord, coupled with those inherent in the cap portion of an electric cap, seemed the logical approach. That is, to use low-energy detonating cord to transmit a relatively innocuous signal and then marry this signal to a cap with the delay timing built into the cap itself.

Early research and development efforts assumed that such a nonelectric delay would have to be compatible with nitroglycerin-type explosives. On this basis, such a product was developed and proved several years ago and is currently on the market. Unfortunately, the criteria established for this product necessitated the use of a costly, sophisticated, low-energy detonating cord with equally costly connectors, which were necessary to assure dependable performance. The net results were high prices which have greatly limited its use. Since this first commercial nonelectric delay was introduced, substantial changes have taken place in the field. The widespread use of relatively insensitive blasting agents as well as primers has led to relaxing the original criteria so that a less costly type of low coreload detonating cord is now feasible. Furthermore, no special attachments would be required for reliable performance. Such a product was originally developed in Canada and has been in use for nine years. Parallel work was undertaken in this country using a different approach which is judged more flexible and, therefore, better suited for the many different field requirements that exist.

At the present time, a non-electric delay system for in-hole initiation of explosives has been developed to meet the requirements for a non-electric system that provides the precise timing of delay electric blasting caps in both the millisecond and standard long period ranges. This system is immune to the hazards of extraneous electricity normally encountered in mining and quarrying operations. This unit consists of two major components, a miniaturized (approximately four grain-foot) PETN detonating cord and a blasting cap complete with delay element as an integral part of the cap.

In principle, this system utilizes a detonation impulse or signal via the miniaturized detonating cord to ignite the delay element which, in turn, actuates the cap. The detonating cord replaces the leg wires of electric blasting caps or the burning powder train of safety fuse.

Advantages of this system are mainly safety oriented because the system eliminates all electrical hazards commonly associated with blasting. It is immune to hazards of premature initiation by stray or extraneous electricity normally encountered in mining or quarrying operations, including induced currents from nearby lightning strikes. Furthermore, the system is resistant to static electricity generated as a result of pneumatic loading.

Also of interest is that the system may be used without restriction in close proximity to radio transmitters, radar, or similar installations. This represents an important safety feature when no knowledge or control exists over transmitting equipment.

A recent advancement on this system is the introduction of a high strength cap which eliminates the need for special primers. Apart from favorable economics involved, the safety advantages inherent in the reduction or elimination of repeated handling and use of high explosives is significant.

These non-electric delay units are now being used in yet another application, this being as trunkline delay system. Because of the low coreload as compared to the conventional trunkline detonating cords, specifically four grains versus 25 to 50 grains, the noise generated by the trunkline system is reduced, provided that the delay/cap assembly is covered with sand or drill cuttings. While the difference is significant in regard to airblast,

the reduction in noise in critical areas provides a tremendous public relations asset. Often times, people living close to a quarrying or mining operation don't know blasting operations are going on except for the noise. When this element is eliminated, the local residents are unaware of the actual blast time with the result that, in due time, they tend to forget that blasting is even in progress.

In closing, I would like to state that the many changes in products and blasting techniques taking place in the field today are being closely and continually monitored should they suggest new or modified accessory products. All in the explosives industry are well aware of the need for greater economy, efficiency, and safety, and all are working to satisfy this need.

BLASTING PROCEDURES AT THE TOMKINS COVE AND HAVERSTRAW PLANTS

By ROBERT E. MEAD

Engineer-Seismologist, Appalachian Stone Division, Martin Marietta Corp., Tomkins Cove, N. Y.

The Appalachian Stone Division of the Martin Marietta Corporation operates two crushed stone plants in its New York area on the west bank of the Hudson River at Tomkins Cove and Haverstraw, New York. These plants produce annually three million tons of high quality crushed stone and graded aggregate and by-products, most of which is delivered to the New York City area by a fleet of company-owned and rented deck scows. The mineral produced at Haverstraw is diabase, while Tomkins Cove produces dolomite.

The Tomkins Cove quarry has been in operation for about one hundred and forty years. It began as a lime plant around 1830. In the 1850's, the plant was acquired by Calvin Tomkins. By 1910, the plant had a capacity of 300 tons per hour. Because of the ever increasing demand for crushed stone, a new plant was built in 1910 that was capable of producing 1,000 tons per hour. The crushers that were installed in this plant were designed by Thomas A. Edision and are still crushing around 1,000 tons per hour after sixty years of operation. The stone mined at this quarry is the Wappinger Limestone and is of Cambro-Ordovician age. The stone is mined on two levels. The main level varies in height from 50 to 100 feet, while the lower level is around 40 feet in height.

Blast holes are drilled by a 30-R drill, which has been converted to a down-the-hole drill. The diameter of the drill hole is 6¾ inches. This machine drills at an average penetration of 25 feet per hour. Drill holes are spaced 15 feet apart, with a burden of 20 feet. The blast holes are drilled six feet below the quarry floor on the main level and seven feet below the quarry floor on the lower level. The depth of water in the drill holes on the main level averages ten feet. On the lower level, the average depth of water in the drill holes is 25 feet.

Due to the near proximity of private dwellings to the quarry property boundary lines, we shoot an average of ten holes in a quarry blast on the main level, and fifteen holes in a quarry blast on the lower level. A powder factor of .55 is used for primary blasts on the main level. On the lower level, a powder factor of.60 is used. The powder factor used refers to the weight of explosives in pounds required to break one cubic yard of rock in the solid. On the lower level, where we are using the .60 powder factor, one pound of explosives will break approximately four tons of stone.

Prior to drilling blast holes on the quarry face, elevations are taken at the collar of each hole location and also on the quarry floor below to determine the height of the quarry face for each drill hole. The height of the quarry face, plus the sublevel drilling, is the loading depth of the blast hole. The loading depth of the hole in feet times the burden and spacing gives the volume of solid stone in cubic feet in front of the blast hole and extending one-half the spacing interval on each side of the blast hole along the line of blast holes. The volume in cubic feet is divided by twenty-seven to convert the volume to solid cubic yards.

On the lower level, where the quarry face is 40 feet high and the sub-level drilling is seven feet, the loading depth of the hole is 47 feet. To calculate the volume of stone to be blasted by this drill hole, the loading depth of 47 feet is multiplied by 20 feet, the burden, and the product is multiplied by 15 feet, the spacing. This gives us a volume of 14,100 cubic feet. This number converts to 522 solid cubic yards of stone. For a fifteen hole shot on this level, this amounts to 7,830 cubic yards. This figure multiplied by 2.38 gives 18,635 tons.

To determine the amount of explosives necessary to break the volume of stone in front of this drill hole, the volume of 522 cubic yards is multiplied by the powder factor of .60, which results in a weight of 313 pounds. In making up the charge to go in this drill hole, we stay as close as possible to the calculated weight. Any slight variation from this calculated weight of explosives will be due to the different weights of the various types of explosives used.

A loading sheet is made up for the blaster. This sheet shows the number of holes to be loaded, the loading depth of each hole, the number and the type of explosives to be loaded in each hole, and the depth of water in each hole. A note is made on the bottom of this sheet designating the hole at which to initiate the blast and the number of milliseconds in each delay cap.

The day before the primary blast is scheduled to be fired, the Northeast Weather Service, Bedford, Massachusetts, is contacted for a weather forecast for the day of the scheduled blast. If the forecast is favorable, arrangements are made to draw explosives from the magazine at 7:00 A.M. on the day of the blast.

At 7:00 A.M., the blaster draws the explosives shown on the loading sheet from the magazine and places them in the vicinity of the holes to be loaded. The loading crew is made up of the blaster, assistant blaster, two laborers, and a bailing machine operator. Before each hole is loaded, the water in the hole is removed by the bailing machine. When the water in the first hole is removed, two 30-pound cartridges of Tovex Extra are dropped into the hole. Next, two HDP-1 primers are lowered into the hole, threaded on to 50 grain reinforced Primacord downline. Then two 30-pound cartridges of Tovex Extra are dropped into the hole. Next, a HDP-1 primer is drop loaded on the Primacord downline. Then, two 30-pound cartridges of Tovex Extra are dropped. The cartridges of Tovex Extra are cut with a knife as they are dropped so as to make close contact between the explosive and the side of the drill hole. The next part of the charge to be loaded is three 33-pound Tovite cartridges. The first cartridge is lowered by using a wooden tripod and a rope. If it is dropped, the heavy cardboard cartridge may damage the Primacord downline. Next, a HDP-1 primer is drop loaded on the Primacord downline. A second Tovite cartridge is lowered, followed by a HDP-1 primer. The third Tovite cartridge is lowered into the drill hole. Next, four feet of stemming is shovelled into the hole. The fourth cartridge of Tovite is lowered into the hole, and a HDP-1 Primer is drop loaded on the Primacord downline. To complete the loading of the hole, 21 feet of stemming is shovelled into the blast hole.

The Primacord downline is cut off so as to allow about a six-foot extension above the top of the blast hole. A piece of wood about two feet long and one inch in diameter is used to wrap the Primacord extension on. A clove hitch is made in the end of the Primacord downline, and it is slipped over the middle of the two-foot stick and pulled tight. Then, the stick is turned to wrap the Primacord around the stick, and this turning is continued until all of the Primacord is wound onto the stick and the stick is on top of the loaded drill hole. Now, if the charge in the hole should settle a bit, the Primacord will unreel from the stick, and thus, prevent the Primacord from breaking and disappearing down the blast hole.

Each of the remaining fourteen blast holes is loaded in a similar manner.

Prior to connecting the loaded holes together with Primacord, a telephone call is made to the Northeast Weather Service to obtain the latest weather forecast. This weather service provides us with a blasting rating of "Good," "Fair," or "Poor" depending on the altitude of a temperature inversion or isothermal layer above the blast site. If the blasting rating is favorable, the loaded holes can be connected up for firing during the noon lunch period. If, however, the forecast is "Poor," the blast may be postponed until the next day or to such time as the forecaster predicts a favorable time for blasting.

With a blasting rating of "Good," or "Fair," the quarry supervisor instructs the blasters to connect the shot. The holes are connected by two trunk lines of 1.8 grain low energy detonating cord or Minicord. The first hole is instantaneous, and twenty-five milli-second LEDC delay connectors are attached to the downlines of the remaining fourteen holes.

After the noon whistle has sounded, and all employees except the blasting crew have left the quarry, two Number 6 electric blasting caps are taped to the downline of the Number 1 blast hole. A 300-foot blasting cable is attached to the lead wires of the blasting caps, and a blasting machine is set up in a blasting shelter about 300 feet to the rear of the blast site. Stop watches are used to coordinate the firing time and the operation of a seismograph set up about one thousand feet from the blast site. Noise is also monitored with a sound level meter and impact analyzer.

Blasting on the main level creates less loading problems because the depth of water in the drill holes is less than it is on the lower level. The burden and spacing are 20 feet and 15 feet, respectively. The holes are deeper than on the lower level, being from 50 to 100 feet deep. A blast of six holes, with hole depths of 100 feet, will break 6,666 solid cubic yards of stone. Each hole will break 1,111 solid cubic yards. The weight of explosives necessary to break the rock in front of one hole is calculated by multiplying 1,111 solid cubic yards by the powder factor .55; this amounts to 611 pounds of explosives per hole.

After the water has been removed from the hole, the loading procedure is as follows: 60 pounds of Tovex Extra is dropped into the drill hole. Two HDP-1 primers are threaded on to a 50-grain Primacord downline and are lowered to the bottom of the hole. Next, 240 pounds of Tovex Extra is dropped into the hole. One HDP-1 primer is drop loaded on the Primacord downline. Then, 60 pounds of Tovex Extra is dropped into the hole. Above this bottom load, in order of loading, are: 9 feet of stemming, two bags of ammonium nitrate, one HDP-1 primer, 11 feet of stemming, two bags of ammonium nitrate, one HDP-1 primer, 11 feet of stemming, one bag of ammonium nitrate, one HDP-1 primer, and 25 feet of stemming. This completes the loading of the hole. The remaining five holes are loaded in the same manner. Just before blast time, the holes are connected together with a double trunkline of 1.8 grain low energy detonating cord, and 25 milli-second LEDC delay caps.

In the loading of these two primary blasts, we have used water-resistant explosives below the water level in the blast holes. Above the water level in the holes, non-water resistant blasting agents were used.

If it is necessary to delay the blast because of poor blasting weather, or for any other reason, we can be reasonably sure that a delay in the firing time will not adversely affect the blast. Also, in case one of the blast holes does not detonate with the rest of the blast holes, there will be no dynamite or blasting caps mixed in with the broken stone. It is a dangerous situation when a front-end loader or a power shovel has to dig in broken quarry stone that contains unexploded dynamite and blasting caps. It is also dangerous if unexploded dynamite is fed into the stone crusher along with the quarry-run stone. Also, the loaded primary shot is safe from accidental detonation by stray electrical currents, radio frequency energy, static electricity, or lightning, because all the blasting supplies used to load this shot up to this point are non-electric. It becomes sensitive to these hazards only when the blasting caps are attached to the Number 1 hole a couple of minutes before blast time. Several weeks ago, we began to use two Primacord downlines at this quarry to diminish the chance of misfires.

Trac Drill, with compressed air being furnished by a 900 cfm compressor. Secondary drilling is used for development work and to remove toe from in front of a quarry face. This machine drills holes up to 3½ inches in diameter horizontally or at an angle to the horizontal. The holes are drilled up to 30 feet in depth. Forty to sixty per cent dynamite is used in the secondary blasting.

In the loading of these secondary holes, a primer is made of the first stick of dynamite by threading 50-grain Primacord through the dynamite cartridge. This cartridge is loaded into the hole and pushed to the bottom of the hole with a tamping rod. The remainder of the dynamite charge is loaded into the hole, followed by stemming to the collar of the hole. The Primacord downline to the primer at the bottom of the hole is cut off several inches outside the collar of the drill hole. All of the remaining holes are loaded in a similar manner.

Shortly before blast time, the holes are connected by taping an instantaneous electric blasting cap to each Primacord downline and by connecting the lead wires from each blasting cap together to form a series circuit. If more than 300 pounds of explosives are used in the blast, the first 300 pounds will be detonated with instantaneous electric blasting caps. The next 300 pounds will be detonated with twenty-five milli-second delay electric blasting caps. Each additional 300 pounds will require a longer delay electric blasting cap. This use of delayed blasting caps in a secondary blast reduces the amplitude of the ground vibration and also reduces air blast.

The stone mined at Haverstraw is a diabase. It is Triassic in age and is part of the Newark series of shales and sandstone. The deposit is a sill and was formed by an intrusion of a molten mass of diabase into the Newark sandstone. The outcrop of the deposit begins at Mount Ivy, which is several miles north of the Haverstraw quarry and extends south for many miles into the state of New Jersey. It forms the west bank of the Hudson River in this area and is known as the Palisades. The deposit is around 1,000 feet thick.

The Haverstraw quarry is on the west side of the deposit and is not visible from the Hudson River. The stone is presently being quarried on the third and fourth levels. The third level is approximately 115 feet in height, while the fourth level averages 55 feet in height.

Blast holes are drilled by a 40-R drill with a hole diameter of 7⅞ inches. Drilling speed averages 25 feet per hour. Burdens and spacings for these blast holes are 20 feet by 17 feet. On the third level, we have set a limit of eight holes for a primary blast. Blast holes are loaded six feet below the quarry floor.

For a shot with holes 121 feet deep, 1,524 solid cubic yards of stone will be broken by each hole. For the third level, we use a powder factor of .65 to calculate the weight of explosives necessary to break the stone. For 1,524 solid cubic yards of stone, the required weight of explosives is 991 pounds. On this level, the depth of water in the blast holes averages 50 feet. After the water in the hole has been bailed out, the water will return to its former level in a short time, for this is the level of the water table in the rock at this location. Below the water table, we use explosives that have some water resistance, either through the physical properties of the explosive itself or from a waterproof container. Above the water table, we use explosives that are not impervious to water.

The explosive charge for this blast hole is 12 boxes of Tovex Extra at 60 pounds per box, two cartridges of Tovite at 46 pounds each, 3½ bags of ammonium nitrate at 50 pounds per bag, and seven one-pound detonators. This amounts to 994 pounds of explosives.

When the hole has been bailed free of water, the blasting crew begins to load the hole. One box of Tovex Extra is dropped into the hole. Then two HDP-1 detonators are threaded on a 50-grain Primacord downline and lowered to the bottom of the hole. Next, five boxes of Tovex Extra are dropped. This is followed by a HDP-1 primer which is drop loaded on the Primacord downline. Next, five boxes of Tovex Extra are loaded into the hole. Then, a HDP-1 detonator is drop loaded on the Primacord downline. Next, a box of Tovex Extra is loaded into the hole. This completes the base load. Next, 19 feet of stemming is shovelled into the hole. The first deck load consists of two Tovite cartridges and one HDP-1 primer. This is followed by 19 feet of stemming.

The second deck consists of two bags of ammonium nitrate with six per cent diesel oil Number 2 and a HDP-1 primer. This is followed by 19 feet of stemming. The cap load consists of 1½ bags of ammonium nitrate and one HDP-1 primer. Then, 25 feet of stemming is shoveled in the hole to fill it to the collar. The remaining seven holes are loaded in a similar manner, and the holes are connected with a double trunk line of low energy detonating cord and 25 milli-second delays.

After the noon whistle has sounded, and all employees except the blaster and assistant blaster have left the quarry, the blasting caps are attached to the downline of the Number 1 hole and the blast is detonated from a protected shelter about 300 feet to the rear of the blast site.

An eight-hole shot on this level will bring down about 28,500 tons of rock on to the quarry floor. This required the use of 7,952 pounds of explosives.

On the fourth level, the quarry face averages 55 feet in height. The holes on this level are loaded six feet below the quarry floor. Water in the holes on the fourth level averages ten feet in depth.

A powder factor of 0.75 is used for the fourth level. Burden and spacing are the same as on the third level; that is, 20 feet by 17 feet. An average of fourteen holes is used. A fourteen hole shot on this level will move 10,754 solid cubic yards of stone. Converting to tons, this becomes 26,455 tons.

In this shot, the blast hole is 61 feet deep. The depth of the hole, multiplied by the burden and spacing, and the result divided by 27, gives 768 solid cubic yards of stone. This figure, multiplied by the powder factor of 0.75, shows that 576 pounds of explosives will be necessary to break the rock in front of this blast hole.

The explosives charge for this hole is six boxes of Tovex Extra at 60 pounds per box, four bags of ammonium nitrate at 50 pounds each, and five HDP-1 primers at one pound each.

In loading this hole, the water is removed by the bailing machine. Then, one box of Tovex Extra is dropped into the blast hole. Next, two HDP-1 primers are lowered to the bottom of the hole on a downline of reinforced primacord. Then, four boxes of Tovex Extra are dropped into the hole and followed by a HDP-1 primer which is drop loaded down the Primacord downline. This is followed by one box of Tovex Extra. This completes the bottom load.

Next, two bags of ammonium nitrate are poured into the drill hole, followed by a HDP-1 primer. On top of this charge is poured another bag of ammonium nitrate. Next, 16 feet of stemming is loaded into the hole. The remaining bag of ammonium nitrate is the top load; it is poured into the hole and is followed by a HDP-1 primer on the Primacord downline. To complete the loading, 23 feet of stemming is shoveled into the hole. The remaining 13 holes are loaded in a similar manner.

About one hour before blast time, the holes are connected with a double trunk line of low energy detonating cord with 25 milli-second delay blasting caps on each hole from the second through the 14th hole. Hole Number 1 has two adapters attached to the LEDC trunk lines and the Primacord downline. Two Number 6 electric blasting caps are taped on to the Primacord downline. The shot is now armed, and extreme care must be exercised. A 300-foot blasting cable is attached to the lead wires of the blasting caps. The blasting cable extends to a blasting shelter 300 feet to the rear of the blast site.

One minute before blast time, when everyone has left the blast site, the blasting cable is attached to the blasting machine. When the second hand of the stop watch reaches the selected firing time, such as ten minutes, the firing button on the blasting machine is pushed down. This fires all of the holes in the blast. Several weeks ago, we commenced the use of two Primacord downlines to reduce the chance of misfires.

Secondary blasting is carried out in a manner similar to that at the Tomkins Cove

Plant. An Air Trac 1700 Series drill is used for drilling, with compressed air being supplied by a 900 cfm compressor. Forty to sixty per cent dynamite is used to blast rock in the secondary blasting. We use dynamite in stick form in diameters of 1¼, two, and three inches. The quantity of dynamite used amounts to about one-half pound per cubic yard of rock in the solid. This is a powder factor of 0.50.

In loading the first cartridge of dynamite, it is punctured with a copper awl to make a hole through the stick, and a hole is made in one end of the cartridge. Fifty-grain Primacord is threaded through the hole in the side of the cartridge, and the bottom end of the Primacord is inserted in the hole in the end of the cartridge and the Primacord is pulled tight. This dynamite cartridge is pushed to the bottom of the drill hole with a wood tamping pole. The remainder of the charge is loaded into the hole, and this is followed by stemming cartridges to fill the hole to the collar. The Primacord is cut off a few inches outside of the collar of the drill hole to allow room for attaching the blasting cap.

A short time before the blast is to be set off, blasting caps are taped to the short end of Primacord that protrudes from the loaded drill holes, and the lead wires from each cap are connected together to form a series circuit. For the first 300 pounds of explosives, instantaneous electric blasting caps are used. The next 300 pounds of explosives will have 25 milli-second delay electric blasting caps attached. Each 300 pounds of additional explosives will require a longer delay period electric blasting cap. Care must be taken to prevent the blasting cable that connects the electric blasting cap circuit to the blasting machine from coming too close to or crossing power cables, on account of the danger of a premature detonation.

For the past 37 years, this plant has operated without a blasting fatality. No doubt, some of this good safety record can be chalked up to good luck, but we attribute much of this good luck to safe handling and loading procedures. Hard hats, safety glasses, protective gloves, and safety shoes must be used by all employees during the work shift.

The use of the most insensitive explosives in our primary quarry blasting has made the quarry a much safer place to work. The keeping of dynamite and electric blasting caps out of the drill holes in primary quarry blasting will do much to prevent premature blasts and will also eliminate the danger of sensitive explosives in the muckpile in case of misfires.

We have spent much time, money, and effort in making our quarry a safe place to work, and believe that the results are well worth what it cost. After all, we do not want brave men for employees, we want safe men.

QUARRY BLASTING CONTROLS

By EDWARD RUBENS
Sales Mgr., Vibration Measurement Engineers, Inc., Evanston, Ill.

There is something faintly ludicrous about grown men making their living by blowing rock mountains to smithereens, carting the pieces off to some type of construction project and then glueing them back together again. But that's exactly what we do and what we are to discuss today. To say I disapprove of the system would be even more ludicrous than the act itself, because these explosions are necessary to fulfill the needs of society today, and makes the job of vibration consulting engineering a reality.

The vibration or sound consulting engineer does not control noise or vibration. These controls are strictly up to you. Your consultants will make suggestions for control, but if you don't adhere to their words, there are no controls.

For clarity, this review is divided into two parts; that is, vibration and sound. Let's first look at the evolution of vibration measurement and some of the equipment that was used along the way. One of the first machines to gain widespread use was simply called the "pin machine." This unit used pins of various lengths and circumferences standing on end on a plate that had been leveled by adjustment of the plate feet. When the shot went off, if none of the pins fell—"great," but if one or more did, then, by golly, there was some vibration. Theoretically, depending on which pins fell, we were able to determine just how much vibration had reached the machine. Comparison of the pin machine with today's equipment shows that all we were really able to determine was that "sure enough, some pins had fallen down."

The next major step in instrument development was the single plane unit commonly called the "accelerometer." This unit was used either singularly or, more often, in batteries of three to monitor the three mutually perpendicular planes. The use of three instruments to measure each shot became increasingly cumbersome, and brought about the introduction of the three-plane seismolog. This unit monitored the three mutually perpendicular planes and, at the same time, read the frequency of the disturbance and produced the results in the form of a permanent film recording.

Most recently, the Bureau of Mines and some of the states have begun using a new criteria called particle velocity. Simply put, displacement (the readings obtained from the seismolog) was how far a particle traveled, while particle velocity is a read-out on how fast that particle moves. The acceptable safe displacement criteria for years has been an energy ratio equal to 1.0. The newly-acceptable safe particle velocity criteria is a particle velocity equal to two inches per second, which, mathematically, is equivalent to an energy ratio of 1.0. Due to the introduction of the new criteria, several velocity recorders are now available on the market. Since, mathematically, a particle velocity reading can be obtained from either a velocity recorder or a displacement unit, why use one or the other? Because of the engineering design of the velocity recorder, it is possible to use a "direct print" film, and readings are available just minutes after the shot without the necessity of any type of dark room facilities.

But enough of the historical data; let's talk about today's problems. From a safety point of view, the major problem is protecting structures surrounding a blasting site. The most popular question asked of my company is, "What is the rule for the first shot concerning loadings?" There is no hard and fast rule available, but there is a workable formula which gives a good indication. The nomenclature ascribed to the result is scaling factor and the formula reads:

$$\textit{S.F. (Scaling Factor)} = \frac{\textit{Distance in Feet 58}}{\sqrt{\textit{Explosives in Pounds 58}}}$$

Working with this formula, we have found a scaling factor equal to 50 to be safe, so for first shots we use the figure "50," move the math of the equation around, and determine the amount of explosive permissible. As stated previously, this is a good working formula but, by itself, rather restrictive. When it is used with vibration monitoring equipment, we often find loadings can be increased to a scaling factor of 20, and still be termed safe in vibratory content.

A second vibratory problem safety men face is really more mental than physical, and is called "human response." This emotion (if I may call it that) is response to the unexpected, and our company files run the entire gamut from frigidity to pregnancy. There are innumerable stories that can be told, but my favorite is the one about a contractor being sued for child support. It seems this young couple did not have a child figured into their budget, and with all the blasting noise and vibration the contractor was making, they could not sleep. Well, there they were in bed, couldn't sleep, nothing else to do and, well . . . a child-support law suit. The best recommendations that can be made to satisfy this type of complaint is to have the records to prove no damage has been done, and whenever possible, let people know in advance that there will be blasting, but it will be controlled and they will be protected.

The second part of this discussion is noise and the control of it as it relates to safety, health, and welfare of employees. Since time began, noise has been with us a by-product of almost everything we do, and it is rapidly becoming a serious problem. So serious, in fact, that, recently, the government took a good look at industrial noise and were so concerned that we now have the Walsh-Healy Act. Briefly and simply, this Act limits the amount of time an employee can be subjected to specific noise levels without endangering his hearing.

As stated, noise is a by-product of almost everything we do, so the problem now is how much are we producing and what do we do about reducing that which is too high? The first logical step is monitor your operations, paying special attention to high noise potential areas. These measurements should be taken on the "A" weighting network of any reliable sound level meter. The "A" weighting network is prescribed, since its characteristics most closely resemble those of the human ear.

Once these measurements are taken, if you find that any of your employees are being subjected to sounds over those permissible in the Act, administrative or engineering controls must be utilized. If such controls fail to reduce sound levels to within acceptable levels, personal protective equipment must be provided. The simplest administrative measure that can be taken is to move employees from one sound environment to another during the work shift, so that total noise exposure does not exceed the safe limits.

When this type of personnel movement is not practical, engineering steps should be attempted to reduce the levels of noise at their source. The two most common methods used are: first, enclose the source of the problem. When attempting this, make sure sufficient area is allowed within the enclosure to allow maintenance, and be particularly sure that the structure is rigid so as not to allow resonance to the source and addition to the noise. Second, if the source is within a structure already, sound deadening materials applied to walls and ceilings may do the job required better than expected.

The few suggestions just offered will work for machinery, but I must admit they are slightly impracticable for blasting operations. When faced with this problem, take first things first and look to the blast itself to see what can be done to quiet it down. Be sure there is proper stemming, for deeper type patterns, and where there is insufficient room for stemming, matting of sound-deadening materials such as wood or canvas under the regular blasting mats usually do an excellent job.

When all else has been tried and noise is still in excess of permissible limits, the last resort of personal ear protection is the only course remaining open. Several types of protection are available, such as ear muffs or ear plugs, all of which are only effective if they are used properly by the employee and, therein, lies the major problem. How to get the employee to wear this protection? Because it is something new, all types of complaints will be registered, but the most common one will be, "It's uncomfortable." He's right, and there is no way to increase his comfort and still give him the required protection, so you have to provide the motivation to be sure they are worn. Motivation, for different people, will of necessity be as different as the people themselves and, therefore, it is impossible to offer many definite suggestions in this vein.

PIT TRUCK
PREVENTIVE MAINTENANCE AND SAFETY

By LEWIS H. BOYER
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A serious accident sparks a safety study which reveals defects in maintenance checks and procedures and suggests minimum standards.

On November 20, 1969 one of our employees, driving a quarry truck, lost control of his vehicle when the rear universal failed and jumped in panic to his death. Had he stayed with his truck, he would not have been injured.

Immediately after a complete investigation of this accident, we undertook a major study of all of our quarry hauling equipment in all our plants. We called in the factory representatives and gave each piece of haulage equipment a thorough going over for any defects that might exist or were in the process of developing. It was a revealing study. Pictures were taken, a whole new set of check lists was created, and every driver was called in to review these pictures and instructed on the need for careful inspection of their equipment and the reporting of failures. Stress was made on the necessity of not panicking and when and when not to jump from moving equipment.

Our first study involved the speed and stopping abilities of rolling equipment. We painted two yellow lines on a straightaway, one for 20 miles per hour and one for 30 miles per hour. Loaded machines approached this straightaway operating in a gear to pull the loaded machine. We estimated that they were able to make it at 30 miles per hour, or right up against the governor. When they got to the first yellow line, they pushed the clutch in and applied the foot brake. This tested stopping ability. If a truck stops within 130 to 150 feet it shows the truck has good brakes and is under control.

One truck we had rented for several months worked during the summer but had been away from the plant on a dam job for a month, then came back. We had one of our old employees who knew all about operating the machine try this new machine over the same course. He thought his brakes were all right, too. When he applied his brakes at the first yellow line, he could not stop satisfactorily. This was on a new machine that had been rented by us for three months, but nobody thought the brakes were inadequate because there was no need for a complete stop, moving along at that speed, on the work it had been doing.

Once this truck got in the shop, we got into another situation. The mechanics at the shop never do anything about driving the truck to see how the brakes operate after they have been adjusted. The method they use at the shop is to take up on the lever all they can take up on it and then back off half a turn. They consider the brakes are up tight and going backward a half turn will keep them from dragging. The operator loaded up again and came back to us on the straightaway; he applied the brakes and stopped in about a half to a quarter of the length that we considered a satisfactory stopping distance. But his brakes were too close; they were dragging, so he had to go back to the shop for the second time and get his brakes further adjusted so they would not drag.

Now our drivers need not go on thinking they have sufficient brakes. He can drive his machine past the marks and find out whether he stops or whether he has hazardous brakes. He can do this for each day's operation or each shift operation. We think this is a great safety factor.

As one loaded truck approached the incline of one of our stockpiles, we found that he was blowing air. This could happen to any kind of hauling equipment. The air line behind the front wheel which comes across underneath had somehow or other gotten pinched and was losing its air. It could only get up to 85 pounds. This incident indicates that operators are driving equipment with little knowledge of how they are going to stop or hold this heavy equipment. The driver knew all about this leak, but it gave him very little concern safety wise. He was sent to the shop at once to have the hose replaced and cautioned not to try driving the inclines to the piles unless he had maximum air before starting.

After going through this procedure with all 12 of our machines, we have concluded that if the drivers will check their air for maximum pressure before attempting an incline, and test that the machine holds in stopped position or holds well enough that the machine goes down backward slowly on the incline so it can be kept in absolute control, the brakes are sufficient for any emergency, for uphill or downhill operation, or for full speed operation on the level.

Foot control valves are another cause of not having enough air to properly set the brakes. We have found that some new and some rebuilt valves will not deliver enough air and have to be adjusted in the field. Air lines need to be checked to see whether they are mashed shut, damaged, leaking, or filled with solids from the air tank. Further, we have found some frozen brake cams that will not allow brakes to function.

*Improper maintenance can lead to a lack of grease in the planetary gears which may, because of this neglect lock up. The fault here lies with the grease maintenance crew for not checking at each grease cycle, as well as with the driver, who should check to see that the plug or fitting had been used; if it had been taken out by the crew, the dust or dirt would be broken. We then ask how can two different drivers of the machine on two succeeding shifts help but notice or hear this terrible grinding of gears before they get to this condition? This indicates we need some schooling as to what to inspect and what to listen for, an important part of operation of this equipment.

Our inspection revealed that a drive shaft had received a severe jolt at some time, and the tube where it was welded to the pin end of the universal joint had broken loose. Had this not been found on inspection, the joint could have broken loose entirely and caused another emergency, not anticipated.

Another drive shaft taken from one of our 15 ton machines had universal ends that were not aligned properly. They speak of this as out of alignment, but actually it is out of balance and sets up a severe vibration during operation, which will damage the bearings and can cause the shaft to break. It was discovered that the universal flange had two severe cracks that could have caused an emergency, had it broken. It is also most important that we have the proper locks for each type of universal joint, as well as the proper length and diameter bolts for these universal joints to keep all vibration to a minimum which, in turn, keeps bolts from breaking. Caps are necessary to keep loosened bolts from being lost and letting the universal fail.

During our inspection we observed two machines stopped on the inclined road from the quarry. The drivers were out of their machines removing a stone dropped from the tailgate of one of the machines pulling the grade. This is important, because a front wheel hitting a stone going up or down this grade could cause the machine to get out of control. We don't want to criticize, but we would like to ask several questions: (1) The drivers are in front of the machines—is this a safe condition? (2) Are the machines shut down or are the engines still idling—is this a safe condition? (3) Are these machines chucked—is this a safe condition?

Here we might say that we experienced a complete loss of one machine some years ago. The driver stopped on what he thought was a level place and proceeded to get a drink of water. When he looked again, the machine was moving toward the quarry face. Too late, he made another mistake in trying to get into the machine to stop it. Don't ever try this! Fortunately for him, he could not get into the machine and it went over a 50 foot face. What about barriers along this haul road which machines could pull or back up against?

Barriers can be made of individually placed stone on one side and loose dumped material on the other side. We don't say that barriers will stop a loaded truck once it has gotten moving out of control, but they are intended to be where you need them in case of emergency. Before the machine gets out of control, the truck can be maneuvered against them. This takes the panic out of the mind of the operator or even keeps him from thinking about jumping out of a moving machine.

From our survey, we developed a check sheet of information all drivers should know about their machines on each shift. All of these items come naturally and should be checked so that the driver knows his equipment is safe to operate, barring any emergency. We began this survey with a thorough check by the factory representative and a follow-up we made by taking into consideration all these different items as a matter of check and repair before letting the machine go out of the shop. This particular check sheet can be used for any check off on any particular shift. In all of the preventive maintenance checks that the truck people have brought out, the one thing they stress more regularly and more glaringly than anything else is the brakes. It doesn't matter what preventive maintenance sheets you pick up, they will say check the brakes and adjust, if necessary. There is not one of these sheets that they put out that doesn't have it on. You find it on the ten hour check, you find it on the 40 or 50 hour check, the 100 hour check and from 200 to 400 to 600 to 800 to 1000, clear up through 4,000 hours, which is a two year operation. They never let go of this brake business. They want to be sure in operating this heavy equipment that you have adequate brakes. We think you should take a lesson from their thoughts and follow the checkout system.

There is very little servicing during the operation cycle, other than putting in hoist oil and greasing the drive line shaft. All of the greasing is taken care of at the regular time cycle by our greasing operators at the shop. During the drive line check we look for cracks, broken welds, loose bearings, and locking caps lost or broken. Most of this is right near the universal joints on the drive line where loose or missing bolts can be spotted.

FIRE PROTECTION IN THE CEMENT INDUSTRY

By ROLAND I. SPENCER
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One has to frequently ask himself, "But what can burn?" when making a fire protection survey of a modern cement plant. Building construction is mostly fire resistive or noncombustible. Machinery is ruggedly built and for the most part has low fire hazards and low fire potential. Materials flowing through the process are mostly limestone, clay, shale, sand, and cement. Truly, such a plant does outwardly come close to the insurance man's dream of insuring "pig iron under water."

I emphasize the word "outwardly." The opposite of this would, of course, be "inwardly," and as it happens in most all walks of life, the inward facts are not so easily recognized by outward appearances. So let us look inward for a moment.

One measure that can be applied to the fire loss potential in any given class of industry is the loss record. To illustrate 15 examples of typical cement plant losses insured by Factory Insurance Association include approximately 75 per cent of the total dollar loss that occurred during the period of time March 1963—January 1970 for the Earth Products Class, which includes the cement industry, and although not a complete list, these examples of losses total an estimated $1,743,200 combined property damage and business interruption. At first glance we see no predictable statistical loss pattern. Property damage losses range from a low of $2,500 to a high of $718,000. Business interruption claims ranged from a low of $2,000 to a high of $416,000. True, several specific losses stand out and show that serious losses have occurred; however, most could be termed as manageable. A typical reaction to this statistical dribble could be "meaningless," "no problem," "proves our contention that the cement industry has a low fire risk potential," etc.

I think one could make a case out of each of the postulated reactions; however, the one extra thing that the insurance man has to do is to compare premium income with the dollars paid out in losses, and this is where I hope to make you realize your industry does not stand out too well. The Factory Insurance Association's five year experience (1966-1970) for the Earth Products Class indicates that for every dollar that was earned in premium we paid out 99¢ in losses. To this must be added the expense of our doing business, which pushes the overall cost into the red ink column. Quite obviously, if you had to sell cement on the same basis, you wouldn't do so for long.

A summary by type of loss shows that 11 of the 15 examples are fire losses, and that they account for 83.2 per cent of the total dollar loss—approximately $1,450,000. Molten material losses account for two of the 15 examples and represent 14.3 per cent of the total dollar loss—approximately $248,000.

I think it would be well to pause a moment to bring things into perspective Even though the past five years' experience has been predominantly attributable to fire and molten material, it would be foolhardy on anyone's part to conclude that other types of losses are not a potential problem. For example, kiln explosion losses remain an ever present threat.

In grouping the principle cause given for each loss example into the more general categories of contributing factors, we find that for the 15 examples considered seven were due to mechanical breakdown, accounting for 74 per cent of the total dollar loss—approximately $1,288,700. Five losses were due to operational error, representing 22 per cent of the total dollar loss—approximately $376,000. Quite obviously, these are two general contributing factors that are well within the control of the plant management, and I will speak further on this point later.

Conveyor belts were the principal combustibles present in eight of the fires, nonmetallic jacketed cables in trays were in two fires, lube oil and a combustible deposit in a precipitator were the combustible materials present in single cases.

It is obvious that combustible conveyor belts were the main problem in FIA's recent five year underwriting experience of cement plant losses. We find that three of the fire losses involved the clinker conveyor, and that the ignition cause was the all familiar hot clinker in two cases and that one was due to a stalled condition as a result of a motor drive failure, which permitted a heat build-up and subsequent ignition from hot clinkers.

Four of the conveyor belt fires involved raw material handling. One was ignited due to careless use of cutting torch, one was caused by slippage at the drive pulley, one was ignited from hot kiln gases due to a failure of a diverting valve, and one was caused by an electrical fault. One conveyor belt fire involved a product conveyor which was ignited due to slippage at the drive pulley.

Thus our loss experience has shown that regardless of the use of the conveyor belt in a cement plant, i.e., raw material, clinker, or product handling, a fire loss potential is always present.

While this analysis of conveyor belt fires seems rather elementary, a study of the fire protection facilities and loss prevention means available in the various locations involved during the time of the fires also reveals a very basic lack of elementary fire fighting tools. Only in one case was an automatic sprinkler system present. Two heads operated to completely extinguish the fire. Only in one case was there an effective hose line present which permitted employees to extinguish the belt fire. The remaining cases typically involved calling a local fire department, who often had to make a 15 minute run to the plant due to its remoteness. The local fire department's fire fighting efforts were strenuous but mostly ineffective. By the time hose lines were laid, the conveyor and its housing was usually totally involved. Quite often they were hampered by lack of fire fighting water or by difficult accessibility problems.

In summary, the analysis of loss examples is admittedly not very favorable, but it does point up areas of deficiencies involving conveyor belts that are easily correctable as follows:

Conveyor Speed Monitoring

It should be obvious to an industry that depends so heavily upon conveyors and bucket elevators for movement of materials that means must be provided to shutdown a conveyor system whenever a slowdown or slippage occurs. The loss examples illustrate what happens when such devices are not installed. As a conveyor slows down, slips, or stalls, the drive pulley continues to operate at near normal RPM, so the result is eventually fire from heat of friction. Many devices are available, at nominal costs, which detect belt slowdown either in elevators or conveyors. These are interlocked to shutdown the drive motor and to sound an alarm at the control room.

Clinker Belt Specifications

Since the occasional hot clinker is to be expected from the clinker cooler, it is obvious that care must be taken in the selection of the clinker conveyor belt materials of construction. Multiple ply belting with top and bottom neoprene covers rated for 300°F and with polyester carcass rated for 480°F is being used by modern plants. Such belting is also required to meet U. S. Bureau of Mines specifications and will not support combustion as defined by small scale ASTM testing.

Clinker Belt Protection

It would be a serious mistake to assume that the high temperature rated belting discussed above would be able to handle all possible situations. Therefore, it is necessary to provide some means to control hot clinkers. One method in present use is an automatic water quenching system that operates by means of a radiant heat detector which is set to open a solenoid-controlled water valve when temperatures of 250°F are detected. This permits discharge of water through spray nozzles directly on to the clinker belt. When the temperature lowers to 235°F the solenoid-controlled water valve closes.

The above automatic protection is also supplemented by a manual quenching system consisting of a perforated pipe extending along an additional 20 ft. length or more of the clinker belt. While both the automatic and manual systems are primarily for quenching hot clinkers, they are also very valuable as fire protection devices.

Emergency Clinker System

A modern computer controlled plant in the Midwest* provides an emergency transfer system that carries clinkers from the cooler to a steel belt that discharges outside the building. Such a system would be a valuable means for preventing a clinker belt fire when the conditions of upset are beyond the capability of the automatic and manual water quench system.

Automatic Fire Protection for Conveyors

Approved systems of automatic sprinklers should be provided to protect the conveyors that are relatively remote and inaccessible from a fire fighting standpoint. The conveyor's relative importance to continuity of operations also needs to be considered in this determination for need of sprinklers. The sprinkler systems will generally have to be dry pipe or preaction type, as most of the conveyor galleries and tunnels are unheated and subject to freezing.

Inside Hose Connections

Hose connections to a reliable water supply of adequate pressure and volume should be provided for all principal conveyor belt drive areas and for the clinker belt area. Each connection should be equipped with minimum lengths of 100 ft. of 1½ inch woven-jacket rubber-lined fire hose and adjustable solid stream/spray type nozzles of the approved type (by a recognized fire testing laboratory).

Water Supply and Distribution System

Recognizing that lack of fire fighting water is a frequent problem in a cement plant, there must be practical economical solutions for obtaining these water requirements or they will not be met. We must first determine what the anticipated water demands for fire protection will be, both in terms of flow and pressure. This will usually be the combined requirements of automatic sprinklers, inside small hose application, and outside yard hydrant hose use during the most probable set of adverse circumstances. (While I have been emphasizing protection of conveyors, there are other areas in a given cement plant where automatic sprinklers should be provided due to combustible construction and/or occupancy, and the maximum water demand for sprinklers may result from such areas rather than from conveyor protection.)

Since reliability is essential to a fire protection system, a separate fire main supplying yard hydrants and connections to the sprinkler systems is desired. To restrict friction loss, lines should be sized to a minimum of eight inches and preferably should be looped to insure a two way feed to a given area or system. Sectional control valves are a must in any good design to permit flexibility and reliability during planned repairs or underground breaks. The yard hydrants should be spaced at approximately 300 ft. intervals and located near the obvious points of potential fire problems.

Reliable water supplies of adequate pressure and volume to supply the anticipated water demands for fire may come from a variety of sources such as a municipal water system, a gravity tank, fire pumps, and reservoirs and connections to a process water system.

While I have been emphasizing the need for a separate fire main system, it must be recognized that some plants have equivalent reliability in their process water system, in terms of water sources, and pressure and volume available. In such cases it would be feasible to consider a combined process/fire system in the interest of sound economic protection.

Plant Emergency Organization

It is essential that a plant emergency squad be organized and trained due to the usual remoteness in plant location and the special problems involved with cement plant operations. Such an organization should be available during all operating periods. Training should include fire fighting fundamentals as well as other emergency procedures required to handle personnel safety and equipment safety. They should be thoroughly aware of the capabilities and limitations of all fixed special extinguishing systems installed in the plant. Training should include the use of preplanning information developed for the building or department with emphasis on the special hazards involved and possible points of fire loss. The training program should be designed to develop the resourcefulness of the individual member and should include drills that simulate emergencies, involving personnel injuries and equipment damage. Equipment needs for the plant emergency organization should be established by an analysis of the potential emergency situations and be provided by a willing management.

Management

It has been shown that mechanical breakdown and operational error are responsible for 96 per cent of the total dollar loss of the 15 examples analyzed. These two factors are controllable by management, and how well they are controlled depends largely upon management's attitude.

A management that has clearly and concisely shouldered their responsibilities regarding the overall safety and loss prevention program for the plant can be expected to show a more favorable loss record. A management that applies to safety and loss prevention matters the same skill, techniques, and talents that have proven successful in finance, production, and marketing can expect good results.

Besides giving complete support to the organization and training of a plant emergency organization and providing them with adequate equipment, management needs to authorize, fund, and direct a safety and loss prevention program which involves all employees. Such a program should include a preventive maintenance self-inspection procedure for mechanical equipment, including the fixed fire protections systems and devices on a regular basis. Mechanical defects discovered by this self-inspection procedure should be promptly reported, repaired, or equipment replaced.

Operators should be thoroughly trained and given a clear understanding of operational loss potentials and emergency shutdown procedures as a part of the overall management program.

As a back-up to the plant emergency organization, agreements should be made by management with nearby public and private fire departments for response to the plant. Fire department officers should be invited to periodically visit the plant to make them aware of the plant's hazards and of the fixed fire protection facilities available.

In summation, it is hoped that this presentation of the Factory Insurance Association's loss experience, examples of losses, together with an analysis of these, has dispelled the general feeling of "But what can burn?" While the principal thrust of this paper concerns combustible conveyor belt fires and loss prevention practices for them, there is no intent to infer that they are the only problem involving fire in a cement plant.

Space does not permit a complete discussion; however, I feel that I should highlight other areas of major loss potential which could, in themselves, be fitting subjects for loss prevention papers as follows:

Computers and Central Control Rooms

There is probably no other place in a cement plant where such highly concentrated property values are crammed into such a small space, and no other place which could have such a drastic effect on the plant's production. Masses of combustible nonmetallic jacketed cables in troughs or in concealed floor spaces, together with similar potential within the electric equipment consoles, presents an awesome fire loss potential if not properly protected. NFPA Pamphlet No. 75 provides a basic standard for "Protection of Electronic Computer/Data Processing Equipment." These basic principles should be built upon when considering protection for the central control room and the usual cable spreading and relay rooms.

Kilns

The modern computer controlled cement plant kiln is a highly sophisticated piece of equipment as compared to the older manually controlled plants. Flames at the burner end are monitored by closed circuit TV's in the central control room, and temperature and process conditions within are closely controlled and measured, with the computer making instantaneous adjustments in the process feeds as needed. It is my hope that this type of control will all but eliminate the off-ratio firing explosion potentials and the molten material losses. Light-off explosions will continue to be a loss potential until adequate combustion safeguards are provided.

Nonmetallic Jacketed Cables in Troughs

Similar to the computer and control room potential, but in operating areas of the plant, would be serious fire loss problems caused by massive groupings of combustible cables in troughs or trays. This proved to be the case in the largest single loss, where an electrical fault in cable trays caused ignition and subsequent involvement of No.'s 1 and 2 conveyor belts. Cable jacketing and insulating is a very rapidly changing field, and I anticipate that truly fire resistant jacketed cables will be available to all of industry at reasonable costs in the not-too-distant future. This will be a preferable solution rather than using combustible cables with fixed fire protection to control a fire once initiated.

Electrostatic Precipitators

The modern cement plant incorporating electrostatic precipitators for control of particle emissions in the kiln exhaust gases has a built-in process equipment bottleneck that has fire loss potential. Aside from the obvious explosion potential due to off-ratio firing, combustible deposits have been known to build up on the grids and have ignited under favorable conditions.

*Lone Star Cement, Greencastle, Ind.

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