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# COAL FATAL

UNITED STATES
DEPARTMENT OF INTERIOR
BUREAU OF MINES
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SUBJECT: Hoisting accidents and their prevention, Federal Smelting and Mining Company, Mullan, Idaho, October 6, 1936.

The hoisting accident in the Morning mine at Mullan, Idaho, has aroused considerable interest in methods of preventing similar accidents.

Morning mine, Mullan, Idaho

Ten men were killed when a man cage fell 900 feet in the Morning mine of the Federal Smelting and Mining Company, Mullan, Idaho, at 12:10 a.m., Tuesday, October 6, 1936. Immediately prior to the accident five men, including the cager, got on the lower deck of the 2-deck cage at the 3450-foot level. They were hoisted to the 3050-foot level in order to complete loading men on both decks. The cager then permitted six men to get on the lower deck, making a total of ten men. The cage doors were then closed and fastened. The hoist engineer was signalled to lower the upper deck flush with the station floor and this was done. The cager unfasted the lock at the top of the upper cage door and was in the act of raising the bar extending across the cage door, about midway, when the hoist rope broke about 1200 feet above the cage. According to the cager the cage appeared to fall, bounce, and then fall again. As the rope went by it was whipping from side to side in the cage compartment. The cage fell about 900 feet to the bulkhead below where it was smashed and badly twisted.

One of ten men was found on top of the cage and whether or not this man fell down the shaft in the excitement, or whether he, in some unaccountable manner, was thrown out of the cage on to the top, is not known.

The chippy or service cage is used exclusively for hoisting and lowering men and material; it runs in one of three compartments in the main shaft.

The rope attached to the chippy was 3/8 of an inch thick and 4-1/2 inches wide, being flat, made up of 13 primary strands 3/8 inch in diameter, each of the primary strands consisting of 4 secondary strands of 7 wires to the strand, or a total of 364 wires. The 3/8 inch diameter strands are manufactured by the John Roebling's Sons Company, and the ropes are made up of the Federal Smelting and Mining Company by sewing the strands together with no.

16 wire.

The rope which broke was put in service January 17, 1936. The ropes are changed regularly at the end of a year regardless of the amount of wear. The weight per linear foot is 2.83 pounds and the breaking stress is 72.8 tons. The chippy cage hoist is powered b a 2300 volt alternating current, 350-horsepower, 60-cycle, 3-phase motor, gear-connected to a single-reel Norderg hoist. The rope is attached to the cage by shackling about 6 feet of the rope bent back upon itself after passing around the thimble. The chippy cage is also equipped with two safety ropes about 4 feet long extending from the cross head and firmly bolted to the hoisting rope immediately above one of the shackles. All ropes are inspected weekly and the safety catches on the chippy cage are also inspected weekly and tested periodically.

The safety catches are operated by springs which cause the catches to protrude, forcing the catches with a type of pick point to "dig into" the faces of the guide (rather than on the side as with the usual arrangement) when the tension on the hoisting rope is released.

The rope is inspected visually and waste material is held against the rope to indicate or/catch projecting broken wire. The rope is heavily treated with a tarry compound which is forced in between the strands, probably making it difficult to determine actually the condition of the rope visually as the broken strands may be flattened against the rope and not discerned by the type of test used at this mine. The weight of the point of the rupture was Cage, 3600 pounds; or a total of 8,596 pounds. Since the breaking strain of new rope was placed at 72.8 tons the safety factor at the time the rope broke figures about 17 to 1 but inasmuch as the rope broke, the figures do not represent the actual conditions.

The break was rather clean as evidenced by the fact that the loose wires or fraying did not extend more than two feet from the point where the rope was undisturbed. There was some slight corrosion in evidence, but most of the wires retained their ductility as indicated by their broken ends which, for the most part, had been drawn out to a needle-like point at the time of breaking. This is the characteristic type of break under tension, since steel under exceptional stress is subjected to a marked reduction in area of the steel at the point where rupture is likely to occur. When the reduction in area is well started, the steel is likely to continue to elongate even when no additional weight and the area be reduced until rupture finally occurs. Earlier in the shift at the end of which the accident occurred, a load of about 18,000 pounds had been lowered on the cage, the material handled consisting of green lagging; it is possible that due to corrosion and breaking of wires or possibly due to some inherent weakness the tensile strength of the rope had been so reduced that the above mentioned load may have started a reduction in the cross sectional area of the wires of the rope but, the removal of the load occurred before actual rupture occurred. Later on the weight of five extra men getting onto the cage plus the tension placed on the rope in pulling the cage from the 3450 level to 3050 may have been sufficient to again start the reduction of area in the steel rope and ultimately to cause the rupture.

Apparently there is no indication on the guides that the safety catches contacted them; if the safety catches failed to operate it is probably due to the fact that 1200 feet of rope kept sufficient tension on the coil springs to prevent their action. Also there is a possibility that the guides were so warn that the catches would not make contact; even if the catches had held it is probable that the 3396 pounds of rope between the break and the cage, falling on the cage, would have carried it to the bottom of the shaft.

The general manager states that hereafter new ropes will be removed at the end of six months and steamed out in order to remove the tarry dressing so that careful and systematic inspection of the rope may be made; if any defects are disclosed the rope and safety catches be inspected more thoroughly in the future than they have been in the past and the rule permitting not more than nine men on each deck of the cage should be rigidly enforced.

Among other things this accident indicates the desirability of having an emergency set of catches that can be operated from the man cage independtly of rope tension. In addition a set of chairs or chains might be installed at every shaft station that may be operated from the cage when the cage is stopped at a shaft station to take or discharge men; however, shaft station chairs have in themselves some definite hazards unless they are carefully designed, installed, maintained and operated.

A hoisting accident at the Louise mine, Manganiferous Mining Company, in which three lives were lost on October 27, 1930. At the time of the accident the ore-hoisting compartment of the shaft was being cleaned by three men who had laid planks across the top of the skip and stood on the planks while scraping accumulated material from the cross timbers. The mining captain was at the collar of the shaft and as soon as a set was cleaned he would signal the hoisting engineer to lower the cage about five feet to the next set. Shortly after one of these stops the rope broke and the skip fell about 220 feet, killing the three men.

The skip was used to hoist men only when cleaning the shaft; the rope was at least six and may have been thirteen years old. The rope was not lubricated and this is said to have been due to possibility of abrasion because of dust in the shaft. A casual examination had been made of the rope two days before the accident and ore had been hoisted in the skip practically up to the time of the accident. The rope was hard and brittle where it parted and due to weather conditions the rope was undoubtedly cold. Approximately 30 seconds elapsed between the time the drum stopped and the rope broke. The part of the rope that broke did not run over the head sheave as the skip came into the dump and the skip was lowered slowly without any jerks. There were no safety devices on the skip. The general opinion is that the skip caught on the guides, allowing slack to accumulate in the rope and the skip then dropped, breaking the rope.

This accident indicates the necessity of equipping all cages or skips with adequate safety catches, and requiring periodical drop tests to make it reasonably sure that the catches are kept in working condition. There should also be frequent careful inspections of the hoisting rope and certainly no rope should be held in operation as long as 13 years unless the most abnormal conditions are present.

A shaft accident at the Allison mine of the W.J. Rainey Coal Company, Allison, Pa. At about 6:00 a.m., October 20, 1931, one man was killed and eight injured at the Allison mine as twelve men were being lowered on the man cage, when, as is customary, the hoistman, after having accelerated the cage for about 125 feet, threw the controller to the "off" position, and attempted to retard the speed of the cage by using the hand brake. Apparently, the hand brake did not operate, or it did not retard the cage as quickly as the hoistman thought it should, and, becoming excited, he threw off the power that automatically operated a solenoid switch which, in turn, threw a clutch releasing the emergency brake. When the emergency brake took hold, 28 bolts holding the brake lining on one of the 5-foot brake arcs of the post brake were sheared, and caused the brake lining to be thrown out from between the brake shoe and the brake drum. The counterweight was propelled upward with such force that it was carried be ond the upper end of its T-steel guards and two of the iron weights were thrown down the shaft. One of the counterweights struck a man who was standing 12 feet from the bottom of the shaft, breaking his leg. Of the 12 men on the cage, two received only minor abrasions and walked home after the accident; 9 men were taken to the hospital and two of these, after being examinated, were found to have no major injuries and were discharged from the hospital; the others, who fell about 140 feet in cage, had broken legs at or below the knee, and broken ankles.

Although the State mine inspector had inspected the emergency brake several days before the accident, apparently, the brake was not tested while the cage was in operation, and the oil in th dash-pot at the foot of the brake post was not examined. The safety dogs were found to operate in this case, as the hoisting rope was not broken. The hoist was not provided with an overspeed device; however, overwinding was prevented by a cut-out in the power circuit 3 or 4 feet above the level of the surface landing, and by a second cut-out about 10 feet above the surface landing.

It may have been possible that the bolts holding the one section of the brake lining were loose, and when the emergency brake was applied, the bolts were sheared, throwing the lining out of contact with the drum and the brake shoe. It is also possible that the dash-pot was too low, thereby causing the brake to take hold too abruptly when the emergency brake was operated.

Following this accident it was recommended that the emergency brake should be tested monthly with the cage in operation and loaded with the maximum permissible load; that the oil in the dash-pot should be checked once a week; that a visible oil feed should be connected to the dash-pot to keep the level of the oil at the proper height; that the brake-shoe lining should be long enough to fold over the end of the brake shoe and should be clamped securely in place; that brass bolts should be used to hold the lining in place; that the empty cage should run up and down the shaft before the men are lowered at the beginning of the shift; and that written reports of all inspections should be made.

Electric hoist accidents at two California gold mines:

> "Fainting, sleeping, and other similar conditions affect hoistmen and have been and are the cause of bad accidents at mine shafts. While miners and others are being hoisted or lowered, it would appear that there should be two hoistmen on duty; this is a rule at some mines in this country and abroad. Mr. Ash sends from Berkley a brief account of a hoistman who fainted at the Kennedy gold mine and of one who slept at the Central Eureka gold mine, both near Jackson, California. In the first incident the hoist at the 4800-foot shaft was driven by an 800-horse power electric motor and was equipped with Lilly overspeed and overwind gear. the hoistman, an elderly man, fainted and the hoist 'ran away' and pieces of the motor flew in all directions. What probably happened is that when the hoist began to attain excessive velocity the hoist reversed the motor to plug it, causing it to heat so rapidly as to practically blow up.
> The hoistman was found unconscious but injured. The control gear was tested from time to time, but the working of the overspeed gear is not determined readily and this part of the device evidently was not functioning at the time. One man on one skip in this shaft was injured.
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> "In the second incident the hoistman fell asleep 'on the job' and a skip lodged in the top of the steel head frame."

These accidents point out the desirability of having a second man in attendance at all times while men are being lowered or hoisted in shafts. It also points out the desirability of having hoisting engineers pass a rigid physical examination at least every five years and it is believed that operating companies should take upon themselves the responsibility of having the hoisting engineer examined every six months. All hoists should be provided with an overspeed overwind device, one of the most common of which is the Lilly controller. The functioning of this device is described in the following article taken from "Bollen Pulley Hoist at Magma", Mining Congress Journal, volume 21, pages 34 and 35, February 1935:

> "For safety the hoist is fitted with a Lilly Contoller of model 'D' type with a man safety attachments. Whenever the safety stop acts, it will open the solenoid circuit and shut off the power from the motor for any one of the following reasons:
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> 1. In case the hoist speed exceeds normal at any point.
> 2. In case the operator fails to slow down the hoist at any predetermined and adjusted point and fails to continue to slow down between this point and the landing level.
> 3. In case of overwind.
> 4. In case operator fails to reverse the hoist after skip has reached the landing or limit of travel.
> 5. In case power goes off the line for any cause.
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> "Whenever the safety stop acts, the brake is graduall applied without serious shock in its application but at the same time with sufficient rapidity to serve the purpose intended. A solenoid, which is normally energized, is used in connection with the brake cylinder. In case of interruption of current or acting of the safety stop, the solenoid is de-energized and thereby actuates the brake operating mechanism in such a manner that the brake is set by weight. The brake is set automatically and entirely independently of the operator in case of interruption of power current or action of the safety stop. It is also impossible for the operator to release the brake when the current is off the line."

Suitable signalling devices are also important in considering the safety of hoists. A description of such a device is found in the Mining Congress Journal, volume 21, page 59, March 1935, in an article on "Hoisting Problems in Lead-Silver Mines in Utah":

> "The efforts to minimize accidents in such shafts have been very successful. Contributing to this success is the improvement in the human element brought about by wise cooperation of the companies, the State Commission and the men. Another contributing factor is the perfection of signaling devices, including those for signaling direct from the cage.

In some mines the successful operation of the cage signaling system is such that it has been adopted to the exclusion of signaling from pull switches mounted at the stations. In such cases the pull cord on the cage is located so that it can be reached by a station tender just as readily as could a pull switch mounted on the station post. The device is such that the signal relay at the engineer's platform will respond only to the direct current impulse from the battery on the cage."

The use of regenerative braking, as an added precaution for increasing safety in mine hoists, is described in an article in the Mining Congress Journal, October 1935, page 19; and on page 20 is described solenoids for applying brakes. This is part of an article on "Electric Equipment for Homestake's New Hoist."

"The adjustable generator voltage control system (Ward Leonard) employed for both hoists, provides a means of starting, stopping and maneuvering the skips and cage with ease, precision and safety. The speed of the hoist motor is controlled by impressing on its armature the variable voltage of the generator, and its direction of rotation is determined by the polarity of this voltage. As the motor field is maintained at uniform value, the speed is closely proportional to the applied voltage regardless of the load at its coupling.

"Nicety of control is thereby afforded under the varying load conditions which exist while hoisting and retarding. When retarding there is developed a dynamic braking effect as a result of the automatic reversal of the current flowing between the motor and generator as the generator field current is stepped down in value by the operator in moving the master switch toward the 'off' position. Actually the functions of the two machines invert, the motor becoming at this time a generator, through which the energy of the moving hoist system is loaded back into the flywheel motor-generator set (or power lines.) The mechanical brakes therefore are not necessary to stop the hoist but are reserved principally to hold the drums stationary between trips. As a further consequence of this power regenerative feature, overhauling loads may be lowered as positively and safely as when hoisted and without any consumption of energy or wear on the mechanical brakes."

In a tentative draft of a proposed Metal Mining Law with recommended safety orders, as prepared by the Safety Division of the U. S. Bureau of Mines, the following safety features are recommended:

"All hoists shall be equipped with brakes able to stop and to hold the fully loaded unbalanced cage or skip at any point in the shaft or incline. Each hoist shall have ample power to hoist a fully loaded unbalanced cage or skip.

"Cages, used for hoisting or lowering men, shall be provided with approved safety catches, capable of bringing to a stop the fully loaded cage or skip in any part of the shaft or headframe in case the rope or rope connection should break. These safety devices shall be adequately tested at least once per week, and a written record of such tests made and kept on file at the mine.

"When hoisting or lowering men, cage rests or chairs shall be used at all vertical shaft stations, regularly used for hoisting or lowering men, unless their omission be authorized in writing by the chief mining engineer, with written concurrence of the mining commission.

"Shaft repair men shall be furnished with, and wherever feasible shall be required to wear approved webbling safety belts with quick-detachable snaps and ample lengths of approved rope.

"Any rope used for hoisting or lowering men shall be of multiple-wire construction of recognized standard character as published by American Standards Association n its pamphlet M-11. The material shall be adapted to the service in which the cable is to be used. The safety factor shall be not less than that shown in the following table:

Hoisting Rope Safety Factors for Various Depths of Shafts

| Vertical Depth of Shafts | Minimum Factor of Safety for New Rope | Minimum Factor of Safety When Rope Must be Discarded |
|---|---|---|
| Feet | | |
| 500 or less | 8 | 6.4 |
| 500 to 1,000 | 7 | 5.8 |
| 1,000 to 2,000 | 6 | 5.0 |
| 2,000 to 3,000 | 5 | 4.3 |
| 3,000 and more | 4 | 3.6 |

"The safety factor shall be calculated by dividing the breaking strength of the rope (as rated by the manufacturers, or in accordance with tests on a sample by the United States Bureau of Standards) by the maximum rope pull, not including friction or acceleration--that is, by the sum of the maximum weights to be hoisted, including weight of skip or car and cage plus weight of ore or rock plus total weight of rope when extended to bottom of hoistway. If the hoistway is inclined, the calculated component of the weights, parallel with the incline, shall be used.

"'Sheaves and drums must be at least as large as the minimum size recommended by the rope manufacturer and should be as large as conditions permit'. Recommendations contained in U. S. Bureau of Mines Technical Paper 237, Safe Practice in using wire ropes in mines, shall be effective in this State except where they may be at variance with the provisions of these orders.

"No rope shall be used for hoisting or lowering men (a) when the wear has reduced the safety factor to below the points indicated in the foregoing table as/determined by tests of piece showing maximum wear, (b) when on inspection it is found that the number of broken wires exceeds six in any single pitch length or lay of the rope, (c) when the wires on the crown of the strands are worn to less than 65 percent of their original diameter, or (d) when inspection indicates a dangerous amount of corrosion or distortion. When such broken wires are reduced by wear more than 30 percent in cross section, however, the number of brakes in any lay length of rope shall be inspected once in every 24 hours by some competent person designated for the purpose by the operator or superintendent. If upon a hoisting rope is considered unsafe, or if it shall be found to be below the requirements set forth in this section, it shall be put out of use for such purpose forthwith.

"Cages, skips, or cars used in hoisting or lowering men shall be fastened to the hoisting rope by zinc-filled sockets or by clamps to meet detailed recommendations of the American Standards Association, as published in its pamphlet, M-11. At intervals indicated in pamphlet M-11 from 4 to 10 feet of the rope shall be cut off and the rope refastened as therein provided. Clamping shall be so done that at lest 80 percent of the breaking strength of the rope shall be attained. Under no circumstances shall babbitt metal or lead be used to attach hoisting ropes to sockets.

"The hoisting rope shall be firmly clamped to the drum or reel, and at least two turns of the rope shall remain on the drum or reel when the cage or skip is at their lowest working depth.

"Every hoisting rope shall be treated with oil or with some suitable rope-lubricating compound at least twice every month. Such compound shall be chemically neutral and shall be of such as to penetrate the strand and not merely cover the surface of the rope. Otherwise the practices recommended by the American Standards Association in its pamphlet M-11 shall be followed."

In the accident at Mullan, Idaho, the cage is though to have jumped the guides and then jumped back again, indicating that the guides may have been loose and this condition may have existed at the 3050-foot level. It seems possible that many accidents ascribed to failure of catches to operate may have been due to the fact that guides are to badly worn to allow the catches to obtain a hold.