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SAFETY ASPECTS OF GROUNDING PORTABLE TOOLS

By E. J. MATOUSEK
Mgr., General Engineering
International Minerals & Chemicals Corp., Skokie, Ill.

My discussion will not be concerned with the why or how portable tools can become a hazard, but in the event they do, what steps should have been taken to prevent any personnel hazard.

The National Electric and Fire Codes have directed industries and residential construction into safe and reasonable avenues. However, there are certain aspects that may need a bit of historical explanation. Most 110-volt single phase systems have one line grounded. This grounding procedure grew from the prevention of fire caused by lightning primarily in residential construction. There are other valid reasons for grounding 110-volt systems, but to digress into the pros and cons of grounded versus ungrounded electrical systems, would be beyond the scope of this discussion.

We are concerned with grounded electrical systems powering portable tools. In some respects the addition of the ground tends to increase the shock hazard because it brings in one lead of the two necessary to close the circuit and cause the shock. What I mean by this is—in order to cause a shock, the human body must be inserted *in* the circuit.

Normally a person will *not intentionally* touch a hot line, but this is exactly what happens when a workman uses a portable electric tool, which has the hot line shorted to its metal frame. The system and the man are both grounded; the man becomes a part of the circuit and is subjected to a shock.

Basically, the human body can be considered as a salt solution incapsulated with a thin insulated membrane which is the epidermis portion of our skin. This is why intensity of shocks is increased, in the event that hands become moist or minor skin wounds are involved. In other words, the skin's larger resistance breaks down and the current flows readily through the "saline solution."

The severity of the shock depends upon the vital organs that are affected, namely the heart and the brain. This is why shocks between arm and arm, or between arm and leg, are much more hazardous than between leg and leg, or let's say—hand and elbow of the same arm.

Another aspect worth considering in this understanding of shocks is that normally, voluntary muscles operate from electrical impulses generated in the nervous system and usually respond to a frequency of about 50 cycles per second. Hence, contact with 6- cycle extraneous voltage causes a saturating signal that tends to lock the various muscles involved. This is why some shock victims cannot let go of a hot wire, but must fall away from it.

This saturating effect blanks out normal signals; if this occurs in the vicinity of the heart or brain, artificial respiration is required to keep the oxygen entering the body until the paralyzing effect is dissipated and the normal functions of the body take over.

With this brief resume of the physiology of the shock, and applying this understanding to the elimination of a shock from a portable hand tool, it seems obvious that the solution is to prevent *the man from* becoming a part of the circuit. How is this done? One answer is to completely insulate all metal or current carrying exposed parts. The advent of plastics and the extension of its physical characteristics of strength and temperature resistance, makes this possible. I am sure that in the future the insulating technique will provide solutions for many portable tool problems. However, with the existing tools and appliances, which have exposed metal parts on their exterior, we must provide another answer.

The best solution is to ground all metal exposed parts of an appliance with a separate conductor, thereby providing a low resistance path for the stray ground current. Electricity, like humans, will take the path of least resistance. The ground wire protects the man, by taking him out of the ground return circuit. The fuse will blow because of the excessive ground current, and the defective unit will be isolated.

The ground wire has become almost standard in industrial construction for the last ten years. Generally the ground return circuit is formed by a conduit system and receptacles are provided which connect the separate grid. Standardization of plugs and receptacles has been difficult to achieve, and even the solution now accepted does not necessarily solve all problems. Receptacles now in common use provide the ground connection. A major problem is that many tools and appliances do not have three-conductor cords and cannot be used in some receptacles unless an adaptor plug is provided. Similarly, a tool with a three-conductor plug cannot be used in a shop which is equipped with the out of date two-prong receptacles. The accepted solution is by a plug and receptacle that is adaptable to both two and three plugs. If the tool does not have a ground wire, it can be used, but the safety aspect of the three-wire receptacle would be lost.

In a sense, the ground wire in the three-conductor cord is your insurance policy for safety on portable tools with the metal exposed parts. The problem here however, is that one never knows when this insurance policy will expire. Ground wires break or become disconnected, and when this happens —and it happens all too frequently—the user of the tool is exposed to a possible lethal shock.

This happened to a construction worker doing work for a major company some years back—even though they had a strict grounding policy. As a result of this accident, a tool checker was devised to automatically check electrical tools before they were issued. This device acted primarily as a "go—and no go" test for a storekeeper who issued tools. The checker automatically passed a high current through the ground wire and maintained this high current long enough to burn out any whiskers, if that was all that was left of the ground wire. After passing this test, the tool was then subjected to a high voltage test, approximately 500 volts, to check deteriorating insulation. It also tested for a short circuit in the motor armature. If the tool passed these tests, the tool would then be subjected to run voltage and a run test, if the "on" switch of the tool was pressed.

Another feature of this tool checker was its built-in safety factor. In order to operate the tool tester, the tool had to be pressed against a spring plate on the vertical portion of the rest panel on the tool checker. Pushing the tool against this panel, besides assuring a good ground connection, the tool frame operated a micro-switch directly behind the panel to initiate the test procedure. If the tool was faulty, an audio and visual indication was provided and the test would not proceed to the point of applying voltage to the tool. Accessories for testing existing cords were also provided. This automatic tool checker has never been produced commercially, although a unit that uses the same tests but on a manual basis is being marketed.

The essential steps for safe operation of portable 110 volt single phase electrical equipment can be summarized as follows:

1. Use a grounded power system with adequate overcurrent protection for all feeders.

2. Maintain a good ground grid. This can be either a properly installed conduit system, or a supplementary ground wire network.

3. Use standard three-wire receptacles and make sure the ground wire is connected to the ground grid.

4. Use three-wire cords for portable tools and appliances.

5. Periodically check portable tools to be sure that your ground wire insurance is in force.

If these steps are followed, needless loss of life by electrocution from defective 110 volt portable equipment will be prevented.

GROUND FAULTS IN QUARRY ELECTRICAL SYSTEMS

By H. P. CASSEL
The Whitehall Cement Mfg. Co.

Well-planned installation of electrical equipment takes for granted that such equipment will be well grounded, at least to the minimum requirements of the National Electric Code. In the application of both large and small portable electrical equipment, we have at times been negligent in the installation and maintenance of proper grounding.

The use of large, portable, electrically driven equipment in quarries, such as draglines and shovels, usually requires operation at voltages of from 2300 to 13,000 volts. The fact that such voltages are used, plus the uncertainty of obtaining good grounds in areas such as quarries, demands that we carefully examine our grounding practices in this area.

WHAT IS A GROUND FAULT?

When one of the main conductors of power accidentally touches the framework of the machine involved we speak of this as a "ground fault." This accidental contact may be caused by the breakdown of insulation anywhere on the machine. It may be at the point of entrance of the portable cable, in the switches or wiring on the machine, or in the windings of the motors or generators driving the machine. Such a breakdown may occur at anytime and without warning.

When such ground faults occur, personnel standing on the ground and touching the frame of the equipment involved may be subjected to electric shock ranging in intensity from slight to fatal. Since even the best insulation, installed in the most expert manner, is still subjected to occasional breakdown the safety problem involved concerns control of the intensity and duration of the shock hazard when such breakdowns occur.

WHAT CONSTITUTES A SHOCK HAZARD?

A good deal of investigation has been undertaken to determine the limits of human reaction to electric shock. Due to the great variations in individuals and their varied reaction to shock, and to many other variables, the evidence of these studies is only generally conclusive. However, broad limits may be set which will apply to most cases and conditions.

All investigations agree that the severity of any electric shock is a function of intensity and duration.

The intensity of the shock depends on the voltage encountered and the bodily resistance of the individual in that portion of the body through which a particular electrical current may pass. Investigations in this area have set values ranging from 500 to 1000 ohms.

The amount of current flowing through the body having such resistance will depend on the potential or voltage encountered. The following is an indication of what probably will happen with varying amounts of current flowing through the body:

1. 1 milliampere—No sensation.
2. More than 5 ma.—Painful shock.
3. More than 10 ma.—Muscle contraction —25% of population will freeze to contact.
4. More than 15 ma.—50% of population will freeze to contact.
5. More than 30 ma.—Breathing difficult —unconsciousness may occur.
6. 50-100 ma. Possible ventricular fibrillation of heart.
7. 100 ma.—2 amps.—Certain fibrillation of heart.

With these results in mind the mining industry, some years ago, set 100 volts as the maximum allowable potential that should exist between the frame of a machine and the earth during a ground fault.

WHAT HAPPENS WHEN GROUND FAULTS OCCUR?

Let us now examine what might happen when ground faults occur under various types of installations.

A. ***An ungrounded system:***

With an ungrounded system, a single line may be the ground. There will be no interruption of service and unless special ground detection equipment is installed such a ground may go undetected indefinitely. A second ground fault in the frame of a shovel, for example, will cause a fault current to flow through the frame of the shovel, through the treads where they contact the earth and thence through the earth to the original fault. The amount of current flowing will be determined by the total impedance of the system. Since a large part of the total impedance will consist of the rather poor contact between the shovel treads and the earth, a large portion of the full line potential will appear between these two points. Any person standing on the ground and touching any part of the frame would be subjected to this potential. If the line potential would be 2300 volts and the body resistance taken as 500 ohms, almost 4 amperes could flow through the body, with almost certain fatal results.

B. *Underground distribution system—with frame of machinery grounded.*

There has been some thought that the addition of a ground connection to the frame of the machine, running to a ground rod would eliminate hazards due to ground faults. Actually, such protection is far from adequate. With such a ground connection and a ground fault to the frame of the machine plus failure of another phase wire, ground fault current will flow through the machine, the ground connection, to earth and so to the fault. Since the total impedance of this path has been reduced by the lowered resistance to earth of the ground rod, a larger ground fault current will flow than in the previous case. If the ground rod resistance path is in the order of 10 ohms (which seems to be a reasonable value to expect in most quarries) fault currents could be in the neighborhood of 50 to 100 amperes, on a 2400 volt system, and thus a potential of from 500 to 1000 volts would appear between the machine frame and ground. Again assuming the body resistance to be in the order of 500 ohms, this would indicate between 1 and 2 amperes of current through the body, again a fatal dose.

C. Another system makes use of a solidly grounded neutral in a Wye-connected distribution system, with the point of transformer ground being carried along with the power conductors to the frame of the shovel. With a ground fault, a large ground fault current will again flow, which should cause the protective relays to trip out the power circuit. However, during the time necessary for these relays to operate, the frame of the shovel will probably be at a dangerous potential for a short period of time.

D. Having looked at the previously described system, it may be seen that a high degree of protection may be secured by:

1. Providing the lowest practical resistance between the shovel frame and ground.
2. Limiting the ground fault current to such a value, so that the voltage drop between the frame and ground will not exceed a voltage which is ordinarily considered dangerous. The mining industry has set this limit at 100 volts.
3. Disconnecting the power feeders when a ground fault occurs with as little delay as possible.

It is to secure these benefits that modern installations are using impedance or resistance grounded neutral transformer distribution systems. In the event of a ground fault, the ground fault current will flow from the transformer terminal through the main conductor to the shovel frame, returning through the ground conductors to the neutral resistance and thence to the neutral point of the transformer. Under these conditions the ground fault current is limited by the neutral resistor to such a value so that, under the ordinary conditions encountered in quarries, the voltage drop between shovel and ground would not exceed the safe limit of 100 volts. In addition to this, protective relaying is installed in the neutral of the transformer, that will immediately be responsive to ground fault currents and remove the entire feeder circuit from the system.

Summary

Adequate protection of human life and health against electrical shock hazards can be provided. It will consist of these features:

1. All electrical installations to be made with the highest degree of skill possible.
2. Neutral point of Wye-connected trans-

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formers to be grounded through a resistor which will limit ground fault currents to 50 amperes or less.

3. Ground connections from this resistor to be carried through the portable cable and terminated on the frame of the machine involved.

4. Relaying to be installed in the neutral of the transformer which will remove the faulted circuit from the source of supply.

5. Ground connections, cables and rods to be periodically tested to insure the lowest possible resistance in the ground circuit.

To accomplish this may add somewhat to the cost of installations. It will certainly require some effort, time and money to maintain in working order, but unless we agree to do the job to the best of our knowledge and ability, we cannot say we have done everything in our power to make our plants a safe place in which to work.

HAZARDS CAUSED BY IMPROPER APPLICATION OF KNIFE SWITCHES

By G. J. REYNOLDS
Tech. Mgr., United States Gypsum Co., Chicago

The United States Gypsum Company has had several serious accidents in the past several years through the closing of inadequate knife-type so-called "safety" switches on stalled motors or short circuits. This is the greatest single cause of electrical accidents in the company.

Many of the knife switches have been applied in the past as safety lockout devices ahead of motors. The hazard exists in that the knife switches are usually of the lightest type available as intended to be visual disconnect only and to be opened or closed only with the power off, not to interrupt energized circuits. Our main objective is the elimination of the knife switch entirely where possible, where a lockout switch is required. If it cannot be locked out conveniently because the main breaker is too far away, a safety lockout *circuit breaker* should be added for this purpose.

The purpose of this switch is only to visually open the circuit for safety reasons after the power is off. The reduced voltage starter for the motor is at the lower right and the starter stops and starts the motor by means of a push-button above. Therefore, after the motor is stopped, theoretically, it should be perfectly safe to open or close the knifeswitch as there is no load on the circuit at that time.

In one case the starter contacts had fused when inching the motor but the knife switch was safely pulled without damage. Later when it was closed on a starting load, because essentially the starter contacts were fused shut, the switch was closed on a load which the switch did not have capacity to take and the switch exploded.

A maintenance mechanic had been assigned the job of servicing the rollers of the White Raymond mill. He serviced them by positioning them manually in line with a port in the side of the housing and had completed four of the five rollers in this manner. He experienced difficulty in getting the fifth roller into position for servicing. He pointed this out to another mechanic who was walking through this area. The latter said he would "inch" the motor for him. The first mechanic removed his lock on the safety switch and then returned to the Raymond Mill so that he could observe the positioning of the rollers.

He signalled to the second mechanic when he was ready. At the signal, the second mechanic closed the safety switch, pressed the starter button momentarily and only long enough to allow the fifth roller to turn into position. This would have meant that the mill made only one fifth of a revolution before the operator released the starter button.

The first mechanic states that the mill made no more than a fifth of a revolution and that the fifth roller stopped in the position desired. He signalled to the second mechanic that the job had been accomplished and the latter then opened the safety switch and left the scene. The first mechanic then placed his lock on the safety switch and returned to his job of servicing the last roller.

After he completed servicing this last roller he wished to determine if the rollers were functioning properly. At this point a third mechanic was walking through the area and he asked him to start the mill so that he could observe the roller revolutions. The first mechanic removed his lock from the safety switch and then positioned himself again in front of the mill port. On the latter's signal the third mechanic proceeded to close the safety switch.

Immediately on closing the switch on the stalled load, an arc was created and the switch exploded. The cover flew open striking the injured on the chin. He thus sustained a deep laceration in addition to burns of the face, throat and right arm.

Following the injury an examination of the starter was made. All three contact points of the starter were in contact with the points of the running side. One of the contact points was fused in that position.

The first mechanic (the person servicing the rollers) states that neither the safety switch nor controls were touched between the time that the second mechanic "inched" the motor and the time that the injured attempted to close the safety switch.

In reviewing the injury, an analysis was made to determine what could or what could not have happened during the "inching" procedure. If no one touched the controls after he left them, it can be assumed that the starter contact was left in a fused *running* position with the contacts *fused* after the second mechanic had completed the inching procedure.

The electrical explosion that occurred at the time of the accident was caused by the following. The switch did not have snap-action or arc chutes and the handle mechanism was so worn that the blades in closed position barely teased the energized contacts, thus drawing an arc. The arc ionized a pocket of gas about this contact point and this pocket soon spread to envelop a second contact. Ionized gas is a perfect conductor of electricity so therefore a dead short circuit occurred which in turn ionized the rest of the air in the box and created the gaseous explosion. The cover flew off cutting the man's face badly and causing burns to the face, arms, throat and so forth.

A similar situation occurred at our North Kansas City plant July 29, 1959. A short time prior to the accident, the motor driving the duplex stock pump on the liner beater kicked out. The process of restarting the machine was explained to the injured by the maintenance foreman as follows; open the switch to the motor controller (440 volts), reset the overload trip on the controller, close the switch and restart the motor.

In the same enclosure there was also another larger knife switch which controlled the power supply to the liner breaker beater motor control. The motor kicked out again and the injured proceeded to put the motor back into operation. He opened the door on the switch enclosure, grasped the handle on the pump switch and pulled it open.

At that time there was a violent electrical explosion in the enclosure. From the local reports it was assumed that the injured's hand or forearm got close enough to the conductors to draw an arc and start the ionization process to set off the short circuit explosion.

Injuries sustained were temporary blindness (of which he soon recovered) first and deep second degree burns involving the right arm, right side of the thorax and the right side of the abdomen. There also was a small area of burn over the right scapular area. His shirt caught fire, which was responsible for many of the burns, and which could have been worse, had it not been for a fellow employee who ripped his burning shirt off him.

The irony of the entire accident is that a knife switch replacement program had been previously set up and religiously followed throughout several years. The switch that blew up was the last in the plant and had been scheduled for replacement in the very near future.

A similar situation to those in Philadelphia and Kansas City occurred May 19, 1961, in a sand and gravel plant at Bellwood, Ill., where a knife switch blew up burning the man's left hand badly.

In this case a compressor motor starter was actuated by the pressure switch as toggle switch had been bypassed as bad order. The compressor had been down and when the man went to start the compressor, he closed the "safety" knife switch and the compressor started on low pressure. Essentially he started the compressor motor across the line with a knife switch. The knife switch was inadequate for the job and exploded in the man's hand.

The above series of accidents concern primarily a single isolated knife switch. This now leads us to occasions where a plant has a great number of fused knife switches in a single cubical.

In our Boston plant we had a very serious accident in June 28, 1959, due to the explosion of such a panel. The electrician had finished his checking and was standing by waiting for the plant to start up. He was standing approximately two feet in front of the panel with closed doors.

Suddenly upon start up of the plant an arc was evidently drawn from one of the knife switch loose contact points, thus ionizing the air and causing short circuit explosion. The doors blew open with the force and the man who was standing two feet away was totally enveloped in gaseous flames. The Chief Electrician, Rocco Abbruzzese, had just left the scene and upon hearing the explosion and the man's scream, rushed to find the man with his clothing on fire and totally enveloped in flames. Rocco, being the big man that he is, "bear-hugged" the man to put out the flames.

The effect of the injury to the man included:

1. Forty-five days in the hospital.
2. Several skin grafting operations.
3. Partial loss of use of left arm.
4. Disfigurement of left arm.
5. Total 85 days loss to work.
6. Direct cost to company, $4,000 (medical only).

The correction to the above type accident is to replace the fuse knife switch type panels with molded case circuit breaker panels of adequate interrupting capacity. The type that U. S. Gypsum prefers because of their extra safety feature of a rotary safety "lock-out" handle, is the Federal Pacific Circuit Breaker. Each circuit breaker has its own individual lock-out device to which a workman may attach his lock so as to provide the safety lockout function formerly served by the knife switches we have just discussed.

Now that we have emphasized the necessity for correction, the question that I am sure that each of you managers is asking himself is "How should a corrective program be set up to eliminate or alleviate the above type of hazard?" Perhaps the simplest formula is to explain the way we successfully attacked the problem at the United States Gypsum Co.

Our first step was to classify the type switches and their respective hazards as per the excerpt of the classification as shown in the U. S. Gypsum Co., Operating Division, Information Bulletin #604, "Electrical Safety Lockout Switches" as follows:

Make a survey and hazard classification as per the following:

Group I. Extremely hazardous and should be replaced at once

The following characteristics are lacking:

1. **Underrated as to HP requirement per manufacturers recommendation.**
2. **No spring or snap action for closing or opening knife blades.**
3. **No arc chutes.**
4. **Non-interlocked cover.**

Group II. Hazardous but safe if proper precautions are observed

The switches are fully rated but lack one or more of the above safety features such as 2, 3 or 4. These switches should be clearly labeled as hazardous and personnel notified to not operate them while switch is energized.

These should be scheduled for future replacement on planned maintenance basis over a period of possibly several years.

Group III. Safe and suitable for operation

These switches are fully rated and have all the safety features listed in above. The switches of this group would be continued in operation during duration of their life expectancy.

Necessary steps should be taken to replace Group I knife switches with adequate molded case circuit breakers with safety "lockout" handle as promptly as possible.

A planned maintenance schedule should be set up for replacement of the Group II switches.

We secondly had to develop a cost of the total company program. A typical plant was selected and its correction costs multiplied by the number of plants known to have similar conditions. This amount approximated $200,000 installed cost for the company correction program.

With the co-operation of our safety director, Mr. E. C. Beuthin, the program was reviewed with management and their support and approval for future appropriations was obtained.

Our next step was to disseminate the information to our 60 plants in the field through channels that would set up authority for execution and to assume the responsibility for compliance. This was handled through our operation managers, through their production managers and plant works managers.

The seven-page Information Bulletin #604, referred to above, was compiled to cover classification, survey and alternate methods of making correction and was issued to all plants as an operating bulletin for execution.

Completion of each separate plant project, in accordance with the above, is being followed up by the production managers.

FALLS DURING BULK MATERIALS LOADING OPERATIONS

By JAMES M. CHRISTIE
Safety Engineer, Portland Cement Assn., Chicago

My paper is directed to a problem in our industries that is certainly not new. As a matter of fact, in my research I ran across an accident report describing a fatality in this same type of situation back in 1920—just a few years before I was giving any thought to safety work. The title of my paper, "Falls During Bulk Materials Loading Operations," is intended to be specific to a current problem. And I believe it accomplishes this. However, as I stated, this problem is not new. It is merely being brought to our attention most recently, because of an increased usage of trucks for bulk hauling of our products. And, naturally there have been many injuries sustained by our employees.

I wish to sell my point with a few case histories. The case of the fatality I mentioned earlier involved a fall from atop a rail car. A 15-foot fall, the approximate height of a rail car, is certainly a potential fatality whenever it may occur.

Essentially, our problem involves falls to a lower level—whether loading into truck trailers or rail cars. However, it is not necessarily limited to this. One injury that I learned of involved an operator loading a trailer with bulk lime—he tripped and fell on top of trailer and fractured three ribs on his right side. But this accident did not exhaust all the possibilities for injury. He could have fallen into one of the open hatches on the trailer—with the resultant possibility of suffocation.

This happened to a worker loading finely divided material—he tripped while on top of a rail car and fell into a loaded section of the car. For a brief interval he was completely submerged in the material. Fortunately, quick action on the part of another employee saved his life.

Or—another case—this time on a truck. The employee stepped into the opening on top of truck with one leg—suffering severe bruise in groin.

Now the fall to a lower level. Basically—from the top of the rail car or truck trailer to the ground—distances ranging from 10 feet to 15 feet. Would you condone a situation in which an employee regularly works on an irregular surface near an unguarded dropoff of 15 feet? There is much condonement of such work practices in our industries. It appears that the thinking has been something like this—railroad men and truck drivers do it why can't we? Does this sound familiar? Or, the safety equipment creates more hazards than it alleviates—hogwash. I'm sure you have all heard these excuses many times.

In plants where these and similar excuses have been allowed to prevail, we know of many injuries resulting from the falls that occurred. An interesting sidelight is the fact that in almost all cases, after an injury has occurred, some action is taken to prevent further injuries. But only after someone has been injured.

These are the case histories of some injuries sustained in falls during bulk loading:

A bulk car loader lost his balance and fell to the ground when a hatch door that he was pulling open released quite suddenly. He fractured his heel. Another case of lost balance and a fall to the ground from a rail car resulted in multiple fractures, bruises and brain concussion—both of these are similar at the start but the consequences are vastly different.

On truck trailers, I learned of a case where the truck driver drove away from the loading point while the loader was still on the truck. And yet another case of lost balance—this time from a truck trailer—the loader suffered a broken arm when he tried to jump to a platform 8 feet below to avoid a fall.

These case histories certainly are not all inclusive in either number or types of accidents. They do lead us in the direction of solving the problem, however. At the risk of over-simplifying this problem, let me say it in this manner. We have people working in locations where they are exposed to injuries from falling. Our job is to prevent these falls—How? By tying the people in place or by building a fence around them.

By way of explanation, my organization, The Portland Cement Assn., has established certain safety precepts that our members use to guide their safety efforts. We call them "model safe operating practices." The one that is specific to this situation states, in part, "A safety belt and line properly attached, adjusted and anchored shall be worn by each person working on an unprotected perch more than five feet above a lower surface."

I might add that this model safe practice, and all the others, is intended as a minimum requirement for job safety in the cement industry. Our members find need to expand these and to make them specific to certain work locations and situations. We believe this model safe practice covers both the "tying in place" or "building a fence around" situations.

Directly, if a man is on top of a rail car or truck he is working on an unprotected perch—more than 5 feet above a lower surface, and needs the protection of a safety belt and line. On the other hand, if a fence is built around his work location, his chances of falling to a lower surface are negligible. So, I say again, "Tie him in place," or "build a fence around him."

Now, gentlemen, I would like to show some specific examples illustrating the two points I have mentioned.

1. *Man on car with belt and line attached to horizontal overhead cable.*

You will recall that I told you of a case involving a loader who fell into a hatchway and was momentarily submerged in lime. This picture involves the same type situation. Except, this man was using the belt and line shown and only went into the hatchway to around his knees. There is quite a difference in the potential consequences of these two similar cases.

In attempting to apply the principle of "tying the man in place" you will encounter some physical difficulties at your loading points. It amounts to answering the question, "What can we tie the man to?" With a roof overhead, a cable can be extended horizontally over the length of the loading area. As in this case, the life line can be permanently attached to the horizontal cable. Also, a ring attached to the top of the life line allows your bulk loader to work the entire length of the car or truck trailer.

2. *Silos or buildings on both sides of loading area.*

If you don't have a roof or structure over your loading area, you may have structures on either side, as shown in this slide. Here you will note the cables extended over and across the loading area that support the cables extending the length of the loading area. To these, then, the life lines are attached. Please note that these life lines are pulled up and tied off. This is to allow for the 22-foot vertical clearance requirements over the top of the rails.

3. *Pole installed as upright support for one corner of cable arrangement.*

This is intended to show the extent to which one plant has gone to provide a place to tie the bulk loader to his job. They didn't have adequate overhead structure or buildings on both sides of the loading area, so they installed this post as the corner support for their cable. Again, note the life line pulled out of the way for rail movement.

4. *Boom pivoted from side of silo for truck loading.*

One plant has solved the problem of what to tie to by installing a boom on the side of their silo. The boom is pivoted at the silo and is actually a monorail. The life line is attached to a carriage on the monorail and the user can safely traverse the entire length of the boom.

5. *Platform over truck loading point.*

This platform is designed to virtually eliminate fall hazards during bulk loading. It illustrates the point of building a fence around the work location. At this plant, the loader never goes onto the truck trailer. However, the problem is not completely eliminated because someone (in this case the truck driver) must open and close the hatch covers. This practice appears to be quite common around the cement industry. The employer of this worker needs to attend to his protection.

6. *Handrailed walkway alongside silos.*

This is an illustration of the fencing principle as used in loading aggregate from silos. The discharge chutes can be lowered into position and the flow of materials controlled from this handrailed walkway.

7. *Pivoted walkway to get out to truck.*

This situation does not fit neatly into either of the categories I have tried to establish. However, it does involve need for both fencing and tying the loader. The platform on which this employee is standing is hinged and counterweighted to keep it out of the way when a truck trailer (or railroad car) is being spotted. Then it is used as the access to the truck or car. It has handrails; however, once an employee goes beyond these he lacks protection. So, this represents a situation in which both tying and fencing may be applicable.

8. *Suspended handrails at a truck bulk loading point.*

An example of applying the "fencing" principle to a truck bulk loading situation shows the slanted grating leading to the trailer, then the handrail that extends around the working area.

An additional safety innovation, is evident in the stairs and catwalk that are used for access to points where maintenance work will take place. I think you will agree that a great deal of thought has been given to these work situations.

9. *A situation that is not common all over the country.*

On a trip into New York State I saw a type of rail car that I had never seen before. It is called a bottle car and consists of 4 or 5 large metal containers on flat bed rail car. There are no ladders up the sides of the "bottles," and no catwalk from one "bottle" to another. As a partial solution to the problem of how to position a man for loading these cars, one plant installed hinged grating alongside the loading area. These are kept in a raised position until a car is spotted. Then the platform is lowered and it offers a convenient working surface for the loader. I might add, that this arrangement could be improved by installing a cable overhead for use with a safety belt and life line.

There is one other mechanical device regarding bulk loading that I want to discuss. In many of the examples above, you will recall that the bulk loader had to climb up the ladder on the rail car or truck and then hook up his safety belt to the life line. This allows for exposure to falls during the climb up and down the ladder, and momentarily while he is not hooked up to the life line.

I don't want to be accused of advertising a commercial product and I don't have any stock in this company, but I do want to tell you about a product that is being used in some cement plants. It amounts to a life line that is mounted on an automatic reel. The reel contains 16 feet of steel cable that extends or retracts automatically with the normal movement of the user. Then, should he lose his balance and start a rapid extension of the cable, a locking mechanism in the reel stops the movement in about one foot.

To use this device in a bulk loading situation for example, you still need a cable extended horizontally over the loading area. Then, the reel containing the extendable and retractable life line, should be attached to the horizontal cable. It will slide on the horizontal cable allowing freedom of movement the length of the rail car or truck trailer.

The life line will allow for safety during the loaders vertical movements getting on or off a rail car or truck. In answer to possible questions, I would like to explain that I do not know of any tests that have been made on this device—other then by plant people—one plant has dropped a 250-pound weight and the locking mechanism worked properly.

Falls during bulk loading of materials can result in serious, even fatal injuries. They have happened in the past and will happen again unless we exert efforts to provide work situations where fall potential is either eliminated or drastically reduced. And, this won't be an easy task. You are all familiar with the resistance one encounters when attempting to institute any new safety practices or equipment. You may expect such resistance regarding fall protection—both from management, supervision, and employees. However, there are many plants in which the employees are protected from falls and they are still producing efficiently.

I'm sure you realize that I have not covered every conceivable situation—I'm certainly not knowledgeable about all of them. I do hope, though, that I have been able to stimulate you to review your bulk loading situations with an eye towards reducing fall potential and eliminating these injury sources.

BELT CONVEYOR HAZARDS

By LESLIE S. VOLTZ
Safety Engineer, Consumers Div., Vulcan Materials Co., Chicago, Ill.

My remarks are pointed primarily to the management of the smaller companies who do not have actively organized accident prevention programs, and to the larger companies who do have such programs but fail to make them effective because of the poor attitudes of operating personnel. As a safety engineer I cannot be honest if I judge our progress as an industry by a code of legalistic moralism. I must judge the results on our success in preventing all personal injuries.

The tragedy of belt conveyor accidents is that we do know how to prevent them. We do know the essential rules, on the mechanical and electrical devices and their operation, to eliminate such hazards to our employees. We do know the necessity of specific rules and regulations which must be hammered (and this can be taken literally for some employees) into the minds of our management and men concerning the operation of belt conveyors.

Some of the things I say here may make you angry and I hope they do—*in fact I* wouldn't care if you got so mad you pushed me out the door—*If* in so doing I could only convince some of you of your lack of an intelligent approach to belt conveyor safety.

Possibly many of you have stood by a belt conveyor and watched it roll along quietly with its load, the occasional click of the splices passing over the idlers being the only sound you heard. It doesn't make a lot of noise to put fear in your mind and seems so innocent as it travels along at 350 to 450 feet per minute. This very characteristic makes it fascinating and seemingly harmless.

In fact, I have often thought of this type conveyor in the same manner as a person might think of the waves that roll in so quietly and peacefully at a beach. Yet we know in many cases beneath all this serene beauty there is a deadly undertow. You may be only a few feet from danger . . . and so it is with a belt conveyor. You may be only a few inches from a serious personal injury.

The following should never let you forget one basic rule of belt conveyor accident prevention, that is, provision for an effective "lock and tag" system. I have called this "Death Takes a Holiday."

A working foreman about my size and age was instructed to repair the chute at the bottom of a 42-inch belt conveyor from the screening building to the load out bins. The conveyor was not running and according to the man's statement, he pulled the emergency cord to make it inoperative. He then proceeded to get on the belt and start the repairs.

All head and tail pulleys should be guarded, but the wing type tail pulley is a particularly dangerous type; however it did not contribute to this accident. A general view up the conveyor from the tail pulley shows the emergency cord. This is the long trip our man will have to take—220 feet to the head pulley at a belt speed of 400 feet per minute.

A view of skirt plates at the chute to be repaired would show the emergency cord on the left which the foreman said he pulled at this point. The employee was standing between the angle supporting the skirt plate and the conveyor cover when the belt was started from the control center at the load out bins.

He was knocked down by the cover and started up the conveyor head first. As he was traveling about seven feet per second, he could not pull the emergency cord.

He was flattened by the ½-inch belting, used to shape the material on the belt before it comes to the weighing device. The clearance from the bottom of the ½-inch angle supporting this is 21 inches and it is only 11 inches from the trough of the belt to the crown of the belting.

Again, he entered the conveyor covering to continue his journey. His last view of daylight was at the weighing device, where once more he went under cover. Surely, at this point, "death *was* his companion."

At the chute to the screen, where the employee went over the head pulley and into the chute, there was only a 12-inch clearance. He was able to get out by himself and walk from the tower with some assistance. Examination at the hospital did not disclose any fractured bones or serious lacerations. His body, however, was so severely bruised all over that he was disabled for 22 days.

No one can deny that this man was blessed and that "Death" did indeed, "take a holiday!" But why did it have to happen? The plant had been provided with danger tags. Only the previous week locks had been received to institute lock-out systems. The employee had three separate places to tag out, lock-out, or both tag and lock the power to this conveyor, as follows:

1. At the emergency switch at the head pulley of the conveyor.
2. On the control panel at the load out bins.
3. The circuit breaker for the unit under the load out bins.

However, none of the tags were placed at any of these points. Who, then, was responsible? You can each answer these questions for yourself and your own operation.

1. Had the employee been instructed personally on the use of these tags?
2. Had management and supervision insisted *every single time* on the use of the tag out system?

A two hundred foot walk on the part of the employee would have insured his security. Yes, Death took a holiday but don't depend on it! Good management cannot afford to gamble with such odds.

If you are interested in seeing an excellent film on lock out systems get "Lock and Tag." See the June 1961 issue of *National Safety News* for the source for this film.

The next series lists some of the hazards encountered in the process of repairs, or as the result of repairs or maintenance. Please review your own operation as these are given.

1. Guard not replaced following repairs.
2. Ladders incorrectly placed or used.
3. Conveyor walk-ways with openings, no toe boards and absent or missing cleats. The latter are a necessity where frost, or freezing water can accumulate.
4. Falling Hazards—Man trap, material left on stairs or platforms.
5. Pinch bar left on walk-way.
6. Removal of bearing race with 8 lb. sledge hammer.
7. Compressed gas cylinder—unsupported oxygen tank.
8. Tools in bad condition—mushroomed chisel. Note oxygen tank in background.

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9. Unguarded platforms, openings, absence of cleats, etc.

10. Unguarded flexible couplings, motor to speed reducers.

11. Unguarded conveyor drives.

12. Incomplete guarding.

13. Unguarded back stop.

14. Unguarded wing type tail pulley.

15. Overhead dangers. "A Safety Hat Saves a Life."

A quarry mill employee, age 29, was cleaning the tunnel floor under a 42" belt on the tight side, (opposite the emergency cord) where there was an 18-inch clearance between the conveyor structure and the wall. He was using a long handled scoop shovel and throwing the spilled material back onto the top run of the belt. A troughling idler was involved in the accident, and a vertical angle supported the skirt plates. The handle of the shovel was caught between the operating belt and idler, pulling the left arm and shovel blade under the belt. The throat of the shovel held part of the weight off of the employee's arm, and prevented the idler from turning. The employee's statement was as follows:

"It seemed to me an eternity before I was found, although I think it was between two and three hours. I hollered from time to time as loud as I could whenever the conveyor was stopped and on one occasion I unlaced one of my shoes and wedged it between one of the rollers in an attempt to lessen the pain. I also took a shoelace out of the shoe and wound it around my arm as a sort of tourniquet to stop the loss of blood. When released by my fellow employees I fainted and woke up in the hospital."

The report of medical treatment was as follows:

"He was treated for 3rd degree burns of the left forearm and hand. This involved the tendons, muscles, nerves, arteries and veins. He had multiple debridement of the left arm. In order to prepare the arm for the skin grafting, his right thigh was chosen by the doctor as the donor site, and from this area three strips of split thickness skin was taken and placed on the defects. Approximately 75 per cent of the forearm was covered, leaving the other 25 per cent which was composed of dying and exposed flexor tendons in the area of the wrist. Iodoform gauze was packed into the wound and extended proximally down between the radius and ulna in the lower third of the forearm. Vaseline pressure dressings were applied followed by fluff dressings."

He was discharged from the hospital 103 days later, but had to report to the hospital three times a week as an out patient for further debridement of the skin and conditioning of the skin graft. The donor site dressing was changed after two weeks and revealed this wound to be completely healed with no particular difficulty. The only thing remaining is the volar area of the wrist in which remains some of the fibers of the deep flexor tendon which should be saved to give him a pinching mechanism of the thumb and index finger. Therefore, it was impossible to graft over these areas. Enclosure had to be achieved by secondary intention. After 46 more days, the man was sent to a sanitarium for physical therapy treatment to help reconstruct the function of what remains of the power in his left hand.

Seven and one half months after the accident the employee was re-examined and it was reported that the wounds were healed except for two small areas on the volar aspect of the wrist.

"His fingers reveal very little, if any, active motion and almost no passive motion. He does have 25° of active flexion of the distal phalanges of the thumb and 15° of active flexion of the proximal phalanges of the thumb. He has a loss of sensation compatible with injury to both the median and ulnar nerves. This hand and forearm, in my opinion, represents a 100 per cent disability because of the marked stiffness of the joints of the fingers. I believe there is little hope of obtaining active motion by further tendon surgery. If it were possible, by continued physiotherapy, to obtain some passive motion, there would then be some chance for further surgery. The gap in the median nerve is so great that nothing short of nerve graft would be of any value.

"It would be my impression that either the total disability should be accepted, or to continue with a trial of physiotherapy and splinting to try to mobilize the small joints of the hand. If these small joints can be mobilized, one would then have to plan a large pedicle abdominal flap to replace the scarred tissues on the volar aspect of the forearm, wrist and hand. Following this it might be possible to continue flexor tendon grafting."

After careful study of these medical reports it was decided further treatment would not benefit this man and he agreed on the settlement of his disability as indicated by the doctor as 100 per cent loss of use of the left arm. This man was given the best medical attention possible, however his injury was so severe that although his arm was saved, it was practically useless. The final cost of this injury was as follows:

Hospitals and Sanitariums	$ 3,776
Medical Care	1,193
Temporary Compensation	2,116
Permanent Disability (100%) left arm	10,810
Payment into Special State Fund	200
TOTAL	$18,095

Thus the case was closed . . . a 29-year-old married man with one infant child and a useless left arm.

Many questions may be asked about this accident but few of them can be answered. Only one conclusion is inevitable. Somewhere along the line there was a man, or management, failure.

Regardless of the point of failure, the man has a 100 per cent disability in his left arm, with its attendant losses, for the rest of his life. The corporation settled its legal responsibility for $18,095. Surely we in our industry can and must find a more humane and better way for both parties.

A construction foreman and his superintendent were training a 60" belt conveyor before starting time at a new quarry mill. At the end of the previous day some ice had accumulated on the return idlers, also on the bend and gravity take up pulleys. Before starting time they loosened the bolts on the bottom of the return idlers, next to the walk way, and hammered them in a position to move the belt to the opposite side. During this time they also removed some ice from the pulleys and return idlers.

When this was completed the superintendent left the foreman on the conveyor walk way to adjust the return idlers after the belt was started, if the previous adjustment made had been too great. This was to be done by tapping the bottom of the stand in the correct direction with a ball peen hammer.

To make this correction it was not necessary for the foreman to leave the walk way. When the superintendent arrived at the control, as per agreement with his foreman he instructed the operator to start the crusher and belt. Four or five truck loads of stone had been dumped when these units were shut down from another control center. The attendant was advised that a man had fallen from the belt—another mysterious, but fatal, belt conveyor accident.

This is an example of the unbelievable hazards of belt conveyor operations. A construction foreman with years of experience, who had erected this and many other conveyors on the same job—a superintendent who knew all the hazards but—someway, somehow, somewhere, a failure and death.

I regret I cannot give you the answers to many of the questions my remarks must have left in your minds, but through the years I have reached a few definite conclusions on accident prevention and the most important one is this:

"An organization whose management personnel are the most definitive disciplinarians generally have the best safety records and competitive costs."

Safety and production records go almost hand in hand over a period of time. Often we who are dedicated to the problem of accident prevention fail to accomplish all we could, because management and supervision do not wholly accept the responsibility vested in them for the moral, social, economic and contractual obligations to the employee.

Officials of the United Mine Workers of America have often reminded me in grievance cases that the direction of the working force is the contractual obligation of management. If you abrogate this right, the responsibility is wholly yours, without recourse under our contract. Many times, management and supervision abrogate their right to accident prevention compliance because they fail to enforce safety rules they themselves established, by looking the other way. This is the road to failure.

I leave you to ponder on just four questions, as you return to your responsibilities after the National Safety Congress meetings are concluded.

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1. Is your accident prevention program based on sound concepts and valid precepts?
2. Do you have the stamina, courage and backing personally to take corrective measures to eliminate unsafe conditions in your operations?
3. Do you ever by-pass unsafe acts, even minor ones, without taking corrective action at once—on the spot?
4. Are you willing to face the fact that the obligation to enforce accident prevention measures, *if not fulfilled* does *result in accidents?*

As I intimated at the beginning, I did not accept the request made of me as an opportunity to endear myself to you. I hope to leave with you something you will never forget. If only a few remember, I have been greatly successful.

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