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Haulage Truck Dump Site Safety: An Examination of Reported Injuries

U. S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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By Fred C. Turin, William J. Wiehagen, Jasinder S. Jaspal, and Alan G. Mayton

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HAULAGE TRUCK DUMP SITE SAFETY: AN EXAMINATION OF REPORTED INJURIES

By Fred C. Turin,[1] William J. Wiehagen,[1] Jasinder S. Jaspal,[2] and Alan G. Mayton[2]

ABSTRACT

Dump site injuries occur in all major mineral industries. Working in elevated areas near an edge is a common hazard for operators of off-highway mobile mining equipment. In this Information Circular (IC), serious injuries involving haulage trucks working at dump sites are examined for the period 1988 to 1997. Data were acquired from injury reports gathered by the Mine Safety and Health Administration (MSHA). The IC is organized into three sections. The first presents an overview of the frequency and severity of injuries. The second analyzes injury characteristics using MSHA-defined data fields and author-defined injury classifications. Key findings are discussed in the third section.

In summary, 370 serious injuries were identified that involved trucks at dump sites, of which 26 were fatalities. Although haulage truck activities at dump sites resulted in a small proportion of the total number of injuries at surface mines, these injuries were much more likely to result in death or significant amounts of lost time than most other surface mine injuries. These findings support the belief that haulage truck activities at dump sites are worthy of continued study by those interested in improving the health and safety of workers at surface mines.

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INTRODUCTION

The major mineral industries use mobile equipment in elevated areas near dump points, either through the construction of temporary material stockpiles or the construction of semi-permanent to permanent waste or spoil piles [May 1990]. Dumping over an edge is an efficient means of handling material and is widely practiced. However, working near an edge is considered a common hazard for off-highway mobile equipment, and dumping over an edge has been identified as one of the highest risk activities at a dump site. The amount of risk depends on many factors. These factors include dump site layout, dump site stability, truck performance, amount of light, decision-making abilities of equipment operators, and weather conditions. Important tasks for safety professionals are to quantify work site risks, to provide guidelines for identifying when risks are too great, and to determine what can be done to reduce these risks.

Injury data support the belief that the practice of haulage truck dumping carries significant risk. May [1990] noted that from 1983 to 1987, incidents at dump points were responsible for a disproportionate share of high-severity injuries: that is, while dump point injuries accounted for 0.3% of the injuries in surface mining, they accounted for 4.37% of the fatalities, and each lost workday injury resulted in an average of 67.0 days lost from work. This compared to an average of only 36.9 days for mobile-equipment-related injuries and 29.8 days for all other surface-mining-related injuries. Finally, haulage trucks were involved in 80% of all injuries at dump points, resulting in seven fatalities and 61 lost workday injuries. Krowczyk [1995] noted that from 1991 to 1994, haulage truck operation accounted for 26 fatalities, 27.7% of surface mining fatalities. A sizeable proportion of the fatalities involved rolling off a bench, highwall, or roadway.

In this Information Circular (IC), serious injuries involving haulage trucks working at dump sites are examined for the period from 1988 to 1997. Injury data were acquired from injury reports gathered by the Mine Safety and Health Administration (MSHA). A mine operator is required to submit a report for each incident that meets the criteria in title 30, part 50, of the Code of Federal Regulations. These data were analyzed for coal, metal, and nonmetal mines. This work is an extension of findings reported in U.S. Bureau of Mines' (USBM) IC 9250 by May [1990] and is organized into three sections. The first presents an overview of the frequency and severity of injuries. The second analyzes injury characteristics using MSHA-defined data fields and author-defined injury classifications. Key findings are discussed in the third section.

DEFINITIONS

The following are definitions of selected terms used in this IC.

Berm: A pile or mound of material intended to assist in preventing mobile equipment from traveling over the edge of a bank. Berms are normally used along the edge of haulage roads and dump sites.

Dump site: For this IC, an area where a haulage truck intends to deposit a load of material. In general, a dump site is the active area of a stockpile, waste dump, or spoil pile where material is placed during construction of the pile. It normally lies at the edge or crest of the pile.

Haulage truck: A truck that has an open box body that is used for transporting and dumping material.

Incident result: An author-defined injury classification that describes what happened to a truck.

Lost-time injury: An injury for which a mine employee required time off from work.

Mobile mining equipment: Tracked or rubber-tired, self-propelled equipment used at mining operations.

Mine Safety and Health Administration (MSHA): The mining industry regulatory and enforcement branch of the U.S. Department of Labor.

Operator impact: An author-defined injury classification that describes what happened to a haulage truck operator.

Serious injury: An incident that resulted in a fatality or a lost-time injury.

Spoil pile: A structure consisting of unconsolidated materials once covering a coal deposit removed during surface coal mining operations.

Stockpile: An accumulation of a mineral formed to create a reserve to feed a processing plant or to be shipped directly.

Surface mining: Activities associated with mineral excavation and recovery carried out at or near the earth's surface.

Truck activity: An author-defined injury classification that describes what a truck was doing when an injury occurred.

Waste dump: An area where mine waste material is disposed of or piled.

FREQUENCY AND SEVERITY OF INJURIES ASSOCIATED WITH HAULAGE TRUCKS AT DUMP SITES

The significance of injuries associated with haulage trucks at dump sites was put into perspective by comparing such injuries with all injuries at surface mines and injuries involving mobile mining equipment. This comparison is presented in table 1. The injury data selection process used for this analysis is described in appendix B. In general, these are injuries that likely occurred while a haulage truck was active at a dump site.

There were 79,601 serious injuries at surface mining operations over the 10-year period examined. This number included an average of almost 62 fatalities per year. Surface mobile mining equipment was involved in 20% of these injuries and 42% of the fatalities. The average number of lost workdays due to injury was 14% higher for operators of mobile equipment than for all surface mine workers. This figure shows that injuries that involved mobile mining equipment were more severe than injuries that occurred at surface mines. Three-hundred seventy serious injuries involved haulage trucks at dump sites, which was only 2% of the serious injuries that involved mobile mining equipment. However, these injuries were responsible for a disproportionate share of fatalities and lost workdays. In fact, the average number of lost workdays resulting from injuries that involved haulage trucks at dumps sites were more than 50% higher than injuries that involved mobile mining equipment and more than 70% higher than the average for surface mining.

These findings are consistent with those reported by May [1990] and indicate that while these injuries made up a small fraction of the injuries at surface mines, they were much more likely to be serious or fatal.

Appendix C is a set of tables that summarize serious injury information for surface mining, mobile mining equipment, and haulage trucks at dump sites. These tables supplement the tables and figures presented in the body of this IC.

Figures 1 and 2 display trends in the frequency of serious injuries at surface mines and with mobile equipment. The injury rates presented in figure 1 are based on the number of injuries per 1 million surface hours worked. Figure 1 shows a clear downward trend in serious injuries in surface mining and the use of mobile mining equipment, although the latter dropped at a much slower rate. The number of surface mining fatalities ranged from 52 to 72, with an average of 62 per year. The number of fatalities that involved mobile mining equipment ranged from 17 to 32, with an average of 26 per year. As pictured in figure 2, there were yearly fluctuations in the number of fatalities, but they did not exhibit a downward or upward trend.

Table 2 lists serious injuries by year for haulage trucks active at dump sites. The number of fatal incidents did not decrease, but there was a drop in the number of lost-time injuries beginning in 1992. The average number of serious injuries per year for the period 1988 to1991 was 46. From 1992 to 1997, the average number of serious injuries per year was 31. Also, the average lost workdays from 1995 to 1997 were between 36% and 66% lower than the average for the 10-year period. These findings establish that while haulage truck safety at dump sites remains an important safety concern, there was an improvement in the number and severity of lost-time injuries.

Table 1.—Injuries associated with surface mining, mobile equipment, and haulage trucks at dump sites, 1988-1997

Category	Serious injuries	Fatalities	Lost-time injuries	Lost workdays	Average lost workdays[1]
Surface	79,601	619	78,982	2,289,152	28.98
Mobile equipment	15,601	262	15,339	507,594	33.09
Percentage, surface	20	42	19	22	114
Haulage truck dump site	370	26	344	17,265	50.19
Percentage, mobile equipment	2	10	2	3	152

[1]Average lost workdays = lost workdays ÷ lost-time injuries.

Table 2.—Fatalities and lost-time injuries associated with haulage trucks at dump sites by year

Year	Fatalities	Lost-time injuries	Lost work days	Avg. lost days
1988	2	45	2,545	57
1989	3	42	2,075	49
1990	2	48	3,378	70
1991	6	38	2,489	66
1992	1	31	1,667	54
1993	1	30	1,427	48
1994	2	34	1,636	48
1995	4	20	647	32
1996	3	25	432	17
1997	2	31	969	31
Total	26	344	17,265	50

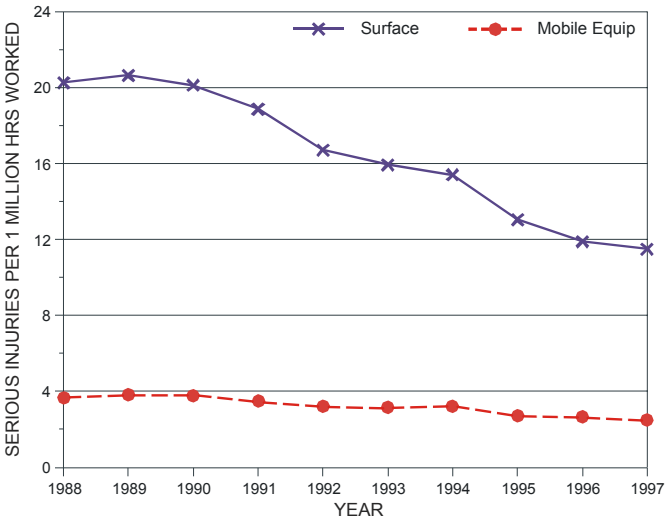

Figure 1.—Serious injury rates associated with surface mining and mobile equipment.

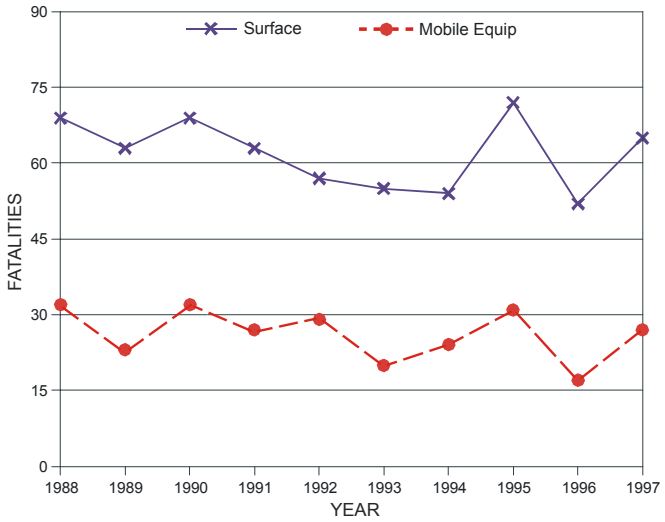

Figure 2.—Fatalities associated with surface mining and mobile equipment.

ANALYSIS OF INJURIES ASSOCIATED WITH HAULAGE TRUCKS AT DUMP SITES

MSHA-DEFINED DATA FIELDS

Figure 3 displays a breakdown of serious injuries associated with haulage trucks by the MSHA data field *degree of injury*. Only fatalities and injuries that resulted in days lost from work were considered. This translates to the four categories presented. Nearly 83% of the serious injuries resulted in days away from work only.

To identify where these injuries occurred, the MSHA data field *canvas class* and *subunit* were analyzed. *Canvas class* is used to identify a general product class based on the Standard Industrial Classification codes for the commodity mined. A *subunit* is used to identify the general type of operation. Underground, strip, auger, preparation plant, and office workers are examples of *subunits*. The results of this analysis are presented in tables 3 and 4 and figures 4 and 5.

- Bituminous coal mines had the highest number of serious injuries—133, or 36% of the total. The largest number of fatalities occurred at stone and metal mines with nine and eight, respectively.
- Anthracite coal mines had the highest average number of lost workdays per injury at 70.13. This was 40% higher than the average for all haulage trucks at dump sites.
- Bituminous coal mines and metal mines had average lost workdays that were about 17% higher than the overall average.
- Nearly 77% of the serious injuries occurred at strip or open-pit mines, with a serious- injury rate of 13.62 injuries per 100 million hours worked. This rate was almost three times as large as that for all other surface operations. These mines had 22 of 26 fatalities and 262 of 344 lost-time injuries.
- More than 60% of the serious injuries and nearly 75% of fatalities occurred at bituminous coal strip mines, stone quarries, and metal open-pit mines. Bituminous coal strip mines had the highest number of serious injuries, nearly 26% of the total. Stone quarries had the most fatalities, nearly 31% of the total.

AUTHOR-DEFINED INJURY CLASSIFICATIONS

MSHA data fields were designed to be broad enough to apply to all types of injuries. The authors developed classifications tailored for the specific types of injuries being analyzed. The authors believed that focused classifications would provide additional information about haulage truck injuries at dump sites. Four primary classifications were defined: *truck activity*, *incident result*, *operator impact*, and *contributing factors*. Two secondary classifications were also defined, *exit cause* and *seat belt usage*. Code definitions for each classification and notes concerning their use are provided in appendix D.

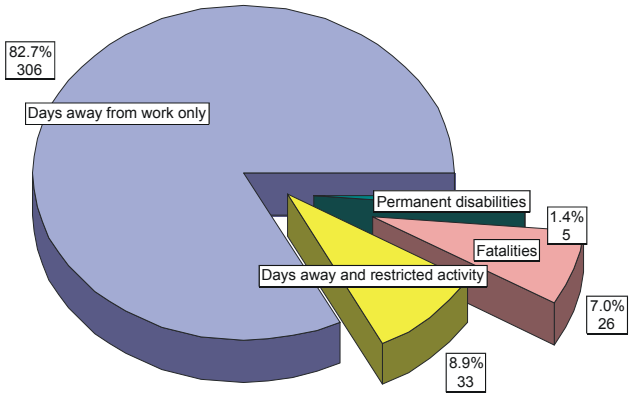

Figure 3.—Breakdown of results of injuries associated with haulage trucks.

Table 3.—Serious injuries associated with haulage trucks at dump sites by product class

Product class	Serious injuries	Fatalities	Lost-time injuries	Lost workdays	Average lost workdays
Bituminous coal	133	6	127	7,424	58.46
Stone	100	9	91	3,897	42.82
Metal	66	8	58	3,386	58.38
Sand and gravel	46	2	44	1,413	32.11
Nonmetal	17	1	16	584	36.50
Anthracite coal	8	0	8	561	70.13
Total	370	26	344	17,265	50.19

Table 4.—Serious injuries associated with haulage trucks at dump sites by operation type per million hours worked

Operation type	Hours worked, millions	Fatalities	Lost-time injuries	Serious injuries per 100 million hours worked[1]	Lost workdays	Average lost workdays
Strip or open pit	2,085	22	262	13.62	12,681	48.40
Mill or prep plant	1,495	3	66	4.61	3,825	57.95
All other surface	285	1	16	5.95	759	47.44
Total	3,865	26	344	9.57	17,265	50.19

[1]Serious injuries per 100 million hours worked = (fatalities + lost-time injuries) x 100 ÷ million hours worked.

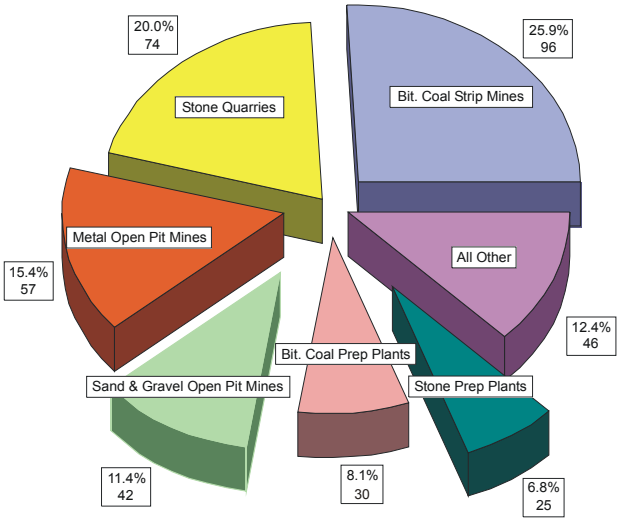

Figure 4.—Serious injuries associated with haulage truck by product class and operation type.

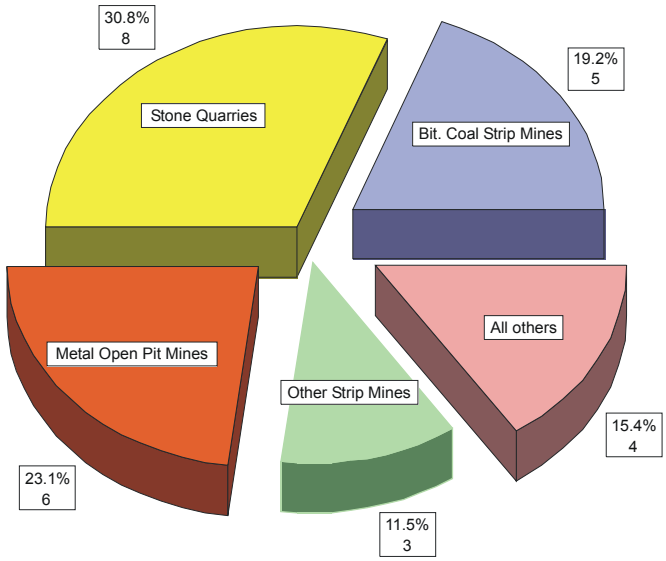

Figure 5.—Fatalities associated with haulage truck by product class and operation type.

Table 5 presents serious injuries by *truck activity* and *incident result*. More than 90% of the serious injuries occurred while stationary dumping or while backing up. Falling over an edge, rolling over, and being bounced and/or jarred resulted in 83% of the serious injuries. Falling over an edge resulted in 37% of the serious injuries and 85% of the fatalities. The combination of backing up and falling over an edge accounted for 26% of the serious injuries and 73% of the fatalities. In fact, one in five of the backing-up and-falling-over-an-edge incidents resulted in death. The second and third most common combinations involved stationary dumping and either rolling over or being bounced and/or jarred.

Injuries classified by *operator impact* are presented in table 6 for the two primary truck activities, stationary dumping and backing up. The majority, 54%, were classified as "struck against object." The "landed outside cab" classification is a special case of the "struck against object" classification. These two classifications make up 68% of the serious injuries and 69% of the fatalities. Eleven of the twenty-six fatalities (42%) occurred when the operator landed outside the cab. This was a key reason for separating these incidents from other "struck against objects" incidents. In particular, 70 of the 95 injuries that involved backing up and falling over an edge were classified as "struck against object" and 17 were classified as "landed outside cab." Nineteen operators were killed while backing up and falling over an edge. A breakdown by effects on the operator is shown in figure 6. Nearly half occurred when the operator landed outside the cab. These findings indicate that backing up, falling over an edge, and landing outside the cab describe incidents most likely to have resulted in a fatality.

Two secondary classifications were used with injuries in which the operator landed outside the cab. These classifications were "exit cause" and "seat belt usage." Table C-20 and C-21 in appendix C lists the serious injuries for these classifications. In 35 of the 52 cases, the operator jumped from the cab, 13 times the operator was thrown from the cab, and four times it was not known whether the operator jumped or was thrown out. In 40 of 52 cases, it was not determined if the operator wore a seat belt, 11 times a seat belt was not worn, and only one incident was reported in which a seat belt was worn.

Detailed incident reports provided more reliable information for fatal injuries. A review of the 11 fatal incidents revealed that seven truck operators were thrown out and were not wearing a seat belt, three either jumped or were thrown out and were not wearing a seat belt, and only one jumped, making it unknown whether a seat belt was worn. Thus, in at least 10 of 11 fatal cases, a seat belt was not being worn.

Table 2 shows a downward trend in the number of haulage truck lost-time injuries. Figure 7 displays serious injury trends by truck activity. Backing-up injuries dropped steadily. Those that occurred while stationary dumping and during all other activities fluctuated over the period examined, but did not show either an upward or downward trend. Beginning in 1994, injuries during stationary dumping surpassed injuries while backing up and were the most frequent. This confirms that the drop in lost-time injuries shown in table 2 was primarily due to the drop in injuries that occurred while backing up.

Table 7 presents contributing factors by incident result. Each serious injury could be assigned up to three contributing factors. Injuries that resulted in falling over an edge had the most contributing factors identified. "Edge failure" and "traveled through a barrier" were identified most often. The most common contributing factors to rollover incidents were "uneven ground" and an "unbalanced or shifted load." The most common contributing factors to bounced or jarred incidents were "mechanical/hydraulic failures" or "unbalanced/shifted loads." The last row of table 7 discloses that 96 of the serious injuries did not have any contributing factors identified.

Table C-22 in appendix C provides a complete list of contributing factors to serious injuries. The two most common contributing factors to fatal injuries were "traveled through a barrier" and "no barrier provided."

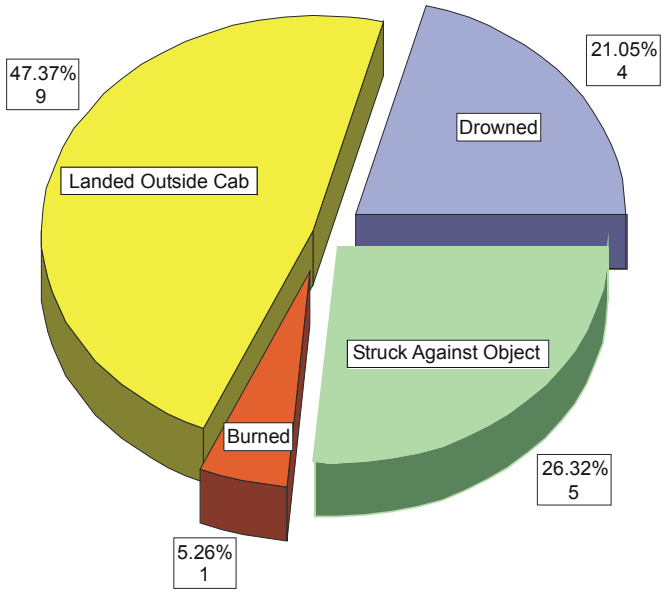

Figure 6.—Fatalities associated with haulage trucks backing up and falling over edge.

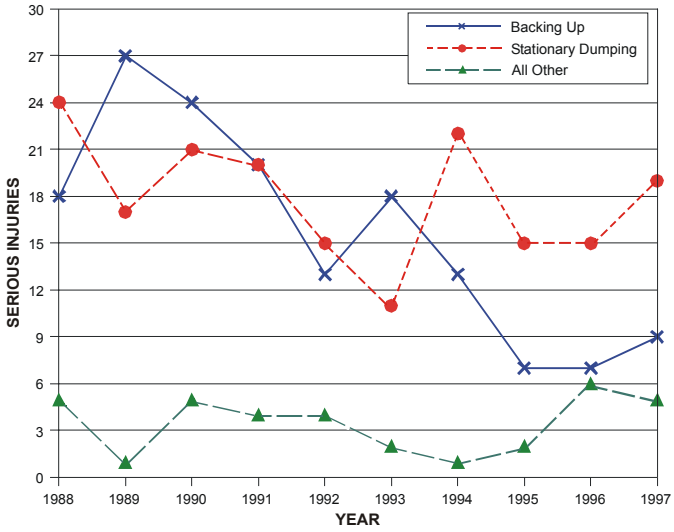

Figure 7.—Serious injuries by haulage truck activity, 1988-1997.

Table 5.—Serious injuries by haulage truck activity (fatalities in parentheses)

Incident result	Stationary dumping	Backing up	Moving forward	Other/unknown	Total
Fell over edge	36 (3)	95 (19)	4 (0)	2 (0)	137 (22)
Rolled over	52 (1)	30 (0)	10 (0)	1 (0)	93 (1)
Bounced or jarred	65 (0)	5 (0)	8 (0)	0 (0)	78 (0)
Collision	0 (0)	7 (0)	5 (0)	0 (0)	12 (0)
Fire	8 (0)	2 (1)	1 (1)	0 (0)	11 (2)
Hung up on edge	4 (0)	6 (0)	0 (0)	0 (0)	10 (0)
Struck by object	1 (0)	2 (0)	0 (0)	0 (0)	3 (0)
Contacted powerline	0 (0)	0 (0)	3 (1)	0 (0)	3 (1)
Unknown/other	13 (0)	9 (0)	1 (0)	0 (0)	23 (0)
Total	179 (4)	156 (20)	32 (2)	3 (0)	370 (26)

Table 6.—Serious injuries by effects on operator and haulage truck activity (fatalities in parentheses)

Operator impact	Stationary dumping	Backing up	All other	Total
Struck against object	84 (2)	99 (5)	17 (0)	200 (7)
Jarred and/or tossed	58 (0)	13 (0)	9 (0)	80 (0)
Landed outside cab	19 (2)	28 (9)	5 (0)	52 (11)
Musculoskeletal injury	10 (0)	5 (0)	1 (0)	16 (0)
All other	8 (0)	11 (6)	3 (2)	22 (8)
Total	179 (4)	156 (20)	35 (2)	370 (26)

Table 7.—Factors contributing to serious injuries by result

Contributing factors	Fell over edge	Rolled over	Bounced or jarred	All other	Total
Edge failure	65	12	0	2	79
Mechanical/hydraulic failure	1	6	35	14	56
Uneven ground	8	35	2	3	48
Load unbalanced or shifted	2	22	18	1	43
Traveled through berm or barrier	27	3	0	3	33
Undercut pile	15	1	0	0	16
No berm or barrier	13	1	0	0	14
All other	4	4	1	12	21
Total	135	84	56	35	310
None	27	17	23	29	96

DISCUSSION

Hours worked at surface mines during the period 1991 to 1997 have remained fairly constant at about 480 million hours per year. During this period, serious injuries in surface mining have steadily dropped by about 8.5% a year, and serious injuries associated with mobile equipment at surface mines have dropped by about 5.5% a year. These trends indicate that efforts to reduce serious injuries in surface mining have realized some success. Serious injuries at dump sites dropped 27% from 1991 to 1992. For the period 1992 to 1997, the number of such injuries remained fairly constant, averaging about 31 per year. These injuries were much more likely to result in death or a significant amount of lost time than most other injuries at surface mines. Although haulage truck activities at dump sites were a small proportion of the injuries at surface mines, these findings support the belief that they are worthy of continued study by researchers interested in improving the health and safety of workers at surface mines.

The majority of the 370 serious injuries at dump sites occurred at strip and open-pit operations. Although these operations contributed 54% of the surface hours worked, they had a disproportionate number of lost-time and fatal injuries. Also, the average number of days lost at strip or open-pit operations was nearly three times larger than the average for all other types of operations. Bituminous coal strip mines, stone quarries, and metal open-pit mines accounted for 80% of the serious injuries, and bituminous coal strip mines had the most serious injuries. When choosing places for further study into the causes of haulage truck injuries at dump sites, it would be wise to consider these types of operations.

The three primary haulage truck activities were broken down into stationary dumping, backing up, and moving forward. More than 90% of the serious injuries occurred during stationary dumping and backing up. The most common types of injuries resulted from a haulage truck falling over an edge while backing up, the operator being bounced and/or jarred while dumping, and the truck rolling over while dumping. Injuries while backing up decreased over the period studied. Injuries while stationary dumping and moving forward fluctuated from year to year without showing either an upward or downward trend. The factor most frequently identified as contributing to a serious injury was edge failure, in particular, edge failure as a truck fell over an edge.

The two most common contributing factors to fatal injuries were “traveled through a barrier” and “no barrier provided.” Eleven of twenty-six fatalities occurred when the operator landed outside the cab. Incidents most likely to result in death were those that involved backing up, falling over an edge, and landing outside the cab. It was determined that a seat belt was not worn in at least 10 of the 11 fatalities categorized as “landed outside cab.” These findings are not surprising and provide more evidence that dump sites need to have adequate edge barriers and that haulage truck operators should wear seat belts.

Devices have been developed to improve a mobile equipment driver’s ability to detect obstacles and hazardous situations. Mirrors, video cameras, and backup alarms are continually being upgraded and added to existing equipment as technology improves. The use of these technologies may help to explain the drop in haulage truck injuries while backing up at dump sites.

Lux [1990] examined limitations to using mirrors on large mobile equipment. He concluded that, in order for a mirror to be effective, an operator must understand how to use it and must take into account its limitations. Researchers at the Spokane Research Laboratory (SRL) of NIOSH tested a number of commercially available and experimental sensors that monitor obstacles in a vehicle's blind spots. None of the sensors had been used in commercial applications on rigid-frame surface mining trucks. It was determined that radio-frequency identification (RFID) and radar technology show the most promise for detecting obstacles in the blind spots of mining equipment. However, more development work is needed to meet the unique requirements of mining equipment and the mine environment [Ruff 2000].

Another important consideration when trying to reduce dump site risk factors is dump site stability. The USBM developed INSLOPE3, a computer software package to analyze the effect of haulage truck operation on dump site stability. INSLOPE3 provides estimates of safe operating distances from slope edges to aid in the development of safe dumping procedures [May 1991].

The two main methods for dumping waste at spoil piles are edge-dumping and short-dumping. While edge-dumping is the most common method, short-dumping is used when there are safety concerns about edge-dumping. Camm [2000] developed a cost model to examine differences in operating and capital costs between the two methods. Managers who use this cost model will be able to make more informed decisions about which method to use.

To identify elements that may be found in a set of safe work practices, the authors extracted information from a number of sources and have provided a compilation of safe work procedures for haulage trucks in appendix A. A review of these materials indicated that they were based on years of experience and informed practice in the use of dump sites.

Safe and efficient dumping depends on a number of factors. Consider, for example, the inspection of a dump site for cracks. What is an unsafe or serious crack? To many, the answer is, "It depends." This illustrates that there can be a lot of variability in the interpretation of safety procedures at dump sites. In particular, safe work practices relevant to the two activities most likely to result in serious injury at dump sites, backing up and stationary dumping, are discussed briefly.

- Haulage truck drivers are taught to back up with the rear of the truck square to the edge or berm by using the near side mirror, so that the left rear tire approaches the berm first. This improves the dumping position and helps keep the truck from penetrating or going through the berm. At the same time, far side mirrors should be used to check for correct orientation and potential obstacles.
- Drivers should travel backward at a moderate-to-slow speed. Backing too fast decreases reaction time if problems develop at the dump site or with the truck and increases the risk that the truck will reach the berm too quickly, so that the truck could go over or through it. Backing through or over a berm is a common cause of injuries at dump sites. *Drivers must not expect a berm or bumper block to stop the truck.*
- Similarly, it is important for drivers, when preparing to dump, to brake to a gradual stop just before reaching the edge or berm. The danger that the slope will fail is increased by braking hard at the last moment.
- Haulage truck operators dumping at the edge of a stockpile or highwall need instruction in how to examine the dump site. Careful inspection of the area prior to and at the start of the shift to check for signs of unstable ground and lack of a berm is a necessity. To ensure safety, the dump site should be checked for cracks along the top edge and over steep slopes, and for sunken or soft areas, all of which indicate an unstable edge.
- Drivers must not dump over the edge if the toe of the stockpile has been removed. Furthermore, they should never dump over the edge of an unstable slope. If there is any question about the stability of an edge, another dump location should be chosen, or material should be dumped short of the edge away from any cracks and then pushed over.
- To operate a safe and effective dump site, sound dumping procedures must be combined with a good maintenance program and meaningful worker training. One way to enhance training for a mobile equipment operator is to use driving simulators. Driving simulators for emergency vehicles are currently on the market. A large driving simulator called the North American Driving Simulator (NADS) is under construction in Iowa City, IA. These systems can provide "situational training," such as slippery roads, vehicle systems failures, and hazardous driver behaviors, that cannot be given safely without using a simulator.

The key to having safe and efficient dump sites is to develop a comprehensive risk reduction strategy that uses up-to-date information and methods. The few examples discussed are not meant to be endorsements of the best or most relevant tools or approaches. Instead they are presented to illustrate several of the important issues that should be considered.

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REFERENCES

Camm TW [2000]. Economics of safety at surface mine spoil piles. Report of Investigations 9653. Pittsburgh, PA: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Spokane Research Laboratory, 9 pp.

Krowczyk C [1995]. Haulage fatalities at surface coal mines, 1991-1994. Denver, CO: Mine Safety and Health Administration, Office of Injury and Employment Information.

Lux WJ [1990]. Limitations on the usefulness of mirrors on construction and earthmoving equipment. SAE Technical Paper Series 901645. Warrendale, PA: Society of Automotive Engineers, 5 pp.

May JP [1990]. Analysis of dump-point accidents involving mobile mining equipment. Information Circular 9250. Pittsburgh, PA: U.S. Dept. of the Interior, Bureau of Mines, Pittsburgh Research Center, 19 pp.

May JP [1991]. User's guide for INSLOPE3: A computer code to analyze the effect of haulage truck operation on dump-point stability. Information Circular 9291. Pittsburgh, PA: U.S. Dept. of the Interior, Bureau of Mines, Pittsburgh Research Center, 20 pp.

Ruff TM [2000]. Test results of collision warning systems for surface mining dump trucks. Report of Investigations 9652. Pittsburgh, PA: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Spokane Research Laboratory, 44 pp.

APPENDIX A.–COMPILATION OF HAULAGE TRUCK SAFEWORK PROCEDURES[1]

CONTENT DESCRIPTION

A literature review was conducted to identify examples of safe work practices for haulage trucks. While the authors organized the information collected into the following categories, they did not develop or alter any of the information. Some of these sources are provided in the bibliography, but a complete bibliography is not included because several sources requested that their identity remain anonymous.

A key source of dump-point safety information is MSHA's *Dump-Point Inspection Handbook* (in press). The purpose of this handbook is to provide MSHA inspection staff with the information needed to understand hazards at dump sites and to better recognize potentially unsafe dump-point conditions and practices. Thus, the handbook offers information on the relevant standards as well as best practices for the use of dump sites. It can be accessed on MSHA's web page at www.msha.gov.

The literature review showed that safety and training procedures can differ significantly relative to mine size, equipment size, and management philosophy. For example, start-up and cab-check procedures can differ depending on the size and model of truck used. Another factor is that larger trucks have the cab mounted at a higher elevation on the frame, which decreases the field of view of the driver dramatically. Most safety manuals do not deal with the issue of limited field of view.

The information presented here is by no means complete. It is included to provide examples of what may be found in a set of safe work procedures. Any work procedure must be tailored to fit the conditions and constraints of the target mine operation.

SURFACE HAULAGE HAZARDS AND PREVENTIVE MEASURES

The material in this section is designed to be used in training programs to increase the awareness of hazards associated with surface haulage and to recommend measures that can be used to minimize these hazards.

WALKING TO AND FROM EQUIPMENT

Potential Hazards

- Muddy walkways, ice, etc.
- Moving vehicles.
- Congested area.

Preventive Measures

- Walk around vehicle as part of preoperation inspection to check for people around the machine.
- Sound the horn or other warning device before starting to move.
- Be sure backup alarm and brakes are operating properly.
- Always look in the direction of travel.
- Be alert for pedestrians.

CHECKING AROUND EQUIPMENT AND MOUNTING AND DISMOUNTING

Make sure vehicle is not loaded and is secured against motion before inspection.

Potential Hazards

- Missing wheel lugs.
- Low tire pressure.
- Tire damage.
- Lowest ladder rung too high.
- Missing or broken steps, ladder rungs, handrails, etc.
- Slick (muddy, greasy or icy) boots and/or ladder.
- Both hands not free for climbing.
- Miners in dangerous position around equipment.
- Poor access to areas that must be checked.
- Undetected suspension or steering damage.

Preventive Measures

- Make a thorough preoperation inspection a habit. Include tires and wheels, ladders and platforms, suspension and steering, and walking around the vehicle to check for persons or obstructions. Report any safety defects.
- Clean mud, grease, or ice off boots and ladders. Wear gloves to ensure a good grip.
- Use belt hooks, pockets, etc., to carry materials up ladders and keep both hands free for climbing. Use ropes to hoist bulkier items. Face ladder and use three points of contact when climbing (two hands and one foot or two feet and one hand in contact with ladder at all times).
- Sound horn or other warning device before starting engine or starting to move.
- Be sure backup alarm is operating properly.
- Always look in the direction of travel.

[1]Materials obtained from mining companies, the Mine Safety and Health Administration, and the Job Training Series for Open Pit Mining (British Columbia)

ENTERING CAB AND STARTING VEHICLE

Potential Hazards

- Loose items in cab.
- Seat belt not buckled.
- Parking brake off when starting engine.
- Congested parking area.
- Dirty windshield resulting in poor visibility.
- Possibility of fire.
- Defective brakes, gauges, steering system, or retarder.

Preventive Measures

- Keep cab free of extraneous material; secure necessary items carried.
- Check equipment for warning tags.
- Make sure parking brake is set and controls are in neutral prior to starting.
- Adjust seat and buckle up.
- Keep cab windows clean.
- Check around equipment before getting on and, to the extent possible, use mirrors before moving.
- Check gauges and warning lights before and after starting engine. Check for smooth idle and unusual smoke or noise. Check wipers and lights.
- Make sure all controls are working properly before moving.
- Check for fuel leaks. Know the location and operation of fire extinguishers.
- Do not use equipment with safety defects.
- Sound horn or other warning device before starting engine or moving equipment.
- Check all brake systems, steering systems, and retarders in accordance with company policy or manufacturer's recommendations.

OPERATIONS TRUCK

- Avoid running over rocks or into potholes or ruts.
- Drive with thumbs on the outside of the steering wheel to avoid injury if the wheel spins.
- At the end of the shift, turn a **NEAT AND LEGIBLE REPORT** into the mine office on the form provided.
- Be sure the truck bed is all the way down before driving under overhead cable bridges, powerlines, or other overhead obstructions.
- Drive defensively at all times.
- Be aware of the locations of runaway ramps, straddle berms, and other means to stop the truck in case of electrical or mechanical failure.
- Check gauges and warning lights frequently. Whenever a gauge does not indicate specific pressure, shut down immediately.
- Observe all signs and signals.

Dumping Hazards

- Backing over a person, equipment, or obstruction.
- Backing over edge of a dump.
- Pulling down highlines and other obstructions.

Dumping Precautions

- Check air gauge and brakes before backing up to dump.
- Whenever possible, view dump crest before turning on dump and backing up. Leave a minimum of one truck width between truck and dump crest when making turns at the dump.
- Do not back up if visibility is impaired.
- Set service brake (electric drive) or parking brake (mechanical drive) before and during dumping.
- Back up to the dump berm squarely and make sure truck is in neutral before dumping.
- Make every effort to back up against the dump berm. However, **NEVER RELY ON THE BERM TO STOP THE TRUCK**. BERMS SHOULD BE USED AS A GUIDE ONLY!
- Plug out any low spots in the dump berm by dumping short.
- Lower truck beds completely before pulling away from a dump location.
- Do not pull truck bed through material after dumping.
- Do not let truck bed come in contact with berm material so that the wheels are lifted off the ground while dumping.
- Use signal lights for dumping at the primary crushers.

Red light: Do not spot on crusher dump pocket and pull out if already spotted.

Amber light: OK to spot on dump pocket, but do not dump. If given an amber light while dumping, stop dumping.

Green light: Proceed to dump.

- If necessary to lower a loaded bed, GENTLY bleed off hoist cylinder pressure using the dump lever. **DO NOT PUSH LEVER ALL THE WAY INTO THE LOWER POSITION OR THE BED WILL FALL**.

BEST PRACTICES FOR SURFACE HAULAGE TRUCK DUMPING

MATERIALS

- If material must be dumped over edge of stockpile or highwall, examine area carefully, especially at the beginning of a shift, for signs of unstable ground and lack of berms.
- If the ground at a dump site could fail, arrange to dump material a safe distance back from the edge.
- Stay in truck when waiting at dump area.
- When dumping at a stockpile, do not dump over the edge where the toe of the stockpile has been removed.

PROCEDURES

• Cross windrows at an angle, one wheel leading, to reduce jarring the load, the truck, and yourself.
• Be sure the dump area has been checked for cracks along the top edge or sunken or soft areas, which indicate an unstable edge. Also check for steep slopes. The weight of a truck near an unstable edge can be enough to break it loose, taking the operator with it.
• Never dump over the edge of an unstable dump slope.
• When possible, approach the dump site from left to right and make sure the dumping berm is in place (contact the supervisor if it is not). This also provides better visibility to look over the area for obstacles or unstable conditions along the dump edge and slope. Keep at least one truck width away from the edge berm. Most mines use mid-axle height as a minimum for berm construction.
• Report loss of nighttime area lights that provide the capability of seeing around the dump point at night. Do not dump in areas where lighting is inadequate.
• Check that the dumping area is level or sloping slightly up toward the edge. A slight-up slope to the edge will help keep the truck under control when backing uphill. It will also drain water away from the edge so the dump edge remains dry and stable.
• If more than one truck is dumping at a time, keep at least two truck-widths apart to spread the weight and to avoid hitting another truck if a tip-over occurs.
• Be aware that rain, melting snow, freezing and thawing, and other weather effects can weaken the dump and lead to unstable slopes.
• Make the turn to back up at least one truck-width away from the dump berm to avoid overloading the dump edge.
• Back up almost perpendicular to the dumping berm so the left rear tire approaches the berm first. This improves dumping position and can help keep the truck from penetrating or going through the berm.
• Back up slowly and come to a gradual stop at the dump point to avoid loading the rear axle and causing the edge of the dump to break away.
• Do not use or expect the berms or bumper blocks to stop the truck. Stop just before the berm. This avoids accidentally breaking through the berm and going over the edge.
• If people or equipment operators are nearby, wait to dump a load. Raising the truck bed can cause materials to fall off and can injure or kill those around the truck.
• Shift the truck into neutral and set the appropriate brake when dumping. This avoids accidental movement forward or backward while the driver is focusing on dumping. Do not use the retarder as a brake.
• Be alert for the presence of material stuck in the bed when hauling wet or damp materials. Materials stuck in the bed can cause truck stability problems.
• Before leaving the dump area, lower the truck bed completely. Lowering the truck bed provides better truck stability, reduces damage to equipment, and reduces the likelihood of electrocution by overhead powerlines.
• When pulling out, turn left whenever possible, which gives a better view of the area the truck is turning toward.

DUMPING IN DESIGNATED AREA

Drivers must dump only at a location designated by the supervisor. IF A DRIVER IS UNSURE WHERE TO DUMP, THEN HE/SHE SHOULDN'T DUMP. Drivers should contact their supervisors and determine the correct dumping location rather than to take a chance and dump at a potentially unsafe area. A supervisor may designate dump locations not only on the basis of production requirements, but also on safety considerations of which drivers may be unaware. When drivers are assigned to a dump location, they should stay alert for potential hazards and notify the supervisor immediately if a problem is spotted.

If dumping is done in an area where dozers are being used to push material over the edge of the pile, drivers should use them appropriately. Loads should be dumped back from the slope edge as directed. Accidents have occurred when a truck dumped a load over an edge even though a dozer had been assigned to push material over. In many of these cases, the crest of the pile was not strong enough to support the weight of the truck or the berms were inadequate.

BACKING ORIENTATION

As a truck is backed at an angle to the slope edge, one set of rear dual tires will reach the edge before the other. If the rear tires on the side of the truck opposite the operator's compartment reach the slope edge first, the chance for an accident increases. This happens when the operator is watching his/her side of the truck and unexpectedly contacts the berm with the other side so that the far-side tires bump the berm too hard and the truck either goes through or over the berm. If the berms are inadequate or other impediments are not in place, then the operator may simply back the far-side dual tires over the edge.

Therefore, it is important for drivers to back their trucks square to the edge of the slope or at a slight angle that places the operator's side closer to the slope edge. Drivers should primarily use the mirrors on their side of the truck when backing. It is much easier to judge backing distance when using the near-side mirrors. They are closer and provide a larger image than the mirrors on the far side of the truck.

In summary, DRIVERS SHOULD BACK SQUARE TO THE EDGE USING THE CLOSEST MIRROR. THEY SHOULD GLANCE OCCASIONALLY AT THE FAR MIRRORS TO CHECK FOR CORRECT ORIENTATION AND POSSIBLE OBSTACLES.

BACKING SPEED

Drivers should approach the slope edge at a moderate-to-slow speed when backing to dump and should apply the brakes gradually while stopping. Braking hard at the last moment imposes a large horizontal force on the truck in addition to the

normal vertical force imposed by the weight of the truck. This additional horizontal force substantially increases the chance of a slope failure. Even when backing to the slope edge slowly, it is important to brake gradually. Braking hard at the last minute at a slow speed will also increase the potential for a slope failure.

In addition to slope failures, there are other hazards associated with backing too fast. It decreases the driver's reaction time if hazards occur at the dump point or problems develop with the truck. It also increases the risk that the driver will contact the berm too fast, going over or through it.

UNLEVEL GROUND

A vehicle's center of gravity rises as the bed is raised into the dump position. If the truck is parked on a slight downhill grade toward the berm or if it is leaning sideways, it may be in danger of tipping. The potential for tipping increases when the load is hanging up in the truck bed or the material is not flowing out freely.

The dump point should NEVER be constructed so a truck is parked on a downward slope toward the berm. If the decline is too steep and material hangs up in the truck bed, then the truck is in danger of tipping over backward. Creating a slope toward a dump point also provides poor drainage, allowing water to accumulate at the berm, which can result in decreased slope strength and soft footing that allows the rear tires to sink. Stopping on a decline also requires additional braking force, which places additional reliance on the braking system and imposes greater forces on the slope, increasing the potential for a slope failure.

THE DUMP POINT SHOULD BE CONSTRUCTED LEVEL OR AT A SLIGHT UPWARD INCLINE. Maintaining the dump point at a slight upward angle (1° to 3°) allows for drainage and decreases the amount of force required to stop the truck. It also decreases the chance of tipping over backward should material hang up in the truck bed.

THE DUMP POINT SHOULD BE CONSTRUCTED SO A HAULAGE TRUCK SITS FLAT AND DOES NOT LEAN TO THE SIDE. If the sideways angle is too steep or material hangs up in the truck bed, the truck is in danger of tipping on its side. This is also a problem when the dump point is soft. The rear tires may sink as the truck bed is raised into the dumping position. If the tires do not sink evenly, the truck will lean to one side, again increasing the chance of tipping over. Soft material will also force the operator to apply more power to the drive wheels when approaching the berm, complicating control of the truck in this potentially hazardous area.

TRUCK BED POSITION

As the operator approaches the dump site, he or she should look for any overhead obstructions, such as powerlines. After backing to the dump point, the truck should be brought to a complete stop and the parking brake or a holding brake applied. The procedures provided in the operator's manual should be followed for a particular truck being operated.

After the load is dumped, the driver should pull out slowly. The transmission should be engaged before the parking brake is released to prevent the truck from rolling backward. The truck bed should be as low as soon as possible. If material is hanging up in the bed, moving the truck can increase the chance for tipping over. The truck bed should be fully lowered before leaving the dump site and entering the haulage road.

HAULAGE TRUCKS BACKING OVER AN EDGE

An operator must STAY ALERT when operating a haulage truck near the crest of a stockpile. They must know where the rear tires are in relation to the slope edge. A surprisingly high number of stockpile accidents occur when a haulage truck is simply backed over the edge of a pile. When operators are end-dumping over the crest of a stockpile, they must make sure that it is in a designated area with adequate berms or other impediments.

Mirrors must be clean and properly adjusted. When dumping at night, lighting should be adequate to see the edge. Brakes must be tested to ensure they are working properly.

Operators should back slowly to ensure there is adequate time to react and stop before contacting the berm. BERMS CANNOT BE RELIED ON TO STOP A TRUCK. When a spotter is used, the spotter should stand where his/her signal can be clearly recognized. Spotters should use signal lights at night and when visibility is limited.

BERMS

Backing through or over a berm is a common cause of stockpile accidents. A normal rule of thumb states that berm height should be equal to mid-axle height of the largest truck using the dump site. For roadways, this is mandatory under 30 CFR 56/57.9300. Coal mine safety and health policy also requires that berms be equal to the axle height of the largest truck at the work site. The berms should be constructed strong enough to survive a moderate impact. However, they should not be relied on to stop a truck. Berms should be used as a visual indicator of where the truck should be stopped or to provide a "feeling" of the berm as the rear tires contact it. A BERM SHOULD BE USED FOR SPOTTING ONLY!

If a berm is present, it should not be assumed that the area is a safe place to dump. The haulage truck driver should verify that material has not been removed from the toe of the pile. Routine supervisory inspections should also be performed to ensure that the slope is stable. The relevant Federal regulations are—

> 30 CFR 56/57.9301. Dump site restraints.
>
> Berms, bumper blocks, safety hooks, or similar impeding devices shall be provided at dumping locations where there is a hazard of overtravel or overturning.
>
> 30 CFR 77.1605 Loading and haulage equipment, installations.

> Berms, bumper blocks, safety hooks, or similar means shall be provided to prevent overtravel and overturning at dumping locations.

Therefore, depending upon the specific mine, an impediment other than a berm may be used. TRUCK DRIVERS MUST MAKE SURE THAT THEY DUMP ONLY WHERE A BERM OR IMPEDING DEVICE IS PROVIDED.

SEAT BELTS

The chance of surviving an accident is greater when a seat belt is worn. In fact, the safest place to be during an accident is in the cab with a seat belt fastened. Nearly half of all mobile mining equipment fatalities involved operators who were not wearing a seat belt or who took it off in a futile attempt to jump clear of the equipment. Staying with the machine is almost always better than attempting to jump out. A significant number of fatalities can be prevented by the simple act of wearing a seat belt and by remaining in the cab.

With a few exceptions, Federal regulations mandate that seat belts be provided on dozers, scrapers, front-end loaders, haulage trucks, etc., and that they be maintained in working condition. More importantly, the regulations state that they must be worn.

DRUG AND ALCOHOL ABUSE

The safe operation of mobile equipment is extremely dependent upon the capabilities of the operator, especially when the size and power of modern equipment are considered. Drugs and alcohol dull senses. They reduce response time, attention span, and the a person's ability to identify an impending problem. More importantly, they inhibit a person's ability to react when in a hazardous situation.

Miners who use drugs or alcohol affect not only themselves, but the people working with them. A person under the influence of drugs or alcohol is more likely to be involved in an accident and suffer an injury. More importantly, a person under the influence of drugs or alcohol is more likely to cause a serious injury or death to a coworker, not to mention damage to company property. FOR EVERYONE'S SAKE, DON'T MIX DRUGS, ALCOHOL, AND MINING.

STOCKPILES

A stockpile is a temporary pile of ore or other material that will be used later. Stockpiles are especially hazardous if activities are being carried out at the top edge and the toe. Loading out material at the toe causes sloughing that can cover a loader. It can also oversteepen the slope, making the top edge of the pile unstable for trucks that may be dumping at the top. Always dump in an area where nothing is happening immediately below and never dump over an oversteepened slope. If possible, dumping should be done at least one truck-length away from the edge and materials, then pushed by dozer to final position. Always look around.

SPOIL PILES

Spoil piles are usually permanently placed materials or spoils. Because the layout and characteristics of dumped materials change, there can be soft spots, weak and loose materials, and steep slopes, all of which can cause unstable piles. Of special concern are dumps that are constructed by trucks end-dumping over the dump edge to form angle-of-repose slopes. Careful inspection of the dump edge for sloughs and cracks along the edge should be done before approaching the dump. Look for the minimum suggested heights (to mid-axle) of dumping berms. Remember also that too much moisture can weaken the pile. BE CAREFUL.

BINS AND HOPPERS

Bins and hoppers are engineered structures for storing or channeling materials. These structures have a specific dump point with features such as overhead obstructions, chutes, gratings, stopping blocks, and guide rails. Look over an area before pulling in to dump to check for any damage to any of these features. Dumping at these areas is very repetitive, and special efforts are needed to maintain driver awareness. STAY ALERT.

STOCKPILING TECHNIQUES

Stockpiling techniques vary depending upon the size of the mine, the type of material handled, and type of equipment available. Some techniques are safer than others and should be used when applicable.

A "Good" Method of Stockpiling

A "good" method of stockpiling involves dumping a load back from the crest of the pile, after which the material is bumped over the edge by a dozer or a front-end loader using other material. This method allows the easy construction and maintenance of berms and keeps mobile equipment away from the edge of the pile where the chance of being involved in an accident is highest. When combined with well-trained operators and routine inspections for signs of slope instability, this method drastically reduces the likelihood of an accident.

A "Fair" Method of Stockpiling

A "fair" method of stockpiling involves dumping a load directly over the crest of the pile. For this method to be performed safely, adequate berms must be maintained and equipment operators must be well trained to recognize stockpile hazards.

Other factors, including the type of material, condition of the material, weather, and type and size of haulage truck, also need to be considered. It is also important to inspect the dump area routinely for signs of slope instability. When using this method, it is important to ensure that material is not removed from the toe of the pile where dumping is taking place.

A "Dangerous" Method of Stockpiling

A "dangerous" method of stockpiling involves dumping a load directly over the crest of a pile where material has beenremoved from the toe. Removing material from the base of a pile generally results in a steepened slope. A steepened slope is less stable and cannot support as much weight, creating a hazard for equipment operating near the crest of the pile if the slope fails. The mine supervisor, loader operator, and haulage truck driver must ensure that dumping does not occur where the slope has been steepened by reclaiming activities. The practice of dumping over the edge of a stockpile in an area where the slope has been loaded out at the toe should be prohibited.

Good Alternative Method

A very good alternative method involves the construction of stockpiles in layers. In this method, loads are dumped as piles on a single level. After a level is complete, it is then smoothed over by a dozer and dumping continues on the next layer. Operating mobile equipment compacts the previous layer and creates a pile of greater strength. The method also permits the slope angle to be maintained lower than the angle of repose, resulting in greater slope stability. Haulage trucks are also kept away from the edge of the pile. From a quality control standpoint, this method also avoids undesirable size separation of material.

BIBLIOGRAPHY

National Mine Health and Safety Academy, Beaver, WV [1996]. Annual refresher workbook. 20 pp.

Glenrock Coal Co., Glenrock, WY [1997]. Off-highway truck safety manual. 27 pp.

Mine Safety and Health Administration [in press]. Dump-point inspection handbook. MSHA Handbook Series. Beaver, WV: U.S. Dept. of Labor, National Health and Safety Academy.

Mine Safety and Health Administration [1992]. Stockpiling safety. Safety Manual 30. Beaver, WV: U.S. Dept. of Labor, National Health and Safety Academy, 58 pp.

Mine Safety and Health Administration [1995]. Surface haulage safety. Safety Manual 22. Beaver, WV: U.S. Dept. of Labor, National Health and Safety Academy, 41 pp.

Mine Safety and Health Administration [1997]. Dump-point safety: Stockpiles and wastepiles. Safety video, VC-858, 14 min. Beaver, WV: U.S. Dept. of Labor, National Health and Safety Academy.

Newmont Gold Co., Carlin, NV [1995]. Truck driver training manual. Training Dept., 21 pp.

Phelps Dodge Morenci, Morenci Mines Division, Morenci, AZ [1992]. Specific codes of safe practice for heavy truck operations. 28 pp.

APPENDIX B.–MSHA PART 50 DATA SELECTION CRITERIA

MSHA Part 50 data for the years 1988 through 1997 were analyzed using the selection criteria in table B-1. Each target group except the dump site group was acquired using the MSHA codes. To acquire the descriptions and numbers of serious injuries at dump site, 3,116 narratives for the load-haul-dump (LHD) group were analyzed, resulting in a final selection of 369 records. To ensure that all fatal incidents were identified, the authors reviewed the 173 fatal injury narratives for the surface mining truck group, which resulted in the selection of 30 fatalities that might have occurred while a haulage truck was active at a dump site. The authors reviewed MSHA fatal accident reports for these 30 incidents, resulting in the addition of one fatal incident not selected using the criteria shown in table B-1.

Table B-1.—Criteria used to search MSHA Part 50 databases

MSHA field data	Target data	Selection criteria	No. of records
Subunit	Surface mining	Surface at underground OR Strip OR Auger OR Culm bank OR Other surface OR Preparation plant	155,992
Degree of injury	Surface mining Serious injuries	Death OR Permanent disability OR Days away from work only OR Days away and restricted activity	79,601
Mining machine	Surface mining Mobile equipment Serious injuries	Bulldozer OR Front-end loader OR Load-haul-dump OR Off-highway ore haulage truck OR Highway ore haulage trucks OR Road grader OR Scraper OR Trucks (not ore haulage)	15, 601
Mining machine	Surface mining Truck Serious injuries	Load-haul-dump OR Off-highway ore haulage truck OR Highway ore haulage trucks OR Trucks (not ore haulage)	7,305
Mine worker activity	Surface mining Truck Load-haul-dump Serious injuries	Escaping a hazard OR Bulldozer OR Front-end loader OR Haulage truck OR Load-haul-dump OR Utility truck OR Surface equipment not elsewhere classified	3,116
Narrative	Surface mining Haulage truck Dump site Serious injuries	Author selection	[1] 369

[1] 370 serious injuries at dump sites were analyzed in this report.

APPENDIX C.—SUPPLEMENTAL INJURY TABLES

SURFACE MINING AND SURFACE MOBILE EQUIPMENT INJURY TABLES

Table C-1.—Fatalities and lost-time injuries by surface mining and mobile equipment by year

Year	Surface mining			Mobile equipment	
	Fatalities	Lost-time injuries	Hours worked	Fatalities	Lost-time injuries
1988	69	9,919	492,698,210	32	1,786
1989	63	10,325	502,994,475	23	1,893
1990	69	10,119	506,406,304	32	1,880
1991	63	9,041	482,370,836	27	1,650
1992	57	7,826	471,459,652	29	1,499
1993	55	7,288	460,721,974	20	1,433
1994	54	7,253	474,369,329	24	1,515
1995	72	6,123	474,539,386	31	1,270
1996	52	5,622	476,888,917	17	1,242
1997	65	5,504	480,996,381	27	1,171
Totals	619	78,982	4,823,445,464	262	15,339

Table C-2.—Serious injuries by surface mining and mobile equipment by degree of injury

Degree of injury	Surface mining		Mobile equipment	
	Number	Percent	Number	Percent
Days away from work only	69,136	86.9	13,965	89.5
Days away and restricted activity	7,472	9.4	1,111	7.1
Permanent disability	2,374	3.0	263	1.7
Death	619	0.8	262	1.7
Total	79,601	100	15,601	100

Table C-3.—Serious injuries and fatalities in surface mining by mine worker activity

Mine worker activity	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Handling supplies or material, loading and unloading	18,371	23.1	54	8.7
Machine maintenance/repair	11,579	14.5	91	14.7
Get on or off equipment	8,973	11.3	25	4.0
Walking/running	6,687	8.4	31	5.0
Hand tools (not powered)	6,419	8.1	17	2.7
Haulage truck	2,439	3.1	68	11.0
Welding and cutting	2,407	3.0	17	2.7
Hand load: shoveling/mucking	1,859	2.3	7	1.1
All other	20,867	26.2	309	49.9
Total	79,601	100	619	100

Table C-4.—Serious injuries and fatalities with mobile equipment by mine worker activity

Mine worker activity	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Getting on or off equipment	4,490	28.8	17	6.5
Haulage truck	2,335	15.0	66	25.2
Machine maintenance/repair	2,305	14.8	28	10.7
Front-end loader	1,277	8.2	25	9.5
Handling supplies or material, loading and unloading	1,075	6.9	15	5.7
Bulldozer	935	6.0	17	6.5
Utility truck	508	3.3	25	9.5
Hand tools (not powered)	384	2.5	3	1.1
All other	2,292	14.7	66	25.2
Total	15,601	100	262	100

Table C-5.—Serious injuries and fatalities in surface mining by mining machine

Mining machine	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Hand tools (not powered)	7,841	9.9	14	2.3
Ore haulage trucks, off-highway	4,926	6.2	126	20.4
Front-end loader	4,389	5.5	52	8.4
Bulldozer	2,962	3.7	23	3.7
Conveyor (all types)	2,233	2.8	35	5.7
Welding machine	2,193	2.8	8	1.3
Trucks (not ore haulage)	2,040	2.6	43	6.9
Dragline or shovel (mining and stripping)	1,778	2.2	26	4.2
Other	13,985	17.6	173	27.9
Missing	37,254	46.8	119	19.2
Total	79,601	100	619	100

Table C-6.—Serious injuries and fatalities with mobile equipment by mining machine

Mining machine	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Ore haulage trucks, off-highway	4,926	31.6	126	48.1
Front-end loader	4,389	28.1	52	19.8
Bulldozer	2,962	19.0	23	16.4
Trucks (not ore haulage)	2,040	13.1	43	8.8
Scraper	681	4.4	11	4.2
Roadgrader	264	1.7	3	1.1
Load-haul-dump	179	1.1	1	1.1
Ore haulage truck, highway	160	1.0	3	0.4
Total	15,601	100	262	100

Table C-7.—Serious injuries and fatalities in surface mining by canvas class

Canvas class	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Stone	25,580	32.1	197	31.8
Bituminous coal	24,238	30.4	198	32.0
Metal	11,018	13.8	75	12.1
Sand and gravel	10,943	13.7	102	16.5
Nonmetal	6,499	8.2	39	6.3
Anthracite coal	1,323	1.7	8	1.3
Total	79,601	100	619	100

Table C-8.—Serious injuries and fatalities with mobile equipment by canvas class

Canvas class	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Bituminous coal	7,107	45.6	91	34.7
Stone	3,785	24.3	75	28.6
Sand and gravel	2,083	13.4	44	16.8
Metal	1,669	10.7	39	14.9
Nonmetal	679	4.4	11	4.2
Anthracite coal	278	1.8	2	0.8
Total	15,601	100	262	100

HAULAGE TRUCK INJURY TABLES - MSHA DATA FIELDS

Table C-9.—Serious injuries and fatalities with haulage trucks by mine worker activity

Mine worker activity	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Haulage truck	317	85.7	22	84.6
Escaping a hazard	31	8.4	1	3.8
Utility truck	10	2.7	1	3.8
Load-haul-dump	7	1.9	1	3.8
Surface equipment not elsewhere classified	2	0.5	0	0.0
Getting on or off equipment	1	0.3	1	3.8
Bulldozer	1	0.3	0	0.0
Front-end loader	1	0.3	0	0.0
Total	370	100	26	100

Table C-10.—Serious injuries and fatalities with haulage trucks by mining machine

Mining machine	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Ore haulage trucks, off-highway	343	92.7	24	92.3
Trucks (not ore haulage)	14	3.8	2	7.7
Ore haulage trucks, highway	11	3.0	0	0.0
Load-haul-dump	2	0.5	0	0.0
Total	370	100	26	100

Table C-11.—Serious injuries and fatalities with haulage trucks by subunit

Subunit	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Strip or open pit	284	76.8	22	84.6
Mill or preparation plant	69	18.6	3	11.5
Surface at underground	8	2.2	1	3.8
Dredge	4	1.1	0	0.0
Culm bank	3	0.8	0	0.0
Auger	2	0.5	0	0.0
Total	370	100	26	100

Table C-12.—Serious injuries and fatalities with haulage trucks by state

State	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Kentucky	64	17.3	4	15.4
West Virginia	38	10.3	1	3.8
Pennsylvania	35	9.5	4	15.4
Nevada	28	7.6	3	11.5
California	19	5.1	2	7.7
Minnesota	16	4.3	0	0.0
Ohio	15	4.1	1	3.8
Indiana	13	3.5	0	0.0
Texas	12	3.2	0	0.0
Virginia	12	3.2	0	0.0
Arizona	10	2.7	3	11.5
All others	108	29.2	8	30.8
Total	370	100	26	100

Table C-13.—Serious injuries and fatalities with haulage trucks by nature of injury

Nature of injury	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Multiple injuries	118	31.9	17	65.4
Sprains, strains	103	27.8	0	0.0
Fracture, chip	43	11.6	0	0.0
Contusion, bruise	36	9.7	0	0.0
Cut, laceration	17	4.6	0	0.0
Burn or scald	6	1.6	2	7.7
Asphyxia, strangulation, drowning	4	1.1	4	15.4
Concussion, brain	3	0.8	0	0.0
All other	40	10.8	3	11.5
Total	370	100	26	100

Table C-14.—Serious injuries and fatalities with haulage trucks by age of victim

Age range	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Less than 20	7	1.9	1	3.8
20 to 29	66	17.8	5	19.2
30 to 39	123	33.2	3	11.5
40 to 49	81	21.9	4	15.4
50 to 59	62	16.8	6	23.1
60 to 69	20	5.4	6	23.1
70 and older	2	0.5	1	3.8
Unknown	9	2.4	0	0.0
Total	370	100	26	100

Table C-15.—Fatalities with haulage trucks by mining experience of victim

Number of years of experience	Total years of mining		Total years at this mine		Total years at this job	
	Number	Percent	Number	Percent	Number	Percent
Less than 1	3	11.5	9	34.7	10	38.5
1 to 5	4	15.4	7	26.9	6	23.1
5 to 15	10	38.5	7	26.9	7	26.9
15 to 30	5	19.2	2	7.7	3	11.5
More than 30	4	15.4	1	3.8	0	0.0
Total	26	100	26	100	26	100

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Table C-16.—Serious injuries and fatalities with haulage trucks by truck activity

Truck activity	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Stationary dumping	179	48.4	4	15.4
Backing up	156	42.2	20	76.9
Moving forward	32	8.6	2	7.7
Other/unknown	3	0.8	0	0.0
Total	370	100	26	100

Table C-17.—Serious injuries and fatalities with haulage trucks by incident

Incident	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Fell over edge	137	37.0	22	84.6
Rolled over	93	25.1	1	3.8
Bounced or jarred	78	21.1	0	0.0
Collision	12	3.2	0	0.0
Fire	11	3.0	2	7.7
Hung up on edge	10	2.7	0	0.0
Struck by object	3	0.8	0	0.0
Contacted powerline	3	0.8	1	3.8
Other	21	5.7	0	0.0
Unknown	2	0.5	0	0.0
Total	370	100	26	100

Table C-18.—Serious injuries and fatalities with haulage trucks by effects on operator

Operator Impact	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Struck against object	200	54.1	7	26.9
Jarred/tossed	80	21.6	0	0.0
Landed outside cab	52	14.1	11	42.3
Musculoskeletal injuries	16	4.3	0	0.0
Struck by object	8	2.2	0	0.0
Burned	8	2.2	3	11.5
Drowned	4	1.1	4	15.4
Electrocuted	2	0.5	1	3.8
Total	370	100	26	100

Table C-19.—Serious injuries by haulage truck activity by year

Year	Stationary dumping	Backing up	Moving forward	Unknown/other	Total
1988	24	18	5	0	47
1989	17	27	1	0	45
1990	21	24	4	1	50
1991	20	20	3	1	44
1992	15	13	4	0	32
1993	11	18	2	0	31
1994	22	13	1	0	36
1995	15	7	1	1	24
1996	15	7	6	0	28
1997	19	9	5	0	33
Total	179	156	32	3	370

Table C-20.—Serious injuries and fatalities by exit cause from haulage truck

Exit cause	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Jumped	35	67.3	1	9.1
Thrown out	13	25.0	7	63.6
Jumped or thrown out	4	7.7	3	27.3
Total	52	100	11	100

Table C-21.—Serious injuries and fatalities with haulage trucks by seat belt use

Use	Serious injuries		Fatalities	
	Number	Percent	Number	Percent
Seat belt worn	1	1.9	0	0.0
Seat belt NOT worn	11	21.2	10	90.9
Unknown	40	76.9	1	9.1
Total	52	100	11	100

Table C-22.—Contributing factors to serious injuries and fatalities with haulage trucks

Contributing factors	Serious injuries		Fatalities	
	Number	Percentage of 370	Number	Percentage of 26
Edge failure	79	21.4	6	23.1
Mechanical/hydraulic failure	56	15.1	2	7.7
Uneven ground	48	13.0	1	3.8
Load unbalanced/shifted	43	11.6	2	7.7
Traveled though berm/barrier	33	8.9	8	30.8
Undercut pile	16	4.3	6	23.1
No berm or barrier	14	3.8	9	34.6
Weather	9	2.4	1	3.8
Truck stalled	7	1.9	0	0.0
Inadequate powerline clearance	4	1.1	1	3.8
Limited visibility	1	0.3	1	3.8
None	96	25.9	0	0.0

APPENDIX D.–CODE LISTING FOR AUTHOR-DEFINED INJURY CLASSIFICATIONS

PRIMARY INJURY CLASSIFICATIONS

A. Truck activity: What was the truck doing?
1. Moving forward
2. Backing up
3. Stationary dumping
4. Other
5. Unknown (not enough information)

Note: These activities are based on truck movement. If the truck was dumping while moving, the activity was coded as either moving forward or backing up. If the truck was dumping, but movement was not indicated, the term "stationary dumping" was used.

B. Incident result: What happened to the truck?
1. Fell over edge, i.e., traveled over an edge and came to rest at a lower level.
2. Hung up on edge, i.e., traveled onto an edge and got stuck without falling over.
3. Rolled over, i.e., quarter rolls and other rolls on the same level.
4. Collision, i.e., collided with mobile equipment or other large stationary objects.
5. Struck by object, i.e., struck by moving object that was not a piece of mobile equipment. This category includes an object coming into the cab.
6. Bounced or jarred, i.e., a sudden release of energy that caused the truck to bounce or lurch forward or backward.
7. Fire
8. Contacted powerline.
9. Other.
10. Unknown (not enough information).

C. Operator impact: What happened to the truck driver?
1. Struck against object, i.e, operator thrown against something within truck cab.
2. Jarred/tossed, i.e., sudden release of energy caused operator to be shaken up or tossed within the truck cab without striking against something. (Examples: truck bed shifted or dropped; the truck was backed over a rock or large chunks, went through a hole, or collided with something at low speed.)
3. Musculoskeletal injury (MSI), i.e., operator hurt while twisting or turning, reaching too far, pulling or pushing on something, or lifting something.
4. Landed outside of cab, i.e., operator either jumped or was thrown from truck cab and struck the ground.
5. Struck by object, i.e., operator hit by moving object that came either from within or outside the cab.
6. Drowned.
7. Burned.
8. Electrocuted.
9. Other.
10. Unknown (not enough information).

D. Contributing factors: Events that contributed to the injury incident.
1. Edge failure, i.e., ground at the edge of the dump site gave way.
2. Mechanical/hydraulic failure, i.e., a mechanical or hydraulic truck part failed.
3. Undercut pile, i.e., material removed from the base of a pile compromised the stability of the pile.
4. Traveled through berm/barrier, i.e., the truck went through an edge berm or barrier.
5. No berm/barrier, i.e, no berm or barrier had been constructed at the dump site edge.
6. Uneven ground, i.e., the truck traveled over elevated ground, through holes, or over obstacles.
7. Load unbalanced or shifted , i.e., truck bed material either shifted or dropped.
8. Weather, i.e., weather conditions were severe.
9. Truck stalled, i.e., truck lost power and moved without operator control.
10. Inadequate powerline clearance, i.e., powerlines in a truck dumping area were close enough to the ground that they could be contacted by a raised bed.
11. Limited visibility, i.e., the truck operator had difficulty seeing because of darkness or severe weather conditions.

Note: More than one factor might have contributed to each incident.

SECONDARY INJURY CLASSIFICATIONS

A. Exit cause. The way the operator left the truck cab in incidents in which the operator landed outside the cab.
1. Jumped.
2. Thrown out.
3. Either jumped or thrown out.

B. Seat belt usage. Indication as to whether the truck operator was wearing a seat belt.
0. Unknown.
1. Seat belt worn.
2. Seat belt NOT worn.

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